

RECOMMENDATIONS FOR IMPLEMENTING A CARBON TAX
IN BOULDER, COLORADO

by

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“While the city recognizes that Boulder’s actions are far too small to impact global greenhouse gas emissions trends, it also recognizes that the cost of inaction could be very high and that inaction represents a missed opportunity for saving money and improving the economic, environmental and social sustainability of the community.”

- City of Boulder, Climate Action Plan, 2006

“A well-designed carbon price is an indispensable part of a strategy for reducing emissions in an efficient way.”

- High-Level Commission on Carbon Prices, 2017

Executive Summary

The City of Boulder, Colorado is interested in revising or replacing its Climate Action Plan (“CAP”) tax, which currently taxes only electricity, with a more comprehensive carbon tax. In doing so, it could become the first city in the United States to implement an explicit tax on carbon. We examine how the City of Boulder, Colorado could structure a carbon tax to best meet its objectives of reducing greenhouse gas (GHG) emissions, encouraging renewable energy growth and energy efficiency initiatives, and raising a steady source of revenue to fund its ongoing climate programs.

The City of Boulder has a history of committing to reducing its greenhouse gas emissions. In 2006, the city published its Climate Action Plan to serve as a roadmap in the city’s efforts to achieve its emissions reduction goals. In the same year, the residents of Boulder approved a ballot measure to implement the CAP tax. The tax charges electricity consumers within Boulder at a set rate per unit of electricity consumed, to be collected by the local electric utility and dispersed to the city. The tax is currently set to expire in 2023. As this date approaches, the city is exploring options for revising or replacing the tax with a version that more closely approximates a traditional carbon tax, while maintaining a steady source of funding for the city.

Simply defined, carbon taxes are tax-based policy mechanisms that put a price on the emissions of greenhouse gases. In general, there are two primary purposes for implementing a carbon tax: 1) to raise revenues for government use, and 2) to incentivize the reduction of emissions of covered greenhouse gases by making it more expensive to engage in activities that create emissions. At a minimum, carbon taxes typically apply to the emissions of carbon dioxide but may also be applied to other contributing gases, such as methane, nitrous oxide, and others. In practice, carbon taxes are often applied to fossil fuel consumption in proportion to the carbon content of those fuels. In this way, fuels with higher carbon contents, such as coal and oil, are taxed at higher rates than less emissions-intensive fuels, such as a natural gas or renewables.

In order to assist Boulder in their efforts to revise or replace their current CAP tax with a version that more closely approximates a traditional carbon tax, we researched existing carbon taxes across the globe to learn how their policies were designed and what worked well in different contexts. From this research, we developed policy design options for the city to consider, which we present along with a review of their respective advantages and disadvantages. Next, we conducted a review of the regulatory framework in Boulder, Colorado in order to determine which options may be legally feasible for the city to implement, and where the city may be constrained by state or federal limitations on municipal taxation authorities. Finally, we developed a tool in Microsoft Excel to model various carbon-pricing scenarios in order to determine the expected emissions reductions, revenues, and consumer impacts of different policy design options at different tax rates.

Through this process, we were able to identify the following two priority areas for the city to consider in revising their current CAP tax:

1) Adjusting the tax rate to account for the emissions intensity of the source

Boulder's current CAP tax applies to electricity consumption but is not explicitly scaled to the emissions intensity of the electricity on the grid. Tying the tax rate to the emissions intensity of the local grid would allow the city to more accurately reflect the damages associated with emissions of greenhouse gases into the atmosphere in the price of electricity. It would also produce a price signal that is responsive to the emissions intensity of the grid over time, which is important for incentivizing fuel switching from higher-emission fuels, such as natural gas for heating, to electricity as the grid becomes cleaner.

2) Incorporating other sources of emissions

The current CAP tax does not include emissions from non-electric emissions sources, such as natural gas burned for heating and industrial purposes, transportation, or waste management. Based on our analysis of the emissions makeup of the city, in addition to our analysis of the legal authorities of the city to implement various policy options, we recommend that the city consider incorporating a tax on natural gas. Incorporating a tax on natural gas would cover a wider range of the city's emissions (70% versus 50% covered under an electricity-only tax) and would prevent revenue from declining over time as renewables are incorporated onto the grid.

Finally, our assessment indicates that taxing transportation at the city level is not feasible at this time. The city does not have the authority to tax motor vehicle fuels directly and other options would be expensive to administer and offer a less tangible link between the taxed activity and actual emissions. We therefore recommend pursuing regional or state-level regulation to address greenhouse gas emissions from the transportation sector.

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List of Acronyms

CAA	Clean Air Act
CAFE	Corporate Average Fuel Economy
CAP	Climate Action Plan
CAPC	Climate Action Plan Committee
CPP	Clean Power Plan
EGU	Electricity Generating Unit
EIA	U.S. Energy Information Administration
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
NSR	New Source Review
TfL	Transport for London
TMF	Transportation Maintenance Fee
VMT	Vehicle Miles Traveled

Introduction

Project Overview

The City of Boulder, Colorado is interested in revising or replacing its Climate Action Plan tax, which currently taxes only electricity, with a more comprehensive carbon tax. In doing so, it could become the first city in the United States to implement an explicit tax on carbon. In this report we examine how the City of Boulder, Colorado could structure a carbon tax to best meet its objectives of reducing greenhouse gas (GHG) emissions, encouraging renewable energy growth and energy efficiency initiatives, and raising a steady source of revenue to fund its ongoing climate programs.

Our objective is to examine the current state of carbon tax policy worldwide, drawing on case studies and the experiences of local jurisdictions, to pinpoint the components of a successful city-scale carbon tax in order to best inform Boulder’s policy-planning process. We then use the results of our research and analysis to propose several specific policy options for Boulder to consider when revising or replacing the existing CAP tax. These recommendations consider pricing proposals for electricity, natural gas, and transportation, and include analyses of factors such as administrative costs and expected revenues and emissions reductions under certain taxation scenarios.

Background

The City of Boulder, Colorado represents a community well suited for climate action. The city is located near Denver along the foothills of the Rocky Mountains. Boulder has a population of just over 100,000 people, and is expected to experience continued population growth (Figure 1).¹²³ Citizens of Boulder are highly educated; approximately 70% of residents have a bachelor's degree or higher.⁴ The City of Boulder is also home to the University of Colorado, as well as federal laboratories, such as the National Center for

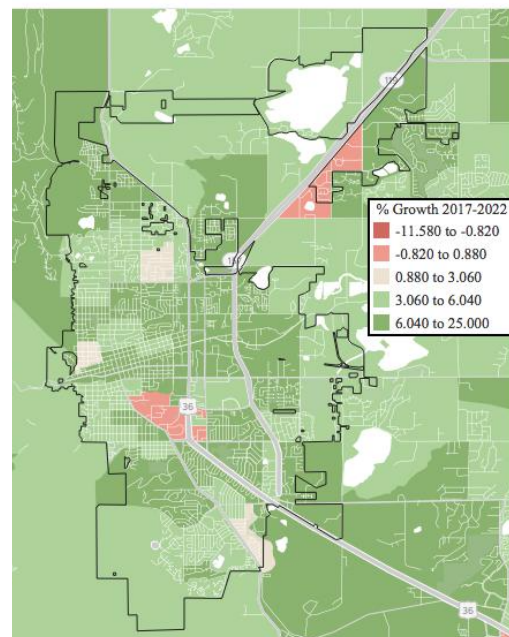


Figure 1: City limits and projected population growth (created in Tableau using data from the City of Boulder and the US Census Bureau).

¹ Alejandro Henao et al., “Sustainable Transportation Infrastructure Investments and Mode Share Changes: A 20-Year Background of Boulder, Colorado,” *Transport Policy* 37 (2015): 64–71.

² City of Boulder, “Boulder City Limits,” February 8, 2018, <https://bouldercolorado.gov/open-data/boulder-city-limits/>.

³ US Census Bureau, “TIGER Products,” accessed March 11, 2018, <https://www.census.gov/geo/maps-data/data/tiger.html>.

⁴ “Demographic & Economic Data for the Boulder Area,” *Boulder Economic Council* (blog), accessed November 23, 2017, <http://bouldereconomiccouncil.org/boulder-economy/demographic-economic-data/>.

Atmospheric Research and the National Oceanic and Atmospheric Administration.^{5,6} Some of the top employers in the area include companies like IBM, Covidien, and Ball Corporation.⁷ Boulder residents are well informed and the city has a long history of environmental activism.

This history of environmental activism led the city to launch its first formal climate change efforts in 2002 through a resolution to establish policies to “take cost-effective actions that benefit the community by reducing local greenhouse gas emissions.”⁸ Since 2002, the city has undertaken several actions to combat climate change including “enacting the country’s most stringent energy code for new buildings, developing a national model for delivering energy efficiency services, and adopting the country’s first voter-approved tax dedicated to addressing climate change, the Climate Action Plan (CAP) tax.”⁹ Further, since 2011 the City of Boulder has explored creating its own municipal electric utility (municipalization) as a path to transition to clean, local and renewable energy.¹⁰ In 2016, the Boulder City Council adopted the Climate Commitment, including goals of an 80% reduction in citywide greenhouse gas emissions below 2005 levels by 2050; an 80% reduction in the emissions from city operations below 2008 levels by 2030; 100% renewable electricity by 2030; and 100 MW of installed local renewable energy generation by 2030.¹¹

The CAP tax is one of the key policies that the City of Boulder has implemented to achieve these goals as it funds programs and services to reduce GHG emissions.

History of the CAP Tax

Boulder’s Climate Action Plan

In 2002, the City Council passed Resolution 906 directing the City Manager to develop an emissions reduction goal and plan for its implementation.¹² In order to align with the

⁵ “Key Industries & Companies in Boulder, Colorado,” *Boulder Economic Council* (blog), accessed November 23, 2017, <http://bouldereconomiccouncil.org/boulder-economy/key-industries-companies/>.

⁶ Brouillard and Van Pelt

⁷ Alicia Wallace, “Top 50 Employers in Boulder and Broomfield Counties: IBM Back on Top,” accessed January 16, 2018, http://www.dailycamera.com/ci_15589565.

⁸ “Resolution No. 906, Establishing a Policy to Take Cost-Effective Actions That Benefit the Community by Reducing Local Greenhouse Gas Emissions” (A Resolution of the City Council of the City of Boulder, 2002), https://www-static.bouldercolorado.gov/docs/City_Bldr_Resolution_906-1-201307081512.pdf.

⁹ “Boulder’s Climate Commitment,” accessed April 17, 2018, https://www-static.bouldercolorado.gov/docs/January_Climate_Commitment_Draft_1.17_low_res-1-201701241028.pdf?_ga=1.11780212.1109385281.1487195792.

¹⁰ “Boulder’s Climate Commitment,” accessed April 17, 2018, https://www-static.bouldercolorado.gov/docs/January_Climate_Commitment_Draft_1.17_low_res-1-201701241028.pdf?_ga=1.11780212.1109385281.1487195792. “Boulder’s Climate Commitment.”

¹¹ “Boulder’s Climate Commitment,” accessed November 23, 2017, <https://bouldercolorado.gov/climate>.

¹² City of Boulder’s Office of Environmental Affairs, “City of Boulder Climate Action Plan,” 2006.

terms of the Kyoto Protocol,¹³ the original target was set at a 7% reduction below 1990 GHG emissions levels by 2012.

In 2006, the City's Office of Environmental Affairs released the Climate Action Plan to serve as a roadmap in the city's efforts to achieve that goal.¹⁴ There are three main pillars to the Plan:

1. Increase energy efficiency;
2. Switch to renewable energy and vehicle fuels; and
3. Reduce vehicle miles traveled.

The Climate Action Plan was intended to build on existing City of Boulder goals and plans in the environmental sphere, such as the Boulder Valley Comprehensive Plan and the City Council's Environmental Goal "to enact and enhance city policies that cause the Boulder community to become a nationwide environmental leader among communities."¹⁵

Initial Funding for the Climate Action Plan

The City estimated that program costs for implementing the Climate Action Plan would range from approximately \$860,000 in 2006 to greater than \$1 million in 2012, for a cumulative cost of \$5.6 million over the seven-year period.¹⁶ Due to various factors, including declining city revenues and a lack of an existing source of internal funding to cover the costs of the Plan, the city determined that funding the Plan would require developing a new source of revenue.¹⁷

Temporary measures were used to initially support the goals of Resolution 906 and the Climate Action Plan. The City Council allocated \$100,000 from the City's General Fund for use in 2004 to develop a greenhouse gas inventory for the city. A two-year increase in the Trash Tax¹⁸ funded ongoing analysis and program development for the years 2005 and 2006.¹⁹ These sources served as stopgap measures as the city pursued a more permanent source of funding.

¹³ The Kyoto Protocol is an international treaty under the United Nations Framework Convention on Climate Change which committed developing countries to quantifiable emissions reductions from a 1990 baseline by 2012.

¹⁴ City of Boulder's Office of Environmental Affairs, "City of Boulder Climate Action Plan," 2006.

¹⁵ City of Boulder's Office of Environmental Affairs.

¹⁶ City of Boulder's Office of Environmental Affairs.

¹⁷ Brouillard and Van Pelt, "A Community Takes Charge: Boulder's Carbon Tax."

¹⁸ The City's Trash Tax is a volume-based tax on the amount of trash collected by trash haulers within the city limits. (City of Boulder's Office of Environmental Affairs, "City of Boulder Climate Action Plan.").

¹⁹ Brouillard and Van Pelt, "A Community Takes Charge: Boulder's Carbon Tax."

Selection of a Long-Term Funding Option

In 2005, the city hired an outside consulting team to research and provide recommendations on potential revenue sources that could meet the city's stipulated requirements for a more permanent funding source. The city required that the funding source(s) generate between \$1 and \$3 million general fund dollars annually and have a logical nexus to the programs being funded.²⁰

The consulting team analyzed a diverse array of funding sources and ultimately recommended thirteen options that they felt met the City of Boulder's requirements:

- “Establish a Boulder Energy Enterprise and Fee
- Create an annual Vehicle Sticker Fee
- Extend the Trash Tax
- Create a Renewable Energy Mitigation Program/ Renewable Energy Mitigation Fund
- Increase the Development Excise Tax
- Create a stand-alone Development Fee
- Increase certain Planning and Development Services fines
- Utilize Special Purpose Districts
- Increase the Admissions Tax
- Levy an Occupational Privilege (“Head”) Tax on employees and employers who work in Boulder
- Increase the Public Accommodations Tax
- Increase Parking Fines
- Utilize Grants and Intergovernmental Revenue Sources”

The consultants identified a variety of revenue sources including taxes, fees, and grants. Of the options presented above, the team recommended Option 1, a Boulder Energy Enterprise and Fee system, which would combine delivery of energy efficiency and renewable energy services with a fee-based structure for raising revenue.

The team further recommended that the City of Boulder consider adopting more than one of the recommended revenue options in order to avoid placing the burden of funding the Plan on a single sector or energy source.

Finally, the team suggested that the city consider allocating the portion of other existing fees and taxes that has a logical nexus to GHG emissions to the implementation of the Plan. This was recommended on the basis that it would institutionalize “GHG awareness in all City actions through the municipal budget process.”²¹

²⁰ The University of Colorado's Wirth Chair et al., “Report to the City of Boulder: An Analysis of Long-Term Funding Sources for Greenhouse Gas Emissions Management” (The City of Boulder, October 7, 2005).

²¹ The University of Colorado's Wirth Chair et al.

City staff sought input on these options from the Climate Action Plan Committee (CAPC) and the City Attorney's Office throughout the first half of 2006. Concurrent with this process, the details of the Climate Action Plan itself were in the process of being finalized. The consultation process with the CAPC revealed a number of limitations of the proposed revenue sources, including:²²

- Difficulty understanding the Boulder Energy Enterprise and Fee system
- Possible state preemption of a city Vehicle Sticker Fee
- Issues with funding building energy measures through a transportation-based fee
- Lack of sufficient nexus to GHGs from raising the Trash Tax
- Narrow focus and potentially limited ability to raise sufficient funds through a Renewable Energy Mitigation Program or a Development Excise Tax

Given these limitations, members of the CAPC put forward two additional proposals for long-term funding sources:

- A Local Energy Consumption Tax/ System Benefit Charge
- A Building Square Footage Fee²³

CAPC members generally supported the idea of a local energy consumption tax over a building square footage fee. City staff consulted with the current investor-owned utility serving Boulder on the process of collecting a charge from customers on the city's behalf. The utility agreed to levy the tax on Boulder's behalf and remit revenues to the city pending Boulder's financial commitment to upgrade the utility's billing system to allow for this additional charge. Finding this to be a viable option, city staff decided to pursue a local energy consumption charge. This would become the basis of the existing Climate Action Plan Tax.

The Climate Action Plan Tax

On November 7, 2006, residents of the City of Boulder voted to approve the Climate Action Plan Tax. In doing so, the city became the first in the nation to pass a municipal energy tax with the explicit goal of combating climate change.²⁴ In 2012, voters approved a five-year extension of the CAP Tax. Voters approved a second extension of the tax in 2015. The tax is currently set to expire on March 31, 2023.²⁵

The CAP tax is an electricity consumption tax that is assessed at differential rates by sector (e.g. residential, commercial, industrial). Residential consumers pay the highest rates per kilowatt-hour of electricity consumed, while industrial consumers pay the

²² These examples are drawn from (Brouillard and Van Pelt).

²³ In this proposal, building square footage would serve as a proxy for energy consumption.

²⁴ Brouillard and Van Pelt, "A Community Takes Charge: Boulder's Carbon Tax."

²⁵ Per the City of Boulder website, accessed March 2018. (<https://bouldercolorado.gov/climate/climate-action-plan-cap-tax>)

lowest rates (Table 1). Tax revenues are collected by Xcel Energy, which includes the tax as a line item on its pre-existing electricity billing system.

Table 1: CAP Tax Rates.

Residential	Commercial	Industrial
Minimum Taxation Rates (\$/kWh)		
\$0.0022	\$0.0004	\$0.002
Maximum Taxation Rates (\$/kWh) ²⁶		
\$0.0049	\$0.0009	\$0.0003

Structure of the Tax

The city chose to structure the electricity charge as a voter-approved tax instead of as a fee in order to demonstrate public support and to avoid potential legal difficulties associated with the passage of a fee. The key differences between a fee and a tax are that:²⁷

- **Fees** are passed by City Council, and must demonstrate an identifiable nexus between the source of revenue and its use; whereas
- **Taxes** require voter approval and offer the city more leeway with regards to the nexus between the revenue source and its use.

The local utility expressed a desire for any charge they levied upon their consumers to be voter-approved.

Taxation Rate Structure

In determining the rate structure for the CAP tax, City staff considered a number of pertinent factors, including:²⁸

- “The proportion of total emissions generated by each sector (e.g. residential, commercial, industrial, transportation, waste);
- The proportion of total emissions reductions expected to originate in each sector as a result of the Climate Action Plan;
- The proportion of total private investment in emissions reduction measures, such as energy efficiency and renewable energy, expected to originate in each sector;

²⁶ Maximum taxation rates were implemented in 2009.

²⁷ The Colorado Supreme Court ruled, in *Bloom v. City of Fort Collins* that, “[u]nlike a tax, a special fee is not designed to raise revenues to defray the general expenses of government, but rather is a charge imposed upon persons or property for the purpose of defraying the cost of a particular governmental service.” (*Bloom v. City of Fort Collins*, 784 P.2d 304 (Colo. 1989))

²⁸ Brouillard and Van Pelt, “A Community Takes Charge: Boulder’s Carbon Tax.”

- The proportion of total City investment in emissions reduction measures expected to be allocated to each sector through programs, services, or education;
- The impact on companies that have set emissions reductions targets;
- The negative impact on incentives for growth and increased production by industrial electricity customers;
- The expected proportion of utility efficiency rebates available to various sectors;
- The potentially limited ability for electricity users to reduce demand;
- The impact on low-income residents;
- The logistics of exempting customers of Xcel’s wind power program, Windsource, for the carbon-neutral electricity obtained through the program; and
- The inability to compensate customers of other Renewable Energy Credit markets.”

Based upon these considerations, Boulder City staff developed and considered three taxation rate structures:²⁹

- An **Emissions Allocation** Model, in which the taxation rate would be differentially set among sectors (e.g. residential, commercial, industrial) in order to equate the percent contribution to total emissions of each sector with the percent contribution to revenue raised under the tax;
- A **City Funding Allocation/ Revenue-Recycling** model, in which the taxation rate would be differentially set among sectors in order to equate the amount paid under the tax by each sector to the amount of investment that sector would receive through city programs funded by the tax; and
- A **Uniform Rate** model, in which the taxation rate would be set uniformly for all sectors, such that every household, business, or industrial facility would pay the same rate per unit of electricity consumed.

Each of these models was perceived as having advantages and disadvantages. A perceived disadvantage of the emissions allocation model is that it would have resulted in the industrial sector providing 20% of the revenue raised under the tax, while only receiving 3% of the funded investment.³⁰

Across all models, the city would reserve the ability to change rates from year to year in order to optimize revenues and outcomes under changing circumstances and design constraints, provided that they remained below pre-determined maximum rates.³¹

Ultimately, the city opted to pursue the city funding allocation/revenue-recycling model. This model would raise a greater percentage of the revenue from the residential sector

²⁹ Brouillard and Van Pelt.

³⁰ Brouillard and Van Pelt.

³¹ Brouillard and Van Pelt.

and was perceived as less burdensome to local industry.³² In order to address the added burden of the CAP tax on low-income households, city staff developed programs to help reduce electricity consumption in these residences, including household rebates for the purchase of energy-efficient appliances and weatherization.

Under the city funding allocation/revenue-recycling model, the tax rate is set so as to generate annual revenues approximately equal to the planned spending by the city on combined residential, commercial, and industrial investments in energy efficiency, renewable energy, and other covered programs. A disadvantage of this approach, from an emissions limitation perspective, is that could result in unclear price signals. For example, if citywide electricity consumption rises and planned city expenditures stay constant, then utilizing a strict city funding/revenue-recycling model would result in a lower tax rate in order to prevent revenues from exceeding planned city expenditures.³³

Project Approach and Methodology

The objective of our report is to make recommendations for how the City of Boulder could replace the CAP tax with a version that more closely approximates a classical carbon tax. To do this, we examine 1) how the city could more closely tie the rate of taxation to the GHG intensity of emissions and 2) how to incorporate other GHG emissions sources beyond electricity into the covered tax base.

In order to answer these questions, we have chosen to take a sector-by-sector approach, analyzing how a carbon tax could be designed in the electricity, natural gas, and transportation sectors in turn. We chose this approach because each sector has unique challenges and potential points of taxation.

Before analyzing individual sectors, we first overview best practices in designing carbon-pricing policies in general. We then assess the regulatory structure that exists at the city level in Colorado as part of our discussion of the authority that the City has to implement taxes in each sector. Next, we assess how a carbon tax could be designed specifically in each sector. We then present an overview of the considerations that the city might take into account when selecting a tax rate. Finally, we present a model to estimate how much revenue would be generated under different tax rate structures and prices and discuss next steps and areas for future research.

Best Practices in Designing a Carbon Tax

To inform our recommendations, we conducted a review of carbon tax policies worldwide. When designing a carbon tax policy there are many design options to consider, including: point of taxation, covered gases, starting tax rate, how quickly the

³² Brouillard and Van Pelt.

³³ Brouillard and Van Pelt.

rate will increase, and potential industry exemptions, among others. By examining other jurisdictions, we hoped to identify best-practices in other jurisdictions with carbon-pricing policies that can inform the design of an effective policy for Boulder.

The team looked at carbon tax policies at the national, regional, state levels, along with exploring carbon-pricing policies at private companies. Very few cities have attempted to implement explicit carbon pricing mechanisms. As a result, most of the recommendations and best practices for implementing carbon taxes have not been tailored to the municipal context. Nevertheless, there are lessons to be learned from the experience of existing national and regional policies.

A review of the policy literature on carbon pricing indicates that there are a number of attributes that tend to positively influence the successful implementation and public acceptance of carbon taxes:

- **Stability:** The High-Level Commission on Carbon Prices concludes that effective carbon-pricing policies require a credible commitment to maintaining a strong and stable price signal into the future. Short-term changes in carbon pricing are not likely to influence consumer behavior in the long run, nor will businesses likely redirect investment towards lower-carbon options without confidence that strong, credible carbon pricing signals will prevail for decades into the future. The efficacy of a carbon-pricing policy in spurring long-term behavioral change is therefore reliant on the ability of policymakers to choose a carbon-price trajectory that consumers believe to be politically durable.³⁴

Policymakers can build policy credibility through stakeholder engagement. Policies with strong political support and buy-in from local interest groups and economic organizations are more likely to be viewed as stable and credible by constituents. Additionally, policies that acknowledge and address distributional issues may also be viewed as having greater credibility.³⁵

- **Predictability:** Carbon pricing initiatives are believed to be most effective when policy pathways are not only stable, but also predictable and clearly conveyed.³⁶ Predictability of long-term pricing policies minimizes policy uncertainty and allows business and residents to make long-term decisions about how to balance consumption and investment in efficiency and other response measures over time.

Policy predictability is enhanced through transparency about the methods by which future carbon prices will be decided. Design features that offer the most

³⁴ High-Level Commission on Carbon Prices, “Report of the High-Level Commission on Carbon Prices” (Washington, D.C.: World Bank, 2017), <https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices/>.

³⁵ High-Level Commission on Carbon Prices.

³⁶ High-Level Commission on Carbon Prices.

predictability include pre-determined pricing schedules or set percentage increases in tax rates for the duration of the policy.³⁷

- **Flexibility:** While it is important to maintain predictability in future pricing pathways for the benefit of affected consumers, there are also benefits to allowing policymakers flexibility to respond to lessons learned and changing market conditions over time. Creating a built-in mechanism for monitoring and adjusting the policy design and pricing over time can allow for policymakers to correct for unexpected outcomes such as insufficient emissions reductions or unacceptably high costs.³⁸

Any price adjustment process should be transparent and clearly communicated to affected businesses and residents in order to minimize the effects of policy uncertainty. One option for balancing price flexibility with policy predictability is the establishment and communication of price “corridors,” or price ranges that may prevail in future periods.³⁹

Regulatory Framework

In this section, we provide an overview of the key provisions granting the authority to, or limiting the ability of, the City of Boulder to create a carbon tax. Although we highlight areas where preemption may occur, we cannot evaluate the legality of or potential legal challenges to taxation options. A comprehensive examination of the city's legal authority would require consultation with a legal professional.

Municipalities are granted limited regulatory authority and may experience a host of roadblocks from both federal and state preemption. The U.S. Constitution explicitly grants the federal government the ability to preempt state authority under Article VI, known as the Supremacy Clause.⁴⁰ States, in turn, may limit the authority granted to cities under their respective State Constitutions.

Preemption at the federal or state level can be express, such that the state explicitly forbids or grants rights to the city, or implicit, such that the state “occupies the field” leaving no room for city-level regulations. Cases of implicit preemption may be difficult to identify with certainty unless a court case has ruled on the question.

We first examine potential preemption issues at the Federal level before narrowing our scope to examine state-level preemption issues.

³⁷ Constraints on the language of ballot measures may limit the information can be conveyed with respect to long-term pricing schedules within the ballot measure itself.

³⁸ High-Level Commission on Carbon Prices, “Report of the High-Level Commission on Carbon Prices.”

³⁹ High-Level Commission on Carbon Prices.

⁴⁰ U.S. Const. art. VI

Federal Preemption: The Clean Air Act

The primary federal statute that we believe has a potential to conflict with a municipal carbon tax is the Clean Air Act (CAA). The CAA is a federal law that authorizes the U.S. Environmental Protection Agency (EPA) to regulate air pollution in the United States. Emissions from both stationary sources, such as power plants or factories, as well as mobile sources, including light duty vehicles, may be regulated under the CAA.

Historically, the CAA has been used to regulate air pollutants such as particulate matter (e.g. soot) or mercury which, when inhaled or ingested, directly harm human health. GHGs, which harm human health indirectly through the negative impacts of climate change, are not an obvious fit for regulation under the CAA. However, after lengthy litigation, in 2009, the EPA released an Endangerment Finding for six GHGs (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride). The issuance of the Endangerment Finding required EPA to regulate GHGs under the CAA.⁴¹

Since the Endangerment Finding, the EPA has promulgated several rules to regulate GHGs that may potentially preempt city-level efforts to create a tax on carbon. The following GHG source categories are currently regulated under the CAA:

1. New or modified stationary sources (e.g., new power plants)
2. Existing stationary sources (e.g., existing power plants)
3. Mobile sources (e.g., vehicle emissions)

As outlined in the introduction of this section, federal law may preempt both state and city regulations by either explicitly forbidding state and local regulation, or by implicitly forbidding regulation by “occupying the field” and leaving no room for further regulation.

In the next section, we provide a brief overview of how each source-category is regulated, including any potential implications for city-level GHG regulation efforts.

New Stationary Source Regulation (“New Source Review”, NSR): Currently, the EPA regulates GHG emissions from "new" sources, power plants that have yet to be built or power plants undergoing substantial modification, under the CAA Title 1 Section C "Prevention of Significant Deterioration of Air Quality" and the Title V Operating Permit Program.⁴² Permitted facilities are required to implement the Best System of Emission Reduction, which vary based on the type of electricity generating unit (EGU).

⁴¹ Environmental Protection Agency; Endangerment and Cause or Contribution Finding for Greenhouse Gasses Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 66,496 (Dec. 15, 2009) (codified at 40 C.F.R. Ch. I).

⁴² Standards of Performance for Greenhouse Gas Emissions From New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units, 80 Fed. Reg. 64,509 (Oct. 23, 2015) (codified at 40 C.F.R.).

There is currently some level of uncertainty about the future of these regulations. In December 2017, EPA Director Scott Pruitt released a memorandum that loosened reporting requirements for electric generating units, and the EPA called for comments on potential conflicts between existing source regulation and the current NSR standards.⁴³ These actions could indicate that the EPA will continue to make changes in NSR standards.

Because NSR standards only cover new or substantially modified EGUs, such standards are unlikely to interact with city-level regulations of electricity end-use.

Existing Stationary Source Regulation: The EPA passed the Clean Power Plan (CPP) in 2015 to regulate emissions from existing GHG sources. The original plan set state-level standards for GHG emissions, allowing states to develop their individual plans to meet emission standards among all power plants in the state.⁴⁴

However, the plan was stayed indefinitely in 2016 after West Virginia and ten other states challenged the constitutionality of the CPP.⁴⁵ As a result, the CPP was never implemented. The Trump Administration is now in the process of repealing the CPP, having issued a formal proposal of repeal in October 2017.⁴⁶

The EPA must still regulate GHG emissions under the CAA, thus requiring the Trump Administration to design a replacement policy for the CPP. The process for repealing and replacing the CPP is ongoing, though early indications suggest regulation will be limited to onsite efficiency measures. It is unknown at this time whether any potential replacement policy will preempt any state or city regulations related to climate change.

Mobile Sources: The EPA, in collaboration with the National Highway Traffic Safety Administration, regulates GHG mobile source emissions through the joint Corporate Average Fuel Economy (CAFE) and GHG standards. The CAFE program was originally enacted by Congress in 1975, and has been updated several times throughout history, with the most recent Obama-era changes setting fuel efficiency standards based on the vehicle's footprint size.⁴⁷ The regulation covers both light-duty vehicles (i.e., typical household vehicles) and medium to heavy vehicles (e.g., semi-trailer trucks, buses).⁴⁸ The stringency of the standards is set to increase over time.

⁴³ State Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Units, 82 Fed. Reg. 61,507 (proposed Feb. 26, 2018) (to be codified at 40 C.F.R. pt. 60).

⁴⁴ 40 C.F.R. § 60 (2015).

⁴⁵ *West Virginia v. EPA*, No. 15-1363 (D.C. Cir. filed Oct. 23, 2015).

⁴⁶ Approval and Promulgation of Air Quality Implementation Plans; Virginia; Amendment to Ambient Air Quality Standard for Ozone, 82 Fed. Reg. 48,035 (proposed Oct. 16, 2017) (to be codified at 40 C.F.R. pt. 52).

⁴⁷ 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg. 62,624 (Oct. 15, 2012) (codified at 40 C.F.R.).

⁴⁸ Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 2, 81 Fed. Reg. 73,478 (Oct. 25, 2016) (codified at 49 C.F.R.).

Under this program, automotive manufacturers are required to have the sales-weighted average fuel economy of their U.S. vehicle fleets meet CAFE efficiency standards. If they do not meet CAFE standards, the manufactures are subject to fines.⁴⁹

The CAFE standards may be subject to change under the Trump Administration or future Administrations. Furthermore, although experts believe the standards are feasible, the automotive industry has pushed back, claiming the standards may be unreasonable.⁵⁰ It is therefore unknown what the long-term impact of mobile source regulations may be.

Overall, much of the federal-level regulation of GHG emissions is very different than Boulder's proposal to implement a carbon tax. Nevertheless, the city should continue to work with legal professionals to ensure carbon tax measures are unlikely to face Federal preemption and follow developing changes in GHG regulation under the Trump Administration.

Home Rule Authority

The City of Boulder, under Article XX Section 6 of the Colorado Constitution, has the authority to pass and enforce laws that are local in nature.⁵¹ Such authority, referred to as “home rule,” is the primary basis under which Boulder may institute a carbon tax.

Broadly, home rule authority in Colorado allows the City to create rules that will not implicitly or explicitly regulate outside of the city’s borders.⁵² If the law is truly local in nature, it cannot be preempted by the state. In turn, the state may regulate all matters of statewide concern (Figure 2). For example, the City may regulate how property lines are assessed in-city but may not control regional roadways.

The line between a matter that is “purely local” versus “of state concern,” however, is not always clear. For example, rent control is not allowed under Colorado state law. On its face, it may seem plausible that the cost of living within the City limits is a matter of local concern. However, when

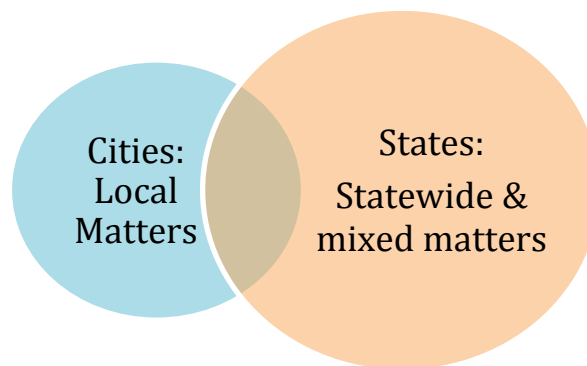


Figure 2: Colorado Home rule laws allow cities to govern in matters that are purely local in nature, whereas states have the authority to govern and preempt cities in matters of statewide concern as well as mixed local and state concerns.

⁴⁹ 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg. 62,624 (Oct. 15, 2012) (codified at 40 C.F.R.).

⁵⁰ Mark Fischetti, “Can U.S. Cars Meet the New 54 Mpg CAFE Standards? Yes They Can,” *Scientific American Blog Network* (blog), November 16, 2011, <https://blogs.scientificamerican.com/observations/can-cars-meet-the-new-54-mpg-cafe-standards-yes-they-can/>.

⁵¹ C.O. Const. art. XX § sect. 6

⁵² *People v. Hizhniak*, 195 Colo. 427, 579 P.2d 1131 (1978).

the town of Telluride, Colorado attempted to institute rent control laws, the court ruled that rent control “implicates both state and local interests, and therefore ... it is properly characterized as a ‘mixed’ concern.” The Court went on to find the town of Telluride’s ordinance invalid as being preempted by the state of Colorado.⁵³

To help untangle the state and local distinction, the Colorado Constitution has established the following three factors to determine if state interest is sufficient to preempt home rule authority:

- "1. Need for statewide uniformity and regulation;
2. Impact of municipal regulations on persons living outside municipality; and
3. Whether a particular matter is traditionally governed by state or local government."⁵⁴

These tests for state preemption are highly dependent on the historical and current context under which the regulation will be created. Therefore, the authority to levy a carbon tax is necessarily tied to the point of taxation, the purpose of the tax, and the practical impacts of such a tax.

In the following sections, we will provide a brief overview of the historical precedent for taxation along the major points of taxation: natural gas, electricity, and transportation.

Electricity Regulation

Colorado has a regulated electricity market, meaning that electric utilities are vertically integrated monopolies that own and control all levels of the supply chain, including generation, transmission, and distribution. Article XXV of the Colorado Constitution recognizes the Public Utilities Commission (PUC) as the governing body of public utilities and grants the PUC authority to regulate utility facilities, services, and rates.⁵⁵ Municipal utilities are exempt from PUC regulation because they operate as non-profit corporations.⁵⁶

The City of Boulder does not own or operate generation assets. It receives electricity from the local investor-owned utility. The City charter affirms that the electric utility shall have all the powers granted by state law to regulate electricity.⁵⁷ As long as the local utility continues to provide power to the City of Boulder, the City will require a partnership with the utility to implement a tax on electricity consumption. For instance, Xcel Energy worked with the City of Boulder to incorporate the current CAP tax as a line item on its electricity billing platform. The utility's cooperation will be required to implement any changes to the billing system required by any new carbon tax policy. If,

⁵³ Lot Thirty-Four Venture, L.L.C. v. Town of Telluride, 976 P.2d 303 (Colo. App. 1998).

⁵⁴ City & County of Denver v. State, 788 P.2d 764 (Colo. 1990).

⁵⁵ C.O. Const. art. XX § sect. 6

⁵⁶ “eGRID Summary Table 2016,” accessed February 26, 2018, https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf.

⁵⁷ Boulder, Colorado, Municipal Charter § 11-7-2

however, the city transitions to electricity service by a municipal or cooperative utility, it will neither require a partnership, nor be subject to PUC regulation.

Our analysis assumes the City will continue to be serviced by the local investor-owned utility, and a municipal tax will require a partnership. This is examined in greater detail in the proposed electricity tax strategies later in the report.

Natural Gas Regulation

Natural gas utilities, like electric utilities, are subject to PUC regulation in Colorado. However, Colorado has an unregulated natural gas market, as set forth by state law.⁵⁸ Under this statute, natural gas utilities may propose voluntary plans to separate natural gas supply from natural gas delivery for retail customers for the PUC to approve or reject.⁵⁹

For example, Xcel Energy, which owns and operates the natural gas pipeline infrastructure in Boulder, is required by law to allow customers the option of entering the competitive market by buying natural gas from any chosen provider, with Xcel providing the transportation and delivery services.⁶⁰ If the utility rejects the request for transportation service, it must provide detailed “reasons for the rejection and shall explain what changes are necessary to make the request acceptable.”⁶¹ The option to use a third party natural gas supplier is expected to be mainly exercised by commercial and industrial customers.

Xcel is the primary natural gas provider serving Boulder customers and operating the pipelines in the region, although other third-party retail providers exist. A tax on natural gas consumption would involve a partnership with all of these local natural gas providers.

A tax on natural gas would not require PUC approval. However, the City would not be allowed to gather data from Xcel on natural gas use from individuals, as this is in violation of PUC rules.⁶² Therefore, any imposed natural gas tax would need to determine a mechanism to tax customers without violating PUC regulations.

⁵⁸ 40 CO. Const. Amend. 2-122

⁵⁹ American Coalition of Competitive Energy Suppliers. 2018. “State-by-State Information.” <http://competitiveenergy.org/consumer-tools/state-by-state-links/#colorado>.

⁶⁰ “Gas Transportation,” Xcel Energy, accessed January 16, 2018, https://www.xcelenergy.com/energy_portfolio/natural_gas/gas_transportation.

⁶¹ 4 Code of Colorado Regulations §723-4

⁶² 4 Code Colo. Regs. §723-4

Transportation and Fuel Regulations

The amount of gasoline consumed by motor vehicles is directly connected to the amount of greenhouse gasses released into the atmosphere. A tax on gasoline consumption would be the most effective way to tax emissions in the transportation sector.⁶³

However, the City of Boulder is explicitly preempted from taxing vehicle fuels by the state of Colorado's Gasoline and Special Fuel Tax.^{64,65} Therefore, a fuel tax may not be implemented by the City. Furthermore, a law professional would need to examine if federal CAFE and GHG standards could preempt attempts to explicitly tax GHG tailpipe emissions from vehicles at the city-level.

In lieu of a gasoline tax, the City will have to pursue more creative options to tax GHG emissions from the transportation sector. Strategies may include taxing vehicle miles traveled, creating a congestion charge, or other methods. Because each strategy involves a unique point of taxation and may have separate preemption issues, we address those issues on an ad-hoc basis later in the report.

Boulder's Emissions Makeup

Boulder published its first GHG inventory in 2005 and has published updated inventories on several occasions since then. To create the GHG inventory, the City utilizes the Global Protocol for Community-Scale Greenhouse Gas Inventories, the recognized standard for greenhouse gas reporting.⁶⁶ In 2016, Boulder produced an estimated total of 1,598,426 metric tons of carbon dioxide equivalent (CO₂e).

The current CAP tax covers electricity emissions, representing about 50% of all emissions in Boulder (Figure 3). However, as previously outlined, the actual amount paid by the tax varies by type of customer. Residential customers, which emit about 18% of electricity emissions (9% of total emissions), pay a higher rate than industrial or commercial customers.

⁶³ David L. Greene, "What Is Greener than a VMT Tax? The Case for an Indexed Energy User Fee to Finance Us Surface Transportation," *Transportation Research Part D-Transport and Environment* 16, no. 6 (August 2011): 451–58, <https://doi.org/10.1016/j.trd.2011.05.003>.

⁶⁴ C.O. Rev. Stat. § 39 art.27.102 (2016).

⁶⁵ C.O. Rev. Stat. § 39 art.27.111 (2016).

⁶⁶ "Boulder's Community Greenhouse Gas Inventory," accessed December 19, 2017, <https://bouldercolorado.gov/climate/boulders-community-greenhouse-gas-inventory>.

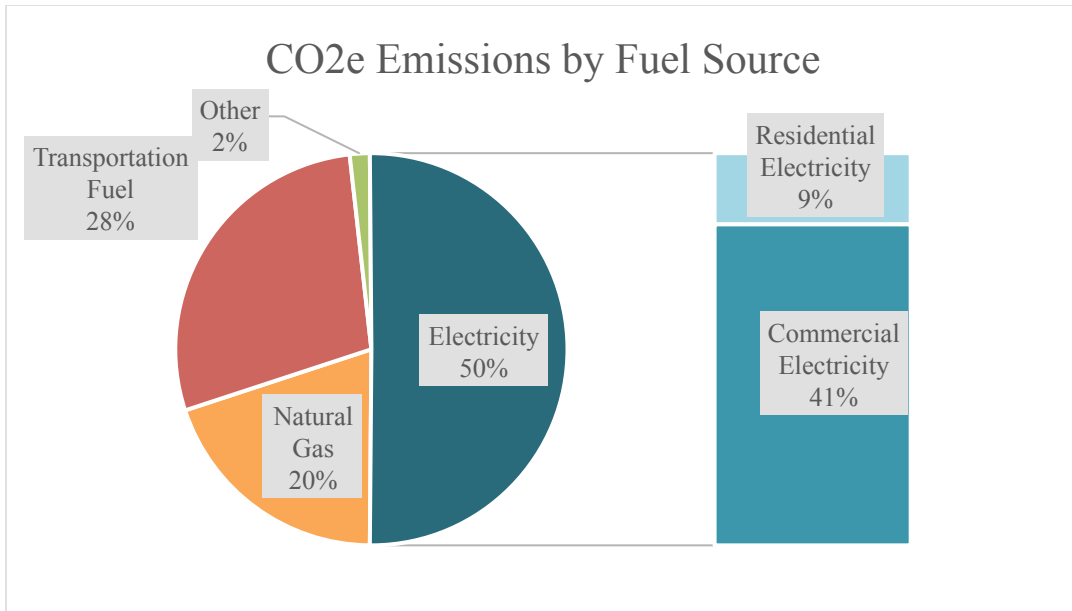


Figure 3: Boulder’s carbon dioxide equivalent emissions by fuel source in 2016.

As previously discussed, natural gas is primarily provided by Xcel Energy but also through third-party retail providers. However, all customers in Boulder currently receive their electricity from Xcel Energy.⁶⁷ Therefore Xcel’s electricity source mix influences the emissions factor of Boulder’s electricity, and subsequent greenhouse gas emissions. Currently, Xcel’s Colorado energy mix is 46% coal, 25% natural gas, 23% wind, and the remaining 6% comes from other renewable energy sources. This equates to a total of 29% of the mix coming from carbon-free sources (Figure 4).⁶⁸ While Xcel estimates that its Colorado electricity mix will be 41% carbon-free by 2021,⁶⁹ the current grid intensity in Colorado is approximately 0.598 tCO₂e/MWh.^{70,71} For comparison, California has a grid intensity of 0.206 tCO₂e/MWh and West Virginia’s grid intensity is 0.903 tCO₂e/MWh.⁷²

⁶⁷ “Boulder’s Community Greenhouse Gas Inventory.”

⁶⁸ “Energy and Carbon Emissions Reporting,” accessed March 19, 2018, <https://www.xcelenergy.com/staticfiles/xcel-responsive/Environment/Carbon/Carbon-Reduction-2016-Energy-and-Carbon-Summary.pdf>.

⁶⁹ “Energy and Carbon Emissions Reporting.”

⁷⁰ Note: Xcel Energy only reports carbon dioxide, not methane (CH₄) and nitrous oxide (N₂O), because these two emissions make up less than 0.5 percent of the total CO₂ equivalent greenhouse gas emissions from electricity generation.

⁷¹ “Energy and Carbon Emissions Reporting.”

⁷² “eGRID Summary Table 2016,” accessed February 26, 2018, https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf.

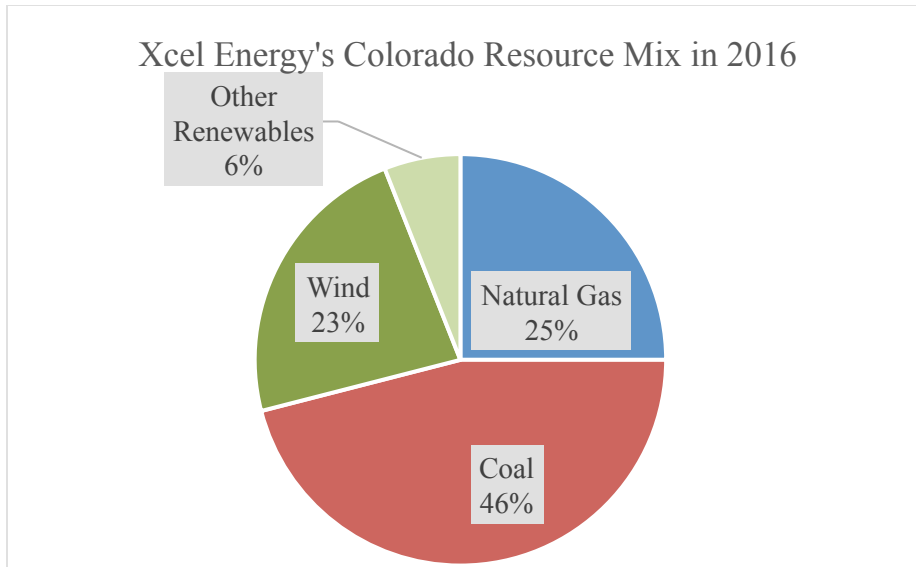


Figure 4: Xcel’s 2016 electricity resource mix for the Colorado System⁷³

Source by Source Analysis of Carbon Tax Options

Below we explore potential carbon tax strategies for three sectors: electricity, natural gas, and transportation. Each sector faces unique challenges; therefore, we consider taxing strategies for each sector individually.

Electricity

The City may have several objectives in taxing the electricity sector, including: (1) accurately reflecting the cost of carbon, (2) maintaining a steady revenue source, and (3) ensuring commercial and industrial (C&I) customers are not disadvantaged. Ideally, a new carbon tax would address all of these goals. In practice, these objectives may require tradeoffs based on the City's priorities. For instance, while the current CAP tax supports the latter two objectives, it fails to reflect the true cost of carbon. Furthermore, a taxation rate set at a measure of the cost of carbon, such as the federal estimates for the Social Cost of Carbon, may result in revenues that are higher than what the City requires to fund its programs, and would likely impose high burdens on electricity-intensive industries unless other design features are included to mitigate these costs.

The current CAP tax is an electricity consumption tax applied as a line item on consumers' electricity bills. Residential, commercial, and industrial consumers pay different rates based on their monthly energy consumption. Currently, residential customers incur the highest tax rate because they receive a majority of the funding benefits from the tax revenue. We suggest a similar method for implementing an

⁷³ Xcel Energy, “Energy and Carbon Emission Reporting: 2016 Summary,” 2016, <https://www.xcelenergy.com/staticfiles/xcel-responsive/Environment/Carbon/Carbon-Reduction-2016-Energy-and-Carbon-Summary.pdf>.

electricity tax, though we explore opportunities to more closely tie the taxation rate to the carbon intensity of the grid to more accurately consider the costs of carbon.

Emissions-based Tax:

Background: Similar to the current CAP tax, the electricity portion of a new carbon tax would likely be an additional line item on users' electricity bills that is based on the user's monthly energy consumption. However, under an emissions-based tax system, the tax rate would be directly tied to the GHG intensity of the consumed electricity.

Under such a system, electricity produced with a higher portion of GHG-intensive fuels such as coal would incur higher tax rates, while electricity produced from renewable resources and other carbon-free sources would incur the lowest tax rates. However, because of the nature of the electrical grid, the City cannot know for certain which of the local utility's power plants are providing electricity to its consumers. The most accurate approximation would be to assume that the power consumed by the city is proportional to the generation mix of the local utility. Therefore, the City could use the local utility's generation mix to estimate the grid intensity and use this intensity to apply a proportional carbon tax.

However, the grid is expected to become less emissions-intensive over time. Unless the tax rate rises over time, declining grid emissions will result in declining revenues. Consequently, the City may consider reserving the ability to adjust the tax value to reflect changes in the generation mix and desired revenues.

Climate benefits: By tying the tax rate to grid emissions, the city ensures that the tax rate will be higher in years where the electricity grid in Boulder is emitting more GHGs, and lower in years where the grid mix favors carbon-free sources of electricity. This will create a price signal for consumers based on the level of emissions associated with using a unit of electricity that will help to encourage efficiency and energy conservation when emissions are at their highest.

Administration: As previously outlined, the City will need to partner with the local utility in order to implement a new tax on electricity consumption. This is how the current CAP tax was created. When partnering with the local electricity provider, the City may incur additional administrative charges. For instance, when creating the current CAP tax, the City had to pay for the additional setup required by the utility to add the charge to consumer's bills. The City may incur similar fees for changing the existing tax or creating a new electricity tax.

Challenges to consider: One challenge with taxing electricity is that it discourages thermal and mobile electrification, which are actions that the City encourages in its Roadmap to Renewable Living.⁷⁴ Another challenge is that a tax tied to the grid emissions intensity is unlikely to produce a steady stream of revenue over time as

⁷⁴ "Boulder's Climate Commitment." n.d. Accessed November 23, 2017. <https://bouldercolorado.gov/climate>.

emissions intensity is projected to decline in future years. Lastly, depending on the tax rate structure (discussed further in the section on Carbon Pricing), an electricity tax may create a high financial burden for energy-intensive industrial and commercial customers, which is something the City may be interested in mitigating.

Variations of the emissions-based tax:

To overcome the challenges above, the City could consider the following variations on the emission-based tax:

- Dynamically scaled emissions-based tax: A dynamically scaled tax on fuel carbon intensity would allow the City to maintain a consistent revenue stream, even as carbon-emitting plants are displaced by renewables. If the carbon intensity value for each fuel source includes embedded carbon, which refers to emissions associated with manufacturing, installing, operating, and decommissioning power facilities, renewables will still incur a carbon tax. This type of tax would be weighted proportionally to the carbon intensity of each energy source, but then scaled based on the overall generation mix. In this way, although the amount of GHG emitted declines over time, the remaining GHG emissions become increasingly expensive. Though this would not completely reflect the carbon intensity of each generation source, as renewables would eventually be highly taxed, this strategy serves to stabilize tax revenues over time.
- Commercial and industrial multiplier: One method to reduce the tax burden for C&I customers is to add a multiplier to each of these sectors' tax rates. For example, the City may decide that C&I customers will only pay rates at 50% of the residential customer rates. Though this would not accurately reflect the sectors' share of GHG emissions, this is a compromise between a full emission-based tax and the City's current CAP tax, which has extremely low rates for C&I customers.
- Electric device rebates: As an incentive for customers to switch to electric vehicles and HVAC systems, the City could offer an annual lump sum rebate for consumers that provide proof of EV and electric heating usage. The rebate amount could correlate to the efficiency of the heating device so more efficient devices receive greater rebates. This could help to ameliorate the effects of the electricity tax on fuel switching from natural gas to electricity, which becomes especially important as electricity is generated with more renewables.

Natural gas

A key step in transitioning from the current CAP tax to a broader carbon tax is the inclusion of sources of GHGs other than electricity into the tax base. Natural gas consumption represents 18% of Boulder's total GHG emissions. Consequently, any tax policy that seeks to put a price on a wide range of Boulder's GHG emissions would ideally include a tax on natural gas consumption.

Although natural gas used to produce electricity is already accounted for under the current electricity consumption tax (and therefore has emissions attributed to electricity in the GHG inventory), natural gas directly used in the residential, commercial and industrial sectors is not. Natural gas is used mainly for space and water heating. A large amount of natural gas emissions also come from fugitive emissions. Fugitive emissions entail the release of methane from producing, processing, and transporting natural gas.⁷⁵

Natural Gas Tax

A natural gas tax represents a charge imposed on natural gas consumption. Boulder could charge residential and commercial customers for natural gas usage, in a similar structure to the Alberta Province natural gas levy (see Case Study below) and Boulder's current electricity consumption tax.

Background: A natural gas tax in Boulder could take the form of a fixed charge per therm of natural gas consumed, added as a line item on the bill. Unlike electricity, the carbon intensity of natural gas is constant and therefore does not require scaling.

Climate Benefits: The current CAP tax does not cover the 18% of GHG in the city associated with direct consumption of natural gas. Including these emissions under a new carbon tax may incentivize consumers to reduce their usage of natural gas through measures like installing smart thermostats and turning down their heat. As the electricity grid becomes cleaner and if the tax rate falls for electricity, the comparatively constant tax rate for natural gas may incentivize fuel switching and electrification of households and businesses, which has positive climate implications. We note, however, that this effect may be less pronounced in the case of a dynamically scaled emissions-based tax, where renewables would eventually become highly taxed.

Administration: Implementing a tax on natural gas would likely be more complicated and incur more administrative costs as compared to an electricity-only tax. Unlike electricity, customers can receive natural gas from multiple providers. Therefore, an additional burden would fall on the City of Boulder to partner with multiple natural gas providers. The City would likely incur the cost of additional setup required by the providers to add the charge to consumer's bills.

Case Study: Alberta

Canada's Alberta Province instituted a carbon levy that applies to natural gas use, among other fuels. The policy is applied to diesel, gasoline, natural gas, and propane use at the

⁷⁵ James Bradbury and Michael Obeiter, "A Close Look at Fugitive Methane Emissions from Natural Gas | World Resources Institute," World Resources Institute, accessed January 8, 2018, <http://www.wri.org/blog/2013/04/close-look-fugitive-methane-emissions-natural-gas>.

gas station and on heating bills. The levy does not include electricity. Marked gas and diesel for agricultural use are also exempt.⁷⁶

The rate of the levy is based on the amount of carbon that is released by the fuel, as opposed to the mass of the fuel. Therefore, the fuels are taxed at different rates. Natural gas is taxed at a rate of \$1.18 USD/GJ. Assuming an average annual fuel consumption of 100 GJ of natural gas, a single residential customer is estimated to pay a total of \$222.94 USD per year. In order to protect low and middle-income residents in the province, rebates are offered to single Albertans who earn less than \$37,026.93 USD/year and families that earn less than \$74,053.87 USD/year.

The Climate Leadership Plan, which includes the carbon levy, is expected to raise \$4.2 billion USD over a three-year period. These funds are used to pay for the aforementioned carbon rebates, build green infrastructure, invest in large-scale renewable energy projects, and to cut other tax rates.⁷⁷

Transportation

As previously outlined, the transportation sector is distinct from electricity and natural gas because the City cannot directly tax the combusted fuel (i.e., gasoline). The team has examined opportunities to create a carbon tax in the transportation sector by exploring the following questions:

1. What, if any, options are there to tax GHG emissions in the transportation sector that are not preempted by federal and state laws?
2. If no feasible options are available, what other taxes could be implemented that would provide the co-benefit of reduced GHG emissions?
3. What options may be better suited for implementation at the state level?

Although the City may also consider partnerships at the County level to regulate transportation, such options were not examined due to the limited scope of this report.

Furthermore, due to the limitations of our analysis, we cannot explore every possible option to charge a fee for vehicle GHG emissions, particularly at the state and federal level. Some commonly implemented options which fall outside of the realm of a tax, such as tax rebates on electric vehicles, are not discussed for the sake of brevity. Instead, we present several policy designs that the team believes provide options for the City to indirectly tax emissions resulting from transportation.

⁷⁶ “Carbon Levy and Rebates,” Alberta Government, accessed January 8, 2018, <https://www.alberta.ca/climate-carbon-pricing.aspx>.

⁷⁷ “Carbon Levy and Rebates.”

City-Level Taxes

Vehicle Miles Traveled Tax

The City could consider directly charging individuals for their vehicle emissions by implementing a tax on the number of vehicle miles traveled (VMT).

Background: Tracking the number of miles a vehicle has traveled (VMT) and creating a charge based on actual vehicle usage, scaled by vehicle weight, has gained momentum in several spheres. State and federal governments think it may be a good way to fill road maintenance funding gaps, climate change advocates hope it will encourage less driving, and insurance companies are using VMT tracking to monitor driving behavior.⁷⁸

Climate Benefits: Generally, a VMT charge could function as a reasonable approximation for a tax on emissions. For a standard combustion-engine vehicle, the amount of GHGs emitted is approximately proportionate to the number of miles driven. However, some vehicles are more efficient than others, causing them to emit fewer GHGs per mile driven than less efficient vehicles. In order to account for this, a VMT charge could be tiered for different vehicle efficiency levels. In this way, high-emitting vehicles are charged more per mile traveled. A VMT charge would not completely address emissions associated with vehicles in traffic or idling.

Administration: Implementation of a VMT charge at the city-level would be challenging. Unlike the state, which regulates vehicle registration, the City does not have any clear authority to track car ownership and there are limited options available for the City to monitor vehicle usage.

One potential option would be for the City to use existing parking permit systems to administer a VMT charge. Boulder already has an existing system to designate Neighborhood Permit Zones, which limits the amount of parking in certain City areas.⁷⁹ Residents pay a \$17 annual fee for parking privileges.⁸⁰ Additionally, the City has several other parking-tracking systems including for public parking in the downtown area, and through the University.⁸¹

However, while it may be possible to incorporate a VMT charge or reporting requirement when citizens register for parking privileges, this strategy may have several limitations. First, residents are unlikely to welcome additional charges on parking. Second, it would only charge a portion of users and completely exclude anyone parking outside of Neighborhood Permit Zones. Finally, it would not target commuters.

⁷⁸ Nick Stockton, "It's Time to Make Every Road a Toll Road," *WIRED*, February 11, 2018, <https://www.wired.com/story/gas-tax-vmt-toll-road/>.

⁷⁹ Boulder Charter and Rev. Code § 2-2-15 (2018).

⁸⁰ Boulder Charter and Rev. Code § 4-20-49 (2018).

⁸¹ City of Boulder, "Access and Parking Services," accessed April 15, 2018, <https://bouldercolorado.gov/parking-services>.

For illustrative purposes, we present information on how the City may design a VMT tax, assuming it is tied to some sort of permitting system (car sticker) that grants parking privileges. The team has identified the following key features of a successful VMT/sticker program:

- Cost per VMT should be tiered based on vehicle efficiency (for example, hybrid owners pay the lowest tier, high-emission vehicles pay the highest tier.)
- Electric vehicles would be required to display a sticker but would be either completely exempt from all costs or charged a small fee to cover administrative costs.
- Vehicle miles traveled could be assessed either by:
 - Self-reporting, to be verified by a small (1-5%) random audit;
 - Charging a standard based on estimates for VMT (average or 75th percentile), and users may opt-in for more precise tracking.
 - Collaborating with state agencies to obtain vehicle registration information, including annual odometer readings; or
 - GPS tracking (opt-in, or data-sharing from insurance companies).

At this time, no city in the U.S. is implementing a VMT charge. Due to the lack of precedent, it is unknown what sort of legal challenges a VMT charge may face. For example, a major challenge may be determining if the City can legally charge VMT that occurred outside of the City limits. Additionally, there may be future preemption issues with a VMT charge at the state or federal level (see State and Federal Level Options section.)

Trip Generation Charge

Background: In 2012, Boulder examined a suite of options to fill a revenue gap for long-term road maintenance.⁸² The team developed a proposal for a fee on buildings based on established estimates for the number of vehicle trips a building was expected to generate.⁸³ Although the team ultimately found an alternative that was simpler to implement, they nonetheless completed comprehensive exploration and found it to be a feasible source of revenue.

Under this proposal, Boulder planned to utilize metrics calculated by the Institute of Transportation Engineers (ITE). The ITE establishes standardized metrics for how many vehicle trips a given building would be expected to generate in a given land use type.⁸⁴ The original model was optimized for suburban settings, and later updated to incorporate mixed-use regions in collaboration with the EPA⁸⁵.

⁸² Jane Brautigam, "Memorandum on the Funding of Operations and Maintenance of the Transportation System," January 22, 2012.

⁸³ Jane Brautigam, "Memorandum on Transportation Funding Update," May 29, 2012.

⁸⁴ "Trip Generation, 10th Edition," Institute of Transportation Engineers, accessed February 14, 2018, <https://www.ite.org/tripgeneration/index.asp>.

⁸⁵ OA US EPA, "Mixed-Use Trip Generation Model," Data and Tools, US EPA, April 28, 2013, <https://www.epa.gov/smartgrowth/mixed-use-trip-generation-model>.

The City planned to tie a fee to each building based on the ITE trip generation estimates. Although the City of Boulder may have had lower overall trip generation rates than what ITE calculated, they justified the charges by basing them on relative differences (not actual trip numbers), so high-generation buildings would be charged relatively more compared to low-generation building. In the original proposal, the revenues from this fee would have been used to pay for road maintenance.⁸⁶

In this section, we explore how well a trip generation charge would approximate a carbon charge for vehicle emissions.

Climate Benefits: The City's original proposal to create an ITE fee was designed for road maintenance and did not consider climate benefits directly. Ultimately, there is a less direct connection between vehicle emissions and the trip generation rate than under other options, such as the VMT tax. The charge is levied upon the building owners and not on the vehicle owners. Additionally, since the charge structure is based on established metrics and not actual measurements, the charge is not necessarily related to the number of trips that truly occur. Further, there is no differentiation based on vehicle efficiency or fuel type.

Administration: A trip generation charge may be easier to administer than other options because it requires no new infrastructure and, according to the City, only limited new administration.⁸⁷ Further, the City has already thoroughly researched trip generation charges in other contexts, and the revenue stream would be relatively stable.

A key difference may be that, if the revenue is not used for road maintenance, the charge would need to be passed as a tax rather than as a fee. The original proposed fee faced some opposition, particularly from local businesses, that felt the ITE rates did not accurately reflect the traffic at their individual locations.⁸⁸ Therefore, passing this measure as a voter-approved tax may be challenging.⁸⁹

Congestion Charge

Background: Another mechanism to reduce vehicle emissions could be to create a congestion-pricing zone in the City. In this system, drivers are charged a flat fee to enter a designated area (typically downtown or high-employment area) during a given time of day. Although no cities in the US have implemented congestion zone charges, a congestion charge is a policy that has been implemented in several major cities throughout the world, including London and Stockholm.

⁸⁶ Jane Brautigam, “Memorandum on Transportation Funding Update and Next Steps,” April 9, 2013.

⁸⁷ Brautigam.

⁸⁸ Chris Hagelin (City of Boulder Senior Planner) in discussion with the authors, November 1, 2017.

⁸⁹ Brautigam, “Memorandum on Transportation Funding Update and Next Steps.”

As an example, London instituted a congestion charge in 2003 as a way to reduce traffic in the busy downtown area of central London. The rate is £11.50 (about \$15.58 US) per day for driving within the charging zone between 7am and 7pm, Monday to Friday.⁹⁰

New York City has made several attempts to create a congestion charge, with the most recent proposal in late 2017. The proposal is primarily designed to raise revenue to upgrade public transportation systems, and cars would pay up to \$11.42 to enter Manhattan's central business district during rush hour.⁹¹

Climate Benefits: While the policy is not a direct tax on tailpipe emissions, it does increase the cost of driving which in turn can incentivize less driving. If it becomes more cost-effective to commute using alternative modes such as public transportation or bike travel, the congestion charge would reduce overall emissions. The City could also consider incorporating a mechanism that incentivizes vehicle travel for low-emissions vehicles. For example, the London charge included exemptions for vehicles with 9 or more passengers and ultra-low emissions vehicles.⁹²

Administration: In London, the charge is enforced with Automatic Plate Number Recognition (ANPR) camera system on the roads leading into the congestion charge zone. The cameras take a picture of each vehicle's license plate that comes into the congestion zone during the previously mentioned times. Transport for London (TfL) is the primary system operator, though some operation is subcontracted to companies including IBM and Siemens Traffic Solutions.⁹³ Similar infrastructure is in place in Stockholm.⁹⁴

Outcomes in other congestion charging systems have been generally positive; in Stockholm, traffic downtown was reduced by about 20%.⁹⁵ In London, the system generated £257.4m (approximately \$360m) over the 2014 - 2015 financial year, representing 8.5% of TfL's annual revenues. However, the system required £80.7 million (approximately \$113m) million, or 30% of the revenues, to administer and maintain the toll system.⁹⁶

Administering a smaller-scale congestion charge in Boulder could be challenging. First, Boulder would need to work with the state to acquire the data necessary to charge citizens based on photo-captured license plates. Additionally, further research would be required to determine if the costs to establish the infrastructure to monitor a congestion zone through something similar to London's ANPR could be recovered at a reasonable

⁹⁰ Transport for London. "Congestion Charge": <https://tfl.gov.uk/modes/driving/congestion-charge>

⁹¹ Mitchell L. Moss, "Fix NYC Advisory Panel Report," January 19, 2018.

⁹² Transport for London. "Congestion Charge": <https://tfl.gov.uk/modes/driving/congestion-charge>

⁹³ Transport for London (2014) "Public and stakeholder consultation on a Variation Order to modify the Congestion Charging scheme", available at: https://consultations.tfl.gov.uk/roads/cc-changes-march-2014/user_uploads/cc-impact-assessment.pdf

⁹⁴ Centre for Transport Studies, 2014, "The Stockholm congestion charges: an overview"

⁹⁵ Centre for Transport Studies, 2014, "The Stockholm congestion charges: an overview"

⁹⁶ Transport for London. "Congestion Charge": <https://tfl.gov.uk/modes/driving/congestion-charge>

timescale. A congestion charge would also likely be unpopular with the substantial population of citizens that commute into downtown Boulder for work.

Finally, it is unknown if there may be legal challenges to a congestion charge in the City of Boulder. Historically, the authority to manage local traffic has been granted to cities. However, in a 2002 case, the Supreme Court of Colorado ruled that automated vehicle identification systems functioned at the scale of mixed local and state concern.⁹⁷ It is unknown if or how this may factor into a congestion charge in Boulder, and the City would need to consult a legal professional for further inquiry.

State and Federal Level Options

Transportation Service Network Charge

Across the US, cities and states already have or are planning to institute a tax on rideshare services such as Uber and Lyft. For example, Chicago, IL currently has a tax of \$0.40 per ride⁹⁸, and is considering increasing by it \$0.15 in 2018 to pay for public transit infrastructure improvements.⁹⁹ Massachusetts imposes a \$0.20 per ride tax on transportation network providers at the state level.¹⁰⁰ The City of Boulder is unable to charge taxes on transportation network providers due to preemption by the Colorado Constitution so any charge would therefore have to occur at the state level.¹⁰¹

A tax on ridesharing, or taxis generally, would have an uncertain relationship with GHG emissions. Rideshare entities can have environmental benefits by reducing the number of people that own and regularly use their vehicles. Further, in some areas the rideshare companies have a carpool feature so more individuals are served by a single car trip. If used effectively, carpooling through a rideshare system has the potential to reduce congestion and emissions.¹⁰²

However, there can also be negative climate impacts. Cars that are not actively serving rides can be driving empty or idling, resulting in increased emissions while not actually providing rides. Additionally, it may be possible that a user that chooses to hail a rideshare would have, in the absence of the service, chosen lower emission transportation option such as public transportation. The Natural Resources Defense Council, in

⁹⁷ City of Commerce City v. State, 40 P.3d 1273 (Colo. 2002).

⁹⁸ Chicago Municipal Code § 3.46.030.B.b.1.ii.

⁹⁹ Hal Dardick and John Byrne, “Emanuel Budget: 15 Cents More per Uber, Lyft Ride; \$1.10 Increase in Monthly Phone Fees,” *Chicago Tribune*, October 18, 2017, <http://www.chicagotribune.com/news/local/politics/ct-met-emanuel-budget-preview-1018-story.html>.

¹⁰⁰ M.A. Session Laws Acts § 159.A1/2.8.A.

¹⁰¹ C.O. Rev. Stat. § 40.10.1.603.

¹⁰² Javier Alonso-Mora et al., “On-Demand High-Capacity Ride-Sharing via Dynamic Trip-Vehicle Assignment,” *Proceedings of the National Academy of Sciences*, January 2, 2017, 201611675, <https://doi.org/10.1073/pnas.1611675114>.

collaboration with the University of California at Berkeley, is studying the dynamic between rideshare companies and the environment.¹⁰³

State Level VMT Charge

Many states, including Colorado, are testing state-level VMT charges. State-level VMT fees are typically not framed as a means to reduce emissions, but rather as an alternate funding mechanism to replace a gasoline tax.¹⁰⁴

Colorado is considering replacing the gasoline tax with a VMT tax because, as efficient cars use less fuel, fuel tax revenue is expected to decline. Further, electric vehicle users pay no gasoline tax, and the rise of electric vehicle usage would reduce future tax revenue. Currently, Colorado has imposed an extra registration charge on EV owners.¹⁰⁵

Tax revenue from gasoline sales in Colorado is used for road maintenance. Therefore, in the view of the state, more efficient vehicles and electric vehicles may not be paying their "fair share" to maintain the roads.¹⁰⁶ A VMT tax, however, would capture electric and high efficiency vehicle usage, and more efficiently allocate the costs of road wear-and-tear to drivers that use the roads the most. The State of Colorado completed a first pilot study on a VMT tax in 2017 and plans on participating in a multi-state pilot in the coming years.¹⁰⁷

A VMT charge is also being considered at the federal level. In 2016, the Congressional Budget Office included a VMT fee among a suite of options to fill budgeting gaps to maintain the national highway system.¹⁰⁸ However, the same report acknowledges the pitfalls of VMT charges, including concerns over privacy and challenges in implementation.

Although neither state nor federal governments are planning to impose VMT charges that would be connected to vehicle emissions, these institutions could still preempt city-level efforts.

¹⁰³ Amanda Eaken, "NRDC Urban Solutions to Lead First Climate Analysis of Uber and Lyft," NRDC, November 13, 2015, <https://www.nrdc.org/experts/amanda-eaken/nrdc-urban-solutions-lead-first-climate-analysis-uber-and-lyft>.

¹⁰⁴ US Department of Energy, "State Fees as Transportation Funding Alternatives," accessed January 30, 2018, https://www.afdc.energy.gov/bulletins/technology_bulletin_2014_03_10.html.

¹⁰⁵ C.O. Rev. Stat. § 42.3.304.25.a.

¹⁰⁶ CH2M, WSP, and PRR, "Colorado Road Usage Charge Pilot Program Final Report," accessed January 13, 2018, <https://www.codot.gov/programs/ruc/programs/ruc/documents/rucpp-final-report>

¹⁰⁷ Kimberlee Rankin, e-mail message to authors, February 2, 2018.

¹⁰⁸ Congressional Budget Office, "Approaches to Make Federal Highway Spending More Productive," February 2016, https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/reports/50150-Federal_Highway_Spending-OneCol.pdf.

Recommendations

Ultimately, the team concludes that although incorporating the transportation sector into a carbon tax would be a valuable step to reduce overall emissions, it may not be worthwhile to pursue at the city-level. Each option presented is likely to require substantial administrative input, and both the revenue and climate outcomes are uncertain. The City could still work to reduce transportation emissions with non-taxation options, such as encouraging EV purchases with rebates and installing additional charging stations.

For the time being, a better strategy may be to continue to monitor state and federal level actions. If Colorado chooses to pursue a VMT tax in lieu of a gasoline tax, the City may gain the regulatory authority to tax gasoline. Compared to a VMT tax, fuel charges are considered more effective at reducing GHG emissions.¹⁰⁹

We caution that this is highly speculative. However, it may be worthwhile for the City to request that, if a VMT tax at the state-level is created, Colorado remove the constitutional ban on municipal level gasoline taxes, or themselves institute a tax tied to emissions from gasoline. Furthermore, there may be opportunities to partner with Boulder County to create county-level policies.

Pricing a Carbon Tax

The City of Boulder may wish to weigh several considerations in choosing a carbon tax rate, including: the goal to be achieved by the tax, how best to achieve the goal, who is impacted, how the rate will be structured, how the policy will interact with other policies, and how the rate will change over time. These considerations are discussed in more detail below. Specific price scenarios are discussed in more detail in the Carbon Tax Analysis section.

Setting a Goal

An important first step for choosing a carbon tax level is deciding which goals should be prioritized. For example, there may be trade-offs to consider if the City is more interested in achieving a targeted reduction in local GHG emissions versus raising a predetermined amount of revenue. Alternatively, the City may prefer to set the price so as to internalize the expected marginal damages associated with the emissions of additional tons of carbon using a metric such as the Social Cost of Carbon. This would allow local businesses and consumers to fully internalize the costs of their emissions, effectively allowing the market to determine the economically efficient amount of emissions reductions and

¹⁰⁹ Yan Liu and Cinzia Cirillo, “Evaluating Policies to Reduce Greenhouse Gas Emissions from Private Transportation,” *Transportation Research Part D-Transport and Environment* 44 (May 2016): 219–33, <https://doi.org/10.1016/j.trd.2016.02.018>.

revenues. The choice of goal to be achieved by the tax has an impact on the choice of price.

There may be more than one strategy to achieve a given carbon tax goal. For instance, if the City's first priority is to reduce emissions, it may seek to accomplish this goal by pricing carbon at a sufficiently high rate so as to influence consumer behavior towards energy conservation and installation of renewables.

However, it is worth noting that, in the municipal context, the level of the tax rate may have a lower correlation with emissions reductions than it would under a national program. This is because Boulder does not have the authority to tax electricity generation at the utility level directly. Instead, Boulder can only tax the end-user consumer. This creates an incentive for consumers to act to conserve electricity, for example through the implementation of energy efficiency measures, but there is no corresponding incentive for the utility to respond to the carbon pricing signal by altering the electricity generating mix to include lower-emissions sources. As a result, the incremental emissions reductions achieved by raising the price of the tax are likely to be smaller than they might be if the fuel or electricity supplier was taxed directly.

An alternate strategy, then, may be to select a lower price to reduce the burden on consumers, but use the raised revenue to implement programs that will reduce emissions beyond the effects of the tax on consumer behavior.¹¹⁰ This strategy aligns with the City's current use of the CAP tax to raise funds for implementing climate-related programs. Moreover, implementing a tax rate significantly higher than the current CAP tax may result in the City raising revenues far in excess of what is needed to fund the Climate Action Plan's programs, which raises questions about how the remaining revenues would be used.

¹¹⁰ The Report of the High-Level Commission on Carbon Prices notes, "Adopting other cost-effective policies can mean that a given emission reduction may be induced with lower carbon prices than if those policies were absent." (High-Level Commission on Carbon Prices, "Report of the High-Level Commission on Carbon Prices.")

Table 2: Comparison of Pricing Estimates by Goal.

Source	Location & System	Goal	Year	Price (\$/metric ton)
Estimates in the Literature				
Interagency Working Group on the Social Cost of Carbon ¹¹¹	N/A	Internalize cost of global marginal damages associated with emissions of CO ₂	2020 2025 2030	\$42 /tCO ₂ * \$46/tCO ₂ \$50/tCO ₂
High-Level Commission on Carbon Prices ¹¹²	N/A	Limit temperature rise to 2°C consistent with Paris Agreement	2020 2030	\$40-80/tCO ₂ \$50-100/tCO ₂
Carbon Pricing Corridor Initiative ¹¹³	N/A	Decarbonize the worldwide power sector	2020 2025 2030	\$24-39/tCO _{2e} \$30-60/tCO _{2e} \$30-100/tCO _{2e}
Existing Carbon Prices				
CARB ¹¹⁴	California, Cap-and-Trade	Achieve 80% GHG emissions reductions from 1990 levels by 2020	2017	\$14.61/tCO _{2e} †
RGGI ¹¹⁵	Northeast & Mid-Atlantic, Regional Greenhouse Gas Initiative	Reduce covered emissions by 2.5% annually	2017	\$3.79/short ton CO ₂ ††
Government of British Columbia	British Columbia, Carbon Tax		2018	\$35/tCO _{2e}
City of Boulder	City of Boulder Climate Action Plan Tax	Raise revenues matching planned CAP expenditures	2017	Residential: \$7.56/tCO ₂ Commercial: \$1.39/tCO ₂ Industrial: \$0.46/tCO ₂

* The Social Cost of Carbon prices reported here are given at a 3% discount rate.

† California cap-and-trade allowance prices are reported from the February 2018 joint auction.

†† RGGI allowance prices are reported from the March 2018 auction.

¹¹¹ Interagency Working Group on Social Cost of Greenhouse Gases, “Technical Support Documents: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866” (Office of Management and Budget, August 2016), https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf.

¹¹² High-Level Commission on Carbon Prices, “Report of the High-Level Commission on Carbon Prices.”

¹¹³ Carbon Disclosure Project, We Mean Business, and Carbon Pricing Leadership Coalition, “Carbon Pricing Corridors: The Market View,” 2017, <https://b8f65cb373b1b7b15feb-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/002/112/original/Carbon-Pricing-Corridors-the-market-view.pdf?1495638527>.

¹¹⁴ California Air Resources Board, “California Cap-and-Trade Program Summary of Joint Auction Settlement Prices and Results,” November 2017, https://www.arb.ca.gov/cc/capandtrade/auction/results_summary.pdf.

¹¹⁵ Potomac Economics, “Market Monitor Report for Auction 39” (RGGI, March 2018), https://www.rggi.org/sites/default/files/Uploads/Auction-Materials/39/Auction_39_Market_Monitor_Report.pdf.

Distributing the Impacts

The City may want to consider the expected impacts of a given carbon price on different groups of Boulder consumers. Higher tax rates may disproportionately burden lower-income residents and energy-intensive industries.

Equity Impacts: Carbon taxes are generally understood to be regressive, posing concerns from an equity perspective. The regressive nature of carbon taxes may be ameliorated through policy design features that reduce the burdens on the lowest-income consumers, such as rebates for low-income consumers. If the City is concerned that the tax rate will pose an equity challenge, they may consider a partial revenue recycling scheme whereby a portion of proceeds are returned to all customers, with lower-income customers receiving the highest benefits by proportion of income.

Competitive Impacts: Frequently cited concerns about carbon taxes include potential impacts on the competitiveness of energy-intensive industries, particularly those with competitors that are not covered by a comparable tax. Even where the economic impacts of carbon pricing to firms may be quantitatively small, these impacts may factor into future decision-making by companies on whether to locate their business in Boulder. The political repercussions of businesses moving to other jurisdictions or choosing not to locate in Boulder due to carbon pricing concerns may be significant. Generally, this phenomenon is thought to undermine support for higher carbon prices.¹¹⁶

Rate structure is one policy design feature that may be used to redistribute the cost burdens of taxation and address potential negative impacts on vulnerable firms. Tax rates may be structured in various ways depending upon the intended outcomes. Rates may be uniform for all sources and users or may be differentiated by source (e.g. transportation, natural gas, electricity), by sector (e.g. residential, commercial, industrial), or both.

The current CAP tax on electricity has a differential rate structure that seeks to allocate cost burdens by sector in proportion with the expected government investment of collected revenues in each sector. The effective carbon tax rate imposed by the current CAP tax on electricity range from \$0.46 per tCO₂ for industrial customers to \$7.56 per tCO₂ for residential customers.

Policy Interactions

Carbon tax policy outcomes may interact with and be influenced by other existing policies. The city may want to consider two types of policy interaction in particular:

Interactions with state and local policies: Carbon pricing may interact with other state and local taxes and policies that impact the price and use of electricity, natural gas, and

¹¹⁶ High-Level Commission on Carbon Prices, “Report of the High-Level Commission on Carbon Prices” (Washington, D.C.: World Bank, 2017), <https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices/>.

various transportation options. These interactions may sometimes create unexpected incentives by generating non-uniform pricing signals. Moreover, academic studies of the policy interaction effects associated with implementing a carbon tax suggest that the social costs and distributional burdens of carbon taxes may be influenced by their interaction with existing taxes. However, experts have suggested that impacts associated with policy interactions are highly dependent upon the ways in which the revenues are used.¹¹⁷ For instance, the total economic cost of a carbon pricing policy may be reduced by using the revenues raised from the carbon tax to offset existing taxes or to reduce distributional burdens through rebates or other programs.

Interactions with other carbon pricing schemes: The City may also want to consider how its tax will align with other carbon pricing schemes within the United States and surrounding countries such as Canada. The effective residential carbon tax rate from the existing CAP tax (\$7.56 per tCO₂) falls between the most recent carbon prices recorded in the California and RGGI markets (\$15.06 per tCO₂e and \$3.80 per short ton CO₂ respectively). However, the rates for commercial and industrial consumers are significantly lower. The City of Boulder may or may not want to consider the prices of other US carbon markets in choosing its own tax rate.

Price Changes

In addition to selecting a starting price that aligns with the City's goals and policy strategies, the City may want to consider how prices should change over time. Many existing carbon taxes contain explicit provisions setting out how prices will rise over time. Price ramping provisions may be included as a fixed percentage increase per year (e.g. 2% increase per year), as a predetermined schedule (e.g. \$5 in 2020, \$10 in 2025, etc.), or may be calculated each year according to a predetermined formula or criteria. Some expert estimates for carbon prices, such as the Social Cost of Carbon¹¹⁸ (Table 3), include built in rate increases over time that correspond to the increase in marginal damages associated with the deferral of emitting a given ton of CO₂ from the present to a future date. (For more on the Social Cost of Carbon, see

¹¹⁷ Marc Hafstead Joseph E. Aldy, "Resolving the Inherent Uncertainty of Carbon Taxes," Text, Joseph E. Aldy, Marc Hafstead, Gilbert E. Metcalf, Brian C. Murray, William A. Pizer, Christina Reichert, and Robertson C. Williams III. 2017. "Resolving the Inherent Uncertainty of Carbon Taxes." Symposium Essays to 41 Harv. Envtl. L. Rev. F. __ (2016)., June 19, 2017, <https://nicholasinstitute.duke.edu/environment/publications/resolving-inherent-uncertainty-carbon-taxes>.

¹¹⁸ The Social Cost of Carbon (SCC or SC-CO₂) is an estimate of the monetary value of the damages associated with an incremental increase of carbon dioxide emissions in a given year. In other words, it measures the expected social and economic cost of emitting an addition unit of carbon into the atmosphere. In the United States, the SCC is often measured in dollars per metric ton of CO₂. The SCC is only intended to estimate the damages associated with the emissions of additional increments of carbon dioxide. This is a key limitation to utilizing the SCC as a pricing benchmark for a carbon tax that covers multiple greenhouse gases.

Appendix.)

Currently, carbon prices in the two U.S. cap-and-trade programs are significantly lower than the estimates produced by experts on the prices needed to reach commonly agreed-upon goals such as limiting global temperature rise to 2 degrees Celsius or less. It is believed that carbon pricing in all districts will eventually need to converge towards higher prices consistent with reducing emissions to net zero by the latter half of the century if such goals are to be achieved. However, there may be real or perceived political and economic ramifications associated with advancing significantly faster than the rest of the country. Furthermore, experts have suggested that coordination and convergence of carbon prices across regions and over time can help to prevent leakage and bolster economic efficiency.¹¹⁹

Table 3: Social Cost of Carbon, 2010-2050 (in 2007 dollars per metric ton of CO₂).

Year	5% Average	3% Average	2.5% Average	High Impact (95th Pct at 3%)
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

Source: Interagency Working Group on Social Cost of Greenhouse Gases, 2016.

Politics

Finally, any potential carbon tax will ultimately need to be approved by the city’s voters before it can be implemented. As such, determination of the optimal price for Boulder’s carbon tax will necessarily be informed by considerations of political feasibility. The City may want to engage voters in dialogue to determine which rates and features of a carbon tax-pricing plan are preferable to voters.

¹¹⁹ High-Level Commission on Carbon Prices, “Report of the High-Level Commission on Carbon Prices” (Washington, D.C.: World Bank, 2017), <https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices/>.

Carbon Tax Analysis

In order to evaluate potential policies, the team developed a model in Microsoft Excel that projects revenues raised and corresponding reductions in fuel emissions for the City of Boulder under various carbon tax rate structures. Our model is based in part on the Washington Carbon Tax Assessment Model.¹²⁰

The model calculates the impact of a given carbon price on electricity and natural gas consumption in each of the three main sectors of the economy: residential, commercial, and industrial. Because we expect some level of reduced fuel use as costs increase, the model estimates change in demand for electricity or natural gas based on standard elasticities of demand. Transportation policies were not evaluated in the model due to the wide scope of inputs and the large amount of data needed.

The model allows us to evaluate projected energy-related emissions, revenues, and costs associated with the electricity and natural gas tax scenarios at different levels of consumption. The model extends to 2050 with an option to change the timeline. The model was designed to cover a wide range of tax pricing options and sensitivities around those. We evaluated a set of illustrative pricing scenarios that we believe to be useful benchmarks amidst the range of potential options.

Methodology

The basic structure of the model is based heavily on the Washington State Carbon Tax Assessment Model. We adapted it to Boulder by using Boulder emissions and consumption data for the electricity and natural gas sectors. The City of Boulder provided emission projections through 2050 for both sectors. We then took the percentage of those emissions in the residential, commercial, and industrial sectors reported in the 2016 Boulder GHG inventory to project the emission distribution out to 2050.

To estimate the change in emissions after a carbon tax is instituted we started with long run demand elasticity estimates from the Washington Carbon Tax Assessment Model (Table 4). Those elasticity estimates were then multiplied by the percentage change in energy price (electricity or natural gas) from the tax and the product was multiplied by the pre-tax emission estimates to get a post-tax emissions estimate.

$$\text{Price change (\%)} = \frac{\text{Carbon tax rate}}{\text{Baseline price}}$$

$$\text{Post-tax emissions} = \text{Pretax emissions} * (1 + \% \Delta \text{ Price} * \text{Elasticity})$$

¹²⁰ Washington State Department of Commerce. "Carbon Tax Assessment Model (CTAM), Available at: <http://www.commerce.wa.gov/growing-the-economy/energy/washington-state-energy-office/carbon-tax/>

Table 4: Long Run Elasticity of Demand Estimates.

Natural Gas	
Residential	-0.40
Commercial & Industrial	-0.35
Electricity	
Residential	-0.50
Commercial	-0.48
Industrial	-0.57

Revenue was then calculated by multiplying the final emissions estimates by the carbon tax price. We estimated average annual payment from different customer sectors by breaking out the portion of the total amount of customers per sector (residential, commercial, and industrial) based on Boulder's estimates. The number of consumers in each sector was divided by the revenue from that sector to get an average annual bill per household or business.

Finally, we converted the carbon tax from a \$/tCO₂e to a more traditional rate that the end user would have to pay. For the electricity sector the price was converted to a \$/kWh value by multiplying by the projected tCO₂e per kilowatt hour. Natural gas is a constant conversion factor because the emission rate of natural gas stays constant over time at 0.05 tCO₂e/MMBtu.

Model Assumptions

Our model relies on assumptions that are important to recognize prior to evaluating its results.

As mentioned above, emissions projections and consumption projections rely on data provided by the City from 2016. The City may consider updating these projections over time as new data becomes available.

The City also provided an estimated breakdown of electricity and natural gas consumption by customer class (residential, commercial, industrial), which is used in the model to determine each class's proportion of emissions. The model assumes the proportion of emissions from each class stays constant over time. Since the City was unable to provide granular data separating industrial and commercial natural gas consumption levels, the model combines the two sectors and looks at them jointly.

Electricity rate estimates are based on Xcel Energy’s most recent rate schedule.¹²¹ While a number of rate schedules exist for each customer class, one rate was chosen for each class for simplification (residential: R, commercial: C, industrial: SG). Present day rate estimates were calculated by applying these rate schedules to annual consumption estimates for the residential and commercial sectors that were published by the City in its “Energy Future Project: PSCo Retail Rate Forecast” spreadsheet. Since the industrial rate includes a demand charge that varies greatly by building and is therefore difficult to estimate, an industrial rate estimate was taken directly from the City’s Retail Rate Forecast spreadsheet. The electricity rate increases over time at rates consistent with Xcel Energy’s 2018-2021 IRP in the near-term and at a rate of 3.1% for the years following 2021, which was a rate recommended by the City.

Natural gas rates are based on estimates published in the 2017 Annual Energy Outlook. The high and low growth rate scenarios use an annual consumption rate change percentage from 2017 Annual Energy Outlook data¹²².

Scenarios

A total of six scenarios were modeled, starting in 2020 and running through 2050. The modeling scenarios in this report focus on the different pricing options that are available and includes sensitivities around renewable energy development. Table 5 below gives a brief description of the scenarios that we evaluated for this report. The model also allows the user to change the following assumptions and inputs:

- Year the tax starts
- How often the rate is increased
- Renewable energy penetration
- Natural gas consumption levels
- Electricity rate increases

Due to the large amount of possible combinations of assumptions and parameters available in the model, we chose to limit the number of scenarios reported to the six listed below. The scenarios were selected to illustrate a wide range of options that Boulder could consider and to highlight how some of the assumptions had different effects on emissions and revenues. We note that these scenarios provide a range of options, but do not reflect any singular recommendation to the City.

¹²¹ Xcel Energy (2018). "Rates." Available at: https://www.xcelenergy.com/company/rates_and_regulations/rates

¹²² EIA (2017). “Annual Energy Outlook 2017”. Available at:

Table 5: Scenario Descriptions.

Scenario Name	Description
Social Cost of Carbon	This scenario sets the tax rate at the social cost of carbon and increases at the SCC's defined rate. The tax is applied uniformly to residential, commercial, and industrial customers in both the electricity and natural gas sectors.
CAP Tax Rate	This scenario takes the current rate structure of the CAP tax and converts the tax from a \$/kWh to a \$/tCO ₂ e based on current grid intensity. The tax is only applied to the electricity sector and held constant until 2050.
CAP Tax Rate with Stable Revenue	This scenario starts with the same rate structure as the previous scenario. As the grid become less carbon-intensive the tax rate increases at a rate that will keep revenue constant until 2050. This tax applies only to the electric sector.
CAP Tax Rate with Natural Gas Tax	This scenario starts with the same rate in the electric sector as the CAP Tax Rate scenario and keeps that rate uniform over time. It then adds in a carbon tax on the natural gas sector to replace the lost revenue from the decreasing carbon intensity of the grid.
High Renewable Energy	This scenario takes the same rate as the CAP Tax Rate with Natural Gas Tax scenario and changes the assumptions in the electricity sector to have high renewable energy penetration. The new levels come close to reaching the 100% renewable energy goal by 2030 set by Boulder.
Low Renewable Energy	This scenario uses the same rate as the CAP Tax Rate with Natural Gas Tax scenario and changes the assumptions in the electricity sector to have low renewable energy penetration. The new level is 10% higher grid intensity than in our baseline.

Results

To best understand the results, it is important to first understand the rate structure that goes into each scenario (Table 6). The highest rates are from the Social Cost of Carbon scenario with rates starting at \$42/tCO₂e and increasing to \$69/tCO₂e in 2050 (1). The next two scenarios only put a tax on the electricity sector that is tied to the carbon intensity of the grid (2 & 3). The CAP tax rate scenario starts with prices of \$7.56/tCO₂e for residential, \$1.39/tCO₂e for commercial and \$0.46/tCO₂e for industrial customers. These rates don't change over time, while in the "CAP tax with stable revenue" scenarios the rates increase over time to keep the revenues close to 2020 values.

The final three scenarios all have the same rate structure. The purpose of these scenarios is to see how incorporating natural gas affects the model (4) and to see how sensitive the results are to our renewable energy growth assumptions (5 & 6). There is a nearly unlimited number of rates and ramp ups that can be used in the model. These scenarios were chosen to represent a range of the different effects that would be seen with different tax structures and under different conditions of renewable energy penetration.

Table 6: Scenario rate structures.

	Social Cost of Carbon (1)	CAP Tax Rate (2)	CAP Tax Rate with Stable Revenue (3)	CAP Tax Rate with Natural Gas Tax (4)	High Renewable Energy (5)	Low Renewable Energy (6)
Electricity 2020 Tax Rates						
Residential	\$42.00	\$7.56	\$7.56	\$7.56	\$7.56	\$7.56
Commercial	\$42.00	\$1.39	\$1.39	\$1.39	\$1.39	\$1.39
Industrial	\$42.00	\$0.46	\$0.46	\$0.46	\$0.46	\$0.46
Electricity 2050 Tax Rates						
Residential	\$69.00	\$7.56	\$33.00	\$7.56	\$7.56	\$7.56
Commercial	\$69.00	\$1.39	\$7.00	\$1.39	\$1.39	\$1.39
Industrial	\$69.00	\$0.46	\$2.00	\$0.46	\$0.46	\$0.46
Natural Gas 2020 Tax Rates						
Residential	\$42.00	\$0.00	\$0.00	\$1.00	\$1.00	\$1.00
Commercial	\$42.00	\$0.00	\$0.00	\$0.05	\$0.05	\$0.05
Natural Gas 2050 Tax Rates						
Residential	\$69.00	\$0.00	\$0.00	\$6.00	\$6.00	\$6.00
Commercial	\$69.00	\$0.00	\$0.00	\$2.50	\$2.50	\$2.50

The primary outcomes that we chose to focus our analysis on are total post-tax emissions and total tax revenue (Table 7). The Social Cost of Carbon scenario has by far the highest amount of revenue because of the high tax rate. The initial revenue in 2020 from a tax on electricity and natural gas set at the SCC would be \$44.9 million and decrease to \$36.7

million in 2050. This decrease is due to the electricity grid becoming less carbon-intensive over time, resulting in less revenue coming from that sector in later years. While total emissions decrease from 1.2 million tCO₂e in 2020 to 0.5 million in 2050, most of that is due to the assumption that grid carbon intensity will decline over time.

The emissions from the Social Cost of Carbon scenario can be compared to the next scenario (CAP tax rate) to see the effect of a high tax on emissions. The rates of the CAP tax scenario are much lower but the difference in emissions reductions is only about 45,000 tCO₂e. This relatively small difference is likely due to the fact that modeled emissions reductions are derived using long-term elasticities of demand that account for demand reductions due to higher prices alone. The model does not include any substitution effects that would likely result in fuel switching more quickly with a higher tax. Therefore, the emission reductions in the SCC scenario are likely to be underestimated.

It is also useful to compare both the revenue and emissions across the three CAP tax scenarios. In the CAP tax rate scenario (Scenario 1), the revenue decreases dramatically over time from \$1.8 million in 2020 to \$447,000 in 2050. This is due to there being fewer GHG emissions from the electricity sector to tax, which can be seen from the emissions decline over time. That revenue can be replaced by either increasing the electricity tax rate over time (as modeled in Scenario 2) or adding a natural gas tax that increase over time (as modeled in Scenario 3).

The final two scenarios (high and low renewable energy) show the sensitivity of the model to our renewable energy assumptions. The renewable energy assumptions are built into the assumption of the carbon intensity of the electricity grid (Figure 5). The high renewable energy scenario was designed to align with the City of Boulder's goal of reaching 100% renewable energy by 2030. This scenario results in much lower emissions than any of the other scenarios due to increased renewable penetration on the grid. However, the amount of renewable penetration in the future is still uncertain and will impact revenue projections. Natural gas has a constant carbon emission profile; adding a greater share of the tax revenue from natural gas could help to reduce some of the revenue uncertainty from the electricity sector.

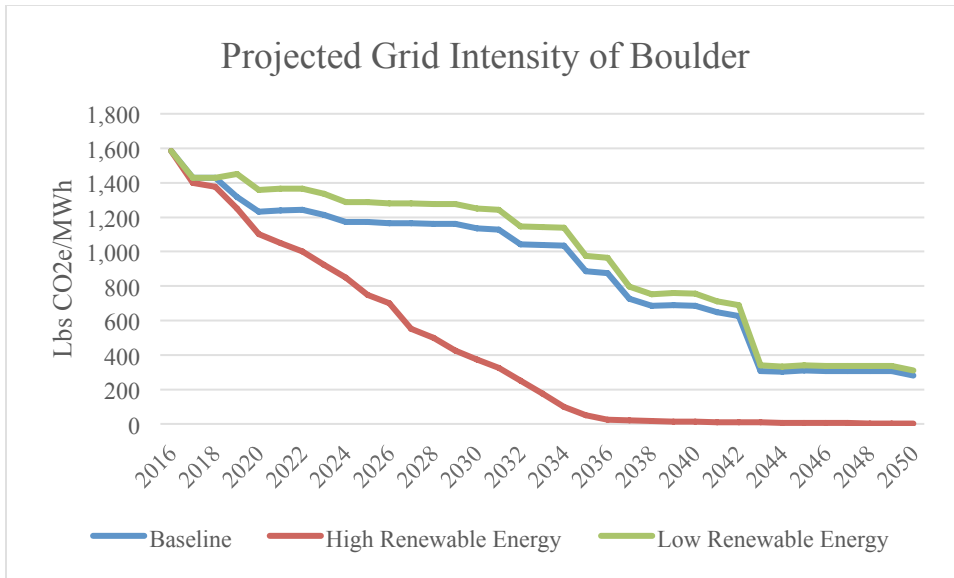


Figure 5: Modeled Carbon Intensity Assumptions.

The low renewable energy scenario assumes that the grid will be 10% more carbon-intensive than our baseline scenario. The 10% increase in carbon intensity was not as dramatic a difference from the baseline scenario as the high renewable scenario. Therefore, the differences are not as drastic, but we believe that is it more likely that the grid will get cleaner as opposed to dirtier and that is why we chose these two options to look at.

Table 7: Total Emissions and Revenue by Scenario.

Scenario	Total Emissions (tCO ₂ e)		Total Revenue (\$)	
	2020	2050	2020	2050
Social Cost of Carbon	1,151,153	531,822	44,894,950	36,695,748
CAP Tax Rate	1,152,537	577,272	1,824,076	447,406
CAP Tax Rate with Stable Revenue	1,152,537	576,494	1,824,076	2,019,224
CAP Tax Rate with Natural Gas Tax	1,152,525	575,140	1,943,228	1,815,310
High Renewable Energy	1,062,282	370,155	1,746,455	1,368,458
Low Renewable Energy	1,236,182	595,715	2,125,642	1,860,174

It is also important to examine how each carbon tax scenario will affect the average annual bill of each customer class (Table 8). The SCC scenario has the highest tax rate and therefore has the most pronounced effect on each customer type's final bill. The high tax burden from this scenario may make it politically unpopular and could put local

businesses at a disadvantage. Notably, although we estimated our results using averages, actual cost burdens are expected to be distributed unevenly, with a small portion of very high emitters facing a very high tax burden. The rest of the scenarios have very similar rates to the current CAP tax and may face less political opposition.

Table 8: Annual average cost to consumers.

	Social Cost of Carbon	CAP Tax Rate	CAP Tax Rate with Stable Revenue	CAP Tax Rate with Natural Gas Tax	High Renewable Energy	Low Renewable Energy
Average Annual Cost to Consumer: Electricity 2020						
Residential ¹²³	\$140	\$27	\$27	\$27	\$24	\$30
Commercial ¹²⁴	\$2,787	\$99	\$99	\$99	\$89	\$109
Industrial ¹²⁵	\$5,709	\$67	\$67	\$67	\$60	\$74
Average Annual Cost to Consumer: Electricity 2050						
Residential	\$59	\$7	\$29	\$7	\$0	\$7
Commercial	\$1,177	\$24	\$123	\$24	\$0	\$27
Industrial	\$2,430	\$17	\$72	\$17	\$0	\$18
Average Annual Cost to Consumer: Natural gas 2020						
Residential	\$136	\$-	\$-	\$4	\$4	\$4
Commercial	\$4,024	\$-	\$-	\$5	\$5	\$5
Average Annual Cost to Consumer: Natural gas 2050						
Residential	\$255	\$-	\$-	\$25	\$25	\$25
Commercial	\$7,504	\$-	\$-	\$303	\$303	\$303

The modeled scenarios are just a small portion of the different rate combinations that can be implemented in a carbon tax on electricity and natural gas. They are intended to provide a sample of the different effects that various levels and tax designs could have on emissions, revenue, and consumers' final bills. However, the results indicate that one promising option to raise revenue for the City and incentivize GHG reductions is to include natural gas in any future CAP tax revision or replacement. Including a natural gas tax with a modified CAP tax that taxes carbon and not kWh would help to keep a stable revenue stream and reduce GHG emissions.

Conclusion

The results of our research and analyses into carbon tax policy options for the City of Boulder suggest that the City, while constrained in some instances by limits on municipal taxation authority and by the high administrative costs of some policy alternatives, nevertheless has several promising options for revising or replacing its current CAP tax.

¹²³ Based on 42,000 customers from the City of Boulder

¹²⁴ Based on 5,500 customers from the City of Boulder

¹²⁵ Based on 2,000 customers from the City of Boulder

While we have presented several different options in the preceding sections, we particularly recommend the following two priority areas for the City to consider in revising their current CAP tax:

1) Adjusting the tax rate to account for the emissions intensity of the source

Boulder's current CAP tax applies to electricity consumption but is not explicitly scaled to the emissions intensity of the electricity on the grid. Tying the tax rate to the emissions intensity of the local grid would allow the city to more accurately reflect the damages associated with emissions of greenhouse gases into the atmosphere in the price of electricity. It would also produce a price signal that is responsive to the emissions intensity of the grid over time, which is important for incentivizing fuel switching from higher-emission fuels, such as natural gas for heating, to electricity as the grid becomes cleaner.

2) Incorporating other sources of emissions

The current CAP tax does not include emissions from non-electric emissions sources, such as natural gas burned for heating and industrial purposes, transportation, or waste management. Based on our analysis of the emissions makeup of the city, in addition to our analysis of the legal authorities of the City to implement various policy options, we recommend that the City consider incorporating a tax on natural gas. Incorporating a tax on natural gas would cover a wider range of the city's emissions (70% versus 50% covered under an electricity-only tax) and would prevent revenue from declining over time as renewables are incorporated onto the grid.

Finally, our assessment indicates that transportation at the city-level is not feasible at this time. The City cannot tax motor vehicle fuel, and other options would be expensive to administer and offer a less tangible link between the taxed activity and actual emissions. We therefore recommend pursuing regional or state-level regulation to address greenhouse gas emissions from the transportation sector.

Next Steps and Further Research

An important next step is for the City to decide on its revenue goals and use the model to determine the optimal carbon tax price.

Once the City identifies its optimal tax structures and prices, it should conduct focus groups or distribute a survey to its residents to gauge its voters' price tolerance. Since the tax will require voter approval, it is important that the City engages with its constituents to create a feasible carbon tax.

Model Revisions

Before deciding on its carbon tax structure, the City may choose to enhance the existing carbon tax model to explore additional policy and design features. Below are a few recommendations to consider that are not yet built into the model:

- How might a carbon tax impact low- and middle-income customers? What tax price might protect these customers from being too economically burdened?
- How will natural gas and electricity consumption change over time if residents switch from fossil-fuel powered devices to electric devices (i.e. EVs, heat pumps)? What carbon tax price might incentivize this switch?
- What would be an appropriate carbon tax rate if the City pursues a dynamically scaled electricity tax scenario?
- How does inflation impact the tax and revenue over time?
- What would the City's revenue be if it included tax exemptions for certain customers (i.e. universities)?
- If the City succeeds in its municipalization efforts, what will the new emissions projection look like?

The City could also improve the model by separating the commercial and industrial natural gas rates. To do so, it must first gather more granular data on the share of natural gas consumption within each of these two customer classes.

Further, the City ought to continue to update the model over time as new data becomes available. In particular, emissions and consumption projections that currently rely on 2016 data could be updated periodically to maintain maximum accuracy.

Regulatory Considerations

Before implementing a tax, it is critical that the City ensure it has the regulatory and legal authority to do so. While regulatory considerations have been noted in this report, the City would be prudent to review its jurisdiction over these recommendations, particularly if it pursues action within the transportation sector.

If the City chooses to implement a natural gas tax, it may also need to gain greater clarity on the natural gas providers servicing the municipality. The option to use a third-party

natural gas supplier is mainly exercised by commercial and industrial customers but may also be available to residential customers. Further research should be done to identify the major industry players and to evaluate the scope of third party suppliers.

Further, the City should continue to monitor carbon initiatives in the transportation sector at the state level, such as a VMT charge. Given the City's limited authority to tax the transportation sector, the City may want to be an active voice in these conversations to support statewide policy.

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Appendix

The Social Cost of Carbon

The Social Cost of Carbon (SCC or SC-CO₂) is an estimate of the monetary value of the damages associated with an incremental increase in carbon dioxide emissions in a given year. In other words, it measures the expected social and economic cost of emitting an additional unit of carbon into the atmosphere. In the United States, the SCC is often measured in dollars per metric ton of CO₂.

Federal agencies began using various expert estimates or agency-specific calculations for the SCC in 2008 in order to quantify the economic benefits of avoided emissions and economic costs of increased emissions in their regulatory impact analyses. This ad-hoc system of calculating the SCC produced disparate estimates between agencies.

In 2010, the federal Interagency Working Group on Social Cost of Greenhouse Gases (IWG) proposed a standardized range of values in order to improve consistency in valuing carbon and other greenhouse gas emissions reductions across federal agencies. The values proposed in 2010 were updated in 2013 and again in 2015. The IWG values have been used by federal agencies in a number of proposed and finalized rulemakings.¹²⁶ Hereafter all references to the SCC refer to the estimates of the IWG.¹²⁷

Methodology

The SCC is intended to include damages from lost agricultural productivity, human health impacts, property damages from sea-level rise and increased flood risk, and the value of ecosystem services lost due to climate change, among other impacts.¹²⁸

There is significant uncertainty associated with estimating the economic damages of these and other climate impacts. The IWG attempts to quantify this uncertainty where possible. To that end, the IWG provides a range of cost estimates under various assumptions.

The IWG uses several analytical methods to characterize uncertainty related to calculations of the SCC. For instance, the SCC is estimated by taking the average value from the distribution of the cost estimates produced by three independent integrated assessment models. Each model is used to produce cost estimates under five different

¹²⁶ Jane A. Leggett, “Federal Citations to the Social Cost of Greenhouse Gases” (Washington, D.C.: Congressional Research Service, March 21, 2017).

¹²⁷ Estimates of the economic costs of carbon produced by other sources will be discussed separately and clearly labeled as such.

¹²⁸ Interagency Working Group on Social Cost of Greenhouse Gases, “Technical Support Documents: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866” (Office of Management and Budget, August 2016), https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf.

scenarios with three constant discount rates.¹²⁹ Due to data limitations and knowledge gaps, not all sources of uncertainty have been characterized or quantified. However, the IWG has noted that, given the nature of the remaining sources of uncertainty, current estimates are likely to underestimate the economic costs associated with carbon emissions.¹³⁰

Table 9: Social Cost of Carbon, 2010-2050 (in 2007 dollars per metric ton of CO₂)

Year	5% Average	3% Average	2.5% Average	High Impact (95th Pct at 3%)
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

Source: Interagency Working Group on Social Cost of Greenhouse Gases, 2016.

Estimates of the SCC rise over time because CO₂ emissions are expected to produce higher incremental damages the further into the future they occur as impacts from climate change place increasing stress on physical and economic systems.¹³¹ Additionally, models estimate many categories of climate damages in proportion to total GDP, which is also expected to grow over time.

The SCC is only intended to estimate the damages associated with the emissions of additional increments of carbon dioxide. This is a key limitation to utilizing the SCC as a pricing benchmark for a carbon tax that covers multiple greenhouse gases.

Key Variables

There are several key variables that have a significant impact on the value of the estimates produced for the SCC. These include the discount rate, the equilibrium climate sensitivity value, the choice of reference case socioeconomic and emissions scenarios, and the inclusion or exclusion of global economic impacts.

¹²⁹ Interagency Working Group on Social Cost of Greenhouse Gases.

¹³⁰ Interagency Working Group on Social Cost of Greenhouse Gases.

¹³¹ Interagency Working Group on Social Cost of Greenhouse Gases.

Discount Rate

The discount rate refers to the rate at which economic damages occurring in the future are valued in the present. The higher the discount rate, the lower the present value placed on future economic damages and vice versa. The choice of discount rate significantly affects the value of the SCC (Table 9).

Experts disagree on the appropriate rate for discounting the future impacts of climate change, particularly given the intergenerational timespan on which climate change occurs. The IWG accounts for this uncertainty by providing SCC estimates at three distinct discount rates: 5%, 3%, and 2.5%. According to the IWG, these rates were chosen to “reflect reasonable judgments under both prescriptive and descriptive approaches to intergenerational discounting.”¹³² The IWG also provides a “high-impact” estimate, which is calculated as the 95th percentile value on the 3% discount rate distribution, and which is intended to represent the marginal damages associated with lower-probability, higher-impact climate change outcomes that would be particularly damaging to society.

The choice of discount rate reflects the relative weight policymakers place on future climate impacts, including those that may primarily affect future generations. As such, the choice of discount rate involves policy and value judgments with far-reaching implications.

Equilibrium Climate Sensitivity

Equilibrium climate sensitivity is a measure of the strength of the climate response to increasing greenhouse gas concentrations in the atmosphere.¹³³ It is defined as the long-term increase in average surface temperature as a result of a doubling of atmospheric carbon dioxide concentrations relative to the pre-industrial period. This value has been estimated to range from 1.5 °C to 4.5 °C, with an expected value of approximately 3 °C.¹³⁴ The choice of equilibrium climate sensitivity impacts the expected damages by altering the assumptions about the timing and severity of future climate impacts.

Reference Case Scenarios

The expected damages resulting from an incremental increase in carbon dioxide emissions in the atmosphere is also dependent upon the socio-economic parameters incorporated into the models, as well as the expected emissions trajectories. In order to

¹³² Interagency Working Group on Social Cost of Greenhouse Gases.

¹³³ Interagency Working Group on Social Cost of Greenhouse Gases.

¹³⁴ Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver and Z.-C. Zhao, 2007: Global Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

account for uncertainty in the future pathways of global population, wealth, and emissions, the IWG utilizes five socio-economic and emissions pathways that are believed to represent a plausible range of possibilities.¹³⁵ Utilizing different scenarios would potentially result in different estimates for the SCC, as damages are considered to be a function of the expected number and wealth of individuals affected by climate change.

Inclusion of Global Impacts

Although federal agencies are not generally required to incorporate global damages into regulatory impact analyses, the IWG and the Office of Management and Budget (OMB) under the Obama Administration have argued that international damages must be included in estimates of the SCC in order to capture the global externality posed by domestic GHG emissions and in order to signal U.S. dedication to international cooperation on climate action.¹³⁶

More recently, the Trump Administration has begun to calculate the SCC as including only climate impacts within the United States. Excluding global impacts from the calculation results in a cost estimate of \$1-\$6 per ton of CO₂ in 2020. As this demonstrates, the estimated SCC differs significantly based upon the decision of whether or not to incorporate economic damages outside of the United States.¹³⁷

¹³⁵ Interagency Working Group on Social Cost of Greenhouse Gases, “Technical Support Documents: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.”

¹³⁶ Interagency Working Group on Social Cost of Greenhouse Gases.

¹³⁷ U.S. Environmental Protection Agency, “Regulatory Impact Analysis for the Review of the Clean Power Plan: Proposal” (Research Triangle Park, NC, October 2017), https://www.epa.gov/sites/production/files/2017-10/documents/ria_proposed-cpp-repeal_2017-10.pdf.