Equitable & Effective Climate Change Mitigation:

Policy Analysis in the City and County of Denver, Colorado

Rani Murali and Emily Kent

Policy Analysis Exercise (PAE)
April 2021

HARVARD Kennedy School
JOHN F. KENNEDY SCHOOL OF GOVERNMENT

Prepared by:
Rani Murali and Emily Kent, Master in Public Policy Candidates, Harvard Kennedy School
(Expected Graduation: May 2021)

Client:
City and County of Denver, Office of Climate Action, Sustainability & Resiliency (CASR)

Client Contacts:
Liz Babcock, Manager of Climate Action, and Jonny Rogers, Renewable Energy Specialist

Faculty Adviser:
Joe Aldy, Professor of the Practice of Public Policy

Seminar Leaders:
Chris Avery, Roy E. Larsen Professor of Public Policy, and Julie Wilson, Harry S. Kahn Senior Lecturer in Social Policy

Cover Photo Source: Lonely Planet

Acknowledgements

We would like to thank our clients at CASR, Liz Babcock and Jonny Rogers; our Harvard Kennedy School (HKS) faculty advisor, Professor Joe Aldy; our HKS PAE seminar leaders, Professors Chris Avery and Julie Wilson; our data visualization professor, Hong Qu; our many expert interviewees both internal and external to CASR; and our families, friends, and classmates. This PAE has been the product of significant and meaningful input from many sources, and we have been extremely appreciative of the willingness to engage with us on such challenging and important questions related to climate change and equity policies.

Table of Contents

Executive Summary

Given the scale of climate change and the solutions required to address it, subnational governments have become key players. Urban areas in particular often have the highest emissions of greenhouse gases (GHGs), so localized climate efforts can have a significant impact. Urban areas also often function at the community-level, making equity concerns more tangible. Centering communities in urban climate action makes it more natural to address equity hand-in-hand with climate goals.

Background: Urban climate leader, ambitious climate & equity goals

The City and County of Denver, Colorado *(referred to as "Denver'' going forward)* has been a progressive leader in climate action for many years. This Policy Analysis Exercise (PAE) is the result of a year-long collaboration with our clients at Denver's Office of Climate Action, Sustainability & Resiliency (CASR), who are responsible for creating and implementing climate change policies for Denver.

CASR has been working towards ambitious climate goals at both the city and state-levels, and despite real progress, there is significant work to be done to meet the planned targets over the next few decades. This work will be cross-sectoral and interdisciplinary.

In addition to planned climate goals, Denver — like many cities in the United States — struggles with adequately addressing the impacts and causes of ongoing racism and environmental injustice. A focus on equity has emerged at the city-level in recent years, and CASR is committed to ensuring that their policies and programs promote equity as well as progress towards climate goals.

The Problem: New funding and the need to spend it efficiently

In November 2020, the residents of Denver passed a ballot measure increasing the sales tax by 0.25 percent to support climate change efforts (managed by CASR). This new sales tax revenue is expected to provide CASR with an additional $30-40 million in funding each year for climate programs. The ballot measure did not specify how the new tax revenue must be spent to achieve climate goals, but it did explicitly note that 50 percent of the new climate funding must simultaneously improve equity in Denver. This stipulation is in line with many current efforts at the subnational- and federal-level in the United States: to use relevant government funding (particularly in the climate and energy spaces) to focus on equity as a key stated goal rather than merely a co-benefit, and to use newly available resources to intentionally rectify past harms.

Since this successful ballot measure constitutes such a drastic infusion of funding for their programs, CASR has to quickly begin planning for a large expansion of their programs — including planning for how to make decisions on what should be funded. However, since their prior work was on a much smaller scale, CASR lacks a formal process to evaluate programs and allocate resources at such a large scale.

Through this PAE, we aim to help CASR address the following problem:

CASR needs a consistent, formalized process for evaluating potential programs and allocating resources, which would then enable them to prioritize new funding to maximize both climate impact (through GHG emission reductions) and community-wide equity.

Focus Area: Developing a flexible, standardized analysis approach

As a natural result of the problem we identified, we decided to focus our efforts on building a flexible, customizable funding screening tool. This tool is intended to support CASR's long-term decision-making processes, rather than analyzing a static set of current programs of interest. We focus on two key program metrics based on CASR's needs and priorities: (1) GHG emission reductions, and (2) equity impact. Finally, as we narrowed our scope, we identified a key goal: to create a tool that provides CASR with a standardized approach for analyzing program impact across their very diverse teams, sectors, and programs to ensure universality and broad applicability.

Screening Tool and Recommendations: Our two-pronged approach

Our screening tool provides CASR with a standardized approach through two prongs: GHG Policy Lever Modeling and a Climate Equity Framework. Our **GHG Policy Lever Modeling** aims to provide CASR with a flexible, user-input-driven calculator that analyzes the quantitative GHG emission reduction impact of different types of policies in the Transport, Buildings, and Energy sectors. The GHG analysis projects emission reductions through 2050. Our **Climate Equity Framework** consists of a five-step process that merges key quantitative and qualitative analyses. The quantitative steps are focused on detailed mapping of Denver to analyze distributional justice, while the qualitative steps review whether policies prioritize recognitional and procedural justice.

As a result of our research and analysis, we recommend the following for CASR:

1 Standardize Program Evaluation

Use our screening tool to compare program impact consistently and transparently, and allocate funding resources accordingly.

2 Consider Policy Portfolios

Consider the overall impact of a policy portfolio, rather than from an individual policy.

3 Balance Tradeoffs to Meet Goals

Balance tradeoffs between impact metrics based on which are most important to maximize to meet CASR's goals.

4 Implement "Win-Win" Programs

Implement high climate and equity impact programs to guarantee short-term progress.

Conclusion: Transparent, consistent climate and justice integration

Every level of the United States government is currently working to address the intersection of climate change and equity priorities, with no perfect solution for balancing these key needs. Given this context, Denver has the opportunity to further establish itself as a leader in this space by integrating climate and justice efforts through a concrete, actionable approach that merges key quantitative and qualitative analyses. Through this approach, it becomes clear that tradeoffs need to be made using a consistent methodology that is flexible enough to handle diverse programs and policy types and transparent enough to help build community trust in programs.

Introduction

This section will discuss the background of our client's situation, the question and problem that we aimed to answer and resolve, and why this particular problem is so important. The rest of this report will then address our high-level research process, present particularly relevant case studies, describe our results though a two-pronged screening tool, discuss findings and recommendations from this work, and conclude with final thoughts for our clients and other interested parties.

Background

The City and County of Denver, Colorado *(referred to as "Denver" going forward)* is the capital and largest city in the state of Colorado, and it is the 19th largest city in the United States (U.S.). It is located in the Mountain West of the U.S. and has a land area of approximately 153 square miles. Denver's population was estimated at 727,211 people in 2019, and it is rapidly growing. The population is over 75 percent White and has an overall poverty rate between 10 and 15 percent.[1]

The City's Office of Climate Action, Sustainability & Resiliency (CASR) was created in 2019 by Denver Mayor Michael Hancock to elevate climate change, sustainability, and resilience efforts. According to CASR, their goals and responsibilities are as follows:

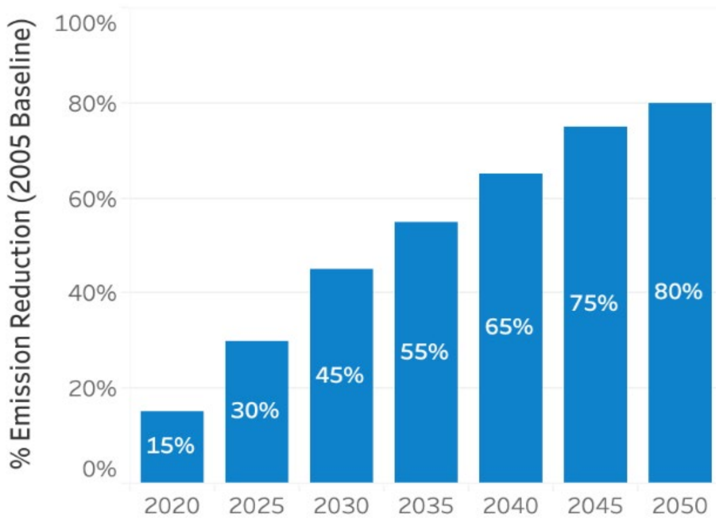
> *"...to manage the City's ambitious emission reduction goals and sustainability programs in collaboration with fellow departments, other units of government, and community partners. The office ensures that the City's targets are aligned with current climate science, promotes the role that climate action and sustainability play in strengthening Denver's economic vitality and a prosperous future for all residents and businesses, and embraces equity as a value and practice in all of its work."*[2]

Figure 1 shows Denver's emission reduction goals, as outlined in their *80x50 Climate Action Plan* developed in 2018.[3] CASR also tracks state-level policies to ensure Denver is compliant and leading the state in climate efforts. In particular, House Bill 1261, which was signed into law in 2019, set ambitious climate goals of reducing state-level greenhouse gas (GHG) emissions by at least 26 percent by 2025, 50 percent by 2030, and 90 percent by 2050 (relative to 2005 statewide GHG levels).[4] The state is currently developing a "GHG Pollution Reduction Roadmap" to detail the action steps needed to meet these ambitious goals.

---

[1] U.S. Census Bureau, "U.S. Census Bureau QuickFacts."
[2] Denver Office of Climate Action, Sustainability, and Resiliency, "About Our Office."
[3] Denver Department of Public Health and Environment, "Denver 80x50 Climate Action Plan."
[4] Colorado General Assembly, "HB19-1261 Climate Action Plan To Reduce Pollution."

Figure 1. Denver's 80x50 Climate Action Plan Citywide Emissions Reduction Goals



Denver plays a key role in this process by helping the state meet its goals and leading by example in the space of climate change and policy innovation. The City tracks and manages environmental and climate impacts from the government itself as well as the entire Denver community, covering areas such as their GHG emissions, air quality, health, land use, and mobility. Denver's GHG emissions were about 11.5 million metric tons of carbon dioxide equivalent (million mt CO_2e) in 2018, making up just under 10 percent of the total GHG emissions from the state of Colorado.[5] The City ranked 7th out of 100 cities scored by the American Council for an Energy-Efficiency Economy (ACEEE) on their "efforts to achieve a clean energy future by improving energy efficiency and scaling up renewable energy."[6]

On November 3, 2020, Denver voters approved Measure 2A, which increased the city's sales tax rate by 0.25 percent to fund climate-related programs and programs designed to reduce GHG emissions and air pollution and adapt to climate change. The new sales tax increase is expected to generate an additional $30-40 million per year for direct use by CASR, allowing for a significant budget increase for them to run their climate action programs. The specific ballot language indicates that "this dedicated funding should maximize investments in communities of color, under resourced communities, and communities most vulnerable to climate change and endeavor to invest 50% of the dedicated funds directly in communities with a strong lens toward equity and race and social justice."[7]

[5] City and County of Denver / Office of Climate Action, Sustainability, and Resiliency (CASR), "Denver Open Data Catalog: Greenhouse Gas Inventories"; Colorado Department of Public Health & Environment, "Colorado Greenhouse Gas Reports."
[6] ACEEE: American Council for an Energy-Efficient Economy, "The City Clean Energy Scorecard."
[7] City and County of Denver, "Ballot Measure 2A: Climate Funding."

The Problem

As CASR balances these ambitious state- and city-level climate change goals along with their substantial new source of funding, they need to be strategic in how they design and implement climate policies. In particular, equity is a key area of concern for CASR, because Denver, like most cities in the U.S., faces challenges of systemic racism and environmental injustices. Existing climate policies, including the new sales tax increase, could be regressive, which only underscores the importance of ensuring that CASR is being intentional with its use of funding to ensure equitable outcomes.

Denver (and city governments more broadly) has struggled to adequately address the impacts of their climate policies on low-income communities and communities of color. Racial inequality and other forms of inequities have the potential to be either exacerbated or alleviated through city climate efforts. The feedback that Denver has received from its communities, their advisory council, and the broader climate field has been that they need to be more actively focused on alleviating historical harms and promoting equity directly through their work. In an article from the Colorado Sun, Denver Councilman Jolon Clark is quoted saying: "stipulations [in Measure 2A] are designed to ensure lower income and marginalized communities receive more benefits from the tax than they pay into it. But critics say the city hasn't provided enough details on how it would implement its strategies."[8] The City of Denver and CASR need a transparent and consistent framework to ensure the benefits of proposed programs are effectively targeting these communities.

Climate change impacts may also disproportionately harm low-income communities. According to an article in Yale Climate Connections, key groups are impacted differently by climate change, and climate impacts can exacerbate existing inequities.[9] For example, many low-income households struggle with high energy burden (the percent of income that is spent on household energy costs), and this issue is likely to worsen in areas where heating or cooling needs become more severe due to climate change.[10] Targeted climate mitigation efforts, such as weatherizing homes for low-income households to better insulate them against the changing climate, can help to remedy some of these disproportionate harms.

PROBLEM STATEMENT

These concerns lead to the key problem that we aim to address through this PAE, which is that CASR **lacks a systematic approach** for prioritizing how to best spend the Measure 2A funding to both:

- maximize GHG emission reductions, and
- improve community-wide equity.

[8] Ochsner, "Denver's Unique Sales Tax to Fight Climate Change Could Be a Blueprint for Future Action Nationwide."
[9] Simmons, "What Is 'Climate Justice'?"
[10] "Low-Income Energy Affordability Data (LEAD) Tool."

GHG emission reductions occur across multiple sectors, most commonly in Denver from energy, buildings, and transportation, and there are specific policymakers for each of these sectors who design and implement their own sets of policies. Greenhouse gas reduction policies can have co-benefits, but they can also have negative side effects – like regressivity through increased electricity prices, for example – that need to be examined. We analyzed the existing and potential climate mitigation policy options for these three key sectors through a variety of research methodologies, described in detail later in this PAE, to determine recommendations for how Denver's government can couple their GHG emission reduction policies with equitable outcomes for their residents.

CASR will soon begin receiving significant requests and proposals for ways to spend their new 2A funding from other city-level government agencies and the general public. They currently do not have a universal process established to evaluate this newly expanded set of requests that can help them allocate funding effectively and enable transparency in funding initiatives and outcomes for the community.

Making this all the more challenging is the fact that this balance between equity and efficiency for GHG mitigation is being worked on at every level of government right now, and no one has found the perfect solution. Ensuring that equity is incorporated into climate change policies is extremely important to many stakeholders – particularly the Biden Administration – but even the Federal government has struggled to pull together a plan to implement these ambitious goals. Similar to the Denver sales tax language, the Biden Administration recently committed that a large portion of clean energy and climate change funding will go towards investing in historically marginalized environmental justice communities, but as of this report, they do not have a set framework or institutionalized plan for ensuring that those investments are appropriately targeted.

Key Focus Area

As a solution to this problem, and based on our research of this issue and conversations with our clients at CASR, we chose to focus our PAE on building a screening tool to help CASR evaluate funding requests and climate policies on the basis of GHG reduction potential and the ability to improve community-wide equity. Our objective is that this tool will provide them with a consistent framework for understanding the impacts of potential policies and best allocating their limited (though recently expanded) resources. We chose to build a flexible, customizable screening tool rather than conducting a static analysis in order to improve CASR's capacity to evaluate and compare potential programs.

We focused this PAE specifically on GHG reduction potential and equity potential (rather than other important metrics such as economic impact) due to specific prioritizations from our clients and advisors on which metrics would be most relevant to Denver and where analysis was most needed. We also prioritized specific sector and program types to focus our attention on the policies with the highest potential for success and the highest likelihood of being implemented by CASR. These scoping decisions are documented throughout the PAE.

Since this problem has yet to be addressed at local, state, or federal levels, we plan to bring these questions of climate effectiveness and equity together to evaluate policies based on both metrics and create a screening tool that accurately portrays the tradeoffs inherent in this type of policy work. Given the enormous scope of CASR's work, they do not always have the internal capacity or resources for a comprehensive, intentional analysis of all proposed policy options across their teams, which is a gap we aim to fill with our tool. Our intention is for our clients at CASR to use our tool and PAE recommendations to inform new program development, particularly in regard to allocating 2A funding. Ideally, our work will also help start conversations around reforming or replacing existing programs to ensure that they maximize climate progress and equity and accelerate tangible action towards Denver's goals.

Defining Equity and Justice

Throughout this PAE, we discuss the equity impacts of climate policies, as well as the need for Denver's climate funding to appropriately and adequately incorporate equity. This section provides background on these concepts, including definitions for relevant justice movements. In particular, Table 1 (below) defines environmental justice, energy justice, climate justice, and climate equity. Each of these justice-oriented fields are relevant to the work of this PAE and Denver's climate efforts, and they are defined to help frame the current conversations around climate and justice, as well as to briefly describe the evolution of these movements over time.

Table 1. Defining Key Equity and Justice Terms

ENVIRONMENTAL JUSTICE Environmental justice is a long-standing, historical movement focused on remedying the disproportionate environmental burdens placed on certain communities, which predates climate and energy justice (defined below). Environmental injustices have typically been in the form of air, water, or land pollution (or environmental degradation), primarily in communities of color and lower-income communities. Environmental justice expert David Schlossberg takes a helpful and comprehensive approach to defining environmental justice with four components: distribution, recognition, participation, and capabilities (described in more detail below).[11]
CLIMATE JUSTICE Climate justice was born out of the environmental justice, racial equity, and climate change activism movements. It is particularly concerned with the uneven distribution of both costs of climate change and benefits of climate solutions. An article in Yale Climate Connections explains that the movement of climate justice "acknowledges climate change can have differing social, economic, public health, and other adverse impacts on underprivileged populations."[12] Climate justice aims to address those differing impacts and target benefits to those most negatively impacted by climate change.

[11] Schlosberg, *Defining Environmental Justice*.
[12] Simmons, "What Is 'Climate Justice'?"

ENERGY JUSTICE

According to the Initiative for Energy Justice, "[e]nergy justice refers to the goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on marginalized communities. Energy justice explicitly centers the concerns of frontline communities and aims to make energy more accessible, affordable, clean, and democratically managed for all communities."[13]

CLIMATE EQUITY

Brandeis University defines equity as "The notion of being fair and impartial as an individual engages with an organization or system, particularly systems of grievance." They go on to explain that equity is often conflated with equality, and "true equity implies that an individual may need to experience or receive something different (not equal) in order to maintain fairness and access."[14]

In the context of climate equity specifically, being fair and impartial generally means that people or communities that have been underserved, disinvested in, or have borne disproportionate harms (environmental or otherwise) may need additional or differential investment and prioritization in receiving the benefits of climate policies and addressing these harms.

Despite not being the main focus of this PAE's analysis, the ongoing environmental justice movement has been the precursor and historical basis for many current climate justice and climate equity efforts. To help define these terms further, it is useful to briefly expand on the definition for environmental justice mentioned in Table 1 above with the following categories:

- ➔ **Distributional** justice focuses on the distribution of both goods and harms in a society.
- ➔ **Recognitional** justice is the idea that both individual and community recognition are key elements of attaining justice.
- ➔ **Participatory (or procedural)** justice emphasizes the need for broad procedural involvement of all individuals and groups in processes that involve decision-making.
- ➔ **Capabilities** justice is the idea that certain individual and group capacities and abilities are needed for communities to function at their full potential.[15]

These components are often applied to other fields of justice as well. Equity and justice efforts can be effective across this entire spectrum, and ideally, they often need to occur across all four categories. While each of these individual components are relevant to our framework, our work is focused on distributional and participatory justice for their applicability to CASR's processes and needs.

---

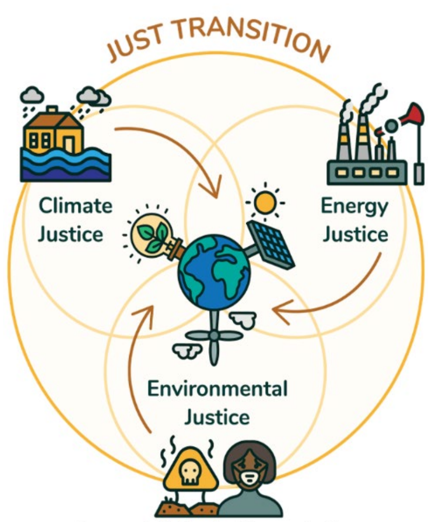
[13] Baker, DeVar, and Prakash, "The Energy Justice Workbook," 5.
[14] Brandeis University, "Our Social Justice Definitions."
[15] Schlosberg, *Defining Environmental Justice*, 8.

The rest of this PAE will focus on what climate equity (as defined in the table above) means for CASR. In particular, it will analyze the equity impacts of Denver's climate policies. It is important to note that these terms, and equity in particular, are used by many different movements and can mean multiple things to different audiences. Climate equity, as used in this PAE, is the idea of targeting and focusing climate program benefits specifically in communities that fall lower on various equity metrics.

Our analysis explores equity impacts in terms of these specific efforts for climate policies to center and benefit individuals and communities that have been underserved and disadvantaged by historical and existing policies and systems. Specific metrics for analyzing equity impact will be described later in this PAE (see the Climate Equity Framework section), but as a brief example, metrics that are frequently highlighted for equity are income and racial demographics. To us, climate equity means recognizing that the costs of climate change – including any costs of potential solutions – are not evenly distributed. Thus, the benefits of climate solutions should be targeted specifically to be at a minimum distributed evenly, and ideally, distributed to communities with more significant burdens (i.e., climate, environmental, or otherwise systemic).

Finally, it is worth noting that the fields of justice defined above are intricately connected, most notably through current efforts on the Just Transition. The quote and image below, both from the Initiative for Energy Justice, explain this interconnected relationship.

> *"The complex lived experiences of marginalized communities reveal an interconnectedness among environmental, climate, and energy justice… Those involved in the movement for the transition away from fossil fuels to renewable energy often frame energy justice, energy equity, and energy democracy as a part of a broader "just transition" to a low-carbon regenerative economy that will remedy the injustices of the fossil-fuel energy system and extractive economy across multiple sectors."*[16]



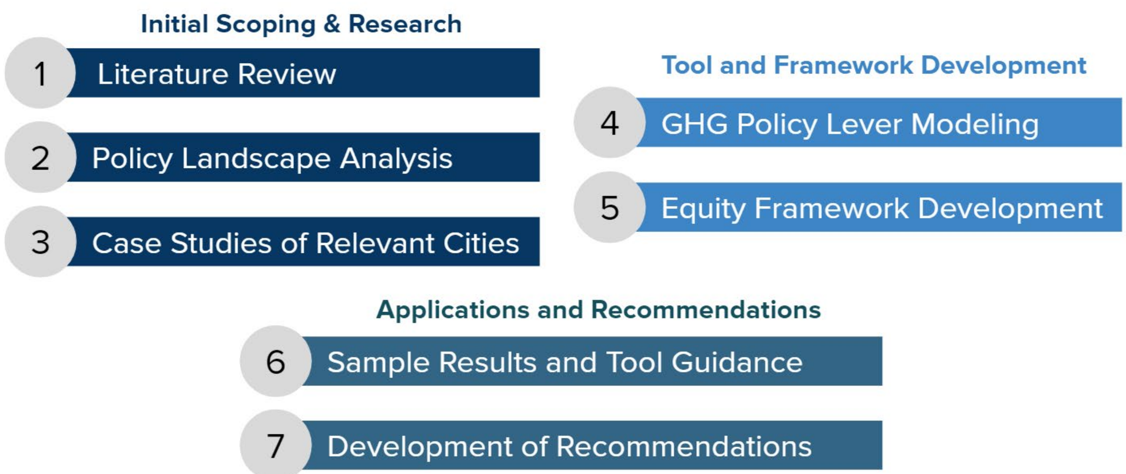
Source: Initiative for Energy Justice

[16] Baker, DeVar, and Prakash, "The Energy Justice Workbook," 5.

Research Process and Methods

This section describes our methodologies for the individual process elements of this PAE (shown in Figure 2 below). More detailed methodologies are available in the appendices for some of the more complex sections of this work, specifically the GHG policy lever modeling. Below are brief descriptions of the key elements of the research process. The methods are listed in intentional order, as the results of each component of the research process informed the subsequent steps.

Figure 2. High-Level Steps of PAE Methodology



High-Level Research Steps

Literature Review

We began our analysis with a literature review of how cities and states are approaching the intersection of climate and equity priorities. Many cities are looking at this issue in unique and innovative ways, but none have developed a method for systematically incorporating both GHG and equity impact analyses in funding decisions and program evaluation. As our literature review led directly to our case study analysis, please see the case study section below for more details on the efforts of other U.S. cities in this space. Our literature review also included a number of useful interviews with subject-matter experts which helped us understand the problem we were addressing and the many different ways that organizations are considering potential solutions. This included interviews with individuals from academia, public utility companies, local non-profit organizations, etc. Our takeaways from these interviews directly informed our design of the screening tool. Details on interviewees can be found in Appendix A.

Policy Landscape Analysis

Through a comprehensive landscape analysis of our clients' programs and administrative processes, we determined that no formalized process for incorporating equity currently exists in CASR programs. This includes both ex-ante program development and prioritization processes as well as any ex-post monitoring and evaluation processes. In addition to understanding the ways in which equity is incorporated into CASR's work, we also used the landscape analysis to gain an understanding of all of CASR's current and proposed climate programs and worked with our clients to identify high priority program types to examine further. Finally, we used this analysis to better understand CASR's existing structures for evaluating GHG emission reduction impact of their programs, which occurs mostly on an ad-hoc, project-by-project basis.

Case Studies

A direct follow-on from our literature review, the case studies we pursued allowed us to examine how other cities are handling the intersection of climate and equity goals. While no other city has exactly solved the problem that Denver is facing, we found that many cities are addressing pieces of the problem in new and interesting ways. The case studies allowed us to dig deeper into these partial solutions, identifying key lessons learned and their applicability to Denver's situation.

GHG Policy Lever Modeling

The GHG policy lever modeling involved building a Microsoft Excel-based tool to project the anticipated emission reductions that would result under various policy scenarios. We developed the tool using sample program types from three key sectors: Energy, Transportation, and Buildings. It estimates the GHG reduction potential of these programs, using Denver's 2019 GHG Inventory (which was provided by our clients) as a baseline for projections and framework for calculations.

Equity Framework Development

Following the GHG impact analysis, we designed the equity framework as a tool to guide the determination of policies and programs that prioritize and incorporate equity considerations (whether they are directly equity-focused, or whether they are primarily climate-focused and equity is a co-benefit). It includes a step-by-step process (including identifying potentially relevant data sources) and a set of considerations based on our detailed equity research and case studies. The framework is designed to analyze the same set of policies as the GHG policy lever modeling in order to quantify the associated equity impacts alongside GHG reduction potential.

Sample Results and Applications of the Screening Tool

The final result of our research is a policy and funding screening tool that combines our GHG policy lever modeling with our equity framework. This approach and its results will be discussed in more detail in later sections. We applied the screening tool for our selected sample program types, producing a range of key outcomes that encompass the programs' GHG and equity impacts. These sample results are illustrative of the types of outcomes produced by our two-pronged approach. The key goal of producing these outcomes is to enable consistent evaluations of different programs against each other. We also outline detailed guidance for how CASR can apply this tool for all future funding proposals, incorporating best practices and lessons learned from our background research and case studies.

Developing Recommendations

Finally, after completing our research and analysis, we prepared a set of recommendations for how CASR can best use our work to support their climate and equity efforts. This includes information on how to use the screening tool itself, as well as key considerations to keep in mind when using our GHG modeling and equity framework to evaluate funding proposals.

Case Studies

This section provides an overview of our case studies, including a high-level summary and key takeaways. To narrow down the case study cities that we reviewed, we used our comprehensive literature review as well as expert interviews and information gathered from attending multiple relevant lectures and webinars (such as a virtual event by the Massachusetts Audubon Society with Joan Fitzgerald, an academic expert at Northeastern University). We found that many U.S. cities and experts are thinking about the intersection of these two traditionally separate issues and are addressing the same problems faced by CASR, but they have yet to find a fully effective solution for how to systematically integrate these considerations into program design and evaluation.

While we decided to focus our case studies on the cities that were the most progressive in this space, it is worth noting that we found a number of other (perhaps less expected) cities that are also doing cutting-edge policy work on the issues of climate and equity, such as Cleveland (OH), Baltimore (MD), and Pittsburgh (PA).

Case Study Highlights

Our analysis focused on the different approaches taken by our case study cities to address these questions, as well as looking into any specific advantages or limitations of those approaches with respect to answering our specified problem. We also reviewed how close these solutions might be to our anticipated approach for Denver. For example, we investigated whether these cities address equity in a broad government-wide sense or specifically address issues of climate equity. We also looked into what concepts or approaches these cities might be taking that we had not previously considered, and compared them to see what might be missing. Finally, we considered which aspects of these cities' approaches might be most applicable to the specific issues that Denver's city government faces and the solution we intend to deliver.

The table below shows a list of the case study cities we examined for our analysis along with a summary of their general approach. More detailed summaries of our case study cities, including their specific actions, programs, and relevant attributes, as well as relative advantages and limitations of their approaches as they relate to Denver's specific situation and the intended goals of the PAE, can be found in Appendix B.

Table 2. Case Study Analysis Summary Findings

City[17]	General Approach
Seattle, Washington	➔ Equity framework and toolkit designed to assess potential implications of a proposed policy on racial equity, for use across all government agencies ➔ Data-driven, evidence-based approach to evaluate how equitably environmental impacts and outcomes are distributed across the population and identify target areas
Portland, Oregon	➔ Racial Equity Toolkit for city bureaus to identify racial impacts of proposed policies and potentially inequitable consequences or burdens on impacted communities ➔ City bureaus required to assess how budget requests benefit and/or burden marginalized communities ➔ Required to conduct basic equity assessment of every proposed climate program
Oakland, California	➔ Comprehensive guidance and recommendations for best practices to help maximize equity in city programs ➔ Mapping tools to identify frontline communities and understand baseline conditions ➔ Engage in partnerships with communities when crafting policies; includes feedback loop to monitor and report progress to frontline communities
Los Angeles, California	➔ City Sustainability Plan lays out environmental justice goals and suggested policies to help meet those goals ➔ Equity Index mapping tool to inform policy design; analyzes factors such as socioeconomic situation, environment, education, and resource access (using various equity indicators)
Providence, Rhode Island	➔ Comprehensive Climate Justice Plan setting key objectives, targets, and strategies to create an equitable, low-carbon, resilient city ➔ Efforts on community engagement and participatory justice in city climate goals and target setting
Austin, Texas	➔ Equity Assessment Tool for city departments to identify distribution of benefits and costs of existing policies ➔ Efforts on community engagement and participatory justice in city climate goals and target setting

[17] "Census Reporter: Making Census Data Easy to Use."

Key Takeaways for Denver

Below are six key takeaways from the case studies shown above, particularly as they pertain to lessons learned from these cities to design a similar approach for Denver.

1 – Community Involvement

Incorporate community engagement in the decision-making processes. This is essential to ensure participatory justice and improve long-term accountability and community trust in the policy process, especially for communities that have been historically burdened by environmental injustices.

2 – Transparency & Consistency

Ensure consistency when comparing programs across government offices and agencies. Processes need to be transparent and consistent across agencies if they are used government-wide. Denver's work on this needs to be universal, adaptable, and transparent.

3 – Leverage Publicly Available Data

Leverage publicly available demographic datasets to assess baseline conditions and identify target communities. Equity frameworks should provide examples of relevant datasets that can be used, particularly when it is possible to leverage existing and national data sources (e.g., from the U.S. Census Bureau or the U.S. Environmental Protection Agency).

4 – Iterate & Monitor Over Time

Develop protocols for monitoring and evaluating program impacts over time, using data and processes that are readily available and repeatable. Incorporate feedback loops that use equity information both for initial targeting as well as future iterations of program updates. Report progress directly to frontline and impacted communities to ensure transparency.

5 – Balance Qualitative & Quantitative

Equity issues cannot fully be addressed through only mapping or quantitative analysis, nor through only qualitative progress such as community engagement. Balance a combination of qualitative review (e.g. surveys and questionnaires) and quantitative analysis (e.g. mapping) to ensure a comprehensive analysis.

6 – Incorporate GHGs & Equity

Incorporate both GHG impact and equity impact in program evaluation. While Oakland, CA was able to analyze and concisely display both climate impact and equity (through community benefits), most cities struggle to combine these (and other) metrics to show overall program impact – making this an important area for improvement in the field.

One key implication of our case studies is that there are many advantages to implementing a consistent, government-wide equity effort; however, that level of equity incorporation is outside of both this PAE's scope and our own areas of expertise. It can also be challenging to create a policy that can be both specific and flexible enough to be applicable to all agencies, types of policy work, and levels of government. While our work is aimed to be most useful directly within the CASR team and will thus be focused on climate equity, later work on this topic could expand that approach to be more broadly applicable. Finally, every city and organization might have a slightly different definition of what equity means for their programs. This PAE uses the definitions provided in the Introduction, but it also learns from and applies other cities' approaches to CASR's work (wherever relevant).

Screening Tool: A Two-Pronged Approach

This section provides a discussion of our proposed solution to the problem we identified for CASR in previous sections. After initial research and scoping, we determined that the best solution was to take a two-pronged approach to program evaluation, allowing for more comprehensive planning for uses of the new 2A funding. This section delves deeper into the tool we developed and its two prongs (GHG policy lever modeling and equity framework), including preliminary sample results for the key program types we investigated.

Program Type Selection

We started by synthesizing a full list of CASR's current and proposed programs and grouping them into the sectors and categories shown in the table below.

Table 3. Summary of CASR's Current and Proposed Programs

Program Type	Examples
Transport Sector	
Electric Vehicle (EV) procurement	➔ City government fleet electrification ➔ Electric bikes (e-bikes) ➔ Public charging infrastructure
Ridesharing	➔ Incentives for shared mobility
Education and training	➔ Fleet/workplace/individual vehicle electrification ➔ Underserved communities campaign
Purchase incentive	➔ EV purchase incentives ➔ EV charging infrastructure installation incentives ➔ E-bike or transit pass incentives
Public-private partnerships	➔ Private funding opportunities ➔ Partnerships with carshare, taxi, or ride-hailing providers

Buildings Sector	
New building codes	➔ EV charging requirements for multi-family and workplace ➔ Green/net-zero building codes ➔ Material use requirements ➔ Green infrastructure
Education and training	➔ Retrofit/energy efficiency guidance for tenants and landlords ➔ Smart leasing program information ➔ Code compliance
Renewable Energy Sector	
Incentives	➔ Renewable energy incentives ➔ Building height incentives ➔ Expedited permitting ➔ Energy efficiency (products)
Existing building performance	➔ Performance standards ➔ System upgrade requirements (retrofits/renovations)
Community solar	➔ Government-owned solar (municipal rooftops, vacant lands, etc.) ➔ Community solar garden
Education and training	➔ Solar installation guidance and education ➔ Workforce development
Incentives	➔ Solar rebate/purchase incentives

Due to the time and resource constraints of this PAE, we narrowed down this list of program types by working with our clients to prioritize which areas of program analysis would be most useful. In particular, we prioritized programs that were either: (1) most likely to be considered by the team in the near future, or (2) most lacking in existing analysis from within CASR's knowledge and capacity. The table below shows the narrowed set of priority programs types that we agreed to analyze in depth.

Table 4. CASR Priority Program Types

Transport Sector Priority Programs	Buildings Sector Priority Programs	Renewable Energy Sector Priority Programs
➔ City government fleet electrification ➔ Multimodal public transportation policies	➔ Subsidies and financial incentives for specific technologies and improvements (e.g., electric heat pumps, building insulation, etc.)	➔ Solar rebates or purchase incentives ➔ Subsidies for participation in community solar projects

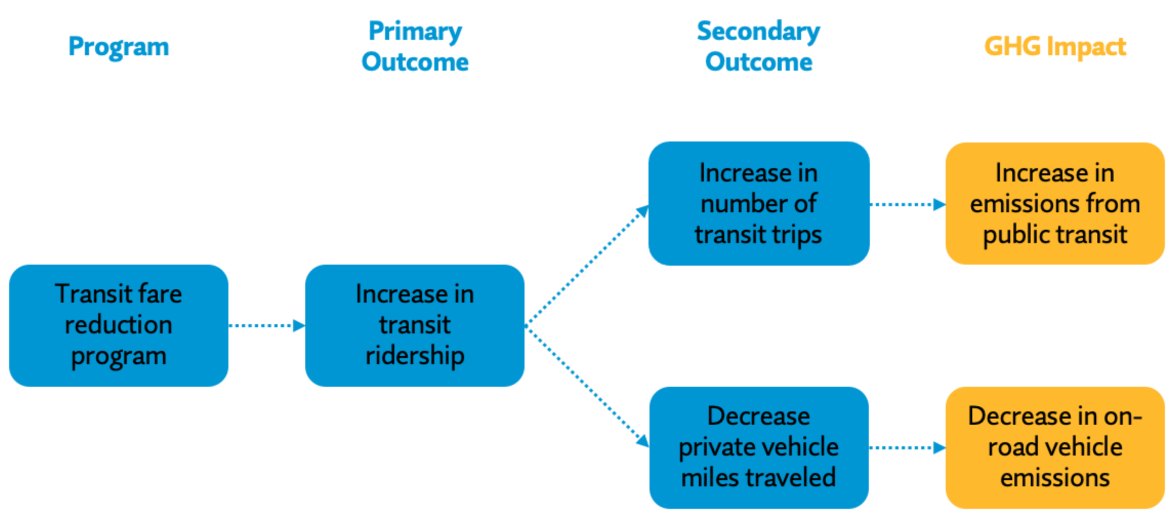
GHG Policy Lever Modeling

We designed the GHG policy lever modeling tool to look at the projected GHG impact of our selected programs (shown in Table 4) over a 30-year time horizon. Our Microsoft Excel-based tool allows for user-defined inputs of program design features (e.g., year implemented, requested funding amount, amount of increase in a certain activity, etc.). We started by estimating "business-as-usual" (BAU) baseline emissions for each sector (Transport, Buildings, and Energy). These emissions are projected to the year 2050 in the absence of the proposed program, using the 2019 Denver GHG Inventory as the base year. Key drivers of our BAU emissions forecast include estimates of population growth, growth in economic activity and consumption, and a change in fuel mix for grid-supplied electricity. We incorporated both publicly available national- or state-level datasets to use as a proxy for Denver and more detailed city-level datasets provided to us by CASR. A complete description of BAU scenario emissions calculation methodologies is included in Appendix C.

The Excel-based tool allows users to input information on proposed programs that request funding in order to examine their relative GHG impact and ultimately, their estimated investment needed per unit of emissions reduced. We started by using sample program characteristics for the priority program types shown in Table 4 to calculate projected emission reductions to the year 2050 within each sector as a result of the programs.

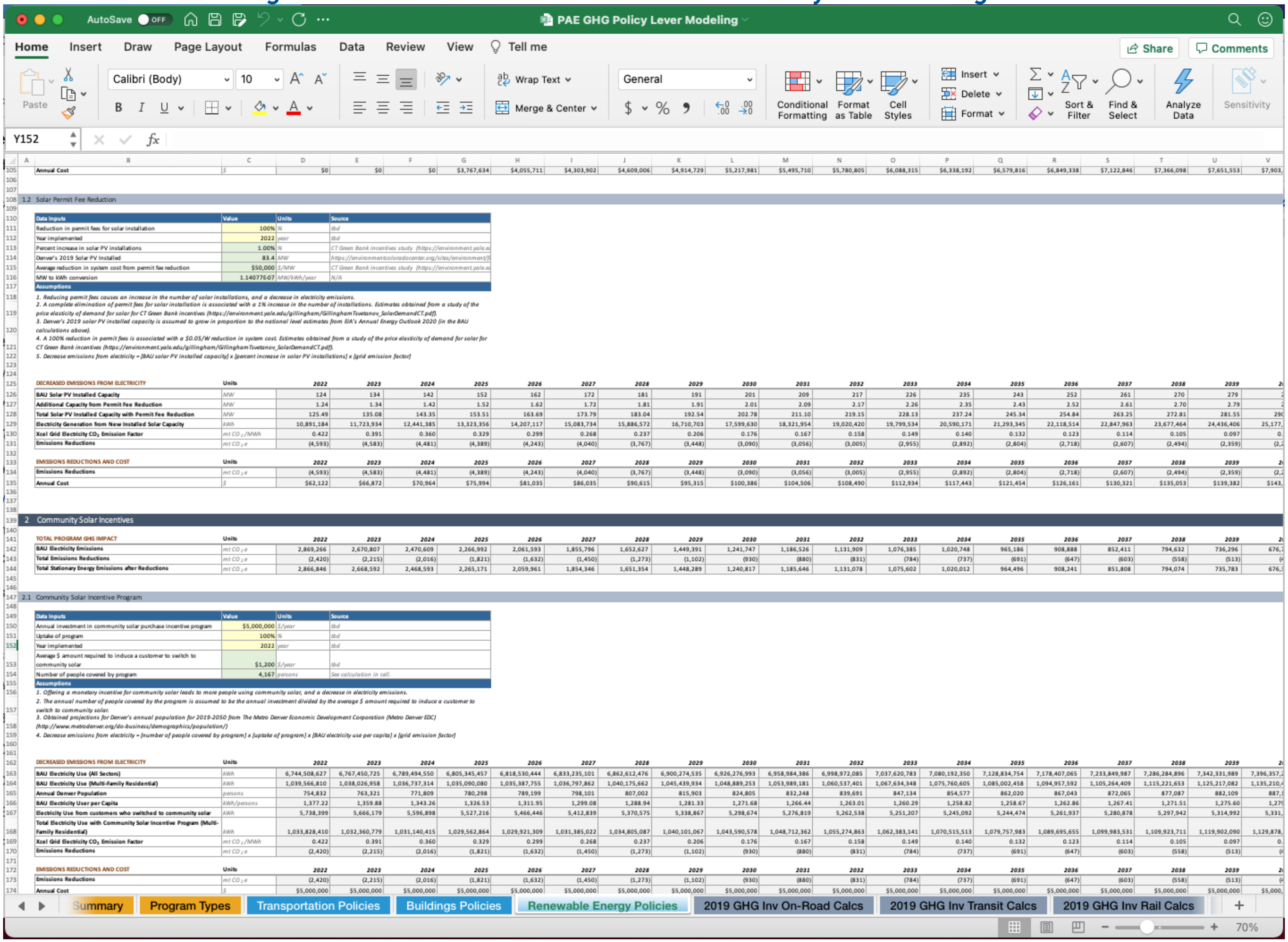
Initial efforts to develop calculations and emission reduction pathways were aided by first mapping out the causal impact of each proposed policy, which enabled clear identification of the direction and magnitude of change for various key metrics. See Figure 3 below for an example of a causal chain for a transit fare reduction program.

Figure 3. Transit Fare Reduction Causal Chain Example



The modeling tool was designed to be flexible so that projected emissions reductions are recalculated when the user adjusts the program design characteristics (i.e., the "policy lever"). In-depth calculation methodologies and associated assumptions for each sample program type analyzed are also included in Appendix C. We used our technical expertise in GHG emissions accounting to develop the methodologies and assumptions, in consultation with CASR. The structure of the tool was designed so that the analysis can be expanded by CASR analysts in the future to incorporate additional program types beyond the priority list identified in Table 4. The sections below discuss specific policy lever analyses for select programs in the three key sectors of transportation, buildings, and renewable energy. Figure 4, below, shows a screenshot of the Excel-based tool.

Figure 4. Screenshot of Microsoft Excel-Based GHG Policy Lever Modeling Tool



The primary outcome metric of the GHG policy lever modeling tool that is comparable across policy options is **GHG Reduction Efficiency**, which summarizes the economic efficiency of the program (i.e., annual investment per unit of GHG emissions reduced). Programs can then be ranked according to their estimated average annual investment per unit of emissions reduced, and these rankings can be used to categorize the potential programs as "Low", "Moderate", or "High" in terms of GHG reduction efficiency.

In the sector sections below, we report the rankings among sample policy levers analyzed in our tool, but it is extremely important to understand that the categorizations should not be seen as absolute and there are no generalized cutoff efficiencies for each category; rather, the values and rankings reported are illustrative of the tool's output using sample program design inputs and are intended for use in comparing different policy and funding requests against one another.

Transportation Policy Levers

We tested our GHG policy lever modeling tool on two main transportation program areas: (1) city government fleet electrification, and (2) multimodal transportation policies. Multimodal transportation policies include transit fare reduction programs (for all riders or specifically for low-income riders) and transit service improvements to increase frequency. Outcomes of these policy levers are described below.

City Government Fleet Electrification Program
GHG Reduction Efficiency: **Moderate**
Average annual investment per emissions reduced = $1,404/mt CO_2e

A **city government fleet electrification program** involves using government funds to purchase electric vehicles that replace conventional fuel vehicles in the city's fleet. The basis of our analysis assumed a certain number of EVs are purchased by the city each year to expand the city fleet or replace an existing gasoline or diesel fleet vehicle. GHG impacts from this program include:

- ➔ *Increase* in electricity emissions from new EVs
- ➔ *Decrease* in on-road gasoline/diesel emissions from replaced conventional fuel vehicles

Transit Fare Reduction Program
GHG Reduction Efficiency: **Low**
Average annual investment per emissions reduced = $4,504/mt CO_2e

A **transit fare reduction program** involves lowering transit bus and/or commuter and light rail fares to encourage public transit use as an alternative to cars. This involves using government funds to supplement the loss in revenue from reduced fares. Fares can be reduced for all riders, though many cities implement fare reductions for low-income riders specifically to limit the regressivity of this policy. The basis of our analysis assumed lowering fares will encourage public transit use either by individuals switching from personal vehicle travel or from cleaner modes of travel like walking or biking. GHG impacts from this program include:

- ➔ *Increase* in transit bus and/or commuter and light rail emissions from additional public transit ridership
- ➔ *Decrease* in private vehicle gasoline/diesel emissions from switching to public transit

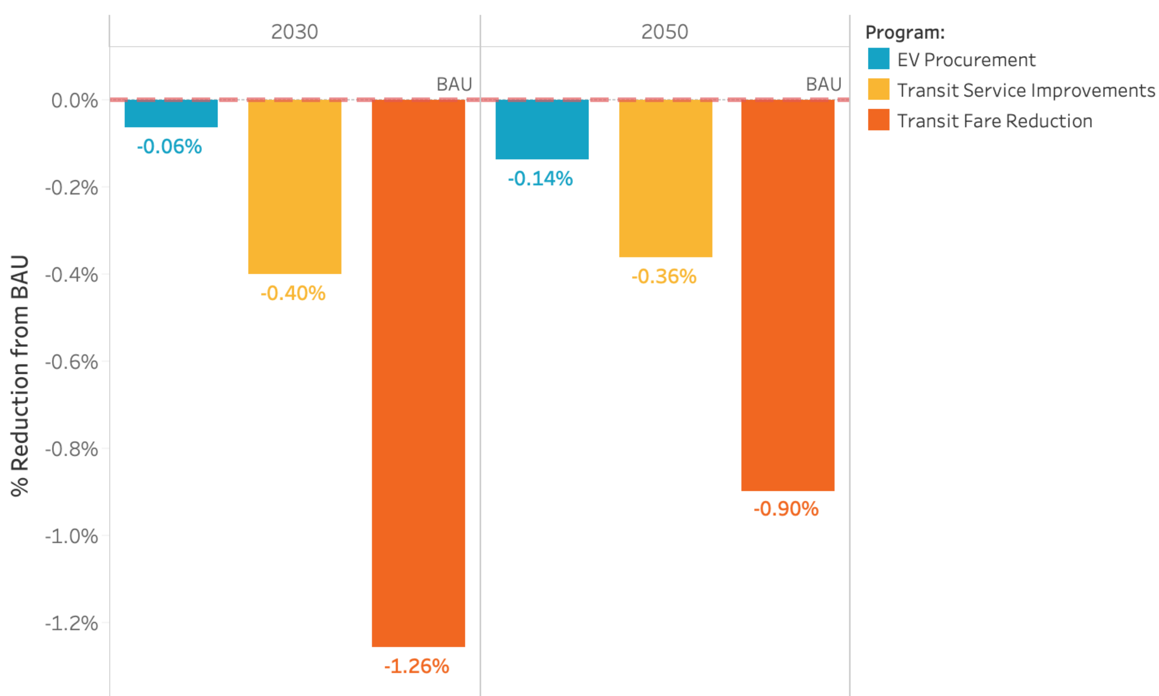
Transit Service Improvement Program
GHG Reduction Efficiency: **High**
Average annual investment per emissions reduced = $941/mt CO_2e

A **transit service improvement program** involves increasing transit frequency to improve reliability and encourage public transit use as an alternative to cars. This involves using funds to make the necessary service improvements to allow for increased frequency of public transit trips (i.e., hiring additional drivers, increasing operating and maintenance funds, etc.). The basis of our analysis assumed increasing transit frequency will encourage public transit use either by individuals switching from personal vehicle travel or from cleaner modes of travel like walking or biking. GHG impacts from this program include:

- ➔ *Increase* in transit bus and/or commuter and light rail emissions from additional public transit ridership
- ➔ *Decrease* in private vehicle gasoline/diesel emissions from switching to public transit

Figure 5 provides an example of the estimated percent reduction in transportation sector emissions from BAU under these three policy scenarios for the years 2030 and 2050.

Figure 5. Transport Emission Reductions from BAU Under Policy Lever Scenarios, 2030 and 2050



Buildings Policy Levers

We tested our GHG policy lever modeling tool on two main buildings program areas: (1) weatherization incentives, and (2) thermal electrification policies. Thermal electrification policies include electric heat pump incentives and electric water heater incentives. Outcomes of these policy levers are described below.

Weatherization Incentive Program
GHG Reduction Efficiency: **Low**
Average annual investment per emissions reduced = $22,371/mt CO_2e

A **weatherization incentive program** involves using government funds to offer a monetary incentive for single-family residential households to weatherize their homes (i.e., update and replace insulation to reduce energy loss). The basis of our analysis assumed offering a monetary incentive will induce more single-family households to weatherize their homes, which reduces energy lost and thus reduces electricity use in those buildings. GHG impacts from this program include:

➔ *Decrease* in electricity emissions from single-family residential homes

Electric Heat Pump Incentive Program
GHG Reduction Efficiency: **High**
Average annual investment per emissions reduced = $356/mt CO_2e

An **electric heat pump incentive program** involves using government funds to offer a monetary incentive for single-family residential households to switch from natural gas to an electric heat pump for heating and cooling their home. The basis of our analysis assumed offering a monetary incentive will induce more single-family households to purchase electric heat pumps to replace their gas systems. GHG impacts from this program include:

➔ *Increase* in electricity emissions from additional electricity needed to power electric heat pump
➔ *Decrease* in natural gas emissions from switching to an electric heating/cooling system.

Electric Water Heater Incentive Program
GHG Reduction Efficiency: **Moderate**
Average annual investment per emissions reduced = $441/mt CO_2e

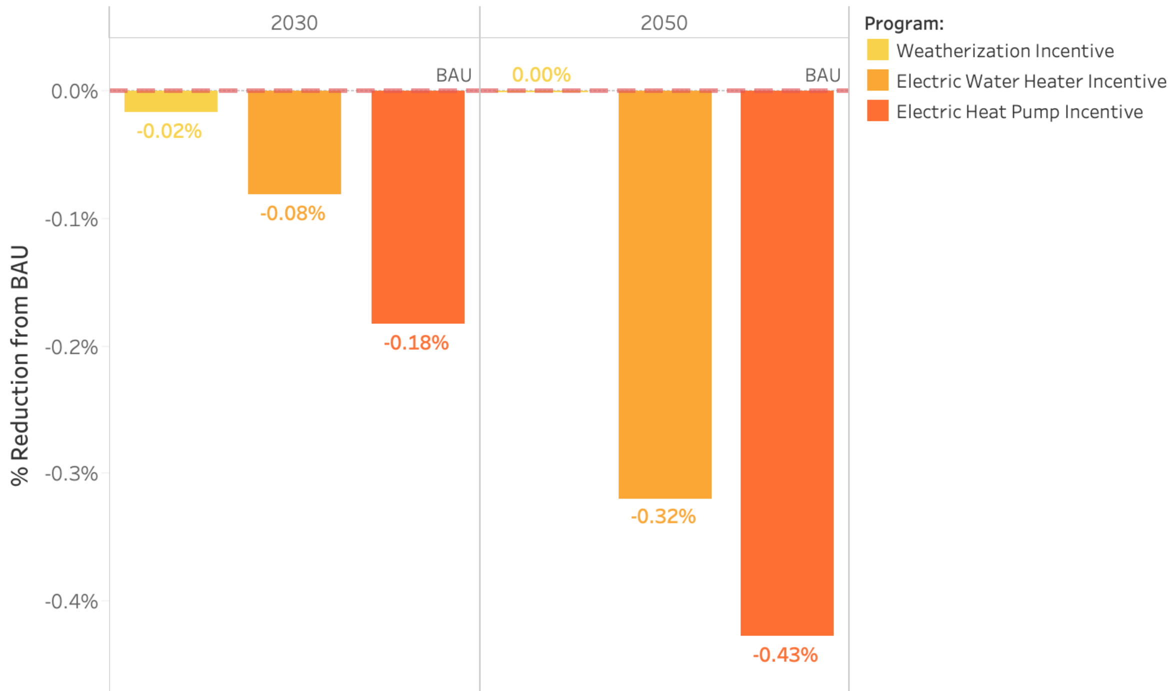
An **electric water heater incentive program** involves using government funds to offer a monetary incentive for single-family residential households to switch from natural gas to an electric water heater. The basis of our analysis assumed offering a monetary incentive will induce more single-family households to purchase electric water heaters to replace their gas systems. GHG impacts from this program include:

➔ *Increase* in electricity emissions from additional electricity needed to power electric water heater

→ *Decrease* in natural gas emissions from switching to an electric water heating system.

Figure 6 provides an example of the estimated percent reduction in buildings sector emissions from BAU under these three policy scenarios for the years 2030 and 2050.

Figure 6. Buildings Emission Reductions from BAU Under Policy Lever Scenarios, 2030 and 2050



Renewable Energy Policy Levers

We tested our GHG policy lever modeling tool on two main renewable energy program areas: (1) solar purchase incentives, and (2) community solar policies. Solar purchase incentives include solar rebates (for varying system sizes) and solar permit fee reductions. Outcomes of these policy levers are described below.

Solar Rebate Program
GHG Reduction Efficiency: **Moderate**
Average annual investment per emissions reduced = $473/mt CO_2e

A **solar rebate program** involves using government funds to offer a rebate for households and businesses to purchase and install solar photovoltaic (PV) systems to supply energy to their homes/buildings. The basis of our analysis assumed offering a monetary incentive will induce more households and businesses to purchase and install solar PV systems, increasing overall solar PV capacity and replacing electricity that would otherwise be obtained from the grid. We do not consider any upstream impacts from solar PV (i.e., manufacturing). GHG impacts from this program include:

→ *Decrease* in electricity emissions for residential and commercial end-uses.

Solar Permit Fee Reduction Program
GHG Reduction Efficiency: **High**
Average annual investment per emissions reduced = $39/mt CO_2e

A **solar permit fee reduction program** involves using government funds to supplement a reduction in permit fees for installing solar PV in businesses and homes. The basis of our analysis assumed offering a reduction in permit fees will induce more households and businesses to purchase and install solar PV systems, increasing overall solar PV capacity and replacing electricity that would otherwise be obtained from the grid. We do not consider any upstream impacts from solar PV (i.e., manufacturing). GHG impacts from this program include:

- ➔ *Decrease* in electricity emissions for residential and commercial end-uses.

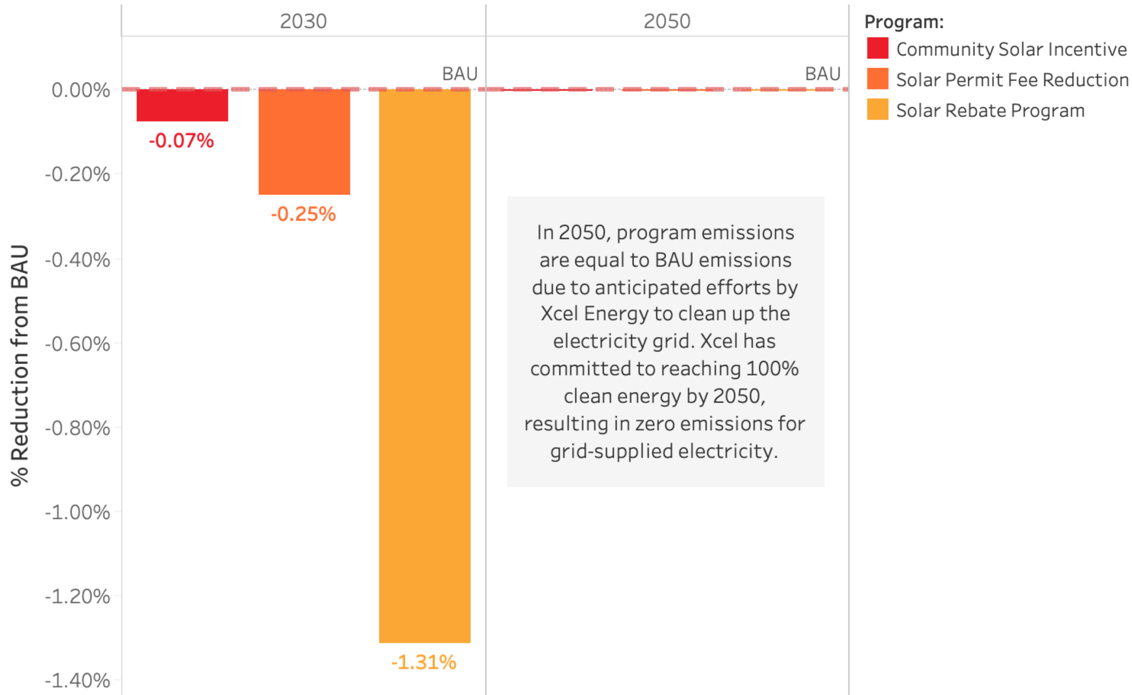
Community Solar Incentive Program
GHG Reduction Efficiency: **Low**
Average annual investment per emissions reduced = $991/mt CO_2e

A **community solar incentive program** involves using government funds to offer a monetary incentive for individuals living in multi-family residential households to switch to a community solar PV program to supply their electricity. The basis of our analysis assumed offering a monetary incentive will induce more individuals living in multi-family households to switch to community solar, replacing electricity that would otherwise be obtained from the grid. GHG impacts from this program include:

- ➔ *Decrease* in electricity emissions for residential end-uses.

Figure 7 provides an example of the estimated percent reduction in electricity emissions from BAU under these three policy scenarios for the years 2030 and 2050.

Figure 7. Electricity Emission Reductions from BAU Under Policy Lever Scenarios, 2030 and 2050



Uncertainty of GHG Modeling

Greenhouse gas emissions forecasting is inherently uncertain in that it relies on assumptions to project future behavior and the state of the world. Modeling potential emissions reductions from a given policy can be very complex depending on the underlying assumptions used and methodology applied. Our goal was to create a slightly simplified tool that would be feasible to develop within our project scope while still providing useful, tangible results for CASR. In order to do this we made several simplifying assumptions which we outline in detail in Appendix C. Given the simplified nature of our modeling tool, the numerical results shown above are highly uncertain. However, our goal for selecting GHG reduction efficiency as the key outcome metric was to allow CASR to compare and rank programs against one another to help inform difficult funding decisions, and we believe that metric is still valuable despite uncertainties.

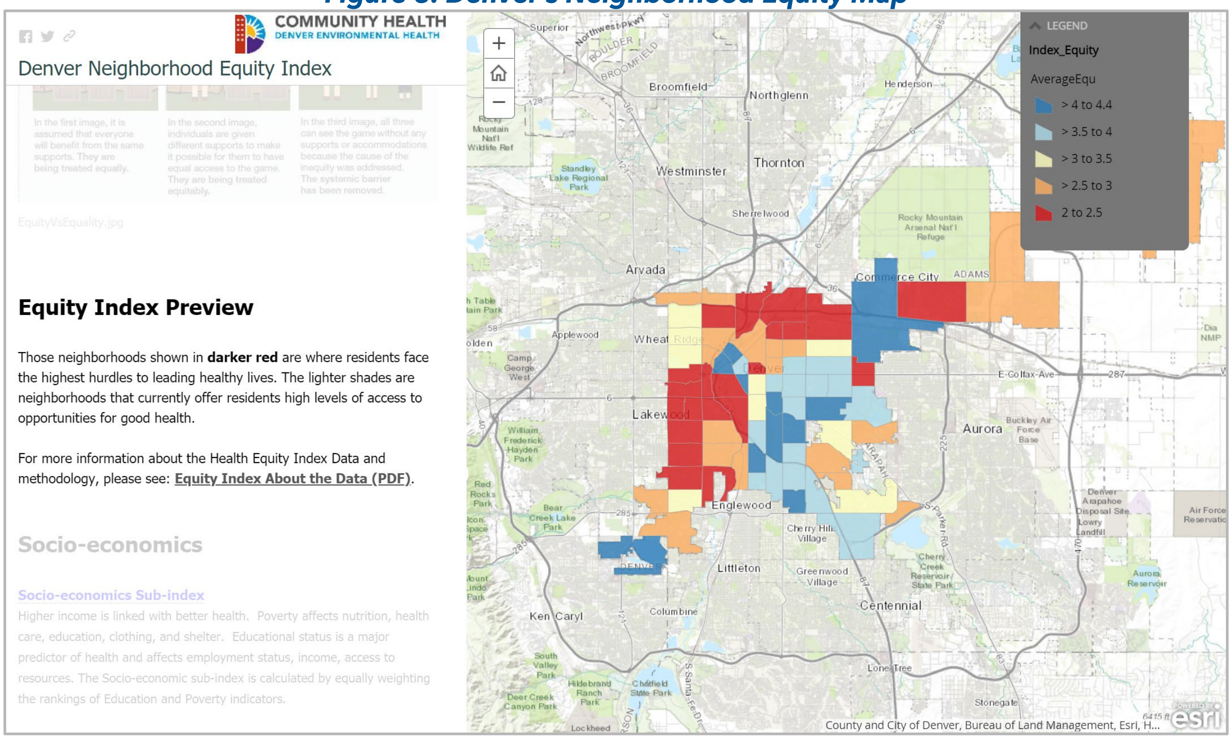
We intentionally structured our GHG policy lever modeling tool so that it is easy to update the underlying assumptions and data sources because we see the tool as a concrete starting point for CASR to use and expand upon in the future. As circumstances change or projections become more certain, CASR can incorporate new data and assumptions to improve the tool's accuracy.

Denver Climate Equity Framework

The Climate Equity Framework is the second prong of our two-pronged approach, and it combines lessons learned from our case studies, literature review, and expert interviews into a usable format for Denver's climate policy decisions. More information on resources consulted in our equity literature review can be found in Appendix D. In this section, we provide a brief background on our process for developing the Climate Equity Framework. We then describe the key steps in the framework, which includes both quantitative equity and vulnerability targeting and qualitative considerations.

As a result of our CASR interviews, we found that while the various climate policy teams are concerned about considering equity in their programs, they are not currently evaluating or analyzing equity in a formal or consistent manner. While various parts of the City government have provided tools, resources, and guidance for incorporating equity, no one solution has been applied to climate policy decisions (or other government decisions more broadly in Denver). The most relevant tool Denver has developed thus far is called the "Denver Neighborhood Equity Index", which was created by the Denver Department of Public Health & Environment to analyze social and equity metrics that contribute to health disparities throughout the city (see below for a snapshot of this arcGIS StoryMap).[18]

Figure 8. Denver's Neighborhood Equity Map[19]



Our **Denver Climate Equity Framework**, described in detail below, builds on this familiar mapping structure to create a similar equity and vulnerability tool but one that is more customized to the concerns of the climate policy teams. It helps to identify appropriate targeting for equity-focused climate funds and incorporates important qualitative considerations outside of the mapping analysis.

---

[18] "Denver Neighborhood Equity Index: ArcGIS StoryMap."
[19] "Denver Neighborhood Equity Index: ArcGIS StoryMap."

While the framework does include quantitative analysis in the equity mapping steps, the Denver Climate Equity Framework does not produce an overall quantitative equity score for programs. This is because the framework is intended for use in comparing multiple potential programs rather than for applying a specific "score" to a program on any absolute scale. Scoring for equity would be particularly challenging because many equity metrics (if they are quantifiable) do not have an agreed upon cut-off value; this is proving challenging for every level of government right now. Given our particular role in this project and lack of local knowledge in Denver, we also do not believe it is our place to make value-based judgements on what communities should consider "good enough" for equity impact. Instead, we are providing the framework so that the CASR program teams (with community involvement, if possible) can evaluate programs against each other on a qualitative scale.

Below are the equity metrics that we chose to focus on for analyzing and targeting relevant communities for investment. More detail on these equity indicators can be found in Appendix E. These metrics were chosen for their relevance to equity decisions (in particular, experts often highlight race and income level as the most important focus of an equity impact review) and because taken together, they help identify communities that have been historically disinvested in and underserved. In addition, the two sources we used for equity data – Denver's Census Bureau data[20] and the Opportunity Atlas[21] – were chosen for their reliability and public availability, as well as their likelihood to be regularly updated over time, facilitating longer-term tracking and analysis.

Table 5. List of Equity Metrics Included in the Denver Climate Equity Framework

Demographic Data and Neighborhood Characteristics	Neighborhood Outcome Metrics
➔ Average Household Size ➔ Median Age ➔ Percent American Indian ➔ Percent Asian ➔ Percent Black ➔ Percent Hispanic ➔ Percent Two or More ➔ Percent White ➔ Population ➔ Foreign-Born Share in 2012-16 ➔ Fraction Non-White in 2010	➔ Census Response Rate Social Capital Proxy ➔ Density of Jobs in 2013 ➔ Fraction College Graduates in 2012-16 ➔ Fraction Single Parents in 2012-16 ➔ Fraction with Short Work Commutes in 2012-16 ➔ Job Growth Rate from 2004 to 2013 ➔ Median Household Income of Residents in 2012-16 ➔ Median Rent 2012-16 ➔ Population Density in 2010 ➔ Poverty Rate in 2012-16 ➔ Owned Housing Units ➔ Rented Housing Units

The rest of this section will explain the content of our Denver Climate Equity Framework. Figure 9, below, shows the five steps to the framework, followed by descriptions of each step. Finally, this section ends with a brief example of how to apply the framework to a sample community solar incentive program.

[20] City and County of Denver, "Denver Open Data Catalog: Census Tracts (2010)."
[21] "The Opportunity Atlas."

Figure 9. Denver Climate Equity Framework

Step 1: Determine the Baseline

As in the GHG Policy Lever Modeling, the first step in the Climate Equity Framework is to understand the baseline against which any proposed policy will be measured. This step will be different for various types of programs, but it consists of exploring what impact a proposed policy is likely to have, and then analyzing the existing quantity of any relevant impact metrics.

For example, when analyzing a transportation policy to provide public transit subsidies to low-income residents in Denver, the baseline might be the number of low-income individuals already regularly using public transit and the original fare for riding any public transit. When analyzing a buildings policy to provide subsidies for weatherizing single-family homes, the baseline might be the number of single-family homes in Denver, split out by those that are or are not in need of weatherization.

Step 2: Mapping and Targeting of Relevant Communities

The second step of the Denver Climate Equity Framework is to utilize our mapping tool which leverages Census Bureau[22] and Opportunity Atlas[23] data (for the equity indicators listed in Table 5 above) to determine climate and social vulnerabilities as well as key geographic

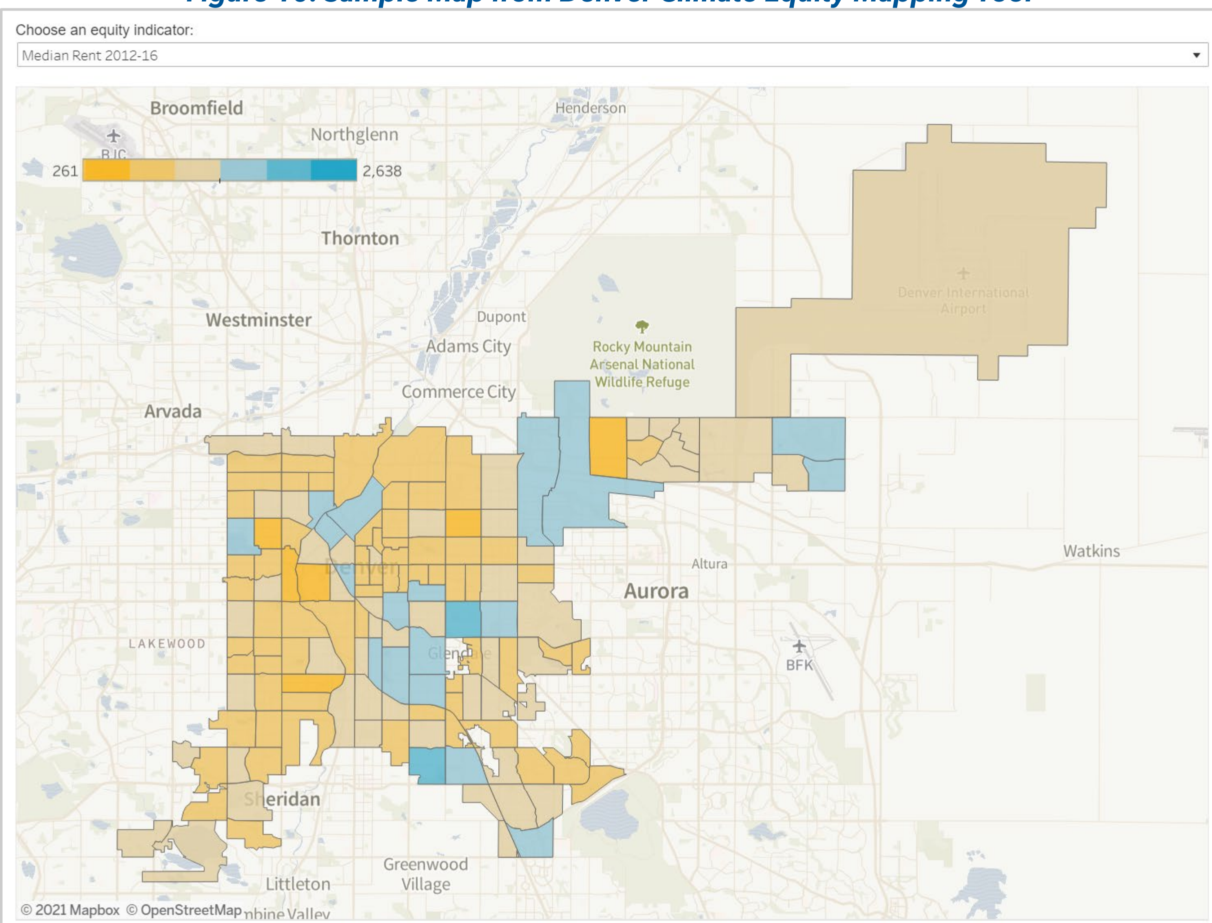
[22] City and County of Denver, "Denver Open Data Catalog: Census Tracts (2010)."
[23] "The Opportunity Atlas."

areas where inequities persist. This portion of the tool focuses on the distributional equity of climate funding to communities that have faced disproportionate burden. Click the button below to access our interactive map, which is hosted as a Tableau Public dashboard.

Click here to go to the Denver Climate Equity Mapping Tool

Below is a screenshot of our interactive mapping tool for one of the equity indicators. Note that where the image says "Choose an equity indicator", the user can click to show the full list of 21 equity metrics in a dropdown menu and can then select different indicators to analyze as relevant for their policy analysis.

Figure 10. Sample Map from Denver Climate Equity Mapping Tool



When analyzing the mapping tool, CASR should think about how their program design targets specific communities in the maps. Step 2 should be used to identify the target communities for a proposed program based on the chosen equity indicators.

Below are a few examples of the specific equity indicators that might be helpful to analyze for different types of programs. Note, however, that the specific decisions within this step will be dependent on the individual program being analyzed, its goals, and its program design.

- ➔ ***Buildings Program Equity Indicators***: median household income; housing ownership (i.e., rented versus owned); poverty rate; population density; median rent; median age.
- ➔ ***Transportation Program Equity Indicators***: median household income; poverty rate; race; median age; commute length; job and population density.
- ➔ ***Renewable Energy Program Equity Indicators***: median household income; housing ownership (i.e., rented versus owned); poverty rate; race; population density; median rent.

Step 3: Analyze Policy Impact in Targeted Communities

In Step 3, the mapping tool from Step 2 will be used to better understand the potential quantitative impact of a proposed policy in targeted communities. For the transit subsidy example from Step 1, this might look like analyzing the number of people or households that can be targeted from certain neighborhoods (Census tracts) that would receive the subsidy. This example could also be analyzed as the percentage of the total subsidy funding that would be implemented in the targeted communities from Step 2.

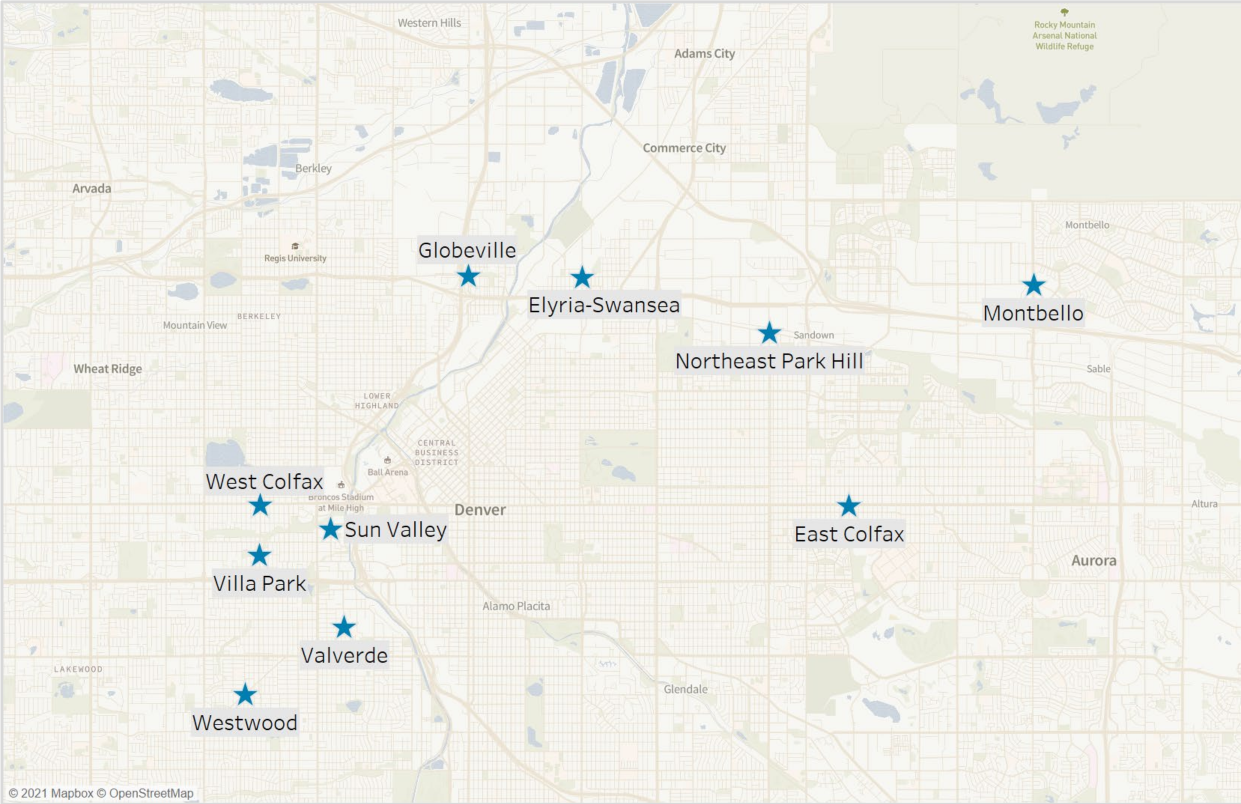
It is important to note that the analysis in Step 3 will be based on the specific proposed program design, as well as any outreach or community engagement efforts for that program. A program designed without equity in mind might not focus resources in the targeted communities from Step 2, while a program intentionally designed with equity in mind should be prioritizing benefits of the program in the identified target communities. This step can also be used to consider whether adjusting the proposed program design is a possibility to better target equity without losing other benefits of the program. Finally, this step can also be helpful in understanding whether existing outreach has been appropriately targeted or whether continued outreach should occur after identifying specific target communities.

In addition to the target communities identified in Step 2, CASR should also consider program impact as it relates to the Denver Neighborhood Equity & Stabilization (NEST) effort at the city-level, which is intended to "preserve the culture and character of these neighborhoods experiencing significant change by helping provide longtime businesses and residents opportunities to remain in place."[24] Below, we have created a map showing the ten neighborhoods currently prioritized in the NEST initiative. As part of Step 3, CASR can also review program impact in these priority Denver neighborhoods.

---

[24] City and County of Denver, "Neighborhood Equity & Stabilization (NEST)."

Figure 11: Denver's Neighborhood Equity & Stabilization (NEST) Initiative



Step 4: Assess Qualitative Equity Considerations

The fourth step of the Denver Climate Equity Framework provides a methodology for consistent, qualitative program assessment through a set of questions and considerations. This portion of the tool focuses more carefully on participatory, recognitional, and capabilities justice as defined in the Introduction. This step builds on processes we researched from our case studies, literature review, and interviews; in particular, it builds off of similar considerations in the scoring criteria for a California Air Resources Board grant program that aims to assess equity in grant applicants' process and design.[25]

These considerations will help determine which climate funding requests adequately incorporate equity into their particular planning and implementation processes, and generally include: community engagement efforts; education, outreach, and training of local community; participatory processes; and demand-driven approaches. To analyze a program in this step, CASR should use the questionnaire in the table below to review the qualitative impact of the proposed program. Note that we developed this questionnaire based on our research, but it is not an all-inclusive list, and CASR or other audiences may want to add additional context-specific questions based on the needs or their communities.

[25] Swenson, "STEP Implementation Grant Solicitation, Appendix D: Scoring Criteria."

Table 6. Questionnaire for Assessing Qualitative Equity Considerations

Equity Consideration Questions	Impact
1. Did the team proposing this program conduct community engagement efforts, particularly targeting appropriate communities identified in previous steps?	❑ Yes ❑ Somewhat ❑ No
2. Does this program include any efforts to have a positive impact on education and training of local community members to encourage local jobs and workforce development?	❑ Yes ❑ Somewhat ❑ No
3. Did the proposing team conduct a genuinely participatory process that included diverse voices from impacted communities?	❑ Yes ❑ Somewhat ❑ No
4. Did the participatory process (if it occurred) defer any amount of decision-making power to participants from impacted communities?	❑ Yes ❑ Somewhat ❑ No
5. Did the proposed project take a demand-driven approach to understand what its recipient communities actually want and need before deciding program targets and goals?	❑ Yes ❑ Somewhat ❑ No
6. Were any community representatives involved through leadership roles or partnerships for policy proposals (in a more extensive capacity than in the above questions)?	❑ Yes ❑ Somewhat ❑ No
7. Were the community representatives involved in designing and supporting the proposed program compensated fairly for their time?	❑ Yes ❑ Somewhat ❑ No
8. Is information about the proposed program accessible to the community and available in multiple languages?	❑ Yes ❑ Somewhat ❑ No
9. Did the program's outreach efforts reach community members from all demographic groups that the program is likely to affect?	❑ Yes ❑ Somewhat ❑ No
10. Did community members have an easy, straightforward manner in which to contact the program team with questions or concerns?	❑ Yes ❑ Somewhat ❑ No

The questionnaire above is intentionally a qualitative-based survey, and to understand the results, CASR can consider how many questions they responded to with "Yes", "Somewhat", or "No" to evaluate a given program's impact. If the evaluator is looking for a more standardized approach, below is a suggestion for interpreting the questionnaire results in a more quantitative manner.

Potential Steps for Quantitative Interpretation of Questionnaire Results:

1. Count the number of "Yes" responses and multiple by 2 points each.
2. Count the number of "Somewhat" responses and multiply by 1 point each.
3. Assign 0 points for any responses of "No".
4. Sum your results from the prior three steps.
5. Determine where your sum from the previous step falls in the following ranges to assign an overall impact ranking for the equity considerations questionnaire:

   0 to 5 points ➞ *LOW*
   6 to 10 points ➞ *MODERATE*
   11 to 20 points ➞ *HIGH*

Step 5: Summarize Equity Impact of Policies

The final step in the Denver Climate Equity Framework is to review the results of Steps 3 and 4 and determine a ranking for programs along an equity impact scale of High, Moderate, or Low. Similar to the GHG modeling, these rankings are not intended to be used on their own; instead, they are intended to help with comparing between similar policy proposals or between competing funding requests to shed light on which proposals would have the most beneficial equity impacts throughout the community. In addition, they can be used to help understand whether changing program design *within* a proposed program can help improve equity impacts. This step will be elaborated on in the application example below.

Finally, as mentioned at the beginning of this section, the framework itself does not result in a final quantitative score. The combination of quantitative mapping analysis and qualitative considerations described in the steps above are intended to be combined into an overall understanding of whether or not a program has a positive impact on targeted communities.

Applying the Denver Climate Equity Framework to A Sample Solar Program

Below shows an example of how to apply the Denver Climate Equity Framework to a community solar incentive program, including a brief description of the program followed by guidance on how one could apply each step of the framework. It is intended to be illustrative of how CASR can think through each step of the framework for a given program to determine its anticipated impact on community-wide equity.

Table 7. Sample Application of the Denver Climate Equity Framework

Background: Community Solar Incentive Program

Community solar provides clean energy options for residential customers that are not able to install their own solar panels because they are their renters living in multi-family housing units or their home is too shaded. The program allows households to switch from grid-supplied electricity to locally-generated solar energy from community solar gardens. Customers are charged a fixed rate for community solar, and the incentive program involves offering a monetary incentive for individuals to switch to community solar (usually in the form of a reduced rate in dollars per kilowatt hour). The incentive is intended to provide more people with access to community solar and increase program uptake.

Source: The Urbanist

Step 1: Determine the Baseline

Step 1 involves identifying a baseline against which the proposed policy will be measured. The baseline for a community solar incentive program consists of the number of multi-family households in Denver (and the percentage of those households that are not already signed up for community solar), as well as average monthly energy costs for multi-family households (including as a percentage of total household income). This information can be obtained from community solar operators or from the utility (Xcel Energy, in Colorado).

Step 2: Mapping and Targeting of Relevant Communities

Step 2 involves using the equity maps to identify target communities for outreach to ensure equitable access to program benefits as well as increase uptake of the program. For a community solar program, target communities could be low-income communities or communities of color with a significant number of multi-family housing units that could substantially benefit from both reduced electricity costs and reduced climate impacts.
We can leverage socioeconomic data from the Census Bureau by utilizing our mapping tool to identify these target communities based on a select set of equity indicators. Key equity indicators to examine in the mapping tool for a community solar incentive program include the following (by Census tract):

- ➔ **Median Household Income and Median Rent:** Low-income communities would benefit most from a community solar program and should be targeted.
- ➔ **Number of Owned versus Rented Housing Units and Population Density:** Community solar is available for people living in multifamily housing units, so areas with a high population density or a large number of renters should be targeted.

- **Racial Breakdown:** Communities of color face disproportionate impacts from climate change and high electricity prices and should be targeted.

Step 3: Analyze Policy Impact in Targeted Communities

Step 3 involves analyzing the potential impacts of the proposed policy on the target communities identified in Step 2. For a community solar incentive program, this would be the following:

- Projected number of households that would switch to community solar if offered the incentive (i.e., program uptake, by race and income level).
- Average annual or monthly electricity cost savings per multi-family household as a result of switching to community solar.
- Anticipated climate benefits from reduced reliance on fossil fuel generated, grid-supplied electricity (e.g., reduced pollutants and improved human health).

  This information can be obtained from various sources, including utilities, existing literature, expert judgment, or community organizations. This step produces quantitative estimates of the equity impact of the program, especially as they relate to the target communities identified in the previous step.

Step 4: Assess Qualitative Equity Considerations

Step 4 involves understanding the qualitative equity impacts of a program, specifically for issues such as community engagement efforts, education, outreach, and training of local community, participatory processes, and demand-driven approaches.

For a community solar incentive program, the responses to the qualitative equity questionnaire in Step 4 will depend on the specific efforts to ensure community involvement and ownership. For example, a community solar incentive program might have excelled at gathering community input through open town meetings, but might not have deferred any decision-making power to the community or compensated the community members for their time. Depending on the exact answers to the questionnaire, this would likely result in a “Moderate” ranking for qualitative equity considerations.

Step 5: Summarize Equity Impact of Policies

Based on Steps 3 and 4 above, the process for Step 5 involves summarizing the overall equity impact of the proposed program. For this community solar incentive program example, we will assume that the program is appropriately targeting the communities identified and analyzed in Step 3 so that program benefits are focused in the relevant communities and result in a “High” ranking. The assumptions for the questionnaire in Step 4 resulted in a “Moderate” ranking, so overall this program would rank “Moderate-High” in terms of overall equity impact.

Findings & Recommendations

This section will describe the final capabilities of our two-pronged screening tool, including the process for using and applying it to relevant climate policy funding requests. It will also synthesize and generalize some of the sample results of the tool, particularly in analyzing policy types that are good to prioritize (i.e., "win-win" policies along our equity and GHG efficiency metrics) and policies that are best to avoid (i.e., "lose-lose" policies). We then highlight our key recommendations for CASR, as well as key limitations in our analysis and areas for further research and exploration.

Applications of the Screening Tool

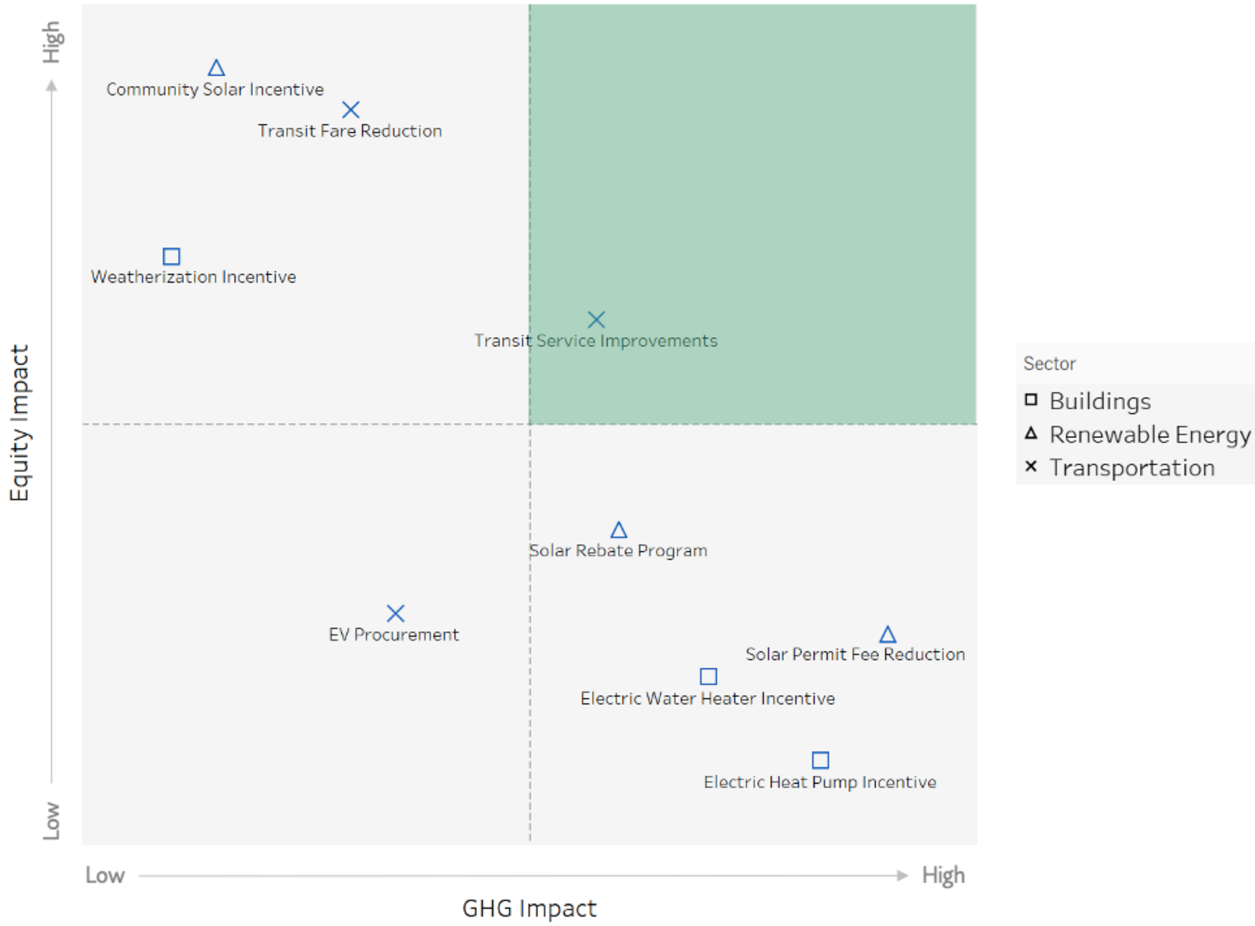
The overall purpose of our work was to create a roadmap for implementing and utilizing our screening tool to make policy funding decisions. The precise scope of our analysis was to design a concrete, efficient, and consistent process for CASR to evaluate new funding requests. Our tool serves as a starting point for future analysis of program and policy proposals and should be used consistently across all teams within CASR.

This section provides guidance for applying our screening tool to evaluate potential programs. Specifically, it includes a discussion of how to interpret the combined results of the two-pronged tool and an explanation of how to think about building a policy portfolio from the results.

Combined Results of the Two-Pronged Approach

As discussed in previous sections, the two prongs of the screening tool each produce a ranking of proposed policies from low to high in terms of equity and GHG impact. The scatterplot below shows an example of how to interpret these rankings for the six sample program types we used to develop and test our tool. This chart is provided as a framework to guide the thought process of how to integrate the results of the two-pronged approach. It is not a direct output of the tool, but after analyzing a set of proposed programs, we suggest sketching a graph similar to the format of the one shown below to help visualize and clarify the results to aid in decision-making. This particular chart is illustrative and should not be used for actually comparing the sample programs.

Figure 12. Visualization for Reporting the Equity versus Efficiency Tradeoff of Sample Policy Levers



The chart above shows the combined results based on the sample programs that we analyzed (using sample data and assumptions). If these were real programs being compared, we would recommend that the city immediately implement a Transit Service Improvement Program, which falls in the “win-win” quadrant (i.e., high on both equity and climate impact), and consider implementing a Community Solar Incentive Program or Solar Permit Fee Reduction Program, which are high impact on at least one metric. In contrast, a City Government Fleet EV Procurement Program falls in the lower left quadrant and should thus be deprioritized compared to the other proposed programs. The results shown in Figure 12 are intended to illustrate how we might consider putting together a successful policy portfolio based on outcomes from our tool (discussed in more detail below).

While the sample results shown in this combined chart are only intended to be illustrative rather than directive, if the landscape of other projects is similar to the ones we analyzed, it might be difficult for a policy to have both a high equity impact and create sufficient reductions in GHG emissions (i.e., “win-win” on both axes). Intentional program design decisions – about where and to which individuals these programs are targeted – can have a significant impact on moving programs along these axes, particularly for equity outcomes. Therefore, this combined-results thought process should include acknowledgement that the programs being analyzed are not static or final, and iterations on program design may be beneficial to achieving program goals across the two axes.

Building a Policy Portfolio

When interpreting the results of the screening tool, CASR should analyze a "portfolio" of policy options to apply the framework not just for individual programs but in aggregate. When building such a policy portfolio, it is important to note that not every program has to be "win-win" in terms of equity and GHG impact, but rather CASR should consider the aggregate climate and equity impact from an entire suite of policy options.

Using our tool to build a policy portfolio involves balancing equity and efficiency across all policy options. For example, there may be some programs that are very effective in reducing GHGs, but are relatively neutral when it comes to equity impact (e.g. city government procurement of EVs may be equity-neutral), while other programs may deliver modest GHG reductions but may better address equity objectives (e.g. a subsidized transit program for low-income riders). Combined, these programs may demonstrate progress on both GHG emissions and equity. In addition to assessing the overall equity and GHG impacts of the entire portfolio, it is important to identify that some pairs of policies may be complementary (on either GHG or equity margins), while other pairs of policies may be substitutes. Implementing a program that trades off equity impact for high GHG impact may put pressure on all other programs to supplement this by prioritizing equity above other considerations.

To build a successful policy portfolio that achieves equity goals, CASR could go one of two routes. First, it could ensure that every single chosen program works towards equity (at least at a moderate level). Or second, it could assume that some programs will not feasibly be able to focus on equity, and instead focus on having extremely positive equity impacts through a few specific, targeted programs. Either of these approaches could help CASR achieve their goals, and deciding between them will likely depend on the available program suggestions (among many other factors in addition to GHG and equity impact).

In general, making decisions between various policy portfolio options may depend on a number of questions that were outside the scope of this analysis but are essential for CASR to consider in combination with this PAE's approach. A key consideration will be the availability of financial resources from the new sales tax, which will determine how many programs can be implemented and at what scale. Additional questions will include economic impacts of policies, political climate and feasibility in the Denver and Colorado contexts, and ease of implementation and administration.

Summary of Key Recommendations for CASR

This section outlines our four key recommendations for CASR when using our screening tool to evaluate new funding proposals.

1 Standardize Program Evaluation

CASR lacks a consistent process for screening potential programs based on their relative GHG and equity impact. Our screening tool can be used to standardize programs' funding resource allocation in order to compare potential impacts in a consistent and transparent manner, which can help build buy-in and trust from stakeholders in the community. In order to ensure that this process is uniform and robust, we recommend that CASR use our framework to evaluate *all* funding requests (i.e., from all sectoral teams within the office) to design effective policy portfolios for every iteration of CASR budgeting.

2 Consider Policy Portfolios

Rather than looking at the isolated impact of individual policies, it is important to look at the combined impact of several policies to design a policy portfolio that meets CASR's needs and accomplishes their ambitious goals. We recommend that CASR consider the overall impact of a set of policies to create successful policy portfolios, rather than expecting high impact from individual policies (described in detail above).

3 Balance Tradeoffs to Meet Goals

Given the diverse outcomes and impacts from potential policies, it will be necessary for CASR to make difficult decisions on which programs they choose to implement in order to maximize benefits, ensure sufficient GHG reductions, and promote community-wide equity. We recommend that CASR balance tradeoffs between impact metrics based on which are most important for meeting CASR's goals.

4 Implement "Win-Win" Programs

As noted above, while tradeoffs typically need to be made and programs rarely meet all goals on their own, some programs do succeed at having both high climate impact and high equity impact. We recommend that whenever these "win-win" programs are identified, they should be quickly implemented to take advantage of their benefits and show short-term progress towards goals.

We believe that by taking these recommendations into account, CASR can efficiently allocate 2A funding and design and implement programs that maximize equity and climate impact to reach their ambitious goals.

Limitations To Our Approach

We would like to caveat our results with the limitation that we were only able to analyze a subset of all of the possible policy levers and programs that a city could undertake to tackle both climate and equity priorities. We chose policies that best fit Denver's particular needs and priorities at the time, but we also aimed to distill some of our results into generalizations that could be more broadly applicable. The inputs, assumptions, and program designs in the tool can be adjusted for additional policies that fit similar structures or causal chains, but the tool would need to be expanded to be able to quickly analyze significantly different types of policies (e.g., waste or agricultural sector policies).

In addition, while our equity work was focused on applicability and usability for the CASR team and their particular resource allocation needs, many cities use government-wide equity processes or tools. While there are many advantages to institutionalizing equity efforts at the city-level (such as consistency across agencies and applicability to multiple sectors and issue areas), a city-wide equity tool is outside the scope of both this PAE and our expertise. Thus, our efforts focused on equity as it relates to climate policy, but as with the GHG analysis portion of our tool, our Denver Climate Equity Framework could be expanded for additional use cases.

Further research and analysis is needed to improve upon our findings and implement similar approaches in other contexts. We encourage others (within CASR or external) who might be interested in improving on our tool and framework to do so. We have provided the best structure we could develop to address the current problems, but this structure was also intentionally developed to allow for incremental improvements such as adding additional policy levers to the GHG analysis or updating assumptions or data inputs as circumstances change.

Conclusion

Below are several key conclusions that we drew from our efforts to conduct this analysis and develop our two-pronged GHG and equity screening tool.

First, we found in our literature review and case studies that every level of the U.S. government is currently working to address the intersection of climate change and equity priorities, with no perfect solution for balancing these key needs. Recent examples include the Biden Administration's new Justice40 Initiative[26] and countless new offices and positions in local governments across the U.S. centered around climate or environmental equity and justice. This is a key issue that many are struggling with, so these

[26] The White House, "FACT SHEET: President Biden Takes Executive Actions to Tackle the Climate Crisis at Home and Abroad, Create Jobs, and Restore Scientific Integrity Across Federal Government"

types of conversations and analyses push Denver and society as a whole closer to achieving an equitable distribution of climate benefits and remediating past harms.

Second, Denver has the opportunity to further establish itself as a leader in this space by integrating climate and justice efforts through a concrete, actionable approach that merges key quantitative and qualitative analyses. Our framework attempts to combine quantitative and qualitative analyses of climate and equity impact, which is a key part of the solution to this integration problem and one that no government has completely achieved thus far. This combined analysis is essential to developing a holistic understanding of the real impacts of these policies on Denver's residents and the environment.

Finally, tradeoffs need to be made using a consistent methodology that is flexible enough to handle diverse programs and policy types and transparent enough to help build community trust in programs. In addition, transparency would allow for future evaluations and public accountability. As became clear throughout our research, it is occasionally possible to find "win-win" solutions, but more often, decision-makers are required to balance important tradeoffs.

In the case of CASR and Denver, the policy-makers and constituents deeply value both climate efforts and equity efforts, so resources need to be filtered to support both of those goals – individually perhaps, but combined wherever possible. This PAE and resulting screening tool provide a structured, consistent process for prioritizing policies along these two key metrics to support CASR's ongoing ambitious work towards achieving a clean and equitable future for Denver.

Appendices

These appendices provide additional details on methodologies used throughout our PAE, background research (such as literature reviews and case studies), and all other relevant information that was excluded from the main section of this PAE but may be relevant to any interested parties.

The appendices are as follows:

- **Appendix A:** *List of Expert Interviews*
- **Appendix B:** *Findings from In-Depth Case Studies*
- **Appendix C:** *Detailed GHG Methodology and Results*
- **Appendix D:** *List of Relevant Equity Literature Review Resources*
- **Appendix E:** *List of Equity Indicators by Source*

Appendix A. List of Expert Interviews

Below are the internal CASR employees and external experts whom we interviewed to support our research on climate and equity policy decisions.

Interviewee
Name: Elizabeth Babcock **Title:** Climate Action Manager Organization: Denver CASR
Name: Jonny Rogers **Title:** Energy Sector Lead Organization: Denver CASR
Name: Michael Salisbury **Title:** Transportation Sector Lead Organization: Denver CASR
Name: Katrina Managan **Title:** Buildings Sector Lead Organization: Denver CASR
Name: Bree Swenson **Title:** Air Pollution Specialist **Organization:** California Air Resources Board
Name: Shawn Queenan **Title:** Solar*Rewards Community Program Manager Organization: Xcel Energy
Name: Cindy Chang **Title:** Executive Director **Organization:** Groundwork Denver
Name: Sanya Carley **Title:** O'Neill Professor; Director, Master of Public Affairs (MPA) Program and O'Neill Online MPA Program **Organization:** Indiana University
Name: Shalanda Baker **Title:** Professor of Law, Public Policy and Urban Affairs **Organization:** Northeastern University

Appendix B. Findings from In-Depth Case Studies[27]

Below are detailed summaries for the six case study cities we reviewed. For context, according to the U.S. Census Bureau, Denver has a population size of 727,211; population density of 4,744 people per square mile; race and ethnicity breakdown of 55 percent White, 29 percent Hispanic, and 8 percent Black; and 11.7 percent of the population living below the poverty line. The table below shows this same specifically selected demographic information for each city we deemed relevant for this analysis. This should not be considered comprehensive and is intended to provide a snapshot of each case study city. Finally, it is worth noting that in the table, race and ethnicity data are included only for any percentages of at least 10 percent.

Approach	Advantages and Limitations
Seattle, Washington	
Demographics: Population: 753,655; Density: 8,987 people/sq. mile; Race & Ethnicity: 63% White; 17% Asian; Below Poverty Line: 9.8%	
Seattle Race & Social Justice Initiative (RSJI): Racial Equity Toolkit (RET) ➔ Questionnaire-driven equity framework to assess potential implications of a proposed policy on racial equity ➔ Focuses specifically on racial equity, designed to be used across all government agencies ➔ Six-step process: 1. Set Outcomes 2. Involve Stakeholders & Analyze Data 3. Determine Benefit and/or Burden 4. Advance Opportunity or Minimize Harm 5. Evaluate. Raise Racial Awareness. Be Accountable 6. Report Back Office of Sustainability & Environment (OSE): Equity & Environment Initiative (EEI) and Environmental Justice Committee (EJC) ➔ Centers community ownership in decision-making, environmental program/policy design	Advantages: ➔ RET takes a data-driven and evidence-based approach ➔ RET emphasizes community engagement throughout data collection and analysis process ➔ Pilot GIS tool combines socioeconomic and environmental hazard data (quantitative and qualitative) to determine who benefits from and who is burdened by environmental and health impacts and outcomes Limitations: ➔ RET limited to equity metrics only (indicators are geographic areas and racial demographics) ➔ No publicly available information on policy outcomes as a result of using the RET

[27] "Census Reporter: Making Census Data Easy to Use."

➔ Environmental Equity Assessment Pilot: GIS tool that evaluates how equitably environmental impacts and outcomes are distributed in Seattle, identifies potential program target areas	
Portland, Oregon	
Demographics: Population: 653,467; Density: 4,898 people/sq. mile; Race & Ethnicity: 70% White; 10% Hispanic; Below Poverty Line: 12.4%	
Office of Equity and Human Rights (OEHR) Racial Equity Toolkit (RET) ➔ Guidance for City Bureaus to integrate explicit consideration of racial equity in planning and decision making, including policies, practices, programs, and budgets ➔ Data-driven approach that involves identifying: 1. Current racial disparities and those most impacted by proposed policies 2. Potential inequitable consequences or burdens on impacted communities ➔ Emphasizes community involvement, tracking and measuring progress over time, and reporting back to stakeholders in a feedback loop ➔ Toolkit adapted for climate-related programs by the Bureau of Planning and Sustainability (BPS) (Equity Toolkit - Decision Support Tool) OEHR Budget Equity Assessment Tool ➔ City Bureaus and their Budget Advisory Committees required to use tool to assess how budget requests benefit and/or burden marginalized communities BPS Climate Action Plan and Equity Implementation Guide ➔ Guidance and best practices for integrating equity into the decision-making processes and implementation of the city's Climate Action Plan, tracking progress with climate-equity metrics ➔ Conducts a basic equity assessment of every action proposed in the 2015 Climate Action Plan	Advantages: ➔ Incorporates equity considerations in budgeting and funding allocation ➔ Emphasizes community engagement in decision-making processes ➔ Data-driven approach to assess baseline, monitor progress, and track program outcomes Limitations: ➔ No explicit guidance to identify vulnerable communities to target for proposed programs

Oakland, California	
Demographics: Population: 433,044; Density: 7,748 people/sq. mile; Race & Ethnicity: 29% White; 27% Hispanic; 24% Black; 14% Asian; Below Poverty Line: 13.9%	
Racial Equity Impact Assessment & Implementation Guide (REIA) ➔ Provides comprehensive recommendations and best practices to help City staff maximize equity throughout their 2030 Equitable Climate Action Plan (ECAP) 10-year implementation period ➔ Includes 3 key principles: 1. Equitable governance (procedural and structural equity) 2. Equitable investment (substantive and distributional equity) 3. Community resilience and engagement ➔ Guidance includes understanding how to: 1. Identify frontline communities (geographies and demographics vulnerable to climate change, leveraging existing sources like CalEnviroScreen 3.0 and Oakland Equity Indicators) and compile data to illuminate baseline conditions 2. Partnering with communities while crafting policies and developing programs 3. Mitigating or reverse key equity gaps that limit access to resources 4. Monitoring and evaluating equity outcomes for reporting back to frontline communities Department of Race and Equity's Racial Equity Implementation Guide ➔ Guidance to help City staff and Departments ensure policies and programs they develop and implement lead to more equitable outcomes ➔ Departments encouraged to identify their own relevant indicators to be tracked and measured, leveraging existing Oakland Equity Indicators	Advantages: ➔ REIA leverages existing equity mapping tools to take an evidence-based approach ➔ REIA emphasizes community engagement throughout data collection and analysis process ➔ REIA process includes feedback loop, reporting progress to frontline communities ➔ ECAP incorporates both an equity impact analysis and a GHG impact analysis for proposed actions (two-pronged) Limitations: ➔ Rich spatial data like those included in CalEnviroScreen are not available in other states

<table>
<tr><th colspan="2">Los Angeles, California</th></tr>
<tr><td colspan="2">Demographics: Population: 3,979,537; Density: 8,486 people/sq. mile; Race & Ethnicity: 48% Hispanic; 29% White; 12% Asian; Below Poverty Line: 16.7%</td></tr>
<tr><td>L.A.'s Green New Deal Sustainability Plan 2019
➔ Full Sustainability Plan for the city (an update to the 2015 plan)
➔ The second of four key principles is “a responsibility to deliver environmental justice and equity through an inclusive economy, producing results at the community level, guided by communities themselves.”
➔ Details the city’s overarching environmental justice goals (many related to health equity) and policies to help meet those goals

L.A. Equity Index
➔ Mapping effort from the L.A. Controller’s Office to show existing disparities and barriers to opportunity by scoring every census tract on a scale of 1 to 10
➔ Analyzes factors such as socioeconomic situation, environment, education, and resource access (using indicators like poverty level, air quality, education level, and access to internet, food, and health insurance)
➔ Goal is to provide city leaders and residents with a data-driven understanding of the different needs of communities within Los Angeles</td><td>Advantages:
➔ City Sustainability Plan is ambitious in prioritizing justice and equity, and plan leverages the CalEnviroScreen system to chart progress
➔ L.A. Equity Index is clear and comprehensive, and it can be used by policymakers across the city government (not specific to climate)

Limitations:
➔ City Sustainability Plan lacks any high-level framework to help decision-makers consider equity outside of the listed programs
➔ Composite equity score from the L.A. Equity Index is a comprehensive summary of many diverse indicators, which could limit the ability to see disparities for specific indicators and to focus on climate equity</td></tr>
<tr><th colspan="2">Providence, Rhode Island</th></tr>
<tr><td colspan="2">Demographics: Population: 179,875; Density: 9,773 people/sq. mile; Race & Ethnicity: 44% Hispanic; 32% White; 15% Black; Below Poverty Line: 22.6%</td></tr>
<tr><td>City of Providence Climate Justice Plan
➔ Plan was developed by the Office of Sustainability and the Racial and Environmental Justice Committee of Providence and includes key objectives, targets, and strategies to create an equitable, low-carbon, resilient city</td><td>Advantages:
➔ Plan is detailed and Providence-specific to provide the city with a clear path forward that is based on community feedback</td></tr>
</table>

Equity and Sustainability Summary Report ➔ Includes seven key principles and values that can be applied to any of Providence's equity and/or environmental work ➔ Result of a significant process of community engagement to understand the needs of the community	Limitations: ➔ Principles and values from Equity and Sustainability Report are forward-looking and ambitious, but may not provide a clear framework for incorporating into current work
Austin, Texas	
Demographics: Population: 979,263; Density: 3,061 people/sq. mile; Race & Ethnicity: 48% White; 34% Hispanic; Below Poverty Line: 12.2%	
Austin Community Climate Plan ➔ Directly acknowledges harms of inequities and racism, particularly when exacerbated by climate change ➔ Draft update to the 2014 plan is increasing efforts on climate equity by engaging with a more racially and economically diverse set of people and by launching the Community Climate Ambassadors Program to reach historically underrepresented groups. ➔ Draft update centers equity throughout the plan in new ways, such as: 1. Prioritizing incentives and targeting communications in low income communities and communities of color 2. Focusing on a Just Transition for new industries and technologies Austin Equity Office ➔ Provides city-wide leadership and guidance on improving equity ➔ Runs an equity training process to help city departments better understand the impact of their work on equity ➔ Leads city departments through the Equity Assessment Tool, which consists of a general set of questions to identify historical contexts, understand who benefits or loses from their policies, and explore opportunities to reduce disparities. ➔ Includes an Equity Action Team that is constituted of local community members and open to all members of the public; this team helped develop the equity assessment tool and now functions as a compass and accountability mechanism	Advantages: ➔ Community Climate Plan aims to pursue goals of participatory justice and incorporates equity as an overarching concern throughout Limitations: ➔ The trainings and assessments of Austin's Equity Office are opaque and seem to focus on impacts existing city programs, rather than exploring potential future equity solutions

Appendix C. Detailed GHG Methodology and Results

This Appendix provides detailed methodologies for our greenhouse gas (GHG) policy lever modeling, including data inputs and sources, assumptions applied in the analysis, and equations for calculations.

Transportation Programs

"Business As Usual" (BAU) Scenario Calculations

On-Road Vehicle BAU Emissions

Gasoline, Diesel, and Ethanol Vehicles:

- According to the Denver Regional Council of Governments (DRCOG), Denver's on-road vehicle miles traveled (VMT) is projected to grow 45% from 2020 to 2050. Using the growth rate for 2020-2050 as a proxy, and using 2019 VMT from the 2019 Denver GHG Inventory as the base year, projected Denver's total annual VMT in the year 2050.
- Obtained national projections for annual on-road VMT (in billion miles) for 2019-2050 from U.S. Department of Energy's Energy Information Administration's (EIA) *Annual Energy Outlook 2020*. Denver's year-over-year change in VMT was assumed to be proportional to the national-level projections. Applied the national estimates to interpolate annual VMT for Denver for years between 2019 and 2050.
- Used Denver's total annual VMT to calculate on-road emissions from gasoline, diesel, and ethanol vehicles for 2020-2050 by applying the same methodology as the 2019 Denver GHG Inventory.

Electric Vehicles:

- Obtained national projections for annual electric vehicle (EV) stock (in thousand vehicles) for 2019-2050 from EIA's *Annual Energy Outlook 2020* and calculated annual percent change.
- Using Denver's 2019 EV stock as the base year, projected annual EV stock to the year 2050 by applying the annual percent changes from the national dataset.
- Obtained projections for Denver's grid emissions intensity for 2019-2050 from an analysis of Xcel's system decarbonization goals.
- Used annual EV stock to calculate on-road emissions from EVs for 2020-2050 by applying the same methodology as the 2019 Denver GHG Inventory. For carbon dioxide (CO_2) emissions, applied annual Xcel electricity emission factor (EF) for 2020-2050. For methane (CH_4) and nitrous oxide (N_2O) emissions, applied the same emission factors used in the 2019 Denver GHG Inventory and kept them constant over the time series.

Data	Assumption	Source
Growth in On-Road VMT from 2019 to 2050	Denver's on-road VMT is projected to grow 45% from 2020 to 2050. Using this as a proxy, assumed on-road VMT grows 45% from 2019 to 2050.	DRCOG's 2050 Metro Vision Regional Transportation Plan

Projected Year-Over-Year Change in On-Road VMT	Denver's year-over-year change in on-road VMT is assumed to be proportional to national-level projections from EIA's *Annual Energy Outlook 2020*.	EIA's *Annual Energy Outlook 2020*
Projected Annual EV Stock	Denver's total annual EV stock is assumed to grow in proportion to national-level projections from EIA's *Annual Energy Outlook 2020*.	EIA's *Annual Energy Outlook 2020*
Projected Annual Electricity CO_2 Emission Factor	The carbon intensity of Denver's electricity grid is assumed to decrease over time due to a mandate requiring the regional utility, Xcel Energy, to reduce their total CO_2 emissions 80% by 2030 and 100% by 2050 (using 2005 as a baseline). Projected annual Xcel CO_2 emission factors were provided by CASR.	CASR Analysis of Xcel's System Decarbonization
Transport Emissions Calculation Methodologies and Emission Factors	Assumed no changes in the methodologies or non-CO_2 emission factors used to calculate transport emissions over time.	2019 Denver GHG Inventory

Transit Bus BAU Emissions

- Obtained national projections for annual transit bus diesel fuel use (in trillion Btu) for 2019-2050 from EIA's *Annual Energy Outlook 2020* and calculated annual percent change.
- Using Denver Regional Transportation District's (RTD's) 2019 transit bus diesel fuel use as the base year, projected annual transit bus diesel fuel use (for the entire RTD system) to the year 2050 by applying the annual percent changes from the national dataset.
- Multiplied by the percentage of total RTD system activity attributable to the City and County of Denver to get Denver's annual transit bus diesel fuel use.
- Used Denver's total annual diesel fuel use to calculate transit bus emissions to 2050 by applying the same methodology as the 2019 Denver GHG Inventory.

Data	Assumption	Source
Projected Annual Transit Bus Diesel Fuel Use	Denver's total annual transit bus diesel fuel use is assumed to grow in proportion to national-level projections from EIA's *Annual Energy Outlook 2020*.	EIA's *Annual Energy Outlook 2020*
Percentage of Total Annual RTD System Activity Attributable to Denver	Assumed constant percentage of total RTD transit bus VMT and diesel fuel use attributable to the City and County of Denver.	2019 Denver GHG Inventory

Transport Emissions Calculation Methodologies and Emission Factors	Assumed no changes in the methodologies or emission factors used to calculate transport emissions over time.	2019 Denver GHG Inventory

Commuter Rail and Light Rail BAU Emissions

- Obtained national projections for annual intercity, transit, and commuter rail electricity use (in trillion Btu) for 2019-2050 from EIA's *Annual Energy Outlook 2020* and calculated annual percent change.
- Using 2019 total commuter and light rail electricity use as the base year, projected annual rail electricity use to the year 2050 by applying the annual percent changes from the national dataset.
- Multiplied by the percentage of total commuter and light rail electricity use attributable to the City and County of Denver to get Denver's annual commuter and light rail electricity use.
- Used Denver's total annual electricity use to calculate commuter and light rail emissions to 2050 by applying the same methodology as the 2019 Denver GHG Inventory.

Data	Assumption	Source
Projected Annual Commuter & Light Rail Electricity Use	Denver's total annual commuter and light rail electricity use is assumed to grow in proportion to national-level projections from EIA's *Annual Energy Outlook 2020*.	EIA's *Annual Energy Outlook 2020*
Percentage of Total Annual Commuter/ Light Rail Electricity Use Attributable to Denver	Assumed constant percentage of total commuter and light rail electricity use attributable to the City and County of Denver.	2019 Denver GHG Inventory
Projected Annual Electricity CO_2 Emission Factor	The carbon intensity of Denver's electricity grid is assumed to decrease over time due to a mandate requiring the regional utility, Xcel Energy, to reduce their total CO_2 emissions 80% by 2030 and 100% by 2050 (using 2005 as a baseline). Projected annual Xcel CO_2 emission factors were provided by CASR.	CASR Analysis of Xcel's System Decarbonization
Transport Emissions Calculation Methodologies and Emission Factors	Assumed no changes in the methodologies or non-CO_2 emission factors used to calculate transport emissions over time.	2019 Denver GHG Inventory

EV Procurement Policy Calculations

City Government Fleet Electrification Program

User Inputs
City-owned EVs in 2019 (# of vehicles)
Annual increase in city-owned EV stock per year (vehicles per year)

- Obtained average EV cost (light-duty vehicles [LDV]) for the years 2019-2050 from EIA's *Annual Energy Outlook 2020.*
- Using the number of city-owned EVs in 2019 as the base year, applied the annual increase defined by the user to estimate annual city-owned EV stock to the year 2050.
- Calculated total annual emissions reduced for 2019-2050 from city government fleet electrification as follows:

$$Annual\ Emissions\ Reduction\ from\ Gas/Diesel\ Vehicles\ = [Annual\ \#\ of\ City\ Owned\ EVs] \times [Average\ Annual\ VMT\ per\ Vehicle] \times [On\ Road\ Gas/Diesel\ EF]$$

$$Annual\ Emissions\ Increase\ from\ Electric\ Vehicles\ = [Annual\ \#\ of\ City\ Owned\ EVs] \times [Average\ Annual\ VMT\ per\ Vehicle] \times [Average\ kWh\ Consumed\ per\ Mile] \times [Grid\ Electricity\ EF]$$

$$Total\ Annual\ Emissions\ Reduction\ from\ Policy\ = [Annual\ Emissions\ Reduction\ from\ Gas/Diesel\ Vehicles] + [Annual\ Emissions\ Increase\ from\ Electric\ Vehicles]$$

- Calculated total annual program cost for 2019-2050 from city government fleet electrification as follows:

$$Total\ Annual\ Program\ Cost\ = [Annual\ \#\ of\ City\ Owned\ EVs] \times [Average\ Cost\ per\ EV]$$

Data	Assumption	Source
Projected Average EV Cost per Year (LDV)	Average annual EV cost in Denver (for light-duty vehicles) is assumed to correspond to national-level estimates from EIA's *Annual Energy Outlook 2020.*	EIA's *Annual Energy Outlook 2020*
Average Annual VMT per Vehicle	Assumed constant average annual VMT per vehicle over time (7,000 VMT/vehicle).	2019 Denver GHG Inventory
Average Electricity Consumed per Mile	Assumed constant average annual electricity consumed per mile over time (0.34 kWh/mile).	2019 Denver GHG Inventory

Grid Electricity Emission Factor	Assumed same annual grid electricity emission factor as the BAU scenario (annual BAU EV emissions [$mtCO_2e$]/annual BAU EV electricity consumption [kWh]).	2019 Denver GHG Inventory
On-Road Gas/Diesel Emission Factor	Assumed constant on-road gas/diesel emission factor over time (0.000467 $mtCO_2e$/VMT).	2019 Denver GHG Inventory

Multimodal Transportation Policy Calculations

<u>Transit Fare Reduction Program</u>

User Inputs
Percent bus transit fare reduction (%)
Percent rail transit fare reduction (%)
Year implemented

- Obtained DRCOG estimates of average weekday transit boardings for 2020, 2030, 2040, and 2050 from CASR. Assumed average weekend boardings were 20% of weekday boardings. Calculated total annual transit boardings for all four years as follows:

$$Annual\ Transit\ Boardings\ (Weekdays)\ =\ [Average\ Weekday\ Transit\ Boardings]\ \times\ [5\ days\ per\ week]\ \times\ [52\ weeks\ per\ year]$$

$$Annual\ Transit\ Boardings\ (Weekends)\ =\ [Average\ Weekday\ Transit\ Boardings]\ \times [0.2]\ [2\ days\ per\ weekend]\ \times\ [52\ weeks\ per\ year]$$

$$Annual\ Transit\ Boardings\ =\ [Annual\ Transit\ Boardings\ (Weekdays)]\ +\ [Annual\ Transit\ Boardings\ (Weekends)]$$

- Obtained 2019 Denver transit bus and commuter/light rail ridership from the RTD Denver 2019 Facts & Figures. Applied that breakdown to obtain annual transit bus boardings and annual transit rail boardings for 2020, 2030, 2040, and 2050. Linearly interpolated transit bus and rail boardings between 2020 and 2030, 2030 and 2040, and 2040 and 2050 to get annual BAU transit bus and rail ridership for all years.
- Obtained the price elasticity of demand for lowering transit bus fares from the Federal Transit Administration's (FTA) Transit Cooperative Research Program (TCRP) *Report 95* and Victoria Transport Policy Institute's *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior*. Using a price elasticity of -0.4, calculated additional transit bus ridership each year from the reduced fare assuming that for every 1% decrease in bus fares, ridership can be expected to increase by a corresponding 0.4% in the 1-2 years following a fare change.

- Calculated total annual emissions increased from transit buses for 2019-2050 as follows:

$$Annual\ Emissions\ Increase\ from\ Transit\ Buses\ = [Additional\ Transit\ Bus\ Ridership\ from\ Reduced\ Fare]\ \times [Transit\ Bus\ EF]$$

- Obtained the price elasticity of demand for lowering transit rail fares from the FTA's TCRP *Report 95* and Victoria Transport Policy Institute's *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior*. Using a price elasticity of -0.2, calculated additional transit rail ridership each year from the reduced fare assuming that for every 1% decrease in rail fares, ridership can be expected to increase by a corresponding 0.2% in the 1-2 years following a fare change.
- Calculated total annual emissions increased from transit rail for 2019-2050 as follows:

$$Annual\ Emissions\ Increase\ from\ Commuter\ and\ Light\ Rail\ = [Additional\ Transit\ Rail\ Ridership\ from\ Reduced\ Fare] \times [Transit\ Rail\ EF]$$

- Obtained the cross-price elasticity of demand for car use with respect to lowering transit bus and/or rail fares from the FTA's TCRP *Report 95* and Victoria Transport Policy Institute's *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior*. Using a cross-price elasticity of 0.1, calculated the annual decrease in passenger vehicle on-road VMT from switching to transit as a result of a transit bus and/or rail fare reduction assuming that for every 1% decrease in bus or rail fares, private vehicle ridership can be expected to decrease by 0.1% in the 1-2 years following the fare change.

$$Annual\ Emissions\ Reduced\ from\ On\ Road\ Gas/Diesel\ Use\ = [Reduced\ On\ Road\ VMT\ from\ Switch\ to\ Transit]\ \times [On\ Road\ Gas/Diesel\ EF]$$

- Calculated total annual emissions reduced for 2019-2050 from a transit fare reduction program as follows:

$$Total\ Annual\ Emissions\ Reduction\ from\ Policy\ = [Annual\ Emissions\ Reduction\ from\ Gas/Diesel\ Vehicles]\ + [Annual\ Emissions\ Increase\ from\ Transit\ Bus\ and/or\ Commuter\ and\ Light\ Rail]$$

- Calculated total annual program cost for 2019-2050 from a transit fare reduction program as revenue lost:

$$Annual\ Revenue\ Lost\ from\ Bus\ Fare\ Reduction\ = [Transit\ Bus\ Ridership\ After\ Fare\ Reduction]\ \times\ [New\ Bus\ Fare]\ - [BAU\ Scenario\ Transit\ Bus\ Ridership]\ \times [Old\ Bus\ Fare]$$

$$Annual\ Revenue\ Lost\ from\ Rail\ Fare\ Reduction\ = [Transit\ Rail\ Ridership\ After\ Fare\ Reduction]\ \times\ [New\ Rail\ Fare] - [BAU\ Scenario\ Transit\ Rail\ Ridership]\ \times [Old\ Rail\ Fare]$$

$$Total\ Annual\ Program\ Cost\ =\ [Annual\ Revenue\ Lost\ from\ Bus\ Fare\ Reduction]\ +\ [Annual\ Revenue\ Lost\ from\ Rail\ Fare\ Reduction]$$

Data	Assumption	Source
Increase in bus transit trips from reduced fare	The price elasticity of demand for lowering transit bus fares is -0.4 (i.e., for every 1% decrease in bus fares, ridership can be expected to increase by a corresponding 0.4% in the 1-2 years following the fare change).	FTA's TCRP Report 95 and Victoria Transport Policy Institute's *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior*
Increase in rail transit trips from reduced fare	The price elasticity of demand for lowering transit rail fares is -0.2 (i.e., for every 1% decrease in rail fares, ridership can be expected to increase by a corresponding 0.2% in the 1-2 years following the fare change).	FTA's TCRP Report 95 and Victoria Transport Policy Institute's *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior*
Decrease in private vehicle trips from reduced transit fare	The cross-price elasticity of demand for car use with respect to lowering transit bus and/or rail fares is 0.1 (i.e., for every 1% decrease in bus or rail fares, private vehicle ridership can be expected to decrease by 0.1% in the 1-2 years following the fare change).	FTA's TCRP Report 95 and Victoria Transport Policy Institute's *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior*
Average transit fare	Assumed an average fare of $3/ticket for transit buses and commuter/light rail.	RTD Denver Fare Information
Annual transit bus and rail ridership	The growth in annual transit bus and transit rail ridership is linearly interpolated for years not included in the DRCOG dataset provided by CASR.	DRCOG data provided by CASR
Transit Bus Emission Factor	Assumed the same annual transit bus emission factor as the BAU scenario (annual BAU transit bus emissions [$mtCO_2e$]/annual BAU transit bus ridership [boardings]).	2019 Denver GHG Inventory
Commuter and Light Rail Emission Factor	Assumed the same annual commuter/light rail emission factor as the BAU scenario (annual BAU rail emissions [$mtCO_2e$]/annual BAU transit rail ridership [boardings]).	2019 Denver GHG Inventory
On-Road Gas/Diesel Emission Factor	Assumed constant on-road gas/diesel emission factor over time (0.000467 $mtCO_2e$/VMT).	2019 Denver GHG Inventory

Program to Improve Transit Service Frequency

User Inputs
Percent increase in frequency of transit service (%)
Year implemented

- Obtained DRCOG estimates of average weekday transit boardings for 2020, 2030, 2040, and 2050 from CASR. Assumed average weekend boardings were 20% of weekday boardings. Calculated total annual transit boardings for all four years as follows:

$$Annual\ Transit\ Boardings\ (Weekdays)\ =\ [Average\ Weekday\ Transit\ Boardings]\ \times\ [5\ days\ per\ week]\ \times\ [52\ weeks\ per\ year]$$

$$Annual\ Transit\ Boardings\ (Weekends)\ =\ [Average\ Weekday\ Transit\ Boardings]\ \times [0.2]\ [2\ days\ per\ weekend]\ \times\ [52\ weeks\ per\ year]$$

$$Annual\ Transit\ Boardings\ =\ [Annual\ Transit\ Boardings\ (Weekdays)]\ +\ [Annual\ Transit\ Boardings\ (Weekends)]$$

- Obtained 2019 Denver transit bus and commuter/light rail ridership from the RTD Denver 2019 Facts & Figures. Applied that breakdown to obtain annual transit bus boardings and annual transit rail boardings for 2020, 2030, 2040, and 2050. Linearly interpolated transit bus and rail boardings between 2020 and 2030, 2030 and 2040, and 2040 and 2050 to get annual BAU transit bus and rail ridership for all years.
- Obtained own-time out-of-vehicle elasticity from the International Energy Agency's (IEA) *Saving Oil in a Hurry* report. Using an elasticity of 0.5, calculated additional transit bus ridership each year from the increased transit service frequency assuming that for every 1% increase in service frequency, the annual number of transit bus trips can be expected to increase by a corresponding 0.5%.
- Calculated total annual emissions increased from transit buses for 2019-2050 as follows:

$$Annual\ Emissions\ Increase\ from\ Transit\ Buses\ =\ [Additional\ Transit\ Bus\ Ridership\ from\ Increased\ Service\ Frequency]\ \times [Transit\ Bus\ EF]$$

- Obtained own-time out-of-vehicle elasticity from the IEA *Saving Oil in a Hurry* report. Using an elasticity of 0.5, calculated additional transit rail ridership each year from the increased transit service frequency assuming that for every 1% increase in service frequency, the annual number of transit rail trips can be expected to increase by a corresponding 0.5%.
- Calculated total annual emissions increased from transit rail for 2019-2050 as follows:

$$Annual\ Emissions\ Increase\ from\ Commuter\ and\ Light\ Rail\ =\ [Additional\ Transit\ Rail\ Ridership\ from\ Increased\ Service\ Frequency]\ \times\ [Transit\ Rail\ EF]$$

- Calculated the annual decrease in passenger vehicle on-road VMT from switching to transit as a result of increased transit service frequency by applying a 60% diversion factor to estimate the number of private vehicle trips reduced, and multiplying by average vehicle trip distance to get VMT:

$$Annual\ Emissions\ Reduced\ from\ On\ Road\ Gas/Diesel\ Use\ = \\ [Reduced\ On\ Road\ VMT\ from\ Switch\ to\ Transit] \\ \times [On\ Road\ Gas/Diesel\ EF]$$

- Calculated total annual emissions reduced for 2019-2050 from a program to improve transit service frequency as follows:

$$Total\ Annual\ Emissions\ Reduction\ from\ Policy\ = \\ [Annual\ Emissions\ Reduction\ from\ Gas/Diesel\ Vehicles] + \\ [Annual\ Emissions\ Increase\ from\ Transit\ Bus\ and/or\ Commuter\ and\ Light\ Rail]$$

- Calculated total annual program cost for 2019-2050 from a program to improve transit service frequency as follows:

$$Additional\ Yearly\ Revenue\ from\ Increasing\ Transit\ Service\ Frequency\ = \\ [Transit\ Bus\ Ridership\ After\ Service\ Increase] \times [Bus\ Fare] - \\ [BAU\ Scenario\ Transit\ Bus\ Ridership] \times [Bus\ Fare] + \\ [Transit\ Rail\ Ridership\ After\ Service\ Increase] \times [Rail\ Fare] - \\ [BAU\ Scenario\ Transit\ Rail\ Ridership] \times [Rail\ Fare]$$

$$Annual\ Cost\ from\ Additional\ Transit\ Riders\ = \\ [Additional\ Transit\ Bus\ Ridership\ from\ Increased\ Service\ Frequency] \times \\ [Average\ Cost\ per\ Bus\ Passenger\ Trip] + \\ [Additional\ Transit\ Rail\ Ridership\ from\ Increased\ Service\ Frequency] \times \\ [Average\ Cost\ per\ Rail\ Passenger\ Trip]$$

$$Total\ Annual\ Program\ Cost\ = \\ [Additional\ Yearly\ Revenue\ from\ Increasing\ Transit\ Service\ Frequency] + \\ [Annual\ Cost\ from\ Additional\ Transit\ Riders]$$

Data	Assumption	Source
Increase in bus and/or rail transit trips from increased service frequency	Own-time out-of-vehicle elasticity is 0.50. Assumed percent increase in public transit trips is equal to percent increase in service frequency multiplied by 0.50.	IEA's *Saving Oil in a Hurry*
Decrease in private vehicle trips from increased transit service frequency	Assumed 60% diversion factor to estimate private vehicle trips reduced as a result of increased transit service, and multiplied by average private vehicle trip distance to get VMT	IEA's *Saving Oil in a Hurry*

Average transit fare	Assumed an average fare of $3/ticket for transit buses and commuter/light rail.	RTD Denver Fare Information
Average cost per passenger trip on transit bus	Assumed an average cost of $2.92/trip for transit bus trips.	FTA's *2016 National Transit Summaries & Trends*
Average cost per passenger trips on commuter/light rail	Assumed an average cost of $7.99/trip for transit rail trips.	FTA's *2016 National Transit Summaries & Trends*
Annual transit bus and rail ridership	The growth in annual transit bus and transit rail ridership is linearly interpolated for years not included in the DRCOG dataset provided by CASR.	DRCOG data provided by CASR
Transit Bus Emission Factor	Assumed the same annual transit bus emission factor as the BAU scenario (annual BAU transit bus emissions [$mtCO_2e$]/annual BAU transit bus ridership [boardings]).	2019 Denver GHG Inventory
Commuter and Light Rail Emission Factor	Assumed the same annual commuter/light rail emission factor as the BAU scenario (annual BAU rail emissions [$mtCO_2e$]/annual BAU transit rail ridership [boardings]).	2019 Denver GHG Inventory
On-Road Gas/Diesel Emission Factor	Assumed constant on-road gas/diesel emission factor over time (0.000467 $mtCO_2e$/VMT).	2019 Denver GHG Inventory
Average private vehicle trip distance	Assumed an average private vehicle trip distance of 8.20 vehicle miles.	IEA's *Saving Oil in a Hurry*

Buildings Programs

BAU Scenario Calculations

Stationary Energy BAU Emissions

- Obtained national projections for annual stationary electricity, natural gas, propane, and diesel consumption (in quads) for 2019-2050 from EIA's *Annual Energy Outlook 2020* and calculated annual percent change.
- Using Denver's 2019 electricity, natural gas, propane, and diesel consumption as the base year, projected annual consumption of these fuels to the year 2050 by applying the annual percent changes from the national dataset.
- Used Denver's total annual electricity, natural gas, propane, and diesel consumption to calculate stationary energy emissions from these fuel types for 2020-2050 by applying the same methodology as the 2019 Denver GHG Inventory.

Fugitive BAU Emissions

- Used Denver's total annual natural gas consumption (estimated above) to calculate fugitive emissions from natural gas leakage, and natural gas production, transmission, and venting and flaring, for 2020-2050 by applying the same methodology as the 2019 Denver GHG Inventory.

Data	Assumption	Source
Projected Annual Stationary Electricity, Natural Gas, Propane, and Diesel Consumption	Denver's total annual stationary electricity, natural gas, propane, and diesel consumption is assumed to grow in proportion to national-level projections from EIA's *Annual Energy Outlook 2020*. Denver's multi-family sector estimates are assumed to grow in proportion to national-level residential sector estimates.	EIA's *Annual Energy Outlook 2020*
Projected Annual Electricity CO_2 Emission Factor	The carbon intensity of Denver's electricity grid is assumed to decrease over time due to a mandate requiring the regional utility, Xcel Energy, to reduce their total CO_2 emissions 80% by 2030 and 100% by 2050 (using 2005 as a baseline). Projected annual Xcel CO_2 emission factors were provided by CASR.	CASR Analysis of Xcel's System Decarbonization
Stationary Energy and Fugitive Emissions Calculation Methodologies and Emission Factors	Assumed no changes in the methodologies or non-CO_2 emission factors used to calculate stationary energy and fugitive emissions over time.	2019 Denver GHG Inventory

Programs for Improved Insulation Calculations

Weatherization Incentive Program

User Inputs
Annual investment in weatherization subsidy program ($ per year)
Year implemented

- Obtained average weatherization cost per unit from the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy *Weatherization Assistance Program (WAP) Fact Sheet*.
- Obtained average annual non weatherized home energy use for residential homes in Colorado from EIA's Electric Sales, Revenue, and Average Price data.

- Obtained average percent decrease in energy use post-weatherization from the National Renewable Energy Lab's (NREL) *WAP Fact Sheet*.
- Calculated total annual electricity emissions reduced for 2019-2050 from a weatherization incentive program as follows:

$$Total\ Annual\ Emissions\ Reduction\ from\ Policy\ = ([Annual\ Investment\ in\ Weatherization\ Subsidy\ Program] \div [Average\ Weatherization\ Cost\ per\ Unit]) \times [Average\ Annual\ Non\ Weatherized\ Home\ Energy\ Use] \times [Average\ \%\ Decrease\ in\ Energy\ Use\ Post\ Weatherization] \times [Grid\ Electricity\ EF]$$

Data	Assumption	Source
Average Weatherization Cost Per Unit	Assumed all single-family residential homes have the same average weatherization cost per household ($4,695).	U.S. DOE's Office of Energy Efficiency and Renewable Energy *WAP Fact Sheet*
Average Annual Non Weatherized Home Energy Use	Assumed all non weatherized single-family residential homes have the same annual energy use corresponding to the state average (8,184 kWh/year)	EIA's Electric Sales, Revenue, and Average Price data (Table 5a)
Average Percent Decrease in Energy Use Post-Weatherization	Assumed all single-family residential homes experience the same reduction in energy use post-weatherization (35%).	NREL's *WAP Fact Sheet*
Grid Electricity Emission Factor	Assumed same annual grid electricity emission factor as the BAU scenario ($mtCO_2e$/MWh).	2019 Denver GHG Inventory

Thermal Electrification Incentives Calculations

Electric Heat Pump Incentive Program

User Inputs
Annual investment in electric heat pump subsidy program ($ per year)
Total value of electric heat pump incentive ($ per household)
Year implemented

- Obtained average annual electricity use from electric heat pumps from the American Council for an Energy-Efficiency Economy's (ACEEE) *Comparative Energy Use of Residential Gas Furnaces and Electric Heat Pumps* report.
- Average annual replaced gas use from installing an electric heat pump is assumed to be equal to the average annual residential gas use for heating and cooling for the state of Colorado, obtained from the American Gas Association.
- Calculated total annual emissions reduced for 2019-2050 from an electric heat pump incentive program as follows:

$$\begin{gathered} Annual\ Emissions\ Reduction\ from\ Natural\ Gas\ Use\ = \\ ([Annual\ Investment\ in\ Electric\ Heat\ Pump\ Subsidy\ Program]\ \div \\ [Total\ \$\ Value\ of\ Electric\ Heat\ Pump\ Incentive\ per\ Household]) \\ \times [Average\ Annual\ Replaced\ Gas\ Use] \\ \times [Natural\ Gas\ EF] \end{gathered}$$

$$\begin{gathered} Annual\ Emissions\ Increase\ from\ Electricity\ Use\ = \\ ([Annual\ Investment\ in\ Electric\ Heat\ Pump\ Subsidy\ Program]\ \div \\ [Total\ \$\ Value\ of\ Electric\ Heat\ Pump\ Incentive\ per\ Household])\ \times \\ [Average\ Annual\ Electricity\ Use\ from\ Electric\ Heat\ Pumps] \times [Grid\ Electricity\ EF] \end{gathered}$$

$$\begin{gathered} Total\ Annual\ Emissions\ Reduction\ from\ Policy\ = \\ [Annual\ Emissions\ Reduction\ from\ Natural\ Gas\ Use]\ + \\ [Annual\ Emissions\ Increase\ from\ Electricity\ Use] \end{gathered}$$

Data	Assumption	Source
Average Annual Electricity Use from Electric Heat Pumps	Assumed all single-family residential homes have the same average annual electricity use from electric heat pumps corresponding to the state average ($9,098/year).	ACEEE's Comparative Energy Use of Residential Gas Furnaces and Electric Heat Pumps report (Table A1)
Average Annual Replaced Gas Use	Assumed annual replaced gas use from installing an electric heat pump is equal to the average annual residential gas use for heating and cooling for the state of Colorado (81,600,000 Btu/year).	American Gas Association
Grid Electricity Emission Factor	Assumed same annual grid electricity emission factor as the BAU scenario ($mtCO_2e$/MWh).	2019 Denver GHG Inventory
Natural Gas Stationary and Fugitive Emission Factor	Assumed same annual emission factor for stationary and fugitive natural gas emissions as the BAU scenario.	2019 Denver GHG Inventory

Electric Water Heater Incentive Program

User Inputs
Annual investment in electric water heater subsidy program ($ per year)
Total value of electric water heater incentive ($ per household)
Year implemented

- Obtained average annual electricity use from electric water heaters and average annual replaced gas use from installing an electric water heater from the U.S. DOE's Office of Energy Efficiency and Renewable Energy's Energy Cost Calculator for Electric and Gas Water Heaters.
- Calculated total annual emissions reduced for 2019-2050 from an electric water heater incentive program as follows:

$$\begin{gathered} Annual\ Emissions\ Reduction\ from\ Natural\ Gas\ Use\ = \\ ([Annual\ Investment\ in\ Electric\ Water\ Heater\ Subsidy\ Program] \div \\ [Total\ \$\ Value\ of\ Electric\ Water\ Heater\ Incentive\ per\ Household]) \\ \times [Average\ Annual\ Replaced\ Gas\ Use] \\ \times [Natural\ Gas\ EF] \end{gathered}$$

$$\begin{gathered} Annual\ Emissions\ Increase\ from\ Electricity\ Use\ = \\ ([Annual\ Investment\ in\ Electric\ Water\ Heater\ Subsidy\ Program] \div \\ [Total\ \$\ Value\ of\ Electric\ Water\ Heater\ Incentive\ per\ Household]) \times \\ [Average\ Annual\ Electricity\ Use\ from\ Electric\ Water\ Heater] \times [Grid\ Electricity\ EF] \\ Total\ Annual\ Emissions\ Reduction\ from\ Policy\ = \\ [Annual\ Emissions\ Reduction\ from\ Natural\ Gas\ Use] + \\ [Annual\ Emissions\ Increase\ from\ Electricity\ Use] \end{gathered}$$

Data	**Assumption**	**Source**
Average Annual Electricity Use from Electric Water Heaters	Assumed all single-family residential homes have the same average annual electricity use from electric water heaters (4,750 kWh/year)	U.S. DOE's Office of Energy Efficiency and Renewable Energy's Energy Cost Calculator for Electric and Gas Water Heaters
Average Annual Replaced Gas Use	Assumed annual replaced gas use from installing an electric water heater is equal to the average annual residential gas use for water heaters (244 therms/year).	U.S. DOE's Office of Energy Efficiency and Renewable Energy's Energy Cost Calculator for Electric and Gas Water Heaters

Grid Electricity Emission Factor	Assumed same annual grid electricity emission factor as the BAU scenario ($mtCO_2e/MWh$).	2019 Denver GHG Inventory
Natural Gas Stationary and Fugitive Emission Factor	Assumed same annual emission factor for stationary and fugitive natural gas emissions as the BAU scenario.	2019 Denver GHG Inventory

Renewable Energy Programs

BAU Scenario Calculations

Electricity BAU Emissions

- Obtained national projections for annual stationary electricity use (in quads) for 2019-2050 from EIA's *Annual Energy Outlook 2020* and calculated annual percent change.
- Using Denver's 2019 electricity use as the base year, projected annual electricity use to the year 2050 by applying the annual percent changes from the national dataset.

Data	Assumption	Source
Projected Annual Stationary Electricity Use	Denver's total annual stationary electricity use is assumed to grow in proportion to national-level projections from EIA's *Annual Energy Outlook 2020*. Denver's multi-family sector estimates are assumed to grow in proportion to national-level residential sector estimates.	EIA's *Annual Energy Outlook 2020*
Projected Annual Electricity CO_2 Emission Factor	The carbon intensity of Denver's electricity grid is assumed to decrease over time due to a mandate requiring the regional utility, Xcel Energy, to reduce their total CO_2 emissions 80% by 2030 and 100% by 2050 (using 2005 as a baseline). Projected annual Xcel CO_2 emission factors were provided by CASR.	CASR Analysis of Xcel's System Decarbonization
Emissions Calculation Methodologies and Emission Factors	Assumed no changes in the methodologies or non-CO_2 emission factors used to calculate electricity emissions over time.	2019 Denver GHG Inventory

Community Solar Incentive Calculations

Community Solar Incentive Program

User Inputs
Annual investment in community solar purchase incentive program ($ per year)
Uptake of program (%)
Year implemented

- Obtained average dollar amount required to induce a customer to switch to community solar (in dollars per year) from CASR expert input.
- Calculated total annual number of people covered by program as:

$$Total\ Annual\ Number\ of\ People\ Covered\ by\ Program\ = \\ [Annual\ Investment\ in\ Community\ Solar\ Purchase\ Incentive\ Program]\ \div \\ [Average\ \$\ Amount\ Required\ to\ Induce\ Switch\ to\ Community\ Solar]$$

- Obtained projections for Denver's annual population for 2019-2050 from The Metro Denver Economic Development Corporation (Metro Denver EDC) and calculated annual BAU electricity use per capita (in kWh per person) by dividing annual BAU electricity use by annual population.
- Assumed that new solar PV installed from a community solar incentive program replaces fossil fuel electricity from the grid. Applied a constant grid electricity emission factor from 2005 (when the grid mix was primarily fossil fuels) to estimate annual emissions reductions from new solar PV installed, obtained from CASR.
- Calculated total annual electricity emissions reduced for 2019-2050 from a community solar incentive program as follows:

$$Total\ Annual\ Emissions\ Reduction\ from\ Policy\ = \\ [Annual\ Number\ of\ People\ Covered\ by\ Program]\ \times [Percent\ Uptake\ of\ Program]\ \times \\ [BAU\ Electricity\ Use\ per\ Capita]\ \times [2005\ Grid\ Electricity\ EF]$$

Data	Assumption	Source
Average $ Amount Required to Induce a Customer to Switch to Community Solar	Assumed all individuals living in multi-family residential homes have the same average dollar amount required to induce them to switch to community solar ($100/month).	CASR expert input
Annual Electricity Use per Capita	Assumed same annual electricity use per capita as the BAU scenario (kWh/person).	2019 Denver GHG Inventory and Metro Denver EDC

Grid Electricity Emission Factor	Assumed a constant grid electricity emission factor from 2005 (when the grid mix was almost all fossil fuels) to estimate annual emissions reductions from new solar PV installed, obtained from CASR (0.8387 $mtCO_2e/MWh$).	CASR expert input

Solar Purchase Incentives Calculations

Solar Rebate Program

User Inputs
Incentive amount for a system ≤ 5 kW ($/W)
Incentive amount for a system > 5 kW and ≤ 10 kW ($/W)
Incentive amount for a system > 10 kW and ≤ 20 kW ($/W)
Year implemented

- Obtained Denver's 2019 solar PV installed capacity (in MW) from Environment America's *Shining Cities 2020*. Assumed constant annual growth in solar PV installations, and a constant annual breakdown of system sizes: 46% ≤ 5 kW, 47% > 5 kW and ≤ 10 kW, and 6% > 10 kW and ≤ 20 kW, obtained from CASR expert input.
- Obtained the average cost for a residential solar PV system (in $/W) from Environment America's *Shining Cities 2020*, which was used to calculate the change in price for the three system sizes as a result of the incentives.
- Obtained the price elasticity of demand for solar PV installations from a Yale University, National Bureau of Economic Research, and University of Kansas study of Connecticut Green Bank solar incentives. Using an elasticity of -0.612, calculated the additional annual installed capacity for each of the three system sizes as follows:

$$Additional\ Annual\ Solar\ PV\ Installed\ Capacity\ from\ Rebate\ Program\ = [BAU\ Solar\ PV\ Installed\ Capacity] \times [\Delta\ Price\ from\ Incentive] \times [Price\ Elasticity\ of\ Demand]$$

- Assumed that new solar PV installed from a solar rebate program program replaces fossil fuel electricity from the grid. Applied a constant grid electricity emission factor from 2005 (when the grid mix was primarily fossil fuels) to estimate annual emissions reductions from new solar PV installed, obtained from CASR.
- Assumed a constant production factor for rooftop solar in Denver (kWh/kW), obtained from CASR expert input. Calculated total annual electricity emissions reduced for 2019-2050 from a solar rebate program as follows:

$$Total\ Annual\ Emissions\ Reduction\ from\ Policy\ = [Electricity\ Generation\ from\ New\ Installed\ Solar\ Capacity] \times [Production\ Factor] \times [2005\ Grid\ Electricity\ EF]$$

- Calculated total annual program cost for 2019-2050 from a solar rebate program as follows:

$$\begin{gathered}\mathit{Total\ Annual\ Program\ Cost}\\ = [\mathit{Additional\ Solar\ PV\ Installed\ Capacity\ from\ Rebate\ Program}] \times\\ [\mathit{Incentive\ Amount}]\end{gathered}$$

Data	Assumption	Source
Increase in solar PV installations from rebate program	The price elasticity of demand is -0.612. Assumed percent increase in solar PV installed capacity is equal to percent change in price multiplied by -0.612.	Yale University, National Bureau of Economic Research, and University of Kansas, "Hurdles and Steps: Estimating Demand for Solar Photovoltaics"
Average Cost for a Residential Solar PV System (DC)	Assumed constant average cost of a residential solar PV system ($2.65/W-DC).	Environment America's *Shining Cities 2020*
Annual Solar PV Installed Capacity	Denver's total annual solar PV installed capacity is assumed to grow 15 MW per year (DC), based on historical trends.	Base year 2019 Estimates from Environment America's *Shining Cities 2020*, and annual growth provided by CASR
Breakdown of System Sizes for Annual Solar PV Capacity	Assumed a constant annual breakdown of system sizes: 46% ≤ 5 kW, 47% > 5 kW and ≤ 10 kW, and 6% > 10 kW and ≤ 20 kW.	CASR expert input
Rooftop Solar PV Production Factor	Assumed constant production factor for residential rooftop solar PV system (1,400 kWh/kW).	CASR expert input
Grid Electricity Emission Factor	Assumed a constant grid electricity emission factor from 2005 (when the grid mix was primarily fossil fuels) to estimate annual emissions reductions from new solar PV installed, obtained from CASR (0.8387 $mtCO_2e$/MWh).	CASR expert input

Solar Permit Fee Reduction

User Inputs
Reduction in permit fees for solar installation (%)
Year implemented

- Obtained Denver's 2019 solar PV installed capacity (in MW) from Environment America's *Shining Cities 2020*. Assumed constant annual growth in solar PV installations, obtained from CASR expert input.
- Obtained the percent increase in solar PV installations from a reduction in permit fees from a Yale University, National Bureau of Economic Research, and University of Kansas study of Connecticut Green Bank solar incentives. A complete elimination of permit fees for solar installation is associated with a 1% increase in installations.
- Assumed that new solar PV installed from a solar rebate program replaces fossil fuel electricity from the grid. Applied a constant grid electricity emission factor from 2005 (when the grid mix was primarily fossil fuels) to estimate annual emissions reductions from new solar PV installed, obtained from CASR.
- Assumed a constant production factor for rooftop solar in Denver (kWh/kW), obtained from CASR expert input. Calculated total annual electricity emissions reduced for 2019-2050 from a solar permit fee reduction as follows:

$$Total\ Annual\ Emissions\ Reduction\ from\ Policy\ = [BAU\ Solar\ PV\ Installed\ Capacity] \times [Percent\ Increase\ in\ Solar\ PV\ Capacity\ from\ Permit\ Fee\ Reduction] \times [Production\ Factor] \times [2005\ Grid\ Electricity\ EF]$$

- Obtained the average reduction in system cost from permit fee reductions from a Yale University, National Bureau of Economic Research, and University of Kansas study of Connecticut Green Bank solar incentives. A 100% reduction in permit fees is associated with a \$0.05/W reduction in system cost.
- Calculated total annual program cost for 2019-2050 from a solar permit fee reduction as follows:

$$Total\ Annual\ Program\ Cost = [Additional\ Solar\ PV\ Installed\ Capacity\ from\ Rebate\ Program] \times [Average\ Reduction\ in\ System\ Cost\ from\ Permit\ Fee\ Reduction]$$

Data	Assumption	Source
Increase in solar PV installations from rebate program	A complete elimination of permit fees for solar installation is associated with a 1% increase in installations.	Yale University, National Bureau of Economic Research, and University of Kansas, "Hurdles and Steps: Estimating Demand for Solar Photovoltaics"
Average Reduction in Solar System Cost from Permit Fee Reduction	Assumed the same average reduction in solar system cost from permit fee reduction for all single-family residential homes (a 100% reduction is associated with a \$0.05/W reduction in system cost).	Yale University, National Bureau of Economic Research, and University of Kansas, "Hurdles and Steps: Estimating Demand for Solar Photovoltaics"

Annual Solar PV Installed Capacity	Denver's total annual solar PV installed capacity is assumed to grow 15 MW per year (DC), based on historical trends.	Base year 2019 Estimates from Environment America's *Shining Cities 2020*, and annual growth provided by CASR
Rooftop Solar PV Production Factor	Assumed constant production factor for residential rooftop solar PV system (1,400 kWh/kW).	CASR expert input
Grid Electricity Emission Factor	Assumed a constant grid electricity emission factor from 2005 (when the grid mix was almost all fossil fuels) to estimate annual emissions reductions from new solar PV installed, obtained from CASR (0.8387 mtCO_2e/MWh).	CASR expert input

Appendix D. List of Relevant Equity Literature Review Resources

This section provides a list of our literature review of relevant equity-related efforts in local governments, states, and organizations. Some of these efforts are focused on climate equity specifically, while many are focused more broadly on incorporating equity into city policies and operations. The resources shown here were used in applying key lessons to the development of our Denver Climate Equity Framework. This literature review was intended to be complementary to the case study analysis, and thus excludes resources from the cities analyzed as case studies.

Equity Literature Review Resources
Organization: International Council for Local Environmental Initiatives (ICLEI) **Resource:** Five Milestones of Emissions Management
Organization: Baltimore, Maryland **Resource:** Equity Assessment Program
Organization: Urban Sustainability Directors Network **Resource:** Equitable, Community-Driven Climate Preparedness Planning
Organization: Atlanta Regional Commission (ARC) **Resource:** Interactive Equity Analysis Tool and Data
Organization: Race Forward for the Zero Cities Project (Michigan) **Resource:** Equity Assessment Tool
Organization: University of California, Berkeley **Resource:** Advancing Equity in California Climate Policy
Organization: American Council for an Energy-Efficient Economy (ACEEE) **Resource:** Equitable Climate Action and Energy Planning
Organization: Journal Article (Journal of Planning Education and Research) **Resource:** Assessing Equity in Local Climate and Sustainability Plans in U.S. Cities
Organization: Association of Bay Area Governments; Metropolitan Transportation Commission **Resource:** Bay Area Equity Analysis Report
Organization: U.S. Environmental Protection Agency **Resource:** EJSCREEN (Environmental Justice Screening and Mapping Tool)
Organization: Government Alliance on Race and Equity (GARE) **Resource:** Tools and Resources

Appendix E. List of Equity Indicators by Source

The table below shows the 21 equity indicators used in our Denver Climate Equity Mapping Tool, separated by source.

Equity Indicator Name	Description	Unit
Denver Open Data Catalogue: Census Tracts (2010)		
Average Household Size	Average size of a household	People
Median Age	Median age of the population	Age
Owned Housing Units	Number of owner occupied housing units	Housing Units
Percent American Indian	Percent of non-Hispanic American Indian in the population	Percent
Percent Asian	Percent of non-Hispanic Asian in the population	Percent
Percent Black	Percent of non-Hispanic Black in the population	Percent
Percent Hispanic	Percent of the population of Hispanic origin	Percent
Percent Two or More	Percent non-Hispanic of two or more races	Percent
Percent White	Percent of non-Hispanic White in the population	Percent
Population	Population in 2010	People
Rented Housing Units	Number of rented housing units	Housing Units
Opportunity Atlas (Neighborhood Characteristics)		
Census Response Rate Social Capital Proxy	Fraction of 2010 Decennial Census forms returned by mail, a proxy for social capital	Fraction
Density of Jobs in 2013	Number of jobs per square mile in 2013	Jobs per Square Mile
Foreign-Born Share in 2012-16	Fraction of residents born outside the U.S. 2012-16	Fraction
Fraction College Graduates in 2012-16	Fraction of residents over age 25 with a college degree 2012-16	Fraction
Fraction Non-White in 2010	Fraction of residents who self-identify as a race/ethnicity other than white non-Hispanic	Fraction

Fraction Single Parents in 2012-16	Fraction of children growing up in single-parent families 2012-16	Fraction
Fraction with Short Work Commutes in 2012-16	Fraction of residents who commute fewer than 15 minutes to work in 2012-16	Fraction
Job Growth Rate from 2004 to 2013	Average annualized job growth rate from 2004 to 2013	Growth Rate
Median Household Income of Residents in 2012-16	Median household income in 2016	Dollars
Median Rent 2012-16	Median rent in this area between 2012-16	Dollars
Population Density in 2010	Number of residents per square mile in 2013	People per Square Mile
Poverty Rate in 2012-16	Fraction of residents below the federal poverty line in 2012-16	Fraction

References

"2016 National Transit Summary and Trends," 2016, 59.

"2018 Equity Indicators Full Report." Accessed February 11, 2021. https://cao94612.s3.amazonaws.com/documents/2018-Equity-Indicators-Full-Report.pdf.

"A Better Future, A Better Now: 2018-2020 Strategic Plan." City of Portland, Bureau of Planning and Sustainability. Accessed February 11, 2021. https://www.portland.gov/sites/default/files/2019-05/bps-strategic-plan.pdf.

ACEEE: American Council for an Energy-Efficient Economy. "Equitable Climate Action and Energy Planning." American Council for an Energy-Efficient Economy. Accessed March 30, 2021. https://database.aceee.org/city/equitable-climate-action.

Advisors, Estolano, and Better World Group. "State of Oregon Climate Equity Blueprint," n.d., 24.

"Annual Energy Outlook 2020." Accessed February 3, 2021. https://www.eia.gov/outlooks/aeo/.

APTAAdmin. "Benefits of Public Transportation." *American Public Transportation Association* (blog). Accessed February 4, 2021. https://apta.com/research-technical-resources/transit-statistics/benefits-of-public-transportation/.

Armstrong, Michael, Michele Crim, Kyle Diesner, Ingrid Fish, Tim Lynch, Faduma Ali, Bill Beamer, et al. "City of Portland and Multnomah County Climate Action Plan Project Team," n.d., 20.

Association of Bay Area Governments, and Metropolitan Transportation Commission. "Bay Area Equity Analysis Report." Accessed March 30, 2021. https://mtc.ca.gov/sites/default/files/A-04_FINAL_PBA_Equity_Analysis_Report.pdf.

Atlanta Regional Commission (ARC). "Interactive Equity Analysis Tool and Data (Formerly ETAs)." Accessed March 30, 2021. https://opendata.atlantaregional.com/documents/GARC::interactive-equity-analysis-tool-and-data-formerly-etas/explore.

Baker, Shalanda, Subin DeVar, and Shiva Prakash. "The Energy Justice Workbook," December 2019. https://iejusa.org/wp-content/uploads/2019/12/The-Energy-Justice-Workbook-2019-web.pdf.

Baltimore. "Baltimore Sustainability Plan: Equitable Implementation." Accessed February 7, 2021. https://www.baltimoresustainability.org/wp-content/uploads/2019/02/Sustainability-Plan_Ch6-Ch7.pdf.

Baltimore City Code. "Subtitle 39: Equity Assessment Program," December 6, 2019. https://civilrights.baltimorecity.gov/sites/default/files/Art.%201%2039-1.pdf.

Brandeis University. “Our Social Justice Definitions.” Accessed March 28, 2021. https://www.brandeis.edu/diversity/resources/definitions.html.

“The Broader Connection between Public Transportation, Energy Conservation and Greenhouse Gas Reduction.” ICF International. Accessed February 4, 2021. https://mk0aptacoma227k83f08.kinstacdn.com/wp-content/uploads/Resources/resources/reportsandpublications/Documents/land_use.pdf.

“Bureau of Planning and Sustainability FY 2021-22 Requested Budget.” Accessed February 11, 2021. https://www.portlandoregon.gov/cbo/article/780702.

Cambridge Systematics, and Moving Cooler Steering Committee, eds. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Washington, D.C: Urban Land Institute, 2009.

Carley, Sanya, Tom P. Evans, Michelle Graff, and David M. Konisky. “A Framework for Evaluating Geographic Disparities in Energy Transition Vulnerability.” *Nature Energy* 3, no. 8 (August 2018): 621–27. https://doi.org/10.1038/s41560-018-0142-z.

City and County of Denver / Office of Climate Action, Sustainability, and Resiliency (CASR). “Denver Final 2019 GHG Inventory,” n.d.

City and County of Denver. “Ballot Measure 2A: Climate Funding.” Accessed February 16, 2021. https://www.denvergov.org/content/denvergov/en/denver-decides/ballot-issues/ballot-measure-2A.html.

“The City Clean Energy Scorecard.” ACEEE: American Council for an Energy-Efficient Economy, 2020. https://www.aceee.org/local-policy/city-scorecard.

City of Oakland. “2030 Equitable Climate Action Plan (ECAP).” Accessed February 11, 2021. https://www.oaklandca.gov/resources/oakland-2030-equitable-climate-action-plan-ecap.

City of Oakland. “Oakland 2030 Equitable Climate Action Plan (ECAP).” Accessed February 7, 2021. https://www.oaklandca.gov/projects/2030ecap.

“City of Portland: Promising Practices in Government to Advance Racial Equity.” Accessed February 11, 2021. https://www.portlandoregon.gov/oehr/article/564991.

“City of Portland and Multnomah County Climate Action Through Equity,” July 12, 2016. https://www.portland.gov/sites/default/files/2019-07/cap-equity-case-study-web29jul.pdf.

“Climate Action Plan: Local Strategies to Address Climate Change,” June 2015. https://www.portland.gov/sites/default/files/2019-07/cap-2015_june30-2015_web_0.pdf.

"Climate Action Plan Progress Report." City of Portland Oregon and Multnomah County. Accessed February 11, 2021. https://www.portland.gov/sites/default/files/2019-07/cap_progress-report2017_web.pdf.

"Climate Change Preparation Strategy: Risk and Vulnerabilities Assessment." City of Portland Oregon and Multnomah County. Accessed February 11, 2021. https://www.portland.gov/sites/default/files/2019-07/risk-vulnerabilities-assessment-press.pdf.

"Climate Change Preparation Strategy." Accessed February 11, 2021. https://www.portland.gov/sites/default/files/2019-07/climate-change-prep-strat-press.pdf.

Colorado Department of Public Health & Environment. "Colorado Greenhouse Gas Reports." Accessed January 26, 2021. https://cdphe.colorado.gov/colorado-greenhouse-gas-reports.

Colorado General Assembly. "HB19-1261 Climate Action Plan To Reduce Pollution." Colorado Legislature. Accessed January 26, 2021. https://leg.colorado.gov/bills/hb19-1261.

Denver Department of Public Health & Environment. "Denver Neighborhood Equity Index: ArcGIS StoryMap," n.d. https://geospatialdenver.maps.arcgis.com/apps/MapJournal/index.html?appid=2f30c73e83204e96824a14680a62a18e.

Denver Department of Public Health and Environment. "Denver 80x50 Climate Action Plan," July 2018.

Denver Office of Climate Action, Sustainability, and Resiliency. "About Our Office." Denver Office of Climate Action, Sustainability, and Resiliency. Accessed January 26, 2021. https://www.denvergov.org/Government/Departments/Climate-Action-Sustainability-Resiliency/About.

"Denver Open Data Catalog: Census Tracts (2010)." Denver. Accessed March 28, 2021. https://www.denvergov.org/opendata/dataset/city-and-county-of-denver-census-tracts-2010.

"Denver Open Data Catalog: Greenhouse Gas Inventories." Denver. Accessed January 26, 2021. https://www.denvergov.org/opendata/dataset/greenhouse-gas-inventories.

"Embedding Environmental Justice into the Washington State Department of Ecology." Accessed February 4, 2021. https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/45590/Embedding%20Environmental%20Justice%20into%20the%20Washington%20State%20Department%20of%20Ecology.pdf?sequence=2&isAllowed=y.

Energy.gov. "Low-Income Energy Affordability Data (LEAD) Tool." Accessed March 28, 2021. https://www.energy.gov/eere/slsc/maps/lead-tool.

Eng, Tiffany. "CalEnviroScreen: A Critical Tool for Achieving Environmental Justice in California," n.d., 60.

"Equity and the Portland Plan." Accessed February 11, 2021. https://www.portlandonline.com/portlandplan/index.cfm?c=52630.

"Equity Toolkit Decision Support Tool." Accessed February 11, 2021. https://www.portland.gov/sites/default/files/2020-02/equity-toolkit-decision-support-tool.pdf.

"Facts Figures Pocket Guide 2020." Accessed February 4, 2021. https://www.rtd-denver.com/sites/default/files/files/2021-01/Facts_Figures_Pocket_Guide_2020.pdf.

"FY 2020-21 Guide to the Budget Equity Assessment Tool | The City of Portland, Oregon." Accessed February 11, 2021. https://www.portlandoregon.gov/oehr/80164.

Government Alliance on Race and Equity. "Tools & Resources." Accessed March 30, 2021. https://www.racialequityalliance.org/tools-resources/.

ICLEI USA. "Five Milestones of Emissions Management." *ICLEI USA* (blog). Accessed February 7, 2021. https://icleiusa.org/programs/emissions-management/5-milestones/.

Litman, Todd. "How Prices and Other Factors Affect Travel Behavior," n.d., 79.

"Mosaic Decrease or Eliminate Transit Fares." Accessed February 3, 2021. https://www.oregon.gov/ODOT/Planning/Documents/Mosaic-Decrease-or-Eliminate-Transit-Fares.pdf.

"Neighborhood Equity & Stabilization (NEST)." Denver. Accessed March 28, 2021. https://www.denvergov.org/Government/Departments/Economic-Development-Opportunity/Neighborhood-Equity.

"Oakland 2030 Equitable Climate Action Plan." City of Oakland, July 2020. https://cao-94612.s3.amazonaws.com/documents/Oakland-ECAP-07-24.pdf.

Oakland. "2030 Equitable Climate Action Plan: Racial Equity Impact Assessment & Implementation Guide." Accessed February 7, 2021. https://cao-94612.s3.amazonaws.com/documents/FINAL_Complete_EF-Racial-Equity-Impact-Assessment_7.3.2020_v2.pdf.

Ochsner, Evan. "Denver's Unique Sales Tax to Fight Climate Change Could Be a Blueprint for Future Action Nationwide." *The Colorado Sun*. October 22, 2020, sec. News. https://coloradosun.com/2020/10/22/denvers-unique-sales-tax-to-fight-climate-change-could-be-a-blueprint-for-future-action-nationwide/.

OEHHA. "CalEnviroScreen." Text. OEHHA, November 27, 2014. https://oehha.ca.gov/calenviroscreen.

"The Opportunity Atlas." Accessed March 28, 2021. https://opportunityatlas.org/.

"Oregon Department of Transportation : Greenhouse Gas Emissions Reduction Toolkit : Planning & Technical Guidance : State of Oregon." Accessed February 4, 2021. https://www.oregon.gov/ODOT/Planning/Pages/GHG-Toolkit.aspx.

"Oregon Greenhouse Gas Reduction Toolkit: Strategy Report." Oregon Sustainable Transportation Initiative. Accessed February 4, 2021. https://www.oregon.gov/odot/Planning/Documents/SR-Transit-Services-Facilities.pdf.

"OSE Racial Equity Toolkits - Environment | Seattle.Gov." Accessed February 11, 2021. https://www.seattle.gov/environment/equity-and-environment/equity-and-environment-initiative/racial-equity-toolkits#2019.

Ostar, Jonathan, Jose Rivera, Julia Meier, and Katie Sawicki. "Community Participants," 2016, 106.

"The Portland Plan Progress Report," 2017, 71.

Portland.gov. "About Planning and Sustainability (BPS)." Accessed February 11, 2021. https://www.portland.gov/bps/about-bps.

Portland.gov. "History and Key Documents of Climate Planning and Action in Portland." Accessed February 11, 2021. https://www.portland.gov/bps/climate-action/history-and-key-documents.

Portland. "ADM-18.31 - City's Equity Budget Tool and Racial Equity Plans." Racial Equity Goals and Strategies | The City of Portland, Oregon | Charter, Code and Policies. Accessed February 7, 2021. https://www.portlandoregon.gov/citycode/article/634752.

"Public Transportation's Role In Responding To Climate Change." Accessed February 11, 2021. https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/PublicTransportationsRoleInRespondingToClimateChange2010.pdf.

"Racial Equity Impact Assessment & Implementation Guide." Accessed February 11, 2021. https://cao-94612.s3.amazonaws.com/documents/FINAL_Complete_EF-Racial-Equity-Impact-Assessment_7.3.2020_v2.pdf.

"Racial Equity Implementation Guide." City of Oakland, Department of Race and Equity. Accessed February 11, 2021. https://www.baaqmd.gov/~/media/files/ab617-community-health/west-oakland/110619-mtg-files/nov-6-2019-equity-worksheet-pdf.pdf?la=en.

"Racial Equity Toolkit: Implementing Greenlining's Racial Equity Framework." The Greenlining Institute. Accessed February 11, 2021. http://greenlining.org/wp-content/uploads/2013/07/GLI-REF-Toolkit.pdf.

"Racial Equity Toolkit (RET) | The City of Portland, Oregon." Accessed February 11, 2021. https://www.portlandoregon.gov/oehr/71685.

"Racial Equity Toolkit - CivilRights | Seattle.Gov." Accessed February 4, 2021. https://www.seattle.gov/civilrights/what-we-do/race-and-social-justice-initiative/racial-equity-toolkit.

"Racial Equity Toolkit to Assess Policies, Initiatives, Programs, and Budget Issues." Seattle Race and Social Justice Initiative. Accessed February 4, 2021. https://www.seattle.gov/Documents/Departments/RSJI/Racial%20Equity%20Toolkit_FINAL_August2012_with%20new%20cncl%20districts(0).pdf.

Race Forward for the Zero Cities Project (Michigan). "Equity Assessment Tool." Accessed March 30, 2021. https://www.michigan.gov/documents/mpsc_old/Equity_Assessment_Tool_FINAL_1-17-19_681345_7.pdf.

"Regional Equity Atlas | The Portland Metro Region's Geography of Opportunity." Accessed February 11, 2021. http://www.equityatlas.org/.

"The Route to Carbon and Energy Savings: Transit Efficiency in 2030 and 2050." Accessed February 4, 2021. https://mk0aptacoma227k83f08.kinstacdn.com/wp-content/uploads/Resources/resources/reportsandpublications/Documents/Route_to_Carbon_and_Energy_Savings_TCRP_J11_Task9.pdf.

RTD - Denver. "Denver RTD Fares." Accessed February 4, 2021. https://www.rtd-denver.com/fares-passes/fares.

"Saving Oil in a Hurry." Text. Accessed February 3, 2021. http://www.oecd.ilibrary.org/energy/saving-oil-in-a-hurry_9789264109421-en.

Schlosberg, David. *Defining Environmental Justice: Theories, Movements, and Nature*. *Defining Environmental Justice*. Oxford University Press. Accessed February 8, 2021. https://oxford-universitypressscholarship-com.ezp-prod1.hul.harvard.edu/view/10.1093/acprof:oso/9780199286294.001.0001/acprof-9780199286294.

Schrock, Greg, Ellen M. Bassett, and Jamaal Green. "Pursuing Equity and Justice in a Changing Climate: Assessing Equity in Local Climate and Sustainability Plans in U.S. Cities." *Journal of Planning Education and Research* 35, no. 3 (September 1, 2015): 282–95. https://doi.org/10.1177/0739456X15580022.

"Seattle Environmental Equity Assessment Pilot: ArcGIS StoryMap." Accessed February 7, 2021. https://www.arcgis.com/apps/MapSeries/index.html?appid=4c14645fec154ae8978dc642c94b76ba.

"Seattle Equity & Environment Agenda." Accessed February 4, 2021. http://www.seattle.gov/Documents/Departments/OSE/Equity/SeattleEEAgenda.pdf.

Seattle Race and Social Justice Initiative. "Racial Equity Toolkit to Assess Policies, Initiatives, Programs, and Budget Issues." Accessed February 7, 2021. https://www.seattle.gov/Documents/Departments/RSJI/Racial%20Equity%20Toolkit_FINAL_August2012_with%20new%20cncl%20districts(0).pdf.

Simmons, Daisy. "What Is 'Climate Justice'?" Yale Climate Connections, July 29, 2020. https://yaleclimateconnections.org/2020/07/what-is-climate-justice/.

Swenson, Bree. "STEP Implementation Grant Solicitation, Appendix D: Scoring Criteria." California Air Resources Board, n.d.

U.S. Census Bureau. "Census Reporter: Making Census Data Easy to Use." Accessed February 7, 2021. https://censusreporter.org/.

"U.S. Census Bureau QuickFacts: Denver City, Colorado." Accessed January 25, 2021. https://www.census.gov/quickfacts/fact/table/denvercitycolorado/PST045219.

United States, National Research Council (U.S.), Transit Development Corporation, and Transit Cooperative Research Program, eds. *Traveler Response to Transportation System Changes*. 3rd ed. TCRP Report 95. Washington, D.C: Transportation Research Board, 2003.

United States Environmental Protection Agency. "EJSCREEN: Environmental Justice Screening and Mapping Tool." US EPA, September 3, 2014. https://www.epa.gov/ejscreen.

Urban Sustainability Directors Network. "Guide to Equitable, Community-Driven Climate Preparedness Planning," May 2017. https://www.usdn.org/uploads/cms/documents/usdn_guide_to_equitable_community-driven_climate_preparedness-_high_res.pdf.

Weisbrod, Glen, and Arlee Reno. "Economic Impact of Public Transportation Investment." American Public Transportation Association. Accessed February 4, 2021. https://mk0aptacoma227k83f08.kinstacdn.com/wp-content/uploads/Resources/resources/reportsandpublications/Documents/economic_impact_of_public_transportation_investment.pdf.

The White House. "FACT SHEET: President Biden Takes Executive Actions to Tackle the Climate Crisis at Home and Abroad, Create Jobs, and Restore Scientific Integrity Across Federal Government." Accessed March 30, 2021. https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/27/fact-sheet-president-biden-takes-executive-actions-to-tackle-the-climate-crisis-at-home-and-abroad-create-jobs-and-restore-scientific-integrity-across-federal-government/.