The Energize Denver Renewable Heating and Cooling Plan

Resilient Existing Buildings and Homes



DENVER
CLIMATE ACTION, SUSTAINABILITY & RESILIENCY

lotus
engineering & sustainability



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ABBREVIATIONS

AC Air conditioner
AHS American Housing Survey
ASHP Air source heat pump
CASR Denver's Office of Climate Action, Sustainability, and Resiliency
CAV Constant air volume
CBECS Commercial Building Energy Consumption Survey
CCASHP Cold climate air source heat pumps
CO Compressor cutoff temperature
COP Coefficient of performance
DHW Domestic hot water
DOE Department of Energy
DX Direct expansion
ER Electric resistance
EUI Energy use intensity
FCU Fan coil unit
GHG Greenhouse gas
HPWH Heat pump water heater
HVAC Heating, ventilation, and air conditioning
HW Hot water
HX Heat exchanger
IECC International Energy Conservation Code.
MFU Multifamily units.
NG Natural gas (later referred to as "gas")
NGWH Natural gas water heater
POU Point of use
PTAC Packaged terminal air conditioner
PTHP Packaged terminal heat pump
SHW Service hot water
VAV Variable air volume
WLHP Water loop heat pump



LETTER FROM THE MAYOR

We are living in a climate crisis. The decisions we make today have the potential to affect quality of life, public health, and community safety for generations. We know that cities are instrumental in leading this change. Denver is committed to reducing our carbon emissions, and we are taking action through a series of new plans and programs.

The Energize Denver Renewable Heating and Cooling Plan: Resilient Existing Building and Homes is an example of our leadership and demonstrates how we will move urgently toward a cost-effective, equitable, climate-safe future for our residents and businesses. This work is the result of in-depth community engagement and detailed analyses of building and home cost-effectiveness, grid impacts, and carbon emissions, all with a strong focus on race and social equity. Buildings and homes generate the most carbon pollution of any sector in Denver, and this plan details how we can significantly reduce these emissions over the next 20 years while improving the lives of our residents and the strength of our businesses.

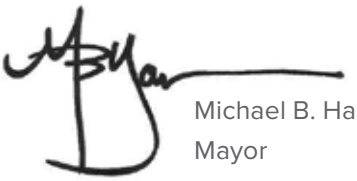
We listened to our community, engaging over 200 community members who live and work across Denver and who reflect the diversity of our city. We heard feedback from those who might be impacted the greatest: our under-resourced community members and our workforce. Leaders in public health, air quality, building operations, and property management guided our program design and informed our discussions on how to mitigate unintended consequences and build the foundation for an equitable transition.

Our technical analyses identified how we can design a successful program that sets reasonable expectations for change and impact yet pushes us toward aggressive action to design a new future. Not only will this plan reduce Denver's carbon emissions, it also will improve public health and safety.

This plan champions the needs of our under-resourced community members. Historic institutional racist practices continue to have impacts that limit an individual's right to a safe and healthy home. Climate solutions that improve quality of life and housing safety, including building and home electrification, can help advance Denver's commitment to build an equitable community.

Major changes to the status quo are needed to ensure that future Denver residents can achieve a high quality of life. These changes require innovation and a new approach to how we have always done things. We are excited to embark on this journey, and we are grateful to have you with us. Together we can reduce harm from climate change and make a better future for all.

Respectfully,



Michael B. Hancock
Mayor

Building Electrification is “not just a technological solution to climate… [it] works at the intersection of environmental, economic, and social justice.”

–Emerald Cities Collaborative and NAACP, as part of the Building Electrification Equity Project



EXECUTIVE SUMMARY

The Energize Denver Renewable Heating and Cooling Plan: Resilient Existing Building and Homes (the plan) provides a guide to decarbonizing existing homes and buildings in the City and County of Denver (Denver).[1]

Today, 97% of natural gas (gas) consumed in buildings and homes is used for space and water heat. The emissions from these uses comprise 24% of Denver's total greenhouse gas emissions. These emissions can be eliminated by replacing traditional gas space and water heating appliances with efficient electric heat pumps that are powered by renewable energy. By 2030, 80% of Denver's electricity will be generated by renewables, a commitment made by Xcel Energy, Denver's utility provider.[2] As more renewable energy powers the grid, the emissions from heat pumps decreases dramatically, eventually reaching zero.[3] "Renewable heating and cooling" refers to the electric heating and cooling technology that will be increasingly powered by renewable sources and replaces gas technology.

Denver can meet its climate and electrification goals with decisive action in the short term.

The objectives of this plan are to outline the process for implementing widespread renewable heating and cooling, to provide specific examples of how this can be done using current technology, and to ensure that progress is made equitably by creating policies that ensure communities most burdened by energy costs and the health impacts of climate change are served first.

Renewable heating and cooling will not only address climate change but also help improve racial equity[4] and quality of life for all Denver residents through:

- **Improved safety.** In a Denver grant-funded weatherization program for income-qualified households, 30% of these homes' gas appliances failed carbon monoxide (CO) safety tests. Transitioning homes to electricity will remove safety concerns associated with CO.
- **Improved public health.** We spend most of our lives indoors, and indoor air quality is often worse than outdoor air quality due to indoor pollutants, including those that come from gas appliances. A recent study from the Harvard T.H. Chan School of Public Health noted that air pollution is the eighth leading cause of death in the United States[5], and Colorado experienced up to 181 premature deaths and $2.023 billion in public health cost impacts in 2017[6]. Gas appliances create a significant, chronic health risk for thousands of residents, including children and seniors, and specifically for people of color (POC). A recent article in Science Advances indicates that POC households are exposed to greater levels of particulate matter 2.5 (PM 2.5) than white households and "residential gas combustion and commercial cooking are the among the largest sources of relative disparities."[7]
- **Reduced exposure to indoor and outdoor air pollutants.** The need to filter outdoor air will increase as the wildfire "season" extends and periods of poor air quality days intensify.
- **Improved access to cooling.** Approximately 30% of Denver homes do not have air conditioning, which is especially critical as the region's average temperatures rise.
- **Enhanced clean energy job opportunities.** Renewable heating and cooling could add approximately 1,000 new jobs.[8]
- **Increased long-term utility costs' stability.** This is crucial for fixed-income households and beneficial for industry.
- **Increased resiliency to climate change.** As temperatures increase, Denver's residents will be more susceptible to heat-related health impacts.

1 This plan references the technology available in 2020 and is expected to be regularly updated over time.

2 For more information see: https://www.xcelenergy.com/company/media_room/news_releases/xcel_energy_announces_2030_clean_energy_plan_to_reduce_carbon_emissions_85%25.

3 It should be noted that Denver also is pursuing aggressive electric vehicle adoption, and when performed in tandem with electrification, there will be a significant increase in electricity consumption. Impacts to the grid are evaluated through this plan and consider the high-level implications from electric vehicle adoption in addition to building electrification.

4 Racial equity is defined as a systemic endeavor, resulting in equitable opportunities and outcomes where race and ethnicity can no longer be used to predict life outcomes, and outcomes for all groups are improved.

5 For more information see: https://rmi.org/uncovering-the-deadly-toll-of-air-pollution-from-buildings/.

6 For more information see: https://rmi.org/health-air-quality-impacts-of-buildings-emissions/.

7 For more information see: https://advances.sciencemag.org/content/7/18/eabf4491.

8 "Inclusive Economics (2021). Denver Building Performance Jobs Model, Version April 15, 2021. Inclusive Economics, Oakland, CA. "

Electrification helps Denver residents adapt to these warmer temperatures without compromising their health. In addition, replacing gas equipment with equipment powered by renewable energy helps slow down and reduce the worst of impending climate change impacts.

COMMUNITY ENGAGEMENT

This plan was shaped over the past year by extensive stakeholder engagement with a diverse group of over 200 community members, including technical and policy experts from Xcel Energy, the city's utility provider. We conducted household interviews and surveys targeted at gaining input from people of color and under-resourced households. We also received ongoing expert input from our advisory groups and workforce roundtables that included public health experts, building energy systems contractors, and building managers with specializations in residential, commercial, and multifamily buildings. The plan was informed by extensive technical analysis of the current heating and cooling of Denver's buildings and homes, investigating how systems can be converted most cost-effectively to renewable heating and cooling, and supplemented with an analysis of implications for the electric grid.

ADVANCING EQUITY

Fewer resources, less protection, and greater proximity to pollution-emitting sites positions low-income communities and communities of color to bear more of the brunt from climate-related disasters even though they have historically contributed the least to climate change. These communities face the biggest challenges to navigate safely and efficiently through future climate-related disasters. Equitable climate solutions are key to ensuring that these communities are granted the protection and support that they are owed.



Photo by: Clay Banks

> *"Race is the number one indicator for the placement of toxic facilities in this country."*
>
> *— NAACP's Environmental and Climate Justice Program*

Denver has committed to addressing equity through its climate work by:

- Developing policies and programs that are informed by equitable decarbonization solutions, such as targeted universalism[9].
- Developing a broad coalition to understand and tackle problems from a variety of perspectives.
- Listening to the voices from under-resourced communities and applying their stories to inform and help develop solutions.
- Ensuring that all community members, particularly those who have been under-resourced for decades, are the direct beneficiaries of climate solutions.

Denver's plan details how renewable heating and cooling can help advance equity by reducing long-term energy burden, modernizing home appliances, providing cooling, and improving indoor air quality. Denver will help further this transition by:

- Developing accessible public outreach materials for under-resourced households.
- Launching an Equity-First pilot project.
- Partnering with equity-focused organizations.
- Promoting equitable housing policies and programs.
- Designing income-based incentives tied to anti-displacement requirements.
- Applying targeted universalism practices when designing equity-first incentives.
- Supporting private sector innovators who target under-resourced households and businesses.

9 Targeted universalism means setting the same goals for all people and allowing different ways to achieve those goals for different groups of people. A targeted universalism approach allows for policy and incentive design to vary based on different starting points, while directing everyone toward the same end goal. For more information, watch: https://www.youtube.com/watch?v=wgGcftWpwUQ&feature=youtu.be.

THE ELECTRIC GRID

Denver's electric grid should not need significant upgrades to accommodate medium or even high levels of electrification adoption. With higher levels of adoption, some infrastructure upgrades may be required, particularly to the distribution system. However, even under an aggressive building electrification adoption scenario (i.e., 50% adoption by 2030), Denver's electric grid still is likely to experience summertime peak demands, resulting in a relatively large amount of "head room" at the high-voltage generation and transmission level of the grid before new capacity requirements are needed. The combination of building and transportation electrification will increase electricity demand over time and in the very long term likely will shift the peak demand from summer to winter. Coordinating the electrification transition with Denver's electric and gas provider, Xcel Energy, will help Denver plan for and encourage smart, efficient electric appliances that mitigate impacts to the electric grid.

THE PLAN: COST-EFFECTIVELY STARTING THE TRANSITION

The Energize Denver Renewable Heating and Cooling Plan outlines how Denver can begin the transition to renewable heating and cooling in existing buildings and homes across the city. Under existing electricity and gas rates, 66% of homes, 69% of multifamily units, and 49% of commercial buildings can be fully electrified when existing systems reach their end of life, while keeping total capital and operating costs within 10% of baseline costs. These same buildings can achieve full cost parity under partial electrification scenarios detailed in this plan.

Gas is inexpensive in Denver today, resulting in fewer buildings able to achieve operational cost parity compared with other cities. However, gas prices will be less stable than electric prices over time, so homes and buildings that transition in a cost-effective way today will achieve more stable utility costs in the long term, as well as cost parity. A notable example of gas price volatility occurred in the winter of 2021 during Winter Storm Uri. As a result of increased gas demand for heating, gas became scarce and affected gas prices regionally. This demonstrated that gas prices are sensitive to supply and demand and can be affected by exogenous factors, such as weather in neighboring states.[10]

As Denver begins to electrify space and water heat, and technology continues to advance, more opportunities for renewable heating and cooling should become cost-effective. Building electrification is currently a much more cost-effective solution than other decarbonization options such as renewable natural gas (e.g., biogas, biomethane, or synthetic natural gas) that is up to four times more expensive than conventional gas or is extremely limited in supply.

CONVERSION PLAYBOOKS FOR MAJOR HEATING SYSTEMS

This plan includes seven "conversion playbooks" that highlight options for partial and full electrification for the most common space and water heating typologies found in Denver's buildings and homes. These options are designed to achieve operational cost parity through partial electrification, as well as outline the costs and technologies to fully electrify.

IMPLEMENTATION STRATEGY

The implementation strategy is the final component of this plan, and it provides 21 solutions the city should implement to effectively and collaboratively influence an equitable electrification transition. These include:

- Communications
- Programs
- Policy
- Incentives

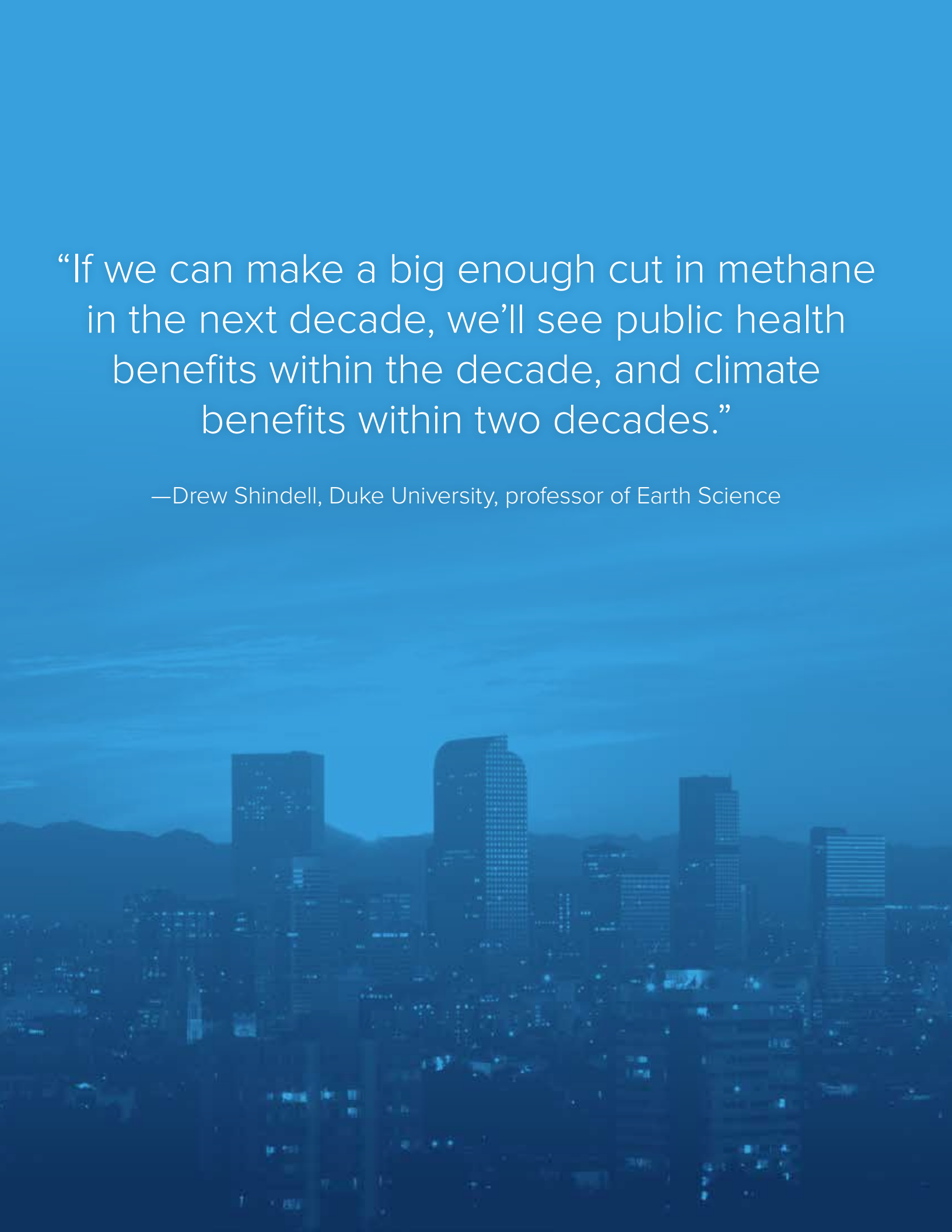
Denver's implementation of this plan is set to occur in a phased approach. Much of this work will begin in the near-term (2021-2024) and continue with several activities until 2040. As the market and technology continue to improve, this plan will be revisited and improved many times on the path to 100% renewable heating and cooling.

CONCLUSION

A managed transition to renewable heating and cooling will provide equitable and cost-effective carbon solutions for Denver's community. Renewable heating and cooling will bring many benefits to our community – most notably improvements for public health, advancements in equity, additional high-road[11] green jobs, and considerable benefits to our quality of life – all while significantly reducing carbon emissions and not burdening the electric grid.

10 For more information see: https://www.utilitydive.com/news/xcel-takes-nearly-1b-fuel-cost-hit-from-february-storms-but-still-sees-q1/599330/.

11 "High road workplaces – those that offer fair pay, good benefits, safe and healthy workplaces, flexibility, respect and more -don't just improve the lives of employees and their families. They also make companies and communities more economically resilient." https://www.asbcouncil.org/sites/main/files/file-attachments/asbc_building_the_high_road_report_2017.pdf.



"If we can make a big enough cut in methane in the next decade, we'll see public health benefits within the decade, and climate benefits within two decades."

—Drew Shindell, Duke University, professor of Earth Science

INTRODUCTION

At present, 24% of Denver's greenhouse gas emissions come from burning natural gas or fossil gas (gas) to provide space heat and hot water in the city's buildings and homes, and 97% of gas is used for space and water heat. These are emissions that can be eliminated by transitioning space and water heat to efficient electric heat pumps run on renewable electricity. Based on utility announcements and work Denver is already pursuing, Denver's electric grid is set to be 80-100% renewable by 2030.

The City and County of Denver will rely on the Energize Denver Renewable Heating and Cooling Plan: Resilient Existing Building and Homes (the plan) as part of Denver's larger Energize Denver effort to transition existing buildings to net zero energy.[12]

The plan details how Denver can cost-effectively reduce building sector carbon emissions through electrification while improving the quality of life for Denver residents. Under existing electricity and gas rates, 66% of homes, 69% of multifamily units, and 49% of commercial buildings can be electrified when existing systems reach the end of life while keeping total capital and operating costs within 10% of baseline costs. These same buildings can achieve full cost parity under partial electrification scenarios detailed in this plan.

Gas is inexpensive in Denver today, resulting in fewer buildings able to achieve operational cost parity compared with other cities. However, gas prices are less stable than electric prices over time, so homes and buildings that transition today will achieve more stable utility costs in the long term, as well as cost parity. A notable example of gas price volatility occurred in the winter of 2021 during Winter Storm Uri. As a result of increased gas demand for heating, gas became scarce and affected gas prices regionally. This demonstrated that gas prices are sensitive to supply and demand and can be affected by exogenous factors, such as weather.[13]

As Denver begins to electrify space and water heat, and technology continues to advance, more opportunities for renewable heating and cooling should become more cost-effective.

The Energize Denver Renewable Heating and Cooling Plan includes the following sections:

- Engaging the Community
- The Case for Renewable Heating and Cooling
- Conversion Playbook for all Major Heating Systems
- Denver's Implementation Strategy

For the purposes of the plan, we use the terms "renewable heating and cooling" and "building electrification" interchangeably. And while Denver differentiates between homes and buildings with homes as single-family residences and duplexes, and buildings as commercial facilities and multifamily buildings, we use the term "buildings" to encompass both homes and buildings when discussing building electrification.

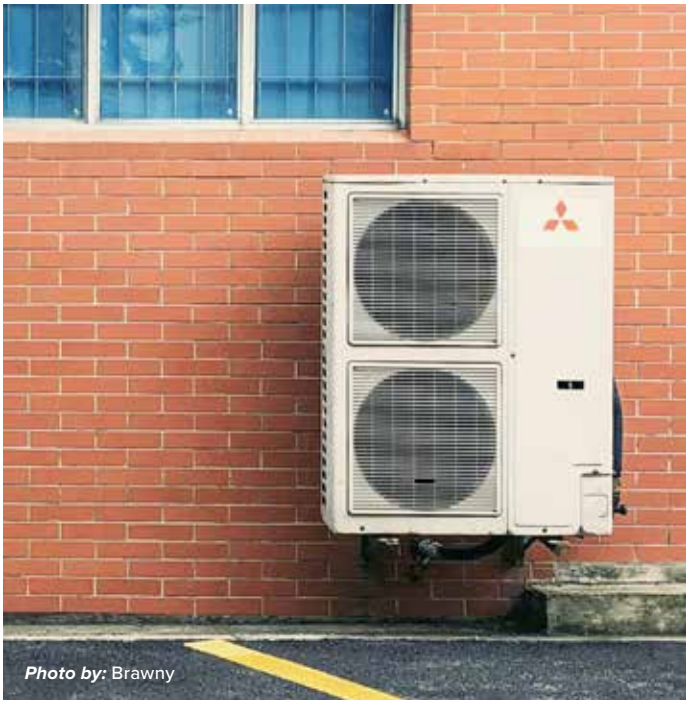


Photo by: Brawny

12 This plan is a snapshot of the technology available in 2020 and will need to be updated regularly over time.

13 For more information see: https://www.utilitydive.com/news/xcel-takes-nearly-1b-fuel-cost-hit-from-february-storms-but-still-sees-q1/599330/.

"For centuries, structural racism in the U.S. housing system has contributed to stark and persistent racial disparities in wealth and financial well-being, especially between Black and white households."

—Washington: Institute for Policy Studies, Racial Wealth Divide Initiative, and Corporation for Enterprise Development, 2016



ENGAGING THE COMMUNITY

METHODOLOGY

Over 200 community members were engaged through informational interviews, online surveys, six advisory group charettes, and two workforce roundtables.[14] Lotus and EOC led engagement.

PUBLIC HEALTH EXPERTS

Physicians for Social Responsibility
National Jewish Hospital
University of Colorado School of Public Health
Western Resource Advocates
Sierra Club
Denver Public Health
Regional Air Quality Council
Colorado Department of Public Health & Environment
Denver Air Quality Division
Green Latinos
Colorado State University

BUILDING PROFESSIONALS

E3 Power
Excel Energy
GB3
Branch Pattern
Group 14 Engineering
Blue Green Aliance
American Petroleum Institute
VEIC
PCD Engineering
Trane
Energy Resource Center
Intego Strategic Finance
RMH Group
ICAST
CEO
Meyers
Iconergy
Hercules Industries
Energy Efficiency Business Coalition
Ambient Energy
SHARC
Mitsubishi Diamond
Boulder Energy Engineers

BUILDING OWNERS AND MANAGERS

BOMA
Unico Properties
Alliance Center
USGBC
CBRE
Sopra Communities
Denver Metro Commercial Association of Realtors
Historic Denver
SWEEP
JLL
CEO
Whiting Management Resource
American Mechanical Service
CO PACE
Golden Spike Apartments
Hines
Community Associations Institute Rocky Mountains
Pipefitters Local 208
Trivium Apartments
AA Metro Denver
Sustainable Neighborhood Network
Denver Housing Authority
Urban Land Conservancy
National Trust for Historic Preservation
Mercy Housing
Historic Denver
Habitat for Humanity
Colorado Oil and Gas Association
Colorado Restaurant Association
Northside Sustainability Alliance
Interneighborhood Coalition

14 Our original stakeholder engagement approach was modified to accommodate COVID-19 safety recommendations.

91

stakeholders participated in advisory groups with specializations in residential, commercial, and multi-family buildings.

44%

of individuals engaged from under-resourced households were people of color.

61

under-resourced households participated in an online survey.

25

under-resourced and POC households were engaged one-on-one through informational interviews.

27

local contractors and building managers participated in workforce roundtables with specializations in residential, commercial, and multi-family buildings.

15%

of contractors were members of a labor union.

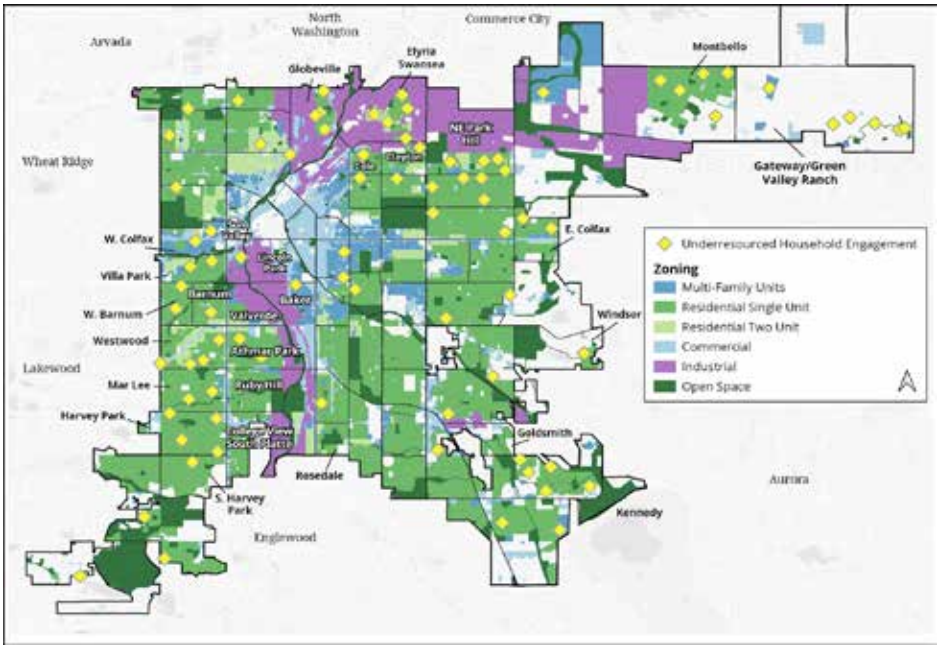


Figure 1: Map of surveyed neighborhoods

With a focus on the diversity of Denver's neighborhoods and community demographics, we surveyed a representative sample set of the community. See Figure 1[15], which includes a map of all engaged households across Denver. It should be noted that each yellow diamond represents a neighborhood area, not a household.

DENVER'S COMMUNITY MEMBERS

The transition to renewable heating and cooling will affect nearly everyone who lives in or owns a building or home in the city. It also will impact the community's workforce, who will be needed to service and install building heating and cooling equipment.

15 Data is sourced from Greenlink at https://www.equitymap.org/.

BUILDING OWNERS AND HOMEOWNERS

Denver is an economically, ethnically, and racially diverse community; consideration of Denver's community demographics will ensure that the implementation of building electrification improves equity and quality of life across the community.

As of 2019, Denver had a population of 727,211. The mean household income was $106,715, with nearly 12% of households classified as living in poverty.[16] Denver's population self-classifies as 55% white, 29% Hispanic, 9% African American, 4% Asian, and 1% Native American.[17] Forty percent of the population is between 25 and 44 years old, and 22% of the population is above 55 years old.

According to the 2019 census, Denver has 314,045 housing units with 294,358 currently occupied and 19,687 vacant.[18] Most homes in Denver were built prior to 1980.[19] At least 30% of homes are rentals in most neighborhoods.[20]

UNDER-RESOURCED NEIGHBORHOODS

Some of Denver's residents will need more help than others when upgrading equipment. Long-standing political systems and structures have created enormous barriers for people of color. Historic practices such as redlining[21] and blockbusting[22] created the foundation for institutional (or systemic) racism and contributed to vast differences in generating family income by preventing homeownership (see Figure 2).

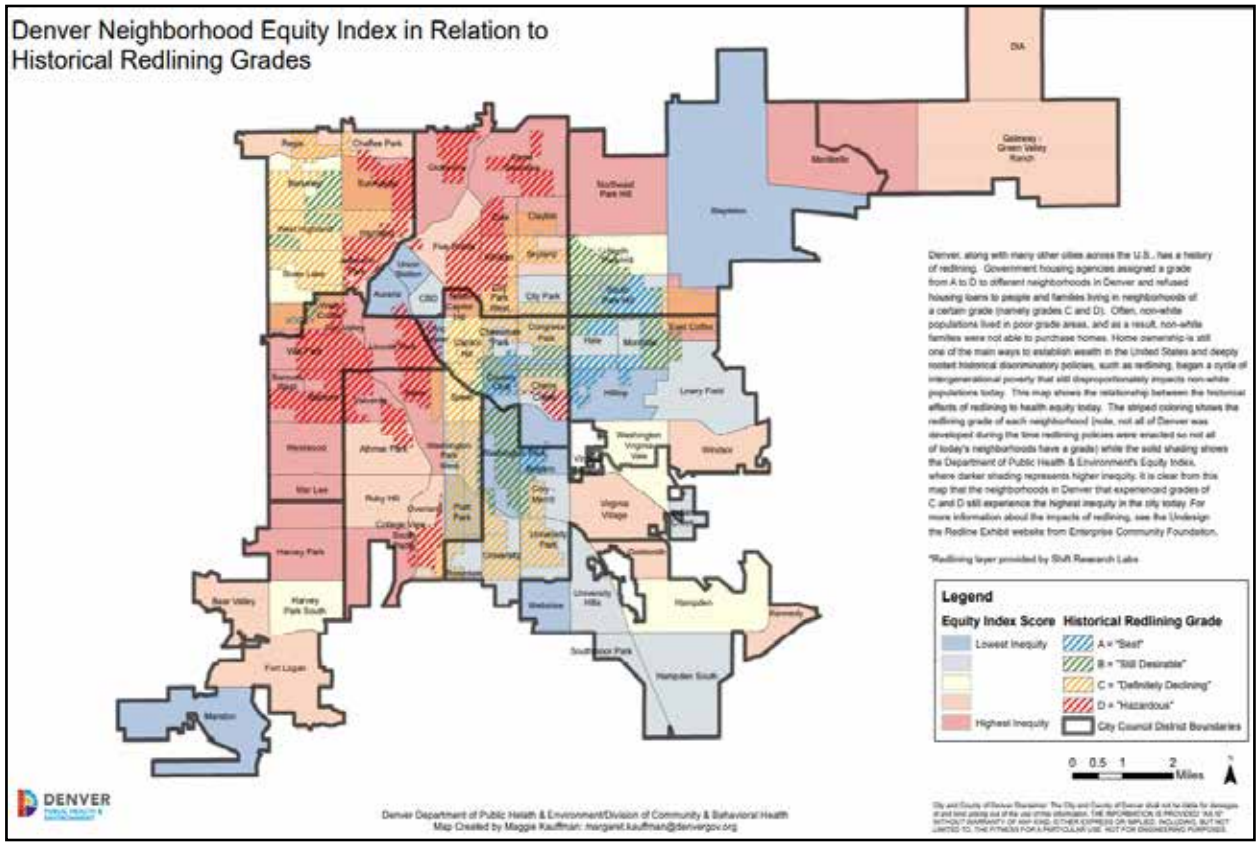


Figure 2: Historic redlining in Denver

16 For more information, see: https://data.census.gov/cedsci/table?q=Denver%20city,%20Colorado&tid=ACSDP1Y2019.DP05&hidePreview=false.

17 Note: Some reported as more than one more race, so the percentages do not add up to 100.

18 A housing unit is classified as occupied if it is the usual residence of the person(s) living in the unit. Vacant units include housing units with no one living in them at the time of the Census.

19 For more information see: https://data.census.gov/cedsci/table?q=S25&q=0500000US08031&d=ACS%201-Year%20Estimates%20Subject%20Tables&tid=ACSST1Y2019.S2504&hidePreview=true.

20 GIS data maps from Greenlink Equity Maps: https://www.equitymap.org/.

21 Redlining is the practice of lending discrimination, where "red" lines used to be drawn on maps to outline communities of color and those with large immigrant populations. Lenders were encouraged not to issue loans to households located in these areas, thus preventing decades of homeownership and investments. Redlining was practiced in Denver from the early 1930s to the late 1960s, when it was banned by the Fair Housing Act in 1968. The impacts of redlining are still felt in communities across the country today.

22 Blockbusting was the historic practice of enticing African Americans to purchase homes at inflated prices in predominately white neighborhoods, while simultaneously encouraging a mass exodus of the current white homeowners. See: https://www.merriam-webster.com/dictionary/blockbusting.

Homeownership is one of the primary ways to build a family's wealth and provides a variety of benefits; a lack of homeownership contributes to greater inequities and vulnerabilities.

The impact of historic racist practices is evident when comparing redlined neighborhoods from the early- to mid-twentieth century to several vulnerability[23] metrics of today.[i]

A closer look at Figures 3 through 8[24,25], clearly shows an inverted L shape that not only matches Denver's original redlined neighborhoods but also indicates the same areas that continue to experience the negative effects of disproportionate environmental, public health, and economic burdens as compared with Denver communities outside of the L area.[26]

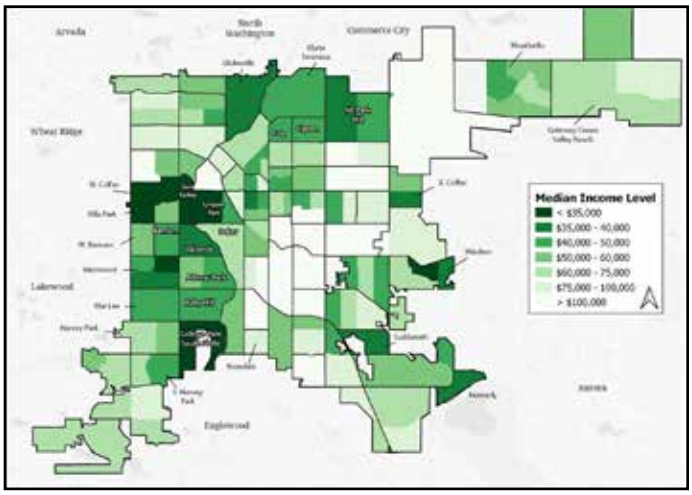


Figure 3. Median income level in Denver

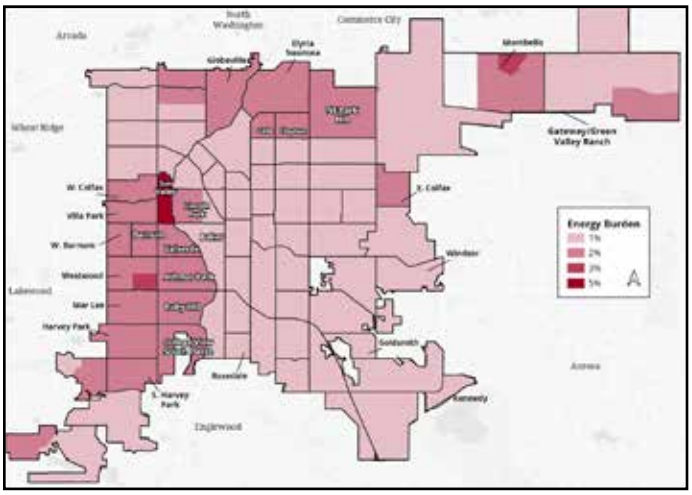


Figure 4. Energy burden in Denver

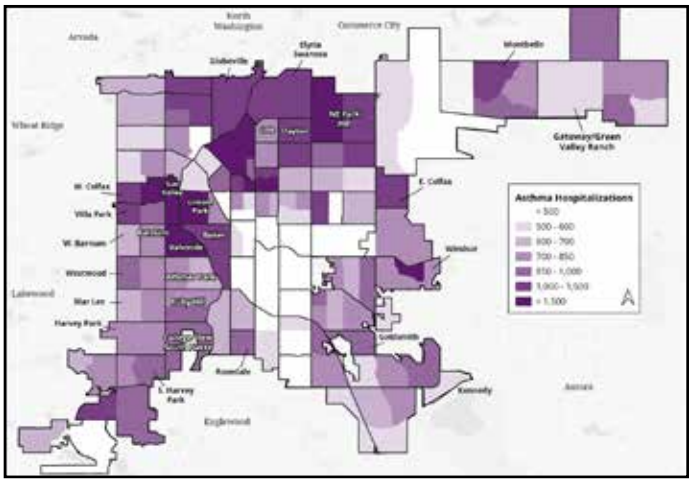


Figure 5. Asthma hospitalizations in Denver

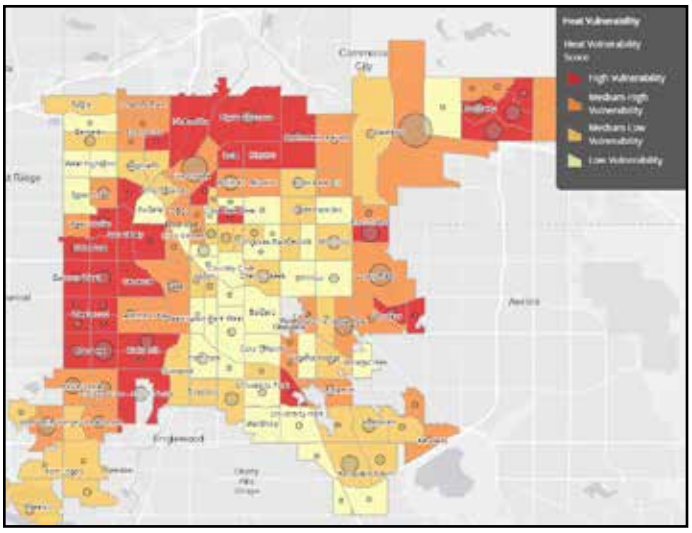


Figure 6. Heat vulnerability in Denver

23 An indication of vulnerability may be inferred using cost and public health metrics.

24 Data from GIS maps was sourced from the City and County of Denver, EPA EJScreen Tool, and Greenlink Equity Maps: https://www.equitymap.org/.

25 Redlining map from Denver Public Health at https://www.denvergov.org/content/dam/denvergov/Portals/771/documents/CH/health-equity/RedliningAnd%20EquityInDenver_9.20.19.pdf.

26 For more on Denver's 'inverted L', see https://denverite.com/2018/12/21/denver-socioeconomic-map-shape/#:~:text=If%20you%20invert%20the%20letter,socioeconomic%20barriers%20in%20the%20city.

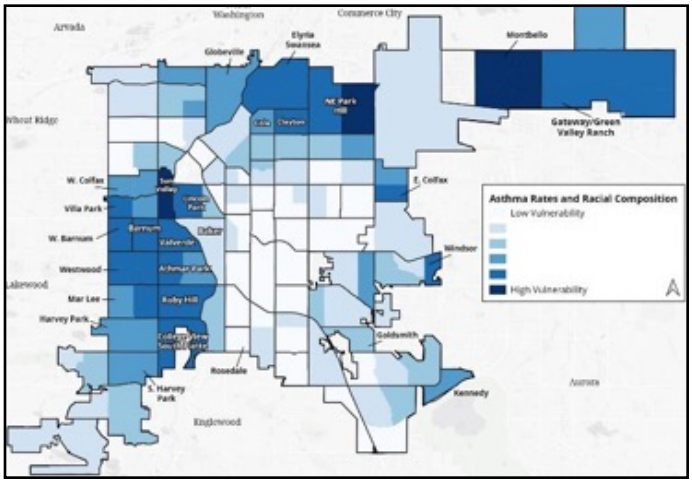


Figure 7. Asthma rates and racial composition in Denver

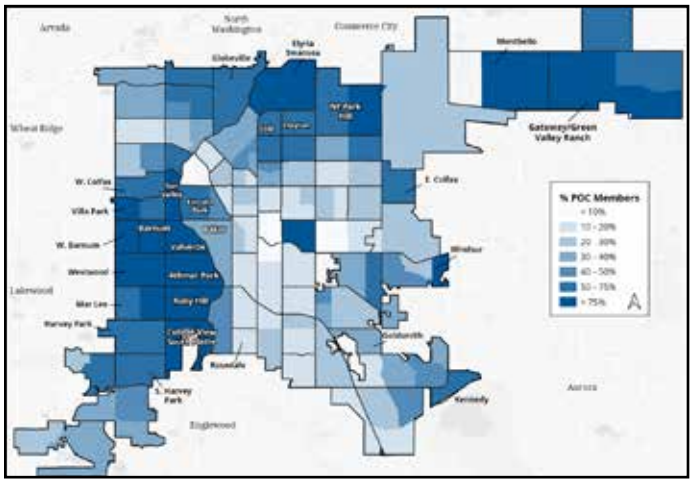


Figure 8. Percent POC population in Denver

Denver's neighborhoods that have the highest energy burden,[27] asthma rates,[28] asthma hospitalization cases, and heat vulnerability are the same ones that once were subjected to redlining.[29] Many of these neighborhoods also have the lowest median incomes and the highest percentage of people self-classifying as a person of color (see Figures 4 and 9).

We found that the following 18 neighborhoods[30] exhibit the greatest vulnerability, according to these metrics. These neighborhoods should be Denver's priority when developing equity-focused support.

1. Athmar Park
2. Baker
3. Barnum
4. College View/South Platte
5. East Colfax
6. Elyria Swansea
7. Globeville
8. Harvey Park
9. Lincoln Park
10. Mar Lee
11. Montbello
12. Northeast Park Hill
13. Ruby Hill
14. Sun Valley
15. Villa Park
16. Valverde
17. Westwood
18. West Colfax

Many institutionally racist practices have limited an individual's right to a safe and healthy home. Ambitious environmental efforts that improve both the condition of a home and quality of life can help advance Denver's commitment toward a more equitable community.

WORKFORCE

Denver's workforce is made up of contractors with experience in a wide variety of projects from residential to commercial, small to large, historic to new, and simple to complex. The United States Bureau of Labor Statistics reports that 7.4% of wage and salary workers in Colorado are union members.[ii] Median income for heating, ventilation, and air conditioning contractors ranges from $43,000 to $66,000.[iii]

According to Advanced Energy Economy's analysis of Colorado's green jobs market, Denver has the most advanced energy jobs of any county in the state, including those related to building electrification. From our analysis of local contractors, we found that there are varying levels of familiarity with and excitement about building electrification. Many of Denver's contractors are only minimally engaged with building electrification jobs, but there is an increasing interest, mainly motivated by consumer demand and utility rebates.

27 Energy burden is defined as the ratio of utility expenses to income; those with a lower income have a greater energy burden, not higher utility rates. Environmental justice advocates suggest that no household should have an energy burden that exceeds 4%. (Four percent is loosely defined and was determined through extensive interviews with low- to moderate-income [LMI] and environmental justice advocates; see the Colorado Energy Office's Insights from the Colorado Energy Office's Low-Income Community Solar Demonstration Project: https://drive.google.com/file/d/1rn-BbSe05kKRMsHXANDi5DsCKhJJRMjR/view.) In Denver, the neighborhoods with the highest energy burden also have the lowest median income.

28 The data source, Greenlinks, combines asthma rates with racial composition to highlight a vulnerability index.

29 It should be noted that these findings are similar to other studies from across the country, see: https://ncrc.org/holc-health/.

30 This information differs slightly from data compiled by Denver Economic Development & Opportunity's (DEDO) division of Neighborhood Equity & Stabilization (NEST) that identified the 10 neighborhoods experiencing rapid socioeconomic changes and at risk of involuntary displacement including: East Colfax, Globeville, Elyria-Swansea, Montbello, Northeast Park Hill, Sun Valley, Valverde, Villa Park, West Colfax, and Westwood. See: https://www.denvergov.org/content/denvergov/en/denver-office-of-economic-development/housing-neighborhoods/priority-neighborhood-small-business-grant.html.

In 2020, Denver had the worst air pollution in 10 years, primarily from wildfires in the Western U.S. Traditional methods to cool buildings, such as opening windows, may no longer be viable if outdoor air pollution continues to be a problem in the summer months.



THE CASE FOR RENEWABLE HEATING AND COOLING

Building decarbonization is a key solution to climate change. Existing buildings and homes can transition from traditional gas space and water heating systems to highly efficient electric systems, enabling them to reach net zero energy over time. The transition to renewable heating and cooling also will improve the quality of life in Denver with increased access to cooling in buildings and improved public health and safety.

CARBON EMISSIONS REDUCTIONS

RENEWABLE HEATING AND COOLING IS POSSIBLE TODAY

Efficient electric air source heat pumps (ASHP) currently are available to replace gas space and water heating systems. The carbon intensity of the electric heat pumps is lower than gas systems in Denver, and it decreases dramatically over time as Denver moves toward 100% renewable electricity, eventually reaching zero emissions.[31]

Air source heat pumps extract heat from the outside air and bring it into the home or building to provide space heating. In the summer, air source heat pumps also provide cooling by moving heat out of the home or building (see Figure 9[iv] and Figure 10).[v]

Heat pump water heaters (HPWH) provide electric water heating. HPWHs use electricity to move heat from the air into a tank to heat water.

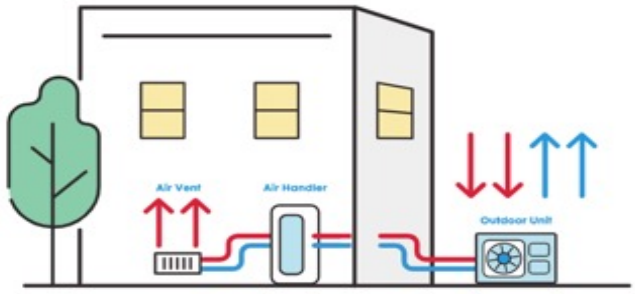


Figure 9. Heat pump operation in a building

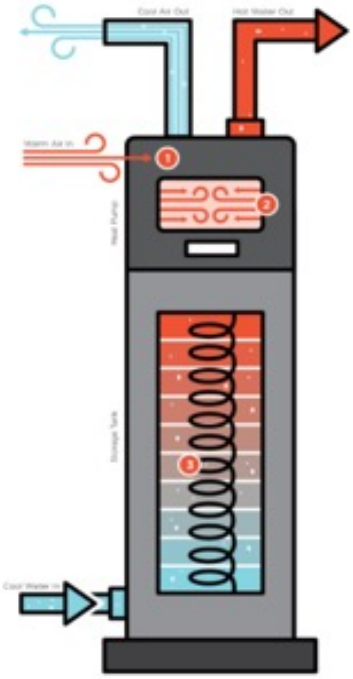


Figure 10: Depiction of a heat pump

31 It should be noted that Denver also is pursuing aggressive electric vehicle adoption, and when performed in tandem with electrification, there will be a significant increase in electricity consumption. Impacts to the grid are evaluated through this plan and consider the high-level implications from electric vehicle adoption in addition to building electrification.

Both ASHPs and HPWHs are up to four times more efficient than their fossil fuel counterparts because they move heat from one place to another instead of generating heat directly. A specific type of heat pump – a cold climate air source heat pump (ccASHP) – is most appropriate for Denver because these heat pumps can operate efficiently at temperatures lower than traditional heat pumps. For a product to be listed as a ccASHP, it must provide a coefficient of performance (COP) of 1.75 at 5 degrees Fahrenheit as well as meet other technical requirements.[32]

Electrification in commercial buildings can be achieved by a variety of air source heat pump technologies such as mini-splits, packaged terminal heat pumps, multi-zone variable refrigerant flow (VRF), or variable refrigerant volume (VRV) systems. These technologies rely on the same principles as used in residential applications.

There are also some electrification technologies with unique applications on the market that utilize underground heat sources to heat and cool buildings and homes. Ground source heat pumps or geothermal systems utilize underground pipes to use the constant temperature of the earth to extract and deposit heat depending on whether the building is in cooling or heating mode. A similar system uses the constant and relatively warm temperature of underground wastewater pipes to move heat to and from a building. Most recently, the National Western Center in Denver is utilizing a wastewater heat recovery system.[33]



Since space and water heating consume 97% of gas used in buildings,[vi] the carbon impact of other sources, specifically cooking and fireplaces, is insignificant and therefore not included in this renewable heating and cooling plan.

DECARBONIZED GAS

Another option to decarbonize buildings is to decarbonize retail gas served to customers. Decarbonized gas can meet some amount of existing gas demand but does not have sufficient economic potential to fully decarbonize Denver's gas consumption. Options to decarbonize gas include the following sources:

Biogas: Biogas refers to methane that is captured from sources such as sewage treatment plants, landfills, dairy farms, and food waste. If not captured, this biogas would typically be emitted as methane directly into the atmosphere.

Gasification of biomass: Methane can be created through a thermal gasification process of biomass (agricultural residue or forestry residue) or purpose-grown energy crops. Since these crops are purpose-grown, supply could theoretically be scaled up, albeit with higher land use.

Hydrogen: Hydrogen can be blended into the gas pipeline at a level up to 7% of the energy content of retail gas without major pipeline and infrastructure upgrades.[34] Hydrogen can be generated as "green hydrogen" – using electrolyzers powered by renewable energy – to reduce associated carbon emissions. Increasing the blend beyond 7% of the energy content would likely require significant upgrades to the gas transmission and distribution systems to prevent leaks.

Synthetic gas: Renewable energy can be used to power a methanation process which converts green hydrogen and carbon dioxide into methane. This supply category also can be scaled up to meet increased demand.

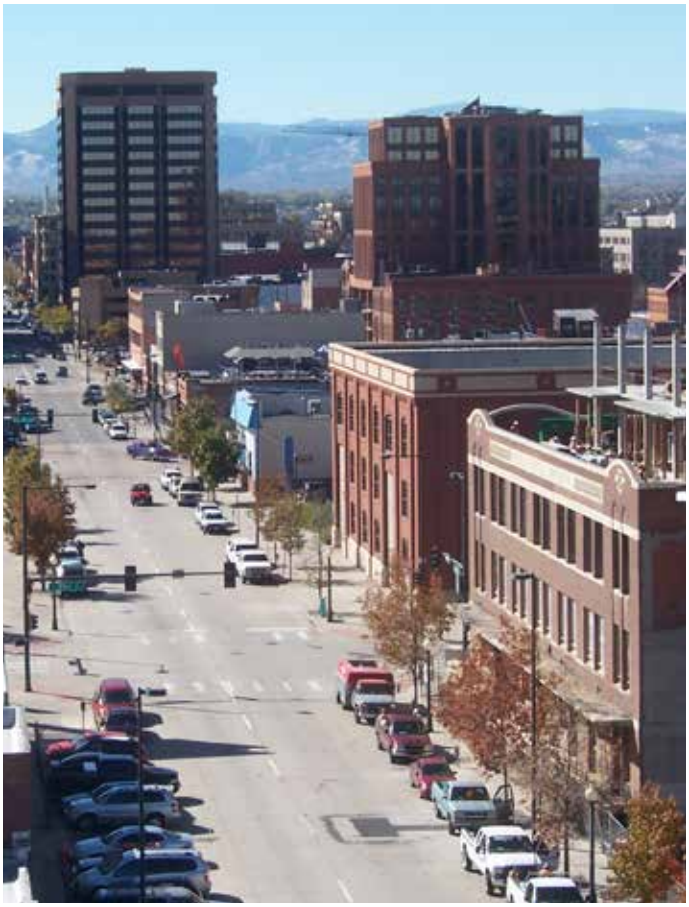
32 A full set of technical requirements for cold climate rated heat pumps from the Northeast Energy Efficiency Partnership (NEEP) can be found here: https://neep.org/sites/default/files/media-files/cold_climate_air-source_heat_pump_specification-version_3.0_final.pdf.

33 See: https://nationalwesterncenter.com/about/what-is-the-nwc/sustainability-regen/energy/.

34 E3 and UC Irvine, "The Challenge of Retail Gas in California's Low Carbon Future": https://ww2.energy.ca.gov/2019publications/CEC-500-2019-055/CEC-500-2019-055-F.pdf.

Biogas has limited supply. Based on supply estimates from Colorado Energy Office's 2019 "Renewable Natural Gas in Transportation: Colorado Market Study"[35], Colorado has enough biogas resources to meet 5-10% of gas demand in a 2030 reference scenario[36]. Expanding renewable gas supply to include biomass residues and energy crops, based on a population-weighted share of national supply, Colorado would be able to meet 14% of reference gas demand in 2030, and potentially up to 53% by 2050[37]. Based on a least-cost planning framework, the synthetic gas supply is likely to be reserved for end uses that are harder and more expensive to electrify like high temperature industrial processes.

Biomass and synthetic gases are expensive. One hundred percent synthetic gas at a scale that could supply existing retail gas demand would be four or more times more expensive than conventional gas[38]. Since biogas supply is not large enough to meet Denver's total gas demand in a reference scenario, synthetic gas or gas derived from purpose-grown crops would need to be developed. Both alternatives are significantly more expensive than conventional gas. Furthermore, synthetic gas is still susceptible to methane leakage in the gas distribution system, which is a significant contributor to GHG emissions[39].



Considering end-to-end efficiency, in a deep decarbonization world, both all-electric end uses and methanated hydrogen would be powered by renewable energy generation resources. All-electric end uses would be subject to transmission and distribution losses in the electricity system (estimated at 5% in Colorado[40]) but also would gain efficiency with heat pump end-uses showing efficiency between 200% and 300%. Gas end uses would be subject to the efficiency losses of methanation, which has an estimated efficiency of 64%[41], as well as the efficiency losses of gas-fueled equipment, which is typically on the order of 80%. All-electric end uses have a higher end-to-end efficiency in this scenario and would require less than 25% of the generated electricity[42].

35 Colorado Energy Office, "Renewable Natural Gas in Transportation: Colorado Market Study": https://energyoffice.colorado.gov/press-releases/colorado-energy-office-study-finds-state-could-eliminate-14m-metric-tons-of.

36 Renewable Natural Gas in Transportation Study estimates approximately 19.5 TBtu of annual RNG production from biogas sources including agriculture, food waste, landfills, and wastewater. The CO GHG Roadmap estimates 479 TBtu of natural gas demand in 2030 in the reference scenario. CO GHG Reduction pollution roadmap: https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap.

37 CO GHG Roadmap assumes total RNG supply (waste, residues) of 65 TBtu in 2030, out of 479 TBtu of natural gas demand in the 2030 reference scenario. In 2050, the CO GHG Roadmap assumes total RNG supply (waste, residues and energy crops) of 239 TBtu in 2050, out of 450 TBtu of natural gas demand in the 2050 reference scenario

38 Commodity component of wholesale natural gas is currently on the order of $2.50/MMBtu ($0.25/th). Transportation and distribution costs are added on top of this to get to $0.52/th volumetric or $0.78/th annual average): https://www.eia.gov/dnav/ng/NG_PRI_FUT_S1_M.htm

38 (cont.) Low cost estimate for synthetic natural gas is $20/MMBtu. Biogas from sources other than landfill gas range from $15/MMBtu to $30/MMBtu. After retail delivery charges, this yields $2.50/th. Based on American Gas Foundation/ICF: https://gasfoundation.org/wp-content/uploads/2019/12/AGF-2019-RNG-Study-Full-Report-FINAL-12-18-19.pdf.

High cost estimate for RNG: $30-$40/MMBtu. After delivery charges, this yields $3.50/th to $4.50/th. E3 and UC Irvine: https://ww2.energy.ca.gov/2019publications/CEC-500-2019-055/CEC-500-2019-055-F.pdf.

39 Emily Grubert. "At scale, renewable natural gas systems could be climate intensive: the influence of methane feedstock and leakage rates": https://iopscience.iop.org/article/10.1088/1748-9326/ab9335.

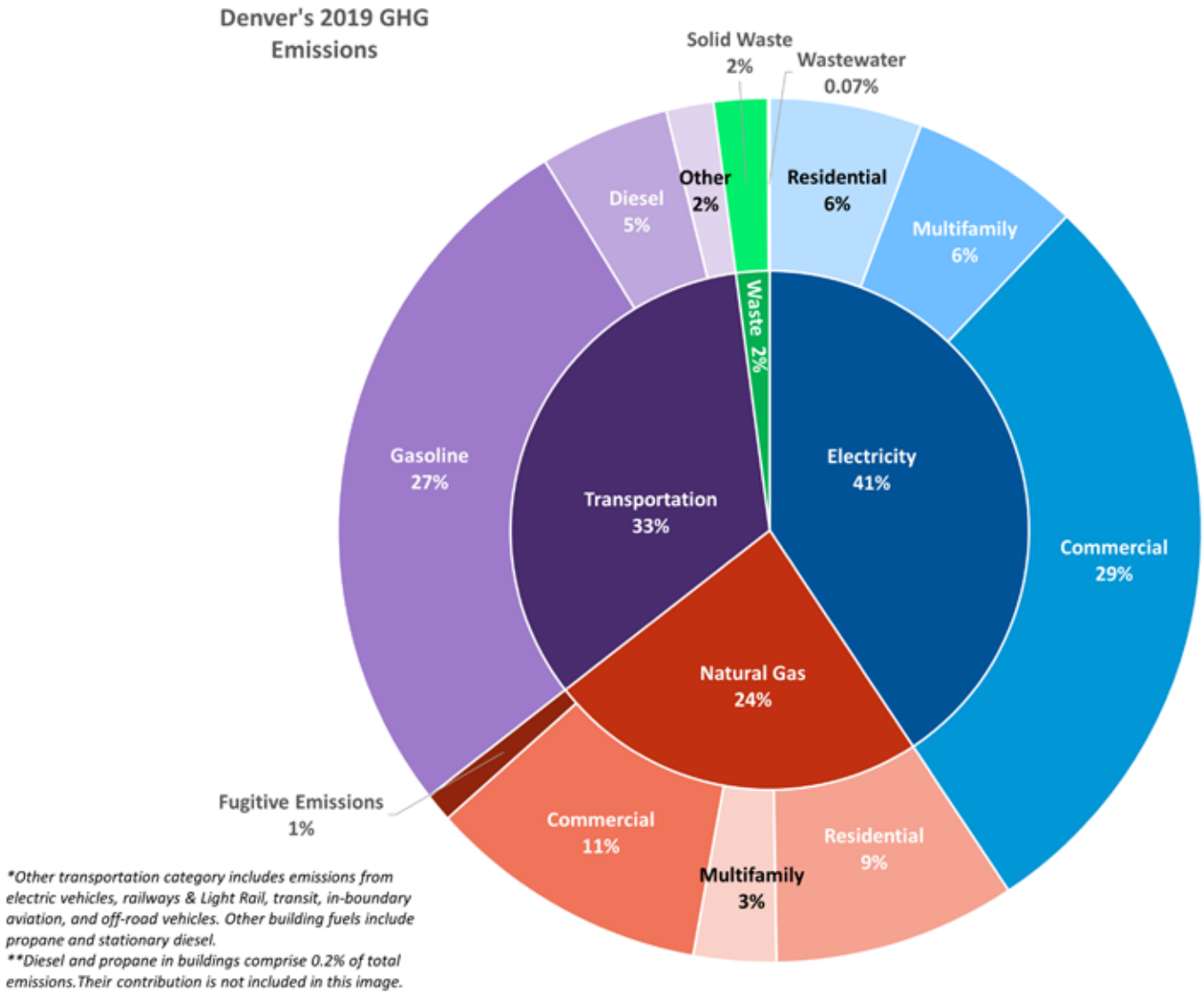
40 EIA. "State Electricity Profile: Colorado", Table 10: https://www.eia.gov/electricity/state/colorado/xls/CO.xlsx.

41 Schaaf et al, 2014. "Methanation of CO2 - storage of renewable energy in a gas distribution system" https://energsustainsoc.biomedcentral.com/articles/10.1186/s13705-014-0029-1.

42 Note that fully delivered energy costs are also dependent on developing sufficient transmission and distribution system capacity either in the electrical grid, or natural gas pipeline network.

DENVER'S CARBON EMISSIONS TODAY

Twenty-four percent of Denver's carbon emissions today come from gas use in buildings and homes; this share of emissions will increase as the electric grid gets cleaner. In 2019, buildings and homes accounted for 64% of all community generated emissions. See Figure 11[43].



43 Denver's GHG emissions inventory assumes a gas distribution leakage rate of 0.3% based on data from the Environmental Defense Fund, see: https://www.edf.org/sites/default/files/US-Natural-Gas-Leakage-Model-User-Guide.pdf. However, the report acknowledges that there may be significant uncertainty in this estimate.

According to data from the U.S. Energy Information Administration (EIA)[43], gas used for space heating and water heating is the dominant fuel source in households, comprising 67% of total space heating and 30% of total water heating emissions (see Figure 12).

There is ample opportunity to electrify homes. For example, our analysis shows that most of Denver's homes and buildings use gas appliances. According to data from the Commercial Building Energy Consumption Survey (CBECS), 88% and 66% of commercial buildings use gas for space heating and water heating, respectively.[45,46] Data from the American Housing Survey (AHS) show a similar trend: 61% of multifamily buildings and 81% of residential homes use gas for space heating, and 79% of multifamily buildings and 84% of residential homes use gas for water heating.

The reverse is true for cooking, where 79% of multifamily buildings and 65% of homes have electric cooking appliances. It should be noted that this data is supported by an online survey completed by Denver residents as part of this project, in which 89% of renters and 83% of homeowners reported using electric stovetops. This suggests that electrifying gas cooking does not need to be a decarbonization policy priority for Denver.

DENVER'S EMISSIONS REDUCTION GOALS

In 2018, Denver committed to an 80% reduction in carbon emissions by 2050 based on 2005 levels (commonly referred to as 80×50).[47] The 80×50 goal is part of Denver's Climate Action Plan, which lays out carbon emissions reduction strategies for each of Denver's main emission sectors: buildings, electricity supply, and transportation.

Considering that buildings and homes comprise nearly two-thirds of Denver's carbon emissions (refer to Figure 12), reducing emissions in buildings and homes is critical to reducing Denver's overall carbon emissions. In response, Denver has developed specific buildings and homes emissions reduction goals as shown in Table 1.[48] These include interim milestones in five-year increments between 2025 and 2040, with an ultimate heating emissions reduction goal of 100% in 2050 for both buildings and homes.

More ambitious goals have recently been suggested by Denver's Climate Action Task Force[49] and include interim milestones between 2025 and 2040, with an ultimate heating emissions reduction goal of 100% by 2040 for both buildings and homes[vii] (see Table 2). Denver has not officially adopted the Climate Action Task Force goals, but this plan is one component that will enable the city to meet the Task Force's recommendations.

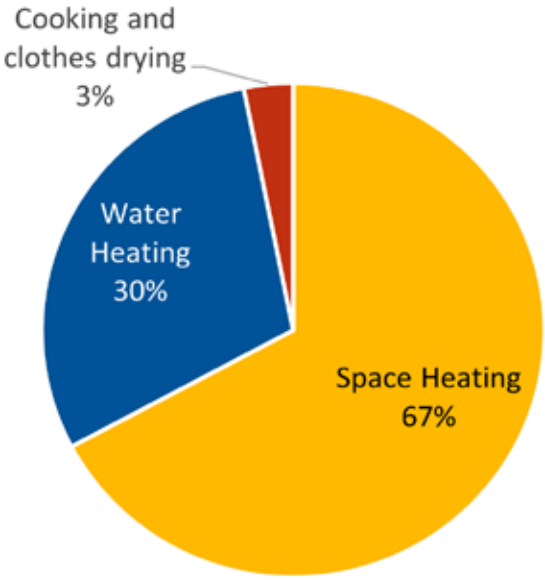


Figure 12. Energy end uses in Denver's buildings and homes

DENVER'S CLIMATE ACTION TASK FORCE

In the first half of 2020 Denver convened a group of local experts, interested stakeholders, and a wide range of community members to participate in the Climate Action Task Force. This group worked collaboratively to engage Denver's communities in climate action work; review Denver's current goals and programs; and recommend new goals, policies, and solutions that will help Denver address climate action in an equitable and effective manner.

The Task Force developed a report on recommendations for Denver to implement within its climate action work. Denver is reviewing the recommendations in order to determine which will be integrated into the city's upcoming climate action work. This Renewable Heating and Cooling Plan will contribute to Denver's ability to achieve the Task Force's recommendations.

44 For more information see: https://www.eia.gov/regional/.

45 This data is supported by the Energize Denver's benchmarking data set (Energize Denver).

46 Other fuels included propane, fuel oil, kerosene, wood, and other miscellaneous sources.

47 For more information see: https://www.denvergov.org/content/dam/denvergov/Portals/771/documents/EQ/80x50/DDPHE_80x50_ClimateActionPlan.pdf.

48 Ibid.

49 Learn more about the Climate Action Task Force at: https://www.denvergov.org/Government/Departments/Climate-Action-Sustainability-Resiliency/Initiatives/Climate-Action/Climate-Action-Stakeholder-Process.

Table 1. Denver's existing 80x50 buildings goals

Denver's 80x50 Climate Action Plan Goals		
Year	**Building Goal**	**Homes Goal**
2025		Reduce emissions by 10%
2030	Reduce emissions by 30%	
2035		Reduce emissions by 20%
2040	Reduce emissions by 50%	Reduce emissions by 25%
2050	Reduce emissions by 100%	

Table 2. Denver's Climate Action Task Force goals

Denver Climate Action Task Force Recommendations		
Year	**Building Goal**	**Homes Goal**
2025		50% of homes implement electrification measures
2030	50% of buildings have zero heating emissions	50% of homes have zero heating emissions
2040	Reduce heating emissions by 100%	

In the buildings and homes sector, Denver intends to reduce emissions generated from the consumption of electricity through Denver's 100% Renewable Energy Plan.[50] Xcel Energy has committed to achieving 85% electric emissions reductions by 2030 as well as 100% electric emissions reductions by 2050. As electricity emissions decline through a greener electric grid and locally sourced renewable energy, emissions from gas consumption will eventually dominate the GHG emission profiles of buildings and homes, leaving gas as the focus for emissions reductions. Gas consumption in new buildings and homes will be addressed through building codes as outlined in Denver's Net Zero Energy New Buildings & Homes Implementation Plan.[51] Gas consumption in existing buildings and homes will be addressed through widespread electrification driven by Denver's partnerships with utilities, businesses, and residents.

It should be noted that the Colorado Greenhouse Gas Pollution Reduction Roadmap published in January 2021 calls for full decarbonization by 2050 based on widespread use of electric heat pumps. To meet the state's carbon goals, the report assumed electric heat pumps would represent 24% of sales of all new heating systems by 2025 and 60% of sales by 2030.[52]



Photo by: Nazrin

50 For more information see: https://www.denvergov.org/content/dam/denvergov/Portals/779/documents/renewables/ExecSummary_100REPlan.pdf.

51 For more information see: https://denvergov.org/files/assets/public/climate-action/documents/denver-nze-implementation-plan_final_v1.pdf.

52 For more information see: https://drive.google.com/file/d/1jzLvFcrDryhhs9ZkT_UXkQM_0LiiYZfq/view.

ELECTRIFICATION LEADS TO ZERO EMISSIONS IN BUILDINGS AND HOMES

In Denver, building electrification will result in a net reduction in greenhouse gas emissions over the lifetime of the building equipment. Total GHG emissions savings will vary by building type and equipment type, but on average for equipment installed in 2021, electrification will result in approximately 20% GHG savings relative to gas appliances over the equipment lifetime. Once the grid is 100% renewable, buildings and homes will have zero emissions from space and water heating.

Table 3 summarizes greenhouse gas emissions savings by technology type. This represents equipment installed in 2021; savings are anticipated to increase annually as electricity becomes cleaner and technology becomes more efficient.

Table 3. Carbon Savings by building type and end use

		Life Cycle Carbon Savings	2030 Annual Carbon Savings
Residential (Avg.)	Space heating	22%	53%
	Water heating	71%	85%
	All-electric	34%	61%
Commercial (Avg.)	Space heating	11%	37%
	Water heating	15%	56%
	All-electric	12%	44%

Note: Carbon savings calculations assumes Xcel Energy meets 2030 and 2050 emissions reduction goals and a methane leakage factor of 2.49%[53]

Buildings that rely more on electric resistance heating for increased capacity may see near-term emissions increasing before electricity emissions decline significantly. By 2030, more efficient options such as ccASHPs, ductless mini-split heat pumps, and best-in-class efficiency heat pumps will save incrementally more emissions, but additional gains are modest. By 2050, all forms of electrified space heating will reduce emissions, including less efficient electric resistance heat.

53 The assumed methane leakage factor of 2.4% represents the entire gas supply chain, while the 0.3% leakage rate used in Denver's GHG emissions inventories represents only the gas distribution system.

BUILDING ELECTRIFICATION: IMPROVED QUALITY OF LIFE

Building electrification is not only an essential strategy to reduce the carbon emissions generated by buildings. Other benefits are equally significant. Understanding these complementary roles is critical in designing policies that address electrification. This approach ultimately will lead to greater adoption across the community and better integrate electrification into a new way of doing business and operating buildings. Among the many quality of life benefits of electrification are increased access to space cooling on hot days, reduced exposure to indoor and outdoor air pollution, and reduced cost burden.

INCREASES ACCESS TO COOLING

Approximately 30% of all homes across Denver do not have central air conditioning today[54]. Denver has been getting warmer (see Figure 13[55]), and climate change will continue to drive an increase in average temperatures. Traditional cooling methods such as opening windows overnight, whole house fans, swamp coolers, or window air conditioners will no longer suffice as the average temperatures increase. People will need cooling in this changed climate, so we must begin planning today to provide this cooling in a way that does not cause carbon pollution to spike. Installing an ASHP enables health benefits provided by both heating and cooling, thus improving quality of life for all who participate in the building electrification transition. Air source heat pumps also will provide more cost-effective, reliable, and efficient

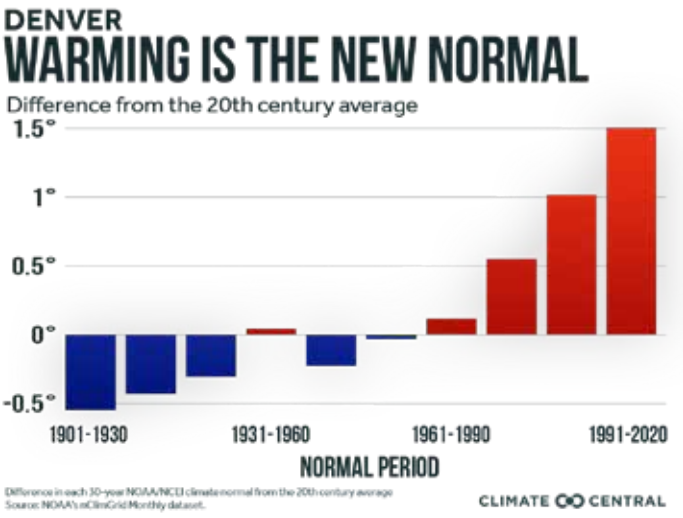


Figure 13. Denver's modeled temperature changes

54 This assumption is based on the intersection of various assumptions: our building stock analysis, in-home inspections through EOC's CARE program, and estimates from Xcel Energy. A scaling factor was applied to develop an appropriate assumption for Denver's residential community.

55 For more information see Climate Central: https://www.climatecentral.org.

cooling compared to traditional air conditioning systems, and they are able to condition indoor air without bringing in outdoor pollutants from transportation or, increasingly, the smoke of wildfires.

LOWERS EXPOSURE TO POLLUTANTS AND IMPROVES PUBLIC HEALTH

Outdoor air quality can be poor in Denver. In the summer, wildfire smoke, emissions from the combustion of fossil fuels, and ozone frequently cause air quality alerts. As a result, the Denver Metro/North Front Range area is classified as having serious ozone nonattainment under the Clean Air Act[56] and faces significant public health impacts. A recent study from the Harvard T.H. Chan School of Public Health noted that air pollution is the eighth leading cause of death in the United States[57], and Colorado experienced up to 181 premature deaths and $2.023 billion in public health cost impacts in 2017[58].

We tend to spend 90% of our lives indoors, and indoor air quality is often worse than outdoor air quality. Indoor air pollutants can be two to five times greater than the concentration of outdoor air pollutants and[viii,ix] is affected by the use of building appliances (see Figure 14). Carbon monoxide (CO), volatile organic compounds (VOCs), nitrogen oxides (NOx), and particulate matter 2.5 (PM 2.5)[59] are emitted by gas appliances and associated with preterm births, low birth weights, and stillbirths. These negative impacts are worse for pregnant mothers who have asthma and for women of color.[x] Residents of homes with gas stoves have nearly three times the rate of asthma compared to homes with electric or induction stoves.[xi,xii] A recent article in Science Advances indicates



Figure 14. Depiction of indoor and outdoor air quality sources from gas appliances

that POC households are exposed to greater levels of PM 2.5 than white households[xiii] and "residential gas combustion and commercial cooking are the among the largest sources of relative disparities."[60]

The health effects caused by gas appliances are even more problematic in under-resourced households that are more likely to live in older homes with poor ventilation and older or less reliable appliances. These households are also more likely to rent and have less control over the type and quality of appliances in their homes.

56 For more information see: https://cdphe.colorado.gov/history-of-ozone-in-colorado#:~:text=Under%20the%20standard%2C%20the%20Denver,set%20by%20the%20federal%20government.

57 For more information see: https://rmi.org/uncovering-the-deadly-toll-of-air-pollution-from-buildings/.

58 For more information see: https://rmi.org/health-air-quality-impacts-of-buildings-emissions/.

59 Ozone and PM 2.5 are typical markers of outdoor air quality and are produced from the combustion of natural gas.

60 For more information see: https://advances.sciencemag.org/content/7/18/eabf4491.

IMPROVES SAFETY

Gas appliances impact safety because they increase exposure to carbon monoxide (CO). Carbon monoxide is an odorless, poisonous, and potentially fatal gas, and many households may be exposed to it without even knowingit is why, in 2009, the Colorado state legislature mandated the installation of carbon monoxide detectors in all homes. Carbon monoxide poisoning is the second most common cause of non-medicinal poisonings death. According to the CDC[61], over 10,000 are poisoned by carbon monoxide needing medical treatment each year and more than 438 people in the U.S. die annually from carbon monoxide poisoning. In a Denver grant-funded weatherization program for income-qualified households, 30% of these home's gas appliances failed carbon monoxide safety tests. People of color and low-income households are the least likely to have carbon monoxide detectors in their home.

While it will take a long time to phase out gas, which may remain necessary in some industrial or other applications, a reduction in gas usage will improve community safety. Gas is first extracted from gas wells, processed at a plant, and then distributed to end users through pipelines. Gas leaks are possible at the wellheads, processing plants, along connection points in the distribution process, and in homes. Not only is climate change further exacerbated each time gas leaks methane into the atmosphere – methane is a greenhouse gas 28 times more impactful than carbon dioxide[62] – people adjacent to the leak are at an increased risk of injury or death. Though rare, gas leakages can be deadly.[63] There have been significant pipeline incidents in Colorado since 2000, cumulatively resulting in three fatalities, 26 injuries, and over $41 million in costs[xiv].

CONTRIBUTES TO INNOVATIVE GRID MANAGEMENT

Electrification has the potential to improve the use of the electric grid and inspire new utility performance incentive mechanisms, whereby the utility rewards the customer for using energy in a way that reduces the impact on the grid. Demand response mechanisms such as HPWHs can help utilities further control the grid and manage end loads.[xv] Heat pump water heating already stores heat energy and can be used as a flexible grid asset if coupled with appropriate controls schemes as demonstrated by Xcel Energy.



Photo by: Daniel Tausis

REDUCES COST BURDEN

Through better management of end uses, electricity consumers may benefit from different rate structures, including how the electric grid system maintenance is paid for. Consider time-of-use (TOU) rates, which not only could reduce electric costs over the long term but may reduce the need for additional power plants, further contributing to long-term cost savings. Our analysis found that in the near-term, a managed transition has the potential to either maintain annual utility costs or keep annual utility costs within 10% of today's costs.[64]

To support an equitable transition for TOU metering, consider the fact that many under-resourced community members may have difficulty shifting their times of energy use. Elderly people, night shift workers, multi-generational households, and those with essential medical equipment are among the rate payers who have limited flexibility in energy use timing. It is important that cohesive and structured efforts are made to avoid fixed cost increases with any rate changes; it will be important for Denver to advocate for this in conversations with Xcel Energy and the Public Utilities Commission. High fixed costs on monthly bills negatively affect under-resourced ratepayers the most.

61 For more information, see: https://www.ncsl.org/research/environment-and-natural-resources/carbon-monoxide-detectors-state-statutes.aspx.

62 For more on global warming potentials of GHGs: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials.

63 For more information: https://www.denverpost.com/2017/05/02/firestone-explosion-cause-cut-gas-line/.

64 Our analysis of cost savings assumes TOU rates are in place.

Electrification of appliances is not a unique idea – it is part of a general trend and where many U.S. cities are heading.[xvi] Proactively preparing for this transition positions ratepayers to take advantage of potential cost savings but not end up subject to the stranded asset costs of gas infrastructure. In addition, building owners and homeowners will save on gas connection fees that may increase over time as more people avoid installing gas-fueled appliances. Stranded asset costs related to gas represent the existing investment in gas infrastructure that will need to continue to be maintained even as fewer users on the system are paying towards that upkeep.

Today's gas costs are low, and preliminary information suggests that not all electric appliances may yield annual utility cost savings immediately. Yet this price differential is expected to shift in the coming years, signaling that all-electric homes and buildings may result in annual cost savings in the near future.

ADVANCES EQUITY

Electrification can help Denver's communities by reducing long-term energy burden, modernizing home appliances, providing cooling, and improving indoor air quality.

Rising utility costs especially hurt those living at or below the federal poverty line.[65] Environmental justice organizations and leaders advocate for an energy burden of no more than 4% of annual income.[xvii] Getting ahead of the impending electrification transition ensures that those with fewer resources are not left paying more in gas costs to support stranded assets. A successful transition would allow households to transition to renewable heating and cooling regardless of economic status.

As a result of historic redlining practices that disproportionally impact people of color and promote ongoing inequality in Denver, many houses in impacted areas are older and have not been regularly updated with the latest home technologies. Electrification provides an opportunity to leapfrog technologies, going straight to the most advanced systems.

It is critical to note that Denver's redlined communities (see Figure 3) are nearly 12 degrees Fahrenheit hotter than nearby neighborhoods,[xviii] and the Rocky Mountain Climate Organization estimates that Denver's temperatures will continue to climb over time.[xix] Approximately 30% of homes do not have cooling[66].



Given disparities in housing quality, we can assume that at a minimum this proportion of under-resourced residents and people of color do not have cooling either: neighborhoods with the highest heat vulnerability score are the same neighborhoods facing the greatest inequities. Rising temperatures exacerbate the long litany of public health risks faced by under-resourced and POC communities. A growing body of research is highlighting the effects of heat exposure on pregnancy risks especially among black women[67]. Electrification, through the deployment of heat pumps, provides simultaneous heating and cooling, supplying a much-needed quality of life and safety resource.

Gas appliances contribute to poor air quality. Meanwhile, Denver's most vulnerable neighborhoods have the highest asthma hospitalization rates locally. Electrifying appliances can help alleviate some of the outdoor and indoor contributors to public health concerns, particularly respiratory illnesses such as asthma.

64 Note: For the purposes of this study, we are considering cost-burdened households as those living at or below 80% of the area's median income (AMI) as defined by the Colorado Housing and Financing Authority (CHFA). This definition is consistent with Energy Outreach Colorado's low- to moderate-income (LMI) classification for participation in the Colorado Affordable Residential Energy (CARE) program.

65 This assumption is based on the intersection of various assumptions: our building stock analysis, in-home inspections through EOC's CARE program, and estimates from Xcel Energy. A scaling factor was applied to develop an appropriate assumption for Denver's residential community.

66 See: https://www.nytimes.com/2020/06/18/climate/climate-change-pregnancy-study.html.

ADDS HIGH-ROAD GREEN JOBS

Denver is currently building an overarching green jobs strategy for its climate work. Through intentional design, building electrification has the opportunity to grow high-road green jobs in Denver. The American Sustainable Business Council states that high-road jobs include "family-friendly benefits," flexibility, a livable and fair wage, opportunities for growth and development, and promoting health and safety.

An analysis by Inclusive Economics forecasts that building electrification for both space and water heating will result in 643 to 1,047 jobs in Denver within the next 30 years[xxi]; the final impact will depend on implemented policies. The types of jobs that may be created are presented in Figure 15. As indicated, these jobs will primarily include construction sector work – retrofitting and upgrading existing buildings, and activities needed to support the transition such as panel upgrades, ductwork, and gas disconnects. Not included in these values are ongoing operations and maintenance jobs and supply chain jobs.

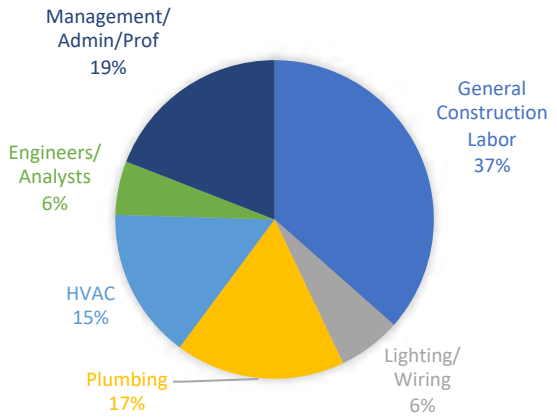
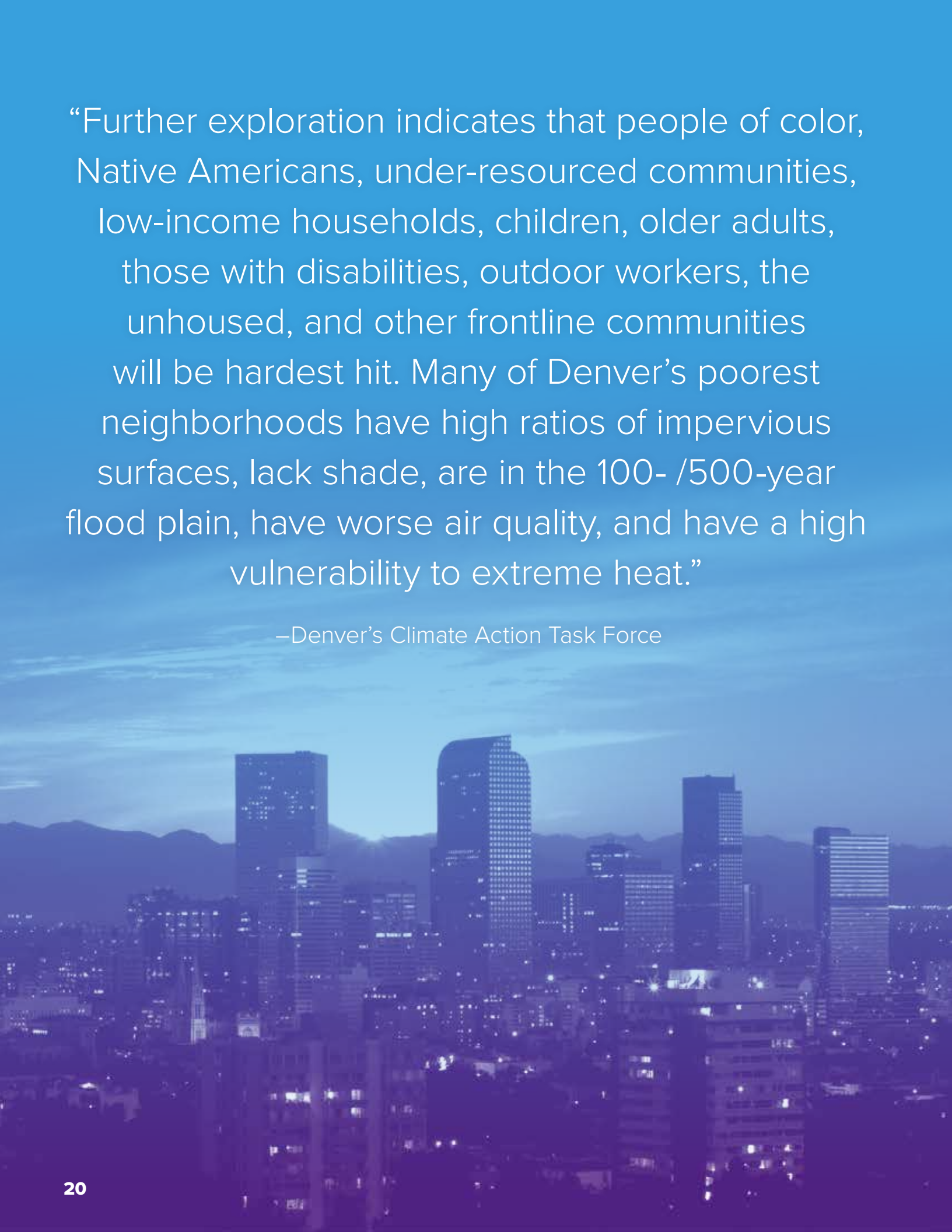


Figure 15: Distribution of work by trade for electrification jobs

INCREASES RESILIENCY TO CLIMATE CHANGE

As temperatures increase, Denver's residents will be more susceptible to heat related health impacts. Electrification helps Denver residents adapt to these warmer temperatures without compromising their health. In the absence of cooling, which is particularly problematic for under-resourced households, residents employ traditional methods to cool themselves, such as opening windows in the cool evening. These options will become less available if outdoor air quality continues to suffer from wildfires and other outdoor pollutants. Providing central cooling reduces the risk of heat related health impacts, while limiting exposure to outdoor pollutants.

In addition, replacing gas equipment with equipment powered by renewable energy, helps slow down and reduce the worst of impending climate change impacts.



"Further exploration indicates that people of color, Native Americans, under-resourced communities, low-income households, children, older adults, those with disabilities, outdoor workers, the unhoused, and other frontline communities will be hardest hit. Many of Denver's poorest neighborhoods have high ratios of impervious surfaces, lack shade, are in the 100- /500-year flood plain, have worse air quality, and have a high vulnerability to extreme heat."

—Denver's Climate Action Task Force

THE ELECTRIC GRID

Denver's electric and gas provider – Xcel Energy – is an integral partner to building electrification. Xcel Energy has committed to reducing carbon emissions from the generation of electricity by 85% by 2030 and 100% by 2050.[68] As the electric grid becomes cleaner, emissions from electricity consumption in buildings will decrease, eventually reaching zero, bolstering the case for renewable heating and cooling.

METHODOLOGY FOR ANALYZING ELECTRIC GRID IMPACTS

New building electrification loads may place additional strain on the electric grid, potentially requiring investment in grid upgrades. To forecast the extent of future investment, Xcel Energy provided historical gas and electricity system load data from 2019. At the city level, simulated diversified building electrification load shapes were layered on top of historical loads to examine the potential for building electrification to increase peak load on the system. Different technology packages were examined with increasing penetration rates to characterize these potential impacts over time. This approach is designed to isolate the relative peak impacts of incremental building electrification loads between winter and summer historical peaks. This analysis does not consider other load growth, nor does it consider more extreme weather years; enabling a focus on relative seasonal peak impacts from loads in existing buildings.

At the local distribution level, Xcel Energy provided 2019 historical load data for several representative feeders. A qualitative review of this data demonstrated different scenarios of potential local distribution capacity to serve new electric loads.[69]

ELECTRIC GRID RESULTS

Denver's electric grid provides the critical energy infrastructure needed to support the transition to a carbon-free future. Today, Denver's electric grid experiences the highest hours of electricity demand during the summer, when air conditioning demands are greatest.

In the near term, Denver should be able to electrify at least 50% of buildings without requiring additional system-level generation and transmission capacity. However, achieving Denver's long-term climate goals and 100% electrification may require incremental generation capacity. Both building and vehicle electrification will increase total electricity demand over time. Electric vehicles, and the shift toward electric transportation more broadly, will increase electricity demand in all seasons. The electric grid impacts of buildings will be more seasonal and highest during winter when cold temperatures trigger greater electric heating demands in buildings.



68 For more information see: https://www.xcelenergy.com/company/media_room/news_releases/xcel_energy_announces_2030_clean_energy_plan_to_reduce_carbon_emissions_85%25.

69 The distribution level analysis is qualitative and is not meant to replace a detailed engineering study. Suggested future work includes power flow modeling with the existing grid topology, deeper N-1 contingency modeling, as well as a characterization of all feeders, with corresponding customer accounts and hourly demands. Additionally, formal allocation of load growth both from building electrification and other loads at each feeder would be necessary.

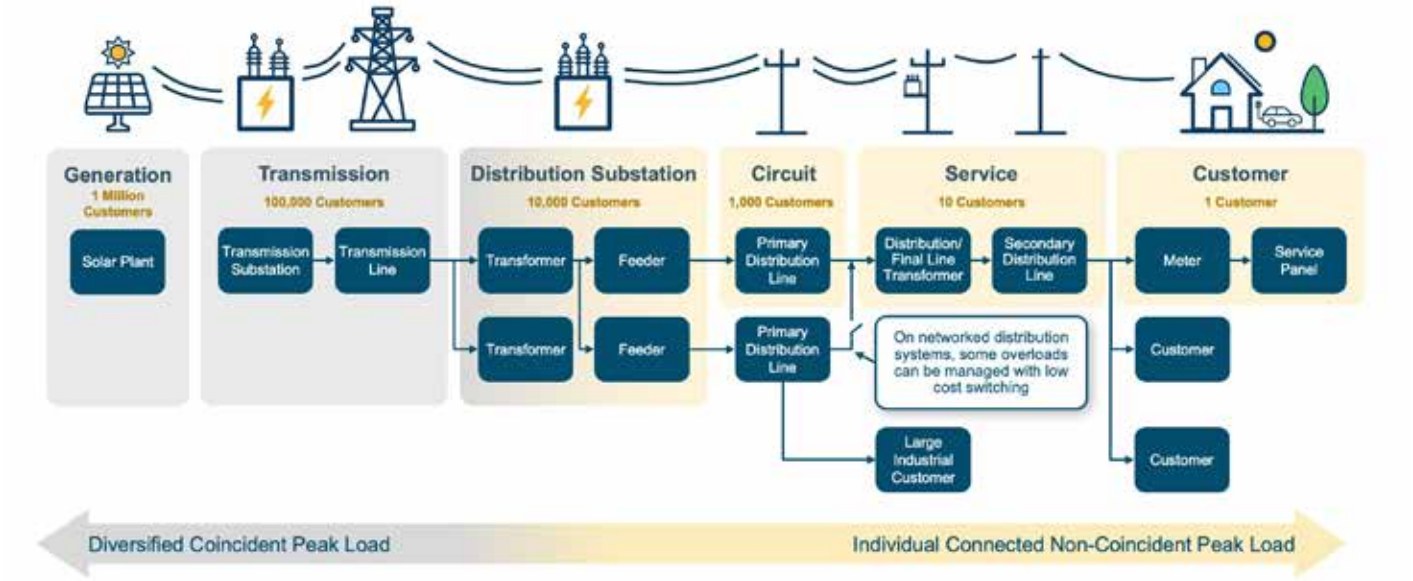


Figure 16: Illustrative schematic of the electric distribution infrastructure

Figure 16 above illustrates the key elements of the electric grid based on voltage. On the left side of the figure are systems at the generation and transmission levels in grey, and to some degree at the distribution substation. Peak demand impacts in these systems are defined by the combined impacts of buildings, electric vehicles, and other end uses. On these higher voltage portions of the electric grid, peak demand is driven by the diversified impact of all of these loads.

On the right side of the figure in yellow, peak demand impacts at the circuit, service drop, and customer levels are driven more by individual buildings and end use. In effect, peak demand impacts are calculated more often based on the total potential for electric demand (i.e., the connected, or non-diversified loads). As a result, the addition of new building electrification end uses is more likely to trigger the need for infrastructure updates at the lower voltage system portions of the electric grid.

At relatively low levels of saturation, building electrification will improve the utilization of the current electric grid and could put downward pressure on utility rates while improving the economics of building electrification[70]. Incremental growth of building electrification loads will advance the timing of infrastructure upgrade requirements, particularly in the distribution system.

However, even under an aggressive building electrification adoption scenario (i.e., if Denver electrifies 50% of its existing building stock by 2030), Denver's electricity system is still likely to experience summertime peak demands, as long as relatively efficient ASHPs are used for space heating in existing buildings (see Figure 17).[71] This means that there is a relatively large amount of "head room" at the high-voltage generation and transmission level of the grid, before new capacity requirements will be needed.

70 As a caveat, it is important to consider overutilization and give equipment sufficient time to cool down from periods of high demand. Insufficient levels of cool down time between periods of high demand can shorten the useful life of some distribution equipment.

71 Balanced scenario: 15% ccASHPs, 50% dual fuel (hybrid) systems, and deep shell retrofits. 50% Hybrid scenario: 50% hybrid systems and 50% ccASHPs. Min ccASHPs and shell scenario: deep shell retrofits and minimum ccASHPs. High ccASHP scenario: all ccASHPs are consistent with highest performing units with COP of at least 2.9 at 5 degrees Fahrenheit. Min ccASHP scenario: all ccASHPs are consistent with minimum performing units with COP of at least 1.75 at 5 degrees Fahrenheit.

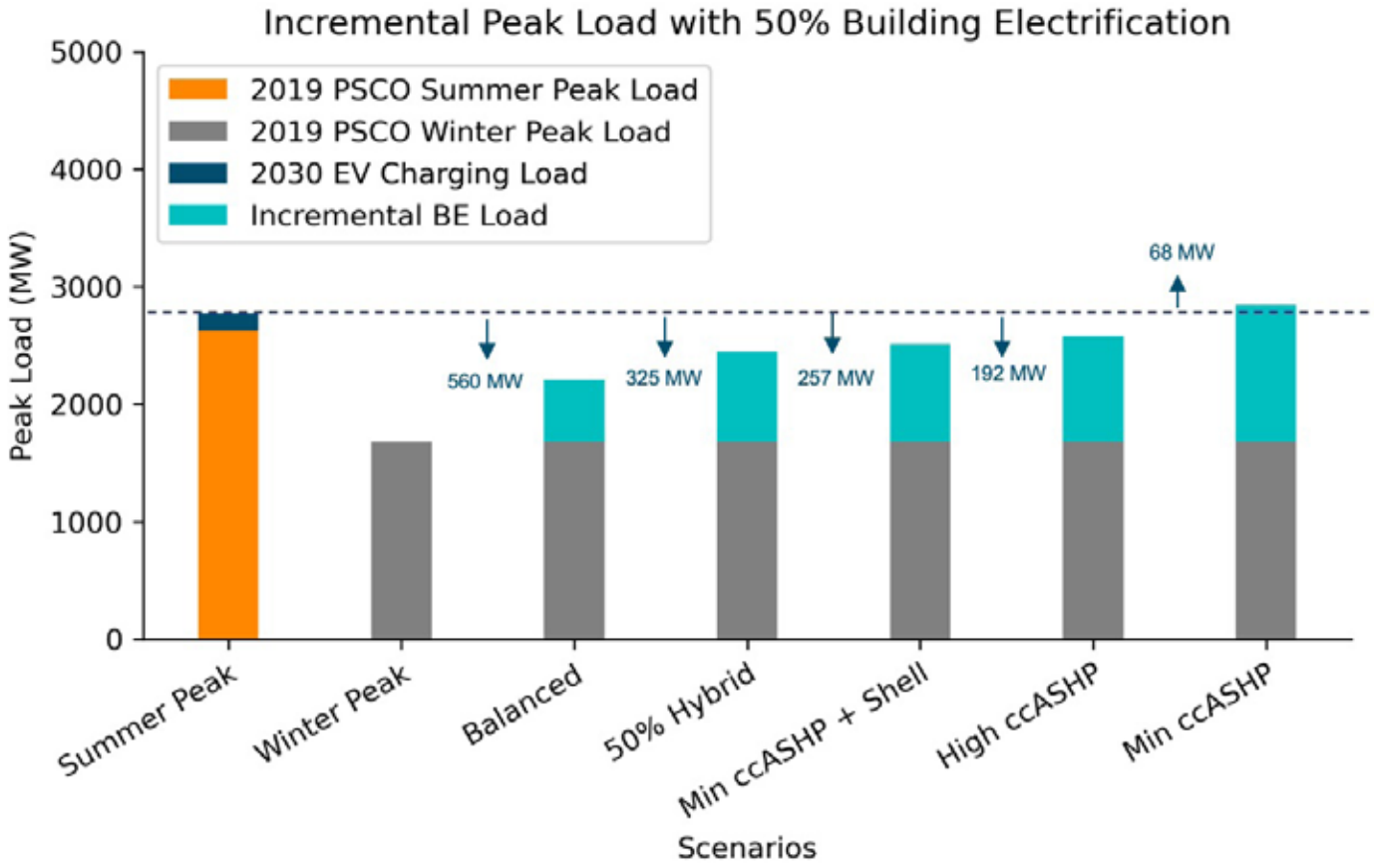


Figure 17: Estimated incremental winter peak load impacts in Denver due to 50% electrification of the existing building stock, relative to 2019 PSCO summer peak load

At the distribution substation level, our analysis of six illustrative feeders provided by Xcel Energy for Denver suggests that transformer- and feeder-level upgrades will be required, in some instances at low levels of building electrification saturation, but in many cases prior to the system level upgrades. These will need to be assessed on a case-by-case basis. Likewise, many customers undertaking building electrification of their homes and businesses will need service-level and service-panel upgrades to accommodate new building electrification loads. However, the size and timing of these upgrades will depend on how much existing "head room" there is on the substation, circuit, service drop, or panel, as well as what kind of electric equipment is installed.

Building shell upgrades and heat pumps that are cold climate specific, hybrid (gas and electric), and higher efficiency all will help reduce wintertime peak electric demands associated with building electrification. These can defer the need for distribution system upgrades in many cases. This mix of technologies is represented in the Balanced scenario in Figure 17.

Achieving Denver's climate goals will require a more robust electric distribution grid to accommodate both transportation electrification goals, as well as new building electrification impacts. However, the exact nature of grid impacts will depend in large part on the types of heat pumps installed in buildings, and grid impacts could be mitigated significantly by building shell

improvements and other energy efficiency hybrid heat pumps as well as high-efficiency ccASHPs.

The current electric distribution planning framework requires long lead times to ensure prudent investment of ratepayer dollars. A key challenge in planning for the timing and sizing of grid distribution upgrades is that the scale and timing of future grid impacts remains uncertain but is nonetheless forecasted to dramatically increase if Denver is to achieve its climate, energy, and electrification goals. Planning for this carbon-free future could be facilitated if Denver is able to work effectively with Xcel Energy and the Colorado Public Utilities Commission.

XCEL ENERGY'S FORECASTS

Xcel Energy recently published a Technical Appendix in its 2021 Clean Energy Plan filing that forecasts building electrification and transportation electrification loads consistent with Colorado's Greenhouse Gas Pollution Reduction Roadmap[72]. In the roadmap, heat pump adoption is projected to reach 62% of installed stock for the residential sector and 74% for the commercial sector in 2040 (see Table 4). Based on this scenario, Xcel Energy forecasted that the coincident system peak demand for the year would remain in the summer until approximately 2040. By 2050 (or 90% residential heat pump adoption and 96% commercial heat pump adoption), winter peak demand would only be approximately 7% greater than the summer peak demand (see Table 5). While Xcel Energy's projections are for all of Colorado, this confirms the finding in this analysis that there is likely enough seasonal headroom at the bulk system level to accommodate building electrification loads of 50% or greater without driving the system to a winter peak. Xcel Energy's analysis did not explore distribution level impacts.

Table 4. Heat pump adoption in HVAC applications from Colorado's 2021 GHG Pollution Reduction Roadmap

Sector	2030	2040	2050
Residential	23%	62%	90%
Commercial	26%	73%	96%

Table 5. "Roadmap" scenario: coincident peak demand from Xcel Energy's Clean Energy Plan Technical Appendix

Sector	2030	2040	2050
Coincident Summer Peak Demand (MW)	7,441	8,840	9,229
Coincident Winter Peak Demand (MW)	5,805	8,799	9,882

72 CO GHG Reduction pollution roadmap: https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap.

CONVERSION PLAN

FOR MAJOR HEATING TYPOLOGIES



Renewable heating and cooling technology is available to replace all gas equipment types. However, to effectively manage the transition, we identified which equipment types (and consequently home and building types) can yield the largest impact on carbon emissions – and are easiest to electrify.

Denver's building stock was divided into buildings and homes. An evaluation of the impact on under-resourced households was included in the single-family residences and multifamily homes.

We formulated conversion playbooks that allow for both **full** and **partial** electrification in the near-term (five to seven years) with the ultimate goal of **full** electrification.

METHODOLOGY

The team that developed the models and economic analysis consisted of building modelers at NORESCO, professional estimators at AECOM, and consultants at E3. We looked at representative buildings and homes for each major system typology. While these models and results are representative of Denver's building stock, building and homeowners are strongly encouraged to consult with contractors and installers to understand which electrification options best suit their needs and the unique characteristics of their building.



Photo by: Sigmund

EVALUATING TECHNOLOGY REPLACEMENTS

We analyzed various databases for information on HVAC systems, water heating equipment, and cooking appliances most commonly used in Denver. We then identified the frequency of equipment use and associated building types. We used this characterization to identify the most suitable electric technologies for replacement of gas equipment.

Following this, we modeled simulations to estimate the impact of switching from gas to electric equipment. We used prototype buildings developed by the U.S. Department of Energy (DOE) as the starting point for these simulations and then modified our prototypes to better reflect Denver buildings. From these simulations and building characteristics, we produced detailed hourly energy use data to examine the energy, emissions, and cost impacts of switching from gas to electric equipment.

ASSESSING CAPITAL AND OPERATIONAL COST

We developed capital cost estimates for each prototype building including estimates for both proposed renewable heating and cooling technologies and corresponding comparable gas-fueled equipment. Capital estimates include all costs to complete the project including for equipment, labor, demolition, disposal, contractor overhead, profit margin, design and engineering, duct or electrical service modifications, and any other infrastructure upgrade costs associated with installation. Capital costs then were compared for building electrification technologies and gas-fueled equipment to help inform an understanding of the economic barriers of near-term building electrification.

Operational cost impacts of building electrification technologies were evaluated using hourly building simulation results for each prototype building and portfolio of equipment choices. Total energy bills were calculated using prototype buildings both with typical gas-fueled equipment to set a baseline and electric equipment to determine net bill impacts. First-year electricity bills were calculated using Xcel Energy's existing TOU rates, while first-year gas bills were calculated using Xcel Energy's retail gas rates. Rates were specified to customer type; for example, residential prototype buildings were evaluated on residential rate tariffs. The annual HVAC operating costs listed in the playbook typologies include space heating, space cooling, and fan/air distribution energy – this includes savings from increased cooling efficiency of a heat pump.

After reviewing full electrification options, we also studied partial electrification options where a heat pump is paired with a small gas furnace that can supplement the heat pump in cold temperatures. Not all heat pumps require supplemental heat, however. Utilizing gas for space heating needs below a certain temperature allowed the team to model how to achieve operating cost as well as capital parity for a large variety of building and system types. Through partial electrification, capital cost parity is achieved by the ability to avoid the electrical upgrades that may accompany electric resistance heating. In addition, partial electrification allows for operating cost parity by making the most of both the gas furnace and the electric heat pumps. Heat pumps are more economical to operate during "warm" hours above 15 degrees Fahrenheit, and the gas furnace is more economical during colder hours below 15 degrees Fahrenheit. In the long run, as emissions targets become more stringent, and a mature market and workforce reduce other consumer costs, supplemental gas backup heat can be phased out in favor of fully electric retrofits in all cases.

COMMON HEATING SYSTEM TYPOLOGIES

While our analysis included 15 different models to accommodate the variety in buildings and homes throughout Denver, we were able to find commonalities in heating system types and their conversion plans. Four typologies emerged for space heating and three for water heating that represented 70% of Denver's commercial and multifamily buildings, and 66% of Denver's homes. Less frequent systems such as boiler-supplemented water loop heat pumps, individual space heaters, and other miscellaneous system types comprise the remaining 30% of square footage in existing commercial buildings.

Space heating

- Building and home space heating typology 1: Gas furnaces (32% commercial, 66% residential)
- Building space heating typology 2: Rooftop units (257% commercial)
- Building space heating typology 3: Packaged terminal air conditioning unit (PTAC) (2% commercial)
- Building space heating typology 4: Boiler systems (11% commercial)

Water heating

- Building and home water heating typology 1: Individual system with tank (96% of single family and multifamily residences, 4% of commercial spaces)
- Building water heating typology 2: Central system with tank (48% of commercial space)
- Building and home water heating typology 3: Gas point of use system (21% of commercial space)
- Note: around 27% of commercial buildings utilize a combination of Typology 2 and 3: both a central system with tank as well as point of use.

SUMMARY OF FINDINGS

Operational cost impacts in Denver are driven by Denver's unique combination of electricity rates and gas rates, along with relative technology efficiencies. Electricity rates in Colorado are on par with national averages, while retail gas rates are among the cheapest in the country. Furthermore, for a typical home, fixed monthly charges make up a proportionally larger amount of annual gas bills than annual electricity bills. Higher fixed charges for retail gas yield lower volumetric charges, meaning that partial electrification will see lower bill savings than full electrification, which would be necessary to avoid the fixed charges in gas rates as the rate is currently structured. However, gas prices are less stable than electric prices over time, so homes and buildings that can transition cost-effectively today can achieve more stable utility costs over time as well as cost parity today. As our entire economy shifts away from fossil fuels, we are likely to see an increase in costs for remaining fossil fuel users; a recent study in California suggested that as gas use declines by 40%, gas prices are likely to start to increase substantially[73].

Building electrification benefits all consumer types. Having partial and full electrification options allows consumers to achieve their goals. Partial electrification may be more appropriate for buildings with higher heating bills or outdated electrical panels, or for customers who are concerned with increased operating costs. Full electrification may be more appropriate for those who are motivated by carbon reductions, want to leapfrog interim steps, or are looking to pursue electric vehicle charging or on-site solar.

73 For more information, see: https://ww2.energy.ca.gov/2019publications/CEC-500-2019-055/CEC-500-2019-055-F.pdf.

Technologies that are cost-effective today:

- **Ductless mini-split heat pumps:** These achieve improved efficiency by reducing the need for fan power from the baseline ducted furnace system. Increased efficiency helps these systems reach operating cost parity.
- **Heat pumps with supplemental gas backup heat:** While heat pumps still can have a coefficient of performance (COP) above 2.0 at temperatures below freezing, they do operate less efficiently at very cold temperatures. If gas backup heat is used in these less efficient hours, it can mitigate bill impacts, while still enabling heat pumps to reduce emissions during more efficient, warmer temperature hours.
- **Heat pumps in small commercial buildings:** Commercial retail gas rates have high fixed costs of nearly $535 per year. Small- or medium-sized commercial buildings with lower space heating loads can avoid these high fixed costs by fully electrifying. The fixed cost can represent nearly 50% of a customer's gas bill, adding extra incentive to electrifying load, and helping these building typologies achieve operating cost parity.

Technologies that are particularly promising from an operating cost perspective include:

- **Heat pump water heaters:** Due to the poor efficiency of gas tanked water heaters (~0.62 Uniform Energy Factor [UEF]), and the high efficiency of heat pump water heaters (UEF >2.0 for standard HPWH, >3.0 for efficient HPWH), these devices yield minimal bill increases, and possible bill savings. They do carry an additional capital cost to install today, but this may decrease with time or be covered by incentives.
- **Cold climate heat pumps sized to building heating load:** Higher efficiency and higher output at lower temperatures than federal minimum standard heat pumps, potentially eliminating the need for supplemental electric or gas backup heat altogether. The higher efficiency of these systems improves operational cost impacts. These would cost more to install today, but equipment costs may decrease over time and could offset the need for panel upgrades for full electrification.

Heat pump water heaters can serve all single-family residences in Denver, multifamily buildings with decentralized water heating, as well as small commercial spaces. Cold climate heat pumps are uniquely positioned to serve Denver's climate in single family homes,



multifamily buildings, as well as small commercial buildings that currently utilize a furnace.

Over time, complete electrification will become easier and more affordable. Following is a list of conditions that should prompt Denver to reevaluate planning to enable an equitable and efficient transition to full electrification:

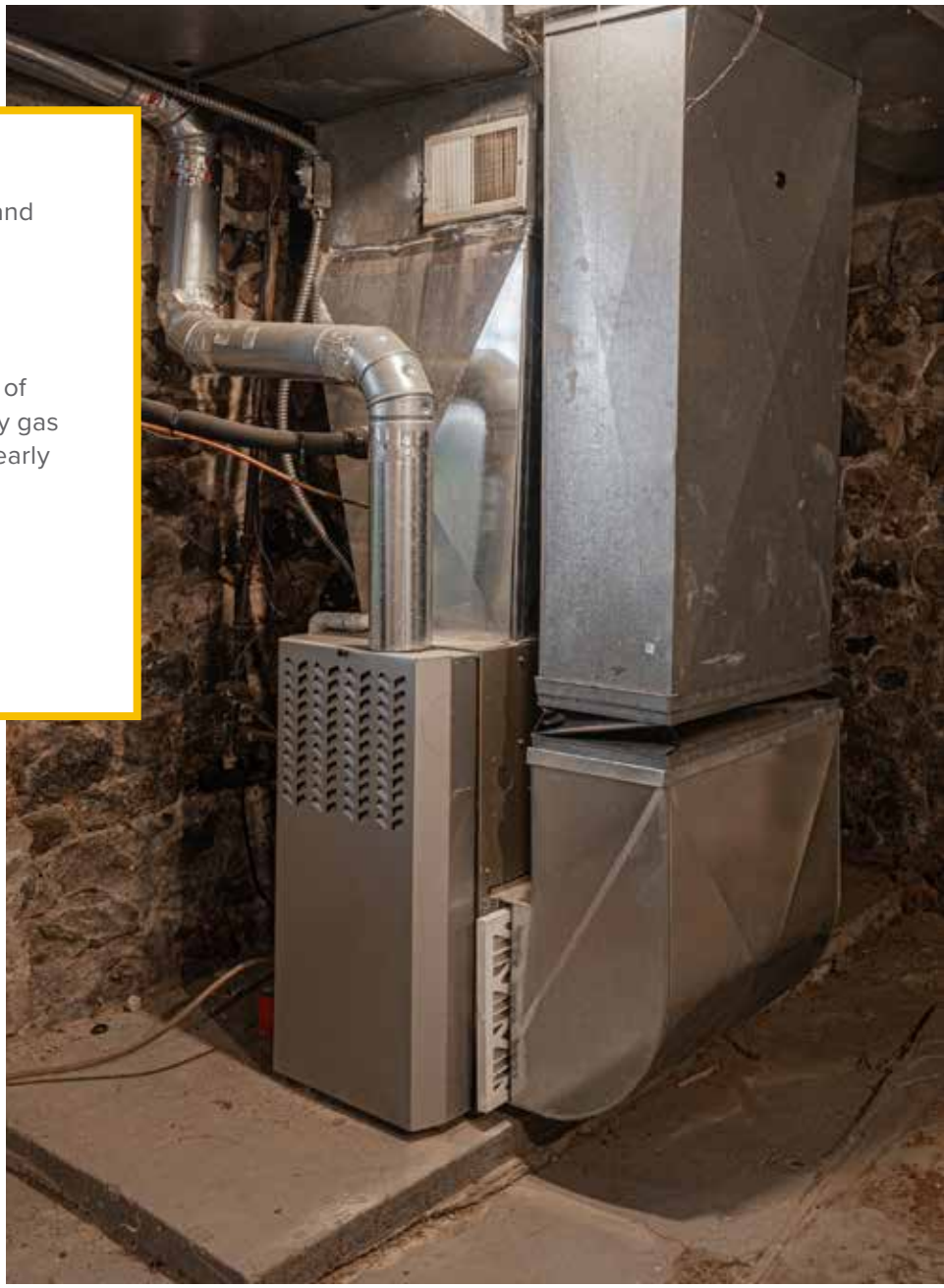
- Better COPs (based on proven performance)
- Proven ccASHP performance at lower cutoff temperatures
- Lower capital costs
- Improved technology (i.e., electric boilers)
- Changes in the ratio of gas to electric rates

A note on all carbon emissions reductions achieved in 2030 in every following typology: The lower end of the range represents an 80% renewable grid (as filed in Xcel Energy's Clean Energy Plan) and the upper end represents a 100% renewable grid (a goal for the City and County of Denver).

Approximately 30% of Denver homes do not have air conditioning today. All of the following electrification options would provide cooling to homes and buildings that do not have it today. Costs shown below are for homes that already have AC, under the assumption that heat pumps are highly efficient and will provide cooling at the lowest available costs.

BUILDING AND HOME SPACE HEATING TYPOLOGY 1

Gas Furnace



BUILDING TYPES

Denver's homes, small offices, and low- mid- and high-rise apartments.

FOOTPRINT

Comprises 32% of Denver's commercial and multifamily building square footage, and 66% of Denver's residential square footage served by gas space heating; however, likely can apply to nearly 100% of Denver's single-family homes.

TYPICAL BUILDING

2,400-square-foot home.

PARTIAL ELECTRIFICATION OPTION 1

Ductless Mini-Split System With Gas Backup Heating

A home with an existing ducted gas furnace, split system, or hydronic baseboard heating installs a new furnace and a ductless mini-split system that can bypass the furnace in more moderate temperatures. In general, the system is configured for ductless mini-splits to provide heat as the default, but in cases where the heating capacity of the heat pump is insufficient, the gas furnace will provide supplemental backup heat in parallel with the heat pump.

This option is preferable in settings where a home has an existing ducted heating system but does not have sufficient electrical panel space to accommodate electric resistance supplemental heat. If an air conditioning unit needs to be replaced, but the furnace still works, the older furnace can remain to provide backup heat. If only the air conditioner is in need of replacement, the failing compressor can be replaced with a heat pump, saving on capital costs while lowering operating costs.

SUMMARY OF COST AND EMISSIONS IMPACTS

	Standard Gas Furnace/AC	Install Mini-split with Gas Backup	Range of % Difference with Utility Rebates
Capital cost – Furnace and AC units	$14,000–$22,500	$14,000–$27,500	0–8.5%
Capital cost – AC compressor only	$11,000–$14,000	$11,000–$18,000	0–8.5%
Xcel Energy utility rebates	A $500 rebate is available for standard systems, or $600 for cold climate systems		
Annual HVAC operating cost	$633	$609	-4.5%
Gas use reduction	N/A	82%	
2030 carbon emissions reduction	55–82%		

ASSUMPTIONS

- Ideal Heating Seasonal Performance Factor (HSPF): 13
- Recommended gas backup temperature setpoint is 15 degrees F. Higher cutoff temperatures will keep operating costs generally lower, while lower cutoff temperatures will increase emissions reductions. This was selected to balance operating cost impacts and emissions reductions.
- Assumes end of system life for furnace and/or AC – the new system is a new furnace and mini-splits instead of the A/C compressor.

SUMMARY OF BENEFITS

This configuration allows homes, small offices, and low-mid- and high-rise apartments to eliminate most gas consumption and capture most of the emissions benefits of a ductless mini-split heat pump. This system avoids relying on electric resistance supplemental heat in the coldest hours of the year. If there is limited electrical panel space in a home, this avoids a potentially costly panel upgrade. In homes with a furnace that still works, a ductless mini-split can bypass the ducted furnace system providing both heating and cooling and reserving the less efficient existing furnace for the coldest hours of the year, thereby also extending that furnace's life.

PARTIAL ELECTRIFICATION OPTION 2

Ducted Heat Pump Split Systems With Gas Backup Heating

This option has slightly higher capital costs but can be a good solution for those who want to avoid a mini-split mounted on the wall and continue to utilize their existing duct system. Ducted heat pumps look like an air conditioning unit but specific valves in the units allow the heat pump to provide both heating and cooling to a home or building through a ducted forced-air system. During colder periods, when the heat pump cannot provide enough efficient heating, this configuration uses an internal gas furnace to provide additional heat.

This is an ideal configuration for homes or buildings with usable ductwork and an existing air conditioning system that is nearing the end of its useful life. Heat pump units can swap out old air conditioning units and provide renewable space heat in addition to space cooling while relying on the existing furnace to provide supplemental heat below 15 degrees Fahrenheit.

SUMMARY OF COST AND EMISSIONS IMPACTS

	Standard Gas Furnace/AC	Heat Pump with Gas Backup	Range of % Difference with Utility Rebates
Capital cost	$14,000 - $22,500	$14,700 - $31,000	5% - 18%
Xcel Energy utility rebates	An $800 rebate is available for standard systems, or $1,000 for cold climate systems.		
Annual HVAC operating cost	$633	$626	0%
Gas use reduction	N/A	70%	
2030 carbon emissions reduction	45% - 70%		

ASSUMPTIONS

Recommended gas backup temperature setpoint of 20 degrees Fahrenheit. Higher cutoff temperatures will keep operating costs generally lower, while lower cutoff temperatures will increase emissions reductions. This was selected to balance operating cost impacts and emissions reductions.

SUMMARY OF BENEFITS

This system provides many of the emissions savings of an all-electric heat pump for most of the year but avoids a large panel upgrade. This is a great solution for homes, small offices, and low- mid- and high-rise apartments with central heating and cooling to reduce heating emissions while maintaining operating cost parity.

FULL ELECTRIFICATION OPTION 1

Ductless Mini-Split System

Ductless mini-split heat pumps provide heating and cooling to buildings without the need for ductwork. An outdoor compressor circulates a refrigerant through pipes to evaporator units inside a home or building. Typically, there will be several indoor units, each serving a discrete space. Supplemental heat is provided by electric resistance strip heat.

This is an ideal system for homes, small offices, and low- mid- and high-rise apartments that do not have existing ductwork or ductwork that is no longer functioning properly. Full electrification is more likely to trigger some electrical upgrades but not in all cases, therefore the capital cost could potentially be higher compared to partial electrification options. If the existing electrical panel has capacity, this option is optimal as it has a minimal effect on operating cost while realizing the full climate benefits of electrification.

SUMMARY OF COST AND EMISSIONS IMPACTS

	Standard Gas Furnace/AC	Install Mini-split with Gas Backup	Range of % Difference with Utility Rebates
Capital cost – Furnace and AC units	$14,000 - $22,500	$16,500 - $33,000	15-30%
Xcel Energy utility rebates	A $500 rebate is available for standard systems, or the rebate is $600 for cold climate systems.		
Annual HVAC operating cost	$633	$661	5%
Gas use reduction	N/A	100%	
2030 carbon emissions reduction	64% - 100%		

ASSUMPTIONS

Ideal HSPF (yields bill savings): 13

SUMMARY OF BENEFITS

Ductless mini-splits are a more efficient option than ducted heat pumps due to a lack of a ducted/forced air system; this saves any energy from a large fan motor. Ductless mini-split heat pumps also can be much quieter than a forced air HVAC system, increasing comfort for the occupant. Ductless heat pumps allow for zonal control in a home as air does not need to circulate through the whole house like in a ducted system.

FULL ELECTRIFICATION OPTION 2

Heat Pump Split Systems With Electric Resistance Backup Heating

Ducted heat pumps look like an air conditioning unit but specific valves in the units allow the heat pump to provide both heating and cooling to a home building through a ducted forced-air system. Unlike gas backup heating, this configuration uses an internal electric resistance heater to provide additional heat during colder periods when the heat pump cannot provide enough efficient heating.

This is an ideal configuration for homes or buildings with usable ductwork and an existing air conditioning system that is nearing the end of its useful life. Heat pump units can swap out old air conditioning units and provide low emissions space heat in addition to space cooling. Full electrification is more likely to trigger the need for some electrical upgrades but not in all cases, therefore the capital cost is potentially higher compared to partial electrification options.

SUMMARY OF COST AND EMISSIONS IMPACTS

	Standard Gas Furnace/AC	Install Mini-split with Gas Backup	Range of % Difference with Utility Rebates
Capital cost – Furnace and AC units	$14,000 - $22,500	$19,000 - $38,000	35% - 60%
Xcel Energy utility rebates	A $800 rebate is available for standard systems, or $1,000 for cold climate systems.		
Annual HVAC operating cost	$633	$718	13% (5% total utility cost increase)
Gas use reduction	N/A	100%	
2030 carbon emissions reduction	61% - 100%		

ASSUMPTIONS

Ideal HSPF (yields bill savings): 12.8

SUMMARY OF BENEFITS

This is an all-electric system that likely will be able to reuse much of the existing ductwork. Space cooling with a heat pump is typically more efficient than in baseline air conditioning systems, resulting in energy savings in the summer (included above).

SECONDARY EQUIPMENT OPTION

Cold climate heat pump technology operates at higher heat output capacity at lower temperatures, reducing the amount of supplemental or backup heat, or potentially removing the need for electric resistance altogether.



Figure 18. Minisplit installation in Lyons, CO

RENEWABLE HEATING AND COOLING PROJECT SPOTLIGHT: MINISPLIT INSTALLATION IN LYONS, CO

"We love our heat pumps."

Hannah Finch Phillips, free range artist, purchased a single-family home that was originally built in the 1930s with an addition from the 1960s. Motivated to conserve energy and reduce carbon, she wanted to live in an all-electric home. Due to the home's construction, it was difficult to add HVAC and part of the home had no ductwork. She worked with Shawn LeMons at Mitsubishi to install a mini-split system. The system keeps up with the winter heating load and has lowered monthly energy (i.e., electricity) bills. When she's able to install solar PV, her home will be carbon free.

BUILDING SPACE HEATING TYPOLOGY 2

Rooftop Units

BUILDING TYPES

Denver's small offices, warehouses, and retail spaces.

FOOTPRINT

Comprises 26% of Denver's building square footage served by gas space heating.

TYPICAL BUILDING

5,503-square-foot small office.



PARTIAL ELECTRIFICATION OPTION

Heat Pump Rooftop Unit With Gas Backup Heating

A heat pump rooftop unit (RTU) is a box on the roof just like a furnace/air conditioning (AC) RTU. The heat pump RTU can be installed and operated as a like-for-like replacement with a standard furnace/AC RTU. They provide both heating and cooling to a building through a ducted forced-air system. During colder periods, when the heat pump cannot provide enough efficient heating, this configuration uses an internal gas furnace (inside the RTU) to provide additional heat.

This is an ideal configuration for buildings with usable ductwork and an existing furnace/AC roof top unit that is nearing the end of its useful life. Because this option is utilizing gas for supplemental heat, it is very unlikely that electrical upgrades will be needed to complete the retrofit.

SUMMARY OF COST AND EMISSIONS IMPACTS

	Standard Gas Furnace/AC RTU	Heat Pump RTU with Gas Backup	Range of % Difference
Capital cost	$43,000 - $68,000	$43,000 - $81,000	0 - 12%
Annual HVAC operating cost	$2,274	$2,276	0%
Gas use reduction	N/A	81%	
2030 carbon emissions reduction	51% - 81%		

ASSUMPTIONS

- Minimum HSPF: 8.2
- Recommended gas backup temperature setpoint of 15 degrees Fahrenheit to achieve operating cost parity. Higher cutoff temperatures will keep operating costs generally lower, while lower cutoff temperatures will increase emissions reductions. This was selected to balance operating cost impacts and emissions reductions.
- Xcel Energy currently does not offer prescriptive rebates for commercial heat pumps. However, customers can apply for incentives through the custom program.

SUMMARY OF BENEFITS

A heat pump rooftop unit (RTU) with gas backup can be installed and operated for a very similar cost as a like-for-like replacement with a standard furnace/AC RTU.

FULL ELECTRIFICATION OPTION

Heat Pump Rooftop Unit With Electric Resistance Backup Heating

The heat pump RTU can be installed and operated as a like-for-like replacement with a standard furnace/AC RTU to provide both heating and cooling to a building through a ducted forced-air system. Unlike the partial electrification option, which uses gas backup heating during colder periods, this configuration uses an internal electric resistance heater to provide additional heat. Capital costs are higher for this option because many buildings will need electrical upgrades to accommodate the electric resistance backup heat. Operating costs are higher because the electric resistance backup heat on the coldest days is inefficient and thus increases electrical demand.

SUMMARY OF COST AND EMISSIONS IMPACTS

	Standard Gas Furnace/AC RTU	Heat Pump RTU with Electric Resistance Backup	Range of % Difference
Capital cost	$43,000 - $68,000	$66,000 - $120,000	50% - 72%
Annual HVAC operating cost	$2,274	$2,504	10%
Annual total utility operating cost	$7,270	$6,906	-5%
Gas use reduction	N/A	100%	
2030 carbon emissions reduction	60% - 100%		

ASSUMPTIONS

Ideal HSPF (yields bill savings): 12.8

SUMMARY OF BENEFITS

A heat pump RTU or commercial single zone split system with electric resistance backup can be installed and operated with much of the same ductwork as the existing system. Space cooling with a heat pump is typically more efficient than in baseline air conditioning systems, resulting in energy savings in the summer (included above). This option maximizes the carbon benefit of a heat pump installation.

Some small commercial spaces present a unique opportunity to fully electrify a building and simultaneously lower total operating costs. By completely removing any gas end uses in the building, a customer can avoid paying the annual $535 charge for the fixed cost of having gas service to the building.

SECONDARY EQUIPMENT OPTION

Mini-split heat pumps are a good alternative to RTUs for buildings up to seven stories high and under. Cold-climate heat pumps operate efficiently and may not always need backup heating, even when the temperature drops below 5 degrees Fahrenheit.

Packaged Terminal Air Conditioning Unit

BUILDING TYPES

Denver's small hotels and mid-rise apartments.

FOOTPRINT

Comprises 2% of Denver's commercial and multifamily building square footage served by gas space heating.

TYPICAL BUILDING

42,558-square-foot small hotel.



Photo by: www.totalhomesupply.com

PARTIAL ELECTRIFICATION OPTION

Heat Pump With Gas Backup Heating

Packaged terminal heat pumps look like packaged terminal air conditioners but specific valves in the units allow the heat pump to provide both heating and cooling to an apartment or hotel room through a ducted forced-air system. During colder periods, when the heat pump cannot provide enough efficient heating, this configuration uses an internal gas furnace to provide additional heat.

Ductless mini-split systems may sometimes work in these buildings, but the conversion may not always be simply from a PTAC to a mini split.

SUMMARY OF COST AND EMISSIONS IMPACTS

	PTAC	Heat Pump with Gas Backup	Range of % Difference with Utility Rebates
Capital cost	$214,000 - $315,000	$340,000 - $580,000	78%
Annual HVAC operating cost	$1,964	$1,775	-9.7%
Gas use reduction	N/A	58%	
2030 carbon emissions reduction	29% - 58%		

ASSUMPTIONS

- COP: 3.0
- Recommended gas backup temperature setpoint of 15 degrees Fahrenheit. Higher cutoff temperatures will keep operating costs generally lower, while lower cutoff temperatures will increase emissions reductions. This was selected to balance operating cost impacts and emissions reductions.

SUMMARY OF BENEFITS

This system provides many of the emissions savings of an all-electric packaged terminal heat pump for most of the year but avoids a large panel upgrade. This option also has the opportunity to lower operating costs.

FULL ELECTRIFICATION OPTION

Packaged Terminal Heat Pump With Electric Resistance Backup Heating

Packaged terminal heat pumps look like packaged terminal air conditioners, but specific valves in the units allow the heat pump to provide both heating and cooling to a home building through a ducted forced-air system.

Unlike the partial electrification option which uses gas backup heating during colder periods, this configuration uses an internal electric resistance heater to provide additional heat. Capital costs are higher for this option because many buildings will need electrical upgrades to accommodate the electric resistance backup heat. Operating costs are higher because the electric resistance backup heat on the coldest days is inefficient and runs on electricity.

SUMMARY OF COST AND EMISSIONS IMPACTS

	PTAC	Packaged Terminal Heat Pump with Electric Resistance Backup	Range of % Difference with Utility Rebates
Capital cost	$214,000 - $315,000	$370,000 - $690,000	97%
Annual HVAC operating cost	$1,964	$2,683	36% (12% total utility cost increase)
Gas use reduction	N/A	100%	
2030 carbon emissions reduction	34% - 100%		

ASSUMPTIONS

COP 3.0

SUMMARY OF BENEFITS

A packaged terminal heat pump with electric resistance heating provides an all-electric option that reduces the number of changes to systems where there is already an existing packaged terminal air conditioner.

PLAYBOOKS FOR PARTIAL AND FULL ELECTRIFICATION BY TYPOLOGY 4

Boiler Systems



BUILDING TYPES

Denver's large offices and large hotels.

FOOTPRINT

Comprises 11% of Denver's commercial building square footage served by gas space heating.

TYPICAL BUILDING

499,000-square-foot office.

FULL ELECTRIFICATION OPTION

Electric Boiler With Cooling Tower And Water Loop Heat Pump

The existing boiler, chiller, and cooling towers are replaced with electric boilers and a new cooling tower. Air handlers are replaced with units meant to supply fresh outdoor air only. Any zone units (e.g., VAV boxes) are replaced with water loop heat pumps. Distribution water piping likely will need to be resized and replaced.

SUMMARY OF COST AND EMISSIONS IMPACTS

	Conventional VAV System	WSHP System	Range of % Difference with Utility Rebates
Capital cost	$10,000,000 - $14,750,000	$14,000,000 - $31,000,000	66%
Annual HVAC operating cost	$77,824	$175,891	126% (19% total utility cost increase)
Gas use reduction	N/A	100%	
2030 carbon emissions reduction	80-100%		

SUMMARY OF BENEFITS

This is the most efficient option and provides the most reduction in emissions. However, the installation requirements are extensive in many buildings and it will likely be many years before the technology options reach cost parity with the existing gas-fed systems, for both installation and operations.

SECONDARY EQUIPMENT OPTIONS

- **Partial electrification: Heat recovery chiller and gas boiler.** Capital costs are expected to be approximately 7% greater than a conventional system. Maintaining the existing boiler ensures that the heating needs of the building are maintained while adding the heat recovery chiller provides a means to reduce emissions during periods of simultaneous heating and cooling. This configuration also reduces the need to reconfigure the distribution system. Although heat recovery systems can be an effective solution, this technology has not yet reached wide industry adoption and therefore is considered a secondary option that will require careful design and implementation to produce a functional and emissions-saving installation.
- **Full electrification: Heat pump boilers, keeping the existing chiller and air system.** Capital costs are expected to be approximately 800% greater than a conventional system. Although heat pump boiler systems can be an effective solution, this technology has not yet reached wide industry adoption and therefore is considered a secondary option that will require careful design and implementation to produce a functional and emissions-saving installation.
- **Full electrification: Electric boilers, keep the existing chiller and air system.** Much of the existing system can remain with this option, lowering the capital cost. However, using electric boilers will create a high peak demand, likely significantly increasing the utility costs and lowering the emissions savings compared to other options.

Individual System with Tank

BUILDING TYPES

Denver's homes, low-rise multifamily.

FOOTPRINT

Comprises 96% of Denver's residential building square footage and 4% of commercial and multifamily square footage served by gas water heating.

TYPICAL BUILDING

2,400-square-foot home with three occupants.



FULL ELECTRIFICATION OPTION

Heat Pump Water Heater

This example assumes a 50-gallon heat pump water heater, assumed to be in an unconditioned interior space (e.g., garage or unconditioned basement).

SUMMARY OF COST AND EMISSIONS IMPACTS

	Individual System with Tank	Heat Pump Water Heater	Range of % Difference with Utility Rebates
Capital cost	$1,200 - $2,400	$1,200 - $4,000	0% - 48%
Xcel Energy utility rebates	A $600 rebate is available for heat pump water heaters, or $800 for grid-connected heat pump water heaters		
Annual water heating operating cost	$107	$117	10% (less than 1% total utility cost increase)
Gas use reduction	N/A	100%	
2030 carbon emissions reduction	85% - 100%		

ASSUMPTIONS

Target Uniform Energy Factor (UEF): 3.1.

SUMMARY OF BENEFITS

Due to the poor efficiency of gas tanked water heaters (~0.62 UEF), and the high efficiency of heat pump water heaters (UEF >2.0 for standard HPWH, >3.0 for efficient HPWH), these devices yield minimal bill impacts, and likely will result in bill savings. This eliminates on-site gas consumption and associated risk while reducing carbon emissions by 85%. Domestic hot water is supplied at the same temperature as typical gas-heated hot water, so users will not notice any difference.

Central System with Tank

BUILDING TYPES

Small, medium, large offices, mid-rise residential, high-rise residential, hotel.

FOOTPRINT

Comprises 48% of Denver's commercial and multifamily building square footage served by gas water heating. 27% of commercial square footage in Denver utilize both Water Heating Typology 2 and 3.

TYPICAL BUILDING

5,503-square-foot small office.



FULL ELECTRIFICATION OPTION

Central Heat Pump Water Heater

This typology includes a central tanked HPWH with additional electric resistance heating elements to satisfy periods of increased hot water demand.[74]

This typology can be very cost-effective if there is enough floor space for a large hot water storage tank. In our prototype model, we assumed this was not the case, and the electric resistance unit is providing a lot of supplemental water heating. In real life, if a large hot water tank is utilized, the water heater is able to operate almost exclusively in heat pump mode, this would result in a much smaller percent increase in annual operating costs, while having a significant amount of gas reduction.

SUMMARY OF COST AND EMISSIONS IMPACTS

	Central System with Tank	Electric Water Heating System	Average % Difference
Capital cost	$15,000 - $20,000	$16,000 - $25,000	7-20%
Annual water heating operating cost	$54	$120	122% (4% total utility cost increase)
Gas use reduction	N/A	100%	
2030 carbon emissions reduction	70% - 100%		

ASSUMPTIONS

- Uniform Energy Factor (UEF): 3.0.
- An increase of $66 in annual water heating costs may be worth it if it enables a small commercial space to fully electrify the building thereby avoiding the annual $535 fixed gas charge and lowering operating costs by $469 annually.

SUMMARY OF BENEFITS

A heat pump water heating tank with a supplemental electric resistance swing tank can provide the same level of domestic hot water at the same temperature as conventional gas-fueled tank water heaters, but with significant emissions reductions. The electric resistance heating component responds to periods of increased hot water demand.

74 For a small office, these results assume a 15,400 Btu/hr central HPWH with a UEF of 2.0 and a 50-gallon primary tank, along with a 20-gallon swing tank with 1.5 kW of electric resistance heating. Larger buildings would have scaled-up systems.

HOME WATER HEATING TYPOLOGY 3

Gas Point-of-Use System



BUILDING TYPES

Retail, warehouse.

FOOTPRINT

Comprises 21% of Denver's commercial building square footage served by gas water heating. 27% of commercial building square footage in Denver utilize both Water Heating Typology 2 and 3.

TYPICAL BUILDING

24,695-square-foot retail building.

FULL ELECTRIFICATION OPTION

Electric Point-Of-Use System

These building typologies do not pipe domestic hot water through the building like other building typologies and instead rely on point-of-use tankless water heating.

SUMMARY OF COST AND EMISSIONS IMPACTS

	POU Gas Tankless Water Heater	POU Electric Resistance Tankless Water Heater	Average % Difference
Capital cost	$2,200 - $3,600	$4,000 - $5,000	30-45%
Annual water heating operating cost	$451	$2,601	470% (5% total utility cost increase)
Gas use reduction	N/A	100%	
2030 carbon emissions reduction	30% - 100%		

ASSUMPTIONS

Uniform Energy Factor (UEF): 1.0

SUMMARY OF BENEFITS

Despite relying on electric resistance heat, the 2030 electric grid has a low enough emissions factor to still reduce emissions relative to gas water heating. This technology package is suitable when whole building electrification is considered, or when emissions reductions are prioritized, and water heating bills are not a significant portion of critical expenses.

SMALL GAS USES AND CUSTOM ELECTRIFICATION

While 97% of Denver's gas emissions result from space and water heating in buildings and homes, other common end uses of gas include gas cooking at home and in commercial spaces, as well as gas fireplaces and heaters. In addition, research labs and industrial manufacturing at times utilize gas for high-heat processes. There are a number of electric alternatives on the market today that can replace their gas counterparts.

For **household cooking**, a number of excellent options exist. While many consumers are familiar with electric-resistance ranges, induction technology also should be considered. Electric resistance ranges often have lower upfront costs and eliminate the negative impacts of gas cooking on indoor air quality. Induction cooking units can come with a higher upfront cost, but they are much more efficient and safer than both electric or gas counterparts. Induction cooking works by heating the pot or pan through electromagnetic waves rather than the stovetop itself. This means there is no wasted heat in the process, a spill is not going to burn onto the stovetop or, in the event of an oil spill, cause a kitchen fire. The top six of eight ranges selected by Consumer Reports in 2020 were electric, and the top two were induction cooktops. For those who are not currently in the market for a new range but are induction-curious, many countertop induction options exist. These range between single-burner options (starting at $40), increasing all the way to four-plus burner countertop models. While gas cooking appliances are 25-40% efficient, electric appliances are 70-95% efficient, resulting in lower energy use and much less waste heat, so the kitchen stays cooler and an air conditioner does not have to work as hard.



For restaurants and other commercial cooking operations, similar technology exists, and many high-end restaurants are starting to convert some of their operations to induction cooking. Cooking processes that require precision often are better served through electric or induction cooking. Electric cooking also produces far less waste heat, keeping the commercial kitchen space much cooler on top of improving the air quality for workers in the kitchen.

Gas clothes dryers also have excellent electric counterparts. While electric resistance is the product that most consumers know, there are a number of newer entrants on the market that bring significant energy efficiency and use about half the energy of an electric resistance dryer. These new product offerings are very commonplace in Europe and Asia and utilize either condensing or heat pump technology to dry clothes. These products run on 120V outlets, use as much energy as a hair dryer, and operate at a lower temperature, extending the life of your clothes. Many of these units are also a combined washer and dryer, so that one machine will both wash and dry your clothes, saving floor space and effort. In addition, condensing and heat pump dryers do not use a vent, saving energy in an HVAC system that does not have to recondition makeup air.

Gas fireplaces cause indoor air quality challenges that can be resolved through electrification. Most consumers are familiar with electric resistance, but a better electric alternative exists. A number of companies provide both the look and feel of a real fire with swirling fire-like water vapor and LEDs. Termed "water vapor fireplaces", this technology utilizes a 120V outlet and can warm spaces up to 800 square feet – sufficient for both commercial and residential usage. Most importantly, unlike their gas counterparts, the electric options do not emit carbon dioxide or carbon monoxide.

Outdoor gas and propane heaters have become increasingly popular. While these are ubiquitous on home and restaurant patios, the electric counterparts that plug into either 120V or 240V outlets use infrared technology that does not waste energy heating the space around the people, but instead heats up surfaces– such as people or their clothing – directly. Most importantly, this warming effect is not impacted by a breeze or wind as the infrared technology only heats solid objects.

Twenty percent of Denver's gas usage comes from users Xcel Energy has classified as industrial customers. Some gas usage is for space and water heating, but some is for **process loads**. Within the manufacturing sector, there is ample opportunity for electrification and carbon emissions reduction. While electrification of processes that currently utilize gas can reduce the embodied carbon of the final product, it is also possible to garner additional co-benefits such as increased precision and control, and reduced waste as a result of fewer defects. Low- and medium-heat processes – those below 600 degrees Fahrenheit – can be served through heat pump technology. Heat pumps, electric boilers, microwaves, and infrared heaters all have the potential to reduce reliance on gas in the manufacturing sector while improving process precision. Food, tobacco, transport equipment, chemicals, textiles, beverage, and pulp and paper are some of the industries most suited to decarbonization as a lot of the process load is below 600 degrees Fahrenheit. Some industrial processes are going to be harder to electrify because they are directly dependent on high heat systems often driven by gas. Electrification alternatives for high-heat process are still under development.

Hospital HVAC systems are uniquely positioned for electrification and garnering its full benefits given the amount of simultaneous heating and cooling that often can take place in the building. Utilizing a water loop heat pump or VRF system can significantly lower carbon emissions from a building. Other processes that occur in hospitals or research lab settings also may have viable electric counterparts. As mentioned above, heat processes below 600 degrees Fahrenheit likely can be served by heat pumps and other technologies such as microwave or infrared devices that can advance electrification. Altogether avoiding gas in a sterile lab setting can reduce the energy costs of maintaining air quality in a clean room or laboratory. Hospital and other emergency facilities have backup generators, but these are usually diesel-powered (not gas), and this plan does not cover diesel systems.



DENVER'S RENEWABLE HEATING AND COOLING

IMPLEMENTATION STRATEGY



INFORMING THE IMPLEMENTATION STRATEGY

WORKFORCE

We engaged 25 workforce members representing union and non-union contractors and building operators through two roundtables. These contributors were experienced with small and large projects in both the commercial and residential sectors. They provided insight into Denver's current workforce landscape and opportunities to evolve workforce development alongside electrification.

Twenty percent of building energy and construction sector employers say it is very difficult to find qualified candidates for building retrofit projects.[xxii] Current training opportunities for general HVAC opportunities including building electrification consist of degrees from technical colleges such as Emily Griffith Technical College, on-the-job training, and union-led apprenticeship programs. Many training opportunities are provided at no cost to students and may even provide stipends and support in finding job placement. Denver Workforce stakeholders provided the following list of frequently used training pathways in Denver:

- AGC – Construction Careers Now
- CHBA – Colorado Home Building Academy
- The Masters Apprentice
- Pipefitters Apprenticeship
- International Brotherhood of Electrical Workers IBEW Apprenticeship and Pre-Apprenticeship
- Local 720 (LiUNA)
- Boilermakers Local 101 Boilercode Workforce Program
- GRID Alternatives
- Mile High Youth Corps

INFLUENTIAL POLICIES AND PROGRAMS

Colorado has been at the forefront of progressive environmental policy development starting with the first voter-approved Renewable Portfolio Standard in 2004. Several Colorado bills listed below have passed recently that may directly or indirectly encourage electrification.

- Colorado House Bill 19-1261 set statewide goals for a reduction in GHG emissions, targeting a 50% reduction in emissions by 2030 and a 90% reduction in statewide emissions by 2050 (compared to the state's 2005 baseline). The beneficial use of electricity to meet the state's goals is specifically mentioned in the text of the bill.[75]
  - Colorado completed a GHG Pollution Reduction Roadmap to identify the pathways to meeting the state's targets. Within the roadmap, beneficial electrification using heat pumps is a key emissions reduction strategy. A study by the Colorado Energy Office regarding beneficial electrification potential shows that with the right policy in place, 200,000 homes could have heat pumps by 2030.[76]
- Colorado House Bill 19-1231 updated energy efficiency and water efficiency standards for new appliances.[77] This helped ensure new electric appliances comply with strict efficiency standards.
- House Bill 19-1272 clarified that housing authorities may use the CO Commercial Property Assessed Clean Energy (C-PACE) program to finance energy improvements.[78] This opened the door to financing for electrification from C-PACE for housing authorities.
- House Bill 19-1170 updated the Residential Tenants Health and Safety Act to clarify that a residential premise is not habitable if it lacks functioning appliances in good working order.[79] This ensureed that building owners have clear responsibilities to provide working appliances and equipment in residential rental properties.
- Senate Bill 20-204 established an air quality enterprise fund to address air quality issues.[80] This fund could be considered for use in supporting electrification programs that have a direct air quality benefit.

75 For more information see: https://leg.colorado.gov/bills/hb19-1261.
76 For more information see: https://drive.google.com/file/d/1jzLvFcrDryhhs9ZkT_UXkQM_0LiiYZfq/view.
77 For more information see: https://leg.colorado.gov/bills/hb19-1231.
78 For more information see: https://leg.colorado.gov/bills/hb19-1272.
79 For more information see: https://leg.colorado.gov/bills/hb19-1170.
80 For more information see: https://leg.colorado.gov/bills/sb20-204.

Senate Bill 21-246 was recently passed through the legislature and advocates for beneficial electrification. This bill will require the Public Utilities Commission to establish energy savings targets and approve plans for investor-owned-utilities, including Xcel Energy, to promote the use of efficient electric equipment.

Denver continues to be a leader in the state with bold building policies designed to reduce carbon emissions in new and existing buildings and homes. Denver voters recently passed Ballot Measure 2A – creating the Climate Protection Fund (CPF) – to provide the city with a fund that supports the implementation of climate-related policies and programs. A minimum of 50% of the revenue is required to support projects benefiting under-resourced communities.[81] The Energize Denver Task Force is developing a building performance policy (BPP) that will lay out a prescriptive path to reduce energy use in existing buildings. Both the CPF and the BPP will improve building electrification and help guide and ease the electrification transition.

RENEWABLE HEATING AND COOLING EFFORTS CURRENTLY UNDERWAY IN DENVER

There is not yet consistent and widespread electrification messaging in Colorado. Colorado Sierra Club and Physicians for Social Responsibility (PSR) are currently advocating for electrification and sharing this messaging with their communities and constituents. Climate Nexus and other smaller nonprofits are conducting gas and electrification perception studies across the state and within Denver.

Xcel Energy currently provides incentives for heat pumps and other electric technologies in the residential sector; building owners interested in commercial rebates can contact their Xcel Energy account manager directly to discuss customized programs. See Table 6 for electrification rebates that are currently available. Additional rebates are available for building envelope improvements and energy audits.

Individual HVAC firms are working with their clients to install electric appliances. According to our workforce roundtables, uptake is slow but increasing, and is led by consumer demand.

Table 6: Electrification incentives currently available to Denver residents

Program[82]	Program Administrator	Rebate Amount	Details
Residential Heat Pump[83]	Xcel Energy	$800 for standard ducted ASHP	Rebates are available for ASHPs, dual fuel ASHPs, and ground source heat pumps. Installation must be completed by a qualifying contractor and systems must meet certain efficiency thresholds. Incentives are higher for projects in income-qualified homes.
Residential Mini-Split Heat Pump[84]	Xcel Energy	$500 for standard ductless ASHP	Also available for dual fuel mini split systems. Mini-split cooling-only units are not eligible. Installation must be completed by a qualifying contractor and systems must meet certain efficiency thresholds. Incentives are higher for projects in income-qualified homes.
Cold Climate Heat Pump	Xcel Energy	$600 for ductless, $1000 for ducted	Installation must be completed by a qualifying contractor and systems must meet certain efficiency thresholds. Incentives are higher for projects in income-qualified homes.

81 For more information see: https://www.denvergov.org/content/denvergov/en/denver-decides/ballot-issues/ballot-measure-2A.html.

82 For more information see: https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Regulatory%20Filings/CO%20Recent%20Filings/20AL-0412E_AL-1834_DSMCA-E_Legal_Notice_2020.pdf.

83 For more information see: https://co.my.xcelenergy.com/s/residential/home-rebates.

84 Ibid.

Table 6: Electrification incentives currently available to Denver residents (cont.)

Program[82]	Program Administrator	Rebate Amount	Details
Residential Heat Pump Water Heater[85]	Xcel Energy	$600 for Standard HPWH, $800 for Grid Connected HPWH	Installation must be completed by a qualifying contractor and systems must be on the list of eligible HPWHs before purchase. Systems with a tank larger than 80 gallons are not eligible. Incentives are higher for projects in income-qualified homes. Projects in market-rate homes also have an upstream rebate for contractors.
Colorado Affordable Residential Energy (CARE)[86]	Energy Outreach Colorado (EOC)	Varies	CARE provides free weatherization services for income-qualified households; for certain projects this may include HVAC system equipment replacement. Rebates are managed and received by EOC after the work is completed.
Crisis Intervention Program (CIP)[87]	EOC	Varies	CIP provides free repair and/or replacement of heating systems for income-qualified households; generally does not include fuel switching projects.
Energy Efficiency Financing[88]	CO RENU Loan Program OR Energy Smart	Varies	Low-interest loans (with interest as low as 2.75%) are available with flexible terms and loan amounts. Boulder County residents work with the Energy Smart program; the rest of the state works through the RENU Loan Program.
Multifamily Building Efficiency[89]	Xcel Energy	Rebates offered through Custom program	Multifamily buildings can receive rebates for HVAC equipment and domestic water heaters, including heat pumps. Project must be identified through a compulsory free energy assessment from Xcel's program administrator to be eligible.
Nonprofit Energy Efficiency Program (NEEP) / Affordable Housing Rebate Program (AHRP)[90]	Energy Outreach Colorado (EOC) and Xcel	Rebate is up to 100% of eligible material and installation cost	These programs are intended to reduce energy use and costs in nonprofit facilities serving the income-qualified community and in multifamily affordable housing (non-single family). Rebates are provided up to 100% of the installation costs when determined cost effective through Xcel's Custom analysis program. Should the equipment be determined not cost-effective by the analysis, the equipment would be eligible for applicable prescriptive rebates.

85 For more information see: https://co.my.xcelenergy.com/s/residential/home-rebates/water-heaters.

86 For more information see: https://www.energyoutreach.org/programs-for-individuals/care-program/.

87 For more information see: https://www.energyoutreach.org/programs-for-individuals/heating-system-repair-replacement/.

88 For more information see: https://www.xcelenergy.com/programs_and_rebates/residential_programs_and_rebates/home_energy_efficiency/energy_efficiency_financing_for_new_homes.

89 For more information see: https://www.xcelenergy.com/programs_and_rebates/business_programs_and_rebates/rates/multifamily_building_efficiency.

90 For more information see: https://www.xcelenergy.com/programs_and_rebates/business_programs_and_rebates/income_qualified_rebate_programs_for_buildings.

RENEWABLE HEATING AND COOLING IN OTHER STATES AND CITIES

Many states, local governments, and utilities are creating incentives for electrification and expanding consumer education and outreach on ASHPs, ground source heat pumps, HPWHs, electric cooking appliances, and electric dryers. Some of these entities are also developing workforce development opportunities. These are the most active states in building electrification:

- California
- Connecticut
- Maine
- Massachusetts
- New Hampshire
- New York
- Rhode Island
- Oregon
- Vermont
- Washington

The most frequent type of incentives offered are upstream rebates for manufacturers and distributors, downstream rebates for customers, and training and education programs for contractors. Programs that allow incentives to be "layered"[91] or "stacked" – and programs that aim to educate and promote electric heating technologies – are also common. Less common are programs that provide bulk-purchase discounts for heat pump technologies or loaner equipment that allows consumers to test out induction stoves before they make the move to purchase one. Upstream rebate programs often include a requirement that the discount be passed on to the customer, as well as a certification requirement or vetting of distributors and installers approved to receive the rebates.

REAL AND PERCEIVED BARRIERS

Through feedback received via stakeholder engagement, our original research, and technical analyses, we identified 20 primary building electrification barriers that Denver needs to navigate in the deployment of renewable heating and cooling (see Table 7). All these identified issues are not surprising or unique to the energy transition in buildings but are common barriers to any technology transition. Recognizing and understanding these barriers informs the specific actions that Denver can take to support the electrification transition. Barriers are categorized into the following types:[92]

- Economic
- Social and institutional
- Technical and infrastructure
- Policy and regulatory

A barrier may be real or perceived. A real barrier is based on science and/or is a function of current economic and societal structures. A perceived barrier is one that may be considered to be real but is not necessarily supported by science. Both types of barriers must be addressed; however, the mechanisms used to address a real barrier may be rooted in policies, incentives, and programs, while a perceived barrier may be overcome with outreach, engagement, and messaging.

91 Layering of incentives supports greater adoption of electrification technologies because it allows consumers to benefit from multiple resources that support the transition from both a financial and a technical perspective. An example of incentive layering may be an upstream discount to a distributor that is passed on to the customer, combined with a downstream discount to the customer to support either equipment purchases or necessary infrastructure (e.g., panel upgrades).

92 The four types of barriers align with those identified in the Northeast Energy Efficiency Partnerships (NEEP) 2017 report Northeast Regional Assessment of Strategic Electrification.

Table 7: Summary of primary barriers to electrification

Barrier Type	Barrier
Economic	1. Higher capital cost. 2. Low gas prices. 3. Additional technology upgrades add to project costs. 4. Additional energy efficiency and health and safety upgrades increase cost. 5. Accessing capital and credit may be difficult. 6. High energy burden. 7. Stranded assets increase costs.
Social and Institutional	1. Lack of awareness among home and building owners. 2. Contractors are unfamiliar with new technology. 3. Limited training for contractors. 4. Gas cooking is preferred. 5. Improved homes can lead to renter displacement.
Technical and Infrastructure	1. Some spaces have physical limitations. 2. Current technology limits heat pump performance at lower temperatures. 3. Electric resistance backup heating increases costs and contributes to greater demand on the grid.
Policy and Regulatory	1. Utility rates and structure do not encourage electrification. 2. Current energy efficiency programs do not address electrification. 3. Denver's building permitting department does not regularly approve a significant number of electrification permits. 4. There are gaps in current equipment incentives. 5. Inequities exist in current incentive models.

DENVER'S RENEWABLE HEATING AND COOLING IMPLEMENTATION STRATEGY

The plan contains 21 solutions designed to overcome electrification barriers and lead Denver's community toward an equitable electrification transition. These solutions were derived from in-depth research, conversations with Denver's Renewable Heating and Cooling Advisory Group and Energize Denver's Workforce stakeholders, and our project team's analyses. Action types and individual actions are shown in Table 8.

Table 8: Electrification solutions for Denver

Action Type	Solution
Communications	1. Develop accessible public outreach materials. 2. Share and promote website and outreach materials with partners. 3. Expand existing building electrification website. 4. Promote and market website and outreach materials.
Programs	1. Launch demonstration projects in key neighborhoods. 2. Develop technical assistance programs. 3. Support and expand Clean Energy Workforce Programs.
Policies	1. Develop and adopt new code and policy language that encourages and eventually requires electrification. 2. Elevate equitable housing through electrification policies and programs. 3. Support and advocate for state-level policies and regulations to advance electrification and address long-term utility system maintenance costs where appropriate. 4. Ensure quick permitting for electrification projects. 5. Formally incorporate avoided externality costs into energy programs and policymaking.
Incentives	1. Provide supplemental incentives. 2. Partner with Xcel Energy to expand its incentive offerings. 3. Apply targeted universalism[93] practices to designing equity-first incentives. 4. Reallocate gas efficiency funds to support building envelope improvements. 5. Design financing options. 6. Support private innovation that advances electrification. 7. Phase in different incentive levels and types. 8. Work with Xcel Energy to integrate space heating as a service and tariffed on-bill financing. 9. Focus incentives on higher-efficiency systems.

93 Targeted universalism means setting the same goals for all people and allowing different ways to achieve those goals for different groups of people. A targeted universalism approaches allow for policy and incentive design to vary based on different starting points, while directing everyone towards the same end goal. For more information, watch: https://www.youtube.com/watch?v=wgGcftWpwUQ&feature=youtu.be.

COMMUNICATIONS

1. DEVELOP ACCESSIBLE PUBLIC OUTREACH MATERIALS.

Denver should develop public outreach materials that are available on the website and for download to share with partners, residents, and businesses. The materials should be applicable to different audiences and leverage existing Denver programs for additional promotion. The audiences may include:

- Homeowners (both market-rate and under-resourced)
- Commercial building owners
- Multifamily building owners
- Residential tenants
- Commercial tenants
- Multifamily tenants
- Under-resourced households
- Property managers
- Contractors
- Distributors of heat pump equipment
- Organizations pursuing similar goals (e.g., energy efficiency, equity, decarbonization, etc.)
- General public

All public outreach materials should be culturally appropriate, available in Denver's top six languages (i.e., English, Spanish, Vietnamese, Arabic, Somali, and Amharic), and accessible to those who are hearing or visually impaired.

For each audience, information should cover, at a minimum:

1. The value that electrification will bring to them.

2. What they need to know about electrification.

3. The core challenges for their sector.

4. The key messages Denver wants to convey (i.e., information about available incentives or training programs).

5. Potential electrification "pain points."

Some of the various outreach materials that Denver should consider creating, including details on the audience, priority level, and existing available materials that can be leveraged, are shown in Table 9.

Messaging should be hyper-targeted. For example:

- Messaging on indoor air quality impacts should be targeted to neighborhoods and households with children.
- Messaging on reductions in energy burden should be targeted to neighborhoods with high rates of poverty.
- Messaging to building owners and contractors should discuss the available technology, how to maintain and operate electric equipment, and opportunities for training and certification.
- Messaging to younger and wealthier audiences should focus on electrification as "high-tech," modern, or luxury.
- Messaging to "Early Adopters" should focus on the connection between building electrification, transportation electrification, and renewable energy. This messaging also can focus on "energy effectiveness" and "electrification as a lifestyle."
- Messaging should address different audiences along the technology adoption curve shown Figure 19:
  - Celebrate and reward the "Innovators" and "Early Adopters."
  - Address the concerns of the "Early Majority" and "Late Majority" groups, who generally are more hesitant to adopt new technologies and can be encouraged by success stories from "Innovators" and "Early Adopters" as well as detailed resources about the new technology, and information on the supports and incentives available for them to make the switch.
  - Focus on code updates and prescriptive requirements to message to the "Laggards"—this group only will adopt the new technology when they absolutely have to, regardless of positive messaging.

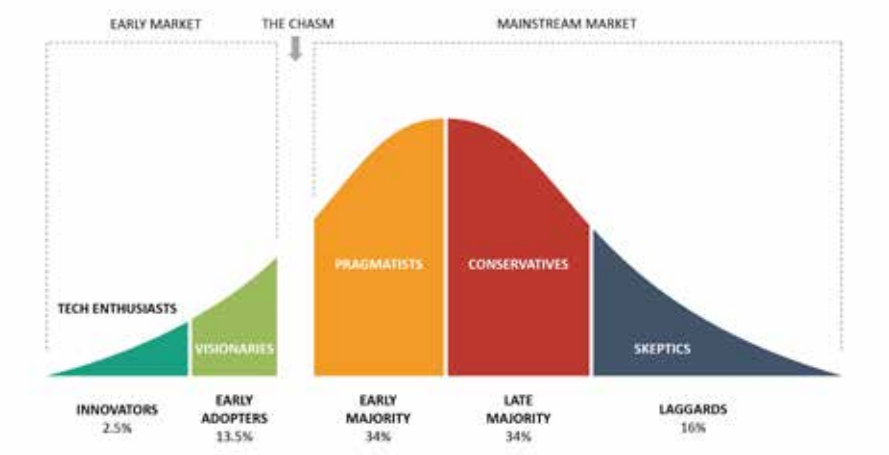


Figure 19: Technology adoption curve

Within outreach materials, it will be necessary to recognize that many households and businesses, particularly those that are under-resourced, are operating in survival mode. Especially during the 2020–2021 COVID-19 pandemic, meeting basic needs of food, safety, housing, and warmth have been paramount. Layering on another request for adjustment or change can feel daunting and unattainable. Therefore, it is essential to have electrification messaging that is informed by this and aligns messaging with a community's values, needs, and style. The outreach materials need to "meet people where they are at," and, in doing so, demonstrate respect for Denver's community in tandem with providing support to overcoming other barriers, such as financing and funding.

2. SHARE AND PROMOTE WEBSITE AND OUTREACH MATERIALS WITH PARTNERS.

Partner with community-based organizations to ensure the outreach materials reach each partners' communities and networks. Several organizations in Denver and the Metro area are advocating for and pursuing home and building electrification alongside Denver's efforts. Denver should collaborate with these partners to promote and market Denver's electrification website and the materials that it contains. For instance, outreach materials that include messaging on public health benefits of electrification should be shared with public health entities and providers, while materials focusing on workforce development and training around electrification should be shared with contractors.

Denver should work with partners to identify the most appropriate ways to effectively message to the partners' networks; a combination of web presence, engaging videos, appearances on the radio and news, and printed mailers and flyers are more likely to engage a larger number of community members than one single format. Partners to engage in the distribution of outreach materials include (but are not limited to):

- Alliance Center
- American Lung Association
- Blue Green Alliance
- Colorado Energy Office
- Colorado Health Foundation
- Conservation Colorado
- Denver Housing Authority
- Denver Metro Association of Realtors
- Denver Metro Commercial Realtors
- Denver Public Health
- Denver Urban Renewal Authority
- Energy Outreach Colorado
- Green Latinos
- Groundwork Denver
- Healthy Air and Water Colorado
- Historic Denver
- Local contractor community
- Mercy Housing
- Mitsubishi Diamond
- Mom's Clean Air Force
- Physicians for Social Responsibility
- Regional Air Quality Council
- Sierra Club
- Sustainable Neighborhoods Network
- Urban Land Conservancy
- Western Resource Advocates
- Xcel Energy

3. LAUNCH A RENEWABLE HEATING AND COOLING WEBSITE.

Denver's renewable heating and cooling website should be a one-stop-shop for all things regarding building electrification, featuring attractive and engaging content. The website may reference or be part of a larger website that provides resources on energy efficiency, electric transportation, and renewable energy. Examples of other state- and city-managed websites include the state of Minnesota's Air Source Heat Pump Collaborative, the state of California's The Switch Is On, the city of Boulder's Comfort 365, and Utah Clean Energy. The website should be mobile and smart phone compatible.

The website should provide outreach material, public education, and an outline of the sequence of activities required to enable the transition. A variety of different material types should include videos, StoryMaps, and printable outreach materials. Further details on the specific materials that should be considered for different audiences is included in Table 9.

Table 9. Outreach material details

Website material	Audience	Priority level	Existing materials to utilize?
Step-by-step guides and toolkits, specific to each building typology	Building owners Homeowners Property managers Contractors	High	No
List of qualified contractors	Building owners Homeowners Property managers Contractors Under-resourced	High	Xcel Energy has a list of contractors qualified to work on projects for rebates.
A step-by-step guide on making a building "electrification-ready" and the associated cost savings from efficiency	Building owners Homeowners Property managers Contractors Under-resourced	High	EOC materials
Detailed information on the resources available to support electrification (rebates, incentives, technical assistance, etc.)	Building owners Homeowners Property managers Contractors Under-resourced	High	Xcel Energy rebate and incentive materials
Denver contact person for questions and resources	General public	High	NA
References to published stories in newspaper outlets and neighborhood newsletters	Building owners Under-resourced households	Medium	No
Case studies of successful electrification transition projects, including links to Denver electrification pilot projects	Building owners Homeowners Property managers Contractors	Medium	No
Online example calculator that shows the potential costs and savings for electrification based on basic building data	Building owners Property managers Contractors	Medium	See example calculators from DOE
Videos that include tours and interviews with building owners and contractors from successful projects	Building owners Homeowners Property managers Contractors Under-resourced households	Low	No
Recordings of success stories on local radio stations	General public	Low	No

Materials should be presented in a way that ensures the reader understands electrification and why it is important. At a minimum, information should include details on:

- **Carbon reductions**: Discuss why decarbonization is necessary to achieve Denver's climate and building heating goals and visually demonstrate how building electrification supports building decarbonization.
- **Connection with other electric initiatives and goals**: Discuss the relationship between electrification, the greening of the electric grid, Denver's renewable energy goals, and the relationship between electrification and electric vehicles.
- **Technology primer**: Provide a frank discussion on the reliability, efficiency, and shortcomings of heat pumps. Discuss what users can expect today and what the next five and 10 years may look like for electric technology. Include a discussion of when/if backup heat might be necessary.
- **Benefits of electrification**: Discuss all the benefits that come with electrification beyond carbon reductions, spotlighting the ones that resonate most with Denver's community: safety, reliability, public health (especially impacts on children), efficiency, and cost.
  - Conversations with Denver's stakeholders have shown that messaging on health benefits is particularly important for outreach to the general public.
- **Best practices**: Provide best practices on the installation and maintenance processes, equipment recommendations, and efficiency ratings.
- **Electrification process**: Detail the sequence of activities that enable the transition from gas appliances to electric appliances, including from getting an initial energy audit to commissioning the system. Discuss where electrification fits into the broader decarbonization path and encourage consumers to consider energy efficiency and weatherization, renewable energy, and electric vehicles in tandem with building electrification.
- **Frequently Asked Questions (FAQs):**
  - Which end uses and which buildings are good candidates for electrification?
  - Which are the entities and organizations that will support electrification?
  - What exactly does building electrification mean?
  - What can I expect to happen when I electrify my home or building?
  - When should I consider replacing gas equipment with electric options?
  - Where can I go for technical assistance, resources, incentives, and rebates?
  - Why is electrification important for Denver's climate goals?
  - Why is it important for my home/building?
  - How do I electrify my building?
  - How will electrification result in costs or savings for me?

4. PROMOTE AND MARKET WEBSITE AND OUTREACH MATERIALS.

Promote the website and the outreach materials that it contains through Denver's networks and via existing programs. Existing Denver programs and activities that should be integrated include:

- Denver's Benchmarking Program**:** Include electrification messaging into Denver's Benchmarking Program scorecards and outreach, including a filter for all-electric buildings on the website. Information provided should include specific details on how electrification will impact a building's scorecard, costs and processes related to pursuing electrification, and resources (incentives, rebates, technical assistance, etc.) available to building owners.
- Green Buildings Ordinance**:** Work across departments in Denver to include electrification as an eligible project under the Green Buildings Ordinance.
- Denver's Building Department**:** Ensure that permitting information for electrification projects is easy to find, encourages electrification over gas equipment (to the degree possible), and the process of submitting a permit is straightforward for the user.
- Denver Urban Renewal Authority (DURA)'s Housing Rehabilitation program: Ensure that it is clear that eligible electrification projects qualify for support under DURA's program, and, if Denver is offering additional programs and incentives, link to those on DURA's website.
- Denver's Smart Leasing Program**:** Provide education on how electrification impacts building owners and tenants within the Smart Leasing Program outreach materials. This should include details on financing and leasing options available for electrification, the costs and benefits to tenants and building owners, and the resources (incentives, on-bill financing, technical assistance, etc.) available to tenants and building owners.

- Denver's Healthy Families and Healthy Homes Program**:** Incorporate checks for air quality issues and information about the health benefits of electrification in outreach materials and services associated with the Healthy Families Healthy Homes program. Specifically, information should be included within the residential health program and the childcare program.
  - Denver's Nonprofit Energy Efficiency Program: Ensure electrification resources and information are woven into services provided through Denver's Office of Nonprofit Engagement Nonprofit Energy Efficiency Program.
  - Denver's Sustainable Neighborhoods: Provide information on electrification, including available incentives and support programs, through Denver's Sustainable Neighborhoods program.
- Certifiably Green Denver: Ensure electrification materials are embedded within outreach materials and resources.

In addition to Denver's website, the Colorado Sierra Club, PSR, and the Colorado Energy Office are all supporting building electrification to some degree; where possible, Denver should cross-market its own electrification website through these channels and other relevant networks.

Denver also may consider utilizing earned and paid media to promote the electrification website. This might include:

EARNED MEDIA

- Articles in local papers, business journals, or public radio when the website launches Topics may include:
  - Profiles of early electrification pilot projects
  - Profiles of program successes, especially positive impacts on under-resourced community members, one year into the program

PAID MEDIA

- Commercials on local radio
- Direct mailers to households
- Advertisements on contractor and property manager incentives in business or trade journals
- Advertisements on homeowner and contractor incentives in local papers, including neighborhood newsletters
- Bus stop advertisements
- Paid content in local business journals highlighting successful pilot projects

PROGRAMS

1. LAUNCH DEMONSTRATION PROJECTS IN KEY NEIGHBORHOODS.

Develop open-sourced electrification pilot projects in building-ready and community-ready neighborhoods across different building typologies. These pilot programs can be an opportunity to build confidence and comfort with electrification among building professionals, increase resident awareness of electrification, and inform future city policies and programs.

Each pilot project should showcase the specific electrification technologies relevant for each building typology, challenges for each project and how those challenges were overcome, and resources (including incentives, rebates, and technical assistance) that are available to make projects financially feasible and logistically successful. Denver should consider the following pilot project ideas:

A. ***Equity-First electrification pilot project.*** Denver should implement "equity-first" pilot programs in priority communities, see section *Under-Resourced Neighborhoods*. This project could be at a community center, at a nonprofit organization providing services to under-resourced community members (such as a homeless shelter), in a multifamily affordable housing building, or in under-resourced residential homes. Denver would be the lead sponsor for this project and ideally Xcel Energy and relevant non-profit organizations would co-sponsor the project. By pursuing it in a multifamily apartment building or other commercial building, Denver may be able to illustrate the technologies and processes to overcome some of the financial and spatial barriers that exist with electrification in these settings, while also showcasing the impact that electrification has on improved quality of life in under-resourced communities. Stakeholders in Denver's Electrification Advisory Groups noted that an equity-first pilot project may be most impactful in the Montbello or Green Valley Ranch neighborhoods. Other neighborhoods that could be considered include Elyria-Swansea and Globeville.

B. ***Steam loop pilot project.*** This project would occur at one of the buildings that is on the existing steam loop in central Denver; in 2019 there were 122 downtown buildings heated with steam. Xcel recently increased the rates for steam customers by 36%, and there is interest among building owners on the steam loop to update their heating systems. As steam customers leave the loop, those remaining on it will continue to pay high costs associated with an increasingly stranded asset. Denver can co-sponsor a pilot project, along with interested commercial property owners and Xcel Energy, to illustrate the operational improvements and potential long-term cost savings associated with electrifying these buildings.

C. ***Denver-owned buildings pilot.*** This project would allow Denver to "lead by example" and showcase the processes involved in heat pump installation in a variety of building types and vintages. Denver can sponsor and lead this pilot project, with Xcel Energy acting as a co-sponsor.

D. ***Older buildings pilot project.*** Many older buildings have specific design elements and space constraints that add additional logistical and technical challenges to heat pump installations. By showcasing pilot projects in older buildings and homes, Denver can provide examples of ways to work around these challenges and illustrate specific types of electrification equipment, such as mini-split heat pumps, that may be particularly relevant in these settings. Denver could co-sponsor this pilot project in partnership with commercial building owners and Xcel Energy. Stakeholders in Denver's Electrification Advisory Groups noted that focusing some specific pilot projects on working with historically designated buildings may ensure that additional resources and information are available to support electrification in these types of properties.

E. ***Newer buildings pilot project.*** The type of building and its current appliances (e.g., air conditioning, etc.) can significantly impact the return on investment for electrification. Denver should showcase pilot projects in newer commercial buildings and homes, as these projects may illustrate greater cost savings for the building owners that Denver can capitalize on in its outreach and messaging. Denver could co-sponsor this pilot project in partnership with commercial building owners and Xcel Energy.

F. ***Restaurants pilot project.*** Switching to all-electric cooking appliances could fundamentally change the business model and economics for many restaurants in Denver. A pilot project that specifically focuses on introducing induction technology and propane flames within commercial kitchens may help to ease concerns and fears regarding the transition for restaurant business owners and may have the potential to create better and safer working conditions.

Denver should work to ensure that the website has a page specifically devoted to each pilot project that includes details on its development; video tours of the facility interviews with building owners, operators, and tenants; and information on where to go for further resources to implement a similar project. Additionally, data should be collected and shared regarding the impact of the electrification pilot projects on indoor air quality; this may help inform Denver's other work to ensure that energy programs include indoor air quality improvements in the metrics of programmatic success.

2. DEVELOP TECHNICAL ASSISTANCE PROGRAMS WITH TAILORED STRATEGIES TO SUPPORT SPECIFIC AUDIENCES.

This program would be designed as a municipal-led "one-stop-shop" community energy advising service. Denver should build a suite of energy advising programs available to all residents and businesses that will assist those considering energy upgrades. Consider integrating these programs into the building performance resource hub; electrification could be embedded within the larger advising program. The programs would be accessed through Denver's comprehensive website, managed by a team of energy advisors, and would provide services such as outreach and education, incentive and financing details, connections with the local workforce, etc. Where relevant, the programs should align with existing programs such as Xcel Energy's Home Energy Squad and energy assistance provided by EOC and other weatherization partners. The following lists potential aspects of this service. It should be noted that none of these aspects are mutually exclusive (i.e., Denver can and should consider implementing any number or combination of them).

A. ***Host a dedicated page on the electrification website with program details and resources.*** Refer to existing municipal one-stop-shop energy advisor models such as the state of Minnesota's Air Source Heat Pump Collaborative, the state of California's The Switch Is On, and the city of Boulder's Comfort 365. The BayRen Electrification program is also a leading example of a one-stop shop program that provides support for electrification in homes and multifamily buildings through upstream and downstream incentives, resources and educational materials, and cross-promotion with related programs for solar, electric vehicles, and financing.

B. ***Provide technical assistance and resources to support other building improvements that complement electrification.*** Building improvements may include tenant communications, mold/asbestos remediation, energy efficiency, capital planning, renewable energy deployment, electric vehicles, and building electrification. For example, the SunCommon program in Vermont provides additional incentives for heat pumps when a home installs a solar power system or increases the size of their current solar power system. A similar program in Denver would help to make progress toward Denver's renewable energy and building goals simultaneously. Another option may be developing a group purchasing program for heat pumps that helps buy down the cost of the technology for home and building owners while conducting targeted messaging, outreach, and education to inform people of this program; the HeatSmart Massachusetts program offers this benefit to building owners in the state.

C. ***Provide support services for emergency replacements.*** Providing support for temporary replacement heat in emergency situations to give the home or building owner time to install a heat pump without losing heat for an extended period of time may reduce the instance of emergency like-for-like replacements of gas technology.

D. ***Pre-qualify contractors for incentive-based programs.*** Similar to Xcel Energy's requirement to utilize pre-qualified contractors in its incentive programs, city-funded incentives should develop similar lists, according to municipal guidelines, and make the list available on the program website.

E. ***Provide dedicated contractor support for scoping projects and navigating incentives.*** Providing contractors with the tools and resources to sell and implement electrification projects will ensure that they are able to effectively sell a project, successfully install equipment, and easily navigate the incentive process related to electrification. If upstream rebates to distributors, contractors, and manufacturers are offered, assistance navigating these incentives through a dedicated electrification program advisor will be very valuable to contractors and help them to ensure that they – and their customers – benefit from the available resources. Further, an online tool or calculator that supports scoping and planning an electrification project (similar to the one found here) may help contractors more appropriately scope projects and communicate the financials to customers.

F. ***Develop an induction stove loaner program.*** Stakeholders indicated that having the opportunity to test out induction cooking technology may help community members become more comfortable with using this technology and investing in it for their homes and buildings.

3. CLEAN ENERGY WORKFORCE PROGRAMS

A. Develop and fund an educational program about climate careers in the electrification of buildings for high school students, and partner with high schools to implement programs in high schools serving people of color and under-resourced communities.

B. Work with and allocate ongoing city funding for local workforce partners, pre-apprenticeships, school districts/community colleges, and community-based organizations to create training opportunities and a long-term pipeline of work for electrifying existing buildings and homes.

C. Assess what institutions provide or can provide in terms of upskilling and training on new technology/certifications to existing and transitioning workforce regarding building electrification.

D. Provide property managers and contractors with scholarships or stipends for upskilling training or certifications.

E. Conduct targeted outreach to minority and women-owned enterprises.

POLICIES

1. DEVELOP AND ADOPT NEW CODE AND POLICY LANGUAGE AND REGULATIONS THAT ENCOURAGE AND, WHERE COST-EFFECTIVE, REQUIRE ELECTRIFICATION.

Denver should work with permitting and inspection staff to ensure that all teams are trained on the updated processes and requirements and understand and can communicate the resources available to building owners. Codes and policies might include performance paths and outcome-based compliance paths to ensure that systems perform as they are designed to; as much as is possible, regulations for existing building retrofits and equipment replacement should align with required code for new buildings.

2. ELEVATE EQUITABLE HOUSING THROUGH ELECTRIFICATION POLICIES AND PROGRAMS.

As electrification results in safer, more efficient, and more comfortable and desirable homes, Denver needs to consider the impact of electrification on access to affordable and equitable housing throughout Denver's communities. Denver should work with affordable housing and renter's rights organizations to incorporate anti-displacement language and renters' rights policies into the programs that are developed. Key Denver departments and agencies, such as the Department of Housing Stability, the Agency for Human Rights and Community Partnerships, and the Department of Economic Development and Opportunity, along with external partners such as DURA, Denver Housing Authority, and other affordable housing advocates and agencies should be consulted to ensure that the home- and neighborhood-level improvements that come from electrification investments do not result in the displacement or disenfranchisement of residents.

Many of the policies that will ensure protections for residents and renters are multifactorial policies that extend beyond electrification alone. Denver should consider expanding rental licensing ordinances to include energy efficiency and electrification requirements and resources (such as the city of Boulder's SmartRegs program and Sacramento's Rental Housing and Inspection Program) and updating just-cause eviction policies will support equitable housing, reduce the energy burden for under-resourced communities, and reduce resident displacement. Specific attention should be paid to any additional policies, programs, and incentives that will support equitable housing throughout Denver's most vulnerable neighborhoods.

3. SUPPORT AND ADVOCATE FOR STATE-LEVEL POLICIES AND REGULATIONS TO ADVANCE ELECTRIFICATION WHERE APPROPRIATE.

Outside of directly influencing and advancing electrification through its own policies, Denver should use its leverage as the largest city in Colorado to support and advocate for state-level policy change that will advance beneficial electrification across the state. This may include advocating for:

- Policies through the Public Utilities Commission or state legislation that require regulated utilities to establish programs to support beneficial electrification.
- Legislation that sets statewide goals and targets regarding the adoption of heat pumps and other electrification technologies. LD 1766 in Maine is an example of a model policy that sets a goal of 100,000 heat pumps installed in the state by 2025 and an updated goal of 245,000 homes (or 48% of the housing stock) to include heat pumps by 2020; the legislation sets standards for rebates and energy loans that will support this goal.[94]

94 For more information see: https://www.maine.gov/governor/mills/news/governor-mills-signs-bill-promoting-energy-efficient-heat-pumps-maine-2019-06-14.

- An environmental justice analysis to ensure that those that have been burdened the most by environmental issues are most likely to benefit from new programs and resources that are offered. Washington State's Climate Policy Package requires such an analysis prior to any funds from the Climate Policy fund being spent.[95]
- Utilize data from Denver's pilot projects to inform the "used and useful" parameters of the Public Utilities Commission's infrastructure investment review process. The PUC's current process does not necessarily account for future needs for grid improvements, specifically to distribution substations and final line transformer networks. Upgrades to this infrastructure may be needed in order to mitigate the grid impacts of increased electrification, and Denver's experience could prove useful and informative to the PUC.
- Utility rate structures to manage future gas system maintenance costs as the customer base changes. Ideas to reform gas rates may include seeking additional investment from new customers, accelerating the depreciation timelines for gas system assets, adopt flexible time-based allocation methods for shared costs, prioritize affordable bills for under-resourced households, adopt decoupling methods, and exploring performance based rate making.[96]

4. ENSURE QUICK PERMITTING FOR ELECTRIFICATION PROJECTS.

In collaboration with Denver's building department, work to update the permitting process for electrification projects to reduce the time associated with gathering these permits or otherwise provide non-monetary incentives for electrification. Additionally, Denver may consider adopting permit-related policies that account for the safety hazards of gas equipment, such as increased fees for gas equipment, or requiring a gas leak study or efficiency upgrades when installing gas infrastructure in order to offset the negative emissions and air quality effects of gas. Denver should review the permitting process associated with recent pilot projects for electrification in new construction and use lessons learned to develop a policy around permitting for electrification in new construction and retrofits. Additionally, Denver should provide standard guidance on system sizing and other technical assistance; this could be part of the technical assistance programs noted in the programs section.

5. FORMALLY INCORPORATE HOLISTIC COST-BENEFIT VALUATION INTO ENERGY PROGRAM DEVELOPMENT, PRIORITIZATION, AND POLICYMAKING.

Updated avoided-cost valuation should incorporate factors such as non-energy benefits (e.g., workforce development), carbon benefits (e.g., reduced emissions), and the social cost of carbon (e.g., improved air quality and health outcomes) into the measurement of success and value for energy programs. Currently these non-energy benefits are not included in energy program valuation, often resulting in continued investment in gas infrastructure due to, among other factors, lower gas prices, existing infrastructure to be replaced, and unfamiliarity with alternative technologies.

Denver will need to update the avoided-cost valuation within its own metrics and evaluation of energy programs and policies and work at the regional and state level to support similar updates within the measurement of outcomes and successes for weatherization programs and utility investments. Denver should collaborate with with environmental and public health organizations, community-based advocates, and state and regional agencies, to support these changes on the state and regional scale. Denver's work to support energy-plus-health programs and collaboration with public health partners and researchers in that effort will help to provide defensible data and research to support updated avoided-cost valuations.

95 For more information see: https://www.governor.wa.gov/news-media/inslee-announces-bold-climate-package-2021%E2%80%932023-biennium.

96 For more information see: https://www.raponline.org/knowledge-center/under-pressure-gas-utility-regulation-for-a-time-of-transition/.

FUNDING AND FINANCING

1. PROVIDE SUPPLEMENTAL INCENTIVES.

There are three main types of financial incentives for energy programs: upstream, downstream, and midstream.

- ***Upstream incentives are provided directly to manufacturers and distributors, often from electric utilities or efficiency program administrators.*** Upstream incentives provide wholesale price buy-downs to distributors, effectively reducing the price paid by these entities; these cost savings ideally will be passed on to the customer.
- ***Downstream incentives are provided directly to customers from the utility.*** Customers taking advantage of downstream incentives often receive them in the form of rebate checks.
- ***Midstream incentives, also sometimes referred to as "point-of-sale" incentives, provide an instant discount for customers at the time of the purchase of a product.*** These types of incentives are commonly used to provide lighting rebates to customers when they purchase highly efficient lighting from a retailer and also have been effective for consumer electronic products. Midstream incentives typically are provided by utilities and energy efficiency program administrators.

Upstream and midstream incentives are more effective than downstream incentives.[97] Midstream rebates are a simple way to reimburse the buyer. There is an instant return at the cash register, which alleviates the waiting game that can encumber buyers participating in downstream incentives.

Layering upstream, midstream, and downstream incentives from state-level policies and programs, local governments, and utilities has been shown to be the most effective at encouraging adoption of a desired technology or behavior[98] – they provide help along each step of the transition. Examples include:

- Infrastructure improvements: panel upgrades, wiring upgrades, ductwork improvement, etc.
- Highly efficient equipment defined as that which exceeds the federal minimum efficiency standards.
- Quality of life incentives to incentivize space cooling.
- Point-of-sale incentives for emergency replacements.
- Income-based incentives for both the residential and commercial sectors; incentives would be based on the income level of the tenant in rental properties. These incentives could be tied to anti-displacement requirements recommended under Policies above.

See Figure 21. The orange dots represent incentives where Denver would provide and/or support development, while the blue dots represent incentives that are already provided by other entities.

Incentive types and touchpoints may include the following:

- Incentives for non-equipment-related components of an electrification project.
- Develop upstream rebates for distributors with checks to ensure rebates are passed on to customers.
- Provide midstream rebates for induction stoves at the point of sale.
- Develop a comprehensive incentive program that integrates electrification readiness with equipment installs.
- Consider a pay-for-performance model for incentives paid to contractors.
- Develop technical certification and training programs for contractors, and tie incentives to this certification.
- Develop tiered incentive structures for upstream and downstream incentives based on equity needs.
- Develop "quality of life" incentives that encourage greater consumer adoption of electrification technologies, such as incentives for space cooling and improved indoor air quality.
- Collaborate with Xcel Energy and other program administrators to enhance existing downstream incentive programs in ways that will support electrification.

97 For information see: http://www.swenergy.org/data/sites/1/media/documents/publications/documents/Upstream_Utility_Incentive_Programs_05-2014.pdf.

98 Ibid.



Figure 20: Recommended incentive touchpoints

Examples of rebate programs that are targeted at under-resourced communities include the Silicon Valley Clean Energy program, which provides targeted rebates on heat pump water heaters for under-resourced single-family and multifamily households, including additional rebates for panel upgrades.[99] The Sacramento Municipal Utility District's Home Performance Program provides extensive rebates and financing to homeowners for electrification updates, including specific programs for under-resourced households.[100]

Early incentives targeting the "Enthusiasts" and "Visionaries" seen in Figure 20 may be most appropriate as downstream rebates for consumers, accompanied by a robust messaging and outreach program to educate these groups about the benefits of electrification.

Incentives that may be more effective in influencing the "Early Majority" and "Late Majority" might include distributors as well as training and certification programs for contractors installing the technology; this will ensure that consumers are being informed of the benefits of electrification at every touch point of the process of replacing their equipment.

"Skeptics" may be most impacted by both upstream and downstream incentives, as well as mandates that require electrification over time.

2. PARTNER WITH XCEL ENERGY TO EXPAND ITS AVAILABLE INCENTIVES.

Xcel Energy calculates cost-effectiveness using the Total Resource Cost (TRC) test developed per guidelines issued by the PUC. This test compares the total cost of incentives, administration costs, and customer contributions against the total avoided supply costs and non-resource impacts resulting from the program over the lifetime of the efficiency measure. Traditionally, this has been an insightful metric because it helps utilities focus on those measures that have the greatest potential to reduce energy use; utilities are required to reduce energy to demonstrate compliance with the state's demand side management (DSM) requirements.[101] Most often, non-energy benefits are not included in the TRC, leaving out many of the positive impacts of energy efficiency measures on households, businesses, and the wider community.[102]

99 For more information see: https://www.svcleanenergy.org/water-heating/.

100 For more information see: https://www.smud.org/en/Rebates-and-Savings-Tips/Improve-Home-Efficiency.

101 For more information see: https://www.xcelenergy.com/company/rates_and_regulations/filings/colorado_demand-side_management.

102 For more information see: https://www.veic.org/Media/default/documents/resources/manuals/energy-plus-health-playbook.pdf.

Currently, Colorado does not include public health, customer health and safety, social cost of carbon, or comfort in its cost-effectiveness test.[103] Integrating non-energy and non-monetary benefits into a revised TRC analysis or developing a new method of program evaluation that accounts for these non-energy and non-monetary benefits may lead to an expansion of incentive options. EOC utilizes a modified TRC (mTRC) for its income-qualified energy programs; this mTRC does account for overall community benefits and could be an example of how Xcel Energy can begin to account for these benefits. According to a Settlement Agreement between Xcel Energy, local cities, and program administrators, Xcel Energy intends to provide mTRC ratios at the product level that will include the social cost of carbon and lifetime emissions reduction for electric portfolio options.[104]

Denver should work to determine the advantages of performance-based and multifactor utility incentives and advocate for new and enhanced incentives from the utility that will encourage greater adoption of heat pumps. This could include midstream incentives provided to contractors and equipment installers, as well as upstream incentives for equipment distributors. Denver should encourage the consideration of separate incentives for ground-source and water-source heat pumps, and to develop incentives for businesses that are based on the building square footage, not business size. Denver also should work to address the distribution of incentives between landlords and tenants to avoid split-incentive issues in rental properties.

3. APPLY TARGETED UNIVERSALISM PRACTICES TO DESIGNING EQUITY-FIRST INCENTIVES.

Use targeted universalism practices – where a common goal is achieved by providing different programs and resources to communities based on their needs[105]– to develop additional incentive programs that address the specific needs of under-resourced communities. Denver is embarking on work with the Beneficial Electrification Institute (BEI) to determine what an equitable incentive program would look like for the Denver community.

By allowing for a collaborative process that is informed by community knowledge, Denver will be able to identify shared goals with the community and subsequently co-create programs that address community needs while also supporting Denver's climate goals. This may result in changes to financial incentive levels that are available based on the consumer's needs and income status, training programs that ensure that minority and women-owned businesses are able to benefit from the electrification transition, and programs that support bill payment for households that make the switch to electric and were previously supported through the Low-Income Home Energy Assistance Program (LIHEAP).[106]

4. REALLOCATE GAS EFFICIENCY FUNDS TO SUPPORT BUILDING ENVELOPE IMPROVEMENTS.

Advocate at the PUC and work with Xcel Energy to reallocate the funds that are used to support gas efficiency to be directed specifically toward building envelope improvements. Because heating equipment in buildings (including heat pumps and traditional gas furnaces) has a long life (generally at least 10 to 15 years), gas efficiency funds should be used to improve overall building efficiency, such that the building envelope is improved, the electric equipment that is installed may be downsized slightly, and peak heating demand is decreased. There may be a place for incentives for high-efficiency gas equipment in unique applications for which there is no electric equivalent, but the focus of incentive programs should be on improving the overall energy performance of buildings, beginning with envelope improvements.

5. DESIGN LOW-INTEREST FINANCING OPTIONS.

Denver should work with partners to make financing and credit options available to purchase heat pumps. Access to credit and capital to cover the up-front cost of a heat pump (or other equipment, such as an electric stove or dryer) is a significant barrier for many households and small businesses. Denver could develop a program, in collaboration with partners, to provide access to low- or no-interest financing to support electrification. This financing should be made available for covering the full cost of the project (i.e., including any panel upgrades, necessary duct work, etc., in addition to the electric equipment), and it should be made available to building owners regardless of credit score and history, utilizing a mechanism such as tariffed on-bill financing where the financing is attached to the electric meter. Denver also could partner with existing programs, such as DURA's Single-Family Rehabilitation and Emergency Home Repair programs.[107]

103 For more information see: https://www.nationalenergyscreeningproject.org/wp-content/uploads/2020/09/CO-Info-Factsheet-2.pdf.

104 For more information see: https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Regulatory%20Filings/CO%20Recent%20Filings/20AL-0412E_AL-1834_DSMCA-E_Legal_Notice_2020.pdf.

105 For more information see: https://belonging.berkeley.edu/targeteduniversalism.

106 Based on conversations with staff at the Beneficial Electrification Institute.

107 For information see: https://renewdenver.org/dura-offers-grants-and-loans-for-denver-residents-to-upgrade-their-homes/.

Stakeholders who were engaged throughout this process also identified first-cost assistance programs as a crucial tool that Denver could add to its toolbox to make electrification more accessible to under-resourced households and communities. Stakeholders also expressed support for the idea of a neighborhood-level grant program that could ensure that funds and resources for electrification are available to high-need communities.

6. SUPPORT PRIVATE INNOVATION THAT ADVANCES ELECTRIFICATION.

This is a broad recommendation that can be implemented in a number of ways. Each approach will provide benefits to Denver and its community, and it should be noted that Denver will maximize its impact by implementing as many of these approaches as possible. These potential programs are listed in order of priority for Denver.

A. ***Support programs that allow for building owners to lease or rent electrification equipment.*** There is a significant upfront cost associated with electrifying a building, and this cost can present a barrier for many consumers that do not have capital on-hand or cannot acquire financing to invest in electrification. Programs that allow for the leasing or renting of heat pumps have been effective in other communities at providing a stable and reliable form of heat at low monthly cost. The City of St. John, New Brunswick (Canada), operates a heat pump rental program through St. John Energy that rents heat pumps to customers at a rate of $50.22/month; it should be noted that this monthly cost is much lower than the likely monthly payment on a loan to purchase a heat pump outright. This program may be particularly relevant to support electrification in under-resourced communities.

B. ***Work with businesses to develop third-party ownership models of heat pumps and electrification technologies.*** BlocPower, a Brooklyn-based startup, has pioneered the use of a power-purchase agreement type of model for heat pumps in multifamily housing that has improved the quality of life for residents and provided reliable service and lower costs for building owners. MEETS offers another model for third-party ownership relationships for energy efficiency. Should the utility fund or manage a third-party ownership program for heat pumps, this may also allow for greater demand management of the electricity grid.

C. ***Advocate for building owners to utilize other financing tools that are available.*** Colorado's Property Assessed Clean Energy (C-PACE) program and the Colorado Clean Energy Fund may be effective financing tools for larger projects in commercial and multifamily buildings. Denver should ensure that building owners are aware of these programs, understand how to navigate them, and see that successful projects financed using these tools are made into case studies that ensure others can benefit from these financing tools, as well.

D. ***Advance the use of ground-source and water-source heat pumps where they can be used.*** Geothermal, or ground-source heat pumps, can come with a much higher price tag in individual building applications due to the additional requirement of drilling geothermal wells; however, this equipment is often more efficient and has a longer lifespan than air-source heat pumps. There may be opportunity to re-utilize existing oil and gas wells and equipment to generate geothermal heat for larger commercial buildings or district-scale applications.

7. PHASE IN DIFFERENT INCENTIVE LEVELS AND TYPES.

Denver should incentivize electrification in a phased approach. This could start with incentivizing buildings that have a tighter building envelope and are more efficient, helping mitigate grid impacts from increased demand while still providing an incentive program that is applicable to roughly half of Denver's building stock. The initial phase of incentives also should focus on incentivizing systems that were utilized in the project team's building stock analysis, as those systems have been vetted for Denver's climate and building conditions. The initial phase of incentives also must target the gas equipment that is most commonly installed in Denver based on the building stock analysis; this will result in the greatest number of beneficiaries of the incentives.

In the beginning of Phase 1 (starting in the year 2025) Denver should reassess the available technology and effectiveness of the first phase of incentives to determine opportunities to revise the program. As technologies evolve and equipment design improves, assumptions for equipment efficiency and capacity can be updated; non-energy related cost assumptions may need updates as well. It is possible that technologies will improve to the point that some of the grid impact mitigation strategies within the first phase of incentives can be removed, and a revised incentive program can be more widely available to all types of buildings in Denver.



8. ADVOCATE FORTHE INTEGRATION OF SPACE HEATING AS A SERVICE AND TARIFFED ON-BILL FINANCING INTO XCEL'S ENERGY OFFERINGS.

Space heating as a service would allow Xcel Energy to own and operate the heat pumps inside Denver's homes and buildings; for the owners of the buildings and homes, this would reduce the upfront cost of the equipment, reduce maintenance requirements, provide a reliable form of heat within buildings, and provide Xcel Energy with an additional revenue stream and an opportunity to use heat pumps as a demand management tool for grid management.

A tariffed on-bill financing program would allow all utility customers to access capital from the utility to pay for building efficiency upgrades, including electrification projects. The customer pays back the investment through regular payments on their existing utility bill. The financing is tied to the energy meter rather than the customer; therefore, when a customer moves the repayment obligation transfers to the new customer associated with the meter. Because the financing is tied to the meter, this also means that credit checks are generally not required to access financing, and, in rental properties, the association of the debt obligation with the meter rather than the landlord can help to remediate the split-incentive issue, where landlords are reluctant to invest in property improvements when they will not directly benefit.

9. FOCUS INCENTIVES ON HIGHER-EFFICIENCY SYSTEMS.

The demands on the electric grid that will come from high electrification adoption rates need to be considered in tandem with Denver's electrification transition timeline. By incentivizing higher-efficiency systems, Denver can help to mitigate the initial grid impacts of this transition. Incentives should specifically target heat pumps that are above the federal minimum efficiency standards; these systems are widely available, perform well in cold climates, and are lower in cost than cold-climate heat pumps and other higher-performing options. Currently, Xcel Energy offers rebates for heat pumps that meet high-efficiency requirements; Denver could consider layering additional rebates on top of those already available for even higher-efficiency equipment.

Given the anticipated carbon savings over the lifecycle of equipment, efficient electrification can be pursued immediately when replacing equipment and result in climate benefits.



CONCLUSION

Building electrification is central to Denver's decarbonization goals. We have learned that a managed transition will yield cost parity in the short term and stabilize long-term energy costs for Denver's residents and businesses. Cleaner fuel means cleaner outdoor and indoor air, which improves public health. Building electrification benefits our under-resourced community members by modernizing infrastructure, providing cooling, and improving public health – all of which contribute to improved quality of life. We can successfully transition to a high electrification adoption rate without significantly impacting the electric grid's generation or distribution. As we implement, we will align with Denver's green jobs strategy to ensure that quality jobs will grow and develop alongside electrification.

The conversion playbooks and implementation strategy detail how Denver can lead and be an active participant in the transition. The outcomes of a successful transition will reduce carbon emissions and improve quality of life for all of Denver's residents and businesses.

Denver can meet its climate and electrification goals with decisive action in the short term.

Our plan lays out a solid implementation framework for the next five to seven years based on what we know to be true today. It does not predict what technological advancements might occur, how utility rates may change, or how the market might respond. This transition is expected to be dynamic, and implementation details will evolve as the market changes.

Denver will lead and be an active collaborator with its partners in public health, affordable housing, equipment distribution, community mobilization, policy, workforce, environmental justice, and Xcel Energy. These continued partnerships will ensure that we all move forward together, meeting shared values and goals for a renewable heating and cooling future.

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