On the road to climate action: Analyzing municipal approaches to plan implementation to reduce transportation sector greenhouse gas emissions

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Climate change presents growing challenges to human health and safety, quality of life, and the rate of economic growth in the US and around the world. In fact, a recent report by the Intergovernmental Panel on Climate Change (IPCC) indicates that the global community must take action by 2030 to prevent catastrophic impacts from climate change (IPCC, 2018). In the US, the transportation sector is the leading source of greenhouse gas emissions, which contribute to climate change. Extensive research has demonstrated the strategies that cities can employ to reduce greenhouse gas emissions from the transportation sector, but less work has been done to determine whether cities are effectively planning to implement the strategies suggested by the literature. As the need for climate action becomes more urgent, it is critical for cities to implement high quality transportation climate action strategies.

This thesis contributes to existing research by analyzing the extent to which planning and strategy implementation principles are incorporated into transportation climate action strategies in US cities. It first describes existing literature on climate change, climate action planning, transportation climate action strategies, and implementation planning. A methodology is presented for measuring how well cities incorporate implementation principles into transportation climate action strategies. Finally, findings and conclusions highlight the value of understanding local context, engaging stakeholders like transit providers and electric utilities, and providing implementation details at the strategy level.

Literature Review

The following literature review begins by describing global climate change and the critical role cities play in mitigating greenhouse gas (GHG) emissions. It then turns to GHG emissions from transportation, specifically. An explanation of the local level Climate Action Plan (CAP) framework is provided, followed by a summary of municipal strategies for reducing transportation-related GHG emissions. The literature review concludes with a description of literature on plan evaluation and implementation, revealing the need for further research to deepen our knowledge about how cities can effectively prepare to implement transportation climate action strategies.

The global climate is changing. There is strong scientific consensus that human-generated GHG emissions are likely to have increased global average temperatures by approximately by one degree Celsius above pre-industrial levels (Hoegh-Guldenberg et al., 2018). Changes to the climate create changes in other global systems such as the hydrosphere, biosphere, and geosphere. Global warming has resulted in an increased frequency, intensity, and duration of heat-related events, including heatwaves in most areas. Globally, heavy precipitation events are increasingly intense and some regions are experiencing more intense droughts. These changes pose risks to food security, health, economic growth, and poverty (Hoegh-Guldenberg et al., 2018).

Global Climate Change and Cities

Municipalities generate a significant share of global GHG emissions. Urban areas generate more GHG emissions than rural areas. The exact proportion of GHG emissions from cities is debated in the literature, with estimates ranging from seventy to seventy-five percent of global emissions (International Energy Agency, 2018; IPCC, 2014). GHG emissions per capita vary greatly between cities. Recent studies suggest that the variance is a result of different levels of energy use across cities. Key drivers of energy use per capita include climate, power and fuel sector mix, economic activity, household income, building quality, population density, and gasoline prices (Creutzig et al., 2016; Grubler et al., 2012; Glaeser & Kahn, 2010). Energy use varies across cities based on differences in these key drivers. For example, cities in cold climates typically have higher energy use per capita than cities in warm climates, when all other drivers are held constant.

Cities play a critical role in addressing global climate change. Action by a limited number of local governments could meaningfully reduce global emissions (Moran et al., 2018). Further, cities are growing faster than rural areas, meaning municipal action on climate will be even more impactful as time goes on. More than four billion people (about fifty-five percent of the global population) live in cities worldwide. Another 2.5 billion people will live in urban areas by 2050, ninety percent of whom will live in cities in Asia and Africa (Population Division of the United Nations Department of Economic and Social Affairs, 2018). Beyond the quantitative impact on emissions reductions, cities are uniquely positioned to address climate change. While the federal government is responsible for setting national climate policy, cities are often tasked with implementing national directives. Cities also tend to be more agile than state and national governments because they are smaller and less complex.

In the 1990s, American cities began to develop strategies to address climate change using formal planning frameworks. Typically, cities prepare a response to climate change using a Climate Action Plan (CAP), which is a strategic plan to establish policies and programs for reducing (or mitigating) a community's GHG emissions and adapting to the impacts of climate change (Boswell et al., 2012). CAPs may be visionary, setting broad outlines for future policy development and coordination, or they may be focused on implementation with detailed policy and program information. The International Council on Local Environmental Initiatives (ICLEI) is the informal content guide for cities interested in establishing a CAP. CAPs tend to include GHG emissions reduction goals and focus on land use, transportation, energy use, and waste. The goals are typically identified by taking into account state GHG emissions goals, community values, and key sources of GHG emissions based on a community inventory, CAPS may be stand-alone plans or be integrated into comprehensive land use plans, green plans, sustainability plans, or other community-level planning documents (Boswell et al., 2012).

The following are standard contents of a CAP:

1. Background on climate change and potential impacts
2. Inventory of local GHG emissions

3. Forecast of future GHG emissions
4. Emissions reduction strategies (quantified and based on the best available science and appropriate for the jurisdiction) that cover energy, transportation, solid waste, and land use
5. Adaptation strategies based on the best available science and appropriate for the jurisdiction
6. Implementation program, including assignment of responsibility, timelines, costs, and financing mechanisms
7. Monitoring and evaluation programs (Boswell et al., 2012)

Boswell et al. (2012) recommends the following phases of climate action planning:

Phase 1: Preliminary community commitment

1. Establish community commitment
2. Build community partnerships
3. Establish the role of the plan
4. Assemble a Climate Action Team (CAT)
5. Consider the logistics of plan development
6. Establish a public education and outreach program
7. Audit existing community policies and programs

Phase 2: CAP Development

8. Conduct a baseline GHG emissions inventory and interim forecast
9. Formulate vision and goals

10. Identify GHG emissions reduction target
11. Develop, evaluate, and specify GHG emissions reduction strategies
12. Quantify GHG emissions reduction strategies

Phase 3: Implementation and Monitoring

13. Develop and administer an implementation program
14. Monitor and evaluate implementation and reduction target attainment
15. Modify and update the plan

There is a growing body of literature on the adoption of CAPs. Wheeler (2008) studied CAPs created by the eighteen largest cities in the US and seventeen small cities known for planning innovation (also in the US). He found that fifteen of eighteen large cities and all of the small cities set GHG emissions reduction targets, however, cities had yet to implement many of the strategies they had identified to achieve those targets (Wheeler, 2008). Based on the argument that California tends to lead the way in climate policy, Bedsworth and Hanak (2013) studied the adoption of climate mitigation policies in California cities. They found that seventy percent of jurisdictions in the study had "engaged in comprehensive climate actions". The degree of government authority over the different sectors affected whether cities adopted GHG emissions reduction targets and strategies. Cities were more likely to adopt targets and strategies when they had more authority over the outcome. For example, a city that owned the local water or energy utility was more likely to develop a GHG emissions reduction target in the related sector. Further, population, household size, household income, and strong support from local leaders were all associated with higher rates of adoption. Additional factors for success include partnering with other local governments and private organizations and leveraging cost savings (Bedsworth and Hanak, 2013).

Transportation Sector GHG Emissions

Transportation is the leading end-use sector of GHG emissions in the US. The transportation sector generated 1,821 million metric tons of carbon dioxide equivalents (twenty-seven percent of total US GHG emissions) in 2018 (US EPA, 2020). Carbon dioxide equivalents (CO_2e) are a common unit used to track different types of GHG. Transportation sector GHG emissions primarily come from burning fossil fuel for passenger cars (fifty-nine percent), trucks (twenty-three percent), planes (nine percent), ships (three percent), and trains (two percent). Over ninety percent of the fuel used for transportation is petroleum-based, which primarily includes gasoline and diesel. Passenger cars and light-duty trucks, including sport utility vehicles, pick-up, trucks, and minivans, are the largest source of transportation sector GHG emissions (US EPA, 2019). There are four fundamental ways to reduce GHG emissions from the transportation sector in the US: 1) increase vehicle efficiency, 2) substitute low-carbon energy sources for carbon-intensive sources, 3) increase the efficiency with which transportation systems provide mobility, and 4) reduce transportation demand (Green and Shafer, 2003).

Vehicle efficiency

Increasing the energy efficiency of transportation vehicles could significantly reduce GHG emissions. This is primarily done through improvements in fuel efficiency for light duty vehicles, heavy duty vehicles, and commercial aircrafts. Since 2004, fuel economy for all new vehicles has increased by twenty-nine percent, with the average fuel efficiency of a model year 2017 vehicle at a record high of 24.9 miles per gallon (US EPA, 2017). Automotive companies are increasingly applying technology to increase vehicle power and fuel efficiency, without increasing vehicle weight. Raising diesel engine peak thermal efficiency to fifty-five percent through a combination of various technologies and reducing idling could improve fuel efficiency for heavy duty vehicles (Ludders et al., 1999).

In terms of commercial aircrafts, rail, and cargo shipping, the largest opportunities for further improvements are expected from improved engines and aerodynamics. The literature suggests that a twenty-five to forty-five percent reduction in aircraft energy intensity is possible by 2025, and a forty to fifty percent reduction is possible by 2050 (National Research Council, 2015). Rail is already efficient, but multiple drive trains and load reduction measures can increase fuel efficiency. For example, Amtrak reduced fuel use by eight percent by installing regenerative breaking, optimizing the length and shape of the lead car nose, and reducing weight (International Union of Railways, 2011). The cargo shipping industry reduced GHG emissions by thirty-three percent between 2007 and 2018. Ship technology was one of the drivers of the reductions. Options for improving the fuel efficiency of ships include hull optimization, propulsion and engine improvements, and waste heat recovery (Cariou et al., 2019). While local governments do not typically directly influence or account for all air, rail, or freight activities within city boundaries, fuel efficiency gains can benefit the portion of related emissions that local GHG inventories do capture.

Low-carbon energy sources

Substituting low-carbon energy sources for carbon-intensive sources can also reduce transportation-related GHG emissions. Electrifying transportation can reduce GHG emissions beyond what vehicle fuel efficiency alone can achieve. By using an electric motor instead of an internal combustion engine (ICE), electric vehicles (EVs) displace carbon-intensive fossil fuel. A growing number of EV options exist, including light-duty passenger vehicles, SUVs and trucks, buses, and dump trucks (Alternative Fuels Data Center, 2020). The development of an expanded range of EV options suggests that vehicle manufactures expect escalating momentum in the EV market (Global EV Outlook, 2019). Recently announced plans for electric trucks are especially indicative of the increasing array of EV options for consumers (Global EV Outlook, 2019).

The projected emissions reduction potential of EVs varies. While life-cycle studies have raised concerns that EVs might increase GHG and air pollutant emissions (Hou, 2010; ERI, 2007), recent analyses have demonstrated strong potential for GHG emissions reductions from EVs. In regions with a low share of coal-based electricity, EVs can significantly reduce GHG emissions and air pollution compared to ICE vehicles. In areas where electricity comes predominantly from coal, EVs reduce GHG emissions, but may cause public health concerns by increasing air pollutants. EVs charged with eighty percent renewable energy could reduce GHG emissions by eighty-five percent compared to ICE vehicles (Hou et al, 2015). Fully realizing the carbon emissions reduction potential of EVs will require transitioning to a clean energy grid that provides electricity from non-fossil fuel sources.

Capturing the emissions reduction potential of EVs will also require overcoming the challenges associated with mass adoption. Vehicle stock turn-over is slow and projections about EV market penetration vary based on researchers' assumptions about battery technology, model availability, and future vehicle prices. Bloomberg New Energy Finance projects that EVs will be thirty percent of the global light duty vehicle market by 2040, while the Global EV Outlook projects that they will make up thirty percent of the market by 2030 in the more optimistic of two potential future scenarios (Global EV Outlook, 2019; BNEF, 2019). Barriers to consumer adoption include perceptions about lack of infrastructure (Jensen et al., 2013; Carley et al., 2013), range anxiety (Ebuque and Long, 2012), and high purchase prices compared to ICE vehicles (Krupta et al., 2014). Policy, behavioral, and technological interventions will be required to address these barriers.

Increase travel efficiency

A third option is to increase the efficiency with which transportation systems provide mobility. Shifting from private vehicles toward public transit and non-motorized transportation modes, like bike and walking, increases travel efficiency. Private vehicles consume more energy per person than buses or non-motorized options and this translates into higher GHG emissions. The average passenger car in the US uses approximately one pound of CO_2e per passenger-mile, while a bus trip generates .64 pounds of CO_2e per passenger-mile (US DOT, 2010). Studies show that for every additional passenger-mile traveled on public transportation, private vehicle travel declines by 1.4 to nine miles (Newman and Kenworthy, 1999, Hotzclaw, 2000). GHG emissions can be further reduced by electrifying transit.

Public transit ridership is affected by service quality, as well as individual perceptions, attitudes, and preferences. Accessibility, reliability, frequency, and speed impact transit ridership. When transit is accessible, reliable, and frequent, individuals are more likely to ride (Brown et al., 2016; Brown et al., 2003). On the other hand, people are more likely to drive when public transit is significantly slower than traveling in a private vehicle (Walker and Donovan, 2007) or feels unsafe (Spears et al, 2013). While individual attitudes and choices matter, they are influenced by broader cultural dynamics and institutions. Specifically, public transit ridership can be negatively impacted when riders fear traveling through poor, black, or minority neighborhoods. Significantly increasing public transit ridership will require addressing issues of social and racial inequity (Sheller, 2015).

When it comes to the factors affecting non-motorized modes of transportation, the environment, trip length, and built environment are at play. Hills and bad weather reduce the likelihood that an individual will take a bike or walking trip instead of a car trip (Dunlap, 2015). Further, individuals are typically only willing to walk or bike a few miles per trip (Pucher et al., 2010). Separated facilities encourage users to take non-motorized modes (Azziz et al., 2018). Density can also impact decisions to take non-motorized modes (Cruiez et al., 2016).

Pavement condition is another factor that affects travel efficiency. Studies show that poor pavement quality increases GHG emissions from motor vehicle trips, whether they are in single-passenger vehicles, transit buses, or heavy-duty vehicles. Wang et al. (2014) found that preventative maintenance to maintain smooth pavement could reduce GHG emissions by two percent. Smooth pavement reduces tire rolling resistance (Wang et al., 2020). Applying a more durable pavement that does not require reconstruction to maintain smoothness results in lifecycle GHG emissions reductions (Simões et al., 2017).

Reduce transportation demand

The fourth option is to reduce transportation activity all together. This can be done through travel demand strategies such as increased density and land use policies, congestion pricing, parking policies, and employer incentives for teleworking, biking, walking, or transit trips. The urban form impacts emissions (Cruiez et al., 2016; Silva et al., 2017). Some studies have shown that dense development reduces driving and GHG emissions. For example, Vojnovic (2014) found that reducing the distance between daily destinations, especially home and work, decreases average travel distances leading to lower energy consumption and emissions in the transportation sector and to reduced infrastructure construction requirements. In his review of existing research on driving and compact development, Stevens found that dense development reduces driving, but not by much. He suggested that compact development should not be the only strategy for reducing transportation demand (Stevens, 2017).

Congestion pricing and higher parking prices can also reduce private vehicle use and encourage public transit use. Congestion pricing is the practice of charging drivers a fee in areas where congestion is a problem during certain times of day. Studies show that congestion pricing and parking pricing can effectively reduce transportation demand (i.e. Danielis et al., 2012; Steg, 2003). However, pricing strategies have the potential to disproportionately affect low-income households (Eliasson, 2016). Employer incentives for walking, biking, or transit trips can further reduce employee vehicle miles traveled by up to twenty-five percent (Transit Cooperative Research Program, 1995).

Transportation Climate Action Strategies

Cities do not have the same level of control over all of the four fundamental ways to reduce GHG emissions from the US transportation system. Increasing the energy efficiency of transportation vehicles primarily occurs through federal and state fuel efficiency standards. California was the first state to adopt GHG emissions standards for vehicles under Assembly Bill 1493 in 2002 (California GHG Vehicle Emissions Standards). Since then, twelve states have adopted Zero Emission Vehicle Standards (Berman, 2020). States, utilities, and the federal government wield the influence to develop policies, accelerate regional markets, and invest in ways that advance EVs, but cities, counties, regional governments can also install infrastructure for low-carbon fuel options. Cities are well-positioned to increase the efficiency with which transportation systems provide mobility and reduce transportation activity.

In the transportation sector, the *Moving Cooler* report recommends cities pursue the following transportation climate action strategies to address the areas over which they have the most control (Moving Cooler, 2009). While this is not a comprehensive list, it translates many concepts from the literature on transportation sector GHG Emissions reduction into actionable strategies for cities:

- *Pricing and taxes*: Raise the costs associated with the use of the transportation system, including the cost of vehicle miles of travel and fuel consumption
- *Land use and smart growth:* Create more transportation-efficient land use patterns, and by doing so reduce the number and length of motor vehicle trips
- *Non-motorized transport*: Encourage greater levels of walking and bicycling as alternatives to driving
- *Public transportation improvements*: Expand public transportation by subsidized fares, increasing service on existing routes, or building new infrastructure.
- *Ride-sharing, car-sharing, and other commuting strategies:* Expand services and provide incentives to travelers to choose transportation options other than driving alone

- *Regulatory strategies:* Implement regulations that moderate vehicle travel or reduce speeds to achieve higher fuel efficiency
- *Operational and intelligent transportation system (ITS) strategies:* Improve the operation of the transportation system to make better use of the existing capacity; encourage more efficient driving
- *Capacity expansion and bottleneck relief:* Expand highway capacity to reduce congestion and improve the efficiency of travel
- *Multimodal freight sector strategies:* Promote more efficient freight movement within and across modes

Cities incorporate transportation climate action strategies in CAPs, but may also incorporate strategies into traditional transportation planning processes. City-level transportation planning typically includes a long range (ten to twenty year) transportation plan that is aligned with the city comprehensive plan. Based on the content in these plans, cities develop a shorter list of priority projects, typically in the form of a five-year capital improvement plan (City of Boston, 2017; City of Minneapolis, 2020). Cities are increasingly releasing mobility action plans that focus providing options for people traveling in vehicles other than single-occupancy vehicles (City of Denver, 2017; City of Philadelphia, 2018; City of San Diego, 2015). Mobility action plans are often aligned with bike and pedestrian plans that identify improvements for people walking and biking in the city (City of Denver, 2017; City of Philadelphia, 2018; City of San Diego, 2015).

Implementing Transportation Climate Action Strategies

In addition to the growing body of research on CAP adoption (and subsequently cities' adoption of the transportation climate action strategies included in CAPs), scholars are increasingly studying the quality of transportation climate action strategies included in cities' CAPs. Tang et al. (2010) analyzed forty recently adopted local CAPs in the US based on the extent to which they indicated awareness of climate change, analyzed the impacts of climate change, and included actions to mitigate climate change. Eighty percent of the plans studied included alternative transportation strategies to promote biking, walking, and transit, seventy-seven percent included transit-oriented development and corridor improvements, sixty-five percent included parking standards adjustments, and seventy-two percent included pedestrian-friendly, bicycle-friendly, and transit-oriented community design (Tang, 2010).

Deetjen et al. (2018) analyzed twenty-nine major US cities' CAPs by scoring the extent to which each plan included the following research-backed transportation climate action strategies: parking restrictions, dense development, mass transit, automobile independence, mixed land use zoning, and vehicle electrification. Parking restrictions could include restructured zoning requirements (i.e. revised parking minimums or ratios), improved pricing (i.e. increased off-street parking rates), or high efficiency incentives (i.e. preferential parking for EVs or carpools). Dense development policies are policies that promote density, repurposing existing buildings, or urban growth boundaries. Deetjen et al. (2018) found that many cities lacked parking restriction and dense development policies.

Mass transit policies typically involve public transit network expansion or plans for transit-oriented development. Automobile independence policies aim to reduce vehicle miles traveled by substantial amounts through fuel taxes, higher parking prices, or congestion charges. Mixed land use zoning typically involves developing a city-wide plan for mixed-use and affordable development. Vehicle electrification strategies involved installing EV infrastructure, EV incentives, and electrification of transit. Deetjen et al. scored city CAPs highly for policies supporting mass transit, automobile independence, and mixed land use zoning (Deetjen, 2018).

In *Local Climate Action Planning* (2012), Boswell et al. describe the components of strong CAP implementation. The person or group responsible for plan oversight should be documented in the plan. Responsible entities may include a new entity such as a Sustainability Office or Green Team, or an existing entity such as the Public Works, Planning or City Manager’s office. The entities responsible for overseeing each strategy should also be identified. Cities may choose to continue or modify the group involved in the development of the GHG emissions reduction strategies, or develop a new implementation team. Boswell et al. explain that strategies must be associated with a timeline for implementation in order to be successful. Capacity, including staffing levels, staff expertise, workload, and alignment with staff roles, will impact strategy implementation timelines. Funding will also impact strategy implementation. In fact, Boswell suggests this may be the most challenging aspect of implementation (Boswell, 2012).

Early research on the topic of climate change mitigation found that institutional barriers make it hard to move from political rhetoric to action. Because climate is a cross-cutting issue, many cities that participated in climate mitigation efforts in the late 1990s lacked departments and staff dedicated to climate change mitigation with the technical expertise required to develop solutions. They also faced budgetary constraints (Betsill, 2001). On the other hand, Bulkeley (2010) identified several factors that motivated municipal climate action in the 1990s and early 2000s, including the positive impact of policy entrepreneurs and motivation spurred by a sense of failure to take action on climate at the international level. Policy entrepreneurs are politicians or officials who champion the issue, set the agenda, and establish the basis for policy responses. These champions help overcome administrative and political barriers to initiating climate policy development (Bulkeley, 2010).

While a growing number of city-level sustainability departments and planners are tasked with developing and implementing CAPs (Bulkeley, 2010), cities continue to struggle with CAP implementation. While Wheeler's 2008 study of thirty-five municipalities found that some of the jurisdictions were greening public vehicle fleets and improving energy efficiency, interviewees said many other recommendations were not implemented due to politics. Uncertainty about which strategies to pursue was cited as another barrier to strategy implementation (Wheeler, 2008). Organized interests, such as environmental groups and other civic organizations, have also been found to influence CAP adoption and implementation. Specifically, organized interests are more effective in mayoral as opposed to city manager forms of governments. Further, fiscal stress also impedes climate mitigation program implementation (Sharp et al., 2011).

Few studies are dedicated to examining CAP implementation or transportation climate action strategy implementation. However, research conducted by political scientists on policy analysis is prolific. One of the seminal works was Pressman and Wildavsky's book *Implementation: How Great Expectations in Washington are Dashed in Oakland*, published in 1973. Bryson and Bromiley (1993) introduced a "factor analysis" for project implementation, which involved identifying the factors involved in context and process that were correlated with achieving project goals. The results of a regression model used to analyze 68 case descriptions of major projects indicated that limited technological change, political and economic stability, communication, and problem-solving were critical for successful project implementation (Bryson and Bromiley, 1993).

Studies on plan implementation are increasingly popular. Planning scholars have established three ways to judge implementation success: plan conformance, plan performance, and planning process performance. Plan conformance measures whether the development identified in a plan occurred. This analysis of implementation is outcome specific, and was initially conceived to evaluate comprehensive plans (Talen, 1996). A common approach to evaluating plan conformance for environmental plans involves comparing development to land use plans (i.e. Brody and Highfield, 2005; Laurian et al., 2004). Plan performance evaluates the role of a plan in implementation more broadly. This approach views the consideration of a plan's recommendations in future decision-making as implementation success (Mastop and Faludi, 1997). Mastop and Faludi argue that polices and plans should be updated regularly and that conformity with the original plan should not, and often does not occur. Finally, planning process performance is the most expansive measure of implementation among the three. This method evaluates implementation success by taking the indirect and direct effects of a plan into account (Innes and Booher, 1999). Direct effects of a plan may include physical infrastructure changes, whereas indirect effects may include community capacity building that occurs through the plan development process.

Many transportation climate action strategies are so new that evaluating plan performance or conformance is not yet possible. This would require changes to the built environment or GHG emissions reductions, which take several years. It is possible to study the integration of implementation principles in transportation climate action strategies using plan quality evaluation protocols. Plan evaluation protocols involve identifying plan quality criteria based on the literature and systematically evaluating multiple plans against the criteria (Baer, 1997). Baer suggests the following criteria for assessing the implementation section of plans before outcomes are available:

1. Are implementation provisions appropriate in the plan?
2. Are there priorities for implementation?
3. Is cost of implementation versus non-implementation considered?

4. Is there a time span for plan implementation?
5. Are there provisions for scheduling and coordinating implementation proposals?
6. Can proposals accomplish their intended purpose if implemented?
7. Is there a program or proposal for an impact analysis?
8. Is the agency or person responsible for implementation identified?
9. Can the responsible agency realistically be expected to implement the plan?

Woodruff and Stultz (2016) developed a coding protocol with similar questions to Baer and used it to assess the implementation sections of local US adaptation plans. The researchers identified fifteen criteria for evaluating the implementation elements of the plans. For example, one of the criteria they assessed was the implementation timetable. If the plan did identify a timetable that described when each action would be implemented, it received a score of 1; otherwise it received a score of 0. Assessing the presence/absence of criteria allowed the researchers to generate quantitative measurements of implementation planning quality, which facilitated comparisons between plans and allowed for statistical analyses (Woodruff and Stultz, 2016).

More research is needed to tie studies on policy analysis and plan implementation to city-level transportation climate action strategy implementation. Transportation strategies are of particular interest because, at nearly thirty percent of US GHG emissions, action in this sector could make significant progress toward reducing climate change. A growing number of cities have developed CAPs and scholars have studied the quality of the transportation strategies included in existing CAPs. There are fewer studies, however, on the implementation of CAPs and transportation climate action strategies, specifically. Therefore, this thesis will focus on how high-quality transportation climate action strategies move cities from planning to action. Specifically, the research will address the following question:

To what extent do existing high quality transportation climate action strategies incorporate planning and strategy implementation principles that have been established in the literature?

Methodology

The first step of the methodology involved selecting a sample of cities to analyze. The next step focused on identifying implementation principles and developing an evaluation method for analyzing the extent of the implementation principles in city plans containing transportation climate action strategies.

Sample Selection

A sample of twelve cities was analyzed for this study. Cities were ranked in order of their total transportation climate action strategy score according to Deetjen et al. (2018). Deetjen et al. developed a scoring methodology to analyze the extent to which the twenty-nine largest cities in the US incorporated GHG emission reduction best practices from academic literature into city CAPs. The Deetjen et al. transportation strategy scores were developed by awarding points for parking restriction, mass transit, auto-independence, non-motorized transport, mixed land use zoning, and vehicle electrification policies (Table 1 on the following page). Parking restriction policies, which were deemed essential, had a maximum score of nine, EV policies, which were deemed additional, had a maximum score of three, while the remaining policies, which were deemed priority, had a maximum score of six.

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Table 1. Transportation Strategy Quality Descriptions (Deetjen et al., 2018)

Transportation Climate Action Strategy	Points Awarded	Description
Parking restrictions	3	includes one of restructured zoning requirements
	6	contains 2 of restructured zoning requirements, improved pricing, and high-efficiency incentives
	9	contains all three of restructured zoning requirements, improved pricing, and high-efficiency incentives
Mass transit	2	mentions goals to expand transit network without specific policies or development plans
	4	includes specific plans for transit-oriented development, increased bus lines, expansion of transit network, etc.
	6	outlines a complete overhaul of the current transit system and/or expands the transit network to include rail
Auto Independence	2	mentions need for congestion management and includes one specific policy including ride-sharing, fuel taxes, higher parking prices, etc.
	4	includes two specific policies
	6	includes more than two policies and/or goals to reduce vehicle travel by substantial amounts
Non-motorized transport	2	mentions need to increase non-motorized transport without specific plans
	4	includes specific plans for pedestrian paths, bike lanes, and/or complete streets
	6	develops ambitious program for expanding bike/sidewalk infrastructure, traffic free zones, adding bike racks to buses, etc.
Mixed land use zoning	2	mentions mixed-use planning without specific policies, or implements small-scope plans
	4	develops city-wide plans for mixed-use and affordable development, financial incentives, and specific targets for proximity
	6	includes land use survey for entire city to guide policy
Vehicle Electrification	1	plans to transition city vehicle fleet towards hybrid vehicles
	2	plans for EV charging infrastructure, EV incentives, electrification of transit, fuel taxes, etc.
	3	plans for aggressive vehicle electrification with four or more policies mentioned

The strategy scores were totaled for each city, for a maximum total possible score of thirty-six. Cities with the top twelve scores were selected to represent a sample of cities with high quality transportation climate action strategies (Table 2). Deetjen's framework is useful because the scores begin to classify cities that are leaders on transportation climate action strategies relative to other cities. The cities that scored highly in Deetjen's analysis have high quality CAPs according to other scholars (Tang, 2010; Wheeler, 2008), with the exception of St. Louis, Miami, Riverside, and Austin. Berkeley, CA was selected instead of Riverside, CA because Tang et al. (2010) and Wheeler (2008) described the city's climate action planning as high quality. It is important to note that some cities have released new plans since 2010 that were not included in previous studies. The transportation climate action strategies included in St. Louis, Miami, and Austin's CAPs were reviewed to confirm that they included transportation climate action strategies that scholars have found to reduce GHG emissions. The cities included in the final study sample are listed in Table 3.

Table 2. Transportation Strategy Quality Scores (Deetjen et al, 2018)

City	Parking Restrictions	Mass transit	Auto Independence	Non motorized transport	Mixed land use zoning	Vehicle Electrification	Transport Score
San Francisco	9	4	6	6	4	2	31
St. Louis	6	6	6	6	4	3	31
Portland	6	4	6	6	6	3	31
Denver	6	6	6	6	4	2	30
Los Angeles	6	4	6	4	4	3	27
Miami	9	4	4	4	4	2	27
Boston	9	4	4	4	4	2	27
Riverside	6	4	4	6	4	3	27
San Diego	6	4	4	6	4	3	27
Austin	9	4	4	4	4	2	27
Philadelphia	6	6	2	4	6	2	26
Minneapolis	6	4	6	4	4	2	26

The city CAPs were reviewed, along with other plans containing transportation climate action strategies, such as stand-alone reports, long-range transportation plans, and/or transportation investment plans. For some cities, transportation planning documents provide more details about transportation climate action strategies than the CAPs (Table 3). The goal of analyzing CAPs and transportation planning documents was to compare the most detailed, current, and publicly-available version of transportation climate action strategies between cities.

Table 3. City Planning Document Evaluated

City	Plan
Austin	Austin Community Climate Plan (2015)
Berkeley	Berkeley Climate Action Plan (2009)
Boston	Go Boston 2030 (2017)
Denver	Denver Mobility Action Plan (2017)
Los Angeles	L.A.'s Green New Deal (2019)
Miami	MiPlan: Climate Action Plan (2008)
Minneapolis	Draft Minneapolis Transportation Action Plan (2020)
Philadelphia	Connect: Philadelphia's Strategic Transportation Plan (2018)
Portland	Portland & Multnomah County Climate Action Plan (2015)
San Diego	San Diego Climate Action Plan (2015)
San Francisco	San Francisco Transportation Sector Climate Action Strategy (2017)
Saint Louis	St. Louis Climate and Adaptation Plan (2017)

Implementation Evaluation Protocol

An evaluation protocol was developed to assess transportation climate action strategies against ten principles for plan and strategy implementation. The principles were selected based on an analysis of three climate change mitigation planning guidance documents developed for cities (UN-Habitat, 2015; Boswell, 2012; SEEC 2011). Between the three documents, there was a high level of agreement on implementation principles for climate change mitigation planning and strategy development (Table 4). From this scan, principles that were present across multiple guidance instruments were identified for use in evaluation.

Table 4. Implementation Principles in Climate Change Mitigation Planning Guidance

Principles	*Guiding Principles for City Climate Action Planning* UN-Habitat, 2015	*Local Climate Action Planning* Boswell et al., 2012	*Climate Action Plan Template* Statewide Energy Efficiency Collaborative, 2011
Assignment of responsibilities	x	x	x
Assignment of responsibility for oversight	x	x	x
Assignment of responsibility for implementation		x	x
Identification of costs and benefits	x	x	
Identification of financial support	x	x	
Identification of timelines	x	x	x
Prioritization of strategies	x	x	x
Monitoring and evaluation	x	x	x

In addition, existing climate planning implementation literature and plan evaluation protocols (Woodruff and Stultz, 2016; Baer, 1997) were used to increase the specificity of the principles to create a scoring rubric. For example, *Guiding Principles for Climate Action Planning* (2015) indicates that climate action strategies should have evaluation and monitoring components (UN-Habitat, 2015), but does not specify how to evaluate the quality of the evaluation and monitoring components. Woodruff and Stultz (2015) developed four indicators to analyze the evaluation and monitoring components of climate adaptation plans: an established process to evaluate the plan, a description of when analyses of progress toward objectives will take place and how results will be used, a mention of how to measure progress toward implementing strategies collectively, and a mention of how to measure progress toward implementing each strategy. An evaluation methodology with ten principles and twenty indicators was developed based on the synthesis of climate planning implementation studies and plan evaluation literature (Table 5).

Table 5. Implementation Principles for Transportation Climate Action Strategy Evaluation

Principles	**Description**	**Score**	**Source**
Principle 1: Assignment of Responsibility			
Assignment of responsibility for oversight	Lists entity responsible for oversight and management of the plan	1	Boswell et al., 2012; UN-Habitat, 2015; SEEC, 2011; Baer, 1997; Woodruff and Stultz, 2016
Assignment of responsibility for implementation	Lists entity responsible for implementation of each transportation climate action strategy	1	Boswell et al. 2012; SEEC, 2011; Baer, 1997; Woodruff and Stultz, 2016
Principle 2: Costs and Benefits			
Costs and/or benefits	Lists costs and/or benefits of the plan	1	Boswell et al., 2012; UN-Habitat 2015; Baer, 1997; Woodruff and Stultz, 2016
Costs and benefits detailed	Provides detailed costs and benefits for each transportation climate action strategy	1	Boswell et al., 2012; Woodruff and Stultz,, 2016
Principle 3: Financial Support			
Financial support	Lists financial source(s) for the plan	1	Boswell et al., 2012; UN-Habitat, 2015; Woodruff and Stultz, 2016
Financial support detailed	Specifies funding source for each transportation climate strategy	1	Boswell et al., 2012; UN-Habitat, 2015; Woodruff and Stultz, 2016

Principles	Description	Score	Source
Principle 4: Timelines			
Timelines	Lists timelines for the plan	1	Boswell et al., 2012; UN-Habitat, 2015, SEEC, 2011; Baer, 1997; Woodruff and Stultz, 2016
Timelines detailed	Timeline includes short term, medium term, and long term targets for each transportation climate action strategy	1	Boswell et al., 201; UN-Habitat, 2015; SEEC, 2011; Woodruff and Stultz, 2016
Principle 5: Reporting			
Reporting requirements	Includes requirements for regular reporting on progress	1	Boswell et al., 2012; UN-Habitat; 2015; SEEC, 2011; Baer, 1997; Woodruff and Stultz, 2016
Reporting detailed	Describes reporting format (i.e. annual report, scorecard, electronic dashboard, etc.)	1	Boswell et al., 2012; SEEC, 2011
Principle 6: Evaluation Method			
Evaluation method	Establishes a process to evaluate the success of the plan	1	Boswell et al., 2012; UN-Habitat; 2015; SEEC, 2011; Baer, 1997; Woodruff and Stultz, 2016
Evaluation method detailed	Establishes a process to evaluate the success of each transportation climate action strategy	1	Boswell et al., 2012; UN-Habitat; 2015; SEEC, 2011; Baer, 1997; Woodruff and Stultz, 2016
Principle 7: Implementation Tracking			
Implementation tracking metric	Mentions how to measure progress toward implementation of the plan	1	Boswell et al., 2012; UN-Habitat; 2015; SEEC, 2011; Baer, 1997; Woodruff and Stultz, 2016
Implementation tracking detailed	Mentions how to measure progress toward implementation of all transportation climate action strategies	1	Boswell et al., 2012; UN-Habitat; 2015; SEEC, 2011; Baer, 1997; Woodruff and Stultz, 2016
Principle 8: Mainstreaming			
Mainstreaming	Mentions that the plan will be aligned with other plans	1	Woodruff and Stultz, 2016
Mainstreaming detailed	Identifies specific plans and programs as opportunities for mainstreaming	1	Woodruff and Stultz, 2016

Principles	Description	Score	Source
Principle 9: Plan updates			
Plan updates	Mentions need for updates to the plan	1	Boswell et al., 2012; UN-Habitat; 2015; SEEC, 2011; Woodruff and Stultz, 2016
Plan updates detailed	Includes timetable for updating transportation climate action strategies	1	Boswell et al., 2012; UN-Habitat; 2015; SEEC, 2011; Woodruff and Stultz, 2016
Principle 10: Prioritization			
Prioritization	Transportation climate action strategies are prioritized	1	Boswell et al., 2012; UN-Habitat; 2015; SEEC, 2011; Baer, 1997; Woodruff and Stultz, 2016
Prioritization detailed	Provides detailed description of prioritized transportation climate action strategies	1	Boswell et al., 2012; UN-Habitat; 2015; SEEC, 2011; Baer, 1997; Woodruff and Stultz, 2016

The transportation climate action strategies in each of the plans identified in Table 3 were scored. Scoring involved summing the totals for the twenty indicators to measure the extent of implementation principles included in the transportation climate action strategies section of each city's plan. The literature did not provide sufficient information to rank or weight the implementation principles by relative importance, and as such, each score was summed to allow for the comparison of cities based on the principles incorporated into each plan. Following this ranking, four of the implementation principles (costs and benefits, timelines, implementation tracking, and mainstreaming) were analyzed in more detail to evaluate their quality.

Specifically, content in each city's plan was categorized according to whether the implementation principles were:

0) Not present

1) Present/not explained

2) Present/vague, or

3) Clear.

Findings

City, GHG Emissions Trend, and Plan Summaries

The following section provides overview statistics for the cities in the sample, GHG emissions trends, and a summary of the plan evaluated. For each plan, the coordinating entity, GHG emissions target are provided, along with a brief summary of the transportation climate action strategies and implementation content. The twelve cities' populations ranged from just over 300,000 to nearly four million people. City density ranged from just over 2,600 people/mi^2 to over 17,000 people/mi^2. Median household income ranged from $36,638 to $104,552 per year. Degree days, which measure climate conditions and are used as a proxy for energy required to heat and cool buildings, ranged from 2,700 to 8,400. Total GHG emissions ranged from 4.3 million to 25.1 million metric tons CO_2e annually and transportation sector GHG emissions ranged from one million to 5.4 million metric tons of CO_2e annually (Table 6).

Table 6. Summary of City Demographics and GHG Emissions

	Population (2018)	Metropolitan Statistical Area Population (2010)	City Density (people/mi^2) (2010)	Median HH Income (2014-2018)	Degree Days (Heating + Cooling, 5 yr. avg.)	Total GHG emissions (metric tons CO_2e)	Transportation Sector GHG emissions (metric tons CO_2e)
Austin	964,254	1,362,416	2,653	$67,462	5,000	13.5 million (2016)	4.9 million (2016)
Berkeley	121, 643	3,281,212	10,752	$80,912	3,000	6.1 million (2016)	3.7 million (2016)
Boston	694,583	4,181,019	12,792	$65,883	4,900	6.1 million (2016)	1.7 million (2016)
Denver	716,492	2,374,203	3,922	$63,793	5,000	11.5 million (2017)	3.3 million (2017)
Los Angeles	3,990,456	12,150,996	8,092	$58,385	2,700	25.1 million (2017)	5.3 million (2017)
Miami	470,914	5,501,379	11,136	$36,638	5,000	4.8 million (2008)	1.9 million (2008)
Minneapolis	425,403	2,650,890	7,088	$58,993	8,400	4.3 million (2018)	1 million (2018)
Philadelphia	1,584,138	5,441,567	11,380	$43,744	6,000	20.9 million (2013)	3.5 million (2013)
Portland	653,115	1,849,898	4,375	$65,740	5,000	7.7 million (2013)	2.8 million (2013)
San Diego	1,425,976	2,956,746	4,024	$75,456	2,200	9.8 million (2018)	5.4 million (2018)
San Francisco	883,305	3,281,212	17,179	$104,552	3,000	5.1 million (2018)	2.2 million (2018)
St. Louis	302,838	2,150,706	5,158	$41,107	6,400	6.6 million (2018)	1.1 million (2018)

Sources: BizEE Software Limited, 2017; United States Census Bureau, 2010a, 2018; City of Austin, 2016, City of Berkeley, 2016; City of Boston, 2016; City of Denver, 2017; City of Miami, 2008; City of Minneapolis, 2018; City of Los Angeles, 2019; City of Philadelphia, 2017; City of Portland, 2015; City of San Diego, 2018; City of San Francisco, 2018; City of St. Louis, 2018

Austin

Austin is the least dense area in the sample with a Metropolitan Statistical Area (MSA) population of 1.3 million people and a density of 2,653 people per square mile. In 2016, Austin-Travis County generated 13.5 million metric tons of CO_2e, thirty-six percent of which came from the transportation sector (Table 6). Between 2013 and 2016, the city and county reduced GHG emissions by one percent. During that time, transportation sector GHG emissions also decreased by one percent. This change was a result of vehicle fuel efficiency improvements (City of Austin, 2017b). The City of Austin and Travis County generate a collective GHG emissions inventory. City-specific emissions data are not available.

The City of Austin released the *Austin Community Climate Plan* in 2015. The Austin Office of Sustainability convened the *Community Climate Plan* Steering Committee to lead the development of the plan. The *Community Climate Plan* includes strategies to move the city toward net-zero GHG emissions by 2050. It includes a set of “Transportation and Land Use Sector” actions targeted at transportation demand management and vehicle and fuel efficiency (City of Austin, 2015). In 2017, the City of Austin released the *Austin Community Climate Plan: Implementation Plan*, which outlines actions to bring the city to the interim GHG emissions target of 11.3 million metric tons CO_2e by 2020. The *Implementation Plan* includes three infrastructure and service actions, five land use actions, eight transportation demand action, one vehicle and fuel efficiencies action, and two economics and pricing actions (City of Austin, 2017a).

Berkeley

Berkeley is the smallest city in the sample with 121,643 residents within the city boundaries, despite being situated in an MSA with a relatively high population compared to others in the sample. It is also the only city in the sample that has experienced a recent increase in transportation sector GHG emissions. In 2016, the city of Berkeley generated 6.2 million metric tons of CO_2e, sixty percent of which came from the transportation sector (Table 6). Between 2000 and 2016, the city reduced GHG emissions by fifteen percent, despite a population increase of eighteen percent during the same time period. During that time, transportation sector GHG emissions increased by 8.5 percent to 3.7 million metric tons CO_2e. This change was primarily a result of the population increase (City of Berkeley, 2018).

The City of Berkeley released the *Berkeley Climate Action Plan* in 2009. The planning process was led by a cross-departmental team of city staff with coordination from the City's Office of Energy and Sustainable Development. The *Climate Action Plan* is the result of a city ballot measure that directs that Mayor to develop a CAP to reduce community GHG emissions by eighty percent by 2050. The plan includes a "Sustainable Transportation and Land Use" chapter that includes strategies aimed to:

- Increase the safety, reliability, and frequency of public transit

- Expand other mobility options like shuttle buses into areas where existing transit is less frequent
- Accelerate implementation of the City's Bicycle and Pedestrian Plans
- Ensure that new development is green
- Manage parking effectively to minimize driving demand
- Create incentives for low-carbon vehicles

The transportation climate action strategies are summarized in an implementation table that includes 124 actions. (City of Berkley, 2009). The City Council receives annual updates on plan progress and adjustments to the transportation climate action strategies (City of Berkley, 2018).

Boston

More than half of Boston residents travel to work using a mode other than a car. In 2017, the city of Boston generated 6.1 million metric tons of CO_2e, twenty nine percent of which came from the transportation sector (Table 6). Between 2005 and 2017, the city decreased GHG emissions by twenty-one percent, despite a population increase of thirty percent during the same time period. Transportation sector GHG emissions decreased slightly to 1.7 metric tons CO_2e. This change was a result of more efficient vehicles. The average fuel efficiency of vehicles registered in Boston increased from 19.8 to 21.9 mpg between 2009 and 2014 (City of Boston, 2017b).

The City of Boston released *Go Boston 2030,* the city's long-term mobility plan, in 2017. The plan development process was led by the Boston Department of Transportation in collaboration with a mayoral advisory committee, other city departments, state agencies, a team of consultants, community organizations and advocacy partners. It incorporates goals identified in the *Greenovate Boston*, the city's 2014 CAP update. Specifically, *Greenovate Boston* identifies a twenty-five percent GHG emissions reduction goal by 2025 (City of Boston, 2017a). *Go Boston 2030* includes an action plan with a list of fifty-eight short-term and long-term projects and policies. The action plan is scheduled for implementation within fifteen years of the plan's release (City of Boston, 2014).

Denver

Denver is situated toward the median of the sample in terms of population, density, household income, climate, and GHG emissions. In 2017, the city and county of Denver generated 11.5 million metric tons of CO_2e, twenty-nine percent of which came from the transportation sector (Table 6). Between 2005 and 2017, the city and county reduced GHG emissions by nineteen percent. During that time, transportation sector GHG emissions also increased slightly (City of Denver, 2019). The City and County of Denver County generate a collective GHG emissions inventory. City-specific GHG emissions data are not available.

The City and County of Denver released the *Denver 80x50 Climate Action Plan* in 2018. The plan was developed coordinated by the City & County of Denver Department of Public Health and Environment based on engagement with the Technical Advisory Committee and a Task Force comprised of "systems thinkers". *Denver 80x50* includes a long-term climate goal to reduce GHG emissions by eighty percent from 2005 levels by 2050. The plan includes strategies to move the city toward interim GHG emissions reductions goals set for 2020, 2025, 2030, 2035, 2040, 2045, and 2050. It includes a set of eleven "Decarbonizing Transportation" strategies (City of Denver, 2018). One of the strategies is to implement the *Denver Mobility Action Plan* to realize the 2030 GHG emissions reduction targets (City of Denver, 2017).

Los Angeles

Los Angeles has the largest population of the cities in the sample, along with the highest total GHG emissions and transportation sector GHG emissions. In 2017, the city of Los Angeles generated 25.1 million tons of CO_2e, twenty-one percent of which came from the transportation sector (City of Los Angeles, 2019). Between 1990 and 2017, the city reduced GHG emissions by twenty-five percent. The City of Los Angeles released *L.A.'s Green New Deal* in 2019. The *Green New Deal* is the city's updated sustainability plan. The Mayor's Sustainability team coordinated the planning process, which involved departmental chief sustainability officers, community partners, and stakeholders. The plan includes strategies to reduce GHG emissions by fifty percent by 2025, reduce GHG emissions seventy-five percent by 2025, and achieve carbon-neutrality by 2050. The *Green New Deal* includes three mobility and public transit targets and three zero emission vehicle targets. Each target is associated with milestones and initiatives set to occur between 2021 and 2028 (City of Los Angeles, 2019).

Miami

Miami has the lowest household median income among the cities in the sample. In 2008, the city of Miami generated 4.8 million metric tons of CO_2e, forty percent of which came from the transportation sector (Table 6). The city GHG emissions inventory has not been updated since 2008. The City of Miami released *MiPlan*, the City of Miami's CAP, in 2008. *MiPlan* sets a strategy to reduce GHG emissions by twenty-five percent by 2020. The transportation section of the plan identifies twenty-four actions focused on facilitating and encouraging alternative means of transportation, increasing telecommuting, compressed workweeks, and flexible hours, encouraging higher vehicle fuel efficiency, educating residents about opportunities to reduce GHG emissions from transportation, and tracking progress (City of Miami, 2008).

Minneapolis

Minneapolis has the most heating and cooling degree days among the cities in the sample, along with the lowest GHG emissions from transportation. In 2018, the city of Minneapolis generated 4.3 million metric tons of CO_2e, twenty-four percent of which came from on-road transportation (Table 6). Between 2006 and 2018, the city reduced GHG emissions by seventeen percent. During that time, transportation sector GHG emissions decreased by 8.2 percent (City of Minneapolis, 2019). The City of Minneapolis released the draft *Transportation Action Plan* in 2020. The *Transportation Action Plan* is the city's long-range transportation plan. The Minneapolis Public Works Department led the development of the *Transportation Action Plan*. The *Transportation Action Plan* directly relates to goals identified in the *Minneapolis 2040* comprehensive plan, including climate goals pulled from the 2013 *Minneapolis Climate Action Plan*. Specifically, the *Minneapolis Climate Action Plan* set a goal to reduce GHG emissions by eighty percent by 2050. The draft *Transportation Action Plan* includes walking, biking, bicycling, transit, technology, freight, street operations, and design strategies that collectively include fifty-five actions, as well as an implementation section (City of Minneapolis, 2020).

Philadelphia

The transportation sector in Philadelphia makes up the smallest share of total city GHG emissions compared to other cities in the sample. In 2012, the city of Philadelphia generated 20.9 million metric tons of CO_2e, seventeen percent of which came from the transportation sector (Table 6). Between 2006 and 2012, the city reduced GHG emissions by nine percent. Transportation sector GHG emissions declined by two percent between 2006 and 2012. During that time period, total vehicle miles traveled (VMT) declined, but heavy-duty truck VMT increased. The heavy-duty truck VMT increase was likely driven by the Recession, as well as changes to the VMT calculation methodology. (City of Philadelphia, 2015).

The City of Philadelphia released the *Greenworks: A Vision for Sustainable Philadelphia* in 2016. The Office of Sustainability coordinated the plan development process and engaged residents, community groups, issue experts, and implementation to generate the plan content. Developing a Transportation Master Plan was one of the key next steps identified in

Greenworks (City of Philadelphia, 2016). In August 2018, the Mayor made a commitment to reduce GHG emissions eighty percent by 2050. In October 2018, the city released the *Connect: Philadelphia's Strategic Transportation Plan*. *Connect* includes "Vision Zero", "Transit First", "Great Streets", "Competitive City", and "Efficient Government" goals. Each goal is supported by four to five strategies that are scheduled for implementation within seven years of the plan's release (City of Philadelphia, 2018).

Portland

Portland has one of the longest histories of climate action planning among cities in the sample with records of GHG emissions accounting as early as 1990. In 2013, the city of Portland and Multnomah County generated 7.7 million metric tons of CO_2e, thirty seven percent of which came from the transportation sector (Table 6). Between 1990 and 2013, the city and county reduced GHG emissions by fourteen percent, while population increased by thirty-one percent. Transportation sector GHG emissions decreased by five percent to 2.8 metric tons CO_2e. Emissions per capita from transportation declined by twenty-eight percent as a result of increased vehicle efficiency, increased low carbon fuel use, shifts to more efficient modes of travel like walking, biking, and transit, and neighborhood designs to reduce travel demand (City of Portland & Multnomah County, 2015).

The City of Portland and Multnomah County released the *Portland and Multnomah County Climate Action Plan* in 2015. The plan builds off of a rich history of climate planning – in 1993, Portland was the first US city to adopt a

CAP. The 2015 *Climate Action Plan* was developed by a Steering Committee and an Equity Advisory Group. Staff from the City of Portland (Bureau of Planning and Sustainability, Bureau of Environmental Services, Bureau of Transportation, Office of Management and Finance, and Parks and Recreation Department) and Multnomah County (Department of County Assets, Health Department, and Office of Sustainability) were primary project staff. The plan provides guidance for the city and county to achieve an eighty percent reduction in GHG emissions by 2050 within five years of the plan's release. The "Urban Form and Transportation" chapter of the plan includes three objectives and 48 actions. (City of Portland & Multnomah County, 2015). The city and county track implementation through annual CAP updates (City of Portland & Multnomah County, 2017).

San Diego

San Diego has the least cooling and heating degree days among the cities in the sample. In 2018, the city of San Diego generated 9.8 million metric tons of CO_2e, fifty-five percent of which came from the transportation sector (Table 6). Between 2010 and 2018 the county reduced GHG emissions by twenty-four percent (City of San Diego, 2015). Transportation sector GHG emissions data are not publicly available. The City of San Diego released the *San Diego Climate Action Plan* in 2015. The planning process was guided by an Environmental and Economic Sustainability Task Force, City staff, and stakeholders. The strategies in the plan are designed to achieve the mandatory GHG emissions reductions set by the State of California. The plan provides guidance for the city and county to achieve a fifteen percent reduction by 2020, forty percent reduction by 2030, and fifty percent reduction by 2035. The bicycling, walking and transit section includes six goals and related actions (City of San Diego, 2015). The city tracks implementation through annual progress updates (City of San Diego, 2019).

San Francisco

San Francisco is the densest area in the sample with a Metropolitan Statistical Area (MSA) population nearly 3.3 million people and a density of 17,179 people per square mile. In 2018, the city of San Francisco generated 5.1 million metric tons of CO_2e, forty-five percent of which came from the transportation sector (Table 6). Between 1990 and 2018, the city reduced GHG emissions by thirty-five percent, despite a population increase of twenty-two percent during the same time period. Transportation sector GHG emissions decreased by eleven percent to 2.32 million metric tons CO_2e. This change was a result of higher fuel efficiency standards and cleaner fuels mandated by the State of California (City of San Francisco, 2020). The 2013 San Francisco Climate Action Strategy describes transportation as “one of the toughest challenges in developing a climate action strategy in the city” (City of San Francisco, 2013).

The City of San Francisco released the *San Francisco Transportation Sector Climate Action Strategy* in 2017. The planning process was led by four city agencies: the San Francisco Municipal Transportation Agency, the San Francisco County Transportation Authority, the San Francisco Planning Department and the San Francisco Department of the Environment. The plan builds off of the *2013 San Francisco Climate Action Plan,* which includes a goal to reduce GHG emissions by eighty percent by 2050. It identifies seven climate mitigation program areas in the transportation sector: transit, land use & transportation, pricing & congestion management, transportation demand management, complete streets, zero emissions vehicles & infrastructure, and emerging mobility services & technology. Each program area includes goals, three to four prioritized implementation actions, and long-term strategies. The plan also includes an implementation chapter (City of San Francisco, 2017).

Saint Louis

Saint Louis generates the second lowest transportation sector GHG emissions in the sample, just surpassing Minneapolis. In 2018, the city of St. Louis generated 6.6 million metric tons of CO_2e, forty one percent of which came from the transportation sector (Table 6). Between 2005 and 2018, the city reduced GHG emissions by nineteen percent, while the population declined by seven percent. During that time, transportation sector GHG emissions decreased by forty percent to 1.1 million metric tons CO_2e. (City of St. Louis, 2019). The population decrease was likely a key driver of the significant emissions reduction.

The City of St. Louis released the *St. Louis Climate Action and Adaptation Plan* in 2017. The plan outlines a path to reduce GHG emissions by eighty percent by 2050. It was developed by a consultant team that worked closely with the City Sustainability Director to gather input from key city staff technical stakeholders. The plan includes an objective to “create equitable access to inter-modal transportation”. The objective includes strategies that aim to support integrated land use, congestion and emissions reduction, alternative fuel vehicles, and alternative commutes collectively associated with nineteen actions (City of St. Louis, 2017).

Implementation Principles

The following section describes the extent to which the ten implementation principles are incorporated into the transportation climate action strategies developed by the cities in the sample. The implementation principles include: assignment of responsibility, costs and benefits, financial support, timelines, reporting, evaluation methods, implementation tracking, mainstreaming, plan updates, and prioritization. Many of the cities in the sample incorporated the majority of the principles into the plans that contain transportation climate action strategies, but not all principles were incorporated at the level of detail recommended by the literature.

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Table 7. Implementation Principle Scores by City

Implementation Principles	ATX	BER	BOS	DEN	LA	MIA	MPLS	PHILA	PDX	SD	SF	STL	Totals
1a. Assignment of responsibility for oversight	1	1	1	1	1	1	1	1	1	1	1	1	12
1b. Assignment of responsibility for implementation	1	1	1	0	0	0	0	1	1	1	1	0	7
2a. Costs and/or benefits	1	1	1	1	1	0	0	1	0	0	1	1	8
2b. Costs and benefits detailed	1	0	1	0	0	0	0	0	0	0	0	0	2
3a. Financial support	1	1	1	1	0	1	1	0	1	0	0	0	7
3b. Financial support detailed	1	0	1	0	0	0	0	1	0	0	1	0	4
4a. Timelines	1	1	1	1	1	1	1	1	1	1	1	1	12
4b. Timelines detailed	1	1	1	0	1	0	0	1	1	1	1	0	8
5a. Reporting requirements	1	1	0	1	1	1	1	0	1	1	0	0	8
5b. Reporting requirements detailed	1	1	0	0	1	1	1	0	0	1	0	0	6
6a. Evaluation method	1	1	1	1	1	1	1	1	1	1	1	1	12
6b. Evaluation method detailed	1	1	1	0	1	1	1	1	1	1	1	0	10
7a. Implementation tracking	1	1	1	1	1	1	1	0	1	1	0	0	9
7b. Implementation tracking detailed	1	1	1	0	0	0	1	0	1	1	0	0	6
8a. Mainstreaming	1	1	1	1	1	1	1	1	1	1	1	1	12
8b. Mainstreaming detailed	1	1	1	1	1	1	1	1	1	1	1	1	12
9a. Plan updates	1	1	1	1	1	1	1	1	1	1	1	1	12
9b. Plan updates detailed	1	1	1	0	1	0	1	1	1	0	1	1	9
10a. Prioritization	0	0	1	0	0	0	1	1	1	1	1	1	7
10b. Prioritization detailed	0	0	1	0	0	0	1	1	1	1	1	1	7
Total Score	18	16	18	10	13	11	15	14	16	15	14	10	

Assignment of Responsibility

All cities designated a lead entity responsible for plan oversight. The entity listed was typically the City or the department responsible for coordinating plan development. Seven cities (fifty-eight percent of the sample) assigned responsibility to an entity for transportation climate action strategy implementation. With the exception of one city, lead entities were assigned to specific actions. The lead entity was often the city transportation department, but sustainability departments, environmental departments, planning departments, public works departments, and transit agencies were also listed as leads. Occasionally, finance or city attorney department staff were listed as leads.

Many actions were assigned to two or three lead entities, often a city and a county department or two departments within a city. When multiple leads were listed, it was unclear from the planning documents which entity was expected to initiate or coordinate implementation. County, regional, and state entities were listed in five cities' plans. For example, the *Portland and Multnomah County Climate Action Plan* listed the Multnomah County Office of Sustainability as of one two leads for an action focused on improving county bridges in the city of Portland. Private entities were also occasionally listed as leads. For example, the *Austin Community Climate Plan* included the local utility, Austin Energy, as the lead on EV charging infrastructure installation.

Costs and Benefits

All of the cities commented on the benefits of the transportation climate action strategies. Cities highlighted similar types of benefits. All cities highlighted the impact of the strategies on climate mitigation or GHG emissions reductions. Public health, job creation, equity, and safety were all frequently-cited benefits of the transportation climate action strategies. Climate resilience, community well-being, access, affordability, innovation, and environmental improvements were other benefits that were included in some plans.

Cities' descriptions of benefits varied greatly. First, the terminology was inconsistent. While some cities used the term "benefits", others used "co-benefits", "outcomes", or "impacts". Second, the format cities used to describe the benefits varied. Some cities used icons or a phrase to describe benefits, while others used a narrative or quantified the benefits. For example, the *Portland and Multnomah County Climate Action Plan* used four icons to indicate whether an action had potential to 1) advance equity, 2) improve public health, 3) support jobs and prosperity, and 4) align with the city's Transit First Policy (Figure 1). Taking a different approach, *Go Boston 2030* included a few sentences paired with each action to describe the context and quantify the benefit of the action. Third, the plans varied in the level of detail used to describe the benefits. Some cities used an icon to indicate benefits, while others included a relative level of benefits or indicated which strategies had high potential to provide benefits, and others quantified the benefits.

Figure 1. Co-Benefits, *San Francisco Transportation Sector Climate Action Strategy (2017)*

TRANSIT

Long-Term Strategies:

		GHG REDUCTION POTENTIAL	CO-BENEFITS (equity)	CO-BENEFITS (public health)	CO-BENEFITS (Transit First)	CO-BENEFITS (jobs)	COST $
TRA-1	Maintain and expand local and rapid transit service and make system improvements that increases safety, reliability and accessibility.		✓	✓	✓	✓	$ $ $
TRA-2	Expand regional transit core capacity to accommodate growth and encourage mode shift to transit, walking and bicycling.		✓	✓	✓	✓	$ $ $
TRA-3	Secure Cap and Trade and other grant funds that can support fleet expansion, storage and maintenance needs that will help accommodate future growth and ridership demands.		✓	✓	✓		$ $ $

LEGEND Potential to reduce greenhouse gas emissions · Potential to advance equity · Potential to improve public health · Consistent with Transit First Policy · Potential to support jobs and prosperity · $ Initial Capital Cost (public)

Very few cities included detailed costs in the plans. Two cities (seventeen percent of the sample) described the transportation climate action strategies in terms of cost. Boston and Austin provided planning and infrastructure cost estimates for each strategy. For example, *Go Boston 2030* listed twenty-five million dollars in design and construction costs over five years to develop walk- and bike- friendly mainstreets throughout the city. The City of Boston elected to include costs in *Go Boston 2030* to demonstrate the level of funding needed to implement transportation climate action strategies. As public pressure mounted for the city to take action on transportation, the Mayor's Office reached out to the Department of Transportation to put together a budget for additional resources. In an interview, Boston Transportation Department Director of Planning, Vineet Gupta, explained, "Our leadership asked what it would take to implement the recommendations in Boston 2030. And I said, we need staff" (V. Gupta, personal communication, March 6 2020). As a result, the Boston Department of Transportation received twenty five additional staff who are primarily focused on public engagement for transportation projects.

While Boston and Austin provided the clearest costs and benefits associated with the transportation climate action strategies, other cities did not quantify the cost of specific strategies (Table 8). The *San Francisco Transportation Sector Climate Action Strategy* used a relative cost measure to compare strategies to each other. Strategies were either listed as one, two, or three dollar signs, with three dollar signs being the most expensive. The *Denver Mobility Action Plan* identified costs at the plan level, indicating that the package of transportation climate action strategies would cost approximately two billion dollars between its release and 2030, which is 350 million dollars more than the existing budget. *Connect: Philadelphia's Strategic Transportation Plan* indicated that additional investment was needed to provide the benefits of the transportation climate action strategies included in the plan, but did not provide the relative or quantified costs of the strategies. The Miami, Minneapolis, Portland, San Diego, and St. Louis plans did not comment on costs or cost savings.

Table 8. Costs and Benefits Principle Quality

Lower Quality			**Higher Quality**
Not Present	**Present/not explained**	**Present/vague**	**Clear**
Miami Minneapolis Portland San Diego St. Louis	Berkeley Philadelphia	Denver Los Angeles San Francisco	Austin Boston

Financial Support

Seven cities (fifty-eight percent of the sample) identified funding sources in the plans. Four cities (thirty-three percent of the sample) provided detailed funding sources for at least some of the transportation climate action strategies. Boston and Austin identified funding sources for each transportation climate action strategy. Every city listed the city budget as a source of funding for transportation climate action strategies. Cities also often listed state, federal, and transit agency funding sources in the plans. Some cities included private funders like private grant foundations or private companies with mobility services (i.e. carpooling).

Less frequently-cited sources included utilities, regional funding sources, and user-generated revenue. The *Austin Community Climate Plan* was the only plan to include a utility funding source, which was allocated for EV infrastructure installation. *Go Boston 2030* listed the Metropolitan Planning Organization as the funding source for several complete streets and bike infrastructure projects. The *San Francisco Transportation Sector Climate Action Strategy* identified multiple congestion pricing pilot projects that would generate revenue that could be used to promote transit, walking, and biking programs or transportation projects.

Timelines

All of the cities included timelines in the plans. Of those, eight cities (sixty-seven percent of the sample) included timelines with short-term, medium-term, and long-term targets for the climate action strategies strategy. Like benefits, the terminology used to describe timelines varied from “timeframe” to “strategies &

deliverables” to “milestones and initiatives”. Plans that provided but didn’t explain timelines included a target year for collectively implementing the transportation climate action strategies. For example, the *Denver Mobility Action Plan* stated that all strategies, tactics, and actions would occur between the plan release and 2030. Plans that provided vague timelines failed to provide medium-term targets.

Berkley, Boston, Los Angeles, Portland, and San Diego provided clear, detailed timelines for implementing the transportation climate action strategies (Table 9). For example, *L.A.’s Green New Deal* listed “Launch regionally coordinated advocacy campaign to encourage shared, sustainable mobility options” as a short-term action. Of course, implementation will require additional work, like identifying the stakeholders for the campaign and defining shared, sustainable mobility options, but the action is detailed enough to implement. Short-term actions were planned for one to three years after the plans’ release, mid-term actions were planned for three to ten years after the release, and long-term actions were planned for four to twenty years after the release. The *Portland and Multnomah County Climate Action Plan* had the most condensed timelines with short-term actions targeted for one year after plan release, mid-term actions targeted three years after plan release, and long-term actions targeted four years after plan release. The *San Diego Climate Action Plan* included the longest timeline with Phase One actions occurring after two years of plan release, Phase Two actions occurring three to five years after plan release, and Phase Three actions occurring five to twenty years after plan release.

Table 9. Timelines Principle Quality

Lower Quality			Higher Quality
Not Present	**Present/not explained**	**Present/vague**	**Clear**
	Denver	Austin	Berkeley
	Minneapolis	Philadelphia	Boston
	Miami	San Francisco	San Diego
	St. Louis		Los Angeles
			Portland

Reporting

Eight cities (sixty-seven percent of the sample) included regular reporting requirements in the plans. Six cities (fifty percent of the sample) included details about the frequency of reporting and the reporting format. All reporting was planned on an annual cycle, with some cities describing more formal or detailed reporting every two years. The *Berkley Climate Action Plan* specified that reports will be provided to the City Council and the city will also launch a web portal for reporting. *L.A.'s Green New Deal* also explained that some reporting will occur through an open data portal.

Evaluation Methods

All of the cities identified a process for tracking the success of the plans. Every city in the sample had a GHG emissions reduction goal of eighty percent by 2050. Ten cities (eighty-three percent) provided more detailed goals for tracking the success of the transportation climate action strategies. All of the California cities provided interim GHG emissions targets, as did Boston, Austin, Philadelphia, and Portland. Mode shift and VMT reduction goals were common throughout the plans. For example, the draft *Minneapolis Transportation Action Plan* included goals to reduce VMT per capita by 1.8 percent annually and reduce single occupancy vehicles trips to forty percent of all trips by 2030. Other measures of success included increasing the number of transit riders, increasing the portion of residents who live in walkable neighborhoods, and increasing access to jobs by transit. Interestingly, Los Angeles and San Francisco were the only cities to set EV metrics for success.

Implementation Tracking

Nine cities (seventy-five percent of the sample) identified a process for tracking plan implementation. Six cities (fifty percent of the sample) described the process for tracking transportation climate action strategy implementation. The Miami, Minneapolis, Portland, and San Diego plans provided clear implementation tracking processes by developing a system to indicate whether the transportation climate action strategies were not started, in progress, or complete. The *Portland and Multnomah County Climate Action Plan* includes an additional distinction between actions that are on track or in progress and facing barriers. The Boston, Denver, and Los Angeles plans did not describe the implementation tracking process but rather explained that new committees and systems would be created to guide and track implementation (Table 10).

Table 10. Implementation Tracking Principle Quality

Lower Quality			**Higher Quality**
Not Present	**Present/not explained**	**Present/vague**	**Clear**
Philadelphia	Boston	Berkeley	Miami
San Francisco	Denver		Minneapolis
St. Louis	Los Angeles		Portland
			San Diego

The City of Portland offers a strong model for other cities interested in implementation tracking. The City releases an annual progress update on the 2015 *Portland and Multnomah County Climate Action Plan*. The update tracks implementation progress using a series of four icons to indicate whether planned actions are not started, in progress but facing barriers, on track, or complete. The 2019 update included forty-four transportation climate actions: one was not started, 6 were in progress but facing barriers, thirty-two were on track, and five were complete. City transportation funding, planning scenario evaluations, bike sharing, regional rail, and EVs were complete. Tar sands was not started and the youth transit pass development, federal fuel standards advocacy, Intelligent Transportation Systems and freeway management activities, mobile transportation services expansion, and EV charging station expansion were facing barriers.

Mainstreaming

All of the cities identified opportunities for transportation climate action strategies to fit into specific plans and programs. Nearly all of the cities provided a very clear explanation of how specific strategies or actions fit into plans (Table 11). The plans that were vague provided a list of related plans, but failed to describe how the transportation climate action strategies connected to the related plans. The transportation climate action strategies were frequently tied to local transit plans, city capital plans, local zoning code, small area plans, and bike and pedestrian plans. Some cities (i.e. Boston, Minneapolis) are moving away from mode-specific plans (i.e. Bike and Pedestrian Plans) toward more comprehensive long-range transportation plans.

Less frequently, cities tied transportation climate action strategies to regional plans, development review, accessibility plans, and congestion or parking pricing programs. For example, some transportation projects identified in *Go Boston 2030* were recommended for incorporation into the Metropolitan Planning Organization Transportation Plan for the region. Cities planned to incentivize developers to design for bike, transit, and walk-friendly spaces and require developers to participate in travel demand management programs as part of the development review process. Changes to congestion or parking prices were typically recommended for implementation via existing or new congestion or parking pricing programs. The draft *Minneapolis Transportation Action Plan* aligned the transportation climate action strategies with federal accessibility design requirements.

Table 11. Mainstreaming Principle Quality

Lower Quality			Higher Quality
Not Present	**Present/not explained**	**Present/vague**	**Clear**
	Miami	Denver St. Louis	Austin Berkeley Boston Minneapolis Los Angeles Philadelphia Portland San Diego San Francisco

Plan Updates

All of the cities described the need to update the transportation climate action strategies. Nine cities (seventy-five percent of the sample) provided a timeline for updating the strategies. Some plans stated the need for updates and others described a continuous update process. For example, the *Denver Mobility Action Plan* states, “This plan will be continuously updated based on city council, community and stakeholder input, and evolving circumstances”. The *Austin Community Climate Plan* explains “In 2020 and 2024, a complete qualitative and quantitative review of all actions identified in the 2015 implementation plan will be conducted, as well as an assessment of new opportunities, resulting in a full plan revision.” The timeline for updates varied greatly between cities, with some updates scheduled for a year after the plans’ release and other updates scheduled five to fifteen years after the plans’ release.

Prioritization

Seven cities (fifty eight percent of the sample) prioritized the transportation climate action strategies. The same seven cities provided detailed descriptions of the prioritized activities. Some cities identified priority projects that would occur within five years of the release of the plan. Others ranked priority actions within the transportation climate action strategies. For example, the *San Francisco Transportation Sector Climate Action Strategy* identified one priority action within each of the seven focus areas listed in plan.

Discussion

The following section describes connections between the findings and prior research. The plans studied illustrate the potential to assign transportation climate action strategy implementation to non-city entities, describe the costs and benefits of transportation climate action strategies, and finance transportation climate action strategies. The plans studied also reveal different municipal approaches to establishing timelines and priorities for transportation climate action strategies. Finally, the plans studied demonstrate that some cities are combining implementation planning with transportation climate action strategy development, while others are using a phased approach.

The plans studied demonstrate that transportation climate action strategy implementation does not have to fall solely on municipalities. Many cities' plans include implementation leads that were not part of the municipal government. Boswell et al. found that local government agencies and community partners who were engaged earlier in the process were more likely to agree to take on climate action implementation responsibilities (Boswell at al., 2012). Stakeholder engagement and collaboration appears to be particularly critical for planning to implement transit strategies and road and EV infrastructure strategies over which cities do not typically have direct authority. Six cities in the sample identified the local transit agency as the lead for at least one transit-specific transportation climate action strategy. Assigning responsibility to non-city entities for transportation climate action strategy implementation reveals the potential for cities to expand GHG emissions reduction efforts beyond the infrastructure and services over which they have direct control.

Very few of the cities studied provided costs for transportation climate action strategies in the plans. There are many reasons why cities may choose not to disclose costs. Generating cost estimates takes additional time and technical expertise. It also introduces more political risk from plan opponents who can use the high costs of implementation to advocate against climate action strategies. On the other hand, disclosing costs can help cities procure the resources for implementation. The additional staff added to the Boston Transportation Department as a result of cost estimates offer an example of the positive impact that cost estimates can have. Ultimately, decisions about generating cost estimates for transportation climate action strategies are highly context-specific and should be made with an understanding of the benefits and drawbacks of transparency in this regard.

Outside funding sources listed in the cities' plans point to the value of thinking creatively about how to finance transportation climate action strategies. City budget constraints can be a barrier for climate action implementation (Boswell et al., 2012, Sharp et al, 2011, Betsill et al., 2001). Boswell et al. recommend estimating the cost of climate action strategies so that cities can assemble the costs into a budget and seek funding (Boswell et al., 2012). The range of funding sources listed in the planning documents demonstrate that cities with constrained budgets can achieve emissions reductions without tapping into limited city funds. For example, Austin transportation climate action strategies will be funded by the city as well as the local transit agency, electric utility, a private company, and state and federal grants. Cities with constrained budgets can consider seeking regional, state and federal funds as well as grants, public-private partnerships, and alternative revenue sources such as parking and congestion user fees.

It is encouraging that all of the cities in the study identified GHG emissions reduction targets for tracking transportation climate action strategy success because this performance metric will allow them to track progress. Guidance on implementation tracking was less prevalent among the plans in the sample. This is concerning because implementation is considered to be the most basic level of monitoring by Boswell et al. (Boswell et. al., 2012). While identifying the impact of a strategy on GHG emissions reductions takes time and technical expertise, determining whether or not a strategy was started or completed is a bit more straight-forward. Tracking implementation on a regular basis allows progress on transportation climate action strategies to be easily communicated to decision-makers, which Bryson and Bromiley found to be a key factor in implementation success (Bryson and Bromiley, 1993).

Prioritization is another important component of moving cities from planning to implementing transportation climate action strategies. Previous studies about climate action planning found that uncertainty about which strategies to pursue prevented cities from implementing strategies included in their plans (Wheeler et al., 2008). More than half of the cities studied identified priorities among the transportation climate action strategies. Some cities that prioritized transportation climate action strategies had dozens of actions on the short-term list of priorities, while others had just a handful. For example, Portland started on forty-three transportation climate actions while San Diego started on five transportation climate actions four years after the release of the cities' CAPs. This suggests that there may not be an optimal quantity of priority transportation climate action strategies, but rather, cities should consider the available resources to determine the number and type of strategies to prioritize.

Separating the development of timelines and priorities from the plan's release introduces the risk that transportation climate action strategies may not be implemented. Some of the cities that did not include detailed timelines and priorities identified a future process for addressing the specifics of plan and strategy implementation. For example, *MiPlan* and the *Austin Community Climate Plan* explained that six months to a year after the plans' release, the cities would identify the specifics of implementation. Miami did not develop an implementation plan or implement the *MiPlan* strategies, while Austin released an implementation plan two years later and began implementing the transportation climate action strategies in it. These cases illustrate the possibility of city's priorities shifting between transportation climate action strategy development and implementation. Shifts in priorities are an unavoidable aspect of city planning as administrations, economic conditions, and environmental factors change, so it is important for cities to consider potential future changes when deciding whether or not to phase the development of transportation climate action strategies and plans for implementing them.

Conclusion

This thesis offers several findings on the extent to which municipal transportation climate action strategies incorporate planning and strategy implementation principles. Overall, the cities studied incorporated key implementation principles into transportation climate action strategies although some plans lacked a detailed description of certain principles like costs and benefits and implementation tracking. One finding indicates that implementation planning for municipal transportation climate action strategies is highly context-specific. Decisions about releasing strategy costs and benefits, as well as when to develop strategy implementation plans, vary based on the local policymaking environment. Legislation affects the local policymaking environment and the likelihood that a city will decide to publish information like costs and benefits and implementation plans. For example, cities located in California, where state policy requires that cities develop a climate action plan with certain components, were more likely to provide relative costs and benefits of transportation climate action strategies. Public attitudes also play a role in the principles that cities incorporated in their plans. Boston received public pressure for action on climate and published a very detailed plan, while other cities like St. Louis and Denver where constituents hold a range of attitudes toward climate action published fewer details in the plans.

The context-specific nature of implementation approaches to transportation climate action strategies highlights that what makes sense in one community might not make sense in another. The plans studied ranged from visionary documents (i.e. the *St. Louis Climate Action and Adaptation Plan*) to detailed action plans (i.e. *Austin Community Climate Plan Implementation Plan*). While the *Austin Implementation Plan* scored higher than the *St. Louis Climate Action and Adaptation Plan* due to the extent of implementation principles incorporated, the score does not necessarily indicate that one plan is higher quality than the other. The cities studied revealed that implementation efforts can and do occur without public, formalized implementation plans accompanying the transportation climate action strategies. For example, the *San Francisco Transportation Sector Climate Action Strategy* did not include an implementation tracking or reporting process, but responsible entities have begun the move the strategies forward. This suggests that formalized implementation planning is a tool that planners can leverage to their advantage. In some contexts, a formalized approach to implementation planning is critical for gathering the necessary resources to carry out transportation climate action strategies, and in others, it is not necessary because there is a high degree of trust and commitment among the entities responsible for implementing the strategies.

One best practice that was consistent across the plans was community partner engagement in implementation planning for transportation climate action strategies. Transit agencies, local electric utilities, and government partners at the county, state, and federal level were identified lead the implementation of local transportation climate action strategies and assist with funding them. Stakeholder engagement appears to be especially valuable for the development and implementation of transportation climate action strategies because they tend to cross jurisdictional boundaries. A city may want to install a bike lane along a road that intersects a state highway and crosses a county bridge. By bringing together partners from different government agencies, planners can approach the implementation of transportation climate action strategies in a more holistic way that enhances safety, connectivity, and access, which increases the chances that someone will want to make a trip using a mode other than a single-occupancy vehicle.

These findings offer practitioners insights into how to prepare to implement transportation climate action strategies. Understanding local context is a critical starting point for communities developing an implementation process for transportation climate action strategies. Not all of the implementation principles established in the literature have to be present in a plan for transportation climate action strategies to be implemented. Local resources, like staff and technical expertise, available funding, and local politics impact community decisions to develop and publicize transportation climate action strategy costs and benefits, priorities, timelines, and implementation tracking procedures. Engaging local transit agencies, electric utilities, government partners, and the private sector in the process of developing transportation climate action strategies can expand a community's impact on transportation sector GHG emissions reduction and access to funding. Providing strategy or action-level details about implementation helps to clarify the process for carrying out transportation climate action strategies, but is not always essential for strategy implementation.

The cities in the sample have high quality transportation climate actions strategies and are positioned to implement them based on the implementation principles included in the plans studies. It is important, however, to make the distinction between the implementation principles included in plans and the implementation activities that actually occur. Cities may face barriers that prevent implementation from going as planned. It also is possible for cities to develop implementation procedures that are not described in a formal plan. Given these realities, more research is needed to understand how high quality implementation content in plans corresponds to the implementation of transportation climate action strategies. Future research should incorporate practitioner interviews and cover a sample of thirty or more cities to facilitate statistical analysis. As cities achieve GHG emissions reductions, it will be useful to understand the implementation planning that put them on the road to success.

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