CLIMATE ACTION PLANS:
ANALYSIS OF THE EFFECTS ON FORM OF U.S. CITIES

by

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A Thesis

Submitted to the Faculty of the

Welsh School of Architecture at Cardiff University

in partial fulfilment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

2013

Major subject: Architecture

DECLARATION/STATEMENT

DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed ______________________________

18 June 2014

Date ______________________________

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by citations giving explicit references. A bibliography is appended.

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SUMMARY OF THESIS

CLIMATE ACTION PLANS:
ANALYSIS OF THE EFFECTS ON FORM OF U.S. CITIES

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This study investigates the effectiveness of community climate action plans (CAPs) and their potential impact on the form of U.S. cities. Greenhouse gas (GHG) mitigation and climate change adaptation strategies enacted by cities have the potential to redirect future public and private investment. Three studies have been prepared to better understand the external policy context that cities are working within, the process and tools they are using, and how climate actions are integrated into their comprehensive plans. Study 1 includes detailed case studies of eight U.S. cities that have completed CAPs. The cities are of various sizes and located in different climate regions. The case studies include a review of state and regional plans and policies; climate action plan technical and policy reports; evaluations of cities' integration of climate action plans with their comprehensive plans; and interviews with planning project managers. Study 2 includes a national survey population of nearly 200 cities that have completed CAPs. The survey's independent variables include city fundamentals such as size, location, comprehensive plan requirements, power sources, and political context. Dependent variables are organized into two groups: one for CAP approach and strategies, and the second for policy outcomes that modify the form of cities. Study 3 examines the effectiveness of common strategies utilizing a purpose-built greenhouse gas worksheet calculator. A model town is examined as a baseline community of 50,000 in population that is proposed to double by 2050 to a city of 100,000. A business-as-usual model and two alternatives test mitigation strategies and actions measuring potential effectiveness on GHG emissions. The thesis research findings have significant theoretical and practical implications regarding CAP influence on the future form of U.S. cities. In particular, studies demonstrate the importance of compressing growth into walkable cities with determined and fixed boundaries.

AKNOWLEDGEMENTS

The quest for a PhD stems from my desire to develop a deeper understanding of the climate planning issues and solutions, to better aid my client communities and students in grappling with this epic challenge. Our urban design students graduating in 2014 will spend most of their careers designing low-carbon cities and adapting to a shifting climate.

Advisors Phil Jones and Simon Lannon are international authorities in urban-scale energy modelling and policy. Their encouragement gave me the confidence to stretch myself as a researcher. While my studies focused on U.S. cities, summer teaching and research interaction with Cardiff faculty and students gave me a valuable perspective on international climate policy and practice.

The national survey of cities in the thesis was co-sponsored by Ball State University (BSU) and the American Planning Association (APA). BSU graduate students Trevor Traphagen, Tyler Clark, and Claire Bowers assisted me with survey outreach. APA staff agreed to partner on the survey, adding the organization's credibility to the effort. In particular, I would like to thank APA staff Carolyn Torma, Suzane Rynne, and David Rouse.

My PhD research ran concurrently with Ball State University's effort to successfully launch a new urban design masters program in Indianapolis. BSU colleagues Dean Guillermo De Velasco, Michel Mounayar, Harry Eggink, and Tony Costello were exceedingly supportive. I am particularly grateful for Geralyn Strecker for her technical writing advice.

Special thanks to my parents and siblings for helping me with my Midwest re-assimilation; my friends for their moral support; and for the love of my son Grant, Daughter Ryan, and especially my life partner, Vera.

BRIEF TABLE OF CONTENTS

DETAILED TABLE OF CONTENTS

LIST OF FIGURES

TABLE Page

Chapter 1

INTRODUCTION, CONTEXT, AND PURPOSE

1.1 PROBLEM AND SETTING

The main purpose of this investigation is to explore how climate actions plans (CAPs) prepared by U.S. cities are influencing their future form and what exemplar CAP processes and strategies they are employing to meet greenhouse gas (GHG) emission reduction targets.

This research originated from the direct personal observation of how my client cities were beginning to address new climate action policies enacted by the State of California in 2006 and 2007. These cities struggled to understand the implications of new rules on their growth and development policies and how to incorporate their own strategies into their planning system. California has been a leader in policy development and implementation as it pertains to climate change. However, over one hundred U.S. cities outside Californian have also prepared CAPs worthy of study, and international research contributes to our understanding of effectiveness of GHG emission mitigation strategies.

The 2010 U.S. Census recorded about 20,000 “incorporated places”. The 200 cities surveyed in this thesis are the first 1% to prepare CAPs. Their experience and actions offer an early glimpse of how the nation’s urban regions could evolve over time as more cites consider how they will curb their impact on GHG emissions and adapt to a changing climate.

1.1.1 Background

U.S. cities are acting on their values and perceptions of their own climate context. The climate is clearly changing and threatening cities’ urban environments and human health. Most Americans live in areas that will be negatively impacted by a warming world and understand their actions are in self-interest.

<u>Climate Change Impact on U.S. Cities</u>

Climate change will impact human health and change ecosystems. Cities will face rising sea levels, flooding and droughts, disruption to food supplies, and/or susceptibility to wildland fires. These provide motivation for mitigation of GHG emissions and adaptation planning for coastal cities; cities and regions depending on snowmelt and glacier sources for water; cities that have wildland interface; and cities already located in hot, arid and dry regions.

The U.S. population is growing in areas most susceptible to impacts caused by climate change. In 2010, 52% of the U.S. population lived in coastal watershed counties and another 14.9 million are expected by 2020 (NOAA, 2013). In the fast-growing Southwestern U.S., where competition for already scarce water resources is fierce, average temperatures are expected to increase by between 4ºF and 10ºF above the historical baseline by 2090 (U.S. Global Change Research Program, 2013). Climate change adaptation planning will become an environmental, physical and political reality for these fast-growing regions.

Recent extreme weather events are telegraphing long-term trends of warming global temperatures and precipitation. March 2012 was the 325th consecutive month that has been warmer that the global 20th-century average. March 2012 saw extreme global land temperatures that were both higher and lower than average. Extremes also occurred in precipitation, with hotter and drier weather in the U.S. and Europe and cooler and wetter conditions in Australia. The United States had the warmest March on record (since 1895). The northwest region was wetter than normal, and the southwestern and eastern states were much hotter and drier (NOAA National Climatic Data Center, 2012).

Climate Action Planning Movement

States and communities are initiating sustainable policies and regulations for land use planning, building construction infrastructure investments with a focus on reducing their greenhouse gas impacts. In particular, local governments are making decisions within a dynamic policy, legal, scientific, and research context and are "early adopters" in terms of diagnostic and strategy tools for making informed decisions.

States Become Proactive

As the United States Congress continues to debate merits and policy responses to climate change, state and local governments have already started to act. All but twelve states have prepared or are in the process of preparing CAPs (Center for Climate and Energy Solutions, 2013). Some state CAPs are being implemented through state legislation and regulations; others promote climate awareness by leading by example (LBE). Many have initiated renewable portfolio standards (RPS) with targets, have reduced GHG emissions from state facilities and operations, and require adaptation planning for local government. States have cooperated in creating and participating in regional carbon registries in the West, Midwest, and Northeast. They have laid the groundwork for transition to Cap and Trade, developing renewable energy, and supporting local governments' efforts to mitigate GHG emissions and adapt to a changing climate.

Strategies Reflect the Uniqueness of Cities

Regardless of state LBE efforts, the review of literature and research in this thesis indicates that most local governments follow their own values and have taken the initiative to prepare a CAP for their community and/or municipal operations. GHG mitigation and climate change adaptation strategies employed by cities reflect a diversity of policy, climate and regional economic settings.

The types of strategies and actions cities take reflect their inventory of GHG emissions. In the U.S. over three-quarters of GHG emissions can be influenced by cities efforts of cities in some way. The 2010 U.S. EPA national inventory of GHG sectors indicates that industry, transportation, and commercial and residential sectors combine for 58% of emissions (U.S. EPA, 2012). Electricity accounts for 34%, 70% of which is used by buildings (Architecture 2030, 2011).

Regional and local inventories vary based on their climate and energy supply. For example, Chicago, IL has twice as much CO2e in the grid as Portland, OR (U.S. EPA, 2012). Chicago generates more electricity from coal, and the Northwest uses more hydro, natural gas, nuclear power, and renewable sources. Research in this thesis found that cities in the Northwest and West had about 40% of their emissions coming from transportation compared to 27% nationally. Therefore, cities like Portland, OR, logically focus on creating a walking city and Chicago on decreasing GHG emissions from buildings. These and other factors are contributing to the types of influence CAPs are having on the future form of cities.

1.1.2 The Form of Cities: A Theoretical Perspective

A brief review of the definition of urban form is intended to provide a theoretical basis for discussing how CAPs are influencing the development of U.S. cities. The review of theoretical perspectives is complimented with a brief introduction to transportation and energy strategies relationship to how cities develop over time.

<u>Urban Form Theory</u>

Theoretical definitions of urban form indicate the importance of the interplay between social norms (political and religious), business activity (market forces and intensity), and mobility (modes and routes). Morris, Mumford, Kostof, Christaller, and Lynch offer long-established theoretical perspectives regarding urban form determinates of cities.

Cities within a Larger Environment

In his book *History of Urban Form* (1994), Anthony Morris stresses cities evolve within a larger context of influences. He defines cities' evolution as organic, planned, or both. He proposes cities are responding to natural determinants, such as topography, climate, and available construction materials. Morris also cites the influence of man made social and built determinates including political, economic, and religious values; and block structure, open spaces, and infrastructure (Morris, 1994, pp. 8, 10-18).

Universal Experience of Cities

Lewis Mumford, Spiro Kostof, and Joel Kotkin identify universal functions of cities that influence their form. Mumford provides a comprehensive understanding of the historic development of cities defining cities as "sanctuary, village, and stronghold" where "human life swings between two poles: movement and settlement" (Lewis, 1961). Mumford's writings are further refined in geographer Spiro Kostof*'s* book *The City Shaped* (1991). Kostof discusses the universal experience of cities and claims cities are artifacts of their birthplace, form, and makers. Every city has a unique physical circumstance, exists as part of a cluster, and possesses an identifiable monumental framework (Kostof, 1991). Demographer Joel Kotkin distils the purpose of cities down to being sacred, safe, and busy. Kotkin proposes cities have been designed to accomplish these functions to prolong their growth and primacy (Kotkin, 2005).

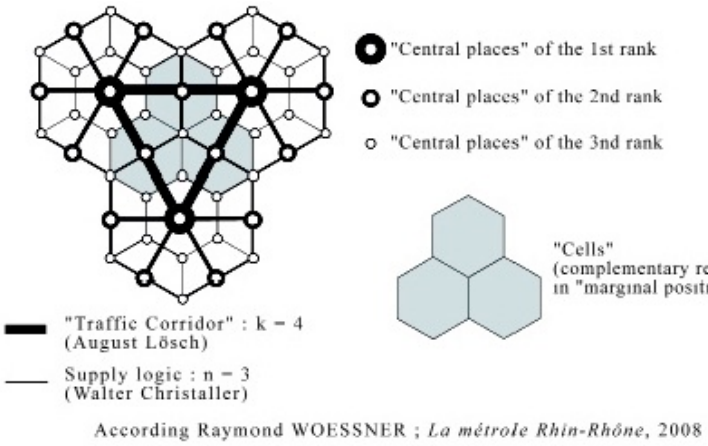
Central Place Theory

In 1933, Walter Christaller published his report *The Central Places in Southern Germany*. The report summarized his efforts to explain the spatial relationship between the size and purpose of cities in terms of market, transportation, and administrative functions. He claimed cities organized themselves in a hierarchy of metropolises, cities, towns, villages, and hamlets. Even though Christaller's Central Place Theory failed to reflect the asymmetry of costs, transportation, and location advantages of cites it was influential in the development of contemporary gravity models used to predict regional development patterns.

Figure 1.1 is based on Christaller's hierarchy of transportation connections and central places (Nicolas, 2009).

Figure 1.1

Christaller's Cells of a Complementary Region



A Theory of Good City Form

Kevin Lynch set out to describe what makes a good city in his 1981 book, *A Theory of Good City Form*. Lynch describes the environmental design attributes of cities as textures of form and meaning where planning, functional, and normative theories of cities grow together acknowledging the importance of form's relationship with function and process (Lynch, 1981, pp. 1-2, 37-38, 49). He identifies five criteria for his theoretical approach: vitality, sense, fit, access, and control (pp. 111-220) and adds two other broader categories of justice and efficiency (pp. 221-235).

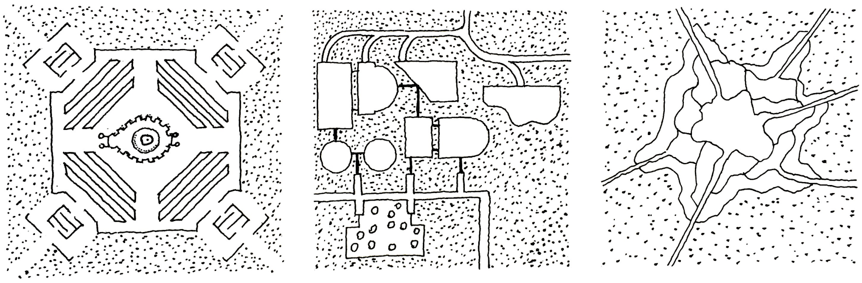
Lynch's normative models explore the motivation for development of a city or "self perception." These include the cosmic city or holy city, practical or functional city, and the organic or living organism city (pp. 73-98).

Figure 1.2 is included in Spiro Kostof's *The City Shaped* (p. 15) and illustrates Lynch's normative models.

> *(A) The cosmic city: a spatial diagram of social hierarchy*
> *(B) The practical city: a functional construct of interrelated parts*
> *(C) The organic city: an invisible, living organism* (p.15)

Figure 1.2

Lynch Normative Models



A. B. C.

Biological Systems Model

Cities use resources to meet transportation, economic, and cultural priorities. A biological systems approach connects city form to resource inputs and waste outputs.

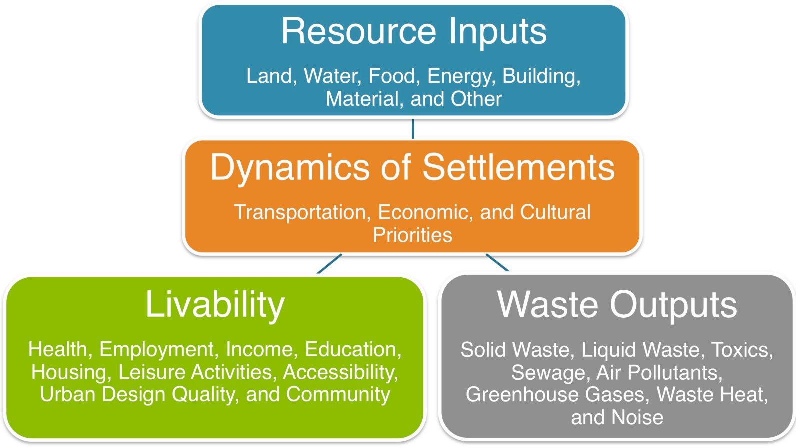
Newman (1999) makes the case in for using the "extended metabolism model of the city" for developing a biological systems way of viewing resource inputs and waste outputs of cities (Figure 1.3). This model strives to use an ecosystem approach as sustainability indicators to view a city's physical design attributes (dynamics of settlements) in the context of its biological and community wellbeing (p. 220).

> *Like all ecosystems, the city is a system, having inputs of energy and materials. The main environmental problems (and economic costs) are related to the growth of these inputs and managing the increased outputs. By looking at the city as a whole and by analysing the pathways along which energy and materials including pollutants move, it is possible to begin to conceive of management systems and technologies which allow for the reintegration of natural processes, increasing the efficiency of resource use, the recycling of wastes as valuable materials and the conservation of (and even production of) energy.* (Newman, Sustainability and Cities: Extending the Metabolism Model, 1999)

Newman's proposals identify processes used for producing urban systems. These include processes employed by government, industry, and commercial/financial institutions for present and future settlements. Improved processes and urban systems can lead to reduction in emissions, resource use, and waste while improving livability.

Figure 1.3

Extended Metabolism Model of Human Development



Adapted from: Sustainability and Cities: Extending the Metabolism Model (Newman, 1999)

Transportation and Urban Form

The movement of people and goods are a key determinate of city form. Cities' spatial patterns are comprised as a hierarchy of activity nodes and linkages. Most regions have generations of regional and local transportation networks.

Nodes and Linkages

Jean-Paul Rodrigue's *The Geography of Transport Systems* (2013) defines *urban form* as the spatial imprint of urban transportation systems and the adjacent urban structures. Rodrigue describes *urban spatial structure* as the relationships and interactions of people, freight, and information and categorizes spatial patterns in degrees of centring and clustering of activities (Rodrigue, 2014).

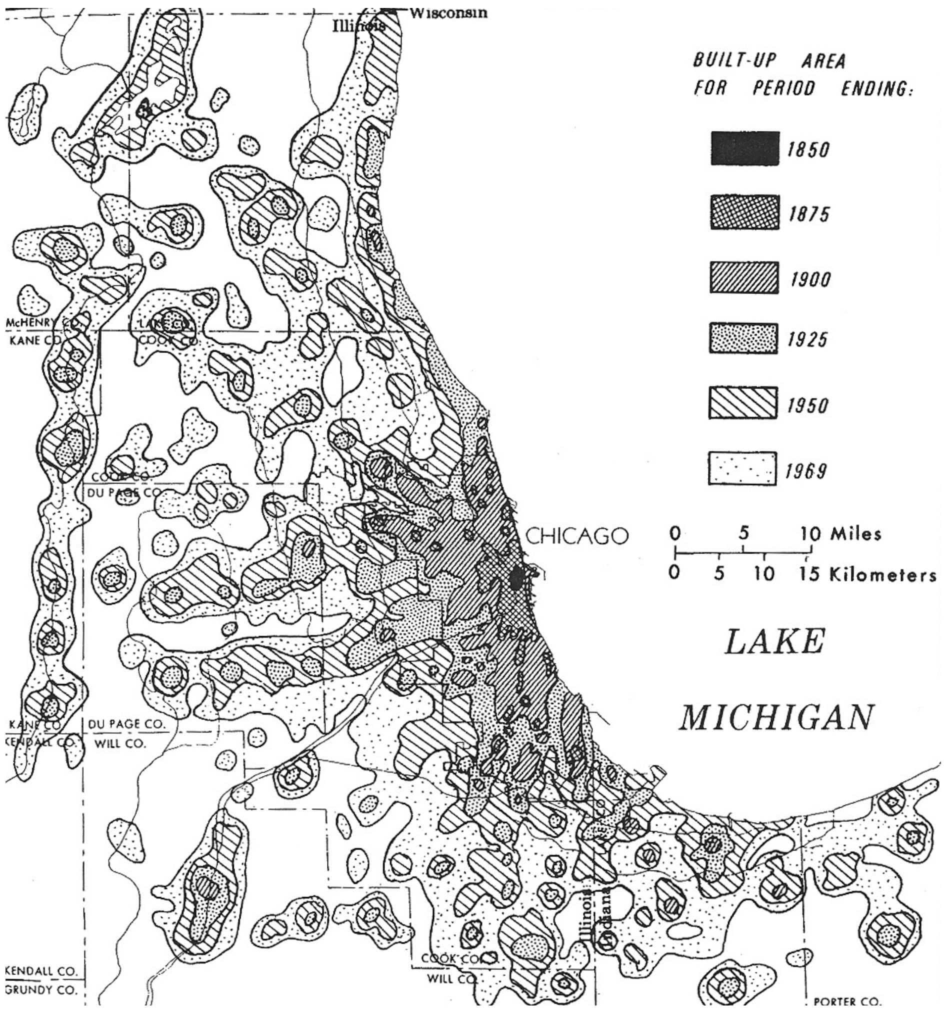
Transportation Eras

In the United States, urban patterns stem from four eras of transportation affecting density, centring, and clustering of urban activities. These include the: walking and horse-car era (1800-1890), electric streetcar era (1890-1920), recreational automobile era (1920-1945), and freeway era (1945-present) (Muller, 2004).

Figure 1.4 is a map prepared by B. J. L. Berry in 1976 showing the generational expansion of Chicago from 1850-1970. The map illustrates the complexity of larger metro areas in terms of their expansion patterns and influence of transportation systems. The recently completed regional plan for Chicago continues to focus on the relationship between growth and transportation investments (Chicago Metropolitan Agency for Planning, 2010).

Figure 1.4

Expansion of Metropolitan Chicago 1850-1970



Rebuilding Automobile Cities

Newman and Kenworthy offer a conceptual plan for reconstructing an auto-oriented city based on transit access, walking distances, and a hierarchy of community centres. They feel it is more effective to restructure automobile-oriented regions into a series of linked cities rather than depending on a single rail line and a few centres. Newman and Kenworthy recommend linked city strategies because they have greater regional penetration. They recommend densities of at least 10,000 people (residents and employees) in a 10-minute walking radius and 100,000 people within a 30-minute walking radius. This density supports amenity patterns and more energy-efficient transportation modes (Newman & Kenworthy, 2006, pp. 43-44, 48).

Planning at Regional and Local Scales

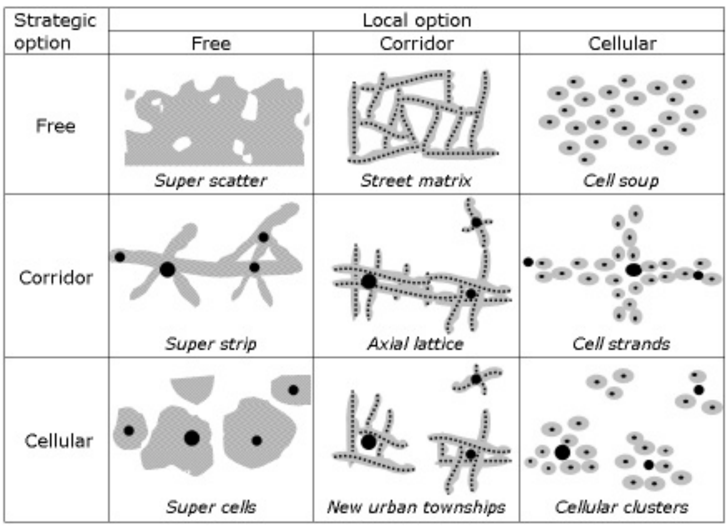
At a regional scale growth is supported by regional and interregional transportation investments. These investments reinforce compaction, dispersal, and expansion growth strategies. Local communities then develop to take advantage of the expanded regional transportation system, such as around a new freeway interchange or transit station.

Academic partners (University of Cambridge, University of West of England, University of Leeds, The Young Foundation, and University of Newcastle upon Tyne) and community stakeholders prepared and modelled strategies for three London metro sub-regions. The research categorized urban form strategies as local typologies and related transportation networks. Figure 1.5 illustrates strategies as free, corridor, and cellular urban forms (Solutions, 2008).

The study identified three types of *policy levers* for influencing the planning options including *regulation* of land use and transportation, *investment* in transportation networks, and *pricing* of land and transportation.

Figure 1.5

Strategic and Local Design Urban Form and Transportation Options

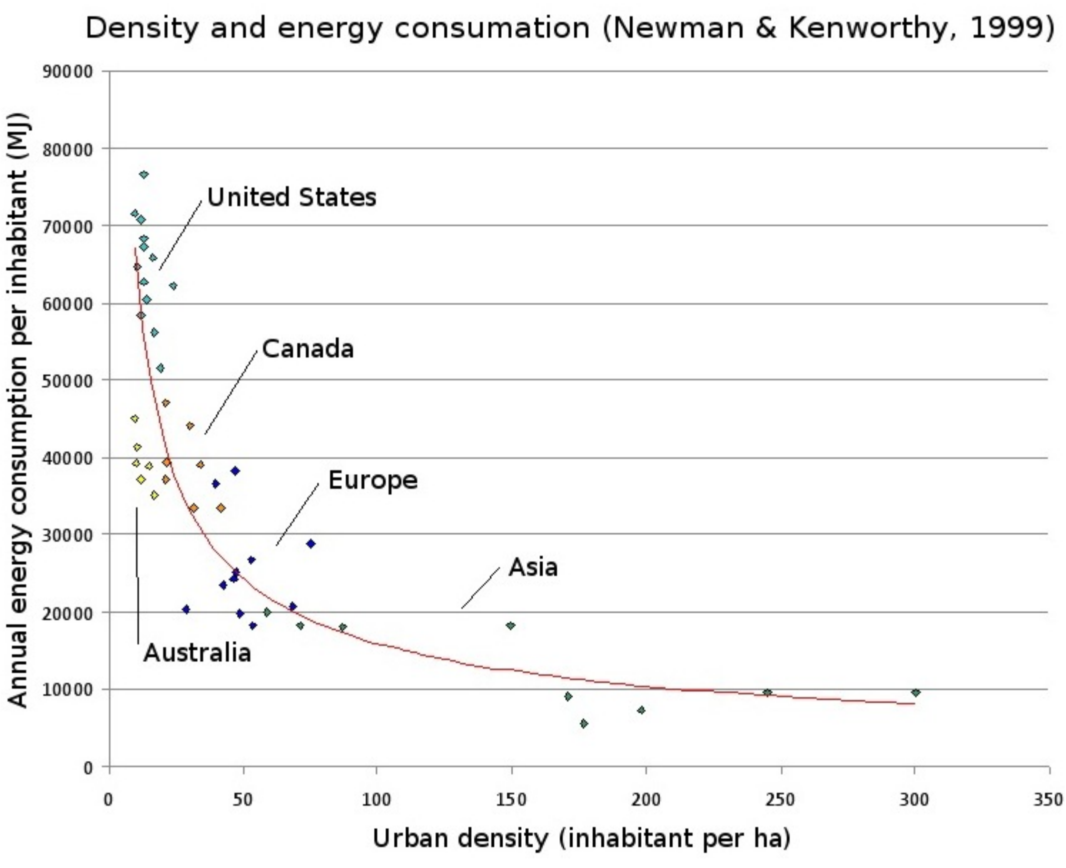


Compact Urban Form and the Energy City

Making cities more compact is a common theme in the literature linking the form of cities and their building and transportation energy usage. Peter Newman of Murdoch University in Australia has researched and written extensively about the relationship between energy use and density of world cities. Figure 1.6 prepared by Newman and Kenworthy (1999) illustrates how increasing residential density results in less annual energy consumption. The results are similar when comparing per capita miles driven and energy use for high-intensity and high-income (jobs and housing density) cities from around the world (Newman & Kenworthy, 2006). Their research indicates U.S. cities have the lower density and a higher per capita energy use than Canada, Australia, and Europe.

Figure 1.6

Residential Density Compared to Energy Use Per Capita



(Le Nechet, 2012)

Summary: The Form of Cities

Defining the form of cities has theoretical and practical foundation. Mumford, Kostof, and others have endeavoured to identify our common human experiences and determinants for the form of cities.

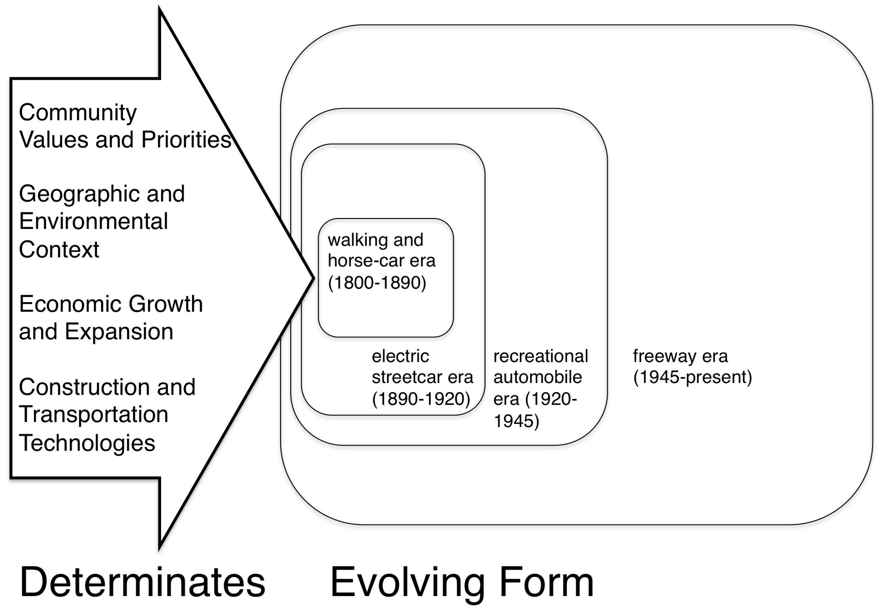
There is a regional dimension to how cities grow. Kostof (1999) reminds us that a universal experience of cities is that they evolve in clusters. Christaller's Central Place Theory (1933) and regional hierarchy assumptions are not perfected but cities' administrative, economic and transportation interrelationships do shape cities. Transportation creates clustered, linear, and nodal patterns (Rodrigue, 2014) and that these patterns can be influenced by regulatory, investment, and pricing policy levers (Solutions, 2008).

The energy performance of cities researched by Newman and Kenworthy (1999, 2006) indicate there is a strong connection between density and mobility systems and energy use. As U.S. cities have expanded outward, their energy use and related GHG emissions have increased (Figure 1.6).

Figure 1.7 includes determinates that influenced the form of U.S. cities' mobility technology eras defined by Muller (2004). It indicates *natural and social determinates* identified by Morris (1994) and Newman's *dynamics of settlements* (1999) influence an evolving city's evolving form.

Figure 1.7

Theoretical Model: Determinates and Evolving Urban Form



1.1.3 Operational Definition of Urban Form

Newman's and Kenworthy's (2006) conceptual plan for rebuilding the automobile city recommends minimum densities, amenities, and penetrating transportation connections that can support energy-efficient transportation and construction patterns. These types of strategies have become part of a comprehensive "smart growth" approach to planning low carbon, energy efficient, and liveable cities. An operation definition needs to address two questions:

- How can the effectiveness of CAP GHG mitigation urban form (land use) strategies be measured and evaluated?
- How are CAP climate adaptation strategies modifying the form of cities?

<u>Mitigation: Reducing GHG Emissions and Urban Form</u>

The targets for CAPs identify a percentage reduction in GHG emissions relative a baseline number. The target typically has a set of goals met through strategies and related actions. In 2012, 70% of U.S. GHG emissions came from commercial and residential buildings, electricity generation, and transportation sectors (U.S. EPA, 2014). In order to meet GHG reduction targets cities are have to enhance the energy efficiency of buildings, reduce the use of electricity and shift generation to renewable sources, and reduce the use of automobiles, enhance efficiency of the fleet, and shift to renewable fuels. For cities, land use or urban form mitigation strategies are an important contributor to meeting local GHG reduction targets.

Density and Connectedness in Context

As Newman and Kenworthy's research indicates, there is a strong correlation between density and energy use, miles travelled, and GHG emissions (Newman & Kenworthy, 2006). However, every city has natural and manmade contexts that contribute the types of choices and policy levers available (Morris, 1994). Natural context can include the types of unique circumstances Kostof (1991) discusses such as water bodies, topography, or climate. Manmade context includes the existing development patterns and supporting transportation systems. These circumstances shape the types of density and mobility strategies that are available or achievable.

Development Pattern Policy Levers

The UK Solutions team effort identifies three ways to view policies regarding development patterns. These include free, corridor, and cellular development patterns.

The pattern choices do not refer to density. According to Newman and Kenworthy, if these patterns are to reduce emissions, the density has to be high enough to support amenities within walking distance and have deep penetration of public transportation. That means creating policies focusing development into high-density *corridors* and *cells*. This includes defining their geographic limits and requiring higher density residential and employment. This is not achievable using the *free* strategic option.

Measuring Density

At a city or local scale, resident and employment density are most often measured as dwelling units per acre (du/a) and floor area ratio (FAR). At a regional scale, residents and jobs per acre or square mile is used to express a more generalized distribution.

Defining Patterns Means Defining Boundaries

Urban form of cities results from a combination of natural and policy boundaries and allowable or required densities. Distribution of population and jobs densities are measured within physical (natural), jurisdictional, or planning unit boundaries. This can include water bodies, topography and limit lines of counties, cities, and municipal service districts. Planning policy boundaries can include central business districts, industrial districts, and neighbourhoods.

Solutions UK categories of cellular, corridor, and free patterns correspond to common U.S. growth management strategies that guide urban form including:

- Cellular–*centred growth* within *fixed boundaries* requiring growth around central districts or in a concentric pattern of expansion
- Corridors–*linear growth* within *determined boundaries* typically associated with transportation routes that include nodal development near stations
- Free–*expanding growth* within *flexible boundaries* associated with auto-oriented urban sprawl

Land Use Planning as Mitigation

Effectiveness of urban form strategies are measured by comparing existing or baseline levels to a future estimated GHG emissions. CAP land use strategies strive to reduce use of cars as the primary transportation mode, reduce expansive extension of infrastructure, and encourage more energy efficient forms of construction. Transportation GHG emission reductions are measured as reduction in vehicular miles travelled (VMT). Infrastructure GHG emissions are measured as embodied CO_2e (energy and other GHG sources required to build roads and utilities) and emissions from maintenance. GHG emissions from buildings are typically measured using national data where multifamily buildings typically perform better than single-family houses.

Adaptation: Urban Form and Resiliency

Adaptation strategies urban form policies define cities' edges and infrastructure to increase their resiliency to climate extremes.

Cities are shaped by natural determinants, such as topography and climate (Morris, 1994). As a result, most cities' built environments interface with natural wildlands and water bodies affected by climate change. CAPs for coastal cities address sea level rise, river cities address increased flooding, and seasonal arid climates cities anticipate drought and wildland fires.

1.1.4 CAPs and Smart Growth

Review of the first generation of CAPs offers a glimpse of how cities are planning for low-carbon futures and are integrating strategies into comprehensive plans and investing in a sustainable patterns and programs. Their efforts to mitigate GHG emissions and adapt to climate change address a broad spectrum form shifting and operational actions. The actions of individual cities to meet the challenges of reducing their climate impact and are an extension of internal and external influences.

CAPs Going Beyond "Smart Growth"

Beginning in the late 1970s and expanding in the 1980s, environmentalists and planners were advocating smart growth as a way to reduce the use of natural resources, protect farm land from suburban development, get higher utilization out of existing infrastructure, and protect the economic primacy of downtowns.

Many popular CAP strategies require cities to optimize their passive performance responding to local climate plus site conditions, plus on demand reduction energy solutions. These strategies run up against the realities of how real estate development is financed, post-war investment in sprawl-inducing transportation infrastructure, Euclidean zoning and energy intensive lifestyles. The policy commitment to implement CAP land use and transportation strategies often resembles "smart growth" concepts discussed by planners in the 1980s. These were meant to shape cities into more compact, centred, and concentric patterns. Now these ideas need to be tested by measuring their

GHG mitigation performance while they embody a broader range of environmental and political objectives.

Need to Integrate CAP Strategies into Community Plans

To be effective, mitigation and adaptation strategies identified in CAPs regarding land use, infrastructure and transportation ideally migrate to city growth management policies and capital improvement plans (CIPs). Successful integration of CAPs into city planning systems is not universally required. States have a variety of requirements for city comprehensive planning. Some do not require comprehensive plans, such as Illinois, but others have detailed guidelines and regulatory requirements, such as California.

Research in this thesis expects to discover a variety of methods for expressing GHG emissions mitigation and climate adaptation in long-range planning functions of cities.

1.2 RESEARCH CONTEXT FOR CLIMATE ACTION PLANS

Cities that have a better understanding about climate change, related impacts, and local responsibility prepare higher-quality CAPs. A study published in *Journal of Environmental Planning and Management* examined 40 U.S. cities that prepared CAPs and found that a greater understanding of climate change improved the quality of their plans in terms of awareness, analysis, and actions (Tang Z. , Brody, Quinn, Chang, & Wei, 2010). Cities are finding evidence regarding climate change from international and national research.

1.2.1 The International Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) provides an international perspective on climate change through supporting research, establishing protocols for GHG emissions sectors, and recommend mitigation approaches to reducing GHG emission to levels that avoid catastrophic climate change. The U.S. EPA uses the IPCC's sectors to inventory GHG emissions and researches climate change scenarios and potential impacts for various regions in the United States.

IPCC-Research and Protocols

The International Panel on Climate Change (IPCC) has issued research findings summarized to support policymaking at the national and international scale. The IPCC was founded in 1988 and in 1990 published its first report underscoring the importance of climate change as a global challenge. Since then, the IPCC has prepared "the most comprehensive scientific reports about climate change produced worldwide" (International Panel on Climate Change, 2012), including three other assessments providing key input into the Kyoto Protocol in 1997 and two others providing scientific and policy guidance for global leaders and policymakers. The IPCC is apolitical regarding research and publications in order to support international efforts to form agreements regarding climate change and Cap-and-Trade policies.

The IPCC has helped establish both the scientific support and protocols for measuring GHG emissions. IPCC assessments have identified seven sectors of GHG emissions that have been adopted as an international protocol: energy supply, transportation and related infrastructure, residential and commercial buildings, industry, agriculture, forestry and waste management. The U.S. Environmental Protection Agency (EPA) and most states and local governments use these for GHG inventory, strategies, and action planning.

The IPCC has three Working Groups:

- *Working Group I (WG I) assesses the physical scientific aspects of the climate system and climate change.*
- *Working Group II (WG II) assesses the vulnerability of socio-economic and natural systems to climate change, negative and positive consequences of climate change, and options for adapting to it.*
- *The IPCC Working Group III (WG III) assesses options for mitigating climate change through limiting or preventing greenhouse gas emissions and enhancing activities that remove them from the atmosphere.* (International Panel on Climate Change, 2012)

<u>IPCC–Predicting Climate Change Impacts</u>

IPCC's *Climate Change 2007*, the Fourth Assessment Report, includes climate change scenarios and related impacts. *Special Report on Emissions Scenarios* (SRES) included policy scenarios that vary in their regional, global, economic, and environmental focus. Working Group I observes changes in temperatures, ocean levels, and weather patterns. Working Group II foresees dwindling fresh water supplies, less resilient ecosystems, reduced food production, rising sea levels jeopardizing coastal areas. A temperature increase of 7.2 ºF could raise sea levels 9" to 20". Working Group

III identifies long-term and near to mid-term (until 2030) mitigation strategies for each of the seven sectors of GHG emitters.

IPCC-Informing GHG Emission Reduction Targets

Climate Change 2007 contains key mitigation technologies and practices by sector that could reduce atmospheric GHG to 445-535ppm CO2 equivalent (CO2e) by 2050--the *target outcome* for avoiding catastrophic climate change. In order to avoid catastrophic climate change, cities are stretching to identify strategies to meet the 80% below 1990 levels of CO2e by 2050 to meet the 450ppm atmospheric CO2e target. Mitigation identified by IPCC generally includes increased use of renewable energy sources, conservation, and carbon storage.

The IPCC has influenced cities. IPCC research established the framework for the Kyoto Protocol target for the U.S. of reducing GHG emissions of 7% below 1990 levels by 2012. Over 500 Mayors have signed the U.S. Conference of Mayors Climate Protection Agreement. The cities are to strive to meet or exceed the Kyoto Protocol targets, advocate for state and federal governments to do the same, and lobby Congress to pass an agreement to establish a Cap-and-Trade system (The United States Conference of Mayors, 2008).

1.2.2 Federal Agency Research

The United States Global Research Program (USGCRP) reflects the efforts of 13 Federal agencies to identify the impact of climate change on the United States. Both international and national research presents a picture of climate change challenging cities' environmental resilience. Among federal agencies, the National Ocean and Atmospheric Administration (NOAA) and U.S. Environmental Protection Agency (EPA) are key in coordinating and broadcasting research findings related to the science and mitigation strategies for climate change.

National Ocean and Atmospheric Administration

NOAA is an international leader in climate and environmental research. The Administration has a prodigious portfolio of research and monitoring activities. NOAA climate change modelling provides a glimpse of alternative futures informing international, national, and local action policies and planning. The administration supports 18 non-profit and university institutes which engage 42 universities in 23 states and the District of Columbia (NOAA, 2013).

U.S. Environmental Protection Agency

The U.S. EPA is an important source for information regarding climate change research, and its mission is to "protect human health and the environment." The agency takes the lead in ensuring the U.S. "plays a leadership role in working with other nations to protect the global environment" (U.S. EPA, 2012). The agency website turns up 270 results to a "climate action plan" keyword search and in the initial effort to prepare a literature review for this thesis was an important resource.

1.2.3 Academic and Non-profit Research

Initial literature reviews yielded primarily government agency sources and early leaders in research, such as the U.S. EPA and Pew Centre on Climate Change. However, since initiating this thesis, researchers in universities and research institutes have shown accelerating interest in regarding public attitudes towards climate change policies and effectiveness of CAPs. As a result, there are a growing number of academic and scientific research journal articles addressing these issues.

Universities–Research and Commitment

Like cities, universities have taken a leading position in climate action planning research and preparing campus CAPs. As of January 2013, 665 universities in the U.S. were signatories to the American College & University Presidents' Climate Commitment; 1,663 submitted GHG emission inventories; and 483 had completed CAPs (American College & University Presidents' Climate Commitment, 2013). These universities are economic partners that have influenced local sustainability policy.

Over the course of preparing this thesis, many universities have increased and refocused their research to address public attitudes about climate change and GHG mitigation and adaptation strategies. Three examples include Yale, Portland State, and University of Southern California. These universities' efforts reflect their regional mission and national and global research interest in climate change, city planning and public policy.

Funded by the National Science Foundation, The Yale Project on Climate Change tracked U.S. citizens' attitudes and beliefs through national surveys and summarized their findings in a 2010 report (Leiserowitz, Smith, & Marlon, 2010). In addition, the Yale Climate and Energy Institute combine the capabilities of multiple university centres to study and propose solutions for climate change (Yale University, 2013).

In Oregon, Portland State's Institute for Sustainable Solutions provides an intersection for research, education, and action for the university. Research falls into three focal areas: urban sustainability, ecosystem services, and social determinates of health (Portland State University, 2013).

University of Southern California (USC) has a suite of centres and institutes addressing climate change including: Energy Institute; Centre for Sustainable Cities; Program for Environmental and Regional Equity; and the Sea Grant Program which researches coastal ecosystem with including climate change adaptation. (University of Southern California, 2013).

Non-profit Policy and Research Institutes and Centres

Traditional environmental non-profits have added climate change to their research agendas. Plus, a plethora of new non-profit research institutes and centres created to collaborate to motivate, inform, and share knowledge about climate change and action planning. Three important non-profit research centres are the Centre for Climate and Energy Solutions (formally Pew Centre for Climate Change founded in 1998); The World Resources Institute (WRI); and the Climate Action Network (CAN).

Centre for Climate and Energy Solutions is "an independent, nonpartisan, non-profit organization working to advance strong policy and action to address the twin challenges of energy and climate change" (Center for Climate and Energy Solutions, 2013). The centre is a reliable source based on collaboration that advocates for innovative policy and action. The centre has authored over 100 peer-reviewed reports and testified before the U.S. Congress 30 times (Center for Climate and Energy Solutions, 2013).

Founded in 1982 as a centre for policy and analysis, the World Resources Institute (WRI) sponsors research and publications about climate change and other global environmental issues (World Resource Institute, 2013). WRI provides publishes its research that supports regional action climate action globally and in the United States. The WRI has a diverse publication library covering a wide range of climate change topics.

A robust source of research reports, surveys and polls is The Climate Action Network (CAN). CAN was founded in 1989 to provide opportunities for groups to form a collaborative response to climate change and advocate for a coordinated policy response. Internationally, over 700 NGOs network through CAN (Climate Action Network, 2013).

1.3 INTERNATIONAL, NATIONAL, AND STATE POLICY CONTEXT

Cities make local decisions in the context of international, national and state policies. Climate change is a global challenge with an inequitable negative impact. Some U.S. communities choose to think globally and act locally, connecting to international perspectives–others do not. National and state-level policies are also influencing city efforts to plan for climate change.

1.3.1 International Treaties

The Kyoto Protocol is an international agreement implementing a United Nations Framework Convention on climate change. The agreement commits counties to meeting binding targets for GHG emission reductions. However, as of 2011 only about 20% of global emissions are governed by the structure set up by Kyoto.

The Obama Administration favours regulation of fossil fuel emissions and supports international treaties requiring meeting targets. However, as with the Bush Administration, President Obama does not support the 1997 Kyoto Protocol. Instead, the U.S. favours a treaty that recognizes the differences between advanced and developing countries. The United State's argument is that developed counties and emerging economic powers of China, Indian, and Brazil need to be treated equally. This is opposed by developing countries. The European Union continues to push for a binding treaty (Broder, 2011).

1.3.2 Federal Actions

In 2009, two key federal actions took place that has shaped the regulation of GHG emissions. The first action was by the Supreme Court. They made two key findings that led to the U.S. EPA being able to regulate GHG emissions under the auspices of the 1990 Clean Air Act. These findings allowed the U.S. EPA to establish emission standards for new vehicles and stationary emission sources, particularly older coal-fired power plants. The second action was by the U.S. EPA. It issued the Mandatory Reporting of Greenhouse Gas Rule, requiring the largest U.S. sources representing 85-90% of U.S. GHG to report their emissions (U.S. EPA, 2011).

1.3.3 State Level CAPs

All but 12 states have prepared or are in the process of preparing CAPs. As of January 2013, there are 12 states have climate adaptation plans, two are in progress and eight other plans that recommend adaptation plans in their CAPs (Center for Climate and Energy Solutions, 2011).

A review of the Florida, Maryland, and Oregon CAPs reveal an emphasis on intergovernmental collaboration and working with industries and NGOs. This holds true for both plan preparation and implementation. The state CAPs include several common strategies for mitigating GHG emissions, including generating and distributing renewable energy; adopting more stringent building codes; increased investment in transportation infrastructure; and facilitating or requiring local governments to prepare CAPs.

1.4 ROLE OF LOCAL GOVERNMENT IN CLIMATE PLANNING

By 2007 over 500 city mayors signed on to the U.S. Conference of Mayors Climate Protection Agreement, pledging efforts to meet or exceed Kyoto Protocol emissions reductions (United Nations Convention on Climate Change, 2011). Many of these mayors' cities have prepared or are in the process of preparing CAPs for their commuity GHG emissions and/or municipal emissions from operations and infrastructure. Each city that chooses to prepare a CAP has to operate in the context of their own unique planning system of advanced, current, and fiscal planning; environmental, climatic, and ecological settings; and citizen beliefs and values.

1.4.1 Planning for the Future

Local governments guide future growth, regulate current development and finance the development and maintenance of infrastructure and services. These three types of planning are often referred to as advanced, current, and fiscal planning.

Advanced planning activities lead to developing policies about future development. This includes preparing citywide comprehensive, strategic, area, and project-level plans. Advanced planning policies identify public infrastructure investment and services necessary to implement growth patterns.

Current planning activities include regulatory oversight and review of private development to ensure it is consistent with advanced planning policies. This includes implementing coordinated public and private development; reviewing development to ensure they implement policies and adhere to regulations; and on-going enforcement of regulations.

Fiscal planning activities include funding municipal operations and services. This is ensures on-going capacity for city services such as utilities, waste collection, parks and recreation, street maintenance, and public safety.

1.4.2 Environmental, Climatic, and Ecological Settings

Cities have their own natural contexts, each with their own challenges. The United States Global Research Program has prepared assessments for nine regions that identify key issues under four climate change scenarios. The assessments reveal anticipated impacts on temperature, hydrology, ecosystems and human health. Cities implementing GHG emissions mitigation and adaptation planning should create strategies based on their unique environmental and adaptation conditions.

1.4.3 Citizen Beliefs and Values

Several studies have explored regional values and political affiliation in terms of believing climate change science and supporting the need to intervene. In 2009, The Pew Centre on Global Climate Change (now Centre for Climate and Energy Solutions or C2ES) published a national survey exploring the support of "Cap-and-Trade" policies and underlying concern and belief in climate change. The report found modest overall support for "Cap-and-Trade" but uneven political and regional concern or belief in climate change (Pew Center on Global Climate Change, 2009). The belief of climate change seems to be a divisive topic among conservative and liberal voters, with liberal voters overwhelmingly favouring limits on GHG emissions. Only 32% of very conservative republicans believed in climate change, compared to 83% of liberal democrats.

Surveys conducted by Stanford University with Ipsos and Reuters revealed that 75% of the country in 2010 and 83% in 2011 believed that global warming exists. The survey indicated that the number of people who are very certain that global warming is happening or not happening grew from 2010 to 2011 indicating polarization of views. A majority of both republicans (54%) and democrats (88%) believe global warming is the result of human activity. Most Americans (72%) expect global warming will continue over the next 100 years (Krosnick, 2011).

Some progressive communities located in conservative states. They are committed to reducing their GHG emissions. Examples cities include Austin, Texas;

Bozeman, Montana; and Bloomington, Indiana. These cities prepared CAPs based on their own values and beliefs in states that are generally opposed to mitigating GHG emissions for political or economic reasons.

1.4.4 Types of Local Government CAPs

In the U.S., about two-thirds of GHG emissions are produced by the transportation sector and commercial and residential building sectors. The balance can be attributed to industry and agriculture. Cities have planning and regulatory control over the transportation and building sectors GHG emissions. Local governments can plan and regulate the efficiency of land use patterns and related transportation, energy efficiency of new construction and renovation, and their own municipal emissions.

Community CAPs (CCAPs) include all emissions originating from both stationary and mobile sources within the city's jurisdiction. This accounts for transportation, commercial and residential buildings, industry, and agriculture sectors. Some communities also include carbon sinks or storage (such as plants) or reduced of heat island effects. A community CAP is holistic in terms of its approach to inventory of GHG emissions, strategies, implementation and result monitoring.

Municipal CAPs (MCAPs) include mitigation of emissions from city operations. This could include a variety of city GHG emission sources, such as municipal buildings, transportation fleets, roadway and parkland operations, streetlights, and waste collection and disposal. An MCAP can be prepared independently or as part of a CCAP.

Adaptation Planning can occur as part of either CCAPs or MCAPs. This could include relocating critical infrastructure above potential sea-level rise sites; reducing development in wildland interface areas to avoid catastrophic wildfires; preventing development along rivers susceptible to flooding; and other methods of making cities more resilient to climate change.

1.5 CLIMATE ACTION PLANNING PROCESS

CAPs provide opportunities for communities to identify actions that will reduce their GHG emissions and better prepare them for the results of climate change.
The CAP process involves four tasks including: preparing an inventory of GHG emissions, development of GHG emissions mitigation and climate change adaptation strategies, adopting an action plan, and monitoring results. Some cities develop their own process and community engagement methods. Others use prepackaged processes, tools

and software tools, such as those provided by ICLEI, a non-profit organization whose mission is to support local governments in preparing CAPs. Most cities have an assertive outreach and communications effort that spreads CAP ownership growing local understanding of the challenges, strategies, and actions.

There is not a legally required common CAP process. With variations, most local CAPs are prepared through a four-step process including making an inventory of GHG emissions, identifying GHG reduction strategies, implementation or action plan, and monitoring the results. ICLEI Local Governments for Sustainability USA is a non-profit leader with over 500 member cities. The organization provides technical assistance and software to cities preparing CAPs and recommends a process with five-milestones:

1. Conduct a baseline inventory and forecast
2. Adopt an emissions reduction target for the target year
3. Develop a local climate action plan
4. Implement policy measures
5. Monitor and verify results
(ICLEI, 2013)

1.5.1 Inventory of Greenhouse Gas Emissions

Developing an inventory for GHG emissions involves identifying a base year, target year, and percentage reductions. Cities also identify benchmark years to track progress. For example, cities that have signed the World Mayors and Local Governments Climate Protection Agreement will endeavour to reduce their carbon equivalent emissions (CO2e) to 80% below 1990 levels by 2050. That will require an estimate of 1990 emissions as a baseline, a current year baseline to see what their emissions are now, and a goal for reductions by 2050.

ICLEI has collaborated with California Air Resources Board and the U.S. EPA to create protocols for developing community GHG emission inventories. Prior to that, cities may have chosen to use the IPCC's categories for emissions: energy supplies, transportation and related infrastructure, residential and commercial buildings, industry, agriculture, forestry, and waste management. Or, they may have to followed a framework established by their unique emissions profile, suggesting other categories that could inform city-specific mitigation strategies.

1.5.2 Strategies and Metrics

The GHG emissions inventory may identify some areas of concentration or immediate opportunities for reductions unique to a city or region. For example, Midwest cities typically have a larger GHG emission from commercial and residential buildings due to heating requirements and a larger proportion of energy generation from coal. Strategies there would logically focus on reducing energy demand through retrofitting buildings and more energy-efficient construction while increasing the amount of energy coming from renewable sources. In the North-western U.S., cities have a larger percentage of emissions coming from the transportation sector. There, strategies might focus on reducing vehicle miles travelled (VMT). Both the Midwest and Northwest strategies mentioned could have a significant impact on the form of cities through increased densities around transit or visible changes to building design, orientation, and siting.

Cities may also consider adaptation strategies in the CAP. This could consider higher temperatures, rising sea levels, wildlands fires, heat islands, flooding or droughts.

1.5.3 Action Planning

Action planning activates the various GHG emission or climate adaptation strategies. These actions can be administrative, regulatory, or financial. The scope of the actions, sequencing, timing, and who is responsible for their implementation are included in most CAPs. Each action requires performance metrics.

In cases where cities are collaborating with regional or statewide partners, CAPs can identify other jurisdictions' responsibilities. For example, a local university or other nearby cities that are in the same air basin or share regional transit services could coordinate CAP actions.

1.5.4 Continual Assessment

CAPs are a way of thinking about the future, where actions are optimized over time to better meet targets. CAPs can include a program of continued assessment. This could include: assigning staff, regular task force or policymaker meetings to review and discuss progress, and on-going community outreach and communications.

1.6 TOOLS FOR DECISION-MAKING

The capacity of communities to inform, conceive, and implement a comprehensive CAP is uneven, at best. Many local governments lack the professional staff and/or local knowledge to prepare a CAP and therefore seek out tools and experts to assist them. In response to this growing demand, there is an expanding field of consulting firms, researchers, and providers of institutional and commercially developed assessment tools.

1.6.1 Best Practice Guidelines

A variety of organizations provide guidance in preparing CAPs. Many of those previously mentioned provide "best practice" recommendations for reducing GHG emissions. Example reports include the United States Conference of Mayors' *Mayors and Climate Protection Best Practices* (Mayors Climate Protection Center, 2010) and ICLEI's *U.S. Mayors Climate Protection Handbook* (ICLEI–Local Governments for Sustainability, 2006). These provide policy, actions, tools, best practices, and resources that can inform and motivate policymakers. Non-profits and public agencies also provide substantial web-based resources. A good example is CoolCalifornia.org, a website presenting recommendations for a six-step CAP process, each step with a webpage of suggestions and resources such as case studies and software tools.

1.6.2 Pre-packaged Tools, Processes, and Protocols

With over 500 member U.S. cities, ICLEI is by far most responsible for supporting many early-adoption cities. Over 100 cities have used their CAPC 2009 Clean Air and Climate Protection software, five-step process, and technical assistance to complete a CAP. ICLEI makes its CACP software is made available to members and provides other free software to non-members for planning a CAP program, municipal operations, and university campuses.

The U.S. EPA provides a clearinghouse for software for comprehensive and specialty applications to quantify GHG emissions. These include software for communities, municipal operations, individuals, schools and universities, national parks, corporate inventories, waste management, electricity use, and building energy use.

ICLEI has worked with utility company Pacific Gas & Electric Company and the State of Oregon Department of Environmental Quality in preparing the *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions*. The protocol provides a national standard for cities to measure and report GHG emissions (ICLEI Local Governments for Sustainabilty USA, 2013).

1.6.3 Customized Spread sheets

Cities that predated ICLEI's tools had staff capabilities or consultant support to develop their own tools custom fit to their inventory and strategic needs. Some cities and regions have created their own spreadsheets or calculators to support state regulatory requirements. Kings County, Washington, has developed a spreadsheet calculator project sponsors fill out to track the lifetime GHG emissions of new development (Kings County, 2013). The spreadsheet helps the county comply with the State of Washington State Environmental Quality Act. Similarly, in California the **Cal**ifornia **E**missions **E**stimator **Mod**el (Claimed) is a calculator that meets the needs of the California Environmental Quality Act (CEQA) for calculating GHG emissions from land use.

1.6.4 Suites and Clouds of the Future

In a presentation at the Wall Street Green Summit in 2011, Neno Duplan, CEO of Locus Technologies, provided an overview of the state of the art in environmental software. Created in 1997, Locus Technologies is one of the more established companies providing emissions management tools. Duplan made several key observations regarding the evolution of software tools. The software provides a holistic approach to managing a variety of environmental factors including GHG emissions. It can be customized for individual users; be cloud-based to access your inventory from any computer; and be accessible at any time in real time. Duplan said there were over 100 new companies have come to the enterprise users marketplace in the past 18 months. Lessons from the enterprise market are being transferred to public customers (Duplan, 2011).

In 2010, the Kresge Foundation gave Chicago a $160,000 grant to prepare the Chicago Continuous Improvement Performance Measurement (Coffee, 2010). The city prepared an RFP and eight teams responded. The city selected Carbonetworks (now ENXSUITE). ENXSUITE has developed a cloud-based software approach with international partners in 40 countries that provide a variety of modelling tools and calculators for energy and emissions management used by businesses and communities (ENXSUITE, 2010). This looks like the future of CAP software tools. A growing number of tools are commercially available via cloud computing complemented with the strategic and technical expertise that is arriving in the marketplace.

1.7 RESEARCH HYPOTHESIS, AIMS, AND QUESTIONS

1.7.1 Hypothesis and Aims

The purpose of this thesis is to better understand how climate action planning is changing the form of U.S. cities. It examines communities' motivations to prepare climate action plans, exemplar processes and tools used, and common strategies cities employ and their effectiveness. The scope of the research is defined by a hypothesis, research aims, and supporting questions.

Hypothesis:

If U.S. cities prepare a climate action plans and translate climate actions into land use policies, then there will be a measurable change in their urban form.

The research addresses three aims:

AIM 1: Assess motivation and process of local government

AIM 2: Compare the types of CAP tools and processes used by cities

AIM 3: Assess how CAPs shape city form

1.7.2 AIM 1: Assess Motivation and Process of Local Government

The first research aim considers what motivates cities to prepare CAPs, the policy context they are working within, and types of planning processes they employ.

Q1-Motivation: Why are cities preparing CAPs?

The first question focuses on understanding why cities prepare CAPs. The main purpose of this investigation is to better understand the relationship between a city's motivation and its chosen CAP strategies and actions. The benefit of understanding what motivates cities to prepare and implement CAPs can help inform, fund, and legislate solutions for increasing local efforts to mitigate their GHG emissions.

Q2-Policy Context: How are cities responding to state and federal policy context regarding preparation of CAPs?

Some cities are located in states that require preparation of GHG inventories, such as California. The second question considers how cities are responding to state or federal policies in their CAPs and how those are influencing strategies for mitigation through land use and transportation policies, energy efficiency standards for vehicles or buildings and adaptation requirements. The potential benefit of understanding the influence of state legislation can lead to more comprehensive, connected, and supportive investment in mitigation strategies at the local and state level.

Q3-Process: How are cities approaching CAP preparation?

The third question addresses the overall process or approach cities are taking in developing their CAP. This includes sequencing of planning steps, public participation, and deliverables. Finding a significant connection between the culture of community engagement and exemplar methods can benefit cities' efforts to develop a process that optimizes participation, education and commitment to action.

1.7.3 AIM 2: Identify the types of CAP tools and processes used by cities

The second aim considers the types of software tools and processes used by cities to prepare and monitor CAPs.

Q4-CAP Tools: Why do communities choose certain tools to inform the CAP process?

A variety of tools are available for communities to use in preparing CAPs. The fourth question asks what tools cities are using to inventory GHG, analyse alternative strategies, prepare an action plan, and monitor progress. Cities can develop custom tools, assemble a la carte suite of tools or purchase a pre-developed tool package. The benefit of comparing these approaches can help identify the pros and cons of tools selection and better understanding of the professional capabilities cities require to prepare a CAP.

1.7.4 AIM 3: Assess how CAPs shape city form

The third research aim considers two questions: how CAP strategies are being integrated into city comprehensive plans and how CAPs are influencing the form of cities.

Q5-CAP Strategies: How are CAP strategies integrated into urban planning policies?

The fifth question addresses how cities are integrating their CAP strategies and actions into their planning systems. This could include modification of comprehensive planning policies, infrastructure planning, or other ways of activating GHG emissions mitigation strategies and adaptation. The benefit of understanding effectiveness of policy implementation can lead to development of exemplars or best practice methods for CAPs.

Q6-Influencing Patterns: How are CAP strategies changing the form of cities?

The sixth question addresses how CAPs are shaping cities. This considers popular strategies and their initial effectiveness in reducing GHG emissions. An intended benefit of this research question will be discovering evidence of how cities' CAP strategies to increase their mitigation and adaptation performance are changing their development patterns.

1.8 SUMMARY AND STRUCTURE OF THESIS

The above questions and working hypotheses suggest there may be substantial reasons to believe that CAPs are changing the form of cities. However, further studies are needed to identify the ways different types of cities are responding to their urban, natural, and political contexts; what strategies are common among different classes of cities; and how their stories project an aggregated pattern of low-carbon cities at a regional or national scale. *The purpose of this thesis is to extend prior work by adding to the existing base of valid information on this topic*.

The remaining chapters are organized as follows:

Chapter 2: Literature Review

The literature review establishes a context for research by summarizing the extent the existing body of research informs how scientific research is impacting public policy; science of climate change is influencing CAP processes; and external public policies (at the state and federal level) are motivating cities to prepare CAPs; the processes and tools they use; and how they implement their CAPs. Ultimately, the intersection of these topics influences the future form of low-carbon cities.

Chapter 3: Methodology

Chapter 3 summarizes the rationale and methods used for the three different research studies that were conducted, and how they relate to each other. The rationale for choosing each method is presented, with a brief description of each method. Sampling strategies common to Studies 1 and 3 are included. Further details are provided in Chapters 4, 5, and 6, where each study is described in detail.

Chapter 4: Case Studies

Chapter 4 describes research questions and methods for Study 1which includes detailed case studies of cities of various sizes and climatic regions. The case studies are generalized, compared, and summarized. The value of the study reflects on the results relative to findings of literature review.

Chapter 5: National Survey of CAP Cities

Methods for Study 2, including sampling, survey design, and process is included in Chapter 3 and 4. The chapter includes results from a national survey of cities that have prepared CAPs. The survey summary is organized to answer research questions and related hypotheses. The value of the study considers its contribution and findings in the context of the literature review and Study 1.

Chapter 6: Strategy Modelling

Study 3 examines the effectiveness of common strategies through quantitative evaluation of a model town. The model town is examined as a base line community that is proposed to double in population by 2050. A business as usual model and growth alternatives test strategies and actions, and their potential mitigation on GHG emissions.

Chapter 7: Summary and Discussions

Chapter 7 summarizes the project's objectives and findings. It discusses the most important relationships between the studies and how findings relate to existing knowledge. Topics include CAP motivation and process; types of tools cities are using; how CAPs are altering the form of cities; and effectiveness of poplar CAP strategies.

Chapter 8: Theoretical and Practical Implications

Chapter 8 discusses theoretical and practical implications of cities preparing CAPs in the context of state and federal actions; universal protocols and tools used by cities in a variety ecological and political contexts; and climate action planning influence on the future form of cities. The chapter concludes with what additional research is needed to further our understanding.

Chapter 2

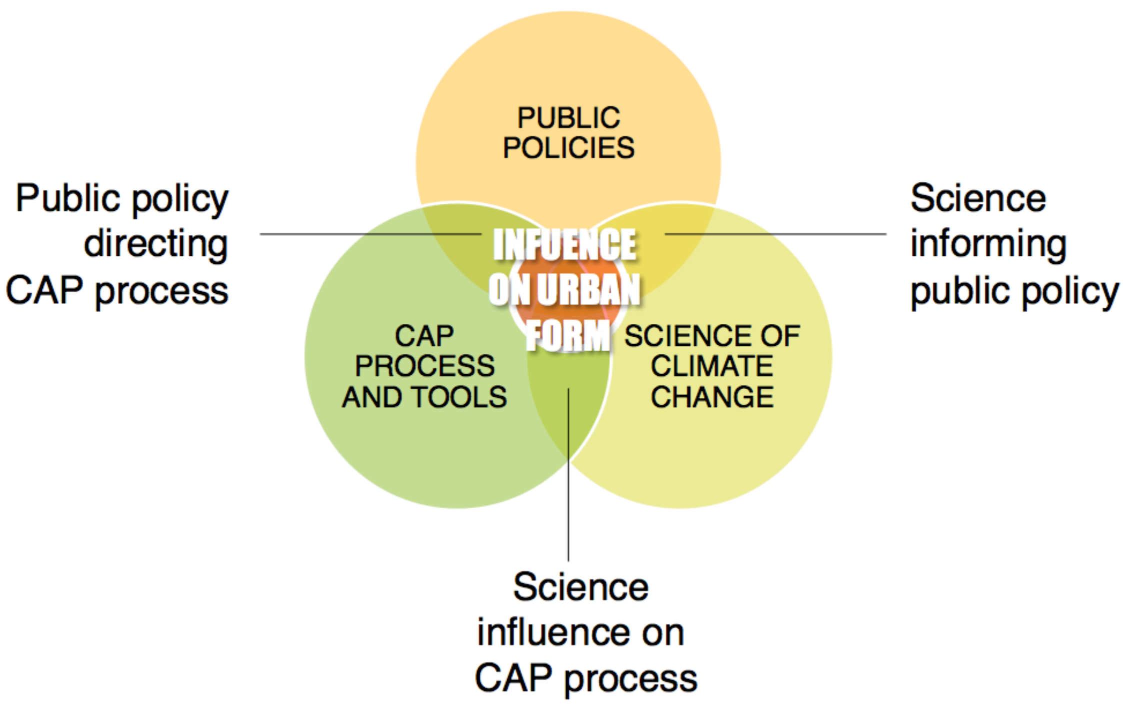
LITERATURE REVIEW

2.1 SCOPE OF REVIEW

An increasing number of communities in the United States are preparing climate action plans (CAPs) either as an expression of their values or in response to policy mandates from state law. The science of climate change is influencing both policies and implementation strategies to reduce greenhouse gas (GHG) emissions and inform adaptation planning. The planning process communities employ, the software tools they use, their follow-through on implementation, and the long-term effect on their urban form varies. The first generation of CAPs prepared by local governments offer much that that can inform future efforts made by thousands of other communities. Initial research revealed relevant literature regarding CAPs in public policy, science of climate change, existing planning tools, and processes (see Figure 2.1).

Figure 2.1

Overview of the Relationships Between Literatures



The body of research for preparing climate action plans has been prepared from a variety of perspectives. This includes literature from scientific research done, or funded by academic institutions and government agencies; public policy efforts at the regional, state and local level; and non-profit and for-profit organizations providing technical assistance to local government. The literature review is scoped to address questions that support the research aims of this thesis:

AIM1: Assess motivation and process of local government

- Q1-Motivation: Why are cities preparing CAPs?
- Q2-Policy Context: How are cities responding to state and federal policy context regarding preparing CAPs?
- Q3-Process: How are cities approaching preparation of CAPs?

AIM 2: Compare the types of CAP tools used by cities

- Q4-CAP Tools: Why do communities choose certain tools to inform the CAP process?

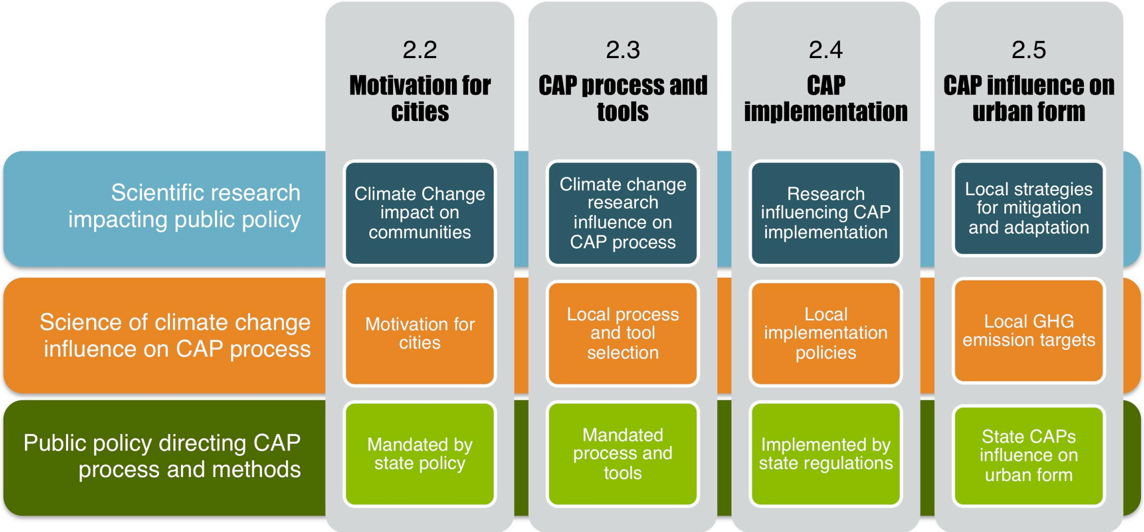
AIM 3: Assess how CAPs shape city form

- Q5-CAP Strategies: How are CAP strategies integrated into urban planning policies?
- Q6-Influencing Patterns: How are CAP strategies changing the form of cities?

Organization of the literature review (see Figure 2.2) addresses community motivation, processes and tools, and implementation in terms of scientific research, their values, and policy mandates.

Figure 2.2

Organization of Topics in Literature Review



The research methods used in preparation of this thesis also required review of various methodologies including case studies, interviewing, creating inventories, and designing surveys. Methodology issues are included in Chapters 2, 3, 4, 5 and 6, where they are connected to the research aims, questions, results, and conclusions.

2.2 MOTIVATION

This part of the literature review examines the various motivations for communities to prepare CAPs. This includes community awareness regarding the science of climate change, how their local values motivate their efforts to mitigate their GHG emissions, and how state policies and regulations influence them. Theoretical frameworks have been developed to explain intrinsic and extrinsic motivations, including self-preservation, local commitment to long-range comprehensive planning, and responding to legal mandates.

2.2.1 Background: Values, Policy, and Regulatory Context for Cities

Cities are responding to international, national, regional, and state initiatives that can influence their motivation for preparing climate action plans. In some cases, cities fulfil regulatory state requirements or act alone as an extension of their local values. The Kyoto Protocol is being renegotiated, and the U.S. Supreme Court has given the EPA the legal muscle to regulate GHG emissions. All but 12 states have prepared or are preparing climate action plans, and most states have climate registries or belong to a regional one.

National and Regional Values

National surveys indicate most Americans believe climate change exists. This includes most democrats and republicans. However, surveys of Americans' values and beliefs regarding climate change indicate both a regional and political bias.

Most Americans Believe in Global Warming

Many polls and surveys have tracked track the beliefs and concerns of the American public. A robust source is The Climate Action Network, which tracks public attitudes through national polls conducted by a variety of news, academic, advocacy, and political organizations. Their website has links to over 150 polls and surveys.

Surveys in 2011 and 2012 by Stanford University, Yale University and The Civil Society Institute reflect America's growing concern about climate change and the related impacts.

Surveys conducted in 2010 and 2011 by Stanford University with Ipsos and Reuters conclude that 75% of the country in 2010 and 83% in 2011 believed global warming has been happening. The survey indicates that the number of people who are very certain that global warming is happening or not happening grew from 2010 and 2011, indicating a polarization of views. Most republicans (54%) and democrats (88%) believe that global warming is the result of human activity. Most Americans (72%) expect global warming will continue in the next 100 years (Krosnick, 2011).

The findings from the 2011 Stanford survey are reinforced by 2012 polling by a team from Yale and George Mason Universities. This study reveals 70% of Americans believe global warming is real, 76% of Americans trust climate scientists, and 57% feel that climate change is a threat to the United States (Leiserowitz A. M.-R., 2012, pp. 3-4).

An August 2012 survey by the Civil Society Institute found that 81% of Americans are concerned about the impacts of climate change on extreme weather events such as floods and fires. Those surveyed also revealed concerns over the availability of safe drinking water (88%). This is especially true for respondents from the drought-prone states of California (92%), Georgia (91%) and Florida (91%) (Civic Society Institute, 2012, pp. 5, 13).

Regional Variations in Values

In 2009, The Pew Centre on Global Climate Change (now Centre for Climate and Energy Solutions or C2ES) published a national survey exploring the support of "Cap-and-Trade" policies and underlining concern and belief in climate change. The report found modest support for "Cap-and-Trade" and uneven political and regional concern or belief in climate change (Pew Research Center, 2009). Belief in climate change seems to be a divisive topic among conservative and liberal voters, with liberal voters overwhelmingly favouring limits on GHG emissions.

Favour Carbon Emissions Limits (2009)	
U.S. Total	*50%*
Northeast	*56%*
Midwest	*44%*
South	*46%*
West-Mountain	*42%*
West-Pacific	*62%*

Percentage of those who say there is solid evidence earth is warming (2009)	
Conservative Republican	*32%*
Liberal Democrat	*83%*

(Pew Research Center, 2009)

Political Party and Climate Change Beliefs

A 2012 poll by the Pew Research Centre indicated who 67% of Americans felt there is "solid evidence" for climate change. Only 42% of those that supported Mitt Romney for President believed in climate change, and of that group, only 18% felt it is attributed to human activity. Overall, 48% of republicans believed in climate change, up from 42% in 2009 (Pew Research Center, 2012). A 2011 Brookings poll underscored the political division around climate change, finding that political party affiliation is the single greatest indicator about a person's views regarding climate change (Brookings Institute, 2011).

Federal Action and Pre-emption

The review of existing federal and state policies pertaining to mitigation of GHG emissions and climate change adaptation reveals a context of collective actions of federal, state, and local levels of government. The U.S. Constitution assigns different roles to levels of government. The United States Constitution approach to Federalism assumes that the level of government closest to an issue will solve it, and when it cannot, a higher level of government will step in.

Traditional Federal Role

The federal government is to regulate environmental issues that are "negative externalities" such as air pollution from manufacturing or emissions from vehicles. The 1965 Water Quality Act and 1963 Clean Air Act and its 1977 amendments responded to how water or air pollution sources in one jurisdiction impacted downwind or downstream communities or states. In a 2008 *North-western University Law Review* article Robert Glicksman makes a case for federal action to address negative externalities of GHG emissions. He highlights the effectiveness of "resource pooling." This takes advantage of the federal government's ability, where states and local governments do not, to overwrite "race to the bottom" policies. This prohibits states from relaxing environmental regulations to be economically competitive by providing consistent federal regulations (Glicksman, 2008).

States Face Federal Inaction and Pre-emption

Weakening of federal environmental laws since the 1980s has led to increased regulatory activity at the state and local level. Some states have strengthened regulations, as in California, or weakened regulations, such as in Texas. This trend has been extended to GHG emissions and climate change where states work at the legal ceiling or floor of federal laws and regulations. California has pre-empted federal law, pushing beyond GHG emissions requirements mandating meeting reduction targets (Burgess, 2009). Texas is the country's largest oil and gas producer and has the least amount of regulation, lax enforcement, and fines low enough that it pays to pollute (National Public Radio, 2009). Texas has challenged monitoring by the EPA, claiming states' rights and unfair regulations but lost in court in 2010 and 2011 (National Public Radio, 2012). In California, cities must comply with state legislation and regulations, but in Texas, cities have little incentive beyond their own values to mitigate their GHG emissions.

Popular arguments for states developing their own standards that challenge the ceiling of federal regulations include innovations in policymaking (Burgess, 2009, pp. 258, 266). California's low-carbon fuel standard requirement established in 2007 requires a 10% reduction in GHG emissions from transportation fuels by 2020 (California Energy Commission, 2013). A similar bill (S.1297) was introduced to the U.S. Senate in 2007 but died in committee and was never voted on (U.S. Senate, 2007).

In addition to congressional actions or inactions, federal agencies and administrations can block states' efforts to increase standards. Under the President

George W. Bush administration, the U.S. EPA rejected California's petition to adopt the new GHG standards for motor vehicle emissions. This is an example of the federal government pre-empting states' ability to explore new and more effective environmental regulations by creating *lower* mandatory standards. Under the Obama administration, California received a waiver allowing the state to regulate GHG emission standards for vehicles beginning in 2009 model years (U.S. EPA, 2012).

Cities Act Locally

The commitment of local government to honour international agreements illustrates how some U.S. cities are "thinking globally and acting locally." By 2009 the World Mayors and Local Governments Climate Protection Agreement was signed by 112 cities, including 28 in the United States (Cities Climate Center, 2009). The World Mayors and Local Governments Climate Protection Agreement reflects cities' efforts to reduce their GHG emissions to 80% below 1990 levels by 2050. Parties to the United Nations Framework Convention on Climate Change adopted the Kyoto Protocol in 1997, requiring a 7% reduction from 1990 levels by 2012. By 2007 over 500 mayors signed on to the U.S. Conference of Mayors Climate Protection Agreement, pledging efforts to meet or exceed Kyoto Protocol emissions reductions (United Nations Framework Convention on Climate Change, 2011).

The Future of Kyoto

In 2001 President George W. Bush refused to support Kyoto, stating, "I oppose the Kyoto Protocol because it exempts 80 percentage of the world, including major population centres such as China and India, from compliance, and would cause serious harm to the U.S. economy" (Bush, 2001). The U.S., Canada, Australia and other industrialized nations are balking at using Kyoto as a foundation for further negotiations because former developing countries, such as China and India, are now among the top emitters of GHG but are not required to reduce their emissions.

In September 2011, the U.S. special envoy for climate change Todd Stern "warned that the US would not countenance a new climate regime that contained 'escape hatches' for some countries, and hinted that countries now labelled as 'developing' should be drawn into taking on obligations on emissions" (Harvey, 2011). The future of the Kyoto Protocol is in question, with key industrialized countries, such as Japan and Russia, saying they will not meet their commitments after Kyoto expires in 2012.

In lieu of congressional support for Kyoto, President Obama has made a commitment to making voluntary GHG emission cuts in "a range of 17% below 2005 levels by 2020" (Presto, 2011). Cities that were early adopters and leaders in responding to international climate change and action planning agreements are still out in front of U.S. commitment to meeting GHG emission reduction targets.

Supreme Court 2009 and the Clean Air Act

On December 7, 2009, the U.S. Supreme Court made two key findings that enable the U.S. EPA to regulate GHG emissions under the auspices of the 1990 Clean Air Act. The first is an Endangerment Finding, which states that six greenhouse gases "in the atmosphere threaten the public health and welfare of current and future generations" (U.S. EPA, 2011). The second is a Cause and Contribute Finding, which states that vehicle emissions also "contribute to the greenhouse gas pollution which threatens public health and welfare" (U.S. EPA, 2011). These findings make it possible for the U.S. EPA to establish emission standards for new vehicles and stationary emission sources, particularly older coal-fired power plants.

The Court's findings have automatically changed the trajectory of emissions from cars and trucks, supporting the efforts of cities preparing CAPs to reduce transportation-related GHG emissions. New emission standards for power plants will reduce the amount of GHG in the power grid, providing regional supply-side reductions that help cities meet their reduction targets for buildings. Moreover, the "EPA says the rules will prevent up 17,000 premature deaths, 11,000 heart attacks and 120,000 asthma attacks annually" (U.S. EPA, 2011, p. 3).

Greenhouse Gas Reporting Program

In 2009, the U.S. EPA issued the Mandatory Reporting of Greenhouse Gas Rule, which requires the largest U.S. sources to report their GHG emissions. Facilities that emit more than 25,000 metric tons of CO^2 per year are required to submit annual reports to the EPA (U.S. EPA, 2011). This will include an estimated 85-90% of U.S. GHG emissions from about 13,000 sources. The reporting data will inform future policymaking regarding GHG emissions.

Regional and State Context

Cities operate in states with various regulatory and policy context that could influence their motivation and approach to mitigation of GHG emissions and adaptation planning. Most states have prepared climate action plans, and studies show some modest results in GHG emission reductions. State and multi-state regional efforts have also cooperated on emission reductions and certifying GHG inventories through regional and national registries. Many states have prepared renewable portfolio standards (RPS) to establish targets for GHG reductions for electricity generation that can help cities meet CAP targets.

State Climate Action Plans

As of October 2011, all but 12 states (in the Mountain West, South and Midwest) have prepared, or are in the process of preparing climate action plans (Center for Climate and Energy Solutions, 2011). These state CAPs range from Lead by Example (LBE) efforts where states are trying to influence local government by setting a good example, such as Florida, or states that have legal and regulatory requirements for local governments, such as California.

The State of Florida has over three-quarters of its population living in coastal counties (National Oceanigraphic Economic Program, 2006). The state is vulnerable to increase hurricane frequency and power, and inundation due to rising sea levels. The state is undertaking a lead by example (LBE) effort and committing to a variety of energy, GHG emission reduction, and economic programs to address climate change (Pew Center on Global Climate Change, 2009). Since 2007, Florida's climate change efforts have included executive orders from the Governor, preparation of a State CAP, and legislation (State of Florida, 2010).

California has a variety of climate and energy legislation that has influenced how local government's plan. Key legislation regarding climate change includes AB 32, SB 375, and SB 97.

- The Global Warming Solutions Act of 2006 (Assembly Bill 32) requires California to reduce GHG to 1990 levels by 2020. AB 32 makes the California Air Resources Board (CARB) responsible for monitoring and reducing GHG (State of California, 2008, pp. ES-1).
- SB 375 creates a process for local governments and their regional partners to collaborate to reduce GHG emissions through "integrated development patterns, improved transportation planning, and other transportation measures and policies" (State of California, 2008, p. 27). The CARB is to work with Metropolitan Planning Organizations (MPOs) to establish GHG targets for reducing emissions from cars and light trucks, which are the source of 31% of California's GHG emissions.

- SB 97 requires GHG be subject to the California Environmental Quality Act (CEQA) (State of California, 2007). In 2009 the Governor's Office of Planning and Research (OPR) recommended amendments to the State CEQA Guidelines to include GHG emissions. Projects are now evaluated for their GHG impacts, and mitigation actions are identified through the CEQA process.

Modest Results at the State Level

A review of research studies and the progress made by states meeting their GHG emission targets indicates they have been making modest progress.

A research study by William Drummond published in the *Journal of the American Planning Association* compared local reductions in GHG emissions to climate action planning and policies at the state level. The study "found that taking climate actions at the state level resulted in modest but measurable reductions in GHG emissions" (Drummond, 2010, p. 426). States with CAPs had reduced their per capita emissions by about 0.6 metric tons primarily from reductions in commercial and transportation sectors. Drummond found that states categorized as "sprawl states" had nonindustrial energy GHG emissions 1.273 metric tons per capita more than "rural states" and over 3 metric tons per capita more than "compact urban states."

The Sonoran Institute analysed how climate change policies at the state level were impacting urbanizing western states. They examined 11 states, eight of which had climate action plans and two that were in the process of completing them. Generally, they found that the state CAPs emphasized: energy efficiency in buildings; reduction in VMT and enhanced pedestrian and transit services; transit-oriented development; and strategies that dictated the location, mix, density and edge conditions of land uses. They concluded that land-use-related strategies for these states could reduce GHG emissions by about 20% (Carter, 2008).

The State of Oregon is an established leader in sustainability and climate change mitigation policies. The 2004 Strategy for Greenhouse Gas Reductions includes a comprehensive and integrated set of recommendations to meet specific GHG reduction targets. The strategy states an action target of arresting "the growth of and begin[ing] to reduce Oregon's greenhouse gas emissions by 2010. Meet a goal of 10 percentage below 1990 Oregon emissions levels by 2020 and at least 75 percentage below 1990 levels by 2050" (Govenors Advisory Group on Global Warming, 2004, p. iv). The total Oregon gross 2004 GHG emissions of 66.407 million metric tons dropped to 66.292 million metric tons by 2008 emissions. Reductions were in transportation, industrial and agricultural sectors. There was a slight increase in commercial and residential sectors (State of Oregon, 2011).

The Climate Registry

The Climate Registry "sets consistent and transparent standards to calculate, verify and publicly report greenhouse gas emissions into a single registry" (The Climate Registry, 2011). It is a non-profit organization that supports collaboration among U.S. States as well as Canadian provinces and Native American nations. The Registry has a long list of partners and members, including businesses, public utilities, universities, the U.S. EPA, states, regional collaborations, and non-profits.

Participation in the Climate Registry was established as a voluntary program that helped members improve efficiency and prepare for carbon emissions trading. However, states like California are using the Registry's tools and technical support for mandatory reporting programs. In 2010 California and other Western Climate Initiative states transferred their Climate Action Registry to the Climate Registry. The Registry's protocols for reporting GHG emissions are becoming the national standard. It is the place where members report both voluntary and required annual reports. It is also supports regional GHG initiatives for efforts capping and trading CO2.

Regional Initiatives

In addition to state legislation and planning, there are three regional initiatives across broader geographic areas where states and local governments agreed to collaborate, including implementing regional cap-and-trade initiatives (Pew Center on Global Climate Change, 2009). These include the Western Climate Initiative, Midwestern Greenhouse Gas Reduction Accord, and Regional Greenhouse Gas Initiative. These regional efforts particularly effect the supply-side of energy production, where electric utilities are now required to work within regional GHG emission caps. The regional initiatives indirectly influence a city's need to prepare CAPs through statewide focus on generation and efficiency and development of renewable energy portfolios and directly through requirements for registering GHG emissions.

Renewable Portfolio Standards (RPS)

As of 2013, 27 states plus the District of Columbia have developed RPS, four states have alternative energy portfolio standards, and seven states have renewable or alternative energy goals (Center for Climate and Energy Solutions, 2013). These states have policies or goals regarding renewable portfolio standards or RPS to lower the amount of GHG emissions in electrical power generation. For example, Colorado has a target of 20% for independent operators and 10% for co-ops and municipal utilities by 2020; California's target is 20% by 2010; and Illinois's target is 25% by 2025 with 18.75% coming from wind (U.S. EPA, 2010). Most of the of the lower 48 states that have climate action plans employ policies for reducing the amount of GHG emissions attributed to electric power generation. The states' ability to meet these RPS targets supports local efforts to reduce GHG emissions.

State Influence vs. Local Values and Resoruces

A 2010 study published in the *Journal of Urban Affairs* compared 960 cities whose mayors were signatories of the Mayors Climate Protection Agreement (MCPA) to 14 local and state independent variables in order to understand potential influence of: state-level policies on local adoption of related climate change policies; and cities' motivations, strengths, barriers, and resources (Krause, 2010). The study concluded that, with the exception of California, in states where legislation enables enforcement, state-level variables did not influence local-level climate planning policies. However, there was a strong correlation between MCPA membership and local charateristics. This included city size, education attainment, median income, political leaning, form of government, per capita general revenue, nearby cities that are also MCPA members, and importance of manufaturing to the economy.

The Krause study was not comprehensive in terms of follow through. It only identifies MCPA memebership and does not consider which cities prepared climate action plans or the impacts of federal-level policies and regulations. However, the research does shed light on the potential ineffectiveness of state "lead-by-example" (LBE) approaches to GHG emission reductions targets, or state-level CAPs. It also suggests the percent of a state's manufacturing GDP or political progressiveness does not influence whether cities chose to be a signatory to the MCPA. MCPA membership seems to be motivated locally.

2.2.2 Adaptation Planning and Climate Change Impact on Communities

Federal, state and regional research, policies, and actions are anticipating impacts of a changing climate. These efforts are helping to inform and regulate investments and actions relating to climate change adaptation.

Federal Research

Federal Government agencies are now focused on regulation and strategic support of state, regional and local climate planning initiatives. The United States Global Change Research Program includes an integrated effort by 13 Federal agencies. In the most resent report from 2009, *Global Climate Change Impacts in the United States,* the Agencies provide a technical assessment of likely impacts of climate change and adaptation challenges by sector and region, and then lay out a six-part research agenda for scientists:

> *Recommendation 1: Expand our understanding of climate change impacts.*
> *Recommendation 2: Refine ability to project climate change including extreme events, at local scales*
> *Recommendation 3: Expand capacity to provide decision makers and the public with relevant information on climate change and its impacts.*
> *Recommendation 4: Improve understanding of thresholds likely to lead to abrupt changes in climate or ecosystems.*
> *Recommendation 5: Improve understanding of the most effective ways to reduce the rate and magnitude of climate change, as well as unintended consequences of such activities.*
> *Recommendation 6: Enhance understanding of how society can adapt to climate change.*

Projected Climate Change in U.S.

The United States Global Change Research Program (USGCRP) has estimated an increase in global temperatures of 3-5° C over the next 100 years. The USGCRP 2009 peer-reviewed summary report maintains there will be regional variations in the U.S. plus surprises in terms of unanticipated impacts. Across the U.S. we should expect to see:

- *Changes to vulnerable ecosystems sensitive to temperature and hydrology/rainfall;*
- *Increased flooding and drought conditions;*
- *Impacts to national food supply;*
- *Increasing near term forest growth due to CO2 levels and long term increase in wildfires, insect infestations and shift in species;*
- *Sea level rise impacting coastal areas;*
- *Melting of permafrost impact on roads and infrastructure in Alaska; and*
- *Human health impacts from a wide variety of changes to air and water quality, extreme weather events and diseases* (United States Global Change Research Program, 2009, p. 12).

Regional Variations

USGCRP reporting includes regional forecasting. The Northeast will be warmer and wetter, causing a shift in forests, agricultural growing regions and fisheries. The Southeast has had and will continue to have wetter fall seasons and drier springs, summers and winters. The higher temperatures will continue to stress people in cities, agriculture and ecosystems. In the Midwestern states, potential impacts crosscut the economy and the environment. The Midwestern states can look forward to reduced water levels in navigable waterways, reduced diversity in fisheries, and less water available for urban and agricultural uses. The Great Plains states could see a drastic rise in temperature. On the high-end GHG emission scenario, temperatures could increase as much as 13ºF by 2090, impacting ground water recharge of aquifers, limiting irrigation, and drying up surface water used by migratory birds. Water shortages in the Western states will lead to increased pressure between urban, environmental and agricultural uses for sharing water. The West will also face reduced biodiversity and increasing invasive species. Western cities are likely to experience worse air quality and related respiratory health impacts. The Northwest is forecasted to have reduced snowfall and related runoff necessary for healthy fisheries and forest ecosystems. Furthermore, all coastal areas can expect a rise in sea level of 8" to 2' (or higher) and increased intensity of storms. A 2' rise in sea level would result in loss of a high portion of the country's remaining coastal wetlands plus impact coastal communities and infrastructure (United States Global Change Research Program, 2009, pp. 107-137).

States' Adaptation Planning and Policies

With states facing such potentially drastic ecological impacts from climate change, some have instituted policies and regulations requiring local communities to plan for adaptation. There are 12 states with climate adaptation plans, two in progress and eight others that recommend adaptation plans in their CAPs (Center for Climate and Energy Solutions, 2011). The varying contexts result in an uneven support for cities

Example State Adaptation Plans

A review of the Florida, Maryland, and Oregon adaptation plans reveals an emphasis on intergovernmental collaboration and working with industries and NGOs. This holds true for both plan preparation and implementation.

The State of Florida has prepared a policy framework for adapting to climate change. *Florida's Resilient Coasts* report identifies key adaptation issues including sea level rise, increased risk of infectious diseases, saltwater intrusion into wells, shore erosion, and stress on urban infrastructure. Recommendations are comprehensive, considering the planning and community process, shoreline ecosystems, urban infrastructure, government organizational response, insurance, and financing (Florida Atlantic University, National Commission on Energy Policy, Bipartisan Policy Center, 2009). The Florida Legislature adopted HB 720 in 2011. The Bill identifies Adaption Action Areas that are optional designated comprehensive planning areas at risk of sea level change requiring priority funding for infrastructure and adaptation planning. The Bill supports preparation of strategies to make at-risk coastal areas more resilient by protecting, accommodating or retreating from rising sea levels. The legislation directly supports local and regional cooperation in the Southeast Florida Regional Compact–a partnership between Broward, Miami-Dade, Palm Beach, and Monroe Counties to adapt to climate change (Florida Department of Community Affairs Division of Community Planning Comprehensive Planning, 2011).

Maryland has the fourth largest coastline of eastern states and has a tradition for regional and statewide planning. In 2008, The Adaptation and Response Working Group, on behalf of the Maryland Commission on Climate Change, completed the *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change*. The Strategy makes six key recommendations:

- *Take action now to protect human habitat and infrastructure from future risks.*
- *Minimize risks and shift to sustainable economies and investments.*
- *Guarantee the safety and wellbeing of Maryland's citizens in times of foreseen and unforeseen risk.*
- *Retain and expand forests, wetlands, and beaches to protect us from coastal flooding.*
- *Give state and local governments the right tools to anticipate and plan for sea-level rise and climate change.*
- *State and local governments must commit resources and time to assure progress* (Adaptation and Response Working Group, 2008).

2.2.3 Motivation for Communities

Motivation for preparing and implementing a CAP can be intrinsic as an expression of voluntary actions reflecting local values or extrinsic with motivation from an external reward or impersonal regulation. Literature review includes traditional economic, social and psychological theory; and surveys that explore the motivation of cities in preparing CAPs.

Taxonomy of Human Motivation

As with individuals, cities have spectrum of motivations ranging from internal to impersonal. Gradations of extrinsic motivation and regulatory styles (R. M. Ryan, 2000) include:

External regulation–external awards and/or punishments

Introjection–focus on approval of others

Identification–conscious valuing of activity

Integration–hierarchical synthesis of goals as congruence

Research Emphasizes Intrinsic and Awareness-building Policies

Applying these organizational categories of motivation to cities can explain a range of influences for preparing CAPs. The *external regulation* assumes there are mandatory or regulatory reasons for cities to prepare a CAP. *Introjection* could happen where regional partners are involved in preparing emission inventories are external funders for are paying for CAP preparation. *Identification* may be through a symbolic group action such as being a signatory of the U.S. Conference of Mayors Climate Protection Agreement. *Integration* could be when local values and goals are similar and easily merged with external regulations for CAP preparation or GHG emissions inventory.

This system of intrinsic and extrinsic values and their role in the pursuit of pro-environmental behaviour has been a topic of intellectual focus for over 30 years. George D. Santopietro's *Journal of Economic Issues* article "Raising Environmental Consciousness versus Creating Economic Incentives as Alternative Policies for Environmental Protection" June 1995, built upon of a generation of research about what motivates people to act in environmentally beneficial ways. He emphasizes influencing the behaviour within households through environmental consciousness-raising policies. He uses J. K Galbraith's definitions of the types of power that could be used to persuade households to act in a pro-environmental way (Santopietro, 1995). These include:

Condign power–using disincentives (extrinsic)

Compensatory power–using incentives (extrinsic)

Conditioning power–consciousness-raising (intrinsic)

Incentives and Disincentives

Classic economic theory assumes we are rational actors motivated by selective rewards or sanctions. However, contemporary theories also view intrinsic and extrinsic motivation as co-conspirators of behaviour. In economics, intrinsic motivation can be "crowded out" or "crowded in" by extrinsic monetary reward or penalty (Frey & Jegen, 2000, pp. 5-7). For example, conservative cities located in California where they have a full spectrum of policy and regulatory legal requirements for reducing GHG emissions may be more extrinsically motivated.

Local Values Driving Cities

Progressive cities located in conservative states without state-level policies or CAPs, like Austin, Texas or Bloomington, Indiana, developed CAPs because their local values compel them. Krause (2010) suggest they are intrinsically motivated and working under their own motivations.

Adam Millard-Ball (2011) of McGill University studied California cities that have completed CAPs. He finds little evidence that climate action plans "play any causal role" in reducing GHG emissions. He claims, "citizens' environmental preferences appear to be a more important driver of both the adoption of climate plans and the pursuit of specific emission reduction measures. Thus, climate plans are largely codifying outcomes that would have been achieved in any case" (p. 289).

Millard-Ball compared cities' indicators for environmental values, such as Sierra Club membership and voting records for pro-environmental initiatives (as cross sectional variables), with a city's propensity to implement strategies meant to reduce GHG emissions such as increased ridesharing, green building ordinances or number of LEED buildings developed (as longitudinal variables). Thus, cities already environmentally predisposed to implement green actions and were acting in ways that reduced their GHG emissions.

Impacts of Climate Change as Motivation

Motivation can also come from "perceived susceptibility" to impacts of climate change. A 2008 survey by researchers at Portland State University, London School of Hygiene & Tropical Medicine and European Centre for Disease Prevention and Control focused on personal motivation for adaptation mitigation behaviour. In a cross-sectional survey of 771 people in the United States, 81% acknowledged climate change is occurring, will impact their way of life, and is a threat to human health. There was a correlation between that belief and their individual actions. The study concluded that:

> *Motivation for voluntary mitigation is mostly dependent on perceived susceptibility to threats and severity of climate change or climate variability impacts, whereas adaptation is largely dependent on the availability of information relevant to climate change* (Semenza, Ploubidis, & George, 2011).

This can be scaled-up to reflect the policy and regulatory behaviour of states that are witnessing environmental impacts of climate change. Cities that have a better understanding about climate change, related impacts and local responsibility prepare higher-quality CAPs. A study of 40 U.S. cities that prepared CAPs found that a greater understanding of climate change improved the quality of their plans in terms of awareness, analysis, and actions (Tang Z. , Brody, Quinn, Chang, & Wei, 2010).

Integration–Co-Benefits

A 2011 survey of 425 U.S cities with populations over 50,000 explored the connection between climate actions and co-benefits (Krause, 2012). The survey addressed two questions:

(1) Why do cities pursue climate protection?
(2) How do these considerations shape subsequent climate planning?

The survey had 255 responses. The three highest "single most important" co-benefits for pursuing a climate program include:

- *Achieving energy and cost savings for the city Government (31.3%)*
- *The preferences and priorities of particular city official(s) (19.7%)*
- *State government requirements or legislation (14.2%)* (Krause, 2012, p. 12)

The research explored how external factors and internal motivations influence climate action planning. Regression analysis identified a significant probability of a connection to external factors including education, political party affiliation, population, and general revenue. Significant probability for internal or stated motivations included climate protection, cost savings, and official pressure. The greatest motivation for climate actions turns out to be financial. The study findings suggest that "climate action may not be a 'paradox of collective action' but rather a rational choice made in the pursuit of co-benefits" (Krause, 2012, p. 25).

Advocacy and CAPs

Environmental advocates are motivated by *integration*. They are trying to move their intrinsic values forward as climate change policies. The front line advocates at the national and international level are familiar actors. Climate change policy web searches reveal the role of established and new environmental organizations that raise awareness of climate change, advocate for mitigation strategies, and implementation.

2.2.4 State Mandates

Thirty-six states have completed climate action plans, and two are in the process of completing a state CAP (Center for Climate and Energy Solutions, 2013). The policies and actions identified in states often cascade to local government. As a result, states' environmental protection role, have expanded to include mitigation of GHG emissions and adaptation planning.

Environmental Review and GHG Impacts

Several states have environmental review laws that require reporting similar to the federal environmental impact statement (EIS) required by the National Environmental Policy Act (NEPA). The scope of state environmental laws has been expanded to include GHG emissions.

In 2009, California adopted new guidelines for the California Environmental Quality Act (CEQA) for determining the significance of impacts from GHG emissions for projects. This extended to all projects requiring CEQA review including citywide comprehensive plans. In addition, a city as the lead agency must identify any inconsistencies between a proposed project and plans for reduction of greenhouse gas emissions (California Natural Resources Agency, 2009).

In Washington, the State Environmental Policy Act (SEPA) also treats GHG emissions as a proxy for environmental impacts. Cities as lead agencies must mitigate impacts by reducing a project's GHG emissions (Washington State Department of Ecology, 2011).

The Minnesota Environmental Policy Act (MEPA) was updated in 2009 to address GHG emissions. The state requires a carbon footprint report for sources within a project boundary and the amount of emissions from electrical power generated outside the boundary for the project (Stoel Rivers LLP, 2010).

Adaptation

Fifteen states have completed climate adaptation plans, four are in progress, and seven others (including the District of Columbia) have one recommended in their climate action plan (Center for Climate and Energy Solutions, 2013). Some states are requiring cities to plan for adaptation and supporting those efforts with priority funding for implementation of projects that improve their resilience.

Like many states on the eastern seaboard, Florida has been planning for sea level rise and has state comprehensive planning requirements for cities. In 2011, the law was amended to allow cities to identify adaptation action areas that become priority state funding areas for resilient infrastructure. Other eastern states are focusing on planning, infrastructure, planning regulations, and building codes that are preparing their cities for a rising sea level.

Inland states have also developed adaptation plans that reflect their own circumstances. In 2010, the Colorado Water Conservation Board prepared a statewide drought mitigation response plan. Kentucky prepared a wildlife action plan in 2010. In 2011 Michigan prepared a plan to prepare for human health impacts of climate change. Pennsylvania in 2010 published a four-part climate adaptation plan addressing infrastructure, public health and safety, tourism, and outdoor recreation (Georgetown Climate Center, 2013). To various degrees, these plans incentivize, regulate, and support local adaptation planning efforts.

2.2.5 Summary of CAP Motivation

Research and literature suggests that motivation for cities preparing CAPs is coming from their own interests, values, and co-benefits. The belief in global warming and climate change varies from region to region and appears to be strongly reflected in conservative and progressive voting patterns. States are preparing CAPs but are primarily lead-by-example (LBE) efforts that do not include policy or regulatory requirements for cities. Exceptions are states that require environmental review that include climate impacts and states that are susceptible to climate change impacts, such as sea level rise.

2.3 CAP PROCESSES AND TOOLS

The second part of the literature review focuses on the types of CAP processes and tools used by communities. There are a variety of approaches to preparing CAPs influenced by generally accepted or mandated protocols. Communities custom-assemble a process and supporting tools, use off-the-shelf systems provided by a third party, or apply a legally required process and tools. Most importantly, there is a growing set of commonly used protocols that guide preparation of GHG inventories.

2.3.1 Background: Protocols

Protocols provide a consistent set of rules for preparing GHG emission inventories. They support the development of a "Cap-and-Trade" system for carbon by creating a set of rules and procedures for counting carbon. Protocols exist at the international, national, regional, and state levels. Local communities use these protocols as a proven method and to be able to register their CO2e emissions.

Protocols are based on a comprehensive assessment of GHG sources, data, and methods. The inclusive process of creating protocols includes a wide range of experts and addressing the many facets of determining a consistent approach to measuring GHG emissions. The complexity and detail of inventory for a country, region, or state is breath taking. For example, the IPCC national summary GHG emission summary includes 68 pages of tables. The Climate Registry's protocols from 2008 are summarized in a 228-page report, including chapters for determining geographical boundaries, greenhouse gases, organizational boundaries, operational boundaries, facility-level reporting, base year, transitional reporting, historical reporting, emission qualification methods, and performance metrics (The Climate Registry, 2008, p. 9).

International Protocols: IPCC Protocols

In 2006 the IPCC published the *Guidelines for National Greenhouse Gas Inventories*. The guidelines are summarized in five reports. These include categories for general, energy, industry, agriculture and forestry, and waste (IPCC, 2012). The IPCC identify the "generic elements of a measurement program" to include a measurement objective, measurement protocol, measurement plan with clear instructions to measurement personnel, and data processing, reporting procedures, and documentation (IPCC, 2006, p. 2.9).

National Protocols: The U.S. EPA Greenhouse Gas Reporting Program (GHGRP)

In 2009, the U.S. EPA issued mandatory GHG reporting for commercial and institutional entities that emit over 25,000 of metric tons of CO2e per year. In June 2011, the EPA allowed stakeholders to try a beta Electronic Greenhouse Gas Reporting Tool (e-GGRT) (U.S. EPA, 2011). The EPA defers to ICLIE and The Climate Registry protocols for communities and to the Greenhouse Gas Protocol for corporations to define "approaches and branding guidelines to develop GHG Protocol-based sector guidance, product rules, and calculation tools" (Greenhouse Gas Protocol, 2012).

States and Regions: The Climate Registry

The Climate Registry "is a non-profit collaboration among North American states, provinces, territories and Native Sovereign Nations that sets consistent and transparent standards to calculate, verify and publicly report greenhouse gas emissions into a single registry" (The Climate Registry, 2011). The Climate Registry members use the organization's protocols, report their GHG emissions and have them verified by a third party every year. Members' GHG inventories are published on the Registry website. The Registry provides online tools, Climate Information System (CRIS), for GHG calculations, reporting, and verification (The Climate Registry, 2011, p. 3).

Local Government Operations

The Local Government Operations Protocol was coordinated by ICLIE for the California Air Resources Board and has become the national standard endorsed by the U.S. EPA (ICLIE, 2012). In California, the protocols for GHG emission inventory for local government operations was prepared by the California Resources Board in cooperation with the California Climate Action Registry and ICLIE. The Local Government Operations Protocol is used by local governments to calculate emissions from municipal operations. The Protocol is to:

- *Enable local governments to develop emissions inventories following internationally recognized GHG accounting and reporting principles defined below with attention to the unique context of local government operations;*
- *Advance the consistent, comparable and relevant quantification of emissions and appropriate, transparent, and policy-relevant reporting of emissions;*
- *Enable measurement towards climate goals;*
- *Promote understanding of the role of local government operations in combating climate change; and*
- *Help to create harmonization between GHG inventories developed and reported to multiple programs*. (California Air Resources Board, California Climate Action Registry, ICLEI - Local Governments for Sustainability, The Climate Registry, 2010, p. 3)

Protocol for GHG Emission Inventories

The development of protocols for local government GHG emission inventories is an evolving process. The Climate Registry has been influential. However, there is still inconsistent accuracy in GHG emission inventories.

The Climate Registry assumes inventory preparation will include three steps: determine which emissions to include; select and apply Registry-approved methods for quantifying emissions for sources; and report emissions data using *The Climate Registry Information System* (*CRIS*) and have reported emissions verified (The Climate Registry, 2008, p. 6).

Key to successful CAP actions is development of an accurate baseline GHG inventory and BAU. A study of 18 U.S. cities' approaches to preparing GHG inventories illustrates a fair amount of variation in approaches. Areas of variability and uncertainty included electric power systems operations, weather variability, and measurement and sampling errors for transportation emissions (Blackhurst, Matthews, Sharrard, Hendrickson, & Azevedo, 2011, pp. 1-9). The authors recommend disaggregating inventories into more finite and actionable categories and comparative benchmarking inventories with peer cities. They encourage more resources be made available for more accurate BAU projections.

C40 and ICLEI Efforts to Create International Protocols for Cities

ICLEI and C40 Cities Climate Leadership Group have drafted international protocols for CCAPs. The protocols are to make it easier to develop effective policy, compare GHG emissions between communities, inform development and consumption policies, and make it easier to aggregate data at a regional and national level (Yunis, 2012, pp. 7-8).

The 76-page report offers a framework for scoping CAP boundaries and sectors for GHG emission inventories. The scoping protocols tier GHG emissions at a local in-city, inter-city (sub national), and international scale. The in-city emission sectors include residential buildings, commercial/institutional buildings, agriculture, forestry, and land use, transport (in-city), waste management (in-city), industrial, and energy industries (Yunis, 2012, p. 12).

2.3.2 Climate Change Research Influence on CAP Process and Tools

Climate change research has increased the accuracy of estimates in terms of understanding potential benefits of GHG inventories, mitigation strategies, monitoring and climate adaptation. The IPCC, U.S. EPA, states and even cities are contributing to the body of knowledge of CAP tools and processes. A survey of 40 cities that completed CAPs found that the quality of their planning related to how much they understood the impacts and science behind climate change (Tang Z. , Brody, Quinn, Chang, & Wei, 2010). Therefore, initiating a process to help stakeholders understand regional and local vulnerabilities can be an important first step.

The IPCC

The IPCC has helped establish both the scientific support and protocols for measuring GHG emissions. IPCC assessments have identified seven sectors of GHG emissions that have been adopted as an international protocol: energy supply, transportation and related infrastructure, residential and commercial buildings, industry, agriculture, forestry and waste management. The U.S. Environmental Protection Agency (EPA) and most states and local governments use these for GHG inventory, strategies, and action planning.

The IPCC's has three Working Groups:

- *Working Group I (WG I) assesses the physical scientific aspects of the climate system and climate change.*
- *Working Group II (WG II) assesses the vulnerability of socio-economic and natural systems to climate change, negative and positive consequences of climate change, and options for adapting to it.*
- *The IPCC Working Group III (WG III) assesses options for mitigating climate change through limiting or preventing greenhouse gas emissions and enhancing activities that remove them from the atmosphere.* (International Panel on Climate Change, 2012)

These groups continuously strive to integrate science and research into their efforts to provide protocols and policy advice for global leaders. They provide a comprehensive assessment and inventory tools to be used by nations.

The Federal Government

The United States Global Research Program (USGCRP) reflects the efforts of 13 Federal agencies to identify the impacts of climate change on the United States. Both international and national research presents a picture of climate change challenging cities' environmental resilience. The USGCRP 2012-2021 Strategic Plan has four objectives: studying climate and global change, preparing the nation for change, assess the U.S. climate, and making science accessible to the public and scientific workforce (U.S. Global Change Research Program, 2013).

Among federal agencies, the National Ocean and Atmospheric Administration (NOAA) and U.S. Environmental Protection Agency (EPA) are key in coordinating and broadcasting research findings related to the science and mitigation strategies for a changing climate. The U.S. EPA connects science to policy and regulatory implementation. The Agency supports the development of GHG reporting and planning tools. The EPA provides educational and technical assistance via their State and Local Climate and Energy Program, including recommendations for process and tools (U.S. EPA, 2012).

Role of State Environmental Agencies

Most states have environmental or natural resource agencies that implement environmental policies and regulations. Their capabilities reflect both the economic capacity and commitment to informing public policy regarding climate change.

Some agencies are proactive and have the resources of a large state like New York. Smaller states like Iowa have added climate change to their more traditional Department of Natural Resources agency agenda.

In New York, the Department of Environmental Conservation has established an Office of Climate Change with two bureaus: Climate Science and Technology and Climate Programs and Partnerships. The Climate Science and Technology Bureau "uses sound science, engineering and economic principles to design solutions that will help stabilize atmospheric greenhouse gas concentrations at acceptable levels; supports the development of climate impact analyses to help New York respond to the impacts of climate change; contributes to state energy and climate planning (Office of Climate Change - N.Y. Dept. of Environmental Conservation, 2013)." The Department steers communities towards ICLEI's CACP software and The Climate Registry for municipal emissions inventory.

The Iowa Department of Natural Resources provides information about the impacts of climate change, summaries of the state GHG inventory, and links to the Iowa Climate Change Advisory Council's webpage. As an LBE state, the Department steers businesses and communities towards voluntary participation in The Climate Registry and federal programs. Their website includes links to CAP tools and educational resources (Iowa Department of Natural Resoruces, 2013).

2.3.3 Local Process and Tools Selection

The CAP process and supporting tools for local government are evolving. ICLEI has been an important leader developing tools, training, and advocacy. However, as the marketplace has expanded, so have commercially developed and provisioned software and alternative approaches. Cities use tools to support the CAP process, establishing GHG emission baselines, benchmarks, and business-as-usual projections; developing scenario and action plans; and monitoring results.

Local CAP Process

The CAP process for a city requires preparation of GHG inventories, identifying benchmarks against their historical emissions, and identifying actions and timelines to meet emission reduction targets. The scope and process of a CAP is developed out in front of the effort to manage resources, community outreach, and meet legal or policy requirements. In some cases, cities want to or are required to report their emission to a third party such as the Climate Registry.

ICLEI Process

ICLEI has worked with the California Air Resource Board and the U.S. EPA to develop protocols for developing GHG emission inventories. Their training and software supports a five-milestone process for preparing a CAP. These steps include:

Milestone One: Conduct a baseline emissions inventory and forecast
Milestone Two: Adopt an emissions reduction target for the forecast year
Milestone Three: Develop a local climate action plan
Milestone Four: Implement policies and measures
Milestone Five: Monitor and verify results
(ICLEI, 2008)

Cities that use ICLEI CAPC or CAPPA software tools use this process as they support decision-making in the five milestones. It also allows ICLEI to provide efficient technical support and training.

U.S. EPA

The EPA suggests a city can use a six-step process. Their suggested approach includes assessing risks and vulnerabilities. Their steps address:

Regional and local risks and vulnerabilities
Baseline emissions
Goals and targets

Identification and screening of mitigation options
Estimated results of mitigation actions
Recommendations and strategy for implementation
(U.S. EPA, 2012)

The EPA emphasizes collaboration with stakeholders; understanding the opportunities for reducing GHG emissions and vulnerabilities to climate change; stetting goals and establishing criteria for reviewing mitigation options; and selecting options and methods for measuring and implementing them. They also recommend using a programmatic approach to CAP implementation.

Custom Approaches

Cities that do not use ICLEI's software tools, or only use them for developing their GHG emissions inventory, may combine or add steps to reflect their local policy-making and action-planning context. Interviews with CAP managers from Berkeley, CA, Chicago, IL, Boulder, CO and Austin, TX revealed cities that designed their CAP processes to suit local political and strategic planning conditions.

<u>Measuring Emissions</u>

Cities must consider whose, what, and how emissions are measured. One of the initial decisions is establishing a boundary for measuring GHG emissions. Using common protocols can help identify what activities are counted (activity principle) and geographic boundaries (territory principle). Data availability can restrict the scope of inventory plus the motivation to prepare a CAP municipal operations and/or the community (Bader & Bleischwitz, 2009, pp. 4-8).

With a goal to be comprehensive in terms of identifying GHG emission sources, cities could identify direct emissions from stationary sources within the city limits; indirect emissions such as energy generation; and other types of indirect and embodied emissions, including waste delivered to a landfill. Cities can consider energy used by consumers; allocate emission to their city from sources such as power plants, including grey emissions from loss in power transmission; and life cycle approach that considers the emissions coming from products and facilities within the city. Most tools that cities use combine two or more of these approaches (Bader & Bleischwitz, 2009, p. 9).

Tools measure GHG emissions one of four ways. The *emissions factor-based method* uses a coefficient to quantify the emissions for activities. The *Mass balance method* tracks CO2 as an element and is often used for power plants. The *Predictive emissions-monitoring system (PEMS)* method combines measuring and calculating emissions where measuring is used to calibrate a model. The *Continuous emissions-monitoring system (CEMS)* method measures emissions in real time, providing the most accurate accounting. Most cities employ tools that use the *emissions factor method* where data samples are used to calibrate a model for various activities. The factor-based approach assumes: $E=A*EF$ where E represents emissions, A represents the activity data and EF represents the emissions factor (Bader & Bleischwitz, 2009, p. 12).

Emissions factors make tools easier to use. The closer it is to an accurate emission quantification, the better the tool. Default emission factors, called tier one factors, tend to be general and least accurate. The next tier is more geographic-specific and uses more localized data. The third tier reflects operating conditions and more specific understanding of equipment technologies used (Bader & Bleischwitz, 2009, p. 13).

Tool Usability and Accessibility

Several variables influence a city's tool selection. These include price, user interface, access, guidance, ability to forecast or run scenarios, and transparency.

Cost

Some free versions of software are available, such as ICLEI's Climate and Air Pollution Assistant (CAPPA) that can be used for municipal CAPs and project planning. These tend to be more limited in the scope of planning and technical assistance they support. The full version of ICLEI's CAPC software and technical support is available only to member cities.

User Interface, Guidance and Access

The friendliness of user interface can vary from an Excel spread sheet to a customized, graphic and guided suite of tools. Many specialized tools are made available by federal, state and regional agencies such as the EPA, California Air Resource Board (CARB), and energy companies. These are usually designed to track more specific emission sources. The amount of technical support and guidance required and provided can vary with cost and membership. ICLEI membership includes software and support, as do a growing number of commercial software tool providers. Generally, commercial products emphasize improved interface, 24-hour online (cloud) access and the ability to customize a suite of tools for a specific city. For example, ENXISUITE (ENXSUITE, 2010) provides a set of full-service tools for cities and was selected through a competitive process by the City of Chicago to provide tools for their CAP implementation (Coffee, 2010).

Scenarios and Transparency

During the action planning process, cities often want to explore planning options and be able to track the success of strategies unique to their city. Some tools are intended for use in conceptual and strategic planning. This includes ICLEI's CAPPA tool and other software that supports local and regional planning measuring traffic, fiscal impacts and other dynamic urban systems impacted by growth policies. I-PLAC3E software is used by Sacramento Area Council of Governments (SACOG) to map out regional and local land use scenarios with feedback regarding travel and air quality impacts, including GHG emissions (Sacramento Area Council of Governments, 2013).

Software tools that employ the emissions factor-based method embed many of their assumptions. Cities that want to customize what and how they are counting and then communicate those results might discover some pre-packaged tools opaque or "black box." To avoid this, Timothy Burroughs, former ICLEI staff and CAP coordinator for Berkeley, CA, has developed his own modelling tools and software tailored to test and track actions and policies (Burroughs, 2010).

2.3.4 Tools for State-Mandated GHG Impact Analysis

A review of the literature has not discovered states requiring specific GHG inventory software. However, states that consider specific GHG emissions an environmental impact do require its measurement and mitigation. The states of Washington, California, and Massachusetts consider the GHG impact of projects.

<u>State of Washington and SEPA</u>

In the state of Washington, the State Environmental Policy Act (SEPA), as an extension of actions by the National Environmental Protection Act (NEPA) review, considers GHG emissions an environmental impact (Department of Ecology, State of Washington, 2013). King County, WA has prepared a worksheet (Excel spread sheet) used to calculate CO_2e emissions from proposed development to satisfy requirements of SEPA (Department of Permitting and Environmental Review, King County, Washington, 2013). The worksheet requires building and paving area as inputs. It calculates lifecycle CO_2e from imbedded, energy and transportation. The worksheet has built-in assumptions about energy efficiency, building lifespan, persons per household, vehicular trip generation rates for land uses, and unit size.

State of California and CEQA

California's SB 97 requires GHG emissions to be measured as an environmental impact, and regions of the state have been collaborating in developing GHG inventories. State air pollution control districts developed the California Emissions Estimator Model (CalEEMod), which "calculates indirect GHG emissions from energy use, water/wastewater conveyance, solid waste disposal, and vegetation planting and/or removal and the benefits from implementing mitigation measures, including GHG mitigation measures developed and approved by California Air Pollution Control Officers Association" (CAPCOA, 2013). Air pollution control districts, including those in San Joaquin Valley, South Coast, and Sacramento, use the software to meet the legal impact review requirements for large-scale projects.

CalEEMod provides a common set of protocols and a menu of mitigation choices for both community and municipal operations. The software is slow, its calculations cannot be saved as projects, and it requires many individual entries, and the software entry assumptions cannot be modified. It is best used for single-run calculations where the user is selecting from pre-set mitigation strategies.

Commonwealth of Massachusetts

The Massachusetts Environmental Policy Act (MEPA) requires preparation of an Environmental Impact Report (EIR). As of 2010, this includes project sponsors to prepare a baseline and mitigated alternative annual GHG emissions from the project. MEPA requires measurement of direct (stationary) and indirect (transportation) emissions. They require the use of a suite of tools to calculate baseline energy use, emissions from onsite processing, and VMT (The Commonwealth of Massachusetts, 2010).

2.3.5 Summary CAP Processes and Tools

For communities preparing CAPs, an increasing number of tools and resources are available that embody protocols developed by international, federal, state and non-profit agencies and organizations. Cities in states that have recognized GHG emissions as an environmental impact must meet requirements and protocols. California, in particular, has made GHG emissions inventory and mitigation necessary in the EIR process for large-scale projects and city planning. The CARB and air pollution control districts have provided tools and protocols to help track the impacts of projects. ICLEI offers a popular tool for GHG inventory, strategy evaluation, and monitoring. Their

CAPC software supports the ICLEI five-milestone process. Many ICLEI membership cities have used this software, but others have developed their own custom spreadsheets. The future of CAP tools seems to also include commercially developed and marketed software with additional implementation, monitoring, and communication capabilities.

2.4 CAP IMPLEMENTATION

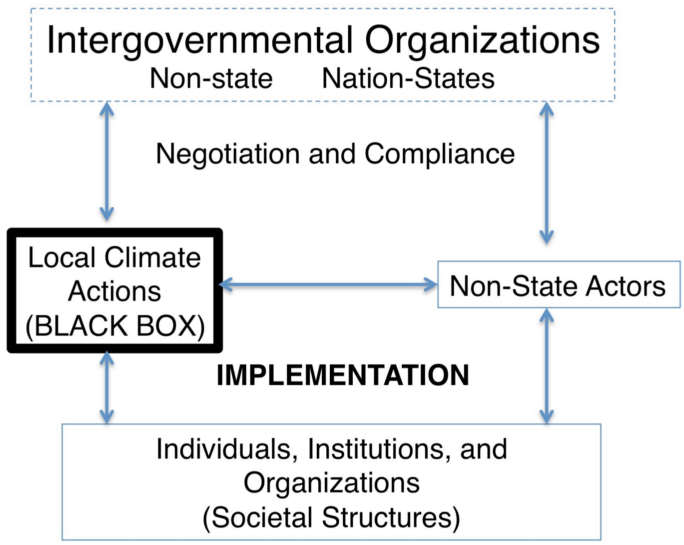
The third part of the literature review addresses CAP implementation. Scientific research, commitment to long-range planning and sustainability policies, and state regulations shape implementation strategies and actions. The success of a CAP to reduce GHG emissions may have operational and physical form results that reflect to various degrees local conditions, values, and state mandates.

2.4.1 Background: Implementation Planning

CAPs consist of targets, goals, strategies and actions. Generally, they establish a reduction target and date with internal goals to be met by strategies comprised of actions. CAPs effectiveness can be influenced by a variety of factors including the quality of the plan, capabilities of the implementing parties, and lack of understanding about federal and state policies.

Figure 2.3

Hierarchical Government Structure of Climate Planning



Adapted from Buckeley& Betsill, 2003

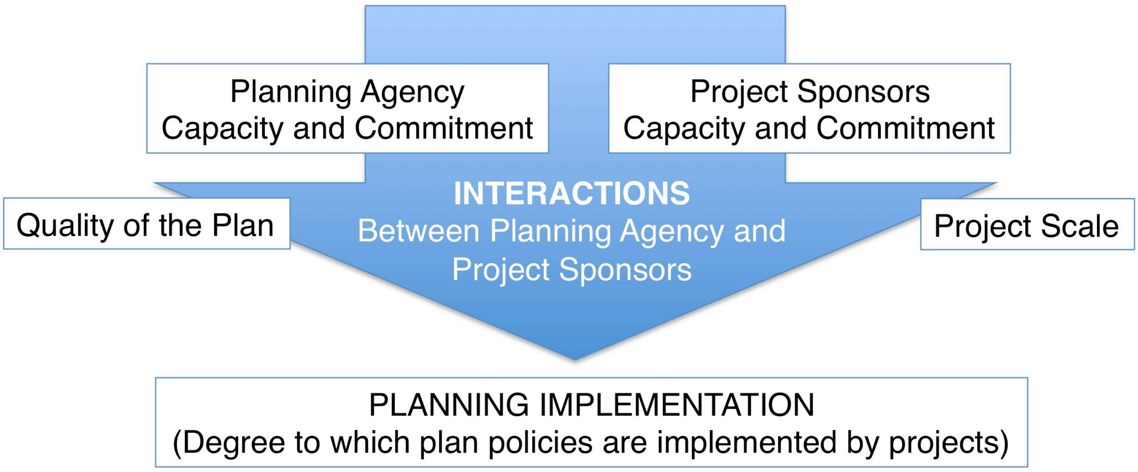
Cities in the Context of Sate, Federal, and International Climate Planning

The spatial boundaries and policy control can lead to "black box" thinking by communities (Figure 2.3) thereby disconnecting local climate planning from upstream policies and actions (Buckeley & Betsill, 2003, pp. 16, 25). Traditionally, cities have not been part of "multi-level governance" that can act "across scales" when it comes to climate action (pp. 25-27). In this *old model* of climate planning, cities focus on what they can control in their CAP. Newer models allow the state and civil society to share power, create networks and partnerships with a variety of public and private actors, and collaborate (p.17).

Addressing GHG emissions from transportation reflects the many of the challenges for local government to influence outcomes. Cities lack the direct powers to reduce travel, shift to renewable fuels, and promote new transportation technologies. This contributes to practical and political problems of reducing transit-related GHG emissions, especially as it pertains to perceptions regarding economic impacts, funding of capital projects, and internal technical capacity (Buckeley & Betsill, 2003, pp. 101-102).

Figure 2.4

Factors that Influence Implementation of Planning Policies



Adapted from Laurian, et al., 2004

Determinates of CAP Implementation

The degrees to which CAPs and comprehensive plans are implemented are due to internal and external factors. Internal factors include the "nature of planning practice, the limitations of planning in the face of uncertainty, planners' biases and roles, flaws in planning goals, the failure of plans to recognize the effect of political agendas on planning decisions, the weakness of some plans and the complexity and comprehensiveness of others" (Laurian, et al., 2004, pp. 577-558). External factors can include policy support and funding availability. The scale and scope of projects affect their contribution to plan implementation. Smaller projects will not have the same impact as larger scoped and implemented developments (p. 559).

Figure 2.4 illustrates factors that influence implementation of planning policies. These include the quality of the plan, the private sector partners' commitment and capacity, planning and development review processes and requirements, and the scale of projects implemented by plan policies.

Core Strategies, Actions, and Metrics–Example of Seattle, Washington

CAP strategies are comprised as a group of actions with indicators to measure results. The Seattle, Washington CAP identifies outcome indicators and actions to be implemented by 2015 and by 2030. The Seattle CAP actions are grouped by transportation and land use, building energy plans, waste plans and adaptation plans. Each is measured against a 2008 baseline emission inventory. The 2030 target is to reduce GHG emissions by 58% in 2030 (GLLO, 2013).

Seattle's transportation and land use actions are organized by: transportation choices, complete communities, and economic signals. Actions are broken into near-term (2015) and long-term (2030) time frames. Performance metrics are by sector, indicator, and target.

A core urban design strategy for Seattle is to implement a network of walkable urban villages and centres that house 45% of the city's population. One land use sector (livability components) emphasizes providing services and open space within a walkable distance of residential areas. The indicators for these include meeting a minimum WalkScore in centres and urban villages and making sure that urban villages are meeting open space goals.

2.4.2 Climate Change Research Influencing CAP Implementation

Scoping includes establishing physical and topical boundaries through "consistent, reproducible, and holistic GHG accounting at a city-scale" (Chavez & Ramaswarmi, 2013). To date, no a protocol has been established for U.S. cities in terms of identifying a method for GHG accounting. Some cities use a consumption-based approach that identifies the emissions from economic consumption of households and businesses, but others use a geopolitical boundary method. Without a solid GHG emissions inventory, it is hard to plan and measure progress.

A 2010 article in the *Journal of the American Planning Association* reviewed the case study results for some of the first cities to prepare CAPs. Thirty CAPs were selected for study and objective was to determine the degree to which the CAPs were informed by their GHG inventories (Boswell, Greve, & Seale, 2010). The study made three observations:

- The GHG emission inventories used protocols but set modest goals and targets for reductions.
- Potential changes that were external to the community and outside their control were not addressed.
- Mitigation actions did not align with reduction goals and targets.

The authors concluded that best practice standards for GHG emission inventories are improving and that cities will need to continue to improve forecasting and informing their goals and actions.

Since 2009, the U.S. has seen a robust expansion of public, professional and non-profit sponsored research and education that have provided methods and tools to help communities prepare and better implement CAPs. Federal agencies provide active support in funding and broadcasting the research results from research groups in universities; involvement of national membership organizations such as ICLEI and U.S. Conference of Mayors Climate Agreement; commitment by professional organizations such as the American Planning Association and American Institute of Architects; and non-profit environmental groups such as the U.S. Green Building Council and Sierra Club. California's Air Resources Board is one of the most influential and effective agencies using research to inform planning and enforcement.

California Air Resources Board–Pioneer and Innovator

California is the only state permitted to have a regulatory agency that deals with air quality because the state established a clean air board before the federal Clean Air Act was passed. In fact, other states are permitted to follow California's standards or use the federal standards and cannot create their own. This makes the California's Air Resources Board a very influential agency (California Air Resource Board, 2010).

The ARB's influence and partnerships with air quality districts, ICLEI, and the EPA have increased the consistency of efforts, particularly in terms of establishing inventory protocols for defining the scope and boundaries of CAPs. The ARB's science-based approach has built on decades of air quality monitoring, planning, and regulatory enforcement. It is nationally influential due to its pioneering role and leadership in "cutting-edge research" and implementation of policy.

The Air Resources Board (ARB) has been tasked with implementing the AB 32 Global Warming Solutions Act of 2006 and SB 375, the Sustainable Communities Climate protection Act of 2008 (California Air Resources Board, 2013). To implement AB 375, the ARB has been working with 18 regional Metropolitan Planning Organizations (MPOs) to prepare sustainable community strategies. Targets at the regional scale have become part of the federally mandated regional transportation plan (RTP).

2.4.3 Climate Actions and Policy Integration

Successful CAP implementation is contingent on how strategies' actions are integrated into other urban planning policies and the role of the public and private sectors in planning and implementation.

To various degrees, cities are moving their climate actions and strategies into their comprehensive plans, where they are implemented through policy implementation and capital improvements planning. In California, New Jersey, and Florida, cites are required to prepare comprehensive plans. In California cities are also required to make their capital improvement plans (CIPs) consistent with their general (comprehensive) plan (Godeschalk & Anderson, 2012, p. 52).

There are a variety of methods for tracking the success of the sustainability policies of a comprehensive plan. These include identifying indicators, benchmarks, and targets, as in the Marin County, California General Plan. Other methods include developing baseline data to measure progress against, defining indicators, creating data books of inventories, using report cards, and utilizing procedures for policy tracking (Godeschalk & Anderson, 2012, pp. 60-61).

Seattle's Environmental Element–Policies and Targets

Seattle's CAP has policy connections to the city comprehensive plan's environmental element. The comprehensive plan includes goals, policies, and 2020 and 2030 targets for transportation, buildings, and waste (City of Seattle, 2013, pp. 11.5-11.7).

Ann Arbor, Michigan–Broad Goals

Ann Arbor's 2012 CAP builds on a long tradition of climate and energy-related policies and planning. The City prepared an energy plan in 1981, joined ICLEI in 1997, and signed the U.S. Conference of Mayors Climate Protection Agreement in 2005 (City of Ann Arbor, 2012, pp. 9-10). In 2013, the City prepared the Sustainability Framework Element for their City Master Plan that includes broad goals but not specific actions (Ann Arbor, 2013).

Bloomington, IN–Actions without a Policy Plan

Bloomington has developed a GHG emissions baseline, targets, goals, and actions. The City Environmental Commission has been tasked to track and advise the City Council on climate actions. The Commission tracks climate actions progress for community and municipal CAPs by "thinking, doing, done, and defending" categories (Vogt, 2010). The City is in the process of preparing a long-range plan as part of the Imagine Bloomington visioning effort. The draft Vision Statement for the long-range plan includes sustainability as a core principle (City of Bloomington, IN, 2013). However, the degree of climate action integration has yet to be determined.

2.4.4 Public–Private Implementation Roles

Most CAPs include extensive engagement of the business community. The culture of business and private sector leadership regarding environmental issues varies from city to city. The review of literature found no case where they were not consulted in the preparation of a CAP.

Minneapolis CAP Steering Committee Process

The Minneapolis CAP process has built on a tradition of environmental planning. The CAP process has included in a Steering Committee with policymaker and community representatives including businesses. Four topical Working Groups have made recommendations regarding GHG reduction strategies. Groups include transportation and land use, buildings and energy, waste and recycling, and environmental justice. The Community Environmental Advisory Commission acts as the day-to-day reviewer and implementation advisors for the plan. The Commission has permanent positions for representatives from the business community (City of Minneaplois, MN, 2013).

Chicago Green Ribbon Committee

Mayor Daley depended on the business community's leadership in preparing the Chicago CAP in 2008. To maintain the momentum, the City has created the Green Ribbon Committee of business and community leaders to make sure the CAP goals are being met and recommend any necessary revisions to the CAP (City of Chicago, IL, 2013).

Newark, NJ Business Community Actions

The Newark business sector is responsible for 40.4% of the city's GHG emissions. The Newark CAP clearly lays out the responsibilities of the business community to implement the plan. Developed with the business community, Chapter 5 of the CAP includes actions regarding business waste practices, energy-efficient buildings, green vehicle fleets, reduction in staff VMT, and other conservation measures (City of Newark, NJ, 2010, pp. 21-22).

2.4.5 CAP Implementation Summary

CAPs are comprised of a system of strategies and actions design to meet goals and targets. Review of literature underscores the importance of starting with a technically solid GHG inventory in terms of scope and method. Without that, establishing a baseline, targets, and monitoring program will be difficult and inaccurate. Since the early 2000s, there has been a broad base of technical support and research to support cities' effort to prepare and implement CAPs. Cities are using a variety of policy structures to implement climate actions, including fully integrating CAP goals and targets into their comprehensive plans and implementing and monitoring actions through policy advisory committees.

2.5 CAPs INFLUENCE ON CITY FORM

One of the primary research objectives in this thesis is to better understand if and how CAP implementation is reshaping American cities. Literature regarding urban form and CAPs is an extension of traditional smart growth strategies popular during the late 1970s and early 1980s. A new view of urban form is also being expressed in district-level implementation of CAPs as eco-city districts.

2.5.1 Background: Smart Growth Roots

Beginning in the late 1970s and expanding in the 1980s, environmentalists and planners were proselytizing principles for smart growth as a way to reduce the use of natural resources, protect farm land from suburban development, get higher utilization out of existing infrastructure, and protect the economic primacy of downtowns.

<u>American Planning Association: Smart Growth</u>

The American Planning Association (APA) has developed a policy guide for smart growth as part of suite of connected policy guides that include climate change, energy, sustainability, and surface transportation. Besides recommended urban form policies, the core principles reflect social, economic, and community health dimensions of a sustainable future. These were later updated to include climate change planning guidance regarding land use and transportation planning and energy efficient construction.

APA–Smart Growth

The APA Board of Directors has enacted comprehensive policies for the professional organization. First adopted in 2002 and then updated in 2012, the policy defines smart growth actions and describes economic, social, transportation, fiscal, conservation, and health benefits (American Planning Association, 2013). The APA has identified 16 core principles for smart growth:

A. *Efficient use of land and infrastructure*
B. *Creation and/or enhancement of economic value*
C. *A greater mix of uses and housing choices*
D. *Neighbourhoods and communities focused around human-scale, mixed-use centres*
E. *A balanced, multi-modal transportation systems providing increased transportation choice*
F. *Conservation and enhancement of environmental and cultural resources*
G. *Preservation or creation of a sense of place*
H. *Increased citizen participation in all aspects of the planning process and at every level of government*
I. *Vibrant centre city life*
J. *Vital small towns and rural areas*
K. *A multi-disciplinary and inclusionary process to accomplish smart growth*
L. *Planning processes and regulations at multiple levels that promote diversity and equity*
M. *Regional view of community, economy and ecological sustainability*
N. *Recognition that institutions, governments, businesses and individuals require a concept of cooperation to support smart growth*

O. *Local, state, and federal policies and programs that support urban investment, compact development and land conservation*
P. *Well-defined community edges, such as agricultural greenbelts, wildlife corridors or greenways permanently preserved as farmland or open space.*

All of these principles would be included in most cities' CAP processes and plans. Several core principles address urban form and sustainability. Principles A, D, E, M, O, and P suggest smart growth cities are efficient and compact, walkable, supported by transit choices, and require a regional perspective.

APA–Smart Growth and Climate Change

These smart growth policies are also connected to the APA's policies on climate change. In 2011 the APA Board adopted polices regarding climate change that stated that "planners can have a significant effect on climate change mitigation through a variety of actions, including encouraging higher density development, reducing vehicle-miles-travelled (VMT), using green building techniques, and supporting alternative energy sources" (American Planning Association, 2011). The APA identifies the following smart growth outcomes that will help communities reach their climate mitigation goals:

- *Sufficient residential density to support multiple modes of transportation*
- *Proximity of land uses that encourage walking and bicycling*
- *More energy-efficient building types and unit sizes*
- *Provision of public open space that substitutes for more energy intensive private open space, such as lawns*
- *Less land consumed for development*
- *More efficient (and more energy-efficient) provision of public services, such as streets and utilities* (American Planning Association, 2011)

2.5.2 Overall Development Patterns

CAP and low-carbon city strategies can influence the form of both new development and existing cities. Professional organizations, universities, and federal agencies have researched and published converging predictions about city design in response to climate change. There are several common drivers for the how reducing GHG emissions will change the form of U.S. cities in the literature reviewed. These include reduction of energy use by the built environment, creating more efficient infrastructure, and reduction of VMT.

Resilient Cities

In their 2009 book, *Resilient Cities: Responding to Peak Oil and Climate Change*, Peter Newman, Timothy Beatley, and Heather Boyer provide a narrative of their collective research that provides steps towards building low carbon cities (Newman, Beatley, & Boyer, 2009). They suggest we need to imagine neighbourhoods without gasoline, diesel, heating oil, and natural gas (p. 14). We are entering the "6th wave" of innovation with a focus on sustainability including: "radical resource productivity, whole system design, bio mimicry, green chemistry, industrial ecology, renewable energy, and green nanotechnology" (p. 53).

A Paradigm Shift

Newman, Beatley, and Boyer promote a paradigm shift offering seven thematic elements of vision for the built environment of resilient cities. These include:

- *Renewable Energy City*–regional and building-scale renewable energy
- *Carbon Neural City*–cities will be carbon neutral because every household and business is
- *Distributed City*–power, waste, and water systems will be a district rather than centralized scale
- *Photosynthetic City*–green infrastructure will include local energy and food production
- *Eco-efficient City*–closed-loop systems will be used for resources
- *Place-Based City*–unique local resource and economic assets will become part of the local identity
- *Sustainable Transport City*–cities will be walking environments supported by transit and electric vehicles (pp. 55-56)

Strategies Influencing Urban Form

Newman, Beatley, and Boyer identify 10 strategies steps to creating resilient cities. Several of these directly address the future form of cities. They recommend redesigning regions to reduce their dependency on oil by creating polycentric cities that foster localism. Cities will be comprised of transit-centred walking districts (TODs, PODs, and GODs). This will include a step-by-step transition to green infrastructure using public investment as demonstration projects (pp. 112-147).

Urban Land Institute–*Growing Cooler*

The 2008 Urban Land Institute (ULI) publication *Growing Cooler* describes what "smart growth would look like" (R. Ewing, 2008, pp. 4-12). The report identifies good examples of existing walkable cities with transit-oriented development, infill development, revitalized downtowns, and mixed-use districts already exist. ULI looked at demographic trends and determined that smart growth could meet the demands of future markets raising the average metropolitan density from 7.6 units per acre in 2003 to 9.0 units per acre by 2025. This higher metropolitan density would result from new projects demanded by the market at an average density of 13 units per acre.

ULI asserts that smart growth can deliver a 30% reduction in VMT and thereby reduce CO2e emissions by 7-10% by 2050. Smart growth patterns with additional strategies, such as congestion pricing and improved transit services, could reduce emissions a total of 38% (R. Ewing, 2008, pp. 4-12). The ULI report states that based on economic forecasts, about two-thirds of development existing in 2050 will have been constructed since 2007. Therefore, implementing smart growth policies can have a significant impact on overall development patterns and support lower CO2e lifestyles.

Pew Centre on Global Climate Change–*Towards a Climate-Friendly Built Environment*

In 2005 the Pew Centre published a paper prepared by researchers from the Oak Ridge National Laboratory focusing on how to prepare cities for climate change. This often-cited paper is comprehensive in terms of defining the challenges and solutions for climate change. It has a brief but informative section on community and urban systems. The report states that higher-density mixed-use development will reduce GHG emissions due to complementary effects. These include:

- *Reduced per-unit-area consumption of district energy for cooling, heating, and power generation;*
- *Reduced municipal infrastructure requirements, including the reduced need for construction of streets and electric, communication, water, and sewage lines, and other services; and*
- *Reduced VMT, including shorter freight and person trips, as well as the substitution of these trips with public transit, walking, and cycling* (Brown, Southworth, & Stovall, 2005, p. 39).

The authors discuss the types of expected VMT and GHG emissions reductions by employing form-changing policies. They also acknowledge that it could take 30 years for the effects of climate-friendly land use policies to have impact. The researchers suggested that more compact gridded streets will support walking and transit; landscaping and tree lined streets can reduce heat islands; and infill mixed-use can reduce the need for extending infrastructure and shorten work trips (Brown, Southworth, & Stovall, 2005, p. 64).

Visions for Sustainable Future–*Retrofitting Cities*

An interdisciplinary collaboration in the U.K. between Cardiff University, Reading University, and Oxford Brooks University is exploring city-scale retrofit scenarios for 2050 (Eames, Dixon, May, & Hunt, 2013). The research also has applicable relevance for the future of the U.S. cities.

The Retrofit 2050 Visions include the Smart Network City, Compact City, and Self-reliant City. These visions are being used to shape the scope of the overall discussion in the U.K. regarding public policy to guide transitions to a future built environment that meets the Climate Change Act GHG emissions reduction goals of 80% by 2050.

Smart Networked City

The Smart Networked City is a “hub within a highly mobile and competitive globally networked society” (Eames, Dixon, May, & Hunt, 2013, pp. 510-512). It responds to markets and has high economic growth. It depends on modest increases in density and business investment.

Compact City

The Compact City is intensive and efficient, focusing on local and regional solutions for governance and social investment. It will have more modest economic growth.

Self Reliant-Green City

The third scenario suggests a future where cities express bioregional solutions that emphasize a shared effort in creating a self-reliant future. This has lower densities, is more land-intensive, and involves lower economic growth.

The university team is using these scenarios to help scope future research and a public engagement process. The research team underscores that successful urban-scale retrofit will be based on an innovative and systematic approach that supports decision-making processes. Large-scale urban retrofitting should consider development patterns, infrastructure, and the governance structures required to support a low-carbon future. The process is allowing communities to explore the socioeconomic implications of meeting 2050 goals of reducing emissions by 80% (Eames, Marvin, Hodson, Dixon, Guthrie, & Lannon, 2012, pp. 1-4).

Eco-Districts

The rise of eco-districts in the U.S. and Europe has expressed sustainable design concepts at town, district and neighbourhood scales. U.S. cities are pursuing the development of eco-districts to implement climate action plans. The first generation of eco-districts are taking advantage of unique circumstances of public property control, enlightened developers, and infrastructure to act as pilot projects, demonstration projects, and as real early phase CAP implementation. These plans and projects reflect the types of comprehensive and integrated design and planning resulting in the most visible changes in the design of cities.

Portland, OR–Five Eco-districts

The non-profit EcoDistricts organization in Portland emphasizes that the neighbourhood is the most important building block in creating a sustainable city. Portland State University and the City of Portland launched the EcoDistricts Initiative to "development practitioners create the neighbourhoods of the future—resilient, vibrant, resource efficient, and just" (EcoDistricts, 2013).

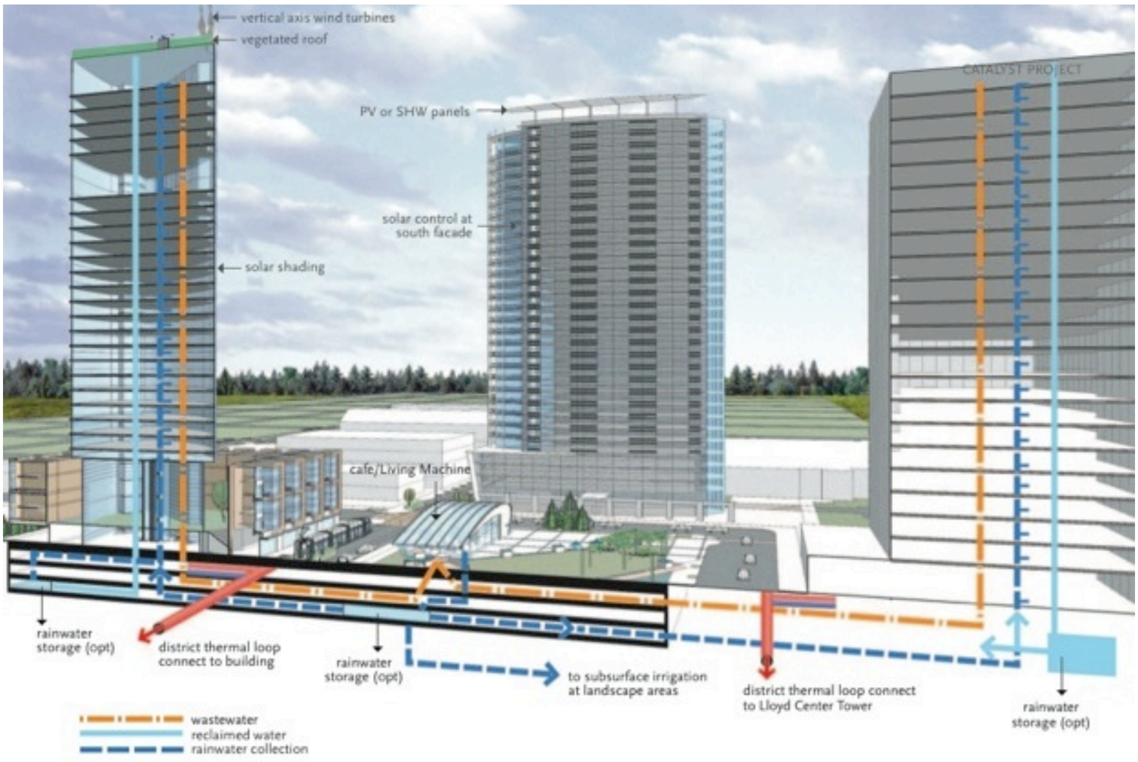
The 2009 Portland Plan (CAP) provides an overall policy direction supported by an eco-district framework with protocols for formation, assessment, feasibility planning, and management. The framework also provides performance criteria for eco-districts including social, design, environmental and management goals, targets, and indicators (EcoDistricts, 2013, pp. 8-13).

The Lloyd Crossing Eco-district is one of five Portland has identified. It was an early demonstration of how integrated low-carbon planning and design could shape cities of the future. The 35-block district is located in central Portland and includes a four-block catalyst project. The site has parking lots and mid-rise office buildings. The proposal examines how to redevelop the blocks to meet habitat, water, energy, placemaking and materials goals. The target for the projects is to have the same ecological performance as a 54-acre mixed-conifer forest. Sustainable urban design strategies are illustrated by developing a design for a four-block portion of the eco-district.

The distinctive-looking catalyst project goal is to exceed LEED Platinum ratings (Figure 2.5). The design includes district thermal hot and cold water, a programmed park that processes the area's stormwater in a "living machine," rainwater storage, and highly efficient wing-shaped mixed-use buildings with passive and active solar and wind turbines (Mithum Architects+Designers+Planners, 2004).

Figure 2.5

Lloyd Crossing Eco-district in Portland



Mithum Architects+Designers+Planners, 2004

Austin, TX–Seaholm EcoDistrict

Austin is one of 10 cities in the United States that has initiated an eco-district program. The city has focuses on an initial pilot project called the Seaholm Development District (Figure 2.6). The former industrial 7.8-acre district includes adaptive reuse of a former municipal power plant plus office, retail, residential, and public open space uses and a new library (City of Austin, 2013). The project goals include zero outdoor water use, 90% wastewater treatment, preservation of all historic building shells, and 40% non-vehicular transit.

Figure 2.6

Seaholm EcoDistrict in Austin

Lake Flato Architects

Seattle, WA–Capitol Hill EcoDistrict

In Seattle, the planning for the Capitol Hill EcoDistrict has resulted in a plan with community, transportation, energy, water, habitat, and materials performance areas. The planning includes a comprehensive analysis of existing environmental assets, baselines and targets for the performance areas. A new transit station is being designed to open up opportunities to extend existing and/or develop new large-scale infrastructure to support a mixed-use TOD. The physical planning is complemented with implementation actions building into the process, community ownership, and capacity to manage the district (GGLO, 2012).

2.5.3 Transportation GHG Mitigation and Urban Form

Transportation is a primary determinate for urban form. It influences density and distribution of urban development patterns in degrees of centring and clustering of activities. The urban spatial structure expresses the relationships and interactions of people, freight, and information (Rodrigue, 2014).

Emissions from transportation are second only to the electricity sector. In 2011, 28% of U.S. GHG emissions were from the transportation sector (U.S. EPA, 2013). In 2001, about 87% of trips were in personal vehicles, and 60% of those were less than five miles.

Most CAPs focus on land use and transportation strategies to reduce travel demand and meet their GHG reduction goals. The U.S. EPA's Smart Growth guidelines emphasize enhancing public transportation choices and investing in walking and biking infrastructure. They also encourage mixed-use zoning that reduces the need for driving (U.S. EPA, 2010, p. 3).

Moving Cooler–Urban Land Institute

ULI's *Moving Cooler* (2009) complements the 2008 report *Growing Cooler*. The transportation strategies report covers a wide range of topics, including pricing and taxes, land use and smart growth, non-motorized transit, public transportation improvements, ride-sharing, regulatory strategies, intelligent transportation systems, capacity expansion, and modular freight sector strategies. The land use and smart growth strategies in *Moving Cooler* emphasizes creating transportation-efficient development patterns that reduce both the length and frequency of vehicle trips (Cambridge Systematics, Inc., 2009, pp. 2-3).

ICLEI and U.S. Mayors' Protection Agreement (MCPA)

ICLEI, MCPA, and the City of Seattle collaborated in creating the *Climate Action Handbook* (2007) that identifies policies, actions, tools, best practices, and resources to support cities' efforts to mitigate GHG emissions. Example management actions for land use planning include "development of dense, mixed-use neighbourhoods" (ICLEI, 2007). This is to benefit communities from a cost standpoint and reduce dependence on driving.

As of 2009, over 1,000 cities had signed the MCPA (American City & County, 2009). This participation shows a commitment to reducing GHG emissions and the potential influence of urban pattern-changing land use and transportation policies.

Built Environment Impact on Transportation

In 2013, the U.S. Department of Energy published a comprehensive summary of the urban form and transportation GHG impacts. The report includes an extensive review of literature and studies providing a contemporary review of how modifying land use and the built environment can reduce energy use and GHG emissions. The report has four key findings:

- *Higher densities, a mix of uses, and walkable neighbourhoods contribute to lower vehicle travel and energy use.*
- *Changes to the built environment could result in a reduction in U.S. transportation energy and GHG emissions from less than 1% to as high as 10% by 2050, the high end corresponding to a reduction of up to 16%–18% in the urban light-duty vehicle travel subsector.*
- *Expansion of federal efforts to influence development through funding incentives and other voluntary initiatives could support more effective land use planning and reduce transportation energy use.*
- *The relationships among built environment metrics, transportation systems, and travel are nonlinear and interactive. Network-based models are best suited to assess these relationships* (Brown, Dunphy, Porter, & Vimmerstedt, 2013, p. 1).

The report identifies a number of factors that describe urban patterns. These include what the authors call the "four Ds": Density, Diversity, Design, and Destination. In terms of density and transportation, the report identifies threshold densities of between 4,000-10,000 persons per square mile to accomplish meaningful reductions in VMT. Neighbourhoods with these more compact densities have a 20-40% decrease in VMT compared to low-density neighbourhoods. Design also matters. A neighbourhood with enhancements that make walking more comfortable will have 5-10% less VMT. These together can reduce GHG emissions up to 10% (Brown, Dunphy, Porter, & Vimmerstedt, 2013, p. 3).

Urban Form Policies and Travel Patterns

One of the primary objectives in low carbon city development is reducing the amount travel. Compact forms of development strive to promote more sustainable patterns of mobility. Dominic Stead and Stephen Marshall of University College London reviewed empirical studies to identify the influence of land use on travel patterns. Their research focused on nine aspects of urban form including:

- *Distance of residence from the urban centre*
- *Settlement size*
- *Mixing of land uses*
- *Provision of local facilities*
- *Density of development*
- *Proximity to transport networks*

- *Availability of residential parking*
- *Road network type*
- *Neighbourhood type* (Stead & Marshall, 2001)

Their literature review examined different travel patterns using five measures:

- *Travel distance*
- *Journey frequency*
- *Modal split*
- *Travel time*
- *Transport energy consumption* (Stead & Marshall, 2001)

Stead and Marshall concluded that travel patterns and land use characteristics were related and could be nested within each other further affecting their influence. Land use, transportation services, and parking policies influence travel demand and modal choice. In addition, socio-economic factors were linked to travel patterns.

2.5.4 Adaptation Planning and Urban Form

Adaptation planning is a global challenge with impacts from a changing climate affecting places uniquely. The coastal zones are facing rising sea levels. Mountain states and traditionally dry desert states are experiencing increased drought, wildland fires, and loss of snowmelt that feeds rivers and provides for agricultural and urban water needs. CAPs typically include adaptation strategies, and much literature provides advice.

International Economic Impacts and Urban Form

Investing in adaptation is an important theme for the World Bank. They have prepared their own report to help cities make intelligent investment decisions regarding adapting to a changing climate. They view cities as important conveners for necessary partnerships that can make them more resilient. The World Bank recommends cities implement climate-smart policies. Their advice is comprehensive, providing adaptation strategies for heat waves, increased precipitation, rising sea levels, and drought. Recommendations affecting urban form include avoiding building in existing and future flood-prone areas, hardening and relocating critical infrastructure, employing green infrastructure, and developing and protecting of natural ecologies that increase protection from extreme weather events (The World Bank Group, 2011, pp. 5, 37, 54-55).

Adaptation Part of ICLEI Process

ICLEI's five-step process includes developing adaptation strategies. They have created software tailored to support cities' decision-making for adaptation. Part of the Climate-resilient Cities Program, the members-only software helps cities conduct resilience studies, set goals, make a preparedness plan, and implement and monitor adaptation actions (ICLEI, 2013). ICEI recommendations will result in cities that protect and enhance their ecosystems to improve their resilience; prepare management plans for wetlands, shore lands, and wildland edges vulnerable to flooding and wildfires; and design infrastructure to anticipate new climate extremes.

ICLEI International Adaptation City Survey

In 2011, ICEI collaborated with MIT in conducting an international survey regarding climate adaptation planning. Of 1,171 ICLEI U.S. member cities, 54% percent answered at least one question, and 39% (298) finished the entire survey (Carmin, Nadkarni, & Rhie, 2012).

The survey had 40 questions organized in six sections: perception of changing weather and precipitation patterns; risk and vulnerability assessment; planning activities; support for and influences on planning; challenges and benefits; and location characteristics. The area of greatest concern for surveyed cities is stormwater management.

Survey result highlights include:

- 79% noticed a change in climate and climate impacts in the past five years
- 48% have experienced environmental impacts
- 19% of all cities have prepared a climate change risk and vulnerabilities assessment, and only 13% of U.S. surveyed cities have completed an assessment
- About two-thirds of the cities expect stormwater management in terms of run-off and surges as their biggest challenge
- 59% of U.S. surveyed cities are preparing adaptation plans compared to 84% of the rest of the survey cities
- 50% of the cities are using a strategic planning method to prepare an adaptation plan
- U.S. cities have the greatest challenge securing funding and allocating staff time for adaptation

Adaptation Planning at a Regional Scale

A U.S. study of regional governments by the National Association of Regional Councils and University of Colorado Denver also indicates awareness of climate impacts and a wide array of assessments that are being undertaken (Colson, Heery, & Walls, 2011). The survey highlighted climate change adaptation policy recommendations that can influence the future form of cities and regions. These include:

- Infrastructure design development (57.6%)
- Zoning and subdivision regulations (39.4 %)
- Building codes and design standards (21.2%)

2.5.5 Summary Urban Form

CAP actions address demand-side and supply-side energy and land use patterns of post war America. Literature emphasizes CAP strategies include traditional smart growth concepts and past strategies to limit fiscal and health impacts of sprawl.

APA and other professional organizations are using GHG emissions as the new metric for smart growth. Compact and transit-oriented patterns are core to most strategies offered in the literature. ULI reports suggest that up to 10% of GHG reductions by 2050 can be accomplished by developing more land-efficient and connected communities. Other strategies for large-scale retrofitting of cities and regions, such as envisioned by Retrofit 2050 in Wales, and implementing CAP strategies at an eco-district scale provide a glimpse of what the ultimate high-performance cities of tomorrow may look like.

Adaptation strategies influencing the future form of cities are focusing on resiliency strategies emphasizing better infrastructure planning, land use planning, and building design.

2.6 SUMMARY AND GAPS IN KNOWLEDGE

This section summarizes review of literature and identifies gaps in knowledge. The research questions posed in the Introduction lay out a comprehensive framework of understanding the state of the art in CAPs for cities. In addition, the review of literature reveals research that estimates and recommends (advice) but little in terms of expanding or understanding of what cities are actually doing and whether their actions have been effective in reducing GHG emissions.

2.6.1 Research Questions Summary

Research aims and questions below are used to summarize key findings in the review of literature.

AIM1: Assess motivation and process of local government

Q1-Motivation: Why are cities preparing CAPs?

Q2-Policy Context: How are cities responding to state and federal policy context regarding preparing CAPs?

Q3-Process: How are cities approaching preparation of CAPs?

Research and literature suggests that motivation for cities preparing CAPs is coming from their own interests, values, and co-benefits. The belief in global warming and climate change varies from region to region and appears to be strongly reflected in conservative and progressive voting patterns. States are preparing CAPs but are primarily lead-by-example (LBE) efforts that do not include policy or regulatory requirements for cities. Exceptions are states that require environmental review that includes climate impacts and states that are susceptible to climate change impacts, such as sea level rise.

The CAP process for a city requires preparing GHG inventories, identifying benchmarks against their historical emissions, and identifying actions and timelines to meet emission reduction targets. The scope and process of a CAP is developed out in front of the effort to manage resources, expand community outreach, and meet legal or policy requirements. In some cases, cities want to or are required to report their emissions to a third party such as the Climate Registry.

AIM 2: Compare the types of CAP tools used by cities

Q4-CAP Tools: Why do communities choose certain tools to inform the CAP process?

For communities preparing CAPs, an increasing number of tools and resources are available that embody protocols developed by international, federal, state and non-profit agencies and organizations. Cities in a few states recognize GHG emissions as an environmental impact, which must meet requirements and protocols. California, in particular, has made GHG emissions inventory and mitigation necessary in the EIR process for large-scale projects and city planning. The CARB and air pollution control districts have provided tools and protocols to help track the impacts of projects. ICLEI offers a popular tool for GHG inventory, strategy evaluation, and monitoring. Their

CAPC software supports the ICLEI five-milestone process. Many ICLEI membership cities have used this software, and others have developed their own custom spreadsheets. The future of CAP tools seems to also include commercially developed and marketed software that has additional implementation, monitoring, and communication capabilities.

AIM 3: Assess how CAPs shape city form

Q5-CAP Strategies: How are CAP strategies integrated into urban planning policies?

Q6-Influencing Patterns: How are CAP strategies changing the form of cities?

CAPs are comprised of a system of strategies and actions designed to meet goals and targets. When land use strategies and actions are fully integrated into policy plans, they change the future form of cities. Mitigation of GHG emissions includes form-making land use and transportation strategies and related policies. Land use and transportation policies influence the density and placement of public and private investment.

Review of literature underscores the importance of starting with a technically solid GHG inventory in terms of scope and method. Without that, establishing a baseline, targets, and monitoring program will be difficult and inaccurate. In the past several years, a broad base of technical support and research has supported cities' efforts to prepare and implement CAPs. Cities are using a variety of policy structures to implement climate actions, including fully integrating CAP goals and targets into their comprehensive plans and implementing and monitoring actions through policy advisory committees.

CAP actions address demand-side and supply-side energy and land use patterns of post war America. Literature emphasizes CAP strategies include traditional smart growth concepts and strategies that have been used in the past to limit fiscal and health impacts of sprawl.

In many respects, APA and other professional organizations are using GHG emissions as the new metric for smart growth. Compact and transit-oriented patterns are core to most strategies offered in the literature. ULI reports suggest that up to 10% of GHG reductions by 2050 can be accomplished by developing more land-efficient and connected communities. Other strategies for large-scale retrofitting of cities and regions, such as envisioned by Retrofit 2050 in Wales, and implementing CAP strategies at an eco-district scale provide a glimpse of what the ultimate high-performance cities of tomorrow may look like.

Adaptation strategies influencing the future form of cities are focusing on resiliency strategies emphasizing better infrastructure planning, land use planning, and building design.

2.6.2 Advice vs. Actions and CAP Effectiveness

The literature review discovered regional surveys of California cities and U.S. and Mexico boarder cities. Most documentation of what CAP cities are doing is in the form of case studies. Research that reviews CAP effectiveness is primarily using case study analysis methods.

City Surveys

Three surveys of cities that have completed CAPs were discovered in the review of literature. These studies' research aims are different than this thesis but reflect the types of focused efforts to ascertain climate actions of cities in various geographic regions.

California Governor's Office of Planning and Research (OPR)

OPR 2012 Annual Planning Survey includes questions regarding climate action plans (California Governor's Office of Planning and Research, 2012). The survey asks a comprehensive set of questions regarding city and county planning activities in the state. The primary survey includes 38 questions with four specifically about climate action plans:

> ***QUESTION:*** *Has your jurisdiction adopted, or is in the process of drafting, policies and/or programs to address climate change and/or to reduce GHG emissions for community and municipal activities? (451 respondents)*
>
> ***RESPONSE:*** *Approximately 80% of jurisdictions have adopted, drafted, or plan to adopt these types of programs and policies. Nearly the same amount of jurisdictions has adopted these policies or programs. Close to 20% of responding jurisdictions have not adopted and are not in the process of developing the policies or programs.*
>
> ***QUESTION:*** *If adopted or in progress, what forms do these policies and/or programs take? (282 respondents)*
>
> ***RESPONSE:*** *Jurisdictions answering Adopted or In Progress to question 30 were then asked to identify the form of the policies and programs. Over 60% of*

these jurisdictions reported Climate Action Plans. The 2010 Annual Planning Survey asked the same question and at the time, only 56% of jurisdictions had adopted or planned to adopt a Climate Action Plan. This is a 9% increase in jurisdictions that have adopted or will adopt Climate Action Plan since 2010.

QUESTION: *What are your Greenhouse Gas reduction targets and years? (249 respondents)*

RESPONSE: *Over 50% of jurisdictions have adopted GHG reduction targets and years. See the Appendix for the targets and years.*

QUESTION: *Does your jurisdiction have a mechanism for tracking progress on meeting your Greenhouse Gas reduction target for community wide and municipal emissions? (459 respondents)*

RESPONSE: *Almost 80% of all respondents do not have mechanisms for tracking progress, although of the jurisdictions that have targets, nearly 55% also have mechanisms to track their project.* (California Governor's Office of Planning and Research, 2012, pp. 31-34)

The California OPR survey is the most complete and comprehensive discovered in the review of literature. The survey provides the clearest picture of what the local jurisdictions (cities, counties, and other units) are doing to respond to AB32 California Global Warming Solutions Act and other implementation legislation.

Boarder Mexico Municipalities and U.S. Counties

A joint research effort by Arizona State University and the Universidad Autonoma de Baja California surveyed U.S. and Mexican boarder cities regarding their climate actions. A survey was sent to the senior planning staff in 45 municipalities and counties on both sides of the boarder. Eleven Mexican municipalities and 18 U.S. counties responded to the survey (Lara-Valencia, Brazel, Mahoney, Raja, & Quintero-Nunez, 2012).

The 40 online survey questions included the types of climate-related activities being employed by Mexican municipalities and U.S. counties. Ten poplar actions included:

- *Promotion of solid waste recycling and waste minimization (75.9%)*
- *Protection of open and natural spaces (65.5%)*
- *Promotion of water saving and water resources protection (65.5%)*
- *Generation of renewable power from existing city facilities (55.2%)*
- *Retrofit municipal buildings to be more energy efficient, healthy, and environmentally sustainable (55.2%)*
- *Use of more energy efficient technologies in public buildings, streetlights, parks, etc. (55.2%)*

- *Use of transit-oriented development or mixed-use development (41.4%)*
- *Promotion of public transit, car sharing, biking or walking to work or school (34.5%)*
- *Purchase of alternative fuel, hybrid/electric, or all electric vehicles (31.0%)*
- *Use of alternative fuels and/or hybrid-electronic technology to run municipal fleets (20.7%)* (Lara-Valencia, Brazel, Mahoney, Raja, & Quintero-Nunez, 2012, p. 280)

Case Study Research and Analysis

Case study and case study analysis are the most common research methods discovered in the review literature. Researchers selected a sample of cities and reviewed their CAPs and analysed their actions against other variables.

Assessing the First Generation of CAPs

In 2008, Wheeler conducted case studies of states with climate action plans and Cities for Climate Protection members. Eighteen cities over 500,000 in population were selected plus 17 smaller cities know for their innovative planning. The research included review of planning documents and interviews with planning officials.

The research assessed their progress with grim results. Key findings for case cities citied that progress was slow, near-term goals too low, mitigation measures were inadequate, implementation problematic, and public understanding insufficient (Wheeler, 2008).

Moving Agenda to Action

This 2009 study examined 40 adopted local climate change action plans in the U.S. and analysed their mitigation strategy effectiveness and adaptation (Tang Z. , Brody, Quinn, Chang, & Wei, 2010). The cases were evaluated based on their awareness, analysis, and actions, where awareness informs the type of analysis prepared and both awareness and analysis inform actions taken.

The study addresses five research questions:

(1) To what extent do local jurisdictions indicate awareness of climate change in their local climate change action plans?
(2) How well do local jurisdictions analyse the impacts of climate change in local climate change action plans?
(3) What actions have local jurisdictions taken to mitigate and adapt to climate change, and which strategies received the greatest and least attention?
(4) Do the traditional contextual variables affect local climate change action plan quality?
(5) How can local climate change action plans be improved to address climate change mitigation and adaptations? (Tang Z. , Brody, Quinn, Chang, & Wei,

2010, p. 43)

The study identifies three groups of independent variables. These include climate risk variables, emission rates, and capacity variables. The dependent variables include indicators for awareness, analysis, and actions. The evaluation includes 36 indicators. Cities that scored lowest had abstract plans and higher-scoring cities had full plans.

Awareness plan component evaluation includes concept of climate change and global warming, concept of greenhouse gas emission, effect and impacts of climate change, and long-term goals and detailed targets for emissions.

The analysis plan evaluation includes the quality of city emission inventory, base year emission, emission trends forecast, vulnerability assessment, cost estimates for mitigation, and analysis tools.

Action plan component evaluation includes communication and collaboration, financial tools, land use policies, transportation policies, energy strategies, waste strategies, resource management strategies, and implementation monitoring strategies.

The study yielded policy data regarding land use and transportation (Table 2.1). Of the 40 cities, most implemented CAP actions as policies for mixed-use development, green buildings/infrastructure, development of alternative transportation, TODs, pedestrian and bike systems, and parking standards.

Table 2.1

Moving Agenda to Action–Land Use and Transportation Policy Data

Adoption of Land Use Policies	
Mixed-use development	65%
Green buildings and infrastructure	60%
Infill and brownfield sites	37.5%
Growth controls	35%
Transportation Policies	
Alternative transportation	80%
TODs/corridors	77.5%
Pedestrian and bike	72.5%
Parking standards	65%

(Tang Z. , Brody, Quinn, Chang, & Wei, 2010, pp. 52-53)

Regression analysis indicates four factors that influence the quality of climate change plans: state mandates, hazard damages, vehicular emissions, and average commuting time.

The study finds a range in CAP quality in cities. The highest-scoring cities include Berkeley, CA (25.9), Bellingham, WA (26.54), and King County, WA (28.65). The three lowest scoring cities are Austin, TX (5.35), Santa Cruz, CA (6.45), and Evanston, IL (6.83). Over two-thirds of the plans scored below the median score.

The study concludes future research should increase the sample size from 40 cities; examine CAPs in the context of other plans, such as comprehensive plans; review the degree that plans are making cities more resilient and sustainable; look at how CAPs mature and progress over time in a longitudinal fashion; and include dependent variables that focus on land use, resource management, and transportation to understand the relationship between risks and actions.

Do CAPs reduce GHG emissions?

Adam Millard-Ball analysed California cities for evidence that CAPs were changing their behaviour. He suggests that actions are connected to their values and not to whether they have completed a CAP.

In 2011, he conducted a cross-sectional study of 478 cities in California. Dependent variables that act as implementation indicators include the number of LEED projects implemented in a community, green building ordinances, solar PV installations, waste diversion, pedestrian and bike facility expenditures, gasoline sales, and auto mode share. Independent variables include treatment and control. Treatment variables include the completed CAP (five) milestones described by ICLEI. Control variables include demographics (population, employment, and education) and politics and progressive polices.

Results indicate that climate planning does not increase the number of LEED projects but may lead to adopting a green building ordinance and increased solar PV installations. No evidence supports reduction in streetlight or pedestrian and bike facility expenditures.

Millard-Ball concludes that implementation of climate-friendly policies would have been achieved in any case. Environmental preferences seem to be behind most of the climate-friendly actions and “that climate plans might be best be interpreted as a signal of these altruistic preferences rather than independent causal mechanism” (Millard-Ball, 2011, p. 301). As a lesson, using the CAP process to raise awareness could change environmental preferences leading to climate action.

2.6.3 Gaps in Knowledge

The literature review discovers predictive research and recommendations. The literature research did not discover national surveys or comprehensive analysis of the state of the art in city CAPs. The most comprehensive effort discovered is *Moving Agenda to Action* (Tang Z. , Brody, Quinn, Chang, & Wei, 2010), research of 40 U.S. cities that analysed CAP documents and ranked cities in terms of quality of their CAP. There is a gap in knowledge regarding what cities are actually doing in terms of mitigation strategies and integration of actions with policy.

The *Moving Agenda to Action* paper identifies future research needs:

> *It is recognized that many jurisdictions involved in this study are still improving their initial local climate change plans. As plans and policies have more time to develop, longitudinal analysis will better pinpoint the factors contributing to policy learning in response to the growing problem of climate change.*
>
> *Finally, a higher plan quality may not automatically mean good action in practice. Future studies should address the implementation effectiveness of local climate change planning. Moreover, the future study will use the subset of climate policies (e.g. land use, resource management, transportation, etc.) as a new dependent variable to further identify the relationship between risk and the types of climate actions used in local jurisdictions.* (Tang Z. , Brody, Quinn, Chang, & Wei, 2010, pp. 57-58)

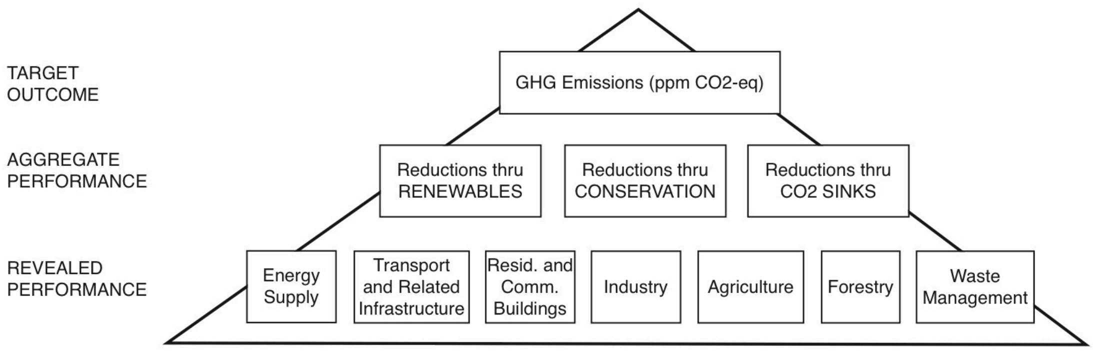
Surveys of CAP cities are regional. No national longitudinal study of CAP cities has examined the relationship between fundamental attributes of cities (political context, regional differences in climate, adaptation needs and eGRID, and community values), the actions they take, and the policies they adopt.

2.7 A THEORETICAL FRAMEWORK

A theoretical framework is developed that identifies potential fundamental elements of cities that can be compared to CAP strategies, policies, and performance. The framework includes CAP city fundamentals, revealed performance, aggregated performance, and target outcomes. The framework is composed from the literature review and acts as a foundation for research projects prepared as part of this thesis.

Figure 2.7

Theoretical Framework: CAP Performance



2.7.1 Strategies and Target Outcomes

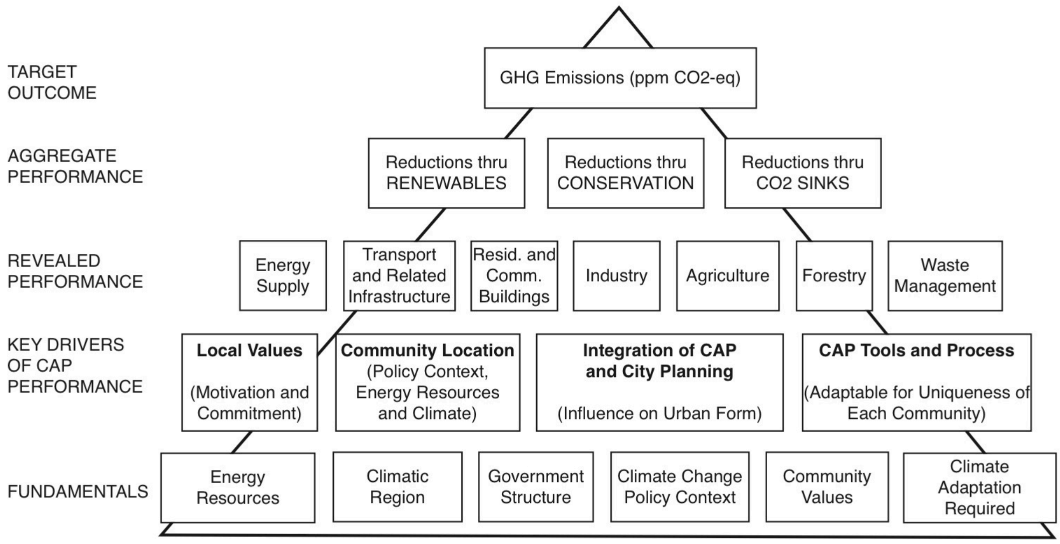
CAP performance is measured by meeting **target outcomes** for emission levels by a certain year (Figure 2.7). GHG inventories for base years are measured by sector of emission sources. These categories can vary from city to city. However, the IPCC has established a protocol for nations that **reveals their performance** in seven categories. CAPs meet targets by establishing goals that are met by aggregating actions into strategies. This **aggregated performance** is the result of effectiveness of multiple strategies that address demand-side goals through conservation, supply-side goals through applying renewable energy sources, and CO2e storage through sinks.

2.7.2 Key Drivers and Fundamentals

Each CAP city has certain attributes that influence their context, capabilities, and motivation (Figure 2.8). These CAP city **fundamentals** include energy resources, climate context, policy context, government structure, climate adaptation needs, and values and beliefs. Cities harness these fundamentals as assets and liabilities informing their CAP preparation. Four **drivers of CAP performance** provide the focus for strategy making.

Figure 2.8

Theoretical Framework for CAP Drivers and Performance



Local Values–The literature review identifies regional and local variations in values as they pertain to belief in climate change, environmental protection, and the role of government. In some cases, researchers found evidence that values are the most important indicator of a city's actions that will lead to reduction in GHG emissions.

Community Location–The location of the CAP city determines the type of state policy, energy resources, ecology, and climate conditions that form the context for CAP goals and strategies. These locational variations are important drivers in terms of setting goals.

Integration of CAP Actions into Policy–Cities' commitments to comprehensive planning, professional capabilities, and funding availability transform CAP actions into form-making policies and operational performance.

CAP Tools and Processes–A process that is educational and informative is identified in literature as an important driver for development of an effective CAP. The tools used to prepare GHG emission inventories and explore effectiveness of strategies in reaching goals and targets can inform the decision-making process.

2.7.3 Theoretical Framework Summary

The theoretical framework is used in Chapter 3.0 Methods of this thesis to explain the organization of research and relationship between studies.

- *Fundamentals* are used to select case study cities (Study 1) and act as independent variables in the survey (Study 2).
- *Drivers of performance* are used as dependent variables in the survey (Study 2).
- *Aggregate performance* is used in selecting and modifying modelling tools (Study 3) to evaluate popular GHG mitigation strategies identified in the survey (Study 2).
- *Target outcome* is used to compare relative success of mitigation strategies (Study 3).

Chapter 3

METHODOLOGY

3.1 RATIONALE FOR STUDIES

The literature review supports the central hypothesis for research: that cities with CAPs are likely to implement policies that instigate changes in their urban form. The literature review reveals research that endeavours to identify various motivations for preparing CAPS; explores various software tools available to cities; attempts to connect CAPs implementation shaping cities; and identifies common CAP strategies used by cities. However, there has not been an effort to connect a multi-method study that focuses on CAPs' future influence on the form of cities.

This chapter discusses thesis research design and methods for studies found in Chapters 4, 5 and 6. The thesis includes three studies:

Study 1: Case Studies (Chapter 4)

Study 2: National Survey of CAP Cities (Chapter 5)

Study 3: Modelling Strategies (Chapter 6)

3.1.1 Background

As of fall 2012, an estimated 200 cities have adopted, or are nearing adoption of a CAP. These cities are located in every climatic region in the United States and are a variety of sizes. The hypothesis underlying this investigation is that CAP process and strategy integration with urban planning policies is resulting in a measurable shift in investment patterns. The studies in this thesis may identify universal results of "smart growth" strategies or, regional variations that reflect the uniqueness of each city in terms of their values, ecological, and political context.

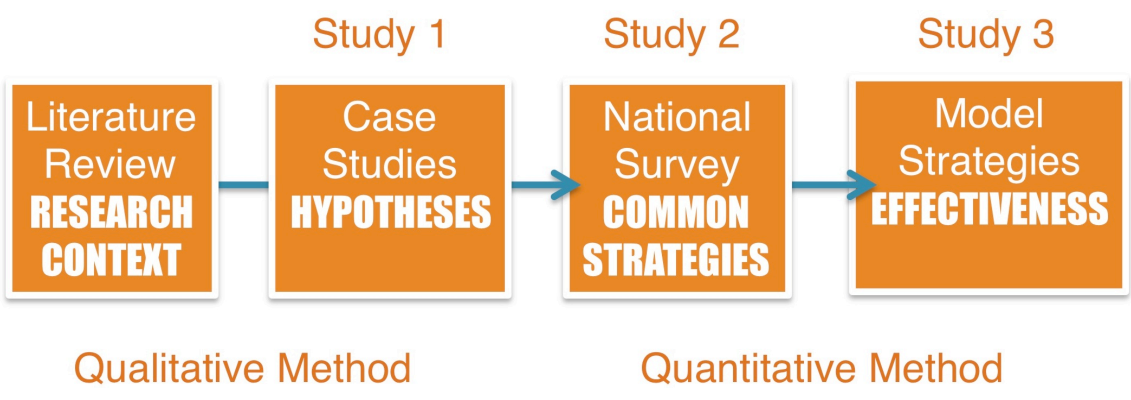
3.1.2 Multi-methodology Sequential Exploratory Approach

This thesis uses a multi-method approach to explore the connections between CAP motivation, tools, and urban form. The research process utilizes sequential qualitative and quantitative research methods (Angell & Townsend, 2011). Qualitative research methods provide generalized outcomes that are used to formulate hypotheses tested by quantitative method (Figure 3.1).

The three-study approach also provides a triangulated comparison and corroboration of overlapping findings, thus reducing potential bias that might result from any single research method (Shenton, 2004, p. 65). Study 1 case study interviews and Study 2 survey address community values and social context (constructivism). Study 2 also provides evidence of causal relationships between variables (empiricism). Study 3 modelling is theoretically informed concrete research (realism) (Olsen, 2004, p. 12).

Figure 3.1

Diagram of Relationship between Studies



3.1.3 Sequence of Studies

The sequence of the studies is designed to inform the central thesis of the research–how CAPs are changing the form of cities. Each study addresses the thesis research aims. The literature review provides theoretical framework and a context for case study selection and metrics for testing CAP performance. Case studies (Study 1) develop hypotheses used to design the national survey of cities that have completed CAPs (Study 2), and modelling strategies used by cites (Study 3). Study 3 modelling tests the effectiveness of common strategies used by CAP cities. Study 3 embeds a single case study to validate the modelled effectiveness methods and findings.

3.2 METHODS USED IN STUDIES

The methods in the studies are described in greater detail in Chapters 4, 5, and 6. The following descriptions review their general process, methods, approach to analysis, and outcomes.

3.2.1 Study 1: Case Studies

Study 1 helps provide the focus for the thesis. Eight communities of various sizes and climatic regions are studied to learn their motivation for preparing climate action plans (CAPs), the tools and methods each used, and CAP strategies that are influencing their evolving urban form. The case studies provided a better understanding about how external state and national policies, city size, form of local government, and climatic region impacted their motivation, process, and outcomes including land use policies.

The case study methodology includes defining variables that could influence the motivation and approach to preparing CAPs. Chosen communities reflect the diversity of CAP conditions, and this study analyses their reports, technical studies, and interviews with planners involved in each community's CAP process. Each was treated as an individual case using the same systematic approach. Once all the studies were completed, common patterns were identified and conclusions drawn to help inform the next steps in the research process, including hypotheses to be tested in Studies 2 and 3.

Each case study includes structured interviews with the CAP planning managers. The interviews complement the database of documentation with the experiences of project managers and participants in the CAP process. The goal is to gain insights into CAP processes and tools not found in available documents. The interview notes are in Appendix A.

The review of case study CAPs involved the initial piloting of a single case study to assess the scope of substantive and methodological issues. After the initial screening and research of documentation, a more detailed analysis is prepared addressing the questions of inquiry. Two phone interviews with managing planners for the CAP are included in the pilot. The pilot influenced both the questioning and methods used for the case studies.

Analysis of Study 1 results include summary of findings from each individual case. The findings from individual cases are then compared, generalized, and summarized by research aim.

Study 1's outcome provides a set of hypotheses used to develop Study 2. This includes hypotheses regarding how a city's fundamentals influence their utilization of various types of strategies and policies that influence their future physical form.

3.2.2 Study 2: Survey of CAP Cities

The Study 2 survey provides data used to test hypotheses. A survey of United States cities is conducted to examine the relationship between their values and context, GHG emission mitigation and adaptation, and policies shaping their urban form. The survey provides a quantitative analysis of independent and dependent variables indicating how fundamental attributes of cities (size, location, form of government, etc.) influence their form.

The survey method uses a five-step process, including designing the method, defining a sampling approach, piloting an on-line survey, initiating the survey and following up with phone calls, and summarizing the survey results.

The self-administered online survey includes a multi-sampling probability method of an estimated 192 cities in the United States that have completed or are in the process of completing CAPs. The initial task included identifying the cities that have done CAPs by reviewing lists from non-profits, government agencies, and professional organizations of cities that have prepared CAPs. To achieve a ±5% margin of error, 128 cities are required to participate in the survey. Ultimately, 157 respondents opened the survey and 128 finished it. The question with the most answers has 141 respondents. The question with the least answers has 116 respondents. The survey results are in Appendix B.

The survey is organized into three sections:

SECTION 1: Community Fundamentals (Independent Variables)
SECTION 2: CAP Approach and Strategies (Dependent Variables)
SECTION 3: Influence on Urban Form (Dependent Variables)

The survey has 27 questions. It collects categorical data with the exception of city population, which is measured on a six-point scale reflecting U.S. Census categories for cities.

The results from Study 2 uses descriptive and probability statistics for the strategy and urban form policy hypotheses. The results are then summarized by research aims and questions. These findings are compared and generalized to define common GHG mitigation strategies being used by CAP cities.

Study 2's outcome provides a quantitative assessment of the correlation between city fundamentals (independent variables) and the strategies and policies that influence their future form (dependent variables). In addition, common mitigation strategies are identified and used to refine research questions to be used as a basis for Study 3 modelling.

3.2.3 Study 3: Modelling Strategies

Study 3 examines the effectiveness of common GHG mitigation strategies used by CAP cities identified in Study 2. Study 3 includes a comparative analysis of a model town's GHG emissions. The process includes testing, selecting, and modifying software tools used to measure effectiveness of GHG emission mitigation urban form, demand-side, and supply-side strategies.

The model town land use and development program is based on U.S. per capita employment figures. The modelling measures GHG emissions of a base line community with a population of 50,000 that is proposed to double by 2050. A business-as-usual model and two alternatives test mitigation strategies and actions, measuring potential effectiveness on GHG emissions.

The results from Study 3 modelling are verified by comparing them to other studies discovered in the review of literature. The modelling tools and results are then validated by a single case study. Study 3 results are summarized by research questions.

The summary pages from the modelling are in Appendix C.

3.3 INTEGRATION OF FINDINGS

The literature review establishes a context for developing a multi-method approach to understanding how CAPs are influencing the form of cities. The reading is summarized as a theoretical framework of city fundamentals, metrics, strategies, and targets. The fundamentals are used as a basis for case study city selection and creating independent variables for CAP survey cities in Study 2.

The use of a multi-method approach for this thesis utilizes exploratory sequential design. Generalized case study (Study 1) research results form hypotheses are used to develop the survey instrument and design the modelling method and variables for measuring effectiveness of CAP strategies. The observed patterns from case studies are compared to, and validated by, the statistical correlations from the survey (Study 2). The common strategies identified in the survey are measured for their effectiveness (Study 3).

3.4 SUMMARY OF METHODOLOGY

The research methods used in the three studies are developed to provide a crosscutting review of how CAPs are changing the form of cities. Together, the studies provide a more comprehensive understanding of the relationship complexities of what communities value, the climate regions where they are located, energy supplies, city size, and other factors are influencing city strategies and urban development policies.

Studies summarized in Chapters 4, 5, and 6 demonstrate how results support hypotheses developed through literature review and case study. These chapters each include more detailed descriptions of study methods and findings. The significance of study findings are discussed in the context of literature review and its contribution to design constructs based on a consistent line of inquiry in a multi-level investigation.

Chapter 4

STUDY 1: CASE STUDIES

ASSESSING THE MOTIVATION, CLIMATE ACTION PLAN PROCESSES, AND POLICY INTEGRATION OF EIGHT CASE STUDY COMMUNITIES

4.1 ABSTRACT

Eight communities of various sizes and climatic regions are studied to learn their motivation for preparing climate action plans (CAPs), tools and methods each use, and how they integrate CAP actions into their comprehensive plans. The case studies provide a better understanding about how external state and national policies, city size, form of local government, and climatic region impact their motivation, process, and outcomes. Case study research includes review of state policies, local CAPs reports, technical studies, and interviews of planning managers. The case studies demonstrate the influence of both international protocols and state legislation on CAP tools, protocols, and community process; that for some communities climate adaptation planning will have a larger impact on their evolving form; and the degree to which GHG emissions strategies are integrated into comprehensive planning varies from community to community and may impact a CAP's effectiveness.

4.2 INTRODUCTION

The marketplace offers a variety of CAP tools and approaches. The motivation, process and tools used are sometimes mandated by state policies, come as part of "package" offered by non-profit organizations and for-profit companies, or are constructed a le cart by a community. Until recently, few independent crosscutting studies have been conducted to examine communities' experiences and outcomes from a CAP process. These case studies are intended provide hypotheses to be addressed in Study 2 and 3.

4.3 CASE STUDY METHOD

Preparation of case studies includes five tasks (Figure 4.1):

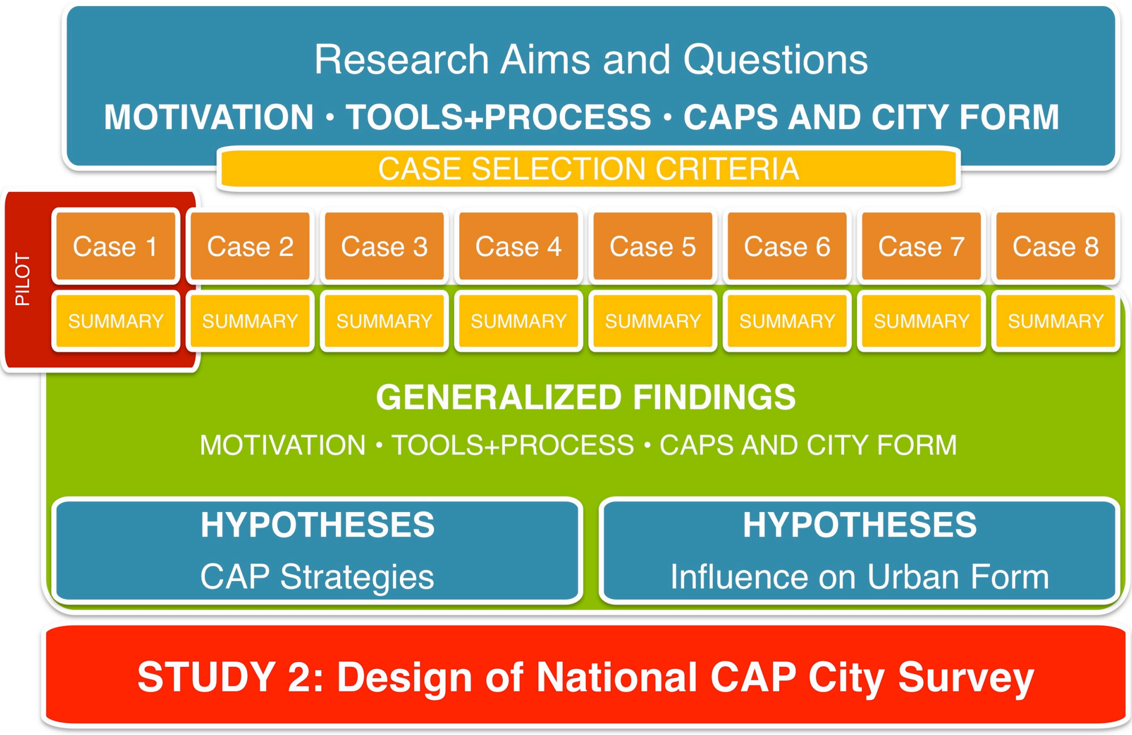
- Case study selection (based on city fundamentals criteria defined in the literature review)
- Executing a pilot case study and interview
- Preparation of case studies
- Generalized findings

- Developing hypotheses to be tested in Study 2

The case study methodology includes defining variables that could influence the motivation and approach to preparing CAPs, choosing communities to study that reflect the diversity of CAP conditions, and analysing reports, technical studies and planners involved in each community's CAP process. Each case study is treated as an individual case using the same systematic approach. Once all the studies are complete, common patterns are identified and conclusions drawn to help inform the next steps in the research process.

Figure 4.1

Case Study Process



4.3.1 Case Study Protocols

The case study method employs five components of research design. These include: "*a study's questions, its propositions, its unit(s) of analysis, the logic linking the data to the propositions, and the criteria for interpreting the findings*" (Yin, 2009).

Robert K. Yin's protocol for design and preparation of case studies includes:

- *Identifying the types of data and information that was to be collected*
- *Creating a case study database--ways in which data, such as books, articles, on-line documents and websites, was collected and stored*
- *Using multiple sources of evidence--including both documents from local and national sources, and interviews*
- *Outlining the case study dissertation chapter that captures a chain of evidence from case studies*
- *Initially screening each case study for its viability*
- *Conducting a pilot case study to test the questions and data collection methods*
- *Using case study interviews to identifying additional data and sources for each case study* (Yin, 2009)

Six types of evidence and sources can be tapped to inform case study questions (Yin, 2009). These include "*documents, archival records, interviews, direct observation, participant observation, and physical artifacts.*" The review of case study CAPs primarily involved four types of evidence:

1) Reviewing local CAP document(s), supporting documentation, and process highlights;
2) Reviewing government sources of state and regional CAP planning and legislation;
3) Reviewing research prepared by institutes and non-profit partners providing CAP tools and advisory services; and
4) Interviewing CAP planning managers and/or participants.

4.3.2 Case Study Interviews

Each case study includes interviews with the CAP planning managers. The interviews complement the database of documentation with the experience of project managers and participants in the CAP process. The goal is to gain insights into CAP processes and tools not found in available documents.

Case study interviews are focused, approximately 60 minutes in length. The questions are established through case study protocols. The interviews include structured questions intended to gain corroboration for information collected through reviewing documents (Figure 4.2). Questions are targeted to address case study topics through planning managers' explanations and reflection on their experiences. The interview notes can be found in Appendix A.

Figure 4.2

Case Study Interview Summary Sheet
Case Study Questions

Questions		**Notes**
Q1- Why did your city prepare a climate action plan?	Degree to which motivation is based on local values: O O O O O Low High	Motivation for CAP:
Q2- How has your city responded to state and federal policy regarding preparing the climate action plan?	Degree to which motivation is based on state-level policies: O O O O O Low High	Voluntary contents of CAP: Mandated contents of CAP:
Q3- How did you choose GHG inventory and modelling software tools?	Degree which an off-the-shelf vs. customized tool kit was used: O O O O O Low High Degree which an off-the-shelf process vs. customized was used: O O O O O Low High	Types of GHG INVENTORY TOOLS: Types of STRATEGY FORMATION TOOLS: Types of ACTION PLANNING TOOLS: Types of IMPLEMENTATION AND MONITORING TOOLS:
Q4- In the future, how will the climate action planning influence the form of your city?	Degree to which CAP is integrated into a comprehensive plan or sustainability plan: O O O O O Low High Degree to which CAP influences the future physical form of the city: O O O O O Low High	Ways in which the CAP is integrated into comprehensive or sustainability planning: CAP strategies that influence: • land use patterns and densities: • infrastructure design: • transportation planning: Other CAP strategies that impact the future shape of the city:
Q5- Why were certain software tools and related processes effective?	Degree to which CAP tools were effective (easy to use, informative and flexible/customizable): O O O O O Low High	Strongest features in CAP tools: Weakest features in CAP tools:

4.3.3 Pilot Case Study

The review of case study CAPs involves an initial piloting of a single case study to assess the scope of substantive and methodological issues. The pilot case study is Key West, FL. After the initial screening and research of documentation, a more detailed analysis is prepared addressing the questions of inquiry and two phone interviews are conducted with managing planners for the CAP. The pilot influences both the questioning and methods used for the case studies.

Influence on Case Study Questions

One of the initial realizations in the pilot case study is that the CAP for Key West is influencing the evolution of the community's form in two ways. First, the low-lying community has focused on climate adaptation planning and this has had a great effect on the community's evolving urban form. This could be true for other communities. Therefore, reviewing documents for both strategies that reduce GHGs and adaptation planning is necessary to better understand how the CAP process is shaping communities. Secondly, the degree of CAP strategy integration into community planning policy documents seems important. The additional reading and discussion during interviews connects strategies in both CAP documents and in community plans.

Influence on Methods

The pilot interview reveals that the performance of the CAP tools, in this case the ICLEI Climate Air and Climate Protection software, has internal and external users and experiences. For the planning team, the tools require City staff to develop information to feed the models. This internal experience must support the external experience. That is, the community and policymakers have to make decisions based on the information the tools generate. In response, interviews are conducted for both staff that manages the GHG emissions modelling and those who use the results to inform community policymaking and action planning.

4.4 CASE STUDIES

The case studies are chosen to reflect different variables that could potentially influence the approach to preparing a CAP. In Chapter 2, a theoretical framework defined six "fundamentals" possessed by communities that affect their approach to climate action planning (Figure 2.3). These include:

- Energy resources
- Climatic regions
- Government structure
- Climate change policy context
- Community values
- Climate adaptation required

Eight communities are chosen that have already prepared CAPs (Figure 4.3). They represent eight of the nine climatic regions in the United States (NOAA, 2010), are located in different eGRID emission sub regions, have various geographic settings with different climate change adaptation challenges, vary in population size (from 35,000 to 2.8 million), have a variety of forms of local government, and have different state policy mandates.

Climatic Regions–The National Oceanic and Atmospheric Administration (NOAA) uses nine *U.S. Standard Regions for Temperature and Precipitation*. This may influence community energy demands, and therefore GHG emissions and climate adaptation planning.

Emissions & Generation Resource Integrated Database (eGRID)–Provided by the U.S. Environmental Protection Agency (U.S. EPA, 2010), the eGRID summarizes indirect GHG from power generation by sub region. This provides multipliers for weighing GHG inventories by sub region based on how electricity is generated. For example, sub regions burning more coal to create electrical power would have a higher eGRID multiplier. Chicago power comes from a higher percentage of coal than Berkeley, CA. In 2005, Chicago's power came from mostly coal-powered generation and had a total GHG output emission rate of 1538 lb/Mwh (pounds of GHG per megawatt hour) compared to 724 lb/Mwh for Berkeley, where nearly half its power came from hydro, nuclear and renewable sources (U.S. EPA, 2010).

Community Geographic Setting–Communities reflect a variety of ecological settings, including coastal areas, mountains, rivers, lakes, plains and woodlands. The location of a community provides climatic response advantages for energy generation or need for climate adaptation–a powerful motivator for low-lying coastal cities.

Community Size–A variety of community sizes are reflected in the selection of case studies. The size of the community may reflect administrative capacity in developing and implementing a CAP.

Form of Local Government–The form of local government includes strong mayor, city council-manager, and other forms. This may influence the overall policymaking approach and implementation responsibilities.

State Climate Change Policies and Regional Initiatives–As of January 2010, all but 14 states had some form of policies regarding climate change (Pew Center on Global Climate Change, 2010). These may directly or indirectly influence how, when, and what a local community must do in preparing and implementing a CAP. In addition to state legislation and planning, there are three regional initiatives across broader geographic areas where states and local governments are collaborating, including implementing regional "Cap-and-Trade" initiatives (Pew Center on Global Climate Change, 2009). Six of the case study cities fall within regional initiative areas. These include:

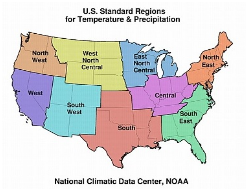
- Western Climate Initiative (Portland, Berkeley, Boulder and Bozeman);
- Midwestern Greenhouse Gas Reduction Accord (Chicago); and
- Regional Greenhouse Gas Initiative (for Northeast and Mid-Atlantic States–Annapolis).

<u>Each case study is organized by the following sections:</u>

- Community Profile Summary
- Motivation for Preparing a CAP
- State Policy Context
- CAP Approach and Process
- Climate Action Planning Tools Used
- Features in Climate Action Planning Tools
- Influence on Urban Form
- Summary

Figure 4.3

Selected Case Study Cities

Case Study City	**Estimated Population (2006)/ Density (2000)** **Source: U.S. Census Bureau** **Per capita GHG (sources: community CAPs) Approx. Nat'l ave. 26.7 tons**	**Climatic Region** (1)  **eGRID Emission Sub regions** (2)  **2004 CO2 emissions**	Form of Local Government	**State Climate Change Policies** (2) (voluntary vs. mandatory compliance) (a) GHG reduction goals/ policies (b) Required CAP (c) Required tools/ methods (d) LBE	Date CAP Adoption/ Revision
Key West, FL	23,262 4,282 pop/SM 16.7 tons (2007)	Southeast FRCC eGRID 1,328 lb/MWh	Commission-Manager	LBE, Targets, Action Plan (a, d)	2009
Bozeman, MT	35,061 2,183 pop/SM	West North Central NWPP eGRID 921 lb/MWh	Commission-Manager	Climate Change Advis. Comm. (d)	2008 MCAP CAP underway
Annapolis, MD	36,408 5,325 pop/SM	Northeast RFCE 1,096 lb/MWh	Mayor-Council	GHG Reduction Act 2009 – requires state plan (a)	2008
Boulder, CO	91,481 3,885 pop/SM	Southwest RMPA/NWPP eGRID 2,036 lb/MWh	Council-Manager	Gov's Action Plan (a, d)	2009
Berkeley, CA	101,555 9,823 pop/SM	West CAMX eGRID 879 lb/MWh	Council-Manager	AB32, SB375 – policies and regulations (a,b,c)	2009
Portland, OR	537,081 3,939 pop/SM	Northwest NWPP eGRID 921 lb/MWh	City Commission	OR Global Warming Commission Principles (a)	2009
Austin, TX	709,893 2,610 pop/SM	South SRMV eGRID 1,135 lb/MWh	Mayor-Council	none	2007
Chicago, Il	2,833,321 12,751 pop/SM	Central RFCW eGRID 1,556 lb/MWh	Mayor-Commission	Gov's Climate Change Advisory Group (a)	2008

Notes:

(1) U.S. Standard Regions for Temperature and Precipitation, NOAA
(2) http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
(3) http://www.pewclimate.org/states-regions, http://www.climatestrategies.us/

4.4.1 Key West, FL

Key West's Community Profile Summary

Key West, FL has a population of approximately 23,300 (U.S. Census Bureau, 2010) and is the home of Key West Community College as well as other small private colleges. It is located in on the southern tip of Florida and on "Land Vulnerable to Sea Level Rise" (U.S. EPA, 2009) where the average elevation is only two feet above high tide (City of Key West, Florida, 2009, p. 3). It is in the Southeast climatic region and has an average annual maximum temperature of 83.8° F, minimum temperature of 72.0°F and 39.40" of precipitation (Southeast Regional Climate Center, 2007). In 2007, Key West emitted an estimated 16.7 tons of GHG per capita compared to the national average of 26.7 tons (City of Key West, 2008). The community is located in the Southern Florida Coastal Plain eco-region (USGS, 2010) characterized by the slow-moving waters and wetlands of the Florida Everglades. Key West has a commission-manager form of government with six city commissioners elected by district and a mayor elected at-large. The Commission appoints a City Manager (City of Key West, 2010). The State of Florida passed the Green House Gas Reduction Act of 2009, requiring the state to be 10% below GHG 1990 levels by 2025 and 80% below 1990 levels by 2050 (Pew Center on Global Climate Change, 2010).

Key West's Motivation for Preparing a Climate Action Plan

According to the Climate Action Plan, the City of Key West is motivated by the consequences of sea level rise due to global warming, local community values, and state legislation. In addition, vocal and active members of the community advocated for preparing a CAP. Since Key West has an average elevation of only two feet above high tides, approximately one third of the city would be inundated if the sea level rose only nine inches by 2100, which is the low end of NOAA estimates. The small community's political leadership demonstrated Key West's commitment to reducing GHG's by signing the Mayors Climate Protection Agreement in 2007 and initiating a community Climate Action Plan process. The State of Florida has its own policies that encourage reducing of GHG at the local level through legislation and leadership-by-example (LBE). The community foresees economic and social benefits from implementing their CAP.

The CAP consultant (Williams, 2010) and retired City Environmental Projects Manager (Mannix, 2010), said activists promoted Commission candidates that would support preparation of a CAP in 2007. Activists from GLE (Green Living and Energy Education) worked with all six communities on the Keys on a coordinated effort. As a result, Key West was one of the first communities in Florida to join ICLEI and prepare a CAP. During the planning process and afterwards, citizen activists continued to pressure the Mayor to follow through on the policies and recommendations in the CAP.

Key West's State Policy Context

The State of Florida has over three-quarters of its population living in coastal counties (National Oceanigraphic Economic Program, 2006). The state is vulnerable to increased hurricane frequency and power, and inundation due to rising sea levels. The state is undertaking an LBE effort and committing to a variety of energy, GHG emission reduction, and economic programs to address climate change (Pew Center on Global Climate Change, 2009). Since 2007, Florida's climate change efforts have included executive orders from the Governor, preparation of a State CAP, and legislation (State of Florida, 2010).

Governor Executive Orders

In 2007 the Governor issued Executive Order 07-127 that established reduction targets for the emissions of greenhouse gases (State of Florida, 2010). Targets are:

- By 2017 reduce greenhouse gas emissions to 2000 levels,
- By 2025 reduce greenhouse gas emissions to 1990 levels, and
- By 2050 reduce greenhouse gas emissions by 80% of 1990 levels.

Executive Order 07-127 further directed a 15% increase in the energy efficiency performance of the 2007 Florida Energy Code for Building Construction and required that the Public Service Commission adopt a 20% renewable portfolio standard (RPS) and a policy for net metering and interconnection.

In 2007 the Governor issued Executive Order 07-126 directs state agencies to prepare a CAP for state facilities, fleet and purchasing--as an LBE effort meant to encourage similar efforts by local governments and districts (State of Florida, 2010).

Florida Climate Action Plan

The Florida Energy and Climate Action Plans were completed in 2008 by a 27-member action team appointed by the Governor representing various interests. The Florida CAP contains 50 policy recommendations regarding energy supply and demand;

transportation and land use; agriculture, forestry, and waste management; government policy and coordination; and adaptation strategies (Center for Climate Strategies, 2009, p. 1). The Plan proposes to:

- Reduce GHG emissions to 20% below 1990 levels by 2020;
- Produce a net economic savings of $28B;
- Expand the Florida's GMP by $38B; and
- Create 148,000 new jobs by 2025.

State Legislation

In 2008, House Bill 7135, 2008 Energy and Economic Development passed unanimously and was signed by the Governor (State of Florida, 2010). The bill establishes requirements and goals for:

- Consolidating state energy policy within the Florida Energy and Climate Commission, established within the Executive Office of the Governor
- Creating a Renewable Portfolio Standard for utilities and Renewable Fuel Standard of at least 20% (Southern Alliance for Clean Energy, 2009)
- Requiring major emitters to report emissions through The Climate Registry and calling for the development of a cap-and-trade system to regulate greenhouse gas emissions
- Creating a new consortium of state universities to bolster and share research and scientific discoveries in energy technologies
- Expanding incentive programs to continue encouraging development in alternative and renewable energy technologies, including the Solar Rebate Program and the Renewable Energy and Energy-Efficient Technologies Grant Program

Key West's CAP Approach and Process

Key West conducted climate action planning for municipal GHG emissions and community-wide GHG emissions. Due to the city's low-lying geography, the community has also focused on climate adaptation (Mannix, 2010).

Municipal CAP (MCAP)

In 2008, the Commission passed a resolution to reduce municipal GHG emissions by 15% of 2005 levels by 2015. This was to demonstrate the City's commitment using an LBE method. The Municipal CAP envisions a reduction of about 2,640 tons of CO^2e (CO^2 equivalent) by 2015 from the 2005 level of 17,596 tons (City of Key West, Florida, 2009, p. 38).

The City Commission directed the Environmental Programs Division to work with the community. The MCAP process community outreach was led by the Climate Action Team appointed by the Commission "subject matter experts" and City staff supported the Action Team. The process included five focus groups: the Commercial Focus Group, Building Focus Group, Solid Waste Focus Group, Sewage Focus Group, and Tree Focus Group. Other standing City committees also contributed to the planning effort, including the Pedestrian Action Committee, Bicycle Action Committee, Clean and Green Committee, Green Coalition, Community Traffic Safety Team, and Employee Green Team (City of Key West, Florida, 2009, pp. 4-5).

The Key West MCAP is based on inventory and related milestones, GHG reduction actions, and implementation strategies. The Climate Protection Task Force employed a five-milestone approach (recommended by ICLEI-Local Governments for Sustainability):

- *Milestone 1–Conduct a Greenhouse Gas Emissions Analysis: Baseline inventory and forecast emissions growth*
- *Milestone 2–Set an Emissions Target*
- *Milestone 3–Develop Local Action Plan*
- *Milestone 4–Implement Local Plan*
- *Milestone 5–Monitor Progress and Report Results*

Community CAP

The community process resulted in recommendations for similar reductions in citywide emissions–reductions of about 60,000 tons of CO^2 from current 400,000 tons (City of Key West, Florida, 2009, p. 16). The 2009 CAP directed the Environmental Programs Division to work with the community to prepare a community-wide strategy to reduce emissions from the following sources:

- Energy Supply – Reduce 9,831 tons per year of CO^2e emissions;
- Solid and Sewage Waste – Reduce 7,055 tons per year of CO^2e emissions;
- Transportation – Reduce 12,681 tons per year of CO^2e emissions;
- Building Efficiencies – Reduce 30,258 tons per year of CO^2e emissions; and

- Sustainability/Sequestration – Absorb 175 tons of CO^2 per year.

Climate Adaptation

The CAP emphasizes adaptation planning, out of necessity, due to the potential inundation of Key West by rising sea levels. The City has assembled a standing steering committee to plan for and monitor changing climate impacts on Key West. The Adaptation Working Group (AWG) supports the City Manager and Environmental Program Manager. They have representatives for Water Resources, Benthic/Fisheries, Infrastructure, Terrestrial, Weather/Sea Level Rise, Human Disease and Economics (City of Key West, 2009, p. 16). In addition to the AWG, the City uses a Green Coordinator to support plan implementation, including education (City of Key West, Florida, 2009, p. 20).

City staff emphasized the CAP has been used as part of the community outreach and communications efforts (Mannix, 2010). The Adaptation Plan has been used to work on strategies with the Commission primarily because it is emotionally difficult to discuss a future where much of Key West's real estate could be under water. The Commission uses the Adaptation Plan for grant writing and funding requests but does not promote it.

<u>Climate Action Planning Tools Used by Key West</u>

Key West used the ICLEI Climate Air and Climate Protection software package by Torrie Smith Associates to support the CAP process (City of Key West, 2008, p. 14). The software was used to prepare the Municipal CAP and inventories for both municipal operations and the community. Baseline for municipal emissions inventory was prepared for 2005, broken down by buildings, water/sewage, vehicle fleet, streetlights, and waste.

Features in Key West's Climate Action Planning Tools

The ICLEI Clean Air Climate Protection (CACP) Software was used to prepare the emission inventories. Over 350 U.S. cities and counties use this software. CACP Software calculates energy, money and GHG savings for existing and future GHG reduction policies (City of Key West, 2008, p. 14). The City's consultant said about 80% of the input categories came directly from the ICLEI software and about 20% was customized (Williams, 2010).

CACP Software calculates emissions for both sources and sectors using "equivalent carbon dioxide units" or CO^2e. This converts non-CO^2 GHGs into CO^2 equivalents. CACP Software is consistent with national and international inventory standards established by the International Panel on Climate Change (IPCC) (City of Key West, 2008, p. 14).

- Sources include: Electricity, propane, diesel, gasoline, landfill gas, and CO2
- Sectors for the community include: Residential, commercial, transportation, and waste
- Sectors for municipal GHG include: Buildings, vehicle fleet, employee commute, streetlights, water/sewer, and waste

According to consultants and former City staff, the ICLEI tools provided a good model to follow for small cities without much experience or resources (Mannix, 2010). The City was an early client partner with ICLEI and experienced some calibration problems, particularly with waste calculations (Williams, 2010). Not finished at the time, ICLEI was working on web-based tools that would have been easier to use. Over time, the version used by the City was updated but was not compatible so data entries were lost (Williams, 2010).

Influence on Key West's Urban Form

The CAP proposals for the community focus on the areas of greatest GHG emissions. The planning recommends a variety of "smart growth" strategies. Transportation was identified as the highest emissions source; therefore, most recommendations were for improved transit–particularly bikes and walking, providing shuttle transit, and ridesharing. Other visible changes will include renewable energy generation and distribution (solar and wind), white and green roofs, landscaping/shade trees, and recycling/waste reduction (City of Key West, Florida, 2009, pp. 14-16).

Despite having a relatively low 2007 per capita GHG emission of 16.7 tons (compared to national average of approximately 26.7 tons), the City is motivated by the spectre of a rising sea level. Key West is on a low-lying key without land available for expansion and therefore is very focused on climate adaptation planning. Sea level rise by 2100 is estimated to be between approximately 9" and 23" (NOAA). In addition, new FEMA (flood insurance) maps reflect a change in Corp of Engineers policies that require projects with at least a 50-year life span to consider scenarios for 1.2 feet, 1.5 feet, and 4.9 feet of sea level change (City of Key West, Florida, 2009, p. 3).

Implications of rising sea levels for Key West include:

- Road elevations due to flooding;

- Impact on community facilities such as the airport;
- Wetlands definitions and other habitat changes;
- Impact on historic structures and sites;
- Infrastructure design (such as storm water pump stations); and
- Building elevations.

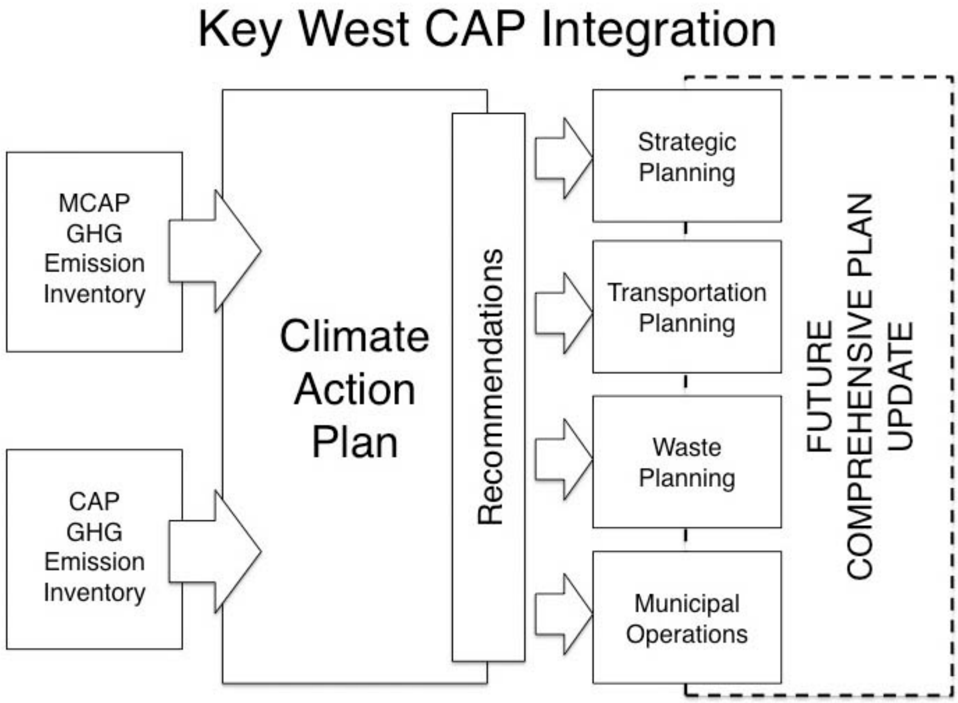
The CAP recommends planning for resiliency and proposes a five-step process for adaptation. These include:

- Preparing a resiliency study;
- Identifying priority planning areas based on risk assessments;
- Setting goals and creating a plan;
- Implementing the plan; and
- Measuring progress.

CAP recommendations have had the greatest impact on the City's strategic planning efforts, infrastructure planning, transportation planning, waste planning, and municipal operations (see Figure 4.4).

Figure 4.4

Key West CAP and City Planning Integration



<u>Summary</u>

- Due to its susceptibility to a rising sea level, Key West is motivated by self-preservation to reduce GHG emissions and employ climate adaptation strategies.
- Activists played an important role in motivating elected officials to prepare and implement the CAP.
- The City and the State of Florida both have developed a lead-by-example (LBE) approach to reducing government GHG emissions.
- Key West has used, with some minor modifications, the ICLEI CACP modelling software and suggested process.
- The CAP will influence the community's form primarily through climate adaptation planning and secondarily by implementing smart growth policies that reduce the use of automobiles, and energy efficiency improvements to buildings.

4.4.2 Bozeman, MT

Community Profile

In 2006 Bozeman, MT had a population of approximately 35,000 (U.S. Census Bureau, 2010). The city is the home of Montana State University. Bozeman is located in the West North Central climatic region at an elevation of 4,810 feet (NOAA, 2010). The city has an average annual maximum temperature of 56.8° F, minimum temperature of 30.3°F and 16.28" of precipitation (Western Regional Climate Center, 2005). The community is located in the Middle Rockies eco-region in the Townsend Basin, which is a semi-arid and treeless floodplain with flood terraces, alluvial fans and hills (U.S. EPA, 2003). Bozeman has a commission-manager form of government with five city commissioners at-large members elected with staggered four-year terms. A mayor can campaign for the position and if elected serve during the last two years of the commission term (City of Bozeman, MT, 2010). In 2009-2010, the State of Montana convened an 18-member Climate Change Advisory Commission (CCAC) managed by the Montana Department of Environmental Quality (DEQ) (Montana Deparment of Environmental Quality, 2010).

Bozeman's Motivation for Preparing a Climate Action Plan

Bozeman has prepared both municipal (MCAP) and community (CCAP) climate action plans. The CAPs were prepared through a successful community advocacy effort led by the Citizens Concerned for Climate Change (Baker, 2010). The Bozeman City Commission signed onto the Mayors Climate Protection Agreement (MCPA) in 2006 and created the Bozeman Climate Protection Taskforce (CTPF) in 2007 (City of Bozeman, 2008, p. iii). The City hired a sustainability coordinator in 2007 and initiated preparation of a CAP (Baker, 2010). Bozeman is also motivated by potential climate change impacts, includes increased catastrophic forest fires, shorter ski and fishing seasons, hotter summers, lower summer river flows, and drought (City of Bozeman, 2008, p. 6).

Bozeman Approach and Process

The City prepared the MCAP in 2008 and as November 2010 was completing its CCAP. The yearlong MCAP process included a 15-member Climate Protection Taskforce (CTPF) that met monthly and focused on municipal operations and management. CTPF worked in three subcommittees: Planning, Building and Energy (PBE); Transportation and Land Use (TLU); and Wastewater and Recycling (WWR).

The CTPF made 40 recommendations for municipal operations, including planning, building, and energy; transportation and land use, wastewater, and recycling; education; and implementation. MCAP goal is to reduce GHG to 12% below 1990 levels by 2012 for municipal operations and 15% below 2000 levels by 2020 (6,083 tons reduced 15% = 5,172 tons). The 2020 emission goal was to coincide with the Bozeman 2020 Community Plan (City of Bozeman, 2008, pp. iii-iv).

The CCAP included an appointed Mayor's Community Climate Plan Taskforce organized in four working groups. Each group met four times over the yearlong process (Meyer, 2010).

The process was supported by ICLEI (Local Governments for Sustainability). Besides providing software tools and technical support, ICLEI's participation resulted in networking opportunities. Staff learned from peer communities, including Bellingham, WA and Boulder, CO (Baker, 2010).

When asked how the CAP process or outcome could be improved, the staff (Meyer, 2010) and consultant (Baker, 2010) suggested:

- Make sure the CAP leads to a comprehensive implementation plan;
- Invest in a communication plan;
- Use peer pressure to influence citizens and businesses to take action; and
- Be sure you have enough time and resources to conduct all the emission inventories, as they can be very demanding on staff.

<u>Bozeman State Policy Context</u>

The State of Montana is part of the Western Climate Initiative. This includes participating in a regional cap-and-trade program (Pew Center on Climate Change, 2010). The state has taken a number of climate-related actions in the past several years, including:

- Creating a bio-fuel standard;
- Establishing a Renewable Portfolio Standard (RPS) with a15% goal by 2015;
- Joining the Western Governors' initiative for clean and diversified energy;
- Creating a Climate Change Advisory Council (2006) to develop a CAP (completed in 2007); and
- In 2009, committing to reducing GHG emissions to 1990 levels by 2020.

Montana CAP

The Montana CAP was completed in 2007 with the assistance of the Climate Change Advisory Council (CCAC)–18 stakeholders, organized in four technical working groups addressing energy supply; transportation and land use; residential, commercial, institutional and industrial; and agriculture, forestry and waste. The CCAC reviewed and commented on technical reports prepared from the Montana Department of Environmental Quality staff with assistance by technical, policy and scientific experts. The CCAC was supported by staff from the Centre for Climate Strategies (CCS) and used a CCS-designed process (State of Montana, 2007, pp. EX-1, EX-2).

The Montana CAP makes 54 policy recommendations that are intended to reduce the state's GHG emission to 1990 levels by 2020. The CAP includes base case (business as usual), production-based (supply side) and consumption-based (demand side) scenarios. The CAP proposes statewide GHG reduction goals based on both production and reduction-side emissions (State of Montana, 2007, pp. 1-9). Analysis of costs and benefits suggests implementing the recommendations will yield a slight overall economic benefit (State of Montana, 2007, pp. EX-5, EX-6).

Montana Legislation

To date, Montana has not passed legislation impacting local government regarding the need for, or the approach to preparing CAPs (Meyer, 2010). Montana CAP's implementation will require a combination of private, public and legislative actions. Some recommendations will require improved technologies (State of Montana, 2007, pp. EX-2).

<u>CAP Tools used by Bozeman</u>

Preparation of the Bozeman MCAP utilized local resources and expertise supported by ICLEI (Local Governments for Sustainability). The City of Bozeman hired a sustainability coordinator who conducted the baseline emissions inventory (City of Bozeman, MT, 2010, p. 1). Bozeman used Clean Air Climate Protection (CACP) software version1.1, June 2005 provided by ICLEI. A baseline inventory was prepared on buildings, vehicle fleets, streetlights, water/sewage, and waste (City of Bozeman, MT, 2010, pp. 8, 9).

Using ICLEI Software Tools

Inventory categories were provided by the GHG inventory software and not by the community. Staff used about 80% of the ICLEI packaged approach, modifying it to fit Bozeman's specific needs. The content of the CAP was also mandated by the grant funding it (Meyer, 2010). Overall, the staff felt ICLEI inventory tools and approach were good for a smaller community without many resources. ICLEI provided tech-support but not as much as hoped for. It took a long time to hear back from ICLEI, and the model was hard to validate due to its opaqueness (Baker, 2010). Valuable outcomes to the MCAP process included acknowledging importance of tracking energy use in city operations (Baker, 2010) and the MCAP's connection to the city's Capital Improvements Plan (CIP) where all expenditures over $10,000 are evaluated on a scale of 1 to 5 in terms of meeting the MCAP objectives (Meyer, 2010).

Features in CAP Tools used by Bozeman

In 2006, Bozeman used STAPPA/ALAPCO and ICLEI's Clean Air Climate Protection Software developed by Torrie Smith Associates, Inc. STAPPA/ALAPCO is now the National Association of Clean Air Agencies (NACAA) and promotes coordination between air quality agencies in the United States and provides a variety of modelling tools (City of Bozeman, 2008, p. 49). NACAA tools provide inventory and forecast capabilities for pollution (nitrogen oxides, sulphur oxides, carbon monoxide, volatile organic compounds and course particulate matter) and GHGs. The NACAA tools are funded by the EPA and can evaluate policies and emission reduction plans as voluntary programs or in support of regulatory actions (National Association of Clean Air Agencies, 2010).

ICIE's software tool has been upgraded from version 1.1 to 2.1.1 (ICLEI Local Governments for Sustainability, 2010). According to ICLEI's website, their software *"CACP 2009 is a one-stop emissions management tool that calculates and tracks emissions and reductions of greenhouse gases."* It supports community efforts to create an emissions inventory for an entire community or for municipal operations; estimate the effect of existing and proposed GHG emissions mitigation actions; estimate future emissions levels; and establish mitigation targets and track progress (ICLEI Local Governments for Sustainability, 2010).

Influence on Bozeman's Urban Form

The 2008 Municipal CAP and updated 2009 Community CAP had recommendations included in the Bozeman Capital Improvements Plan (CIP) and Community Plan (Figure 4.5). Although, these were seemingly less than expected by the community, given the number of recommendations in the CAP (Baker, 2010).

Comprehensive Plan

Bozeman Community Plan was updated in June 2009 (City of Bozeman, 2009, p. i). The 17-chapter, 285-page document has 14 references to climate change. Most of these references fall within Chapter 9: Environmental Quality and Critical Lands. Climate change is included in the following goal and two objectives:

- *Objective G-1.4: Ensure that Bozeman grows in a sustainable manner with consideration for climate change, health and safety, food production, housing, employment opportunities, natural hazard mitigation, and natural resource conservation.*
- *Goal E-3: Help address climate change by taking steps towards reducing the City's greenhouse gas emissions*
- *Objective E-3.1: Reduce greenhouse gas emissions produced by City operations and the community*

Climate change issues are also included in the appendix. These include weather and climate as it pertains to hydrology (as a subsection in Appendix G: Environmental Quality and Critical Lands) and a mention in the water planning section regarding past planning in Bozeman.

While collecting information regarding municipal operations, the Transportation and Land Use Committee made recommendations that could be part of the foundation of the community plan update (City of Bozeman, 2008, pp. 43-48). These included:

- Reducing the community's carbon footprint using incentives and disincentives;
- Improving feasibility of alternative transportation modes with an emphasis on walking and biking;
- Public education; and
- Community-supported agriculture.

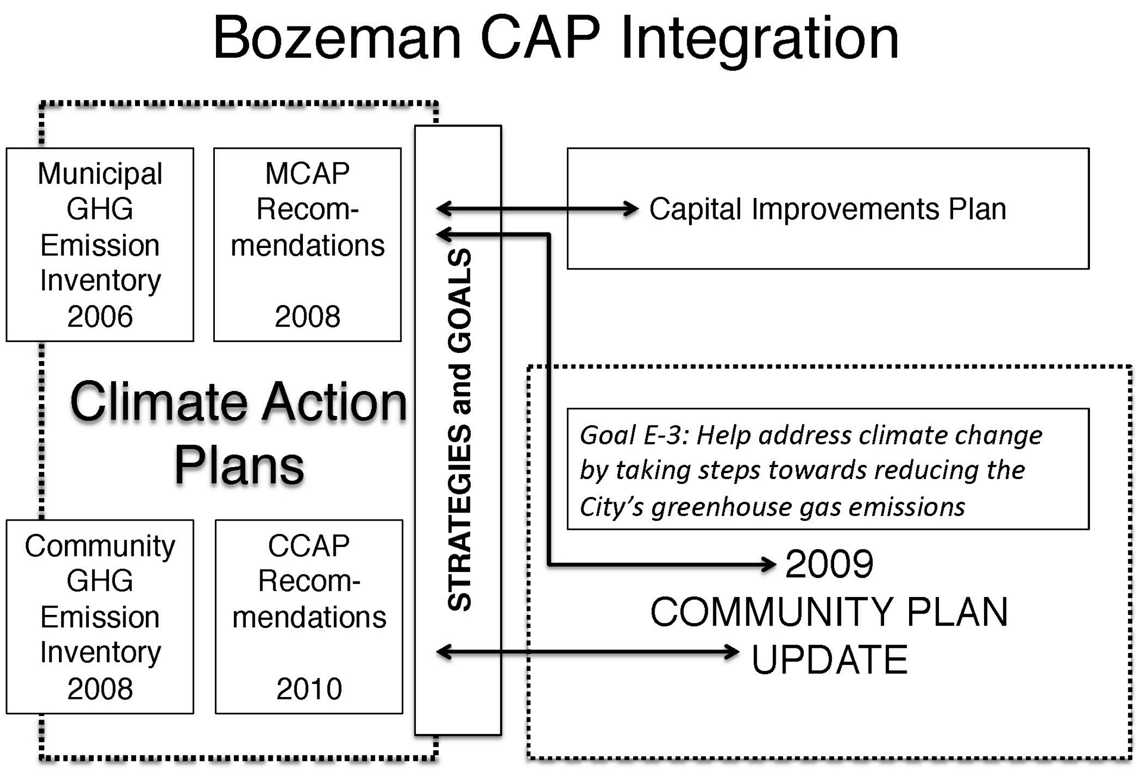
Specific recommendations that may have a direct impact on the city's form include:

- Plan for lightrail transit (LRT);
- TDM–transportation demand reduction program; and
- Better design standards for streets, sidewalks and bike facilities.

All these recommendations are mentioned in the Community Plan, except for lightrail. However, they are linked to climate change or the MCAP process. The CAP process and recommendations have not been central to creating community planning policies. The Community Plan refers to the CAP process and recommendations where it supports sustainability policies. The City's consultant felt the CAP "was referred to enough to justify having a sustainability chapter" (Baker, 2010).

Figure 4.5

Bozeman CAP and City Planning Integration



Summary

- The city was inspired to prepare an MCAP and CCAP by local activists and grant funding.
- The City prepared both an MCAP and CCAP utilizing community advisory committees.

- The State of Montana has pursued an LBE effort to address climate change and has an established comprehensive CAP. However, the State does not require local CAPs or planning related to climate change.
- The MCAP and CCAP used modified tools and approaches provided by ICLEI.
- Networking opportunities through ICLEI were helpful for staff to share experiences and be mentored by other communities.
- ICLEI tools were too opaque and staff needed more technical support.
- The CAPs could have benefitted from additional time for inventory efforts, better communication plan and a more comprehensive implementation plan.
- Most of the CAPs' recommendations were included but not attributed to them. The Community Plan only includes one goal and two objectives supporting climate action planning.

4.4.3 Annapolis, MD

Community Profile

Annapolis, MD had a population of approximately 36,408 in 2006 (U.S. Census Bureau, 2010) and is the location of Johns Hopkins University and several other colleges and universities. It is located on Chesapeake Bay, so a portion of the community rests on “Land Vulnerable to Sea Level Rise” (U.S. EPA, 2009). Annapolis is located in the Northeast climatic region and has an average annual maximum temperature of 65.3° F, minimum average temperature of 49.2°F, and 41.97” of precipitation (Southeast Regional Climate Center, 2007). The community is in the Chesapeake Rolling Coastal Plain eco-region, “a hilly upland with narrow stream divides, incised streams, and well-drained loamy soils” (EoE, 2008). Annapolis has a mayor-council form of government. The mayor chairs the council and manages city departments (City of Annapolis, 2010). The Governor of Maryland proposed the Greenhouse Gas Reduction Act of 2009. SB 278 and HB 315 enacted the Act and were passed by the legislature and signed into law by the Governor in 2009 (State of Maryland, 2009). It requires the Department of the Environment to prepare a GHG inventory, reduce GHG 2006 emission 25% by 2020 and adopt and implement specific plan regulations to reduce GHG.

Annapolis Motivation for Preparing a Climate Action Plan

Annapolis is motivated by its values and out of concern for the impacts of climate change. It is located on Chesapeake Bay with portions of the city that will be impacted by rising sea levels. The city has five creeks/rivers running through it and is subject to flooding (City of Annapolis, 2008, p. 4). The City joined ICLEI in 2003 and signed on to the U.S. Mayors Climate Protection Agreement in 2005.

Annapolis Approach and Process

In 2005 the City created the Energy Efficiency Task Force. The Task Force conducted Municipal Emissions GHG Inventory for municipal operations, including buildings, vehicle fleet, streetlights, water/sewage, waste, and employee commuting. Consultants helped prepare GHG inventory using ICLEI’s software. The inventories for both the community and municipal CAPs assumed a 2006 base year.

The community has a tradition of supporting environmental policies. The process included two larger community workshops and a dozen smaller meetings with community organizations. The CCAP's community engagement process was sponsored by the Environmental Commission (Savage, 2010).

GHG Emission Targets

The long-term goal for Annapolis is to be carbon neutral by 2050 (City of Annapolis, 2008, p. 5). Short and mid-term GHG reduction targets include:

- Short-term for community (2012) is 25% below 2006
- Short-term for city government (2012) is 50% below 2006
- Mid-term for community (2025) is 50% below 2006
- Mid-term for city government (2025) is 75% below 2006

Emission Categories

The city's emission reduction strategy includes community, environment, economic, and neighbourhood categories (City of Annapolis, 2008, pp. 9-19). Community strategies include the goals of diversifying transportation choices, increasing energy efficiency, using more renewable energy, education, waste, and other strategies. Environmental strategies include goals addressing water quality, natural resources, land use, and air quality. Economic strategies include goals for local economic development and green jobs. Strategies for sustainable neighbourhoods include goals for children, health and safety; and education, arts and community.

Key Strategies

Key strategies for the Community CAP combine increased efficiencies and higher utilization of energy from renewable sources (City of Annapolis, 2008, p. 5). In addition, the City is to explore ways to increase recycling to reduce waste. The Municipal CAP established a goal of 15% reduction of city energy use in government buildings by 2020. This in combination with purchasing energy from renewable sources will make a substantial contribution to meeting overall GHG emission reductions. The MCAP assumes 25% of energy from renewable sources supports over 56% of the 2050 goal (City of Annapolis, 2008, p. 5). Strategies also include making energy efficiency upgrades to buildings, lowering employee commute impacts, improving the city fleet, and exploring the potential for geothermal energy for the city.

Measuring Progress–First Scorecard

The City prepared the first annual "scorecard" tracking progress towards meeting emissions targets. The Scorecard is to be a communications tool to keep the community apprised of progress. The Scorecard effort has also made it possible for various City departments to showcase their sustainability programs and GHG emission reductions (Savage, 2010).

Annapolis State Policy Context

The State of Maryland has a State Office of Planning, a state planning board and a tradition for statewide planning and growth management (American Planning Association, 2010). Maryland is a small state of 5.7 million people and 9,773 square miles (U.S. Census Bureau, 2010) with 12,420 miles of shoreline (Maryland Geological Survey, 2007). Much of the ocean shoreline is considered "Land Vulnerable to Sea Level Rise" (U.S. EPA, 2009).

Maryland CAP and Related Legislation

In 2007 the Governor signed an Executive Order that established the Maryland Commission on Climate Change (Maryland Commission on Climate Change, 2010, p. 3). The same year, Maryland joined in the Regional Greenhouse Gas Initiative in pledging to reduce GHG emissions from power plants 10% by 2019 (The Washington Post, 2007). The Greenhouse Gas Emissions Reduction Act of 2009 (GGRA) reduces state GHG emissions 25% by 2020 and up to 90% by 2050 (Maryland Commission on Climate Change, 2010, pp. 3-4).

The state CAP promotes new "green" jobs while protecting existing jobs. The Governor set a goal of 100,000 "green collar" jobs by 2015 (State of Maryland, 2009). A significant number of green jobs will come from renewable energy and efficiency projects. The State is committed to regional initiatives such as the Low-Carbon Fuel Standard, which will help obtain the goals of the GGRA. Maryland has established an RPS goal of 20% by 2022 with a diversity of technologies (US EPA, 2010).

State Requirements for Adaptation Planning

The Maryland CAP increases the need for adaptation planning by local government. The state CAP requires local governments to include a Sea Level Rise Element in their comprehensive plans; identify Critical Areas Buffers along coastal areas; and Emergency Management and Mitigation Plans that include relocation plans for critical facilities, such as hospitals, that are potentially impacted by sea level rise (Maryland Commission on Climate Change, 2008, pp. 5.9-5.10).

CAP Tools Used by Annapolis

Annapolis used ICLEI's Clean Air and Climate Protection (CACP) software and five-step process. The process includes creating an inventory, setting reduction targets, creating and action plan, implementing the plan and monitoring progress (City of Annapolis, 2006, p. 4). The ICEI software came with training and technical support (Savage, 2010).

ICLEI CACP Software Used for Emissions Inventory

The software categorized CCAP emissions into four categories: 2006 GHG emissions for energy, transportation, and waste. Energy included calculations for residential (27% of total GHG), commercial (31% of total GHG) and industrial (9% of total GHG). Transportation was estimated for vehicle miles travelled (VMT) for various vehicles, except those that transported waste (27% of total GHG). Waste inventory calculations included emissions from management and storage of waste (6% of total GHG) (City of Annapolis, 2006, pp. 4-5). The City chose to develop custom spreadsheets to monitor emissions targets. The information has been used in the first annual Scorecard (Savage, 2010).

The Scorecard indicates one of the challenges for Annapolis is to motivate the community to make lifestyle and energy efficiency choices that lower GHG emissions. Over the 2007-2009 period, the Scorecard indicates that municipal emissions dropped 7% and community emissions increased by 16% (City of Annapolis, 2010, p. 3). For example, the community can purchase green energy at reduced rates through Maryland's local power company, Pepco. Local residents can pay less for choosing 50% local wind power as an option versus non-renewable power (Electric Adivisors, Inc., 2010).

Features in Annapolis CAP Tools

According ICLEI's website, the CACP software follows the Local Governments Operations Protocol (ICLEI, 2010). The software comes with technical assistance from ICLEI. The software can:

- *Create emissions inventories for the community as a whole or for the government's internal operations.*
- *Quantify the effect of existing and proposed emissions reduction measures.*
- *Predict future emissions levels.*
- *Set reduction targets and track progress towards meeting those goals.*

ICLEI CACP Software vs. Customized Spread sheets

The CACP software was used primarily for calculating emissions inventories. It provided a big picture view of emissions and supported development of strategies. The City explored using ICLEI's accounting software Climate & Air Pollution Planning Assistant (CAPPA) to help monitor emissions targets. When it came down to monitoring emissions progress, the CAPPA software was harder to use and required the ability to customize spreadsheets. Staff created customized spread sheet tools for preparing the Scorecard (Savage, 2010).

The process of calculating GHG emissions revealed a number of energy efficiency and monitoring opportunities for the City. In the future, staff is considering using the EPA's Portfolio Management software to provide a more detailed inventory and performance tracking for municipal activities (Savage, 2010).

Influence on Annapolis Urban Form

The Community Action Plan and Annapolis Comprehensive Plan were prepared concurrently, rather than sequentially, by different City departments. There was an effort to include some preliminary CAP recommendations in the Comprehensive Plan. However, they are not fully integrated into the Plan. City departments have been focusing on the Scorecard rather than planning policies. There is not yet a schedule or plan to revisit the Comprehensive Plan to more completely integrate CAP recommendations (Savage, 2010).

Comprehensive Plan Organization

The 2009 Annapolis Comprehensive Plan is organized in 10 chapters with three overall themes that came from the community process. These include community character, economic vitality, and the "greening" of Annapolis (City of Annapolis, 2009, pp. 2-5). These themes organize the plan and are the first tier of "guiding questions" for the Plan's implementation (City of Annapolis, 2009, p. 138).

Most of the climate-related planning policies and recommendations are located in Policy 3, Chapter 7: Environment. The Community Action Plan breaks actions into municipal and community categories (City of Annapolis, 2008, pp. 6-8). Most of the municipal actions relate to capital improvements and operational management. The community actions are programmatic and regulatory. The GHG emissions reduction goals and related action items for transportation, energy efficiency, renewable energy, education, and waste are captured in the Comprehensive Plan (see Figure 4.6). Key Comprehensive Plan policies influenced by the CAP include:

Policy 3. Shrink the City's Carbon Footprint and become a community of Green buildings to combat climate change

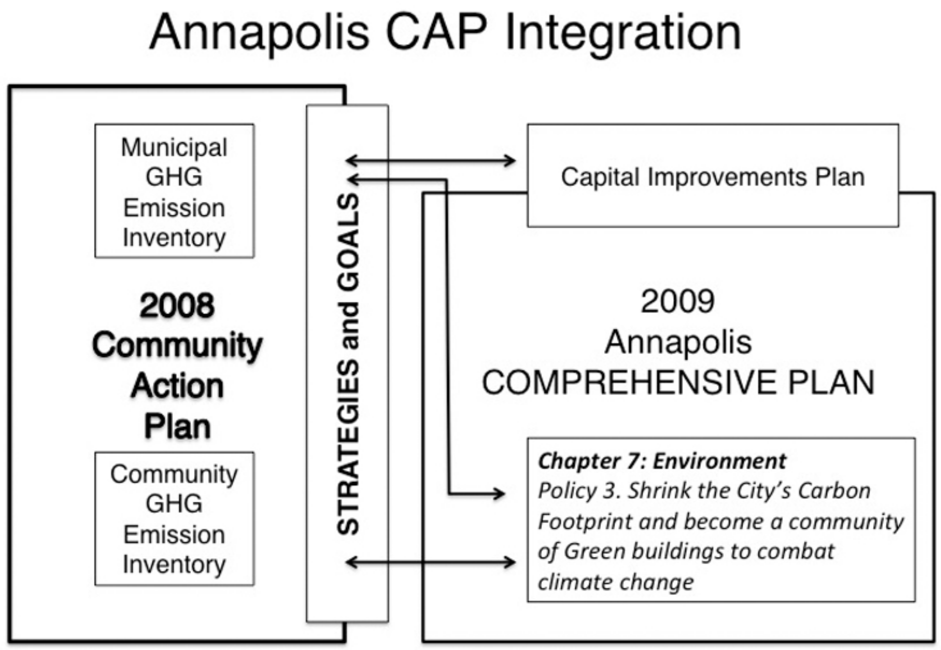
- *3.1 The City's Energy Policy meets the objectives of reducing energy costs, energy consumption, and reliance upon petroleum.*
- *3.2 Achieve the carbon reduction goals in the Sustainable Annapolis Community*
- *Action Plan (CAP) …The emission reduction targets are 50 percent reduction of government emissions (2006 levels) by 2012, 75 percent reduction by 2025, and carbon neutrality by 2050. The reduction targets for the entire Annapolis community are a 25-percent reduction (2006 levels) by 2012, 50 percent reduction by 2025, and carbon neutrality by 2050.*
- *3.3 Promote alternatives to gasoline-fuelled vehicles for transportation to reduce transportation-related greenhouse gas emissions. Support land use patterns that limit vehicular travel demand. Support pedestrian and bike amenities along all major roads.*
- *3.4 Develop a strategy for sea level rise as part of the City's adaptation and response to threats from climate change. This planning effort should be coordinated with the City's Hazard Mitigation Plan and be prepared in coordination with State efforts, as well as the Federal government, U.S. Naval Academy, and County Government* (City of Annapolis, 2009, pp. 97-98).

Adaptation Planning

The Plan includes mapping indicating areas of the community that would be impacted by one meter of sea level rise, flood plains, and steep slopes. In response to the State's requirement to anticipate sea level change, these areas are prohibited from having critical facilities.

Figure 4.6

Annapolis CAP and Comprehensive Plan Integration



Summary

- The political leadership in Annapolis was committed to policies that address climate change.
- Annapolis is also motivated by impacts of rising sea levels due to global warming.
- The City prepared both an MCAP and CCAP utilizing community advisory committees.
- Maryland has statewide planning function and can address a variety of issues within that policy, regulatory and review mechanism.
- The State of Maryland is committed to actions and investments that address mitigation and adaptation.
- The MCAP and CCAP used modified tools and five-step approach provided by ICLEI. The CACP software was used for big picture emissions inventory efforts and a customized spreadsheet tool was used for tracking results.

- The Annapolis Comprehensive Plan incorporates some of the policies influenced by the MCAP and CCAP, primarily the Plan's Environmental Chapter 7. However, there should be more integration of CAP strategies.
- The City needs tore-establish the "green team" comprised of various City departments to coordinate implementation of the CAP.
- The 2007-2009 Scorecard indicates the municipal emissions are down 7% and community emissions are up 16%. The City is searching for ways to motivate the community to make the necessary personal changes to reduce emissions.

4.4.4 Boulder, CO

Community Profile

Boulder, CO had a population of approximately 92,000 in 2006 (US Census, 2010). The city is the location of University of Colorado Boulder campus. Boulder is located in the Central climatic region. The city has an average annual maximum temperature of 64.3° F, minimum average temperature of 38.2ºF, and 18.69" of precipitation (Western Climate Center, 2010). The community is 5,430 feet above sea level at the edge of the Southern Rockies and High-Plains eco-regions comprised of *"smooth to slightly irregular plains having a high percentage of cropland. Grama-buffalo grass is the potential natural vegetation in this region"* (EoE, 2008). Boulder has a council-manager form of government with nine city council members. The Council selects members as Mayor and Vice Mayor. The Commission appoints a City Manager (City of Boulder, 2010). The Governor of Colorado has prepared a climate action plan (2007) and included a "call to legislative action". Policy-working groups are discussing how to meet the goal of reducing GHG 20% by 2020 and 80% by 2050 (Rocky Mountain Climate Organization, 2010).

Motivation for Boulder Climate Action Plan

Boulder has a long tradition for comprehensive, sustainability, and environmental planning. It implemented the first green building code and the first local carbon tax in the United States in 2006 (Koehn, 2010). The mayor and city council took responsibility for pushing the CAP policy agenda, and voters supported their efforts with financing. City staff acknowledged the need for more discussion with the business community about the economic benefits of the green economy in terms of resiliency and job creation (Koehn, 2010).

Climate Adaptation Issues

The community is also concerned about adaptation-related environmental issues. Climate change will likely "diminish the snow pack, increase drought conditions, [increase] insect outbreaks … in the forests, impact habitat for native plants and animals, and have negative impact on the regional economy" (City of Boulder, 2006, p. 5). In September 2010, a large wildlands fire burned northwest of Boulder, destroying 135 homes and forcing 3,500 to evacuate (CBS/AP, 2010). Another fire in October forced 1,700 to evacuate (Pankratz, 2010).

Boulder Climate Action Plan Approach and Process

In 2002 the City signed on to the Mayors Climate Action Agreement and the City Council passed a resolution committing the community to emission targets established by the 1997 Kyoto Protocol (7% below 1990 GHG levels by 2012). Boulder's CAP process was driven by the City Council, which directed staff to prepare concurrent municipal and community emissions inventories and community advisory committees to prepare a draft CAP. After the CAP was prepared, the City continued to refine inventories, monitor progress and search for innovative ways to communicate, implement and finance CAP strategies.

A Community-Based Process

The community outreach and conversation about CAP strategies was driven by the City Council (Koehn, 2010). The CAP was developed with the assistance of appointed and standing advisory committees and experts. These included the Climate Action Plan Advisory Group, Environmental Advisory Committee, and contributing Climate Action Plan community strategists (City of Boulder, 2009, p. 2). The City Council adopted the plan in 2006, and voters support the plan's goals.

Boulder's 2006 Climate Action Plan introduction provides an overview of actions taken by the City to address climate change from 2002 to 2005 (City of Boulder, 2006, p. 4). The City completed the first emission inventory in 2004, and in 2005 Boulder County created the Sustainability Task Force to establish guiding principles for energy use and waste generation. The County passed two key resolutions that were later incorporated into the City of Boulder CAP: "Resolution Adopting a Sustainable Energy Path for Boulder County" and the "Resolution Adopting Zero Waste as a Guiding Principle and Supporting the Creation of a Zero Waste Plan" (City of Boulder, 2006, p. 4).

Key CAP Strategies

CAP includes six key strategies (City of Boulder, 2009, pp. 14-19):

- Reuse–retrofit existing buildings and replace appliances, promote energy conservation
- Build Better–maximize opportunities for energy efficiency in new buildings
- Ramp Up Renewables–promote renewable energy sources for individual buildings, and increase renewable energy sources in regional supply

- Travel Wise–increase percentage of trips via transit, biking and walking; use low-emission vehicles
- Waste Not–reduce and eliminate waste to landfills
- Grow Green–plant trees and protect the urban forest

Each of these CAP strategies, accomplishments and lessons are monitored and communicated by the City. The 2006 carbon tax supported the initial implementation of the CAP programs.

First Carbon Tax in the United States

In 2006 Boulder voters pass the first "carbon tax" in the Unites States (City of Boulder, 2010). Collected by the regional power company (Xcel Energy), the tax is for energy use for residential and commercial buildings, with monthly billings. Customers are not taxed for portions of their bill that are from Xcel's Windsource (wind energy) program. In 2009, the City "increased the rates to the maximums allowed by voters, to fund more extensive programming to accelerate community action to meet the climate action goal by 2012" (City of Boulder, 2010).

Branding ClimateSmart

The 2007 Progress Report outlines programs that had been initiated to meet the CAP's goals by 2012. The "ClimateSmart" branded programs are organized in three groups: ClimateSmart at Work, ClimateSmart at Home, and ClimateSmart on the Road (City of Boulder, 2008, p. 2). Several of the highlighted expanded or new programs in the Progress Report (City of Boulder, 2008, p. 3) included:

- Initiating carbon tax to implement the CAP
- Expanding commercial and residential energy audits
- Expanding energy efficiency programs (weatherization and florescent lighting) and green loan programs
- Focusing transportation programs on transit, fuel-efficiency and renewables
- Developing and launching "ClimateSmart" marketing and education efforts
- Forming the Climate Action Plan Advisory Group

Updated GHG Emission Inventory

In 2009, the City prepared an updated inventory to track progress. CAP review was organized into five sections: inventory, evaluation of current strategies and programs, metrics for results, programmatic recommendations, and summary (City of Boulder, 2009, p. TOC). The GHG inventory was done for both the community and City operations. Consultants worked with the community to update the business-as-usual (BAU) forecast through 2012 to inform policy options. The 2004 inventory was updated to reflect actual energy usage from 2003 to 2007. The inventory included seven sector and source categories (City of Boulder, 2009, p. 7):

- Residential Buildings
- Commercial Buildings
- Industrial Facilities
- Transportation
- Street Lighting
- Solid Waste
- University of Colorado

Supply-side Solutions

The CAP emphasizes energy efficiency and conservation measures for buildings and transportation. Approximately 74% of all local GHG emissions (in 2007) were from buildings and about 22% were from transportation (City of Boulder, 2009). The City was identifying and implementing strategies that focused on the *demand-side* of energy.

The 2008 assessments indicate GHG emissions were declining but not fast enough to meet 2012 targets. The gains by the community were on the *demand-side* of energy. Xcel Energy built one new coal-powered power plant that increased Boulder's coal-source energy from 56% to 65%, but the *supply-side* wiped out the CAPs gains. Despite Colorado's 30% RPS goal by 2020, the City was still held hostage by Xcel's coal-powered portfolio. The City Council made a tough decision to switch from an incentive-based to a regulatory approach to implementation to meet 2012 targets (Koehn, 2010). Also in 2009, the carbon tax was increased to the maximum allowed by the voters in 2009 and the City started to evaluate municipal power options for a referendum in fall of 2011 (Koehn, 2010).

The City is exploring ways to fund implementation of a municipal power program that uses renewable energy. The City is considering placing an energy tax on Xcel Energy that will replace a $4M/year income stream from rights-of-way franchises in the city that currently goes to the General Fund. Then, the City could broker a deal with Xcel to purchase green power and explore other ways to implement locally developed and distributed power (Koehn, 2010).

Social Mobilization

The City is focusing on education and communications to "socially mobilize" the community. Informing people about energy cost trends, related economic impacts and integrating more renewable energy with time-use pricing, make Boulder more economically resilient. This will be particularly important in partnering with the business community. Implementing the CAP will require an estimated $460 million of private sector investment leveraged by about $18 million in public investment. The City will strive to redefine sustainability as a business opportunity resulting in economic prosperity and equity (Koehn, 2010).

Boulder's State Policy Context

The Governor of Colorado's policy agenda emphasized a "new energy economy" to increase the state's capacity for renewable energy and enhance energy efficiency in a way that grows the economy (State of Colorado, 2010). Colorado's Climate Action Plan was completed in 2007 and is an integral part of the New Energy Economy.

Colorado's CAP

The Colorado CAP includes the state's emission profile, GHG reduction goals, strategies, initiatives, adaptation issues and call for legislative action (State of Colorado, 2007, p. 2). The state's emissions have been very near the U.S. profile, and the per capita GHG has remained the same between 1990 and 2005. Emissions have grown because the population has (State of Colorado, 2007, p. 9). The CAP establishes an emissions reduction goal of 20% below 2005 levels by 2020. This is 40% below the business-as-usual projection (State of Colorado, 2007, p. 10). The 2007 Colorado Climate Action Plan contains nine climate initiatives (State of Colorado, 2007, pp. 9-26):

- Agricultural offset market
- Transportation
- Electric energy
- Natural gas
- Solid waste and recycling
- Greenhouse gas emissions reporting
- Leading by example (LBE)
- The Western Climate Initiative

- Climate education and the new energy economy

State-Level Climate Adaptation Issues

The Colorado CAP includes adaptation planning regarding water and forests. Climate change "will amplify Colorado's water related challenges, such as smaller snowpacks, earlier snowmelt, more extreme flooding, greater evaporation, less groundwater, and more frequent droughts" (State of Colorado, 2007, p. 27). The CAP calls for comprehensive drought planning. Restoration and regeneration of forests is important for storing carbon, protecting habitat, and protecting watersheds. The plan recommends that biomass from thinning forests to reduce fire hazards can be added to the state's renewable energy solution (State of Colorado, 2007, p. 28).

Implementing Legislation

The Colorado CAP outlines desired federal and state legislation achievements regarding climate change, including developing a Renewable Portfolio Standards (RPS) of 20% by 2020 and other energy bills that provide incentives for renewable energy development, regulations for energy efficient buildings, and funding for research (State of Colorado, 2007, p. 32). The CAP recommended establishing a Gubernatorial Climate Advisory Panel to give feedback regarding CAP activities. The panel was established in 2008 (State of Colorado, 2007, p. 30).

Since the 2007 CAP was published, the state has enacted a number of bills regarding climate change and energy. In 2010, the Governor signed bills for renewable energy, new energy jobs, community-based renewable energy, and smart grid programs. Important state legislation regarding climate change includes:

- *March 2010 HB 1001 was signed mandating a Renewable Portfolio Standard for Colorado - - highest in U.S., 30% electricity to come from renewable sources by 2020*
- *On April 22, 2008, Governor Bill Ritter issued Executive Order D-004-08, which sets the state-wide greenhouse gas emissions goal at 20% below 2005 levels by 2020 and 80% below 2005 levels by 2050*
- *November 2007, Governor executive order directing Colorado's Air Quality Control Division to propose clean car standards* (Pew Center on Global Climate Change, 2010)

Colorado has a climate registry. The Pew Centre on Climate Change website describes a climate registry as follows:

The Climate Registry aims to develop a common system for entities to report greenhouse gas emissions. The Registry serves as a tool to measure, track, verify and publicly report greenhouse gas emissions consistently and transparently between states. Voluntary, market-based and regulatory greenhouse gas emissions reporting programs are all supported under the Registry. (Pew Center on Global Climate Change, 2010)

<u>CAP Tools Used by Boulder</u>

Boulder created customized tools to calculate GHG emissions, define the business-as-usual scenario, measure progress, and model the CAP strategy. The CAP was locally developed and informed (Koehn, 2010). The 2006 CAP included an inventory of GHG for both the city (as a municipal CAP) and the community. Local consultants developed the customized tools to assess the community CAP's emissions. WSP Environment and Energy was hired in 2004 to prepare the initial GHG inventory and later updated the inventory in 2008 (City of Boulder, 2009, p. 7). WSP used standard methodologies provided by the IPCC.

The IPCC's 2006 manual is organized in five volumes pertaining to: general guidance for reporting; energy, industrial processes, and products; agriculture, forestry and other lands; and waste (Intergovernmental Panel on Climate Change, 2010). The manual includes definitions and worksheets.

<u>Features in CAP Tools Used by Boulder</u>

Because the approach was customized for Boulder, it supported the CAP process inventory updates by testing and monitoring policies and strategies. The modelling could address both sources and sectors:

- *Sectors include residential buildings, commercial buildings, industrial facilities, transportation, street lighting, and solid waste*
- *Sectors were further broken down by energy sources (electricity, natural gas, coal, diesel, etc.) to inform policy and strategies*
- *Sources included vehicle fuel, landfill gas, natural gas, electricity and offsets* (City of Boulder, 2009, p. 7)

Modelling Boulder's Specific Programs

Modelling could address specific questions about the performance of individual programs. For example, the Climate Smart Loan program and transportation program penetration scenarios were measured for costs and benefits (City of Boulder, 2009, p. 3). In 2007, the City added University of Colorado GHG emissions after the University signed on to American College and University Presidents Climate Commitment to reduce their GHG emissions to zero at a future target year (City of Boulder, 2009, p. 7). The custom approach allowed the City to merge the campus and community strategies.

One of the challenges in the inventory process turned out to relying on Excel to provide data, which was not always aggregated in useful ways (Koehn, 2010).

Influence on Boulder's Urban Form

Boulder is in the process of updating its community plan. The existing plan was adopted in 2005 and updated in 2008. It emphasizes "growth through redevelopment" as a way of promoting infill and densification concepts. The Plan is organized in four chapters comprised of planning policies, amendment procedures, land use map descriptions, and plan implementation.

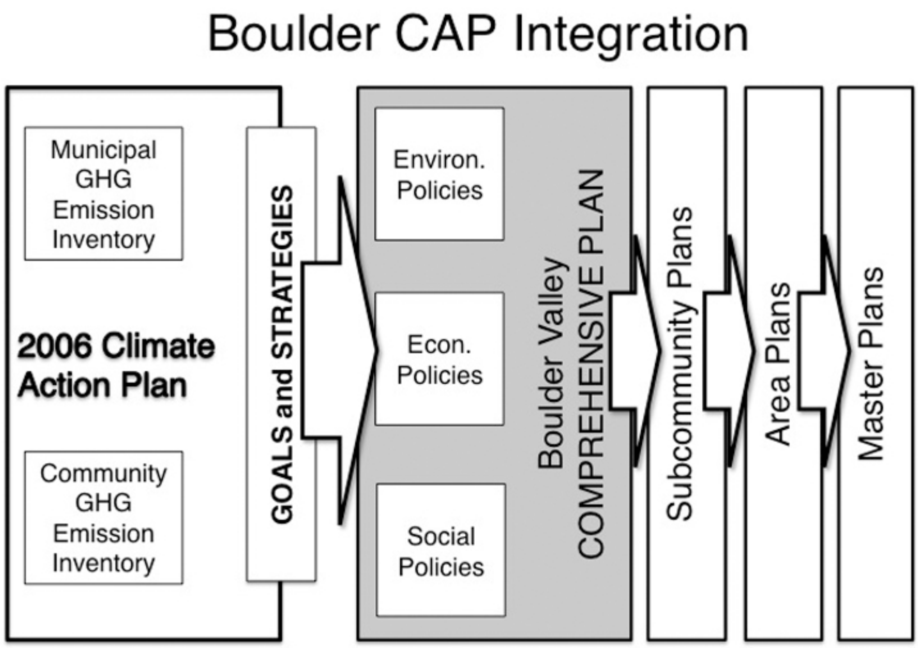
The existing Comprehensive Plan contains environmental policies emphasizing social, economic and environmental dimensions of sustainability. Supporting polices address community engagement and establishing sustainability indicators. The community planning system includes planning at four levels: Boulder Valley Comprehensive Plan, Subcommunity Plans, Area Plans, and Master Plans (City of Boulder, 2005-2008, pp. 6-7). Each level implements a refinement of policies (see Figure 4.7).

A Sustainable Underlay for New Comprehensive Plan

The CAP strategies are being integrated into comprehensive plan update – *Sustainable Boulder: Creating our Future* (City of Boulder, 2010)--that repackages the plan around the triple bottom line of environmental, economic, and social sustainability. The plan will have a "sustainable underlay" (Koehn, 2010). The October 2010 Community Design Briefing Paper emphasizes a sustainable urban form around five key principles emphasizing a community that is compact, connected, complete, green/attractive/distinct, and inclusive (City of Boulder, 2010, p. 1). In addition, analysis indicates the existing plan has more capacity for employment uses than for housing, potentially increasing housing prices and making the community less inclusive. The update proposes increasing housing in mixed-use development collocated with commercial and industrial uses (City of Boulder, 2010, p. 3).

Figure 4.7

Boulder CAP and Boulder Valley Comprehensive Plan Integration



<u>Summary</u>

- The political leadership in Boulder is committed to policies that address climate change and took the lead in developing a CAP.
- Boulder uses a voter-supported energy tax to implement the CAP.
- The Council had to address concerns over the CAP implementation with the business community.
- Boulder is concerned about global warming as it impacts other areas of the Rocky Mountains - - there were two large wildfires in Fall 2010.
- The City prepared the CAP utilizing community advisory committees.
- Colorado has a state CAP and adopted legislation regarding energy and green jobs.
- The MCAP and CCAP used customized approaches locally informed inventory tools, and technical support that met IPCC protocols.
- Updated GHG inventory motivated the community to use more regulations to meet goals, raise energy tax rates and explore a renewable municipal energy solution.

- The Boulder Valley Comprehensive Plan is being updated to reflect an emphasis on sustainability.

4.4.5 Berkeley, CA

Community Profile

Berkeley, CA had a population of approximately 102,000 in 2006 (US Census, 2010) and is the location of University of California Berkeley campus. The city is located in the West climatic region and has an average annual maximum temperature of 64.8° F, average minimum temperature of 49.3ºF, and 23.36" of precipitation (Western Region Climate Center, 2005). The community is located on San Francisco Bay where communities have "Land Vulnerable to Sea Level Rise" (BCDC, 2007). Berkeley is also located in an active seismic zone along the Hayward Fault. It is in the Southern and Central California Chaparral and Oak Woodlands eco-region, "the only Mediterranean climate shrubland in North America" (World Wildlife Fund, 2001). Berkeley has a council-manager form of government with eight city council members elected by district and an elected mayor. The Commission appoints a City Manager (City of Berkeley, 2010). The Governor of California signed Assembly Bill 32: Global Warming Solutions Act in 2006, directing the California Air Resources Board (CARB) to establish the mechanisms to comprehensively implement AB 32 by January 1, 2012 (State of California, 2010). Berkeley voters approved Measure G in 2006 with over 80% committing the city to reducing GHG to 80% below 1990 levels by 2050 (Burroughs, 2010).

Berkeley's Motivation for Preparing a Climate Action Plan

Berkeley is one of the first cities in the U.S. to form local policy regarding climate change and the first to have voters establish GHG emission targets. In 2006, citizens voted (with 81% support) to enact a local policy to reduce the entire community's GHG emissions 80% by 2050 (Burroughs, 2010).

Measure G language:

> *Should the People of the City of Berkeley have a goal of 80% reduction in greenhouse gas emissions by 2050 and advise the Mayor to work with the community to develop a plan for Council adoption in 2007, which sets a ten year emissions reduction target and identifies actions by the City and residents to achieve both the ten year target and the ultimate goal of 80% emissions reduction?* (City of Berkeley, 2006)

As with many coastal areas, Berkeley has concerns about rising sea levels and threats to coastal infrastructure. The city has witnessed serious wildland fires, such as the

1991 “firestorm” that burned over 3,300 housing units in Oakland and Berkeley (Captain Donald R. Parker, 1992). As the rest of California, the community will face increasing pressure on fresh water supplies resulting from the loss of the Sierra snowpack (City of Berkeley, 2009, p. 1).

Berkeley’s CAP Approach and Process

Over a two-year period, Berkeley sponsored Climate Action Workshops, community events and meetings, and media outreach via email, phone calls, and online forms. The Berkeley Office of Energy and Sustainable Development is coordinated by City staff as members of a cross-department “G-Team” (City of Berkeley, 2009, p. 4).

Community Outreach

The CAP process included extensive community outreach and participation. Several community and environmental organizations assisted in outreach. The kick-off community meeting in May 2007 included the following co-sponsors: “Mayor Tom Bates and the City of Berkeley, KyotoUSA, The Sierra Club, Sustainable Berkeley, Shotgun Players, The Ella Baker Centre for Human Rights, the Ecology Centre, Community Energy Services Corporation, StopWaste.Org, the Transportation and Land Use Coalition and more” (City of Berkeley, 2007).

After the initial meeting, the City prepared a community engagement plan that included the first round of seven community workshops. Outreach occurred through phonetrees, emails, and a website designed (www.BerkeleyClimateAction.org) specifically to support the CAP process. Other workshops sponsored by City commissions and community organizations took place in 2008. Two drafts of the CAP were taken to the City Council, and the final draft was adopted June 2, 2009 (City of Berkeley, 2009, pp. 5-6).

CAP Strategy Organization

The CAP strategies are organized in five parts: sustainable transportation and land use; building and energy use; waste reduction and recycling; community outreach and empowerment; and preparing of climate change impacts. Some key goals are requiring net-zero energy use for new construction by 2020; limiting use of wasteful product packaging; mobilizing residents to take action; working with state and regional partners to prepare for climate adaptation (City of Berkeley, 2009, pp. ES-5).

The Executive Summary of the CAP includes a seven-part Vision for the year 2050. This includes:

- *New and existing Berkeley buildings achieve zero net energy consumption through increased energy efficiency and a shift to renewable energy sources such as solar and wind.*
- *Public transit, walking, cycling, and other sustainable mobility modes are the primary means of transportation for Berkeley residents and visitors.*
- *Personal vehicles run on electricity produced from renewable sources or other low-carbon fuels.*
- *Zero waste is sent to landfills.*
- *The majority of food consumed in Berkeley is produced locally, i.e., within a few hundred miles.*
- *Our community is resilient and prepared for the impacts of global warming.*
- *The social and economic benefits of the climate protection effort are shared across the community.* (City of Berkeley, 2009, pp. ES-2)

Berkeley's State Policy Context

California has a variety of climate and energy legislation that has influenced how local government plans. Key legislation regarding climate change includes AB 32, SB 375, and SB 97.

AB 32 The Global Warming Solutions Act of 2006

Berkeley prepared the CAP before The Global Warming Solutions Act of 2006 (Assembly Bill 32), which requires California to reduce GHG to 1990 levels by 2020. AB 32 makes the California Air Resources Board (CARB) responsible for monitoring and reducing GHG (State of California, 2008, pp. ES-1). The CARB has prepared a Scoping Plan containing key strategies for reducing GHG emissions that performs as the CAP for California. The AB 32 Scoping Plan requires local governments to be "15% below today's levels by 2020 to ensure that their municipal and community-wide emissions match the State's reduction targets" (State of California, 2008, pp. ES-5).

AB 375--Regional and Local Planning

In 2008, the governor signed SB 375 creating a process for local governments and their regional partners to collaborate to reduce GHG emissions through "integrated development patterns, improved transportation planning, and other transportation measures and policies" (State of California, 2008, p. 27). The CARB is to work with Metropolitan Planning Organizations (MPOs) to establish GHG targets for reducing emissions from cars and light trucks, which are the source of 31% of California's GHG emissions. The federal government makes MPO's responsible for preparing regional transportation plans. To accomplish GHG emissions targets, MPOs now have a responsibility to support sustainable and energy-efficient regional frameworks (State of California, 2008, pp. 47-48).

SB 97--Required Environmental Review

SB 97 was signed by the governor in 2007 and requires GHG be subject to the California Environmental Quality Act (CEQA) (State of California, 2007). In 2009 the Governor's Office of Planning and Research (OPR) recommended amendments to the State CEQA Guidelines to include GHG emissions. Projects are now evaluated for their GHG impacts, and mitigation actions are identified through the CEQA process. The CARB identifies the threshold for "significance" establishing the need to mitigate impacts (City of Berkeley, 2009, p. 7).

Other Legislation

In addition to AB 32, SB 375 and SB 97, other legislation that less directly influences how CAPs are prepared and what goals should be met. Beginning in the 2009 model year, AB 1493 established new vehicle standards that lower GHG and require 22% reduction by 2012 and 30% by 2016 (California Air Resources Board, 2010). SB 107 requires investor-owned utilities to implement a Renewables Portfolio Standard (RPS) with 22% renewable sources for electrical power generation by 2010 (California Public Utilities Commission, 2007). Governor Schwarzenegger called for a 33% RPS by 2020 (State of California, 2009). In 2008 the Governor issued an executive order (S-13-08) directing state agencies to prepare a Climate Adaptation Strategy (CAS) to be led by the California Resource Agency addressing climate change impacts such as sea level rise, warmer temperatures, shifting precipitation, and extreme weather events (State of California, 2008).

Climate Registry

California has a Climate Registry and Mandatory Reporting (The Climate Registry, 2009). The California Registry was created in 2001 as a voluntary way of reporting GHG. In 2008, it became mandatory through The California Climate Action Registry (CCAR) and The California Air Resource Board's Mandatory Reporting Program. The reporting program includes reporting tools and training.

The program affects:

> *"businesses and public agencies, include operators of power plants, cogeneration facilities, cement plants, refineries, hydrogen plants, retail providers and marketers of electricity, and general stationary combustion facilities emitting 25,000 metric tons of carbon dioxide in a calendar year".* (California Air Resources Board, 2010)

CAP Tools Used by Berkeley

The 2005 GHG inventory for Berkeley was prepared using ICLEI's – Local Governments for Sustainability software. ICLEI's methodology standardizes methods of calculating GHG emissions.

> "*The emissions study, which was conducted by ICLEI Local Governments for Sustainability – collected and analysed data from PG&E, the Metropolitan Transportation Commission, the Bay Area Air Quality Management District, the City of Berkeley and other sources to determine emissions relating to all electricity, natural gas, and transportation in the City.*" (City of Berkeley, 2007)

Starting with ICEI and then Developing Customized Tools

The ICLEI Climate Air and Climate Protection (CACP) software creates GHG emissions inventories for the community and/or for the government's operations. The software helps quantify the performance of both existing and proposed emissions. It measures proposed in CAP strategies, helps inform GHG reduction targets and tracks progress. ICLEI partnered with the California Air Resources Board and the California Climate Action Registry in 2008 to develop Local Government Operating Procedures (LGOP) identifying standard methods and data requirements (ICLEI Local Governments for Sustainability, 2010).

Since the initial ICLEI inventory, the City has designed its own spreadsheets to model and track emissions to provided more control over data and its presentation. ICLEI CACP software was considered too much of a "black box" because assumptions are buried in the software and it cannot be modified to reflect the city's actions and policies. City staff felt the newer web-based ICLEI tools are an improvement and the software is good for smaller communities without staff resources (Burroughs, 2010).

Communications Web Software

Implementing the CAP now has moved into a new phase where communicating progress is a high priority. Berkeley is using data representation software called "SEE-IT" by Communication Strategies Company. The software helps measure and communicates performance, helping make the connection between long-term goals and current actions (Visible Stratgies, 2009).

Features in Berkeley's CAP Tools

ICLEI software provides categories of input for both municipal and community emissions. For municipal, it includes buildings, streetlights, water/sewer, vehicle fleet, and employee commuting. For community emissions, CACP uses seven categories, including residential, commercial, industrial, transportation, waster, and other. Customized tools were prepared to better reflect Berkeley's strategies, and staff developed more transparent spreadsheets that measure progress on specific strategies (Burroughs, 2010).

Influence on Berkeley's Urban Form

The CAP recommendations reinforce many of the City's existing planning policies and initiatives. These include increasing density around BART (transit) stations and along transit corridors, such as San Pablo Avenue and University Avenue. An active, vocal minority of residents have fought density, but the CAP process and recommendations have provided added motivation and political momentum to increase densities around transit (Burroughs, 2010).

Reinforcing Smart Growth Policies

Key recommendations from the CAP are consistent with Berkeley's General Plan, area plans, and mobility planning (see Figure 4.8). CAP strategies address key sectors of GHG emission sources identified in the 2005 inventory (26% residential, 27% commercial, and 47% transportation). Strategies target reduction in sources where gasoline is the leading source of GHG (29% in 2005), including sustainable transportation and land use planning.

Three key CAP sustainable land use and transportation strategies include:

- *Smart growth--walkability, biking and transit supporting design and densities*
- *Improved safety, reliability and frequency of public transit*
- *Pricing strategies for parking, fuel, auto ownership, etc.* (City of Berkeley, 2009, pp. 18-19)

Actions for sustainable transportation and land use include 10 goals:

- *Goal 1: Increase density along transit corridors*
- *Goal 2: Increase and enhance urban green and open space, including local food production, to improve the health and quality of life for residents, protect biodiversity, conserve natural resources, and foster walking and cycling*
- *Goal 3: Manage parking more effectively to minimize driving demand and to encourage and support alternatives to driving*
- *Goal 4: Identify opportunities for generating sustained revenue for implementing community transportation demand management programs*
- *Goal 5: Accelerate Implementation of the City's Bicycle & Pedestrian Plan*
- *Goal 6: Make public transit more frequent, reliable, integrated and accessible*

- *Goal 7: Enhance and expand car sharing and ridesharing programs*
- *Goal 8: Encourage the use of low-carbon vehicles and fuels*
- *Goal 9: Enhance and expand outreach, marketing and education regarding land use and transportation*
- *Goal 10: Green the vehicle fleet used by the City government and increase alternative transportation options for employees of public institutions* (City of Berkeley, 2009, pp. 25-53)

Actions for building energy use strategies include seven goals:

- *Goal 1: Make green building business as usual in the new construction & remodel market*
- *Goal 2: Enhance energy services and standards and reduce costs of energy upgrades for existing residential properties*
- *Goal 3: Enhance Energy Services and Standards for Existing Commercial Properties*
- *Goal 4: Increase residential and commercial renewable energy use*
- *Goal 5: Increase Energy Efficiency and Renewable Energy Use in Public Buildings*
- *Goal 6: Enhance and expand marketing, outreach and education regarding building energy use*
- *Goal 7: Prepare local residents for green collar job opportunities* (City of Berkeley, 2009, pp. 57-85)

Actions for waste reduction and recycling include seven goals:

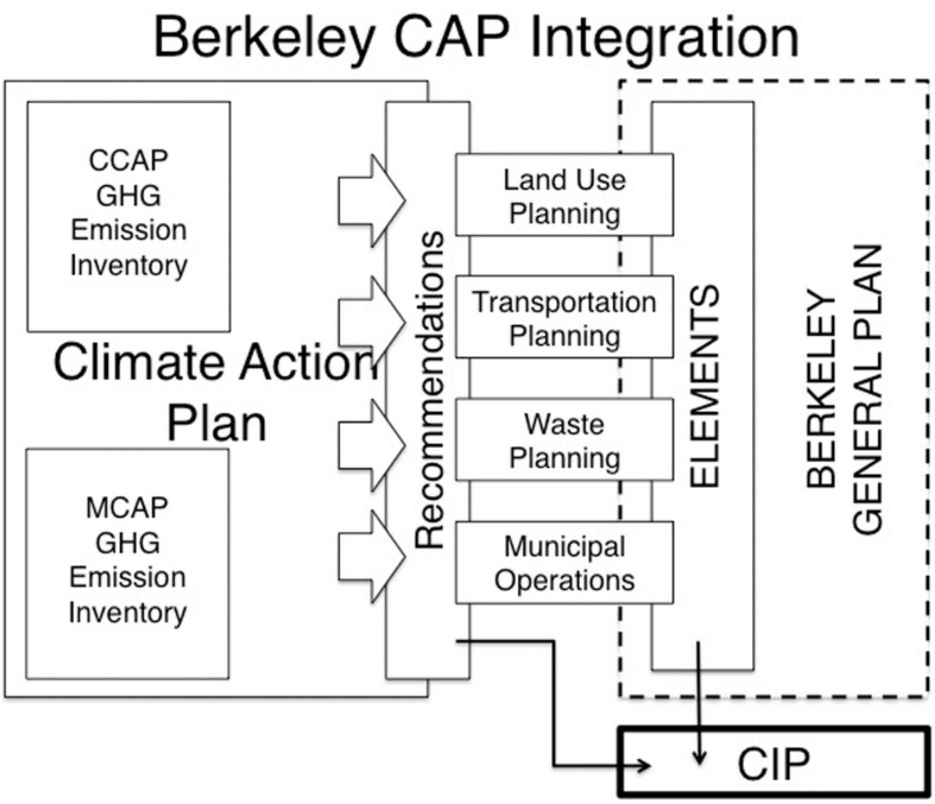
- *Goal 1: Increase residential recycling, composting, and source reduction*
- *Goal 2: Increase recycling, composting & waste reduction in the commercial sector*
- *Goal 3: Increase recycling of construction & demolition (C&D) debris*
- *Goal 4: Expand local capacity to process recycled materials*
- *Goal 5: Expand efforts to eliminate waste at its source*
- *Goal 6: Revise the City solid waste disposal rate structure in order to maintain and enhance incentives, outreach programs and other activities designed to increase waste diversion*
- *Goal 7: Increase recycling, composting, and waste reduction in public institutions*
- *Goal 8: Enhance and expand marketing, outreach, and education regarding waste reduction and recycling* (City of Berkeley, 2009, pp. 90-100)

Climate Adaptation

The CAP identifies actions for climate adaptation with a focus on making Berkeley more resilient to the impacts of climate change. The city must contend with natural hazards that can be amplified by climate change. The city is located on a coastal bay and susceptible to sea level rise; drought and rising temperatures will cause concern for wildfires; and the city is located on the Hayward Fault where earthquakes can cause liquefaction of shore areas and fires. Shrinking snow packs in the Sierra supply much of San Francisco Bay Area's drinking water. The Climate Change Centre predicts the snow pack will decrease by as much as 90% by the end of the century, greatly impacting water supply and hydroelectric power (City of Berkeley, 2009, pp. 102-105).

Figure 4.8

Berkeley CAP and General Plan Integration



Summary

- Community-supported Prop. G directed the City to prepare a plan to reduce the community's GHG emission to 80% below 1990 levels by 2050.
- Political leadership in Berkeley has a tradition of advocacy policymaking and a commitment to environmental and equity issues.
- The Mayor and City Council instigated preparation of a CAP and supported a comprehensive participation program with City commissions and the community.

- Berkeley is concerned about global warming as it impacts other areas of the San Francisco Bay through drought, wildfires, and sea level rise.
- Berkeley prepared a CAP working with ICLEI and used their software to prepare the initial emissions inventory.
- The City developed its own spreadsheet GHG tools customized for measuring and monitoring progress around specific strategies.
- The City is using software that supports communication of, and commenting on GHG emissions progress.
- California has comprehensive legislation regarding emission targets, regional planning for GHG emission reductions, RPS and mandatory reporting through the Climate Registry.
- The CAP strategies reinforce land use and transportation planning policies that lower dependence on automobiles.
- Berkeley will expect new construction to be carbon-neutral by 2020.

4.4.6 Portland, OR

Community Profile

Portland, OR had a population of approximately 537,000 in 2006 (U.S. Census Bureau, 2010) and is the location of Portland State University and several other colleges. It is located on the Columbia River at the north end of the Willamette Valley at an elevation of 50 feet. It is in the Northwest climatic region. The city has an average annual maximum temperature of 62.6º F, average minimum temperature of 46.4ºF, and 42.68" of precipitation (Western Regional Climate Center, 2005). The community is in the Willamette Valley eco-region located between the Cascades and Coast Range. The Willamette Valley eco-region is characterized by terraces and flood plains, foothills, and scatter buttes (EoE, 2009). Portland has a city commission form of government with five city commissioners and an elected mayor. The commissioners oversee the bureaus that manage the daily operations in the city with the help of an elected auditor. The City and Multnomah County are part of the Portland Metropolitan Region, where an elected regional government called Metro provides oversight on regional planning (Metro, 2010). The Oregon Strategy for Green House Gas Reductions (2004) has GHG reduction targets of stabilization by 2010, 10% below 1990 by 2020, and 75% below 1990 by 2050. These recommendations were implemented by HB3543 in 2007 and formed a Global Warming Commission responsible for making recommendations for meeting targets (State of Oregon, 2007).

Portland's Motivation for Preparing a Climate Action Plan

Portland was selected as the most sustainable of the largest 50 cities in the U.S. by SustaianLane (SustainLane, 2010). This recognition reflects Portland's long tradition for sustainable and smart growth planning. Over 20 years ago, the State of Oregon and Portland connected policies with scientific evidence of climate change and treated it as part of a larger sustainability challenge. Oregon established carbon reduction goals in 1989 and a carbon reduction strategy in 1993. In the 2000s, the city began focusing on climate change mitigation. To better coordinate climate change mitigation and planning, the City merged planning and sustainability functions into a single department called the Bureau of Planning and Sustainability (Anderson, 2010).

Portland's Climate Action Plan Approach and Process

Portland's CAP has emerged from a continuum of sustainability planning. The city engaged the community to help motivate and inform them about the benefits and personal strategies required to reduce GHG emissions. Finally, the CAP documentation is organized to both track progress and communicate strategies.

Continual Progress

Portland's 2009 CAP came out of a long process of state, regional, county and city-level climate change policies and actions. In 1989, Oregon's legislature established a statewide carbon reduction goal, and in 1993 the City of Portland established its own GHG emissions reduction strategy. In 2001 Portland and Multnomah County prepared an Action Plan on Global Warming, and in 2005 Portland signed onto the U.S. Mayors Climate Protection Agreement. Oregon prepared a Strategy for GHG Reduction in 2005, and Multnomuh County joins Cool Counties Initiative in 2007. In 2008 Metro passed a resolution to develop a regional CAP. By 2008 GHG emissions in Multnomuh County were 1% below 1990 levels with a goal for Portland/Multnomuh County to be 10% below 1990 levels by 2010. In 2009 Portland completed its CAP in 2009 (City of Portland, 2009, pp. 4-5).

A Community-Based Process

The 2009 CAP builds on plans adopted in 1993 and 2001. A steering committee and technical working groups developed the CAP in 2007 and 2008 and took the draft CAP to the public in 2009 for their added input. Over 400 people attended eight town hall meetings. In addition to meetings with residents, businesses and community organizations, a project website generated further comments. Feedback expressed broad support for the direction of the CAP and a desire to make resources available to implement the plan (City of Portland, 2009, p. 24).

CAP Organization and 2030 Objectives

The core of the CAP focused on communicating 2030 objectives and the 2012 actions required to reach them (City of Portland, 2009, pp. 30-58). The CAP is organized as 18 objectives in eight categories:

- Buildings and Energy–reduce energy use 25% for buildings constructed before 2010, have new buildings achieve net zero GHG emissions, produce 10% of energy locally, and ensure new and remodelled buildings can adapt to climate change.

- Urban Form and Mobility–create neighbourhoods where 90% of city and 80% of county residents can walk or bicycle to access their daily needs, reduce VMT by 30% below 2008 levels, increase efficiency of freight movement, increase average fuel efficiency to 40 MPG, and reduce lifecycle transportation GHG emissions 20%.
- Consumption and Solid Waste–reduce solid waste by 25%, recover 90% of all waste generated, and reduce GHG emission from waste by 40%.
- Urban Forestry and Natural Systems–increase tree canopy to cover one-third of Portland and 50% of streams.
- Food and Agriculture–reduce consumption of GHG-intensive food, and increase consumption of locally grown food.
- Community Engagement–motivate city and county residents to reduce their personal GHG emissions.
- Climate Change Preparation–successfully adapt to changing climate.
- Local Government Operations–reduce GHG emissions from government operations 50% below 1990 levels.

Portland's State Policy Context

Oregon adopted state legislation with carbon reduction goals in 1989 and prepared the Oregon Strategy for GHG Reduction in 2005. The State also has an RPS of 25% by 2025 and an Oregon emissions target of 10% below 1990 by 2020 (Pew Center on Global Climate Change, 2009). These state-level targets have added impact on local government because Oregon's regional planning and growth management framework can support a more comprehensive approach to implementation. This gives cities greater incentive to implement infill and smart growth projects (Anderson, 2010).

Oregon's CAP

In 2004, the Governor's Advisory Group on Global Warming recommendation was published in the Oregon Strategy for Greenhouse Gas Reduction. Strategies supported of four broad strategies:

> *1. Invest in energy, land use and materials efficiency.*
> *2. Replace greenhouse gas-emitting energy resources with cleaner technologies.*
> *3. Increase biological sequestration (farm and forest carbon capture and storage).*
> *4. Promote and support education, research and technology development.*
> (State of Oregon, 2004, p. iii)

Strategies were organized in seven action areas, including integrating actions; energy efficiency; electric generation and supply; transportation; biological sequestration; materials use, recovery, and waste disposal; and state government operations (State of Oregon, 2004, p. iv). The Advisory Group's recommended emission targets were included in follow-up legislation HB 3543.

GHG Target for and Research Capacity for Oregon

In 2007, Oregon's governor signed House Bill 3543, which sets a target of 10% below 1990 GHG emission levels by 2020 and 75% below 1990 levels by 2050 (State of Oregon, 2007). The legislature created the Oregon Climate Change Research Institute (OCCRI). Located at Oregon State University, OCCRI is affiliated with over 100 researchers in other northwester universities and federal laboratories. The institute prepares regional climate predictions and the *Oregon Climate Assessment Report* identifying threats to the state (Oregon Climate Change Research Institue, 2010).

<u>CAP Tools Used by Portland</u>

Portland's GHG credits ICLEI for tools and methods:

> *In general, the methodology follows guidelines developed by ICLEI — Local Governments for Sustainability and uses the Clean Air and Climate Protection software developed jointly by ICLEI and STAPPA/ALAPCO. The inventory presented here is not intended to account for or assert ownership of emissions or emissions reductions, but rather to serve as an aggregate indicator of emissions trends. As best practices for community emissions inventories evolve, Portland and Multnomah County expect to participate in these discussions and strive to apply the most credible methodology possible given the available data.* (City of Portland, 2009, p. 65)

Portland staff said the city was using its own customized framework for tracking GHG emissions (Anderson, 2010). ICLEI's website discusses some of the issues their tracking software encountered:

> *The ICLEI tracking software has been very helpful in this project. However, some challenges have been encountered in the measurement of emissions for Portland and Multnomah County. Data must be consistently available from 1990 through the present. At times those data may not accurately represent emissions for these particular geographic areas. For example, no VMT data is available for Multnomah County alone, only for the larger metropolitan region. On the other hand, the city's decision to use fuel sales data instead may leave out emissions from fuel purchased outside the county but used in the county.*
> (ICLEI, 2008)

Features in Portland’s CAP Tools

The GHG inventory in the 2009 CAP includes emissions from electricity, natural gas, fuel oil, propane, gasoline, diesel, and solid waste disposal. Portland Gas and Electric (PGE) and Pacific Power (PP) “provided data on the number of kilowatt-hours (kWh) sold to residential, commercial and industrial customers… PGE and PP provided data on the kWh of green power sold to customers in Oregon” (City of Portland, 2009, p. 66). The emissions inventory assigns only local sources, not diesel and gasoline used by international or national freight (i.e., port activities), agricultural energy use, sequestration by urban forests, industrial emissions from goods manufactured elsewhere, or offsets (City of Portland, 2009, pp. 65-66).

Going forward, one key focus area for tools is making sure they represent the most up-to-date knowledge about the science of GHG emissions and climate change (Anderson, 2010).

Influence on Portland’s Urban Form

Portland exists within a very comprehensive statewide, regional and community policy framework including state and regional plans. Portland’s growth management boundary was established in the 1970s and contains over 400 square miles and 1.3 million people. Metro, created by the vote of the people in 1977, manages the growth boundary (Metro, 2010).

Merging Sustainability and Comprehensive Planning

The City of Portland has a progressive reputation for sustainable planning, zoning regulations, staffing, and programs, and their planning department program is a best practice leader. Now called the Portland Bureau of Planning and Sustainability (BPS), the department manages the integration of sustainability and urban planning activities. BPS approaches land use planning and development based on sustainability principles and practices (City of Portland, 2010).

The Portland Plan

Portland is currently updating its 25-year-old comprehensive plan, using a visioning planning step as a venue for community engagement. The Portland *Community Visioning Project: visionPDX* began in 2005 and has engaged over 17,000 people (City of Portland, 2010). This effort has now become the basis for a strategic plan called the Portland Plan.

The Portland Plan Community Involvement Committee is leading the Portland Plan process. The plan is going through a four-step process involving analysis, setting the direction, strategies, and draft plan review. The Portland (strategic) Plan will be implemented through updating The Comprehensive Plan, Central City 2035 and Quick Starts (short-term) projects (see Figure 4.9).

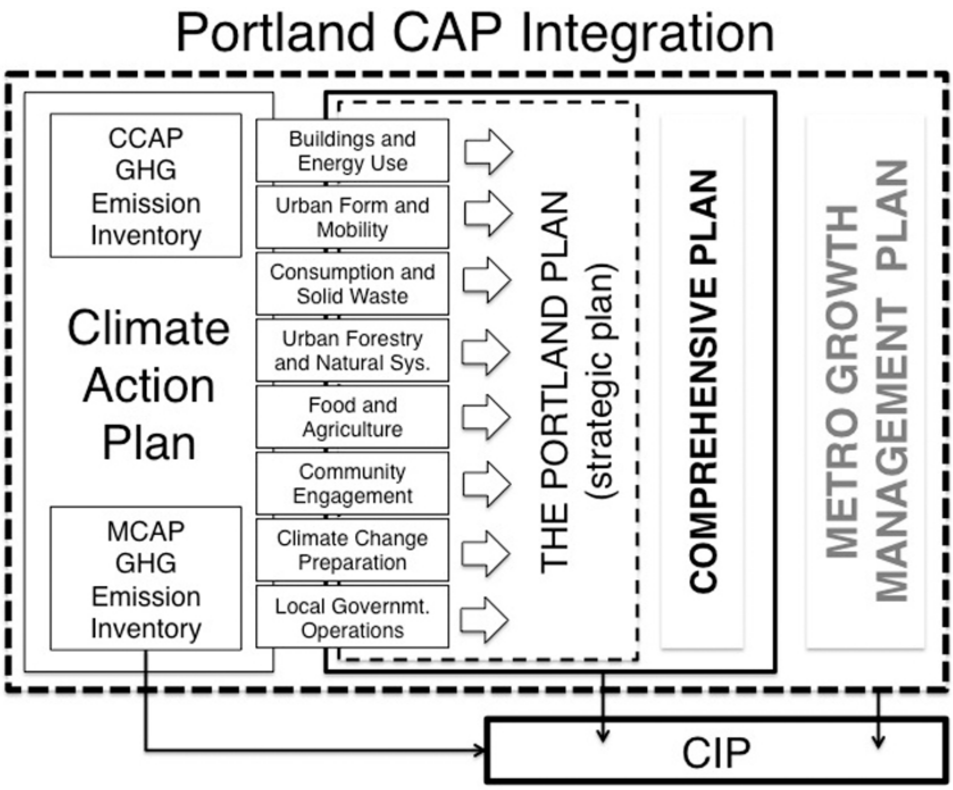
One key recommendation in the CAP is to have 90% of residents in Portland live within 20-minute walk and bike access to their daily needs. The 20-Minute Complete Neighbourhood Concept focuses on creating neighbourhoods with destinations within a walkable proximity. This includes grocery stores and other commercial services, transit stops, open space, and schools. The planning emphasizes creating a quality-walking environment with pedestrian facilities and a high density of intersections (City of Portland, 2009, p. 40). Combined with the region's growth management containment, the 20-minute neighbourhood emphasizes sustainable, quality infill.

Portland's CAP stresses reforestation of the region's watersheds as part of the climate adaptation strategy. It calls for 50% tree canopy coverage over creeks and one-third tree canopy over the city. The planning "strengthen[s] the capacity of natural systems to respond to more severe weather events" (City of Portland, 2009, p. 57).

The CAP is being fully integrated into comprehensive planning, shifting the focus at the local and regional scales and shifted the focus away from traditional zoning and urban design approaches (Anderson, 2010).

Figure 4.9

Portland CAP and Comprehensive Plan Integration



Summary

- Portland established its first carbon reduction strategy in 1993.
- The city is the urban core for a managed growth region (Metro) with a reputation for sustainable planning.
- Portland prepared a CAP working with ICLEI and used their software to prepare the initial emissions inventory.
- Metro has customized GHG tools for measuring and monitoring progress around specific strategies.
- The City is using a strategic planning process for community engagement. The process integrates CAP sustainability and GHG emission goals to inform the comprehensive plan update.
- Oregon is an early adopter of GHG emission legislation and planning and has set an aggressive goal of being 75% below 1990 GHG emission levels.
- Portland's CAP and strategic plan emphasizes "20-minute neighbourhoods" where walking is the primary mode of travel.

- Portland has a goal to reduce energy use 25% for buildings constructed before 2010 and have new buildings meet net zero GHG emissions targets by 2030.

4.4.7 Austin, TX

Community Profile

Austin, TX had a population of approximately 710,000 in 2006 (US Census Bureau, 2010) and is the location of the University of Texas. Austin is located in the South climatic region at an elevation of 658 feet and has an average annual maximum temperature of 78.9º F, average minimum temperature of 58.0ºF, and 33.65" of precipitation (NOAA, 2004). The community is in the Texas Blacklands Prairie eco-region between the Edwards Plateau and East Central Texas Plains ecoregions. The Texas Blacklands Prairie is characterized by tall grasslands and woodlands and forest along creeks (EoE, 2008). Austin has a mayor-council form of government with seven members of the city council (one mayor and six council persons) elected in staggered three-year terms. Texas is one of the few states that without climate change policies; however, in 2005 Governor Rick Perry signed SB 2005, 20 (an expansion of a 1999 bill) that greatly increased the use of renewable energy sources (Renewable Portfolio Standards or RPS) for generating electricity (Pew Center on Global Climate Change, 2010).

Austin's Motivation for Preparing a Climate Action Plan

The Austin Climate Protection Plan (CPP) was announced by Mayor Will Wynn and adopted by the City Council in February 2007. The motivation for preparing the CAP came from leadership that had a longstanding commitment to sustainability. Former Mayor Will Wynn served as Chairman of Austin Energy, the nation's 9th largest community-owned electric utility. He pushed for green building and energy programs and development of a climate action plan (Matthews, 2010).

Austin's municipal energy company, Austin Energy (AE), is a publicly owned company and a city department. AE serves 388,000 customers and a population of more than 900,000 within the Austin metro area (Austin Energy, 2010). AE has a diverse electrical power generation mix including nuclear, coal, natural gas, and renewable sources, primarily from wind and landfill gas. AE has the top performing renewable energy program in the U.S. Renewable sources are (National Renewable Energy Laboratory, 2010).

Austin's Climate Protection Plan Approach and Process

Austin has followed through on its commitment from a policy and program perspective. The Austin Climate Protection Plan (CPP) ordinance provides overall objectives and structure. The community and City are mobilizing to plan and implement the CPP's strategies.

Austin Climate Protection Plan Ordinance

In 2007, the City Council passed a resolution to action in five areas: a municipal plan, utility plan, homes and buildings, community plan, and "go neutral" plan. The first initiative focuses on reducing emissions from City operations, vehicles, and buildings. Every City department is to have a plan and become carbon neutral by 2020. The second initiative is to make Austin Energy the leading public utility in the country for reduced emissions from existing power plants and renewable sources. The third initiative expands Austin's green building program to have all new buildings and upgrades to existing buildings respond to code requirements for increasing efficiencies. The fourth initiative creates a City Climate Action Team that inventories and monitors GHG and identifies communitywide strategies for citizens and businesses. Finally, Austin's CPP provides technical assistance to the community in measuring and reducing their carbon footprints (City of Austin, 2007).

Climate Action Team

City staff from many of the City departments serve on the Climate Action Team responsible for reducing GHG emissions from government operations. Representatives from 10 departments have been meeting approximately six times per year. Their plans include a wide variety of efficiency actions from creating flexible work schedules and recycling, to creating city fleet running on alternative renewable fuels (City of Austin, 2008).

Municipal and Travis County Community Emissions Inventory

Austin Energy took the lead in preparing the CPP. They organized the GHG emissions inventory by the City of Austin Municipal Operations Inventory and Travis County Community Inventory. The municipal operations include part of the scope power plants, landfills, government fleets, building heating, stationary generators, air conditioning refrigerants, wastewater treatment, City building electricity, Austin Water Utility electricity, streetlights and traffic signals, waste from City buildings, and personal vehicles for public use (City of Austin, 2008, pp. 67-68). Travis County community

GHG emissions were categorized by commercial electricity, residential electricity, industrial electricity, residential natural gas, commercial natural gas, and industrial natural gas (City of Austin, 2008, p. 68).

Supply-Side Opportunity

The Austin CPP GHG emission inventories were prepared for both Austin Municipal Operations and community GHG emission for Travis County. Travis County per capita carbon emissions are 14MT CO^2 compared to the U.S. average of 20 MT CO^2 and 27 MT CO^2 for Texas (City of Austin, 2007, p. 18). The smaller carbon footprint reflects Austin has its own municipal energy company and can create and implement targets for both energy supply and demand, an advantage they fully leverage by generating or purchasing green power. AE has a goal of 30% renewable resources by 2020 and is already using biomass, wind and solar (City of Austin, 2007, p. 19).

Leading Partner in The Climate Registry

Austin participated in the developing the local government protocol for The Climate Registry (TCR). Using the Beta of TCR's Local Government Protocol reporting software, the CPP staff worked with other communities to prepare a reporting protocol to complement it. This effort supports Austin's voluntary cap and reduction plan. This is assumed to be an interim approach until a federal cap-and-trade bill is passed and mandatory GHG emissions standards are established (City of Austin, 2007, p. 18).

Demand-Side Strategies

The CPP has an energy efficiency goal of offsetting 800 megawatts of peak demand by 2020 (Austin Energy, 2010). Austin's CPP strategies for municipal operations and the community include a considerable effort to conserve energy. The CPP creates goals for existing and new buildings and supports those goals with mandatory audit requirements for single-family housing (at time-of-sale), multifamily housing and commercial properties.

For municipal building energy efficiency, Austin uses AE's GreenChoice program's emission-free power. For commercial and residential buildings, the City has a green building code program with increasing energy efficiency requirements. Using the International Energy Conservation Code, houses will eventually be "zero energy capable," meaning they will generate as much energy as they use over a year (City of Austin, 2007, p. 22).

Austin's State Policy Context

The Texas economy has a strong connection to oil and natural gas production. In 2002, they provided 17% of all U.S. oil and 30% of all natural gas (University of Texas, 2003, p. 2). The petroleum industry in Texas provided nearly 1.8M jobs in 2007. (CoopersPriceWaterhouse, 2009, p. 3)

Austin is in an Anti-Climate Change Policy State

Texas is one of 14 states without climate change legislation or a CAP and has worked to impede the progress of other states. The State of Texas has "filed seven lawsuits against the EPA, and its members of Congress want to check the EPA's efforts to curb greenhouse gases" (Los Angeles Times, 2010). Two Texas oil companies (Valero Energy Inc. and Tesoro Corp.) have actively lobbied against legislation in California contributing over $2M in support of a ballot measure that "requires the state to abandon implementation of comprehensive greenhouse-gas-reduction program that includes increased renewable energy and cleaner fuel requirements, and mandatory emission reporting and fee requirements for major polluters such as power plants and oil refineries, until suspension is lifted." This was intended to reverse AB32, which limits GHG from automobiles and refineries, and requires one-third of the state's energy come from renewable sources by 2020. The same companies are mounting a campaign against similar House legislation in Washington DC modelled after California's law (Los Angeles Times, 2010).

RPS Legislation

Texas established an RPS in 1990 and updated it in 2005 with Senate Bill 20, establishing an RPS goal of 5,880 MW by 2015. The Texas Legislature also established a goal for the amount of wind power, solar power and other forms of renewable energy to 5,880 MW, or about 5% of the state's electricity, from renewable energy by 2015. Plus, 500 MW must come from renewable energy sources other than wind (New Rules Project, 2009).

CAP Tools Used by Austin

AE and CPP staff developed their own software tools to prepare the GHG emissions inventory. These cutting-edge tools helped inform development of government operations and community emissions reporting protocols. The community inventory required extensive collaboration and a variety of tools matching the scope of sources.

Locally Developed and Shared Protocols for Government Operations

The CPP staff participated in developing the emissions reporting protocol to be used by all local government members of The Climate Registry, an international greenhouse gas reporting body. Austin is the first local government to report its municipal operations GHG inventory to TCR (Matthews, 2010). The city also beta tested TCR's Local Government Operations Protocol and reporting software (City of Austin, 2008, p. 18). CPP collaborated with TCR and other local government representatives to design a community-based reporting protocol to work with the protocols for local government operations (City of Austin, 2008, p. 18).

Travis County Community Inventory

GHG community inventories for Travis County included direct and indirect sources and required extensive data collection in collaboration with business and research.

- *Energy data was collected from: Austin Energy, Bluebonnet Electric Cooperative, Pedernales Electric Cooperative, and Texas Gas Service*
- *On-road vehicle emissions [were] provided by the Capital Area Metropolitan Planning Organization (CAMPO) using EPA Mobile 6 emissions model results*
- *Off-road equipment emissions were provided by the Texas Commission on Environmental Quality (TCEQ)*
- *Train emissions were estimated based on passenger and freight train mileage data provided by CAMPO*
- *Air travel emissions were calculated using the total jet fuel used for refuelling at Austin-Bergstrom International Airport*
- *Bus emissions were estimated using fuel consumption data provided by Capitol Metro and Travis County school districts*
- *Landfill emissions data [were] obtained from area landfill operators, and wastewater treatment plant emissions were estimated using data provided by TCEQ* (City of Austin, 2008, p. 70)

Features in Austin's CAP Tools

Austin Energy and the CPP team developed software that addressed their unique opportunities to take advantage of being a municipal power company (Matthews, 2010). Community emission strategies do not include many of the "smart growth" transit and land use recommendations found in many communities. Instead, the CPP has a strong focus on supply-side strategies for both municipal and community emissions.

Influence on Austin's Urban Form

The Austin Comprehensive Plan is currently being updated using a preferred concept based on community input resulting in a Framework Plan and land use scenarios. The Framework Plan is "the foundation" for the Imagine Austin Comprehensive Plan. It identified four overarching issues that should be completed including integration between elements, sustainability, complete communities and creativity/innovation (City of Austin, 2010, p. 1). The city's consultants also presented "emerging themes" (WRT, 2010).

Framework Plan "Building Blocks"

The Framework identifies 10 required elements and four new elements are organized into eight "building blocks":

- *Land Use and Urban Design (includes Future Land Use and Urban Design elements)*
- *Transportation (includes Traffic Circulation and Mass Transit element)*
- *Housing and Neighbourhoods (includes Housing element)*
- *Economy (includes Economic element)*
- *Conservation and Environmental Resources (includes Conservation and Environmental Resources)*
- *City Facilities and Services (includes Wastewater; Solid Waste, Drainage, Potable Water, Public Service and Facilities; Public Buildings and Facilities: Recreation and Open Space elements)*
- *Society (includes Health and Human Services; Children, Families, and Education elements)*
- *Culture (includes Arts, Culture, and Creativity; Historic and Cultural Preservation elements)* (City of Austin, 2010, p. 2)

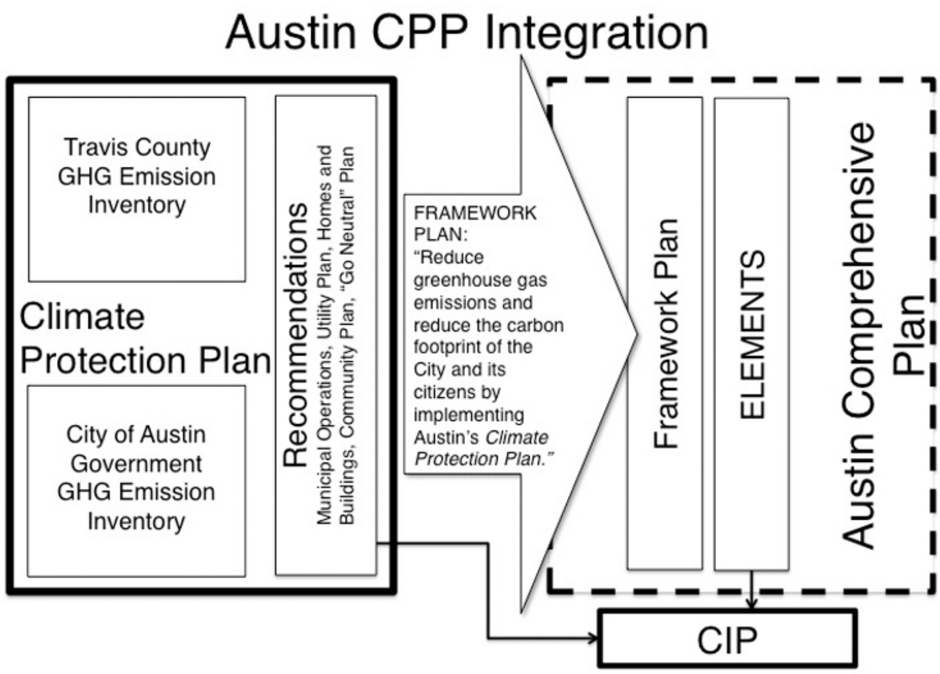
CPP and Comprehensive Plan Not Yet Fully Connected

The Austin Citizens Advisory Task Force is reviewing the preferred draft scenario. Scenario D and the Combined Future Land Use Map identify clusters of land uses, and mixed-use transit corridors (City of Austin, 2010). The Framework Plan contains a single reference to the Climate Protection Plan and only several references to sustainability. The Framework Plan recognizes climate change/GHG emissions as green building and transportation issue going forward but does not include specific policies or reference the PCC (see Figure 4.10).

Austin Energy staff recognized the need for further integrating the CPP recommendations into the Comprehensive Plan. In particular, they feel Austin is too spread out and does not offer the types of mobility choices needed to reduce transportation emissions. In Fall 2010, the CPP and comprehensive planning portfolio were merged into one department with a new Sustainability Director, who will need to ensure the CPP is implemented through the Comprehensive Plan process (Matthews, 2010).

Figure 4.10

Austin CPP and Comprehensive Plan Integration



Summary

- Austin has a tradition of energy efficiency policies for buildings and was a forerunner of the USGBC.
- Austin Energy is the greenest municipal power company in the U.S., and this gives it unique supply-side opportunities to reduce GHG emissions through improvements in efficiencies and renewable energy sources.
- Austin developed its own software to support the city's supply-side and municipal inventory emphasis.
- Austin coordinated the Climate Protection Plan and Comprehensive Plan efforts with the regional MPO and Travis County.
- The City is using a framework planning process for community engagement.

- The process has done a poor job at integrating CPP sustainability and GHG emission goals into the comprehensive plan update.
- Austin is in a state that has strong ties to oil and gas and that has lobbied against Climate Change legislation in other states and Congress.

4.4.8 Chicago. IL

Community Profile

Chicago, IL had a population of approximately 2.8 million in 2006 (US Census Bureau, 2010) and is the location of University of Chicago, North-western University, Illinois Institute of Technology, and several other colleges and universities. Chicago is located in the Central climatic region on southern Lake Michigan at an elevation of 597 feet. The city has an average annual maximum temperature of 60.0º F, average minimum temperature of 43.5ºF, and 38.01" of precipitation (Midwest Regional Climate Centre). Chicago is in the Central Corn Belt Plains eco-region just south of the Southeastern Wisconsin Till Plains eco-region. Formally tall grass prairie, this eco-region has largely been transformed into croplands (EoE, 2009). Chicago has a mayor-council form of government with a very large 50-member city council (with 19 committees) representing 50 wards and elected for four-year terms. The State of Illinois has a Governor's Climate Change Advisory Group that is drafting GHG reduction goals and policies (Illinois EPA, 2007).

Chicago's Motivation for Preparing a Climate Action Plan

Chicago's Mayor Richard M. Daley has pursued environmental sustainability as an essential part of planning and investment. He views Chicago as a leader--it is a city of firsts.

- The Chicago Centre for Green Technology was the first Platinum LEED municipal building in the world (2002).
- Chicago was the first city in the world to have four Platinum LEED buildings (2005).
- The Chicago Climate Exchange, created in 2000, is the nation's first voluntary cap-and-trade program, and has attracted participation both nationally and internationally (City of Chicago, 2008, pp. 8-9).

The Mayor's vision is shared. The motivation for the CAP comes from the private sector interested in green economy jobs, environmental advocates, and the community that views sustainability as a quality-of-life benefit (Coffee, 2010). In 2010 The Field Museum's efforts to outreach to Chicago's diverse communities revealed the desire to integrate sustainability into core objectives for improving their quality-of-life (The Field Museum, 2007).

Climate change also impacts Chicago's quality of life. Sustainability investments in Chicago have been pursued as benefits to the community. In addition, the community is concerned about climate change impacts. Chicago's days over 100ºF could go from five days per year (2010) up to 31 days by 2070 if nothing is done to reduce GHG emissions (City of Chicago, 2008, p. 14).

The Mayor created a multi-stakeholder CAP Task Force that led the community through the CAP process. The Task Force was charged with:

- *Determining the challenges we face as our climate changes*
- *Describing the sources of our greenhouse gas emissions*
- *Setting the goals to reduce our emissions and adapt to changes already affecting us*
- *Finding ways to leverage our knowledge to improve our economy and quality of life*
- *Outlining concrete, achievable goals for all those who make Chicago their home* (City of Chicago, 2008, p. 1)

Chicago CAP Approach and Process

Chicago's approach is complex and comprehensive. The process has engaged business leaders, experts and the community. The City established overall goals based on input and technical input from City staff and technical advisors and mounted a significant community-based implementation program. The City and their funders want the Chicago experience to replicate to support efforts in other communities.

Plan Organization

The CAP is organized as five strategies with an introduction. The strategies focus on energy efficient buildings, clean and renewable energy sources, improved transportation options, reduced waste and industrial pollution, and adaptation. Each of the strategies includes a set of actions, 35 in all. The actions' cost-benefit is measured, including the financial benefit to each participating household (City of Chicago, 2008, pp. 49, 50-52).

CAP Emissions Goals

Chicago signed on to the U.S. Conference of Mayor's Climate Protection Agreement, where cities pledged to meet the Kyoto Protocol of target of reducing GHG emissions 7% below 1990 levels by 2012. The Task Force recommended a more aggressive 25% below 1990 levels by 2020 to put the city was on the path to an 80% reduction by 2050 (City of Chicago, 2008, p. 14).

Three criteria were established for GHG emission reduction goals. “The goal must result in sufficient to avoid a climate that has been adversely impacted; advantageous to Chicago’s quality of life and economy; and feasible given current technologies and resources” (City of Chicago, 2008, p. 14).

The City worked with The Centre for Neighbourhood Technology (CNT) to prepare the CAP, and CNT led the mitigation research team for the Chicago Climate Action Plan (Center for Neighborhood Technology, 2010). CNT was the leading researcher, preparing the energy and greenhouse gas emissions baseline for Chicago and the region. CNT “document[ing] 33 different strategies with measurable reduction potential” (The City of Chicago, Urban Sustainability Associates, The Center for Neighborhood Technology, 2009).

Task Force Process

The Task Force engaged the community and international experts working in three groups. The first focused on methods and guidelines identifying an overall approach based on IPCC’s methods and guidelines. The second group analysed the costs and benefits of various ways to reduce GHG emissions. The third group addressed climate adaptation (City of Chicago, 2008, p. 10). The Task Force members were supported by a formidable group of city and agency staff, plus topical experts. Advisory committees to the Task Force included research; communications; finance; climate impacts and adaptation research; and emissions inventory, mitigation, and economic benefits research (City of Chicago, 2008, pp. 54-55).

Community-Based Implementation

Chicago’s Field Museum’s Division of Environment, Culture and Conservation (ECCo) assisted the Chicago Department of the Environment in engaging Chicago’s neighbourhoods. ECCo’s community partners’ quality-of-life objectives have further influenced The Energy Action Network (EAN).

The EAN has developed a community-based implementation program housed in 21 locations with community-based organizations (CBOs) (Community and Economic Development Association of Cook County, Incorporated, 2010). CBOs affiliated with EAN can apply for funding that contributes to the wellbeing of neighbourhoods. Some of the most successful programs include energy shutoff protection through Low Income

Energy Assistance Program for residents and the Conservation Corps program that offers five weeks of training for neighbourhood-level weatherization efforts and has completed over 17,000 homes (Coffee, 2010).

Sharing Lessons

The City and its funders are developing replicable implementation tools and approaches. The Clinton Foundation was a major supporter of Chicago's CAP process (Coffee, 2010) and partnered with CNT to create an online tool to measure GHG emissions for the world's 40 largest cities (Center for Neighborhood Technology, 2010). CNT worked with the Chicago Department of the Environment to prepare Chicago's Guide–lessons learned from researching and preparing Chicago's CAP (Center for Neighborhood Technology, 2010).

In 2010, the Kresge Foundation gave Chicago a $160,000 grant to prepare the Chicago Continuous Improvement Performance Measurement (Coffee, 2010). The city prepared an RFP, and eight teams responded, and the city selected Carbonetworks (now ENXSUITE). ENXSUITE has developed a cloud-based software approach with international partners in 40 countries, providing a variety of modelling tools and calculators for energy and emissions management used by businesses and communities (ENXSUITE, 2010).

Chicago's State Policy Context

Illinois legislation has intended to reduce GHG emissions by implementing supply-side and demand-side strategies.

Illinois Supply-Side Efforts

The State is planning on greater use of renewable fuels and requires utilities to invest in energy efficiency to meet a 25% RPS goal by 2025. In 2007, new rules required greatly reducing the CO2e from older coal-fired power plants by improving three plants and closing three to reduce GHG emissions by 2.1 million tons per year (Illinois Environmental Protection Agency, 2010).

Illinois helped create The Climate Registry, where 39 states collaborated in creating a GHG emissions reporting system. The Illinois Conservation Climate Initiative (ICCI), in partnership with the Chicago Climate Exchange (CCX) and the Delta Institute, offer farmers and landowners a way to "earn and sell greenhouse gas emission reduction credits through CCX" (Illinois Environmental Protection Agency, 2010). This is an incentive to create carbon-neutral fuels and increase CO2 sinks by planting grasses and trees. Illinois was the first state to sponsor this type of program.

In 2008, Illinois SB680 mandated power companies must allow net metering for distributed renewable energy. Businesses or homes that have solar or wind electricity generation can be credited on a 1:1 basis for power that they put back into the grid (Illinois Attorney General, 2010).

Illinois Demand-side Efforts

Demand-side strategies focus on increasing energy efficiencies in transportation and buildings. In 2006, the Governor signed legislation to limit idling by diesel vehicles in the state's air quality non-attainment areas. The state also instituted incentives for making and selling biodiesel. Illinois became the leading state in the nation in terms of biodiesel. It also is second in the number of gas stations that offer ethanol fuel (E85) (Illinois Environmental Protection Agency, 2010).

In 2005, Illinois adopted higher energy-efficiency commercial building code standards (Illinois Environmental Protection Agency, 2010) which exceed or meet 2006 IECC/ASHRAE 90/1-2004 standards, requiring buildings to be 30% more efficient by 2030 (U.S. Environmental Protection Agency, 2006, p. 3).

As a Lead by Example (LBE) program, the State must reduce energy use in their buildings by 10% in 10-years and use Energy Star lights in all state-owned and leased buildings (Illinois Environmental Protection Agency, 2010).

CAP Tools Used by Chicago

CNT prepared and used the software tools for the GHG inventory for Chicago's CAP for the years 2000 and 2005. The GHG 2000 inventory total was 34.7 million tons of CO^2 equivalents ($MMTCO^2e$). Staff analysed 33 potential emission reduction strategies to demonstrate they could deliver the reduction to meet the 25% below 1990 levels by 2020. The greatest reduction opportunities identified were increasing the efficiency of buildings and transportation (Center for Neighborhood Technologies, 2010).

The GHG emissions baseline year was 2000, the earliest year information was available for. Years 2005 and 1990 were estimated. Emissions sources included: energy from electricity and natural gas use, on-and-off road transportation, aviation, industrial processes, product use, waste, and wastewater. eGRID from the EPA was used to calibrate emissions based on regional power pool emissions (Center for Neighborhood

Technologies, 2010, pp. 6-7). The regional plan includes the GHG emissions inventory prepared as part of the planning process.

Features in Chicago's CAP Tools

Chicago's CAP tools were built to address Chicago's needs. CNT developed a customized approach using IPCC protocols (IPCC 2006, WBCS and WRI 2004) for developing the 2000 and 2005 GHG emissions inventory. The tools and methods addressed two key questions:

> *"What are the most promising strategies for substantially reducing Chicago's greenhouse gas emissions?*
>
> *What scale of deployment of these strategies is necessary to achieve the goal of 25% reduction in greenhouse gas emissions between 1990 and 2020?*" (Center for Neighborhood Technologies, 2010)

CNT Custom Tools

CNT customized the strategy evaluation to measure benefits of each and then aggregated the results to see if they met overall GHG emission targets. CNT accounted for direct sources in geographic boundaries of Chicago, including natural gas, transportation, and non-energy industrial processes and use of GHG in products. They also accounted for indirect emission sources, including consumption of electricity and disposable waste treatment facilities outside city boundaries. Although not a large emission sink benefit, the strategy included calculations for the benefits of carbon sequestration associated with Chicago's trees and land coverage, assuming they had other sustainability benefits such as reduction of heat islands and improved water quality (Center for Neighborhood Technologies, 2010, pp. 17-22).

Next Generation of Software for Management and Communication

ENXSUITE's cloud-based software includes a variety of modelling and calculators for energy and emissions management (ENXSUITE, 2010). Chicago has contracted with ENXSUITE to help measure energy, waste, and water use and other resources to support real-time decisions.

Influence on Chicago's Urban Form

Chicago is the city at the centre of a region with over eight million people, so climate change planning and inventory efforts are happening at both the civic and metro-scale (Figure 4.11).

The Green City

The greening of Chicago has been underway for nearly two decades, largely done as integral parts of projects, programs, and area planning. The City of Chicago does not have a citywide comprehensive plan but uses "strategic plans" with a sustainability emphasis to inform community planning. There are 11 *Community Plans* for downtown, key corridors and neighbourhoods, plus 11 *Open Space and Sustainability Plans* that address open space, river systems and other topics (City of Chicago, 2010).

The Chicago CAP is a strategic plan intended to be integrated into and inform subarea plans in the City over time. The CAP's 33 strategies are also being implemented as projects and programs. The CAP's strategies are having an effect at the neighbourhood level, where the City's partner community organizations are helping to improve residents' quality of life (Coffee, 2010). In addition to the neighbourhood-level efforts, the *Chicago Central Area DeCarbonization Plan* identifies a matrix of strategies for all buildings in downtown Chicago, providing a comprehensive plan for reducing GHG emissions (Adrian Smith + Gordon Gill Architecture, 2011).

The Bourgeoning Region: Land Use, Mobility and Livability

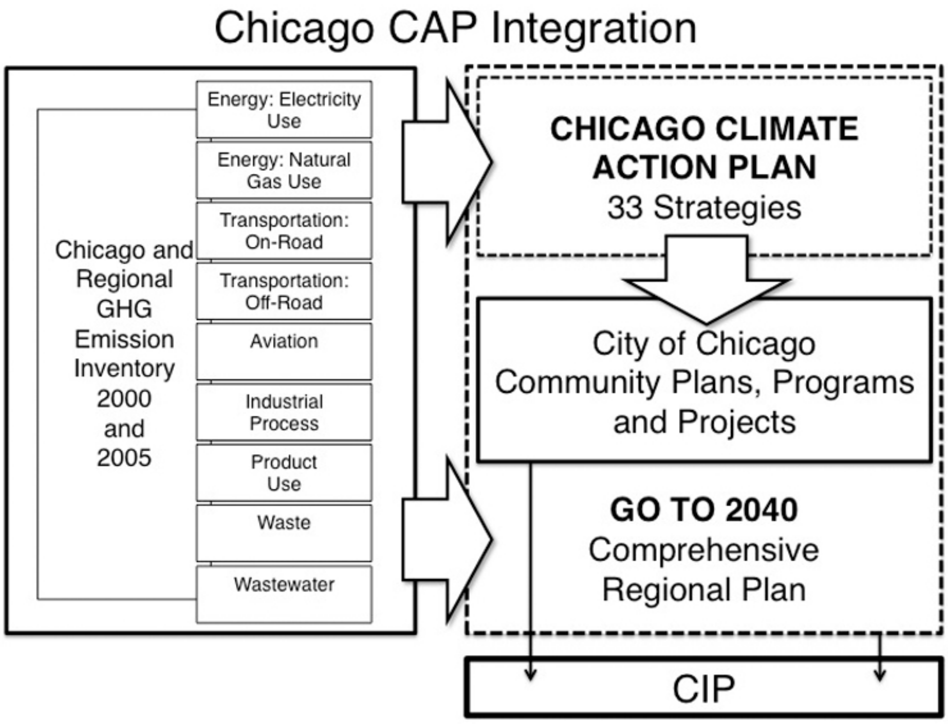
Reduction in GHG emissions to slow climate change is an important objective in the GO TO 2040 Comprehensive Regional Plan. GO TO 2040 references the importance of reducing GHG emissions as reoccurring theme starting with the Introduction. Climate change is referenced as a liveable community issue as well as in an environmental, economic, land use, transportation, energy, and open space issue (Chicago Metropolitan Agency for Planning, 2010).

At the regional level, emissions surveys indicated GHG from regional transportation sources was a greater problem than in the City of Chicago. In 2000, transportation accounted for 21% of Chicago's and 31% of the region's GHG emissions (Center for Neighborhood Technologies, 2010, p. 17). Chicago has recently completed TOD guidelines, and GO TO 2040 emphasizes the sustainability benefits of land use and transportation (Chicago Metropolitan Agency for Planning, 2010, p. 75). Mapping regional infill and transit opportunities inform regional planning policies.

GO TO 2040 emphasizes holistic and coordinated planning and investments. Energy, transport, wastewater, solid waste, open space, and regional supportive agriculture are treated as strategic infrastructure investments that support GHG emission goals.

Figure 4.11

Chicago CAP and Comprehensive Plan Integration



<u>Summary</u>

- Over the past 20 years, the Mayor and business community have viewed Chicago as a sustainability leader.
- The CAP process involved a robust effort of stakeholders, staff, and experts.
- The State of Illinois has RPS and an active legislative agenda for both supply and demand-side aspects of energy.
- Chicago worked with CNT to prepare a custom planning approach and software tools that reflected Chicago's unique needs and opportunities.
- ENXSUITE is developing a cloud-based tool to support constant monitoring and feedback in the CAP implementation.
- Chicago and the metropolitan region prepared inventories at the same time and are integrating recommendations into their respective urban plans.

- Chicago uses strategic sustainability plans to inform community plans, projects, and programs.
- Chicago sustainability emphasizes economic and quality-of-life improvements and has infused many of the recommendations into neighbourhood revitalization efforts with local community-based partners.

4.5 CASE STUDY RESEARCH RESULTS AND DISCUSSION

The case studies provided a qualitative analysis to initiate a research process for exploring potential "best practice" features in CAP tools and processes. The case studies included an effort to understand how community values, public policy and adaptation contexts have influenced CAP preparation and effectiveness.

Once the case studies were completed, they were analysed around the questions of inquiry to develop a framework for understanding:

- The degree to which case study cities are preparing CAPs to satisfy their own local policy agenda or in response to state or federal mandates;
- Types of CAP software tools and processes used by cities in the CAP planning and their satisfaction with them;
- Various CAP strategies employed by case study cities and degree of policy integration into their comprehensive planning; and
- Degree of collaboration by case study cities with partners.

4.5.1 Generalized Comparison of Cases

Figure 4.12 compares the results of case studies. Case studies reflect the variety of planning systems and contexts in which cities prepare CAPs. For the case study cities, motivation for preparing CAPs was local. Advocates, elected leaders, and the public at-large are vested in the preparation of CAPs. State policy has little influence. Most of the case study cities used off-the-shelf software tools and processes but modified them effectively to support the CAP process. There is a large variation between case study cities regarding integration of actions into planning policies and consequential influence their CAP has on urban form. Some have not connected their CAP to the comprehensive plan where others have fully integrated or converted the CAP into the foundational planning policies that will alter their urban form to mitigate GHG emissions and adapt to a changing climate.

Figure 4.12

Comparison of Case Studies

Cases	Motivation	State Policy Influence	Tool Customization	Tools Effectiveness	Influence on Urban Form		Notes
	Degree to which motivation is based on local values	Degree to which motivation is based on state-level policies	Degree which an off-the-shelf vs. customized tool was used	Degree to which CAP tools were effective, easy to use, informative, flexible and customizable	Degree to which CAP is integrated into a comprehensive plan or sustainability plan	Degree to which CAP influences the future physical form of the city	
Key West, FL	•••••	•	•••••	•••	••••	•••	-Local activists motivation -ICLEI tools and process -Adaptation planning for sea level rise
Bozeman, MT	•••••	•	••••	••	••	••	-Local activists motivation -ICLEI tools and process -Poor integration of CAP into comp plan
Annapolis, MD	•••••	••	•••••	•••	••	••	-Local political leadership motivated -Modified ICLEI tools and process -Poor integration of CAP actions into comp plan
Boulder, CO	•••••	•	•	••••	•••••	•••••	-Local political leadership motivated -Customized tools and process -Strong integration of CAP actions into comp plan
Berkeley, CA	•••••	••	••	••••	•••••	•••••	-Citizens motivated -Customized tools and process -Strong integration of CAP actions into comp plan
Portland, OR	•••••	••	••••	••••	•••••	•••••	-Leadership motivated -ICLEI tools for inventory -Strong integration of CAP actions into comp plan
Austin, TX	•••••	•	•••••	••••	•	•	-Local political leadership motivated -Custom tools and process -Poor integration of CAP actions into comp plan
Chicago, IL	•••••	•	•	•••	•	•••	-Local political leadership motivated -Custom tools and process -CAP as strategic plan-no comp plan-implemented with CIP and projects
Average	•••••	•/••	•••/••••	•••/••••	•••	•••	
Notes	Case study cities prepared CAPs based on local motivation		Most case study cities used off-the-shelf software tools	Most found the tools they used to be effective	Large variation between cities in terms of integration of CAP strategies into policy plans	Large variation in effectiveness or emphasis on land use mitigation and urban form	

••••• *High* ••• *Medium* • *Low*

4.5.2 Motivation

The case study communities were motivated by their values, inspired and informed leadership, state regulations, and collaborators.

Citizens Take Charge

Key West and Berkeley residents used the ballot box to express their values. Key West community advocates ran pro-climate mitigation candidates for public office (Williams, 2010) to address their precarious position of being only 24" above high tide. Even though as a small community their mitigation actions will have little effect on overall climate change, they wanted to act on their values. In addition, they focused on adaptation planning anticipating rising sea level and the need to re-examine infrastructure and facilities planning. Building on a longstanding sustainability policy tradition, Berkeley residents gave over 80% support to Proposition G, committing the city to pursue policies that will reduce the community's GHG levels to 80% below 1990 levels (Burroughs, 2010). In Bozeman, local advocates encouraged the City to prepare a CAP (Baker, 2010).

Political Leadership

Chicago and Austin have had strong political and professional leadership. Mayor Daly expressed his interest in making Chicago a green city and followed through with projects and programs. He hired staff that brought a professional and political capacity to work with the business community and neighbourhoods to conceive and launch programs and projects that reduced GHG emissions. Austin former Mayor Will Wynn helped formulate consensus on the city commission to prepare the Climate Protection Plan (CPP) and then became the CEO of Austin Energy (Matthews, 2010), the greenest municipal power company in the United States.

Sustainability Traditions

In different ways, Annapolis, Boulder, and Portland have longstanding policy commitment for sustainability. Annapolis has had a policy emphasis on historic preservation and now sees sea level rise as a threat to their community's history. Boulder has approached planning with an emphasis on its design character and fitting into its ecological setting. These values have translated into a firm commitment to sustainability with an emphasis on climate change mitigation by introducing a sustainability "underlay" to their planning system (Koehn, 2010). Boulder has committed to funding mitigation through the fist local carbon tax in the United States. Portland has been a "best practice" example of regional and transit-oriented planning. In 2008, Portland was identified as the most sustainable city in the United States (SustainLane, 2010) and has redefined its own objectives to better meet the climate change challenge.

Mission of the Funder

Another influence on CAP scope and processes can be attributed to the funders. This includes government grants and private non-profit foundations. In Bozeman, the New Priorities Foundation gave the City a two-year grant to support the GHG inventory and planning for the MCAP and CCAP. The agreement with the funder included the process and deliverables. Maryland Department of Natural Resources provided $40,500 to support the Community Action Plan effort in Annapolis. The Kresge Foundation has funded the implementation and monitoring efforts in Chicago with a $160,000 grant intended to support leading-edge software tools and approaches (Coffee, 2010). In each case, funders used their role as financial partners to shape the process and deliverables to reflect their own environmental mission.

4.5.3 Policy Context

Case study cities are operating in the context of federal, state and local policies, and regulations that have shaped their CAP process or implementation approach.

Federal Policy

In addition to new rules for vehicle fuel efficiency, the U.S. EPA required mandatory reporting for entities that emit more than 25,000 metric tons of CO^2e annually. This has resulted in development of CO^2 reporting for approximately 10,000 of the largest emitters responsible for about 85-90% of the nation's GHG (U.S. EPA, 2011). However, the U.S. has not formed national policies around climate change. The U.S. Congress has been split and unable to form legislation that sets goals that can be used in international negotiations. As a result, leadership on climate mitigation actions has defaulted to local and state governments.

State Leadership

Each case study community had to respond to different contexts of state and regional policies. Austin is located in a state that does not have emission targets. In contrast, Berkeley has to meet the comprehensive climate change policies and regulations of the State of California. Most of the cities, however, are located in states that emphasize LBE where they set examples for governmental GHG emission reductions through their own CAPs and have a more a le carte legislative approach to energy and GHG emissions. Most of the states where the case study communities are located are also part of a regional registry laying the legal groundwork to participate in a future cap-and-trade carbon economy. All the case study cities are located in states with RPS policies.

Adaptation Policies

The need for adaptation planning is another area where states have a variety of policy and regulatory responses. All the case studies addressed adaptation issues with strategies. For some states it is a requirement. Florida requires adaptation planning in the comprehensive planning process. The Maryland CAP requires local governments to include a Sea Level Rise Element in their comprehensive plans; identify Critical Areas Buffers along coastal areas; and Emergency Management and Mitigation Plans that include relocation plans for critical facilities, such as hospitals, that could be impacted by sea level rise (Maryland Commission on Climate Change, 2008, pp. 5.9-5.10). California has legislation that requires state agencies to plan for reducing water use by 20% by 2020; requires general plans to respond to climate impacts; and new environmental review guidelines require planned projects to address heightened hazards impacts of climate change (State of California, 2009, pp. 7-9).

Regional Partners

Most of the case study cities had to collaborate at the regional scale in preparing GHG inventories and/or strategies. Portland Regional Government prepared the GHG emissions inventory for the region. Chicago emissions survey was prepared in collaboration with the metropolitan planning organization. Berkeley's GHG emission survey was prepared by the regional air quality district to provide a baseline for cities and counties. Austin's inventory was prepared with Travis County.

Comprehensive planning at the regional scale for Portland, Chicago, Berkeley, and Austin strived to meet GHG emission reductions by implementing strategies identified in CAPs, particularly as they pertain to land use and transportation planning.

4.5.4 Strategic Variations

The case study CAPs responded to a variety of climatic, energy supply, adaptation, and regional planning contexts demanding unique approaches mixing supply-side, demand-side, and CO_2 storage strategies.

Supply-side Energy Strategies

All the case study cities are located in states with RPS policies. Only Texas has not identified an emissions target. However, there is a large variation between the cities in terms of their ability and willingness to mandate supply-side energy policies to reduce GHG emissions. Austin has the most control over their supply compared to the other case study communities. Austin Energy is a city department. They have pushed to increase the amount of renewable sources and have lowered their GHG emissions as a result. Boulder found that despite of all their best efforts to reduce GHG emission through reducing energy demand, it was erased by development of a single coal plant developed by Xcel Energy. In response, the City of Boulder is working on a plan to purchase the distribution franchise from Xcel and replace the revenues with an energy tax (Koehn, 2010). This gives the City control over the amount of renewable energy used by controlling distribution.

Demand-side Strategies

Berkeley and Portland have an advantage of being in the CAMX and NWPP subareas eGRIDs with 2004 CO^2 output emission rates of 879 lb/MMh and 921 lb/MMh (U.S. EPA, 2007, p. 2). These regions' power sources have generous amounts of renewable, hydro, and nuclear energy sources. Chicago is located in the RFCW subarea eGRID that had a 1,556 lb/MMh CO^2 output emission rate in 2004 is and therefore striving to reduce electrical energy use (U.S. EPA, 2007, p. 2). Berkeley and Portland have been focusing on demand-side approaches that emphasize energy-efficient buildings and more closely connect mobility and land use, reducing GHG emissions from transportation. Berkeley requires new buildings to be carbon neutral by 2020 and increased density around transit. Portland is emphasizing walking as the primary mode for travel through its "20-minute neighbourhood" concept. Like Portland, Chicago has taken an aggressive approach to demand-side planning at the neighbourhood level. The City has allocated resources through community development corporations and other community-based organizations to administer weatherization and green retrofit programs improving the performance of the city's building stock. In addition to the neighbourhood-level efforts, the *Chicago Central Area DeCarbonization Plan* identifies a matrix of strategies for all of the buildings in downtown Chicago, providing a comprehensive plan for reducing GHG emissions (Adrian Smith + Gordon Gill Architecture, 2011).

Adaptation Emphasis

Adaptation strategies are shaping the case study cities' interface with coastal areas and wildlands; approach to resource management, particularly water; and infrastructure design. Key West's MCAP and CCAP included GHG emissions mitigation strategies emphasizing waste reduction and transportation–and because the community is only two feet above high tide, a focus on adaptation related to infrastructure. Annapolis and Berkeley are also coastal cities and concerned about sea level rise. Mountain communities of Boulder and Bozeman are facing increased threat of wild fires and drought. Despite its coastal location, Berkeley also faces similar challenges. Both Berkeley and Boulder have suffered from catastrophic wild fires. Chicago's CAP includes an emphasis on reduction of heat islands through increasing landscaped areas and tree canopy.

4.5.5 CAP Tools and Processes

CAP tools have evolved from customized spreadsheets to packaged tools, and processes from non-profits and agencies to integrated software tools providing a comprehensive range of calculators, monitoring software, and communications software.

Evolution of Software Tools

CAP tools used by case study communities reflect the evolving sophistication and shared knowledge of the professional community. Case study communities that were the early pioneers developed their own spreadsheet tools and relied on IPCC protocols. Boulder wanted to keep their CAP effort local using local professionals and customized spreadsheets. Smaller case study communities, such as Key West, Bozeman, and Annapolis, relied on ICLEI's five-step process and software. Larger case study cities with dedicated specialized staff, such as Berkeley, Portland, Chicago, and Austin, were able to develop or manage the process and related tools.

Case study CAP process managers identified four areas where their initial tools need improvement. Tools should be:

- Less "black box" or opaque: Stock or packaged software tools can hide assumptions related to strategies.
- Customizable to reflect local opportunities and related strategies: Localized opportunities and constraints should dictate approaches to identifying, measuring and monitoring strategies.

- Able to easily support communication and education programs: Spreadsheet results for GHG inventories, strategies, and monitoring should be easily converted into visual communication tools.
- Based on "good science": Cities should be improving the quality and currency of information in terms of GHG emission inventory, strategy modelling, and monitoring progress.

CAP Process Benefits

Just going through the CAP process resulted in benefits for the case study communities. The process, of doing the GHG inventory for their MCAP, Key West, and Bozeman found they were not fully aware of what they were spending on energy cost for facilities (Mannix, 2010). Chicago brought together an amazing array of experts and volunteers to inform the process leading to broad support from the business community and City leadership in taking action. In Berkeley, action planning required engaging the community and weighing their values in regard to environmental priorities, reinforcing hard-to-implement land use and transit policies.

Case study CAP process managers identified three areas where they felt their own CAP process was beneficial:

- Municipal operations: Just by counting energy usage, communities were able to identify easy-to-implement conservation methods; and the process rallied staff from various departments (and regional agencies) to collaborate on improving city services.
- Supporting and confirming existing policies: The CAP process confirmed existing urban planning policies that were hard to gain consistent policymaker support for.
- CAP and urban plan integration: The CAP process and implementation of actions required communities to consider how the CAP mitigation and adaptation actions would shape their comprehensive plans and city form.

ICLEI Paved the Way

ICLEI's mission and capabilities made it a forerunner in organizing, supporting initial efforts to preparing CAPs, and providing software tools. Over 500 U.S. cities are ICLEI members, including all the case study cities, which had various levels of collaboration with ICLEI. The smaller case study communities (Key West, Bozeman and Annapolis) used ICLEI's process and tools. Bozeman managers said they valued the networking opportunities ICLEI provided, where other cities helped as mentors (Baker, 2010).

Custom Spreadsheets

Berkeley, Boulder, Austin, and Chicago developed their own customized spreadsheet tools. They also all collaborated with or depended on regional partners for developing GHG emission inventories and then prepared spreadsheet calculators that addressed their unique reduction needs and opportunities. Berkeley's CAP coordinator spent several years working with ICLEI preparing CAPs and understood how to create his own tools tailored to measure strategies and monitor results (Burroughs, 2010). Boulder was the first U.S. city to implement a local carbon tax and wanted to keep their effort local and connect monitoring to their financing and regulatory actions (Koehn, 2010). Austin focused on supply-side strategies because they have a municipal power company and the in-house expertise to develop the tools (Matthews, 2010). In addition to making custom tools for Chicago, the City's funding partners (the Clinton Foundation) wanted the City's consultants, Centre for Neighbourhood Technologies, to create an online tool to measure GHG emissions for the world's 40 largest cities (Center for Neighborhood Technology, 2010). Chicago's funders wanted the inventory and planning tools to become transferable knowledge.

Next Generation: Clouds and Communication

The Kresge Foundation gave Chicago a $160,000 grant to prepare the Chicago Continuous Improvement Performance Measurement (Coffee, 2010). An RFP was prepared and eight teams responded. Carbonetworks (now ENXSUITE) was the software vendor selected to work with the City. ENXSUITE has developed a cloud-based software approach with international partners in 40 countries that provide a variety of modelling tools and calculators for energy and emissions management used by businesses and communities (ENXSUITE, 2010). This looks like the future of CAP tools. There are a growing number of commercially available software tools via cloud computing, complemented with the strategic and technical expertise arriving in the marketplace.

4.5.6 Influence on Urban Form

Case study CAP cities utilized a variety of mitigation and adaptation strategies, and actions resulting physical planning responses. The recommendations of the CAPs have influenced the relationship between land use and transportation; building design; use of landscaping and water; visibility of localized energy development and distribution; and design of the natural edges of cities.

<u>Degree of CAP and Urban Planning Integration</u>

The degree of integration of CAP actions into local planning policies varied for each case study city, reflecting their planning traditions, state laws and timing. Three categories--*strategic, comprehensive and bifurcated*--have been used to explain how CAP strategies have been integrated into comprehensive planning.

Strategic Planning Cities

Boulder, Portland and Chicago approached CAPs as strategic plans that informed other policies and have been generally successful in integrating and acting on CAP recommendations. Boulder has a longstanding tradition for sustainable planning and used the CAP as a strategic plan that informs all of the regional, community and neighbourhood planning layers. The Boulder CAP contributes to the sustainable "underlay" policies that inform other planning layers, ensuring full integration of recommendations. Portland considers their CAP (The Portland Plan) the strategic plan that informs their comprehensive plan. Its recommendations are the basis for updating the planning policies for the city. Chicago does not have comprehensive plan. The City uses strategic plans to inform district and neighbourhood plans. The Chicago Climate Action Plan has 33 recommendations that are implemented through other plans and programs. The city has attracted over $100M in funding to implement programs identified in the CAP (Coffee, 2010).

Comprehensive Planning Cities

Berkeley and Key West are located in states that have state requirements for city comprehensive planning and CAP integration. Berkeley's CAP recommendations were inserted into their updated comprehensive plan and then went through a state-required environmental review process (EIR). California has a system of policies and implementing regulations for GHG emission reductions. Key West completed the CAP prior to the State of Florida's legislation requiring metrics in comprehensive plans for sea level rise and GHG emissions. Future updates to Key West's comprehensive plan must address these new requirements (Mannix, 2010). The CAP is being used to inform the citywide strategic planning process with the City Commission, a transportation planning study, solid waste study and city operations (Williams, 2010).

Bifurcated Planning Processes: Need for Further Coordination

Austin, Bozeman, and Annapolis have yet to comprehensively integrate their CAP recommendations into their planning systems. In each case, the lack of coordination has come from separately managed efforts.

Austin's CAP has only a tenuous policy connection to the current comprehensive plan update even though the CAP and comprehensive planning processes overlapped. Austin Energy staff managed the CAP. The Comprehensive Plan was managed by planning staff. To avoid further bifurcation, a new senior position has been created to coordinate environmental and comprehensive planning (Matthews, 2010).

Most of Bozeman's CAP recommendations are mentioned in their Community Plan. However, the CAP process and recommendations have not been central to creating community planning policies. The Community Plan refers to the CAP process and recommendations where it supports sustainability policies, but the City's consultant felt the CAP "was referred to enough to justify having a sustainability chapter" (Baker, 2010).

The Annapolis Community Action Plan and Comprehensive Plan were prepared concurrently, rather than sequentially, by different City departments. There was an effort to include some preliminary CAP recommendations in the Comprehensive Plan; however, recommendations are not yet fully integrated (Savage, 2010).

<u>Transportation-based Strategies</u>

All the case study communities made recommendations regarding transit, particularly non-motorized, and land use. All the case study communities' CAPs made recommendations about improving walking conditions, biking and land use and transportation connections. These recommendations and implementing planning policies are encouraging more nodal development patterns and higher density development.

Walking as a Primary Transit Mode

Key West, Bozeman and Annapolis CAPs emphasize reducing the use of autos and providing additional pedestrian and biking facilities. For Portland, transportation represents about 40% of GHG emissions, so The Portland Plan focuses on creating conditions where walking become the principal transit mode. Portland's "20-Minute

Neighbourhood” policy requires that 90% of the people living in the city will be able to walk to their daily needs by 2030. The 20-Minute Complete Neighbourhood Concept focuses on creating neighbourhoods with destinations within a walkable proximity. This includes grocery stores and other commercial services, transit stops, open space, and schools. The planning emphasizes creating high quality walking environments with pedestrian facilities and a high density of intersections (City of Portland, 2009, p. 40). Combined with the region’s growth management containment, the 20-minute neighbourhood emphasizes sustainable, quality infill.

Transit-oriented Development

Berkeley and Boulder CAPs underscore the need to improve transit and land use relationships to reduce VMT and related GHG emissions. In Berkeley, 47% of GHG emissions are from transportation. In an effort to reduce VMT, the Berkeley CAP process confirmed existing policies regarding transit-oriented development around BART stations and key commercial corridors that have been hard to implement due to a vocal minority of anti-growth citizens (Burroughs, 2010). Boulder’s CAP strives to reduce VMTs by increasing transit choices.

The regional planning contexts for Portland and Chicago expand the cities’ transit options to outlying bedroom and satellite communities. The Portland Plan identifies “mobility actions” that inform the Metro Growth Management Plan. The GO TO 2040 Plan for the greater Chicago region advances “Transportation: On-Road” and “Transportation: Off-Road” CAP recommendations. Both Portland and Chicago coordinated GHG emission inventory efforts with regional planning agencies.

<u>Building Design and Urban Form</u>

Buildings use approximately 40% of U.S. energy. All the case study cities’ CAPs identify strategies and actions to reduce their GHG emissions. Berkeley requires new buildings to be carbon neutral by 2020, and Boulder requires it by 2030.

2030 Challenge: Zero Carbon Buildings

The *2030 Challenge* has been endorsed by the American Institute of Architects and U.S. Conference of Mayors. The *2030 Challenge* is an effort by Architecture 2030, a non-profit organization, to reduce the impact of buildings on climate change. The *2030 Challenge* proposes making new buildings climate-neutral by 2030 by reducing fossil fuel use. For example, by 2015 new buildings should use 70% less fossil fuel and 0% by 2030. This is to be achieved through sustainable design practices, on-site energy generation and using up to 20% of energy from renewable sources purchased from the grid (Architecture 2030, 2011).

The *2030 Challenge* has recommended codes that can guide new development in terms of “2030 Challenge Interim Code Equivalents”. This approach identifies percentages below various building codes that equal the necessary efficiencies to meet net zero goals of 2030. For example, buildings 30% below the 2006 International Energy Conservation Code (IECC) meets the 2030 Challenge (Architecture 2030, 2008, p. 4).

Building Codes

Most of the case study cities are in states that use the IECC, part of the suite of International Building Codes. All of the case study cities have either been required by the state, or have adopted the 2006 or 2009 the IECC on their own. Bozeman, Annapolis, Berkeley, and Chicago are in states that have adopted the 2009 IECC for both commercial and residential buildings (Post, 2010). Title 24 in California is even more stringent. These codes are influencing the form of buildings, blocks, and neighbourhoods.

Urban Form and Buildings

Many IECC measures and strategies proposed by case study cities will influence the design of building envelopes to optimize their performance through passive and active design strategies. In addition, buildings must generate a portion of their own power needs and have access to renewable energy sources. Solar and wind power designed into buildings and sites, and building and block grid solar orientation. Striving for energy efficiencies will also be an incentive for higher density development. Building and site design strategies can be extended to water recycling and stormwater management practices to reduce energy spent on water treatment and adapt to increasing drought and flooding conditions.

<u>Forestation, Carbon Sinks and Heat Islands</u>

At a local or regional scale, forests have a contributing cooling and carbon sequestration role but do not replace other actions. Sequestration is part of a comprehensive carbon-neutral solution of case study cities.

Cooling Heat Islands

Chicago and Portland CAP strategies include urban forestry and urban gardening for sequestration and cooling. Even though the amount of carbon stored in trees is relatively low, street trees aid cooling and unpaved areas aid stormwater management. In

Chicago, the number of days over 100ºF is predicted to increase from five days in 2010 up to a potential of 31 days by 2070 (City of Chicago, 2008, p. 14). Anticipating this climate shift, Chicago has begun an aggressive urban forestry program. Portland's CAP recommends under tree coverage for one-third of the city and half of streams.

Regional and Urban Forests and Water Management

Urban and regional reforestation programs could substantially change the visual character and ecology of case study cities. At the regional scale (Metropolitan Portland, Greater Chicago and the San Francisco Bay Area/Berkeley) watersheds and agricultural hinterlands are viewed as part of their sequestration strategies, water quality, and stormwater storage solutions. Cities and their supporting regions must adapt to increasing drought and flooding conditions, and urban forestry can make a valuable contribution.

<u>Adaptation Planning and Urban Form</u>

The visual character of the edges of case study communities will transform over time to respond to climate change. CAP adaptation strategies respond to drought, threats of wildfires, and rising sea levels.

Wildfires and Urban Form

Bozeman, Berkeley and Boulder are in locations that are susceptible to wildland fires that are predicted to increase with warmer and drier summers. Berkeley and Oakland lost over 3,300 housing units in the 1991 Oakland Hills fire, and Boulder evacuated one third of the city during a 2010 wildfire. This has tempered how the cities have planned their wildlands interface and development review process. Berkeley (and East Bay Regional Parks) has reduced the amount of non-native vegetation in the regional park and instituted fire-resistant landscape and building design standards.

Sea Level Rise

Key West and Annapolis adaptation strategies respond to threats of rising sea levels. Key West is examining how to provide urban infrastructure looking 50 years ahead (Mannix, 2010). As much as one third of Key West could be underwater by 2100, requiring a different approach to street design and location and design of critical public facilities. The State of Maryland requires Annapolis to plan for relocating critical public facilities to higher elevations if they are in a coastal zone subject to sea level rise.

4.5.7 Potential CAP Tools for Strategy Modelling and Analysis

Study 3 includes modelling the effectiveness of CAP strategies used by cities. Software tools will be tested and adapted for use in the study. The case studies have identified issues related to performance of software tools used in the CAP process.

Case study communities used a variety of software tools and approaches. They used off-the-self software and processes, developed their own spreadsheets, and worked with others to develop a course towards new best practice models. Each community had to develop and adhere to protocols for collecting data and modelling scenarios. The IPCC has developed protocols for creating GHG emission inventories meant to support a carbon registry as a basis for international cap-and-trade. The protocols identify seven categories for GHG inventories, but many of the case study cities developed their own categories reflecting their own emission reduction opportunities.

Tools that support local government have various features and characteristics reflecting their purpose. Not all tools are the same, varying depending on their age, original purpose (general vs. specialized) and whether they are part of a larger suite of tools. Case study cities represented a cross section of CAP issues and professional capabilities. Planning managers desired to find new tools that provided opportunities for customization and integration.

Study 1's exploration of tools used by communities is the basis for four findings that can be addressed in Study 2:

- Cities use tools that reflect their level of professional capacities and strategic needs.
- Early choices for tools reflect the objectives of their sponsors/designers, and are not flexible.
- Cities desire increased customization of software for GHG emissions inventory, strategic planning, monitoring implementation, and communication in the CAP process.
- The next generation of tools will be customizable and part of a suite of tools offering a variety of analytical and communication capabilities.

4.5.8 CAP Survey Research Hypotheses

Two theoretical threads from the case studies establish a set of hypotheses to be researched in the Study 2 survey. These include hypotheses regarding how a city's fundamentals influence CAP strategies they are employing and how fundamentals influence their urban form. The hypotheses are the basis for developing research questions for Study 2.

Hypotheses: CAP Strategies

The larger cities of Chicago, Portland, and Austin collaborated in the development of GHG inventories and actions.

- *Larger cities are more likely to engage in regional cooperation.*

Chicago has a lot of coal in the fuel mix for power and Berkeley and Portland has more of a balanced mix. Chicago's CAP is more building centric and the western cities have a greater focus on transportation.

- *Climatic regions influence a city's GHG emission inventory (and therefore CAP strategies).*
- *Cities with larger amounts of GHG emissions in their electrical grid employ strategies that reduce energy use.*

Berkeley and Chicago are in states with RPS and provide financial incentives for weatherization or rooftop power. Berkeley and Boulder have city manager-form of government.

- Power companies that implement state renewable portfolio standards (RPS) policies provide more economic incentives.
- Professional City Manager cities are more likely to employ supply-side strategies.

Berkeley and Key West are in states with comprehensive plan requirements are both coastal cities.

- *Cities in states with laws that require comprehensive plans are more likely balance mitigation and adaptation strategies.*

California Air Resources Board has been a leader in working with air districts, cities, and non-profits to develop GHG inventory tools.

- *Cities in states that require GHG emissions inventories for local government are more likely to use similar CAP software tools.*

Key West and Bozemann prepared a MCAP first and then a CCAP. All the other cities integrated the MCAP into their CCAPs.

- Cities that prepare a CCAP are more likely to prepare an MCAP.

Berkeley, Boulder, Portland, and Austin have a tradition of developing sustainable planning policies and programs.

- *Cities with a tradition of environmental policies are more likely to prepare a CAP.*

Hypotheses: CAP Influence On Urban Form

Chicago and Portland collaborated on regional transportation planning.

- *Larger cities are more likely to focus on land use and transportation strategies.*

Western cities have a higher percentage of GHG inventory in transportation and commitment to public transit. Berkeley has about 40% of the CO2e in the eGRID as Chicago.

- *Climatic regions influence compactness patterns resulting from CAP strategies.*
- *Cities with smaller amounts of CO2 in their power source emissions are more likely to focus on land use and transportation strategies.*

Austin's CAP has a supply-side focus because the power company is a city department.

- *Cities with power companies that provide efficiency incentives are more likely to employ building and site design strategies.*

Boulder and Berkeley have city manager form of government and strong comprehensive planning traditions. Case study cities in states that require comprehensive planning integrated their CAPs into plans. California now requires GHG emissions included as an environmental impact that has to be measured in plans and projects.

- *Professional City Manager cities are more likely to integrate CAP strategies in their comprehensive plans.*
- *Cities in states with laws that require comprehensive plans are more likely to integrate GHG emissions mitigation strategies into comprehensive plans.*
- *Cities in states that require GHG emissions inventories for local government are more likely to integrate CAP strategies into their comprehensive plans.*

Florida and Maryland require infrastructure to be designed for resilience due to hurricanes and sea level rise.

- *Cities that prepare an MCAP have more efficient infrastructure design.*

Berkeley, Boulder, and Portland have TOD, restricted boundaries, and/or central district policies that concentrate development.

- *Cities with a tradition of environmental advocacy have CAPs that emphasizes compact development patterns.*

4.6 VALUE OF STUDY

The case studies make further contributions to our understanding about how CAP processes and recommendations respond to a city's available energy resources, ecological setting, and political context. The study illuminates how software tools have evolved and their relative success supporting various types of cities. By examining both the CAPs and comprehensive plans of the case study cities, the study extends our understanding of how CAP recommendations are being integrated into comprehensive plans, thereby influencing urban form. This includes cities that use strategic planning to establish overall climate action and urban planning framework; have a tradition of comprehensive planning and fully integrate their CAP into the comprehensive plan; and have bifurcated their CAP and comprehensive planning processes poorly integrating CAP strategies and actions. Finally, the case study research has provided a set of research hypotheses for Study 2 survey of CAP cities.

Chapter 5

STUDY 2: NATIONAL SURVEY OF CAP CITIES

EXAMINING THE RELATIONSHIPS BETWEEN CITY FUNDAMENTALS AND CLIMATE ACTION PLANNING INFLUENCE ON URBAN FORM

5.1 ABSTRACT

The 2010 U.S. Census recorded about 20,000 "incorporated places." The approximately 200 U.S. cities surveyed in this study are among the first 1% to prepare climate action plans. Their experiences and actions offer an early glimpse of how the nation's urban regions could evolve over time as more cites consider how they will curb their impact on greenhouse gas emissions and adapt to a changing climate. The research asks original questions about what motivates cities to prepare climate actions, how they integrate the climate action plans into comprehensive plans, and the types of policies they pursue that will influence their urban form. A regression analysis of a 27-question survey considers the probability of how city fundamentals (size, location, form of government, etc.), climate action planning strategies, and policy outcomes influence the design of cities. Preliminary results from survey respondents indicate statistically significant connections between what motivates a city to prepare a climate action plan, and how likely they are to collaborate regionally; the size of cities, requirements for preparing comprehensive plans, and how well they integrate their climate action strategies into city planning policies; and climate action plans, growth patterns, and energy efficiency requirement relationship to electric power providers. The study is co-sponsored by the American Planning Association (APA) and was presented at the 2013 National APA Conference in Chicago.

5.2 INTRODUCTION

Based on the findings from the CAP city case studies, the research asks original questions about the nature of GHG emissions mitigation and community climate adaptation planning. The research explores the relationship between growth policies influenced by climate planning and the changing form of cities. The study includes follow-up questions from research partner the American Planning Association (APA). APA's research director and staff added questions, so this research adds to 2007 surveys focused on energy and climate change.

The study is the fourth stage and third research method of PhD research. This quantitative research builds on the qualitative research with a survey of U.S. cities that have completed CAPs.

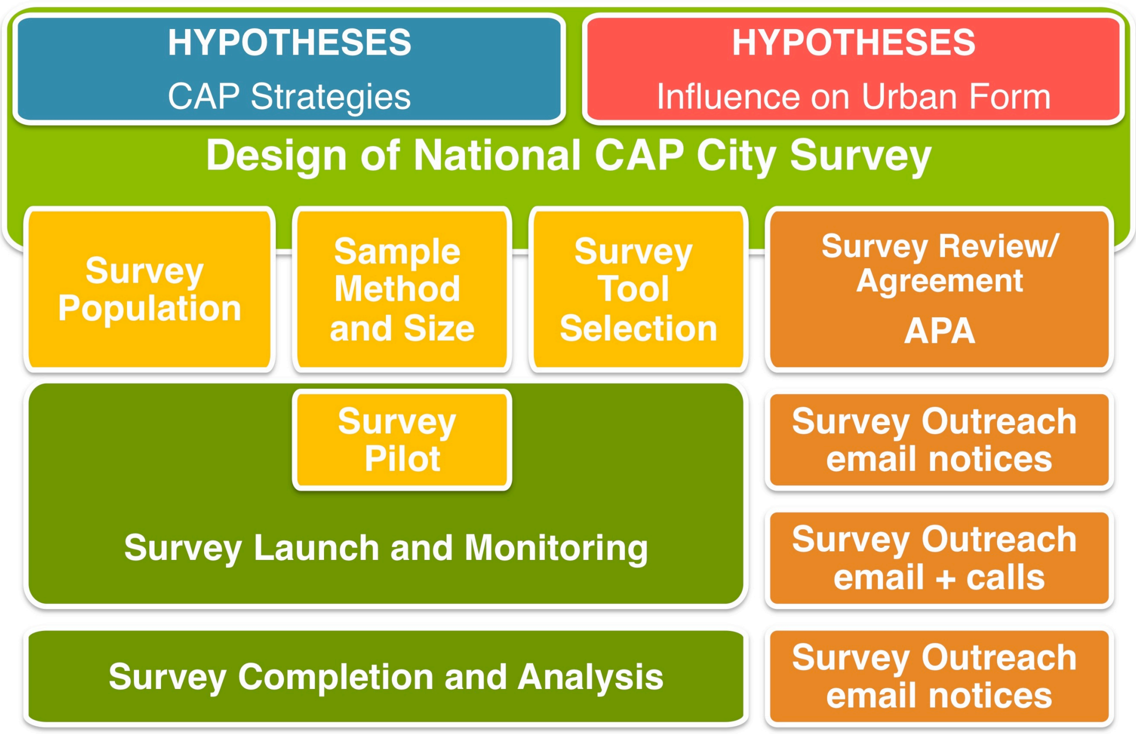
5.3 SURVEY METHOD

A survey of United States cities examines the relationship between their values, policy contexts, GHG emission mitigation, and adaptation strategies on policies shaping their urban form. The survey provides a quantitative analysis of independent and dependent variables indicating how fundamental attributes of cities (size, location, structure of government, etc.) influence their form. A 27-question survey uses a sample of 192 cities that have completed CAPs. A regression analysis is used to identify the probability of city fundamentals and CAP strategies and policy outcomes that influence urban form.

The survey questions, summary of responses, and example tables can be found in Appendix B.

Figure 5.1

Overall Survey Approach



The survey design and process is diagrammed in Figure 5.1. The survey is designed to test hypothesis about strategies and policies influencing the form of cities. The population size of cities that have completed a CAP helped determine the sample size. A survey tool is selected and the survey is piloted. After the survey is launched, it is monitored until the required number of cities responded. Parallel with the design and administration of the survey, communications and outreach activities keep participants informed about the process and their participation.

5.3.1 Sampling Method

The initial task included identifying cities that have completed CAPs by reviewing lists from non-profit, government agencies and professional organizations. Sources include ICLEI, APA, EPA, climate registries, and website searches by state. An estimated 192 cities in the United States have completed or substantially completed CAPs.

Sample Size Method

The search for cities with completed CAPs was conducted during spring of 2012. Initially, 192 cities were identified as having completed CAPs. Of the 192 cities contacted to participate, 142 completed the first section of the survey. Of these, 82% (117) had completed a CAP. Assuming this is representative of the population, the initial population of 192 cities would include 157 cities that have completed a CAP and could complete the survey. The survey population of 157 cities requires at least 111 cities to respond for a ±5% margin of error.

The sample size is determined by a method for "Determining Minimum Returned Sample Size for a Given Population Size for Continuous and Categorical Data" (Bartlett, Kotrlik, & Higgins, 2001, pp. 47-48). Table 6.1 includes the method for determining the sample size.

Table 5.1
Determining Sample Size for Categorical Data
(Bartlett, Kotrlik, & Higgins, 2001, pp. 47-48)

$$\underline{n}_o = \frac{(t)^2 * (p)(q)}{(\underline{d})^2}$$

$$\underline{n}_o = \frac{(1.96)^2 * (.5)(.5)}{(.05)^2}$$

$$\underline{n}_o = 384$$

Where t = value for selected alpha level of .025 in each tail = 1.96
(the alpha level of .05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error for a sample over 120).
Where (p)(q) = estimate of variance = .25.
(maximum possible proportion (.5) * 1- maximum possible proportion (.5) produces maximum possible sample size).
Where d = acceptable margin of error for proportion being estimated = .05
(error researcher is willing to except).

Since this sample of 384 exceeds 5% of the population (157*.05=7.85), Cochran's (1977) correction formula should be used to calculate the final sample size. These calculations are as follows:

$$n_1 = \frac{n_o}{(1 + n_o / \text{Population})}$$

$$n_1 = \frac{(384)}{(1 + 384/157)} = 111$$

Where population size = 157
Where n0 = required return sample size according to Cochran's formula= 384
Where n1 = required return sample size because sample > 5% of population

These procedures result in a minimum returned sample size of 111 and assuming a response rate of 70%, a minimum drawn sample size of 111 should be used. These calculations were based on the following:

Where anticipated return/response rate = 70%.
Where n2 = sample size adjusted for response rate.
Where minimum sample size (corrected) = 111.
Therefore, n2 = 111/.70 = 158.

For regression analysis, at least five observations are required for each independent variable (Bartlett, Kotrlik, & Higgins, 2001). The draft survey identifies nine questions that provide independent variables. For example, the independent variable of climatic region would require at least five cities for each of the nine regions. This would be true for the other independent variables as well if they are to be used in a regression analysis and results are to be generalized. Due to the high number of degrees of freedom (df) for some questions and the low number of sample cities, some probability outcomes may not be valid so a comparative method is used.

Inclusion or Exclusion Criteria

There were three criteria for inclusion of a city in the survey:

- Cities must have completed or significantly completed a CAP.
- The planning manager for the CAP must fill out the survey.
- The surveys must be returned within the research deadline.

Subject City Recruitment

The survey was co-sponsored by Ball Sate University and the American Planning Association--both trusted sources in the planning profession. It provides and opportunity for APA to follow up on research from 2007 and expand that participation to help define best practice preparation of CAPs.

There were three stages of outreach. First, an invitation to participate in the survey was sent out to the list of cities that had completed a CAP. The second stage included emailing a link to an online survey. The third stage included email reminders and follow-up phone calls for those cities that had not responded.

Anonymity and Confidentiality of Data

The research strived to understand cities' efforts to mitigate GHG emissions and how adapting to climate change is shaping policies about their development form. The survey did not collect personal information. Collection of survey data happened over a two-month period, and data was stored within the online survey service and then exported as excel and PDF files and stored on local networks.

Access to data collected was limited to the research team and stored on dedicated computers backed-up onto external media. Survey findings were shared with co-sponsors APA, presented at conferences, and intended for use in publications.

5.3.2 Survey Instruments

Planners involved with the CAP process filled out the survey (Figure 5.2), and it was administered through a commercially available internet-based service, which has the capacity to export results in spreadsheet and PDF formats.

Survey Design

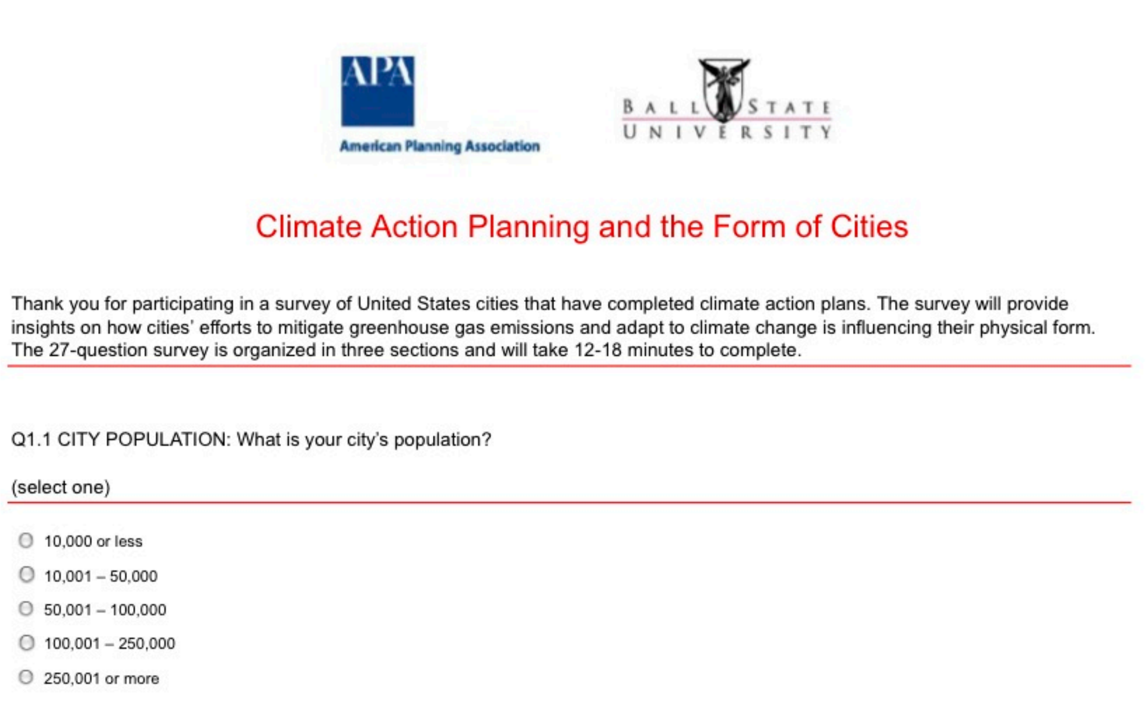
The survey is organized into three sections:

SECTION 1: Community Fundamentals (Independent Variables)

SECTION 2: CAP Approach and Strategies (Dependent Variables)

SECTION 3: Influence on Urban Form (Dependent Variables)

Figure 5.2
Online Survey



APA American Planning Association

BALL STATE UNIVERSITY

Climate Action Planning and the Form of Cities

Thank you for participating in a survey of United States cities that have completed climate action plans. The survey will provide insights on how cities' efforts to mitigate greenhouse gas emissions and adapt to climate change is influencing their physical form. The 27-question survey is organized in three sections and will take 12-18 minutes to complete.

Q1.1 CITY POPULATION: What is your city's population?

(select one)

- 10,000 or less
- 10,001 – 50,000
- 50,001 – 100,000
- 100,001 – 250,000
- 250,001 or more

The survey has 27 questions and collects categorical data with the exception of city population. City population is measured on a six-point scale reflecting US Census categories for cities. The survey and methods were reviewed with APA staff and Cardiff University PhD advisors.

Independent and Dependent Variables

The survey includes nine independent variables: (1) city population (2) climatic region (3) eGRID emission subregion (4) source of electrical power (5) form of local government (6) comprehensive plan requirements (7) state climate change policies (8) type of CAP (9) motivation for preparing a CAP. Each of the dependent variables addresses the research aims and questions.

5.3.3 Survey Process

The survey was designed, sampled, piloted, and summarized over an eight-month timeline. The process was organized into five steps:

Step 1: Methods and Survey Design

The draft survey design and methods description was reviewed with Cardiff University advisors and APA research staff.

Step 2: Sampling

A list of cities was prepared and emails were sent out to selected communities.

Step 3: Online Survey and Pilot Survey

A case study city, advisors and APA pilot-tested the survey online.

Step 4: Send Survey and Follow-up Phone Calls

The survey was updated based and adjusted based on the pilot. The survey was emailed to the selected cities. Those not responding within the two-week window received reminder emails and then follow-up phone calls.

Step 5: Survey Results and Summary

At the end of the survey period, results and key findings was summarized.

5.4 THEORETICAL FOUNDATION

A set of hypotheses, based on the literature review and case studies, was used to design the survey. The first section of the survey included independent variables of city fundamentals previously described. The second and third survey sections included dependent variables. Dependent variables regarding CAP strategies used by cities (Figure 5.3) were addressed in the second section of the survey. Dependent variables regarding urban form were included in the third section of the survey (Figure 5.3).

5.4.1 Survey Section Two: Strategy Variables

Section 2 included seven questions related to potential strategies for GHG emission mitigation and climate adaptation. Figure 5.2 illustrates the tested probabilities between independent fundamental variables and dependent CAP strategy variables. For example, the survey strived to ascertain the relationship between a city's comprehensive plan requirements (Q1.6) and its supply (Q2.3) and reduction (Q2.4) strategies, and climate adaptation strategies (Q2.5).

5.4.2 Survey Section Three: Urban Form Variables

Section 3 includes six questions related to potential urban form policies addressing GHG emission mitigation and climate adaptation. Figure 5.3 also illustrates the tested probabilities between independent fundamentals variables and dependent urban form variables. For example, the survey strives to ascertain the relationship between a city power source (Q1.4) and building and site design requirements and (Q3.5) and reduction (Q2.4) strategies, and city size (Q1.1) and transportation and land use policies (Q3.3).

Figure 5.3

CAP Strategy Dependent Variables *Urban Form Dependent Variables*

5.5 RESULTS

Of the 192 cities invited to participate, 159 started the survey (82% of the total population), 142 cities that completed Section 1, and 117 survey cities (82% of respondents) substantially completed their CAP and participated in Section 2 and 3 of the survey. The highest number of responses for a survey question is 89%, and the least is 70%.

Section 1 summarizes information about independent variables, or fundamentals, of responding cities. Sections 2 and 3 summarize findings and how they support the hypothesis. Many questions included an answer category of "other" that allowed respondents to elaborate on their experience and status.

5.5.1 Section 1–Summary of Independent Variables

The 142 cities that completed Section 1 of the survey represent the spectrum of cities that have completed CAPs in terms of their geographic distribution and size.

Q1.1 and Q1.2 Population Size and Climate Region

Of the cities surveyed, 27% are between 50,001 and 100,000 in population, 31% are smaller, and 42% larger. The survey requests respondents to identify their climate regions. Of the 11 climate regions represented, most are from the West (33%), Northeast (13%), Upper Midwest (11%) and the Northwest (11%).

Q1.3 eGRID Regions

The survey response reflects the high proportion of western cities that have prepared CAPs, particularly in California. Most of the cities responding to the survey are located in the CMAX eGRID region in California (32%). The second highest number of respondents is from NWPP (10%). This area includes portions of California, Wyoming, Arizona, New Mexico, and Montana, and all of Oregon, Washington, Idaho, and Utah. The third highest eGRID region represented in the survey is NEWE (6%), which includes the New England states of Connecticut, Massachusetts, Rhode Island, New Hampshire, Vermont, and Maine. Fourth is SRVC (6%), which includes North and South Carolina and parts of Virginia.

Q1.4 Power Providers

Most cities receive their electrical power from commercial providers (78%). The remaining responding cities have municipal power (18%) or other types of providers, including public utilities, investor-owned utilities and the Tennessee Valley Authority (8%).

Q1.5 Form of Government

Over 60% of the cities have either Mayor-Council (42%) or Council-Manager (19%) form of government. Other types reported included Weak Mayor (10%), Strong Mayor (14%), Commission-Manager (6%), and other hybrid forms.

Q1.6 Comprehensive Plan Requirements

Most of the survey cities have comprehensive plans (86%). Four in ten cities (38%) participate in regional planning and have elements or sections of their plans that are required by state law (40%). Over one-third of the cities (36%) use a strategic planning approach to prepare comprehensive plans. Only 3% of the respondents do not have some sort of a comprehensive plan.

For cities located in states with comprehensive plan elements or sections required by law, about the same number (84%) have comprehensive plans. More of these cities (68% vs. 40% of all surveyed cities) participate in a regional planning framework and use some sort of strategic planning approach to inform planning policy (63% vs. 37% of all surveyed cities).

Q1.7 State Climate Change Policies

Most CAP cities surveyed are located in states that are actively pursuing climate change policies. Only 27% of the cities in the survey are located in states respondents felt were not influencing their climate change mitigation or adaptation policies. Over a third of the cities are located in states that: lead-by-example with their own CAP (38%); have renewable portfolio standards (54%); use incentives (44%), have state energy efficiency regulations (53%), and air quality regulations (56%). A third (33%) of the cities surveyed are in states that regulate GHG emissions, and 22% have climate adaptation policies or regulations.

Q1.8 Motivation for Preparing CAP

Cities credit local political leadership (63%) and local citizen advocates (46%) as their primary motivation for preparing a CAP. Over a third (36%) identify a strong local sustainability tradition. Motivations also include conditions from the funder to complete a CAP (10%) and state requirements (9%).

Q1.9 Type of CAP

Most (59%) of the cities in the survey have prepared both a Community CAP and Municipal CAP, 3% have just a CCAP, and 16% only a MCAP. Some of the cities have draft CAPs (11%) that are in the approval process, and 10% have not completed or prepared CAPs.

5.5.2 Section 2 Findings–Strategy (Dependent) Variables

The second section of the survey queries cities about their CAP strategies. Each question is developed to inform a hypothesis about the relationship between the dependent variable with independent variable in Section 1.

Q1.1: Does city size influence how it cooperates?

Hypothesis: Larger cities are more likely to engage in regional cooperation. (Q1.1-Q2.1)

Over half (54%) of respondent cities have not participated in some sort of regional cooperation. However, 30% have cooperated in preparation of preparing GHG emissions inventory, 12% have participated in common regional mitigation or adaptation strategies, and 11% have shared regional responsibilities and actions.

There is not a significant probability (*p*=.34) of a connection between larger cities (>250,000 population) size and regional cooperation. However, only 43% of larger cities over 250,000 in population have NOT participated in regional CAP efforts compared to 56% of smaller cities. Cities of 100,001-250,00 in population are least likely (73%) to cooperate regionally, followed by small towns (63%) with less than 10,000 in population, mid-size cities (52%) with 50,001-100,000 in population, and small cities (45%) with 10,001-50,000 in population.

Descriptive data show marginal support for large cities over 250,000 in population being more likely to participate in regional CAP efforts. Anecdotal responses under "other" in the survey responses suggest many cities in California that have completed CAPs have done so as part of a regional effort. About 64% of cities in the CAMX eGRID region, which includes most of California, have participated in regional CAP efforts, compared to 46% of all survey respondents. In particular, California cities are cooperating in preparation of GHG inventories, with half (50%) of cities in the CAMX eGRID region compared to 30% of all surveyed cities.

<u>Q1.2: Are there mitigation strategies common to various climatic regions?</u>

Hypothesis: Climatic regions influence a city's GHG emission inventory (and therefore CAP strategies). (Q1.2-Q2.2, 2.3, 2.4)

For surveyed CAP cities, the top GHG emission sectors identified are transportation (42% as highest and 40% as second highest) and residential and commercial buildings (36% as highest and 34% as second highest). The third highest sector is energy (9% as highest and 13% second highest). Intuitively, it would be expected to find a relationship between climate and GHG emission sectors. However, survey data do not generally indicate a significant probability of a connection.

Over half of the cities surveyed have some sort of incentive program (52%). The most popular incentives are solar (44%) and to a lesser extent wind (15%), geothermal (8%), and biomass (6%). The regional emphasis for types of incentives largely reflects what one would expect. In the Southwest, 71% of cities have incentives for solar power compared to 44% of all CAP cities. The Southwest (29%) and Upper Midwest (25%) CAP cities have higher use of incentives for wind power versus all CAP survey cities

(15%). The Upper Midwest (25%) and Northwest (21%) CAP survey cities are more likely to provide incentives for geothermal compared to all survey cities (8%).

The most popular demand-side strategies include energy efficiency requirements for new and renovated buildings (70%), compact and higher density development (67%), and reducing VMT (66%). Regional variations in strategies used by survey CAP cities include compact development in the West (79%) and Northeast (71%) compared to the average survey city (66%); reduction in VMT in the South (83%) and West (77%) versus the average survey CAP city (66%); and energy efficient buildings in the South (100%), West (81%), and Northeast (79%) compared to all survey cities (70%).

The survey data do not indicate a statistical probability of a connection between demand-side or supply-side strategies and climate region. However, the descriptive data seem to reflect common sense expectations. CAP cities take advantage of renewable energy sources and employ GHG reduction mitigation strategies that address regional climate characteristics.

Q1.3: How does the amount of CO2e in the grid influence city strategies?

Hypothesis: Cities with larger amounts of CO2e in their electrical grid emphasize strategies that reduce energy use. (Q1.3-Q2.4)

Overall, cities report balanced strategies that do not favour building efficiency standards over other common strategies such as reduction of VMT or compact development. Of surveyed cities, 70% have strategies for requiring energy-efficient new and remodelled construction. Sixty-six percent of cities have strategies for reducing of VMT and 67% have strategies for higher density and more compact development. This hypothesis is not supported by survey data, and there is no statistical probability of a connection between demand-side strategies and eGRID regions.

Comparing strategies for cities in the eGRID regions with the highest amount of CO2e to the six lowest (Table 5.2) also does not reveal a dominant strategy. Cities with highest and lowest amounts of CO2e in their grids generally balance their demand-side strategies. However, CAP survey cities with the lowest amount of CO2e in their eGRID more often use compact development (67% vs. 39%), VMT reductions (63% vs. 50%), and building energy conservation (66% vs. 39%) demand reduction strategies. Fifty percent of cities in top six highest CO2e eGRID regions apply building energy efficiency strategies more than any other strategy. This marginally supports the hypothesis.

Table 5.2

Comparison of Highest and Lowest eGRID Regions

The six eGRID regions with the highest amount of CO2e are:

	CO2e (lb/M/Wh)					
	Total	Non-baseload	Total	A*	B	C
SPNO SPP North	1,971.39	2,180.31	1	0	1	1
RMPA WECC Rockies	1,892.47	1,624.42	4	2	1	2
MROE MRO East	1,844.71	1,837.05	4	2	2	2
SRMW SERC Midwest	1,840.41	2,111.90	1	0	1	0
MROW MRO West	1,831.95	2,170.67	8	3	4	2
HIOA HICC Oahu	1,821.60	1,864.07	0	0	0	0
Total			18	7	9	7

Cities in the regions above emphasize reduction of VMT (7 of 18=50%), energy efficiency requirements for buildings (9 of 18=39%), and compact development (7 of 18=39%) as demand reduction strategies.

The six eGRID regions with the lowest amounts of CO2e are:

	CO2e (lb/M/Wh)					
	Total	Non-baseload	Total	A*	B	C
AKMS ASCC Miscellaneous	500.56	1,462.06	0	0	0	0
NYUP NPCC Upstate NY	724.79	1,520.77	1	1	0	0
CAMX WECC California	727.26	1,085.56	45	31	31	33
NYCW NPCC NYC/Westchester	817.90	1,529.06	0	0	0	0
NWPP WECC Northwest	907.26	1,340.48	15	10	8	7
NEWE NPCC New England	934.77	1,321.12	9	5	5	6
Total			70	47	44	46

Cities in the regions above emphasize compact and higher density development (47 of 70=67%), energy efficiency requirements for buildings (46 of 70=66%), and decreasing VMT (44 of 70=63%) in their demand reduction strategies.

** A= compact development B= VMT reduction C= energy-efficient buildings*

It is also hard to ignore California's influence when comparing eGRID regions. CAMX (California) cities represent a large portion of the low CO2e eGRID region cities and are implementing demand-side strategies more frequently than the other CAP survey cities. CAMX cities are using compact development strategies (76% compared to 63% of all other cities), VMT reduction strategies (76% compared to 66% of all other cities), and energy efficiency requirements for buildings (80% compared to 71% of all other cities).

Q1.4: How do commercial power companies influence strategies?

Hypothesis: Cities served by municipal power companies provide more economic incentives. (Q1.4-Q2.2, 2.6)

The survey data indicate a significant probability (p=.02) of a connection between cities having a municipal power company or department, and whether they offer financial incentives. Eighty-two percent of cities with municipal power provide some sort of economic incentives compared to 53% of cities with commercial providers. This seems particularly true for energy audits where 52% of cities with municipal power offer audits compared to 27% for cities with commercial providers. The survey descriptive and probability data supports the hypothesis.

Q1.5: Does the form of local government influence the types of strategies used?

Hypothesis: Cities with professional city managers are more likely to employ supply-side strategies. (Q1.5-Q2.3)

The survey suggests that a council-manager form of government is more likely to employ incentives than other forms of government. A very marginally significant probability shows connection between the city manger form of city government and offering incentives for renewable energy (p=.16). Sixty-seven percent of council-manager cities surveyed use incentives compared to 50% of all other forms of city governments. Fifty-two percent of council-manager cities have incentives for solar power compared to 45% of all surveyed cities. Similarly, 24% for wind compared to 15% of all surveyed cities and 14% for geothermal compared to 8% of all surveyed cities. Professional city managers seem to be facilitating incentive programs. The council-manager form of government is popular in California, where 46% of survey cities from the CAMX eGRID region have council-manager government compared to 19% of all cities surveyed.

Q1.6: How do state comprehensive planning requirements influence CAP GHG emission mitigation and climate adaptation strategies?

Hypothesis: Cities in states with laws that require comprehensive plans are more likely to employ balanced mitigation and adaptation strategies. (Q1.6-Q2.3, 2.4, 2.5)

The survey data do not indicate a statistical probability of a connection between comprehensive plan requirements by states and supply-side, demand-side or adaptation strategies. States with and without state comprehensive planning requirements employed similar supply-side and demand-side strategies. However, a higher percentage of surveyed cities in states with comprehensive planning requirements included drought, flooding, and wildland fire strategies in their CAPs.

Surveyed cities with state comprehensive plan requirements have a higher likelihood of providing incentives for solar power (50% vs. 45% of all surveyed cities), but slightly less of the cities have incentives for wind (14% vs. 15% of all surveyed cities) and biomass (2% vs. 6% of all surveyed cities).

The demand-side strategies are very similar to cities without state comprehensive plan requirements. They are slightly higher in the use of compact development strategies (68% vs. 67% of all surveyed cities), similar in VMT reduction strategies (66% vs. 66% of all surveyed cities), and lower in energy efficiency requirements for new and remodelled construction (64% vs. 71% of all surveyed cities).

Survey cities in states with comprehensive planning requirements employ more adaptation strategies. These included greater percentage of drought adaptation strategies (45% vs. 37% of all surveyed cities), flooding adaptation strategies (48% vs. 44% of all surveyed cities), and strategies to reduce wildland fires (32% vs. 25% of all surveyed cities).

Q1.7: How do state climate or energy policies and regulations influence city CAP preparation?

Hypothesis: Cities in states with GHG emissions regulations are more likely to use similar types of CAP software tools. (Q1.7-Q2.7)

Thirty-seven percent of survey cities are in states that have GHG emissions regulations. They are more likely to use custom spread sheets prepared by staff or consultants for GHG inventories (51% vs. 44% for all survey cities), mitigation planning (63% vs. 50% for all survey cities), and monitoring action plans (61% vs. 54% for all survey cities).

Sixty-one percent of cities surveyed use packaged software from a non-profit for developing their GHG emissions inventory, such as ICLEI’s CAPPA software. In addition, 13 cities specifically identify software from ICLEI in the “other” category for inventorying emissions. For testing mitigation strategies, 56% of surveyed cities use custom spreadsheets. Forty-one percent of cities use packaged software from a non-profit, and six cities specifically referred to ICLEI tools for this step in the “other” category for testing mitigation strategies. Fifty-four percent of survey cities use custom spread sheets developed by staff or consultants for managing and monitoring progress and 41% use packaged software from a non-profit. Four cities also mentioned they are using ICLEI software.

Over a third (36%) of surveyed cities do not consider their CAP influenced by state policies. They are less likely to use custom spreadsheets tools (33%) and more likely to use package software from a non-profit (74%).

Survey cities located in states with RPS are most likely to use custom spreadsheets developed by staff of consultants. In RPS states, 56% use custom spreadsheets for GHG emissions inventory, 64% for exploring mitigation strategies, and 66% for monitoring their action plans.

As with inventory and mitigation strategy tools, cities surveyed that do not feel they are influenced by state GHG mitigation or climate adaptation polices tend to more frequently use software packages from non-profits (53% vs. 40% of all surveyed cities) and commercial providers (7% vs. 3% of all surveyed cities).

It is clear that ICLEI continues to be an important provider of software tools for CAP cities, particularly for GHG inventory preparation, with 61% of cities using tools from non-profit providers and 13 cities specifically identifying ICLEI tools. After the inventory step, more cities are using customized tools for their mitigation strategies (50% vs. 41% from non-profit providers) and action plan monitoring (54% vs. 38% from non-profit providers). However, only 10% of surveyed cities use packaged software from commercial providers in the monitoring phase.

<u>Q1.8: Are cities that prepare CAPs motivated by leadership or regulations?</u>

Hypothesis: Motivation for preparing CAPs primarily comes from leadership. (Q1.8-Q1.9)

Sixty-three percent of the cities identify local political leadership as an important motivator. Forty-five percent of the cities surveyed cite citizen advocates as important motivators in preparing a CAP. The mission of an external funder influences 10% of survey cities and 20% of cities that prepared a community CAP.

Thirty-six percent of the cities surveyed identify their local sustainability tradition as important motivation for preparing their CAP. Of those cities, only 9% cited it is a state requirement.

Preparing both a municipal CAP and community CAP was more common among cities that identified citizen advocacy (65% vs. 55% of all cities surveyed), local leadership (69% vs. 58% of all surveyed cities), and a sustainability tradition (63% vs.

58% of all surveyed cities) as motivation for preparing a CAP. This group also cited the mission of the funder as a motivation more often than the survey city average (69% vs. 58%).

5.5.3 Section 3 Findings–Urban Form (Dependent) Variables

The third section of the survey asks cities about how the CAP is influencing their urban form. Each question was developed to inform a hypothesis about the relationship between the dependent variable with independent variable in Section 1.

<u>Q1.1: Does city size influence how CAPs shape urban form?</u>

Hypothesis: Larger cities are more likely to focus on land use-transportation strategies. (Q1.1-Q3.3)

The data do not indicate a probable connection between larger cities (over 250,000 population) and degree of CAP influence on transportation and land use planning (p=.38). However, larger cities seem to employ form-making transportation and land use policies more often than smaller cities. Larger cities with populations over 250,000 promote policies in their CAPs for higher density nodal development around transit more often (70%) than smaller cities (54%).

CAPs influencing policies for increasing density and infill development are more often implemented by larger cities over 250,000 in population (60% vs. 48% for all survey cities). Cities with a population of 100,001-250,000 also more often allow or require more commercial density near transit (50% vs. 39% of all surveyed cities). Midsize cities (50,001-100,00 population) are less likely to employ reduced parking standards (38% vs. 49% for all survey cities) and increase the price of parking (4% vs. 12% for all survey cities). Small cities (10,001-50,000 population) emphasize walking and biking more than the average percentage (93% vs. 84% of all surveyed cities).

<u>Q1.2: Are particular form-making strategies common to various climatic regions</u>?

Hypothesis: Climatic regions influence compactness patterns resulting from CAP strategies. (1.2-Q3.2)

The data do not indicate an overall probable connection between climatic regions and degree of CAP influence on development pattern policies. There are climate regions where survey city CAPs are influencing compactness patterns more than others. In particular, West, Northwest, and Upper Midwest climate regions are employing more form-changing policies than other regions both in terms supporting existing policies (Table 5.3) and adding new policies (Table 5.4).

Cities in the Upper Midwest CAP strategies are reinforcing their policies for centring development around their downtown (75% vs. 64% for all survey cities) and increasing residential densities (50% vs. 41% of all survey cities). This is also true for CAP strategies' influence on creation of new policies that centre development in and adjacent to downtowns (50% vs. 39% for all survey cities) and policy influence for protecting watersheds and natural systems (42% vs. 31% for all survey cities).

For West and Northwestern climate regions, CAP strategies already support existing strategies. For example, the percentage of cities with CAP strategies that support existing policies for centring development in and adjacent to downtowns is 69% but influencing new policies is lower at 36%.

Table 5.3

CAPs Supporting Existing Policies

Region	Number of cities in climate region	Reducing the amount or rate of city expansion Centering development in and around downtown	Increasing overall city residential densities	Protecting watersheds natural systems	
All	111	17%	64%	41%	49%
Upper Midwest	12	25%	75%	50%	58%
West	39	23%	69%	49%	44%
Northwest	14	21%	50%	29%	50%

Table 5.4

CAPs Supporting New Policies

Region	Number of cities in climate region	Reducing the amount or rate of city expansion	Centring development in and around downtown	Increasing overall city residential densities	Protecting watersheds natural systems
All	111	10%	39%	32%	31%
Upper Midwest	12	25%	50%	42%	42%
West	39	13%	36%	36%	26%
Northwest	14	14%	36%	29%	29%

Q1.3: How does the amount of CO2 in the grid influence urban form?

Hypothesis: Cities with smaller amounts of CO2 in their power source emissions are more likely to focus on transit-oriented development policies. (Q1.3-Q3.3)

Table 5.5 shows the five-eGRID regions with the most survey respondents and CAPs representing 70 survey cities. Compared to the average of all 110 survey cities, more CAMX (California) cities have policies that encourage density and infill near transit; NWPP (Northwest) cites are reducing parking standards; AZNM (Arizona and New Mexico) cities are emphasizing walking, biking, and increasing density and promoting transit-oriented development; RFCM (Michigan) is increasing density around transit and reducing parking requirements; and NEWE (New England) are increasing transit services and reducing parking requirements.

Table 5.5

eGRID Regions with Most CAPs Surveyed

eGRID	No. of Survey Cities Responses	CO2e lb per M/Wh*	Notes:
U.S.	110	1,222	
CAMX	38	661	• 63% supporting or requiring density for infill development near transit (vs. 47% of al survey cities) • 50% increasing commercial density for infill near transit (vs. 38% of all survey cities) • 53% reducing required parking standards (vs. 48% of all survey cities)
NWPP	14	823	• 57% reducing required parking standards (vs. 48% of all survey cities)
AZNM	6	1,197	• 100% emphasizing walking and biking (vs. 84% of all survey cities) • 50% increasing density and transit-oriented development (vs. 37% of all survey cities)
RFCM	6	1,669	• 50% increasing in density and transit-oriented development (vs. 37% of all survey cities) • 67% reducing required parking standards (vs. 48% of all survey cities)
NEWE	6	734	• 83% increasing transit services (vs. 48% of all survey cities) • 67% reducing required parking standards (vs. 48% of all survey cities)
Total	70		

** U.S. EPA, 2009*

The analysis of the high and low eGRID regions' cities strategies does not support the hypothesis that cities with less CO2e in their energy supply are more likely to focus on transit-oriented development. The eGRID regions with the least amount of CO2e lb per M/Wh share reduced parking requirements as a common strategy. The cities in high CO2e lb per M/Wh are more often emphasizing increased density and transit-oriented development.

<u>Q1.4: How do commercial power companies influence urban form?</u>

Hypothesis: Cities with commercial power companies are more likely to employ building and site design strategies. (Q1.4-Q3.5)

Descriptive data analysis provides modest support for this thesis (Table 5.6). Cities with commercial power companies are more likely to adopt higher energy efficiency standards than cities their own power company. Cities with commercial power company service have only a slightly higher likelihood of employing development standards or guidelines for climate responsive buildings and sites, or require onsite storm water management. None of the survey cities require net zero development.

Table 5.6

Influence of Power Companies

	Cities with Private Power Company	Cities with Municipal Power Company
Higher Building Energy Efficiency Standards	51%	31%
Climate-Responsive Building and/or Site Development Guidelines	8%	6%
Onsite Storm Water Management	46%	44%

<u>Q1.5: Does the form of local government influence CAP strategies that impact their form?</u>

Hypothesis: Professional Manager cities (council-manager or commission-manager) are more likely to integrate CAP strategies in their comprehensive plans. (Q1.5-Q3.1)

Descriptive statistics suggest survey cities with a council-manager and commission-manager form of government more frequently integrate CAP policies into their comprehensive plans (Table 5.7). Council-manager and commission-manager cities more often than other forms of governing: plan to integrate CAP strategies into the comprehensive plan; expressed CAP strategies throughout the comprehensive plan as goals and policies; added new sections or elements emphasizing environmental or climate change policies; added or modifying a few existing goals and policies; and included CAP implementation policies in their comprehensive plans.

Table 5.7

Influence of City Manager Form of Government

	City Manager Cities	Other Forms of Government
Not yet, but plan to integrate CAP strategies into the comprehensive plan	43%	38%
Expressed CAP strategies throughout the comprehensive plan as goals and policies	39%	32%
Added new sections or elements emphasizing environmental or climate change policies	32%	23%
Added or modifying a few existing goals and policies	21%	19%
Included CAP implementation policies in their comprehensive plans	21%	12%

Q1.6: How do state comprehensive planning requirements influence form-giving strategies?

Hypothesis: Cities in states with laws that require comprehensive plans are more likely to integrate GHG emissions mitigation strategies into comprehensive plans. (Q1.6-Q3.1, Q3.2, Q3.3, Q3.4, Q3.5, Q3.6)

Descriptive statistics indicate cities located in states that require plan elements or sections more frequently and consistently integrate their form-giving CAP strategies into comprehensive plan policies than cities in states without requirements (Table 5.8).

Surveyed cities in states with comprehensive plan requirements more thoroughly integrate CAP policies into their comprehensive plans, add new sections, modify existing goals and policies, and add implementation policies. They more often support existing polices regarding concentric and compact development while protecting watersheds. New policies more often focus on increasing residential densities and reducing impacts on natural areas adjacent to cities. A higher percentage of cities in states that have require comprehensive requirements employ land use-transportation policies to implement CAP strategies. They more often have policies about storm water management and adaptation policies for wildland interface, droughts and flooding.

Table 5.8

State Comprehensive Plan Requirements and Planning Policies

	Local Policy Implementing CAP	Percentage of cities that have elements or sections required by state law	Percentage of all survey cities
	Number of survey cities	44 (39%)	112 (100%)
Degree of CAP and Urban Planning Integration	Expressed CAP strategies have throughout the comprehensive plan as goals and policies	39%	32%
	Added new sections or elements emphasizing environmental or climate change policies	41%	23%
	Added or modifying a few existing goals and policies	25%	19%
	Implementation policies	18%	12%
CAPs Supporting Existing Policies	Reducing the amount or rate of outward city expansion	23%	17%
	Emphasizing centring development in and around the city's downtown	70%	64%
	Increasing overall allowable residential densities	55%	41%
	Protecting watersheds and other natural systems in and/or adjacent to the city	48%	46%
CAPs Influencing New Policies	Reducing the amount or rate of outward city expansion	11%	10%

	Emphasizing centring development in and around the city's downtown	39%	39%
	Increasing overall allowable residential densities	36%	32%
	Protecting watersheds and other natural systems in and/or adjacent to the city	30%	31%
Transportation and Land Use Planning	Increasing the number or density of nodal, transit oriented developments	82%	84%
	Supporting or requiring increased density for infill development near transit	45%	38%
	Allowing or requiring higher density commercial development near transit	56%	47%
Infrastructure Design	Investing in water distribution	30%	21%
Building and Site Design	Requiring onsite stormwater management	55%	46%
Adapting to Climate Change	Reducing or regulating development in wildland and urban interface areas	16%	12%
	Limiting development in low-lying areas prone to flooding	33%	29%
	Requiring water conservation or allowing use of recycled water	33%	27%

Q1.7: How do state climate and/or energy policies and regulations influence city CAP strategies and resulting city form?

Hypothesis: Cities in states that require GHG emissions inventories for local government are more likely to integrate CAP strategies into their comprehensive plans. (Q1.7-Q3.1)

There is not significant probability that cities citing the state does not influence their mitigation and adaptation policies have or will include CAP strategies into their comprehensive plans (p=.21). Cities in states with GHG emissions regulations have a modestly higher frequency of CAP strategy integration in comprehensive plans.

Surveyed cities with state GHG emission regulations are more likely to fully integrate CAP strategies (36%) compared to all cities (32%), add new sections for climate change in their plans (33% vs. 23% of all surveyed cities), add or modified existing goals (23% vs. 18% of all surveyed cities), and include implementation policies (18% vs. 12% of all surveyed cities).

Q1.8: Are cities that prepare MCAPs more likely to have infrastructure standards influenced by CAP strategies?

Hypothesis: Cities that prepare an MCAP more often have strategies that influence infrastructure design. (Q1.9-Q3.4)

The survey data do not indicate a significant probability of a connection between cities that prepared only MCAPs and influence on infrastructure design compared to all other survey cities (p=.25). Surveyed cities with adopted MCAPs have infrastructure design policies more often for water treatment (35%), water distribution (40%), storm water management (60%), and design standards for streets, bikes and pedestrian facilities (70%) than all surveyed cities (21%, 21%, 44%, and 65%).

Q1.9: How does a tradition of environmental advocacy influence a city's form?

Hypothesis: Cities with a tradition of environmental advocacy have CAPs that emphasize compact development patterns. (Q1.8-Q3.2)

The survey data do not indicate a significant probability of a connection between city local sustainability traditions and policies influencing overall city form.

Surveyed cities with local sustainability traditions *support existing policies* with CAPs about as often as other survey cities. They reduce outward expansion 17% compared to 17% of all survey cities, centre development downtown 76% compared to 65% of all survey cities, increase overall residential densities 40% compared to 41% of all survey cities, and protect watersheds and natural systems adjacent to the city 52% compared to 48% of all survey cities.

Surveyed cities with local sustainability traditions *influence new policies* with CAPs about as often as other survey cities. They reduce outward expansion 12% compared to 10% of all survey cities, centre development downtown 43% compared to 39% of all survey cities, increase overall residential densities 29% compared to 32% of all survey cities, and protect watersheds and natural systems adjacent to the city 45% compared to 47% of all survey cities.

Similarly, cities with sustainability traditions have transportation and land use policies about as often as all survey cities. They employ strategies that influence polices for increasing nodal development 38% compared to 37% of all survey cities, increase infill and density near transit 48% compared to 47% of all survey cities, and allows or requires higher commercial density near transit 40% compared to 38% of all survey cities.

5.5.4 Survey Results and Research Questions

The survey builds on the findings from Study 1: Case Studies by providing quantitative data explore the motivation, strategic, and policy aspects of CAPs and how they are shaping the future of cities. The following summary connects key findings from the survey to research questions guiding this thesis.

AIM1: Assess motivation and process of local government

Q1-Motivation: Why are cities preparing CAPs?

Review of planning documents and interviews of CAP planning managers in Study 1 suggested that elected leadership and local environmental advocates were important motivators. Cities credit local political leadership (62%) and local citizens advocates (45%) as their primary motivation for preparing a CAP. Over a third (36%) identify a strong local sustainability tradition. Motivations also include conditions from the funder to complete a CAP (9%) and state requirements (9%).

Cities that prepared both municipal and community CAPs credited local elected leaders, mission of the CAP funder, citizen advocates, and local sustainability traditions more often than state requirements as their motivation. However, a local tradition for environmental advocacy does not seem to influence the types of strategies a city uses in its CAP.

Q2-Policy Context: How are cities responding to state and federal policy context regarding preparing CAPs?

One third (33%) of the survey cities are located in the CAMX eGRID in California, where state legislation has required cities to plan for lower GHG emissions. Yet, a relatively small percentage of survey cities cite state requirements as primary motivators for preparing a CAP. Only 33% of the cities in the CAMX eGRID cite the state's requirements as motivation. It seems that even in California, 63% of the of the survey cities credit local leadership for preparing their CAP. This is even higher than the average of all survey cities (62%).

Q3-Process: How are cities approaching preparation of CAPs?

Most survey cities are preparing both municipal and community CAPs (59%) and endeavouring to integrate their CAP strategies into their comprehensive plans. Most cities are making the effort to be comprehensive and follow through with implementation of CAP actions. Only 4% of the cities do not have a comprehensive plan, and only 7% have no plans to move CAP strategies into their comprehensive plan.

AIM 2: Compare the types of GHG/CO2 tools used by cities

Q4-CAP Tools: Why do communities choose certain tools to inform the CAP process?

Interviews of CAP planning managers in Study 1 suggested cities were using a variety of tools based on their staff capabilities and need for customization. The survey indicates that for GHG inventories most cities used software tools provided by non-profits (62%), and many cities identified ICLEI's software tools in particular. That percentage shifted towards customized spread sheets prepared by consultants or staff (50%) for determining mitigation strategies and monitoring planning progress (54%). And for tracking results, cities are increasingly using commercial software packages (9%).

AIM 3: Assess how CAPs shape city form

Q5-CAP Strategies: How are CAP strategies integrated into urban planning policies?

Case study cities in Study 1 are put in three categories in terms of how they integrate their CAPs into their comprehensive plans. They fully integrate their CAPs, use their CAPs as a strategic planning effort, or have not integrated their CAPs. Nearly nine in 10 (87%) survey cities have comprehensive plans, 40% have sections required by state law, 36% use a strategic planning method, and 39% participate in some sort of regional planning. Sixty-two of 116 survey cities (53%) did not participate in a regional effort in preparing their CAP. The rest of the cities collaborated in GHG inventory preparation (30%), have common mitigation or adaptation strategies (12%), and shared responsibility and actions (11%). Survey responses seem to reflect the various planning systems and degrees of CAP integration categories identified in Study 1 case studies.

Q6-Influencing Patterns: How are CAP strategies changing the form of cities?

CAP cites are becoming more centred, nodal and transit-oriented, denser, and more walkable and bikeable. These concepts have long been touted as smart growth principles that protect farmland, reduce energy and resource use, and make cities more social and liveable. Cities are also using them to reduce their GHG emissions.

CAP strategies are reinforcing and influencing change in comprehensive planning policies. In particular, CAP strategies are reinforcing city commitments to developing in and adjacent to downtowns. Six-four percent of survey cities are doing this. Thirty-nine percent say their CAP has influenced policies regarding centring development toward their downtowns.

Other policies influenced by CAPs include reducing the rate of outward expansion (10%), increasing overall densities (32%), and protecting watersheds and natural areas adjacent to their city (31%). Forty-seven percent of cities identified other ways the CAP was influencing their policies. Examples included transit-oriented development and neighbourhood-oriented development.

Over 8 in 10 survey cities (84%) reported that their CAP emphasizes walking and biking. This is by far the most popular land use and transportation strategy. It is followed by reducing parking requirements (49%), expanding transit services (48%), increasing the number and density of transit-oriented developments (38%), and increasing the density of commercial development near transit (38%).

CAP influence over infrastructure policies seems to be supporting city form policies. The most popular infrastructure strategy is to promote biking and walking (65%). Stormwater infrastructure was cited by 44% of survey cities. Water treatment and distribution were both identified by 21% of survey cities as infrastructure influenced by their CAP.

Almost half (48%) of survey cities are pursuing higher energy-efficiency standards for buildings and on-site stormwater management (46%). Only 8% of survey cities are implementing development standards for climate-responsive building and block orientation.

Adaptation planning is becoming an increasingly important area of policymaking. However, adaptation planning is not part of the traditional smart growth agenda. In particular, 30% of survey cities CAPs are identifying heat islands as a challenge to be met with added landscaping with an added benefit as a CO2 sink. Another 29% are planning for increased flooding and 27% more for drought. Other adaptation actions submitted by survey cities include coastal zone management and on-going vulnerability assessments.

5.5.5 Hypothesis and Survey Results

The survey was designed to test 17 hypotheses for probability of linkages between independent and dependent variables. Descriptive statistics (percentages) are also used to compare the frequency (percentage) of cities using form-making strategies and policies. The large number of degrees of freedom (df) in the questions made probability statistics difficult to employ unless the question could be collapsed into a 2x2 Fishers probability table that works well for small samples sizes (under 200).

Significant and Marginally Significant Probability

Three hypotheses provided significant or marginally significant probabilities for independent and dependent variables.

There seems to be a high probability (p=.02) that cities with municipal power companies are providing more economic incentives for implementing CAP strategies. Descriptive statistics seem to bare this out, showing a higher percentage of cities with municipal power are providing incentives compared to the average survey city.

The hypothesis that larger cities are participating in regional planning more often has a very marginally significant probability of a connection (p=.17). The descriptive statistics seem to support this hypothesis. Sixty-two percent of cities over 250,000 in population are participating in regional CAP efforts compared to 43% of all survey cities.

There is also a very marginally significant probability (p=.16) that cities with professional managers form of government are more likely to employ supply-side strategies. Sixty-seven percent of council-manager cities surveyed use incentives compared to 50% of all other forms of city governments.

Descriptive Statistics Support of Hypotheses

Ten other hypotheses seem to be supported or modestly supported by descriptive statistics.

Hypothesis: Climatic regions influence a city's GHG emission inventory

In particular, West, Northwest and Upper Midwest climate regions are employing more form-changing policies than other regions both in terms supporting existing policies and adding new policies.

Hypothesis: Motivation for preparing CAPs primarily comes from leadership

Sixty-three percent of the cities identify local political leadership as an important motivator. Forty-five percent of the cities surveyed cite citizen advocates as important motivators in preparing a CAP. The mission of an external funder influences 10% of survey cities and 20% of cities that prepared a community CAP.

Hypothesis: Larger cities are more likely to focus on land use and transportation strategies

A comparison of larger and smaller cities employing form-making transportation and land-use policies indicate larger cities do it more often. Larger cities with populations over 250,000 promote policies in their CAPs for higher-density nodal development around transit more often (70%) than smaller cities (54%).

Hypothesis: Climatic regions influence compactness patterns resulting from CAP strategies

In some climate regions, CAPs seem to influence compactness patterns more than others. In particular, cities in the West, Northwest and Upper Midwest climate regions are employing more form-changing policies than other regions both in terms supporting existing policies and adding new policies.

Hypothesis: Cities with commercial power companies are more likely to employ building and site design strategies

Descriptive data analysis provides modest support for this hypothesis. Cities with commercial power companies are more likely to adopt higher energy efficiency standards (51%) than cities with their own power company (31%). Eight percent of the cities with commercial power company service have development standards or guidelines for climate-responsive buildings and sites compared to 6% of municipal power cities. Forty-four percent of survey cities with municipal power and 46% of cities with commercial power require onsite stormwater management. None of the survey cities require net zero development.

Hypothesis: Professional Manager cities (council-manager or commission-manager) are more likely to integrate CAP strategies in their comprehensive plans

Descriptive statistics seem to suggest survey cities with a council-manager and commission-manager form of government somewhat more frequently integrate CAP policies into their comprehensive plans.

Hypothesis: Cities in states with GHG emissions regulations are more likely to use similar types of CAP software tools

This hypothesis has modest support of descriptive statistics. Thirty-seven percent of survey cities are in states that have GHG emissions regulations. They are more likely to use custom spread sheets prepared by staff or consultants for GHG inventories (51% vs. 44% for all survey cities), mitigation planning (63% vs. 50% for all survey cities), and monitoring action plans (61% vs. 54% for all survey cities).

Hypothesis: Cities in states with laws that require comprehensive plans are more likely to integrate GHG emissions mitigation strategies into comprehensive plans

A higher percentage of cities located in states that require plan elements or sections more frequently and consistently integrate form-giving CAP strategies into their comprehensive plan policies than cities in states without requirements.

Hypothesis: Cities in states that require GHG emissions inventories for local government are more likely to integrate CAP strategies into their comprehensive plans

Cities in states with GHG emissions regulations have a modestly higher frequency of CAP strategy integrations in comprehensive plans. Surveyed cities with state GHG emission regulations are more likely to fully integrate CAP strategies, add new sections for climate change, add or modify existing goals, and include implementation policies.

Hypothesis: Cities that prepare an MCAP more often have strategies that influence infrastructure design

Surveyed cities with adopted MCAPs have infrastructure design policies more often for water treatment, water distribution, stormwater management, and design standards for streets, bikes and pedestrian facilities than all surveyed cities.

<u>Unsupported Hypotheses</u>

Four hypotheses are not supported by probability or descriptive statistics.

Hypothesis: Cities with larger amounts of CO2e in their electrical grid emphasize strategies that reduce energy use

Comparing strategies for cities in the eGRID regions with the highest amount of CO2e to the six lowest does not reveal a dominant strategy. Cities with highest and lowest amounts of CO2e in their grids generally balance their demand-side strategies. This does support the hypothesis.

Hypothesis: Cities in states with laws that require comprehensive plans are more likely to employ balanced mitigation and adaptation strategies

States with and without state comprehensive planning requirements employed similar supply-side and demand-side strategies. However, there are a higher percentage of surveyed cities in states with comprehensive planning requirements that included drought, flooding, and wildland fire strategies in their CAPs.

Hypothesis: Cities with smaller amounts of CO2e in their power source emissions (eGRIDs) are more likely to focus on transit-oriented development policies

The analysis of the five-eGRID regions with the most survey cities indicates high and low CO2e grid cities' strategies do not support the hypothesis. Cities with less CO2e in their energy supply are more likely to focus on transit-oriented development. The eGRID regions with the least amount of CO2e lb per M/Wh share reduced parking standards as a common strategy. Cities with high CO2e lb per M/Wh more often emphasize increasing density and transit-oriented development.

Hypothesis: Cities with a tradition of environmental advocacy have CAPs that emphasize compact development patterns

Supply-side, demand-side and transportation policies for cities with an environmental and sustainability tradition were not more likely to emphasize compact development.

5.6 DISCUSSION–IMPLICATIONS FOR STUDY 3

The survey is the most comprehensive and has the largest sample size of U.S. CAP cities of any survey to date. It provides a way of understanding universal and unique experience of cities as they join the first generation of cities preparing CAPs. The survey was designed to include many of the urban planning strategies and actions used by case study cities in Study 1 and the review of literature. Cities responded to these questions and provided other insights in "other" answers. The survey suggests:

1. Survey cities' motivation for preparing CAPs primarily comes from their own values and leadership, not from regulations.
2. CAP cities are employing similar strategies for mitigating GHG emissions, regardless of climate region or eGRID.
3. Cities are responding to different adaptation challenges.

The discussion of the study findings expands on these overall conclusions identifying universal city and regional CAP strategies, the influence of ecological and political context, and how these are conspiring to influence the future form of cities.

5.6.1 Universal Strategies

Cities are using similar urban planning strategies while addressing regional environmental issues and opportunities. Cities are employing many “old school” smart growth strategies and now measuring their effectiveness in terms of meeting emission reduction targets. The most popular growth management strategies include compact, transit-oriented, and centred development. These are employed by many of the CAP cities with some regional variations. Most (87%) of the CAP cities have comprehensive plans, over a third have a sustainability tradition, and nearly two-thirds credit local political leadership in motivating the preparation of their CAP. These seem to be some of the important universal experiences and strategies with some regional variations.

5.6.2 Influence of Context on CAP Strategies and Policies

CAP cities operate within various political, climate, and energy supply contexts. Their context has some influence over their strategy development and policy implementation.

<u>Political Context</u>

As discussed in the literature review, clear biases are built into conservative and progressive politics regarding climate change and action. This plays out at a state and regional level where inland states and states that provide coal, oil, and gas are more conservative. However, both the literature and the survey indicate it is the leadership of cities, regardless of their state politics, that are the catalyst for preparing a CAP.

The survey treats the form of local government as a fundamental characteristic. This does not seem to be a factor except that city manager or professionally managed cities are more likely to employ supply-side energy strategies, particularly in using incentive programs.

<u>Regional Cooperation</u>

Cities typically do not exist as islands but are part of a connected regional urban constellation of regional centres, satellites (with jobs-housing balance), and suburbs (bedroom towns and cities). The size of the city has some connection to how likely they are to engage in regional cooperation. Larger cities over 250,000 in population are more likely to be a regional centre and engage in regional planning. Smaller cities with populations of 10,001-50,000 are also more likely to cooperate regionally as satellite or suburb cities within an urban region.

Climate Region Variations in Strategies and Policies

The survey reveals some regional variations in strategic emphasis. In particular, West, Northwest and Upper Midwest climate regions are employing more form-changing policies than other regions both in terms supporting existing policies and adding new policies.

Cities in the Upper Midwest CAP strategies are both reinforcing their existing and introducing new policies for centring development in and near their downtown and increasing residential densities. CAPs are also influencing development of new policies for protecting watersheds and natural systems.

For West and Northwestern climate regions, CAP strategies more often support existing policies for centring development in and adjacent to downtowns (69%) rather than influencing new ones (36%). Many states in the Northwest climate region have been leaders in advancing comprehensive and regional planning practice. Most cities in these states have already made the policy commitment to downtown investment for economic vitality and environmental sustainability reasons. Their CAPs are embracing and reinforcing these policies.

The survey responses suggest there are differences in supply and demand strategies in various climate regions. Cities in the Northwest, Southwest, and Upper Midwest climate regions provide more incentives for renewable energy. Southwest Region cities are more likely to provide funding incentives for renewables. Cities in the West Climate Region are more likely to utilize demand-side strategies that make their cities more efficient.

Energy Supply Context

There are 26 eGRID regions. CAMX region has 46 CAP cities, and nine other eGRID regions have one or no survey CAP city. In order to better understand the strategy and policy differences, Study 2 compares the six highest and six lowest eGRID regions' strategies and analyses CAP implementation policies common to the five eGRID regions with the largest number of cities.

Comparing strategies for cities in the eGRID regions with the six highest and six lowest amount of CO2e does not reveal a dominant strategy. Cities with highest and lowest amounts of CO2e in their grids generally balance their demand-side strategies with some variation. CAP survey cities with the lowest amount of CO2e in their eGRID more often employ strategies for compact development, VMT reductions, and building energy conservation.

The policy analysis of the five eGRID regions with the greatest number of CAP cities indicates cities with the least amount of CO2e in the grid share reduced parking requirements as a common implementation policy. Cities in eGRID regions with the highest amount of CO2e in their grid emphasize policies that increase density and support transit-oriented development.

Regional eGRID variations include:

- More CAMX (California) cities have policies that encourage density and infill near transit;
- NWPP (Northwest) cites are reducing parking standards;
- AZNM (Arizona and New Mexico) cities are emphasizing walking and biking and increasing density and transit-oriented development;
- RFCM (Michigan) cities are increasing density around transit and reducing parking standards; and
- NEWE (New England) cities are increasing transit services and reducing parking standards.

Climate Change Context and Adaptation Planning

Adaptation planning is not part of the traditional smart growth agenda. However, cities recognize climate change as an important part of their future context and will influence the form of the city. In particular, CAP survey cities identify heat islands as a challenge to be met with added landscaping that serves as a CO2 sink. Additional popular adaptation strategies and policies include planning for increased flooding and drought, coastal zone management, and on-going vulnerability assessments.

Regional variation in adaptation planning reflects projected climate trends. The Southwest climate region CAP cities more often plan for wildland fires, flooding, and drought; South and West climate regions have a higher concern regarding sea level rise; and the West, Southwest, and South regions are anticipating drought conditions.

5.6.3 Infrastructure and Building Design

In addition to land use strategies, infrastructure, site deign, and building design strategies will influence how cities are designed and built.

CAP influence over infrastructure policies seems to support city form policies for both mitigation and adaptation. Nearly two-thirds of CAP cities are enhancing biking and walking infrastructure to implement VMT reduction strategies. Other common adaptation strategies included investing in stormwater management, water treatment, and water distribution infrastructure.

Cities in the Upper Midwest climate region have placed a particular emphasis on improving infrastructure. This includes water treatment and distribution, stormwater facilities, sanitary sewer and power distribution. CAP cities in the Southeast, Northeast and Ohio Valley climate regions also emphasized the need to plan for upgrading their "wet utilities."

Surprisingly, most CAP survey cities did not emphasize building and site design as an important strategy or implementation action. Nearly half the cities identified increasing the energy efficiency of buildings and need for on-site stormwater management, but only 8% were implementing new development standards for climate-responsive building, site, or block design. None of the CAP cities included net zero targets for new development.

5.6.4 Implications for Study 3 Strategy Modelling

The modelling in Study 3 is intended to test the effectiveness of popular CAP action plan strategies. The study illustrates common land use strategies citied by CAP survey cities. In addition, there are operational and management strategies CAP cities identified as important mitigation actions. Modelling should also demonstrate how variations in supply-side eGRID and renewable energy contexts impact city form and action plan performance.

Study 2 has provided a clear set of common strategies to model. The following three questions present three categories of variables Study 3 will address: urban form, demand-side city operations and management, and supply-side strategies.

Land Use Strategies: How effective is the increasing density, compactness, and centeredness of communities in reducing GHG emissions?

Demand-side Strategies: How effective are demand-side strategies, such as increasing energy efficiency of buildings and improving mobility services, in reducing GHG emissions?

Supply-side Strategies: How effective are common demand-side strategies in combination with supply-side strategies?

5.7 VALUE OF STUDY

The national survey of CAP cities makes further contributions to our understanding the motivation for cities to prepare CAPs, the types of tools and processes they are using, and how CAP strategies and implementation policies are shaping cities. First, it tells us that CAP cities are primarily influenced and motivated by local elected leadership and not by state policies. Most (87%) of the CAP cities have comprehensive plans, over a third have a sustainability tradition, and nearly two-thirds credit local political leadership in motivating the preparation of their CAP. Secondly, CAP cities are relying on ICLEI tools for GHG inventory and less so for strategies and implementation monitoring. Thirdly, cities are using traditional smart growth strategies as mitigation actions, regardless of their region. The most popular growth management strategies include compact, transit-oriented, and centred development. However, cities in eGRID regions with larger amounts of CO2e are emphasizing different strategies regarding density, infill development, transit oriented development, transit services, parking standards, and walking and biking infrastructure. Cities in the Upper Midwest, West, and Northwest eco-regions are using more form-changing GHG emissions mitigation policies.

The CAP city survey is the most robust to date, and the large amount of data collected can be used to ask other questions and be the basis for more focused topical research. The study includes original questions that increase our understanding of what is motivating cities, the profiles of cities that are preparing CAPs, their leading strategies, and implementation policies. Finally, Study 2 has provided questions for the next study that will test the effectiveness of popular GHG mitigation strategies.

Chapter 6

STUDY 3: MODELING CAP STRATEGIES

MODELING EFFECTIVENESS OF COMMON GHG MITIGATION STRATEGIES

6.1 ABSTRACT

This chapter uses a mathematical model to describe the effectiveness of common strategies identified in a national U.S. survey of cities that have completed climate action plans is described using a mathematical model. A business-as-usual, compact, centred, and transit corridor city scenarios are compared to a 2015 baseline city of 50,000. Each scenario is modelled at a population of 100,000 to test and describe the effectiveness of demand and supply-side strategies, including energy efficiency, renewable energy, and mobility (transit) policies. A single case study city is used to analyse the validity of the modelling tool.

6.2 INTRODUCTION

Study 2's survey is the most comprehensive and has the largest sample size of U.S. CAP cities of any survey to date. It provides a way of understanding universal and unique experiences of cities as they join the first generation of communities preparing CAPs. Study 2 was designed to include many of the urban planning strategies and actions used by case study cities in Study 1 and the review of literature. The summary of Study 2 results expands on original research aim 3 and question 6.

6.2.1 Key Findings from Study 2

The survey results indicate many cities are reinforcing existing and applying new growth strategies and policies. These include land use, demand-side, and supply-side strategies:

Land Use Strategies

- CAPs are making cities more compact, concentric, and centred with a higher "passive performance"--walking and biking.
- CAP strategies are reinforcing and influencing city commitments to developing in and adjacent to downtowns.
- High eGRID CO2e cities are emphasizing on increasing density and transit-oriented development and low CO2e cities share reduced parking requirements as a common strategy.

- CAP cities are reducing parking requirements and expanding transit services.

Demand-side Strategies

- CAP survey cities are pursuing higher energy efficiency standards.
- CAP city infrastructure investments emphasize walking and biking infrastructure.

Supply-side Strategies

- Most CAP cities are providing incentives for renewable energy and are in states with RPS policies.

6.2.2 Study 3 Research Questions

The three questions below expand on research aim 3 and question 6 and guide further inquiry regarding the effectiveness of popular CAP strategies that are influencing the form of cites.

Q6A-Land Use Strategies: How effective are increasing community density, compactness, and centeredness in reducing GHG emissions?

Q6B-Demand-side Strategies: How effective are demand-side strategies, such as increasing energy efficiency of buildings and improving mobility services, in reducing GHG emissions?

Q6C-Supply-side Strategies: How effective are common demand-side strategies in combination with supply-side strategies?

6.3 MODELING METHOD

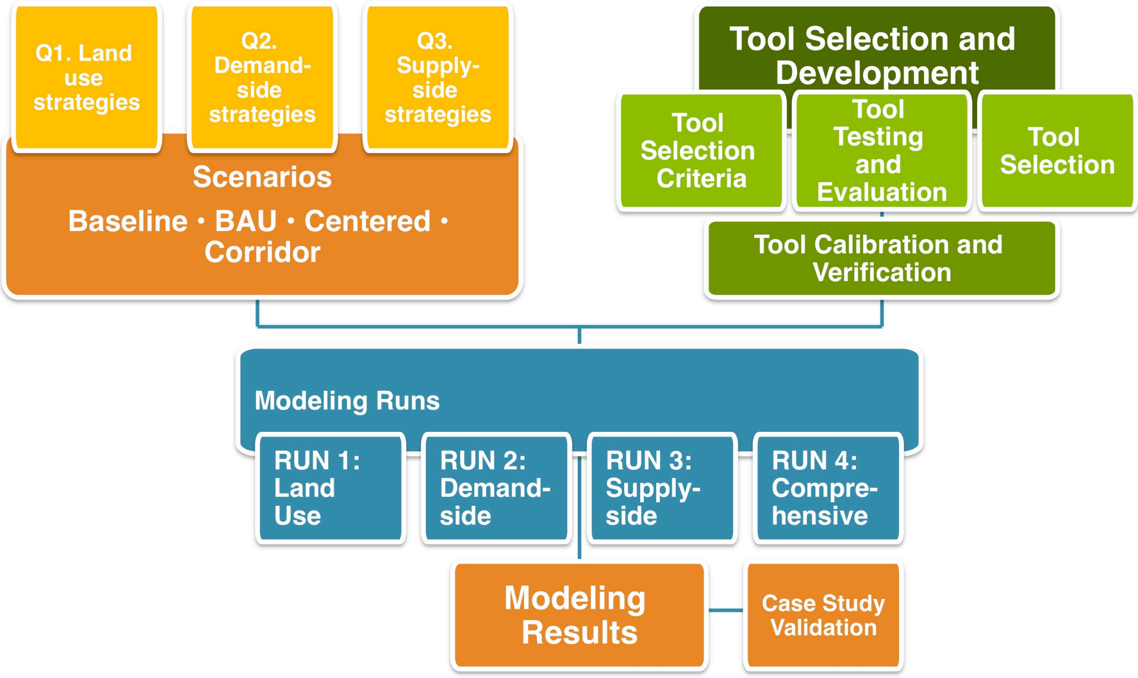
A four-part process describes the effectiveness of land use, demand-side, and supply-side strategies. A hypothetical typical U.S. city is developed from U.S. census data used to construct a baseline scenario. The baseline, business as usual, and two land use scenarios are created. Software is evaluated, selected, modified and then is used to describe the effectiveness of common CAP strategies.

The overall methodical construction of the modelling process is illustrated in Figure 6.1. The process includes four steps: (1) Development of land use scenarios; (2) Tool selection and development; (3) Modelling runs; and (4) Case study verification.

Summary sheets from modelling runs for model cities scenarios and the validation case study can be found in Appendix C.

Figure 6.1

Overall Modelling Approach



6.3.1 Land Use Scenarios and Supply-side and Demand-side Assumptions

The study uses a mathematical model of a typical U.S. city to describe the effectiveness of various CAP land use planning, demand-side operational, and supply-side GHG emission reduction strategies. Four scenarios are prepared to compare how cities perform in terms of reducing GHG emissions and reaching a long-term reduction target.

Cities with 50,001 to 100,000 populations had the highest response rate (26% of total CAP cities) in the survey. These cities are primarily located in western states and subject to dynamic population growth. To test how the most common CAP city could expand, a 50,000-population baseline city is grown to a population of 100,000. The time period is assumed to be 2015 to 2050.

Three land use scenarios are developed employing popular smart growth strategies assuming the same city population and job growth. These include a land-intensive business-as-usual (BAU) city developed along freeways. The BAU incorporates population growth projections without regulatory or technical interventions. Its boundary is FLEXIBLE, expanding to accommodate future growth. A centred city scenario has a FIXED boundary. Constrained to its original boundary, growth is compressed and centred in a high density transit-oriented downtown. The third scenario is a corridor city. Its boundary is DETERMINED through planned expansion along a transit corridor. The scenarios are simplifications of real world conditions whose development programs can be defined and used in a descriptive mathematical model.

CAP Strategy Context

Study 2 results identify how CAP cities are striving to meet their GHG reduction targets by employing a suite of strategies. They establish a baseline emissions level, estimate a BAU trajectory, apply strategies, and estimate their effectiveness in reducing GHG emissions.

Figure 6.2

GHG Emission Strategy Context: Goals and Target

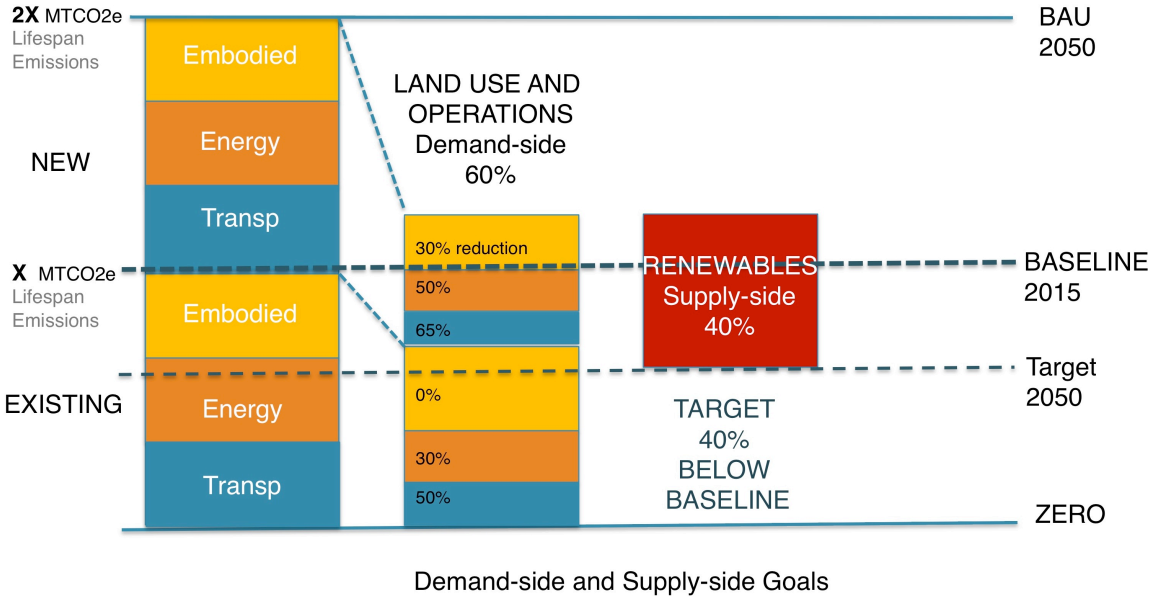


Figure 6.2 illustrates the relationship between a GHG reduction target and goals for demand-side and supply-side strategies. CAP cities set goals to reduce their annual CO2e to meet long-term targets relative to a baseline. The city employs a series of mitigation strategies and supporting actions to meet goals for reducing emissions from embodied, energy, and transportation sources for the new (future) development and existing development. The then further reduce GHG emissions by increasing the amount of renewable energy to meet a target that is 80% below their baseline.

Demand-side and Embodied CO2e Goals and Rationale

Demand-side strategies and actions mitigate GHG emissions from buildings and transportation. Assumptions reflect common strategies and actions employed by CAP cities to meet goals.

Transportation Goal

Goal: The scenarios' reductions in CO2e missions from transportation are achieved by increasing fuel efficiency, increasing low CO2e fuel mix (80mpg equivalent by 2050), and reducing VMT (30%).

Rationale: Passed by Congress in 2007, the Energy Independence and Security Act (EISA) mandates increasing CAFE standards for cars and small trucks from 34.1 MPG in 2010 to 54.5 in 2025 to meet a 40% reduction goal in CO2e (Center for Climate and Energy Solutions, 2013). In 2006, 97% of GHG emissions from transportation were from burning of fossil fuels (U.S. Department of Transportation, 2013). Since 82% of transportation GHG emissions are from autos, light, medium, and heavy trucks (Burbank, 2009, p. 8), the 2007 CAFÉ standards will have a significant benefit and should lead to reductions well beyond 40% by 2050.

The model uses a VMT calculator developed by ICLEI to generate household VMT based on data from San Francisco, Chicago, and Los Angles. Single-family 4 DU/a residential densities in the VMT calculator result in an 8,026 annual VMT per capita compared to a townhouse 22 DU/a densities result in 4,705 VMT per capita, a 42% reduction. Additional improvements in pedestrian infrastructure and transit service can further reduce VMT. Therefore, an overall goal of 30% reduction below the BAU is assumed to be achievable.

Building Energy Efficiency Goal

Goal: A 50% energy reduction target in building energy use reflects highly achievable efficiencies in new construction and gradual improvements made to the existing building stock.

Rationale: Code and professional commitment towards high performance construction aim to meet net zero energy goals by 2030. The American Institute of Architects has made a policy commitment to advocate and design for net zero energy and CO2e buildings by 2030 (American Institute of Archtiects, 2013). Member firms keep an annual log of projects to track overall progress.

The International Energy Conservation Code (IECC) is used as an equivalency for energy efficiency in many U.S. building codes. The 2012 IECC is a 30% improvement over the 2006 code (Ireland, 2011). The IECC goal is to ratchet down energy use in buildings towards net zero energy.

Embodied Energy Goal

Goal: A target of 30% is assumed for reductions in embodied CO2e in new buildings. Averaged with existing buildings, this results in an overall target of 15%.

Rationale: As buildings become more energy-efficient, their operational and embodied CO2e get closer together. In some cases, a slight increase in embodied energy could lead to greater savings in operational energy and reductions in related CO2e. Compared to current construction practice, designing to use less material and materials with less embodied CO2e could result in up to a 22% reduction in embodied CO2e in office buildings, 20% in schools, and 25% in housing (Connaughton, Weight, Jones, & Moon, 2011). A longer-term goal of 30% is used for new construction, assuming continued improvements in materials and methods.

Supply-side Goals and Rationale

The survey results indicate cities are employing supply-side incentives and strategies to reduce the amount of 2050 CO2e in their energy supply. The modelling tests assumptions about the amount of CO2e reduction targets for commercial power grid and onsite sources. A total reduction of 40% in CO2e in the power supply is by 2050 is assumed.

Power CO2e Content Goals

Target: Improvements to the national energy supply will result in 30% reduction of CO2e.

Rational: Most states have committed to a Renewable Portfolio Standard (RPS) that sets targets for reducing of CO2e in their power supply. All but 13 states have RPS goals or standards. A summary of states' RPS programs indicates targets range from 12.5% by 2025 for Ohio to 33% by 2020 for California (North Carolina Solar Center, 2013).

Onsite and District Generation Goals

Goal: Using local energy sources, including solar, wind, and geothermal, is assumed to reduce the CO2e by an additional 10%.

Rational: Aggressive use of onsite renewables can technically create net zero energy projects. However, applying these to existing buildings will be driven by costs. On average, a 10% of total CO2e related to energy is a more realistic target.

6.3.2 Modelling Software Selection and Development

An accessible and adaptable mathematical modelling tool is selected that describes the effectiveness of climate actions taken by cities.

The mathematical modelling tool must:

- Clarify and control the conditions and variables to make the inputs and outcomes easier to analyse;
- Provide estimates based on assumptions; and
- Measure the amount of CO2e resulting from CAP strategies.

Table 6.1 summarizes the attributes of three types of modelling software reviewed for use in Study 3. These include top-down policy review software tools providing a set of policy choices that are used to initiate a CAP process; action-planning software requiring data collection and entry; and spreadsheets used to track project-level implementation and CAP progress meeting reduction goals.

Table 6.1

Comparing Types of Emission Calculators

	Pros	Cons
Top-down policy review tools	• Easy to use • Designed to test broad strategies	• Proprietary • Modifying set menu difficult (by design)
Action planning tools	• Connect targets and actions • Can include municipal actions • Can support broadened scope of fugitive emissions • Data makes it more exact	• Big tool requiring collecting and entering data • Can lack transparency of assumptions • Meant to be comprehensive
Project-level tools	• Can measure the effectiveness of broad strategies at a project level • Bottom-up, project-specific inputs	• Lacks actions for municipal and fugitive emissions • Site and metric-specific

Four Types of Tools Tested

Four types of software were tested for use in Study 3 before selecting an emissions worksheet tool used by Kings County, Washington. These included ICLEI's CACPA software and 2009 Clean Air and Climate Protection (CACP) software; the California Emissions Estimator Model (CalEEMod) developed by ENVIRON International Corporation in collaboration with California Air Districts (2011); and Version 1.7 (2011) King County Department of Development and Environmental Services SEPA GHG Emissions Worksheet. All of the tools are based on spread sheets and do not require spatial data inputs.

CAPPA

ICLEI Climate and Air Pollution Planning Assistant (CAPPA) software is designed as freeware to help cities explore strategies. It is an example of a top-down policy tool. The software does not allow scoping a project, abstracting a city, and is not adjustable. Users do not have permissions to modify the software.

CACP

CACP software is a popular tool used by U.S. cities that are ICLEI members. It was most often cited by survey cities as the tool used for creating GHG and other airborne pollutant emission inventories. It is comprehensive and provides opportunities to test various mitigation options for both community and municipal emissions. As a "big" program, it is difficult to modify, not very transparent, and requires significant data collection and entry.

CalEEMod

California communities and air quality districts use CalEEMod to model development impacts for GHG and other airborne pollutants. It works best for single-run calculations where users select from pre-set mitigation strategies for both community and municipal operations. However, for repetitive runs it is slow, calculations cannot be easily saved as projects, data requires many individual entries, and assumptions cannot be modified beyond a fixed set of policy options.

King County GHG Emission Worksheet

King County's emissions worksheet is used for project-scale emissions calculations and requires conversion of city-scale land use assumptions into a compatible development program. It calculates embodied, energy, and transportation lifespan MTCO2e for land uses and paving. Data that support the worksheet come from King

County, federal agencies, and the State of Washington. The data sources are referenced and can be updated.

Model Modifications

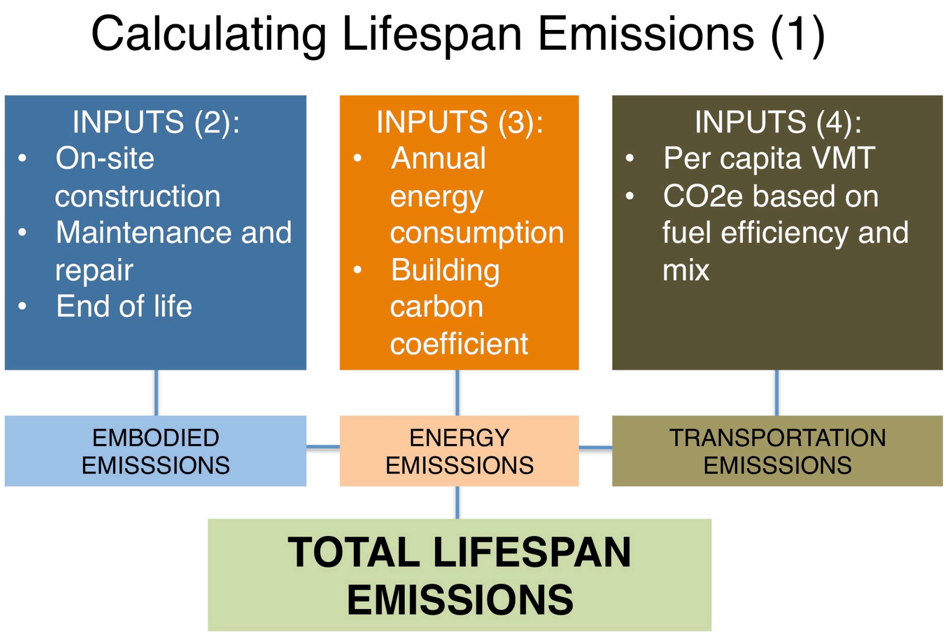
The King County worksheet is an Excel spread sheet used to calculate CO2e emissions from proposed development to satisfy requirements of the State of Washington's State Environmental Policy Act (SEPA). The worksheet requires land use and paving area as inputs. It calculates lifespan CO2e from embedded, energy and transportation. The worksheet's assumptions about energy efficiency, building lifespan, persons per household, vehicular trip generation rates for land uses, and unit size can be changed. This provides an "open book" tool for describing and comparing urban land use, operational, and energy supply GHG emissions mitigation strategies.

Model Modifications

Figure 6.3 illustrates the overall structure of the modified worksheet. The spreadsheet measures lifespan emissions and can be used to compare overall development patterns in combination with other actions.

Figure 6.3

Worksheet Structure and Data Inputs



(1) King County, WA CO2e Worksheet
(2) Athena Impact Calculator
(3) 2010 Building Energy Data Book, EIA 2003 Commercial Buildings Energy Consumption Survey
(4) ICLIE VMT Estimator, Transportation Energy Data Book-Center for Transportation Analysis

Figure 6.4

Development Summary and Emissions Worksheet

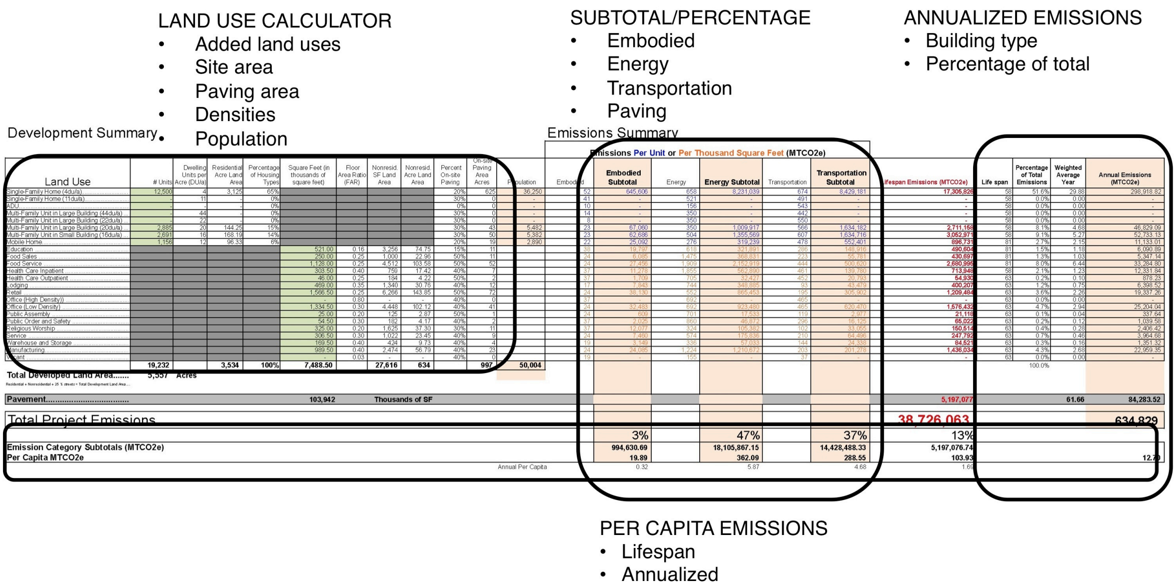


Figure 6.4 is the summary sheet for the modified emissions calculator. The worksheet was modified in five significant ways with the overall objective to create a more sensitive tool with additional outputs to evaluate top-down strategies.

- The summary worksheet includes additional land use and building types making it outputs more sensitive.
- A land use calculator was added to the summary that auto summarized site area, paving area, densities, and population.
- Subtotals for emissions by building type/land use for embodied, energy, and transportation emissions were added for comparison of strategies and land use scenarios.
- The emissions were weighted and annualized with a percentage of total summaries.
- The per capita emissions were summarized as lifespan and annual emissions.

Figure 6.5

Embodied Emission Worksheet

PERCENTAGE REDUCTION BY RESIDENTIAL AND NONRESIDENTIAL BUILDING TYPES

Embodied Emissions Worksheet

Section I: Buildings

Type (Residential) or Principal Activity (Commercial)	# thousand sq feet/ unit or building	Life span related embodied GHG missions (MTCO2e/ unit)	Life span related embodied GHG missions (MTCO2e/ thousand square feet) - See calculations in table to right	Percentage Reduction in Embodied CO2e	Total Embodied Emissions MTCO2e/m2	Total Embodied Emissions MTCO2e/1,000SF
Single-Family Home (4 du/a)............................	2.53	52	20	0%	0.22	20.44
Single-Family Home (11du/a)............................	2.00	41	20	0%	0.22	20.44
ADU..	0.60	10	17	0%	0.18	17.00
Multi-Family Unit in Large Building (44 du/a)......	0.85	14	17	0%	0.18	16.72
Multi-Family Unit in Large Building (22 du/a)......	0.85	8	10	0%	0.11	9.75
Multi-Family Unit in Small Building (20 du/a)......	1.39	23	17	0%	0.18	16.72
Multi-Family Unit in Small Building (16 du/a)	1.39	23	17	0%	0.18	16.72
Mobile Home..	1.06	22	20	0%	0.22	20.44
Education	25.6	973	38	0%	0.41	38.00
Food Sales	5.6	136	24	0%	0.26	24.34
Food Service	5.6	136	24	0%	0.26	24.34
Health Care Inpatient	241.4	8,971	37	0%	0.4	37.16
Health Care Outpatient	10.4	386	37	0%	0.4	37.16
Lodging	35.8	599	17	0%	0.18	16.72
Retail...	9.7	236	24	0%	0.26	24.34
Office Multi-level Steel Frame	14.8	550	37	0%	0.4	37.16
Office Single Story	14.8	360	24	0%	0.26	24.34
Public Assembly	14.2	346	24	0%	0.26	24.34
Public Order and Safety	15.5	576	37	0%	0.4	37.16
Religious Worship	10.1	375	37	0%	0.4	37.16
Service	6.5	158	24	0%	0.26	24.34
Warehouse and Storage	16.9	314	19	0%	0.2	18.58
Other	21.9	533	24	0%	0.26	24.34
Vacant	14.1	262	19	0%	0.2	18.58

Section II: Pavement.......................................

All Types of Pavement....................................				50

ADDED RESIDENTIAL AND NONRESIDENTIAL BUILDING TYPES

EMOBODIED EMISSIONS - - ADDED RESIDENTIAL AND NONRESIDENTIAL BUILDING TYPES

- SF wood frame
- MF walk-up wood frame (2L)
- ADU wood frame
- Mixed-use apartments wood frame (3-4L)
- Low density commercial metal stud (1L)
- High density commercial steel frame (3-4L)
- Institutional buildings - - education and healthcare

Figure 6.5 is the modified worksheet for calculating embodied emissions. The embodied emissions worksheet was modified in three significant ways to make the calculator more sensitive and allow strategies to be applied to individual building types.

- The worksheet has additional residential and non-residentiall building types Table 6.4). It allows building type adjustments and summarizes emissions in life span CO2e and by percentage of the scenario's total embodied emissions.
- Embodied emission were recalculated for building type using Athena Eco Calculator, which measures lifespan MTCO2e/SF and validated by review of case studies done by other researchers (Table 6.5).
- Added building types include single family wood frame construction, accessory dwelling unit wood frame, multi-family wood frame walk-up apartment, mixed-use apartments with wood frame over concrete podium, low density metal stud commercial building, high density steel frame commercial building, and institutional (hospital and educational buildings).

Figure 6.6

Energy Emissions Worksheet

CARBON COEFFICIENT UPDATED

- Reflects amount of CO2e is in the grid - - US average
- 2005 data updated to 2010

Energy Emissions Worksheet

Type (Residential) or Principal Activity (Commercial)	Energy consumption per building per year (million Btu)	Percentage reduction in energy consupmtion	Carbon Coefficient for Buildings	Percentage reduction in CO2e in energy supply	MTCO2e per building per year	Floorspace per Building (thousand square feet)	MTCE per thousand square feet per year	MTCO2e per thousand square feet per year	Average Building Life Span	Lifespan Energy Related MTCO2e emissions per unit	Lifespan Energy Related MTCO2e emissions per thousand square feet
Single-Family Home (4du/a)	10[illegible].3	0%	0.10[illegible]	0%	11.37	2.53	4.5	16.5	57.9	658	261
Single-Family Home (11du/a)	8[illegible].8	0%	0.10[illegible]	0%	8.99	2.00	4.5	16.5	57.9	521	260
ADU	2[illegible].5	0%	0.10[illegible]	0%	2.70	0.60	4.5	16.5	57.9	156	260
Multi-Family Unit in Large Building (44du/a)	4[illegible].0	0%	0.10[illegible]	0%	4.35	0.85	5.1	18.8	80.5	350	413
Multi-Family Unit in Large Building (22du/a)	4[illegible].0	0%	0.10[illegible]	0%	4.35	0.85	5.1	18.8	80.5	350	413
Multi-Family Unit in Large Building (20du/a)	4[illegible].0	0%	0.10[illegible]	0%	4.35	1.39	3.1	11.5	80.5	350	252
Multi-Family Unit in Small Building (16du/a)	5[illegible].0	0%	0.10[illegible]	0%	6.25	1.39	4.5	16.5	80.5	504	362
Mobile Home	4[illegible].0	0%	0.10[illegible]	0%	4.77	1.06	4.5	16.5	57.9	276	260
Education	2,12[illegible].0	0%	0.11[illegible]	0%	252.88	25.6	9.9	36.2	62.5	15,817	618
Food Sales	1,11[illegible].0	0%	0.11[illegible]	0%	132.09	5.6	23.6	86.5	62.5	8,262	1,475
Food Service	1,43[illegible].0	0%	0.11[illegible]	0%	170.88	5.6	30.5	111.9	62.5	10,688	1,909
Health Care Inpatient	60,15[illegible].0	0%	0.11[illegible]	0%	7,158.09	241.4	29.7	108.7	62.5	447,716	1,855
Health Care Outpatient	98[illegible].0	0%	0.11[illegible]	0%	117.22	10.4	11.3	41.3	62.5	7,331	705
Lodging	3,57[illegible].0	0%	0.11[illegible]	0%	425.78	35.8	11.9	43.6	62.5	26,631	744
Retail	72[illegible].0	0%	0.11[illegible]	0%	85.68	9.7	8.8	32.4	62.5	5,359	552
Office (High Density)	1,37[illegible].0	0%	0.11[illegible]	0%	163.74	14.8	11.1	40.6	62.5	10,242	692
Office (Low Density)	1,37[illegible].0	0%	0.11[illegible]	0%	163.74	14.8	11.1	40.6	62.5	10,242	692
Public Assembly	1,33[illegible].0	0%	0.11[illegible]	0%	159.22	14.2	11.2	41.1	62.5	9,959	701
Public Order and Safety	1,79[illegible].0	0%	0.11[illegible]	0%	213.13	15.5	13.8	50.4	62.5	13,331	860
Religious Worship	44[illegible].0	0%	0.11[illegible]	0%	52.36	10.1	5.2	19.0	62.5	3,275	324
Service	50[illegible].0	0%	0.11[illegible]	0%	59.62	6.5	9.2	33.6	62.5	3,729	574
Warehouse and Storage	76[illegible].0	0%	0.11[illegible]	0%	90.92	16.9	5.4	19.7	62.5	5,687	336
Other	3,60[illegible].0	0%	0.11[illegible]	0%	428.40	21.9	19.6	71.7	62.5	26,795	1,224
Vacant	29[illegible].0	0%	0.11[illegible]	0%	34.99	14.1	2.5	9.1	62.5	2,188	155

ADDED RESIDENTIAL AND NONRESIDENTIAL BUILDING TYPES

- Higher density infill building types
- Specialty housing–ADUs

DEMAND-SIDE AND SUPPLY-SIDE MITIGATION (Green)

- Percentage adjustment for goals and strategies by building type

The energy emissions worksheet (Figure 6.6) calculates the energy use and converts it into CO2e emissions for each building type. The calculator was modified in three significant ways.

- As with the other sheets, there were additional residential and non-residential building types added. In particular, higher density buildings were developed to simulate infill development in scenarios.
- The carbon coefficient was updated to better reflect the average CO2e in the grid being used by residential and commercial building types (Table 6.3).
- Mitigation assumptions can be made for each building type making assumptions for both demand-side efficiencies and supply-side percentage of renewable energy.

Figure 6.7

Transportation Emission Worksheet

Transportation Emissions Worksheet

Type (Residential) or Principal Activity (Commercial)	# people/ unit or building	# thousand sq feet/ unit or building	# people or employees/ thousand square feet	vehicle related GHG emissions (metric tonnes CO2e per person per year)	MTCO2e/ year/ unit	MTCO2e/ year/ thousand square feet	Average Building Life Span	Life span transportation related GHG emissions (MTCO2e/ per unit)	Life span transportation related GHG emissions (MTCO2e/ thousand sq feet)	Percent reduction in VMT
Single-Family Home (4du/a)	2.9	2.53	1.1	4.0	11.6	4.6	57.9	674	267	0%
Single-Family Home (11du/a)	2.5	2.53	1.0	3.4	8.5	3.4	57.9	491	194	0%
ADU	1.9	2.53	0.8	4.9	9.4	3.7	57.9	543	215	0%
Multi-Family Unit in Large Building (44du/a)	1.9	0.85	2.2	2.9	5.5	6.5	80.5	442	522	0%
Multi-Family Unit in Large Building (22du/a)	1.9	0.85	2.2	3.6	6.8	8.1	80.5	550	649	0%
Multi-Family Unit in Large Building (20du/a)	2.0	0.85	2.4	3.5	7.0	8.3	80.5	566	669	0%
Multi-Family Unit in Small Building (16du/a)	2.0	1.39	1.4	3.8	7.5	5.4	80.5	607	436	0%
Mobile Home	2.5	1.06	2.4	3.3	8.3	7.8	57.9	478	450	0%
Education	30.0	25.6	1.2	3.9	117.0	4.6	62.5	7,317	286	0%
Food Sales	5.1	5.6	0.9	3.9	20.0	3.6	62.5	1,249	223	0%
Food Service	10.2	5.6	1.8	3.9	39.7	7.1	62.5	2,485	444	0%
Health Care Inpatient	455.5	241.4	1.9	3.9	1777.5	7.4	62.5	111,179	461	0%
Health Care Outpatient	19.3	10.4	1.9	3.9	75.2	7.2	62.5	4,701	452	0%
Lodging	13.6	35.8	0.4	3.9	53.1	1.5	62.5	3,319	93	0%
Retail (Other Than Mall)	7.8	9.7	0.8	3.9	30.3	3.1	62.5	1,894	195	0%
Office High Density	28.2	14.8	1.9	3.9	110.0	7.4	62.5	6,881	465	0%
Office Low Density	28.2	14.8	1.9	3.9	110.0	7.4	62.5	6,881	465	0%
Public Assembly	6.9	14.2	0.5	3.9	27.0	1.9	62.5	1,691	119	0%
Public Order and Safety	18.8	15.5	1.2	3.9	73.3	4.7	62.5	4,586	296	0%
Religious Worship	4.2	10.1	0.4	3.9	16.4	1.6	62.5	1,027	102	0%
Service	5.6	6.5	0.9	3.9	21.9	3.4	62.5	1,368	210	0%
Warehouse and Storage	9.9	16.9	0.6	3.9	38.8	2.3	62.5	2,427	144	0%
Other	18.3	21.9	0.8	3.9	71.2	3.3	62.5	4,455	203	0%
Vacant	2.1	14.1	0.2	3.9	8.3	0.6	62.5	520	37	0%

ICLEI VMT Est Tool	Density du/ac	Annual Miles/DU	Per Capita Miles/DU at 2.60 pp/hh	MTCO2e per person per year
	4	20,874	7,198	4.0
	11	15,201	6,080	3.4
	8	16,797	8,841	4.9
	44	9,843	5,181	2.9
	22	12,234	6,439	3.6
	20	12,603	6,302	3.5
	16	13,516	6,758	3.8
	12	14,792	5,917	3.3
			6,994	3.9
			6,994	3.9
			6,994	3.9
			6,994	3.9
			6,994	3.9
			6,994	3.9
			6,994	3.9
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			6,994	3.9
			6,994	3.9
			6,994	3.9
			6,994	3.9
			6,994	3.9

ADDED RESIDENTIAL AND NONRESIDENTIAL BUILDING TYPES
- Higher density infill building types
- Specialty housing–ADUs

VMT REDUCTION PERCENTAGES
- Percentage adjustment for goals and strategies by building type

VMT GENERATED BY ICLEI SPREADSHEET CALCULATOR
- Reflects VMT reduction based on density

Figure 6.7 indicates the modifications made to the transportation emissions worksheet. As the other sheets, it has been made more sensitive to changes in density. It allows building type-level mitigation assumptions to be made. It has been modified in three significant ways.

- The worksheet has additional residential and non-residential building types that provide more accurate assessment of scenario-related VMT emissions.
- A VMT calculator was included in the worksheet. The worksheet now auto-generates VMT data for each building type (Table 6.2). The original calculator uses a simple per capita state level VMT and does not distinguish between uses or density.
- The worksheet allows percentage adjustment for VMT reductions for each building type providing outputs for unmitigated density-only calculations and mitigated.

Worksheet Calibration

The bottom-up, project-level capabilities in the worksheet are hybridized with top-down planning features like those found in the CAPPA software. The changes make the worksheet more sensitive and a better strategy tool. New features are added that better reflect policy choices made by cities and external actions by regional agencies, states, and federal agencies.

Land use characteristics and operational assumptions for baseline and BAU scenarios reflect national averages. The worksheet already uses a combination of national data and data specific to the Kings County region. The worksheet is updated to reflect the "typical U.S. city." VMT and CO2e coefficients for construction are updated using national data. In addition, the building occupancy densities (people per 1,000 GSF of building space) assumptions have been updated for transportation emissions to be consistent with the land use tables.

Table 6.2

Annual Per Capita VMT and Related CO2e

Density du/ac	Persons per DU	Annual Miles/DU (ICLEI)	Per Capita Miles	lbs/MTCO2e per person per year (1)
4	2.9	20,874	7,198	4.0
8	2.5	16,797	6,719	3.7
11	2.5	15,201	6,080	3.3
12	2.5	14,792	5,917	3.2
16	2.0	13,516	6,758	3.8
20	2.0	12,603	6,301	3.5
22	1.9	12,234	6,439	3.6
30	1.9	11,099	5,842	3.3
44	1.9	9,843	5,181	2.9
52	1.9	9,341	4,916	2.7

Note:

(1) VMT per person x gallons of gasoline per mile x CO2e per gallon / 2,205 lbs/MT = Annual pounds of CO2e per person

VMT and Related CO2e Data Calibration

The worksheet uses State of Washington average VMT for year 2007. The VMT data is updated using ICLEI's VMT Estimation Tool. It is a spread sheet that estimates the VMT for various residential densities "based on empirical research about housing density and travel conducted in over 3,000 census tracts in the metropolitan areas of

Chicago, San Francisco and Los Angeles" (ICLEI Local Governments for Sustainability USA, 2013).

Table 6.2 summarizes per capita annual emissions VMT based on the ICLEI VMT Estimation Tool. The tool requires entering a baseline residential density and a proposed density. The calculated reduction is subtracted from the baseline to get an annual household VMT and then divided by persons per household for a per capita annual VMT.

A weighed average of residential VMT is used for non-residential uses to reflect the general level of auto dependency in a scenario. Lower-density residential cities require more driving than cities with more compact and dense residential neighbourhoods.

CO2e Coefficients Calibration

The Carbon Dioxide Emission Coefficients for Buildings used in the worksheet's energy emissions calculations are based on 2005 data. The coefficient identifies the emissions for an averaging of fuel sources (coal, natural gas, petroleum, and electricity consumption). Updated coefficients are published by the U.S. Department of Energy for 2010 (D&R International, Ltd., 2012). Table 6.3 shows the Calculations for updating the coefficients.

Table 6.3

Carbon Dioxide Emission Coefficients for Buildings (MMT CO2 per Quadrillion Btu)

	2005	2010 (1)
Commercial	124.0	118.7
Residential	108.0	105.6

Source: Building Energy Data Book Table 1.4.8 (1)

Embodied CO2e Calibration

The worksheet updates construction data assumption for embodied CO2e to reflect national data and a greater variety of building types. The global warming potential for buildings uses the Athena Eco Calculator, which measures lifespan MTCO2e/SF. The Kings County worksheet uses only one building type, a low-rise building in Vancouver, BC, for embodied CO2e. A newer version of the Athena software is used to recalculate the lifecycle emissions impact for the worksheet for six building types using an average U.S. location (Table 6.4). These added building types correspond to land use assumptions for the scenarios, making the worksheet more sensitive.

Table 6.4

Building Types Developed for Lifetime Carbon Emissions Estimates

RESIDENTIAL	**COMMERCIAL**
Low-Density Single-Family • 2L wood stud construction over basement • 3,001 GSF	Low-Density • 1L commercial pad, 3 tenants • 13,000 GSF • Steel columns and joist • Steel studs and stucco • Storefronts
Accessory Dwelling Unit (ADU) • 1L wood stud construction on concrete slab • 600 GSF	High-Density • 3L steel frame over below-grade parking • 58,125 GSF • Commercial grade windows, plaster finish • Metal studs and drywall interior walls
Medium-Density Multifamily • 2L wood frame construction • Slab on grade • 8DUs @ 850 GSF = 6,800 GSF	
High-Density Multifamily • 100 DU @ 850 GSF/DU = 85,000 GSF • 3L Type V wood frame over 1L Type I concrete block • Residential specification windows and brick veneer • Ground floor units, commercial and/or parking • Slopped roof, wood truss, composite shingle	

A sensitivity analysis of Athena's Impact Estimator results is conducted by comparing results with studies from the United States, Canada, and United Kingdom. The Athena results for the various building types are reviewed with other case studies and the modelling embodied CO2e assumptions adjusted (Table 6.5).

Table 6.5

Building Type Embodied CO2e Sensitivity Analysis

Modelling Assumptions	Athena Impact Calculator (1)	Case Studies
Single-Family (Wood Frame) ***Assume:*** ***.220 MTCO2e/m2***	46,900 kgCO2e 280 m2 **.169 MTCO2e/m2**	HIGH (2) 51,400 kgCO2e 225 m2 **.224 MTCO2e/m2** MID. 49,300 kgCO2e **.219 MTCO2e/m2** LOW (no basement) 30,000 kgCO2e **.133 MTCO2e/m2**
Single-Story Commercial (Metal Stud) ***Assume:*** ***.262 MTCO2e/m2***	314,000 kgCO2e 1,200 m2 **.262 MTCO2e/m2**	Grocery Store (4) 3,528 MTCO2e 9,393 m2 **.376 MTCO2e/m2** Warehouse (4) 8,257 MTCO2e 35,400 m2 **.233 MTCO2e/m2**
High-Density Residential/Mixed-use (Wood Frame) ***Assume:*** ***.180 MTCO2e/m2***	1,050,000 kgCO2e 8,000 m2 **.131 MTCO2e/m2**	HIGH (3) (LESOSAI) 3 kgCO2e/m2 per year 60 yrs x 3 = 180 kgCO2e **.180 MTCO2e/m2** LOW (3) (Athena Impact Est.) **.138 MTCO2e/m2**
Multi-Story Office (Steel Frame) ***Assume:*** ***.400 MTCO2e/m2***	3,920,000 kgCO2e 7,200 m2 **.544 MTCO2e/m2**	10-L Office (4) 14,937 MTCO2e 33,018 m2 **.452 MTCO2e/m2** 16,480 m2 (5) **.300-.410 MTCO2e/m2**
Hospital ***Assume:*** ***.400 MTCO2e/m2***	NA	10,752 m2 (5) **.360-490 MTCO2e/m2**
School/Education ***Assume:*** ***.409 MTCO2e/m2***	NA	13,500 m2 (5) **.380-.520 MTCO2e/m2**

Notes:
1. See Table 6.2 for program description of building types
2. Single-family estimates from NAHB (Carnow, 2008, pp. 2-8)
3. 6L Wood frame multi-family project in Vancouver, BC modelled (Tanner & etal, 2012, pp. 77-80)
4. Non-residential UK case studies (Sansom & Pope, 2012)
5. Comparative analysis of structural systems for three building types by the Alliance for Sustainable Building Products (Burridge, 2013)

6.3.3 Four Model Runs

The baseline scenario is modelled without mitigation as a single land use-only run as a basis for comparison. Four model runs are prepared for the BAU, centred city, and corridor city scenarios. These isolate the benefits of compact and transit-supported land use patterns, improved operations, and reduced CO2e in their energy supply.

Run 1 LAND USE: The first model run describes the effectiveness of land use and transit patterns strategies. These are referred to as unmitigated or land use-only scenarios.

Run 2 DEMAND-SIDE: The second model run test describes the effectiveness of demand reduction strategies for transportation, energy, and embodied CO2e. These include increased energy efficiency for new and existing buildings and a reduction in embodied energy. A reduction in VMT reflects improved transit services.

Run 3 SUPPLY-SIDE: The third run describes the effectiveness of employing supply-side strategies. These assume reduction in the amount of CO2e in the electric energy supply and/or providing onsite energy from renewable sources.

Run 4 COMPREHENSIVE: The fourth model run of the land use scenarios includes both demand-side and supply-side strategies describing the cumulative benefits of a comprehensive approach. These are referred to as mitigated scenarios.

6.3.4 Verification and Validity Case Study

The modelling process includes on-going verification of the model modifications, and a single case study is used to check the validity of the results.

Verification of Worksheet

The Study 2 survey indicates that cities are using a full suite of smart growth and other strategies to strive to meet GHG emission reduction goals. The worksheet describes the effectiveness of strategies without the fuzziness introduced by the dynamics of climatic location, state policies, or community politics. The scenarios are evidence-based simplifications of real world conditions. The worksheet is designed to clarify and control the conditions and variables to make the inputs and outcomes easier to analyse.

The worksheet is a mathematical model that attempts to balance testing theoretical explanations and data. It does not use spatial information, so it cannot identify all the potential implications of implementing land use and other strategies.

The worksheet is "debugged" during the modification process. The original King County worksheet is run with parallel baseline land uses. The progressive updates to the worksheet are reviewed relative the original Washington State-specific assumptions. The four model runs are reviewed for unexpected outcomes, and any unexpected anomalies are inspected.

Validation: Case Study

A single case study is used as a sensitivity analysis of the worksheet model outputs. This study considers how a scenario and worksheet approach for determining lifespan embodied, energy, and transportation categories supports a traditional top-down CAP approach at a city-scale and bottom-up inputs at district and site scales.

The validation case study process includes case selection criteria and case selection, development of a land use program, worksheet calibration, modelling runs, and summary of results.

6.4 CITY FORM SCENARIOS

The modelling results in CO2e estimates for a baseline and three future growth scenarios. These include a BAU and two land use scenarios that utilize popular strategies identified in the Study 2 CAP city survey. Two strategies include a city-centre scenario emphasizing compact growth within a fixed boundary and a transit-oriented scenario that allows city expansion along a determined corridor.

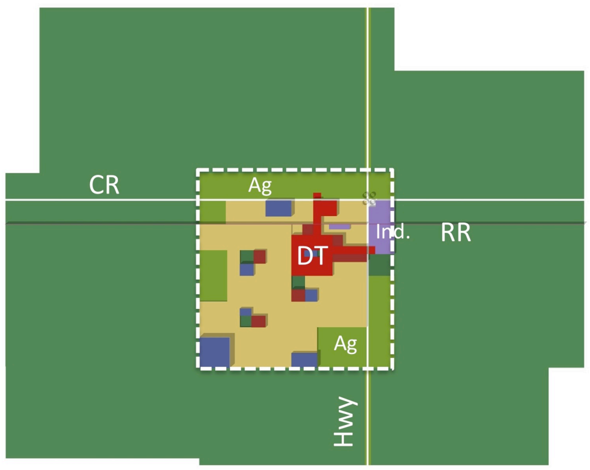
The baseline is a city with a population of 50,000 people. The scenarios are modelled at a population of 100,000. Cities of 50,001-100,000 in population were the most common survey city size category.

6.4.1 Baseline Scenario: The Average U.S. City

The baseline represents a city of "national averages". The baseline city is located in a region that is growing and assumed to have a current population of 50,000. The person per household is the U.S. average of 2.60 (U.S. Census, 2013). Climate conditions and eGRID CO2e are also the national average. The baseline city is located at the intersection of a highway and major county road and is expanding onto agricultural lands (Figure 6.8).

Figure 6.8

Conceptual Baseline City Diagram



Baseline Scenario
50,000 Population
5,557 ac

- Based on U.S. averages
- Low-density
- Suburban edge expansion
- Auto-dependent

Note: Not to scale

Land Use Program Table

Table 6.7 is a summary of the land use program assumptions for the baseline city. The land use program provides necessary data inputs for the worksheet. These include:

- Number of dwelling units (DU);
- Types of DUs;
- Types of non-residential (NR) development;
- Thousands of square feet of NR development; and
- Amounts of pavement.

The land use program used to calculate GHG emissions does not include parks, open space, or vacant land. It assumes that 25% of the city land area is paved public streets and roads.

Residential Program Assumptions

The building type categories are from the 2001 Residential Energy Consumption Survey (EIA, 2003). The percentage breakdown of the types of DUs reflects the national average as defined by the U.S. census. The density is expressed as units per acre. The amount of on-site paving is estimated based on typical parcel sizes, access, and parking requirements for residential building types.

Non-residential Program Assumptions

The breakdown of NR building types reflects the categories found in the Commercial Building Energy Consumption Survey (EIA, 2013). The baseline program is determined by multiplying the per capita employment by the amount of building area per employee. Densities for NR uses are expressed as floor area rations (FARs). FARs is used to calculate the amounts of land required for each use.

Table 6.6 summarizes the national total and per capital number of jobs by North American Industry Classification System (NAICS) categories (Buearu of Labor Statistics, 2012). These are multiplied by the baseline city's 50,000 population and assigned by building type in Table 6.7. Estimates for institutional uses, such as churches, use multiple sources to estimate the per capita development program. Public safety and public assembly categories require review of cases and estimates (Table 6.6).

The national average employee density was derived from a study commissioned by the State of New Jersey that researched average employees per gross square feet of building (Listokin & etal, 2006). The New Jersey study compares studies completed in the U.S. that calculate persons per 1,000 GSF for various building types. The study includes an averaging of all the studies. That average is used in the baseline program.

The amount of on-site paving is estimated based on typical parcel sizes, access, and parking requirements for each land use.

Table 6.6

2010 Jobs Per Capita Calculations

Employment Title	2007 NAICS Code	Millions of Jobs (1)	Jobs Per Capita (2)
Total		143.1	.463
Mining	21	.655	.002
Utilities	22	.552	.002
Construction	23	5.53	.018
Manufacturing	31-33	11.52	.037
Wholesale Trade	42	5.46	.018
Retail Trade	44, 45	14.41	.047
Transp./Warehousing	48	4.18	.014
Warehouse/Storage	493	0.63	.002
Information	51	2.71	.009
Finance and Insurance	52	5.69	.018
RE, Rent. And Leas.	53	1.94	.006
Prof. Scientific Tech	54	7.42	.024
Management	55	1.83	.006
Admin/Waste/Rem	56	7.40	.024
Education Services	61	3.15	.010
Health Care/Soc Srvs	62	16.41	.053
Outpatient/Labs/Amb	6214, 6215, 6219	1.08	.003
Hospitals Private	622	4.67	.015
Arts/Entert./Rec	71	1.91	.006
Accom/Food Srv	72	11.11	.036
Accommodation	721	1.76	.006
Food Serv.	722	9.35	.030
Other Services	81	6.03	.020
Religious/Civic		2.96	.010
Religious		1.68	.005
Fed Gov	NA	2.97	.010
State and Local Gov.	NA	19.51	.063
Ag/Forest/Fish/Hunt	11	2.14	.007

Notes:

(1) *Source: BLS, Table 2.7 Employment and Output by Industry*
(2) *Assumes national population of 309 million*

Table 6.7

Baseline City Land Use Program

Type (Residential) or Principal Activity (Commercial)		**Building Type Assumptions (1)**		**Total Units 50,000/2.6P PH=19,230 # Units**	**Square Feet (in 1,000s of square feet)**	**Land Use Program Conversion**	**Site Paving Percentage**
Single-Family Home			65%	12,500		3,125 a @ 4 DU/a	20% 625 a
Multi-Family Unit in Large Building			15%	2,885		144 a @ 20 DU/a	30% 43 a
Multi-Family Unit in Small Building			14% (2)	2,691		168 a @ 16 DU/a	30% 50 a
Mobile Home			6%	1,154		96 a @ 12 DU/a	20% 19 a
BUILDING TYPE CATEGORY	**2007 NAICS Code**	**Jobs/ Pop (3)**	**Jobs/ 1000 sf (4)**	**Per Capita GSF**	**Program in 1,000's**	**Resid. Program Subtotal 3,534 a**	**Resid. Paving Subtotal 737 a**
Education	61	0.01	.96	10.42	521	75 a @ 0.16 FAR	15% 11 a
Food Sales	NA	-	-	5.0	250	23 a @ 0.25 FAR	50% 11 a
Food Service	722	0.03	1.33	22.56	1,128	104 a @ 0.25 FAR	50% 57 a
Health Care Inpatient	622	0.015	2.47	6.07	303.5	17 a @ 0.40 FAR	40% 7 a
Health Care Outpatient	6214, 6215, 6219	0.003	3.26	0.92	46	4 a @ 0.25 FAR	50% 2 a
Lodging	721	0.006	0.64	9.38	469	31 a @ 0.35 FAR	40% 12 a
Retail (Other Than Mall)	44, 45	0.047	1.50	31.33	1,566.5	144 a @ 0.25 FAR	50% 72 a
Office (Commercial)	51-56,	0.087	3.26	26.69	1,334.5	102 a @ 0.30 FAR	40% 41 a
Public Assembly	NA	-	-	0.5	25	3 a @ 0.20 FAR	50% 2 a
Public Order and Safety	NA	.0019	1.74	1.09	54.5	4 a @ 0.30 FAR	40% 2 a
Religious Worship	NA	-	-	6.5	325	37 a @ 0.20 FAR	30% 11 a
Service	81	0.02	3.26	6.13	306.5	23 a @ 0.30 FAR	40% 9 a
Warehouse and Storage	493	0.002	.59	3.39	169.5	10 a @ 0.40 FAR	40% 4 a
Other (Manufacturing)	31-33	0.037	1.87	19.79	989.5	57 a @ 0.40 FAR	40% 23 a
Non-residential Subtotal					**7,488.5**	**634 a**	**264 a**
Land Use Subtotal						**4,167 a**	**1,001 a**
ROW/Roads Subtotal (25%)						**1,389 a**	**1,389 a**
TOTAL						**5,557 a**	**2,386 a**

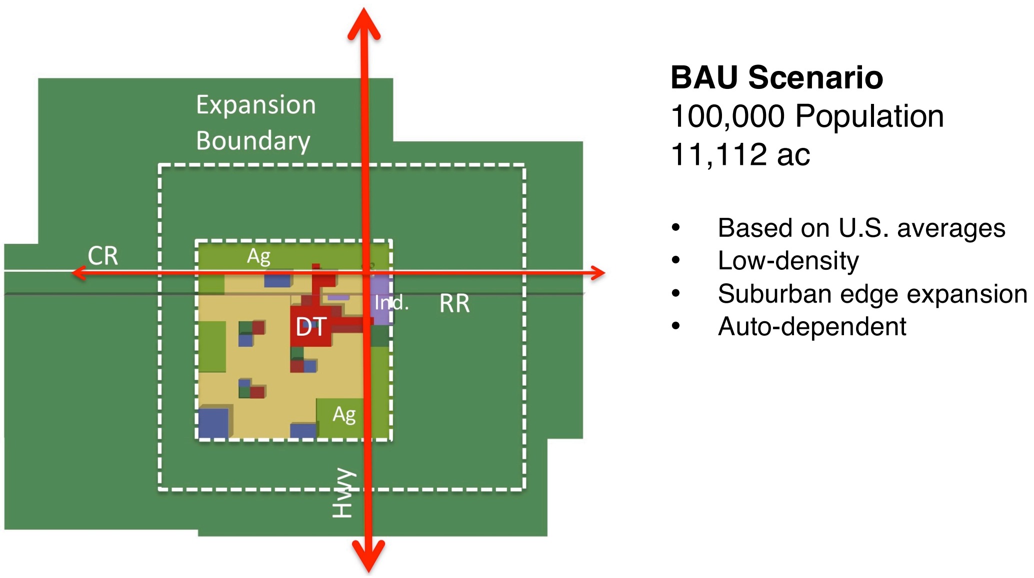
Notes:

(1) Housing percentages based on national average in the 2005 U.S. Census
(2) In the U.S. Census, attached single-family and small multifamily are combined into a single category
(3) 2010 jobs per capita calculations, see Table 6.6
(4) Summary of statistics from derived from national study on non-residential multipliers

6.4.2 Business-as-Usual (BAU) Scenario

The business-as-usual (BAU) scenario assumes the city will grow from its current 50,000 population to 100,000 while maintaining the same density and doubling its land area. The conceptual land use diagram (Figure 6.9) representing the BAU scenario embodies many attributes of typical moderate growth auto-oriented communities. Highways are the primary regional transportation connector. Growth is supported by roadway construction and generally expands onto affordable agricultural lands contiguous to the city. The scenario assumes the baseline city will expand with no redevelopment of existing uses.

Figure 6.9
Conceptual BAU City Diagram



Note: Not to scale

<u>BAU Land Use Program</u>

This scenario assumes low-density development is extended into expansion areas. Table 6.8 summarizes the development program for the BAU scenario. The table identifies the mix of uses, programmed land area, paved area inside the property line that supports the land use, and paving attributed to roads and rights-of-way (ROW). The table includes DU/a as a measure the scenario's residential uses and FAR for NR uses.

Housing

The population count is doubled in the BAU scenario, adding 19,230 DUs for a total of 38,460 DUs. The program includes a total 7,066 acres of housing in the program with 1,474 acres of roadways (25% of land area) for a total 8,540 gross acres. The program assumes 65% the housing is single-family developed at 4 DU/a using 88% of the residential land and 75% of all programed land in the BAU city. Multifamily units comprise 29% of the housing stock, developed at a modest 16-20 DU/a using less than 9% of residential land and only 7% of the total programmed land in the BAU city. Mobile homes are 6% of the housing total, developed at 12 DU/a.

Non-residential (NR)

Non-residential densities reflect post war auto-oriented development patterns of parking fields, and with FARs of 0.20 to 0.30 for commercial uses, 0.15 to 0.40 for institutional uses, and 0.40 for warehouse and industrial uses. The program includes a total of 1,268 acres of programed NR and 1,690 gross acres including streets. The NR land comprises 15% of all programmed lands.

Paving and Roads

The GHG worksheet requires paving to be included due to its considerable lifespan CO2e. Paving site coverage is based primarily on the amount of surface parking required by each land use. As the suburban and least intensive scenario, the BAU has the greatest amount of surface parking and therefore the highest amount of paving lifespan CO2e. It contains 2,002 acres of on-site paving in the BAU Scenario and 2,778 acres of paving in streets and right-of-ways. Paving makes up 43% of the total land area in the BAU Scenario.

Table 6.8

Business-as-Usual (BAU) Land Use Program

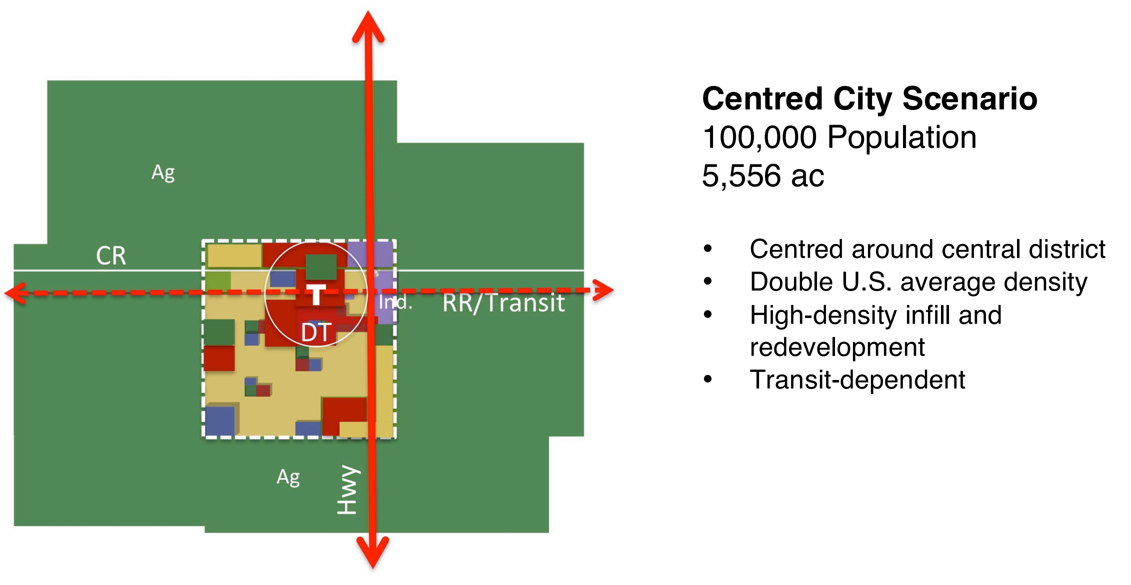
Type (Residential) or Principal Activity (Commercial)		**Building Type Assumptions**		**Total Units 100,000/2.6PPH=38,460 # Units**	**Square Feet (in 1,000s of square feet)**	**Land Use Program Conversion**	**Site Paving Percentage**
Single-Family Home			65%	25,000		6,250 a @ 4 DU/a	20% 1,250 a
Multi-Family Unit in Large Building			15%	5,770		288 ac @ 20 DU/a	30% 86 a
Multi-Family Unit in Small Building			14% (2)	5,382		336 a @ 16 DU/a	30% 100 a
Mobile Home			6%	2,308		192 a @ 12 DU/a	20% 38 a
BUILDING TYPE CATEGORY	**2007 NAICS Code**	**Jobs/ Pop**	**Jobs/ 1000 sf**	**Per Capita GSF**	**Program in 1,000's**	**Resid. Program Subtotal 7,066 a**	**Resid. Paving Subtotal 1,474 a**
Education	61	0.01	.96	10.42	1,042	150 a @ 0.16 FAR	15% 22 a
Food Sales	NA	-	-	5.0	500	46 a @ 0.25 FAR	50% 22 a
Food Service	722	0.03	1.33	22.56	2,256	208 a @ 0.25 FAR	50% 104 a
Health Care Inpatient	622	0.015	2.47	6.07	607	34 a @ 0.40 FAR	40% 14 a
Health Care Outpatient	6214, 6215, 6219	0.003	3.26	0.92	92	8 a @ 0.25 FAR	50% 4 a
Lodging	721	0.006	0.64	9.38	938	62 a @ 0.35 FAR	40% 24 a
Retail (Other Than Mall)	44, 45	0.047	1.50	31.33	3,133	288 a @ 0.25 FAR	50% 144 a
Office (Commercial)	51-56,	0.087	3.26	26.69	2,669	204 a @ 0.30 FAR	40% 82 a
Public Assembly	NA	-	-	0.5	50	6 a @ 0.20 FAR	50% 4 a
Public Order and Safety	NA	.0019	1.74	1.09	109	8 a @ 0.30 FAR	40% 4 a
Religious Worship	NA	-	-	6.5	650	74 a @ 0.20 FAR	30% 22 a
Service	81	0.02	3.26	6.13	613	46 a @ 0.30 FAR	40% 18 a
Warehouse and Storage	493	0.002	.59	3.39	339	20 a @ 0.40 FAR	40% 8 a
Other (Manufacturing)	31-33	0.037	1.87	19.79	1,979	57 a @ 0.40 FAR	40% 23 a
Non-residential Subtotal					**14,977**	**1,268 a**	**528 a**
Land Use Subtotal						**8,336 a**	**2,002 a**
ROW/Roads Subtotal (25%)						**2,778 a**	**2,778 a**
TOTAL						**11,Centred7 72 a**	

6.4.3 Centred City Scenario

The centred city scenario assumes the city will grow from its current 50,000 population to 100,000 at a higher density and contained within the existing boundary. The conceptual centred city scenario land use diagram (Figure 6.10) illustrates a community that has focused its growth in its traditional centre by redeveloping low-density uses, adding uses on exiting surface parking, and increasing density. The highway is supplemented with a regional transit station in the city centre. Future growth is to be supported by transit, walking, and biking. Agricultural lands contiguous to the city are protected.

Figure 6.10

Conceptual Centred City Diagram



Note: Not to scale

<u>Centred City Scenario Land Use Program</u>

This scenario inserts higher-density development into the existing city. Table 6.9 summarizes the development program for the centred city scenario. The table identifies the mix of uses, programmed land area, paved area inside the property line that supports the land use, and paving attributed to public streets and roads. Residential uses are measured in DU/a and NR uses by FAR.

In order to meet the higher densities, the centred city scenario:

- Converts 25% of NR land converted to residential at an average of 44 DU/a;
- Redevelops 20% of low-density residential land at 22 DU/a;
- Redevelops 30% of NR land at an average of 0.74 FAR; and
- Replaces lost low-density housing with Accessory Dwelling Units (ADUs) on existing single-family lots.

Housing

The housing count for the centred city scenario is over doubled in proportion with the existing units, adding 25,930 DUs to the baseline 19,230 DUs for a total of 45,160 DUs. The program includes a total 3,687 acres of housing program with 841 acres of roadways (25% of land area) for a total 4,533 gross acres. In order to meet the higher required densities, the proportion of multifamily housing is increased. Multifamily units comprise 68% of the housing stock on 1,028 acres of programmed land, using about 28% of residential land. Only 23% of the housing is assumed to be single-family. Six percent of the housing total is in accessory dwelling units (ADUs) that are collocated on single-family lots. Together they use 2,568 acres, representing about 70% of residential land and 62% of all programmed land. Mobile homes are 3% of the housing total, developed at 12 DU/a.

Non-residential (NR)

NR densities increase through redevelopment and higher-density infill. The development program assumes development of existing parking lots resulting in urban-scale projects. Commercial uses have FARs of 0.67, institutional uses 0.43 to 1.07, and service, industrial and warehouse uses at 1.07. Programmed NR totals 482 acres and 643 gross acres, including streets. The NR land comprises about 12% of programmed lands.

Table 6.9

Centred City Scenario Land Use Program

Type (Residential) or Principal Activity (Commercial)		**Building Type Assumptions**		**Total Units 100,000/2.6 PPH= 38,460 # Units**	**Square Feet (in 1,000s of square feet)**	**Land Use Program Conversion**	**Site Paving Percentage**
Single-Family Home			27%	10,272		2,568 a @ 4 DU/a	20% 514 a
ADU (replacement) (4)			6%	3,049			
Multi-Family Unit in Large Building 1 (infill–NR) (1)			18%	8,290		159 a @ 52 DU/a	30% 48 a
Multi-Family Unit in Large Building 2 (infill–residential redevelopment) (2)			32%	16,771		557 a @ 30 DU/a	30% 167 a
Multi-Family Unit in Large Building 3 (existing)			8%	2,885		144 a @ 20 DU/a	30% 43 a
Multi-Family Unit in Small Building (existing)			7%	2,691		168 a @ 16 DU/a	30% 50 ac
Mobile Home (existing)			3%	1,154		96 a @ 12 DU/a	20% 19 ac
BUILDING TYPE CATEGORY	**2007 NAICS Code**	**Jobs/ Pop**	**Jobs/ 1000 sf**	**Per Capita GSF**	**Program in 1,000's**	**Resid. Program Subtotal 3,687 a**	**Resid. Paving Subtotal 841 a**
Education	61	0.01	.96	10.42	1,042	56 a @ 0.43 FAR	15% 8 a
Food Sales	NA	-	-	5.0	500	17 a @ 0.67 FAR	50% 9 a
Food Service	722	0.03	1.33	22.56	2,256	77 a @ 0.67 FAR	50% 39 a
Health Care Inpatient	622	0.015	2.47	6.07	607	13 a @ 1.07 FAR	40% 5 a
Health Care Outpatient	6214, 6215, 6219	0.003	3.26	0.92	92	3 a @ 0.67 FAR	50% 2 a
Lodging	721	0.006	0.64	9.38	938	23 a @ 0.93 FAR	40% 9 a
Retail (Other Than Mall)	44, 45	0.047	1.50	31.33	3,133	107 a @ 0.67 FAR	50% 54 a
Office (Commercial)	51-56,	0.087	3.26	26.69	2,669	77 a @ 0.80 FAR	40% 31 a
Public Assembly	NA	-	-	0.5	50	2 a @ 0.53 FAR	50% 1 a
Public Order and Safety	NA	.0019	1.74	1.09	109	3 a @ 0.8 FAR	40% 2 a
Religious Worship	NA	-	-	6.5	650	28 a @ 0.53 FAR	30% 8 a
Service	81	0.02	3.26	6.13	613	18 a @ 0.80 FAR	40% 7 a
Warehouse and Storage	493	0.002	.59	3.39	339	8 a @ 1.07 FAR	40% 3 a
Other (Manufacturing)	31-33	0.037	1.87	19.79	1,979	43 a @ 1.07 FAR	40% 17 a
Non-residential Subtotal					**14,977**	**482 a**	**195 a**
Land Use Subtotal						**4,167 a**	
ROW/Roads Subtotal (25%)						**1,389 a**	**1,389 a**
TOTAL						**5,558 a**	**2,425 a**

Paving and Roads

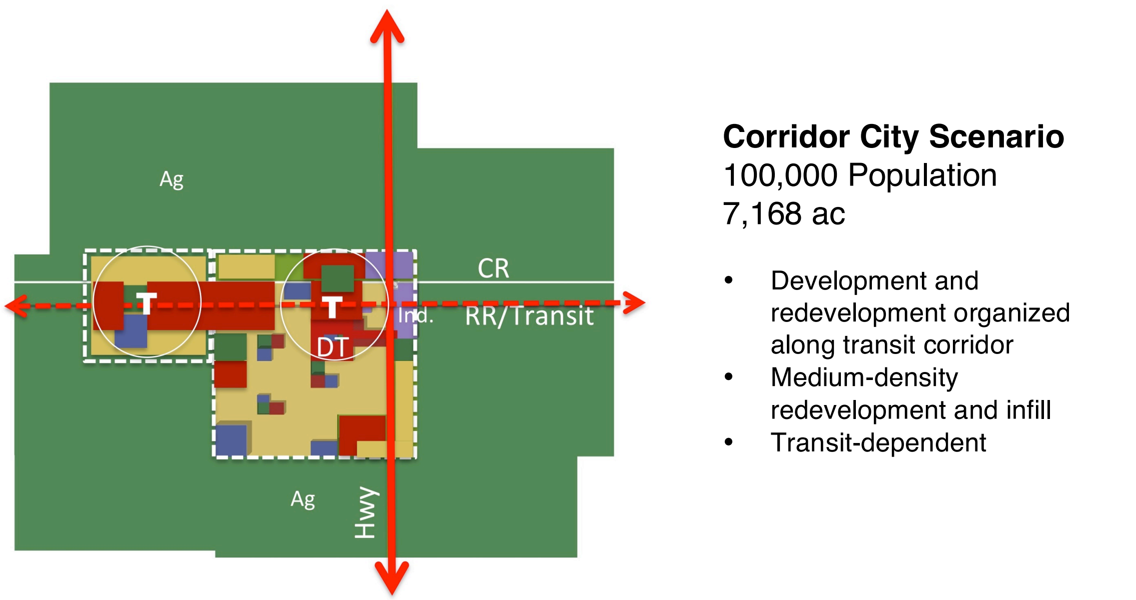
The program assumes a percentage of site paving is based on the amount of surface parking required to support land uses. As the urban scenario, the centred city has the least amount of surface parking and therefore the lowest amount of paving lifespan CO2e. Paving makes up about 44% of the total land area in the scenario. The centred city scenario includes 1,036 acres of on-site paving and 1,389 acres of paving in streets and right-of-ways for a total of 2,425 acres of paving. In contrast, the BAU scenario has nearly twice the amount as the centred city scenario.

6.4.4 Corridor City Scenario

The corridor city scenario assumes the city will grow from its current 50,000 population to 100,000 along a transit corridor. Growth is to occur primarily in the within its existing boundary and expanding about 30% along a transit corridor for a total of 7,168 acres (Table 6.10).

Figure 6.11

Conceptual Corridor City Diagram



Note: Not to scale

The conceptual land use diagram (Figure 6.11) illustrates a community that has grown along a transit corridor with compact development around transit stops and in its traditional centre by redeveloping low density uses, adding uses on exiting parking fields, and increasing density. Growth is supported by transit, walking and biking. Other than in the transit corridor, agricultural lands contiguous to the city are protected.

In order to accomplish doubling population and only expanding land area by about 30%, the scenario:

- Converts 25% NR land to residential at 22 DU/a;
- Redevelops 6% of low-density residential land at 20 DU/a;
- Assumes 15% of expansion land is used for NR uses at 0.40 FAR (3.36 MSF);
- Redevelops existing NR to include infill (2.79 MSF); and
- Includes Accessory Dwelling Units (ADUs) on existing lots.

Housing

The corridor city scenario approximately doubles the number of existing units, adding 20,161 DUs for a total of 39,391 DUs. Additional single-family units in the expansion area are over twice as dense, with more multifamily development. The program includes a total 4,699 acres of housing and 1,566 acres of roadways (25% of land area) for a total 6,265 gross acres. Sixty percent of the housing is single-family, including low (4 DU/a) and medium-density (11 DU/a) units. Two percent of the housing total is accessory dwelling units (ADUs) that are collocated on single-family lots. Single-family development uses 3,985 acres, representing about 84% of residential land and 74% of all programmed land. Thirty-six percent of the housing units (14,042 DUs) are multifamily, developed at 16-22 DU/a on 714 acres of programmed land using 15% of residential land. Mobile homes are 3% of the housing total, developed at 12 DU/a.

Non-residential (NR)

Non-residential densities increase through redevelopment and higher density infill. The development program assumes development of existing parking lots resulting in urban-scale projects. The baseline city average NR FAR of 0.22 is increased to 0.42 in the corridor city scenario. The scenario assumes there will be 12.16 MSF of NR, of which 8.94 MSF is within the baseline city boundaries and 3.22 MSF in expansion areas.

There are a total of 677 acres of programed NR and 903 gross acres including streets. The NR land comprises about 13% of programmed lands.

Paving and Roads

The program assumes paving site coverage is based on the amount of surface parking required by land uses. The corridor city scenario has a lower amount of paved area for parking compared to the BAU scenario and therefore a lower amount of lifespan CO2e. Paving makes up about 44% of the total land area in the scenario, with 1,302 acres of on-site paving in the corridor city scenario and 1,805 acres of paving in streets and right-of-ways for a total of 3,175 acres of paving. The corridor city scenario has 65% of the paving the BAU scenario.

Table 6.10

Corridor City Scenario Land Use Program

Type (Residential) or Principal Activity (Commercial)		Building Type Assumptions		Total Units 100,000/2.6 PPH= 38,460 # Units	Square Feet (in 1,000s of square feet)	Land Use Program Conversion	Site Paving Percentage
Single-Family Home 1			30%	11,688		2,922 a @ 4 DU/a	20% 584 a
ADU (replacement)			2%	812			NA
Single-Family Home 2 (expansion)			30%	11,693		1,063 a @ 11 DU/a	20% 213 a
Multi-Family Unit in Large Building 1 (infill–NR)			9%	3,487		159 a @ 22 DU/a	30% 43 a
Multi-Family Unit in Large Building 1 (infill–SF)			11%	4,050		203 a @ 20 du/a	30% 61 a
Multi-Family Unit in Large Building 2			8%	2,885		144 a @ 20 DU/a	30% 43 a
Multi-Family Unit in Small Building			7%	2,691		168 a @ 16 DU/a	30% 50 a
Mobile Home			3%	1,154		96 a @ 12 DU/a	20% 19 a
BUILDING TYPE CATEGORY	**2007 NAICS Code**	**Jobs/ Pop**	**Jobs/ 1000 sf**	**Per Capita GSF**	**Program in 1,000's**	**Resid. Program Subtotal 4,699 a**	**Resid. Paving Subtotal 1,013 a**
Education	61	0.01	.96	10.42	1,042	80 a @ 0.30 FAR	15% 12 a
Food Sales (5)	NA	-	-	5.0	500	24 a @ 0.48 FAR	50% 12 a
Food Service	722	0.03	1.33	22.56	2,256	108 a @ 0.48 FAR	50% 54 a
Health Care Inpatient	622	0.015	2.47	6.07	607	18 a @ 0.76 FAR	40% 7 a
Health Care Outpatient	6214, 6215, 6219	0.003	3.26	0.92	92	3 a @ 0.67 FAR	50% 2 a
Lodging	721	0.006	0.64	9.38	938	32 a @ 0.67 FAR	40% 13 a

Retail (Other Than Mall)	44, 45	0.047	1.50	31.33	3,133	150 a @ 0.48 FAR	50% 75 a
Office (Commercial)	51-56,	0.087	3.26	26.69	2,669	107 a @ 0.57 FAR	40% 43 a
Public Assembly (6)	NA	-	-	0.5	50	3 a @ 0.38 FAR	50% 2 a
Public Order and Safety (7)	NA	.0019	1.74	1.09	109	4 a @ 0.57 FAR	40% 2 a
Religious Worship (8)	NA	-	-	6.5	650	39 a @ 0.38 FAR	30% 12 a
Service	81	0.02	3.26	6.13	613	25 a @ 0.57 FAR	40% 10 a
Warehouse and Storage	493	0.002	.59	3.39	339	10 a @ 0.76 FAR	40% 4 a
Other (Manufacturing)	31-33	0.037	1.87	19.79	1,979	60 a @ 0.76 FAR	40% 24 a
Non-residential Subtotal					**14,977**	**677 a**	**371 a**
Land Use Subtotal						**5,418 a**	**1,384 a**
ROW/Roads Subtotal (25%)						**1,792 a**	**1,792 a**
TOTAL						**7,168 a (approx. 30% increase)**	**3,175 a**

6.5 MODELING RESULTS

The modelling evaluates common land use, demand-side operational, and supply-side strategies identified in Study 2's national survey of CAP cities. Modelling measures the lifetime CO2e and annual emissions from embodied, energy, and transportation sources. The results describe the effectiveness of common strategies for the three land use scenarios.

6.5.1 Scenario Modelling Results

Three model runs are prepared for the BAU, centred city, and corridor city scenarios (Figure 6.12). These describe the benefits of compact and transit-supported land use patterns, improved operations, and reduced CO2e in their energy supply.

<u>Compact Growth and Mitigation</u>

The scenarios that are more compact and transit-oriented have lower lifespan emissions. However, all the scenarios benefit greatly from demand-side strategies that reduce energy demand by buildings, reduce VMT, and improve vehicle fleet fuel efficiencies. This describes why land use planning strategies should be complemented with other mitigation strategies to meet deeper CO2e reduction targets.

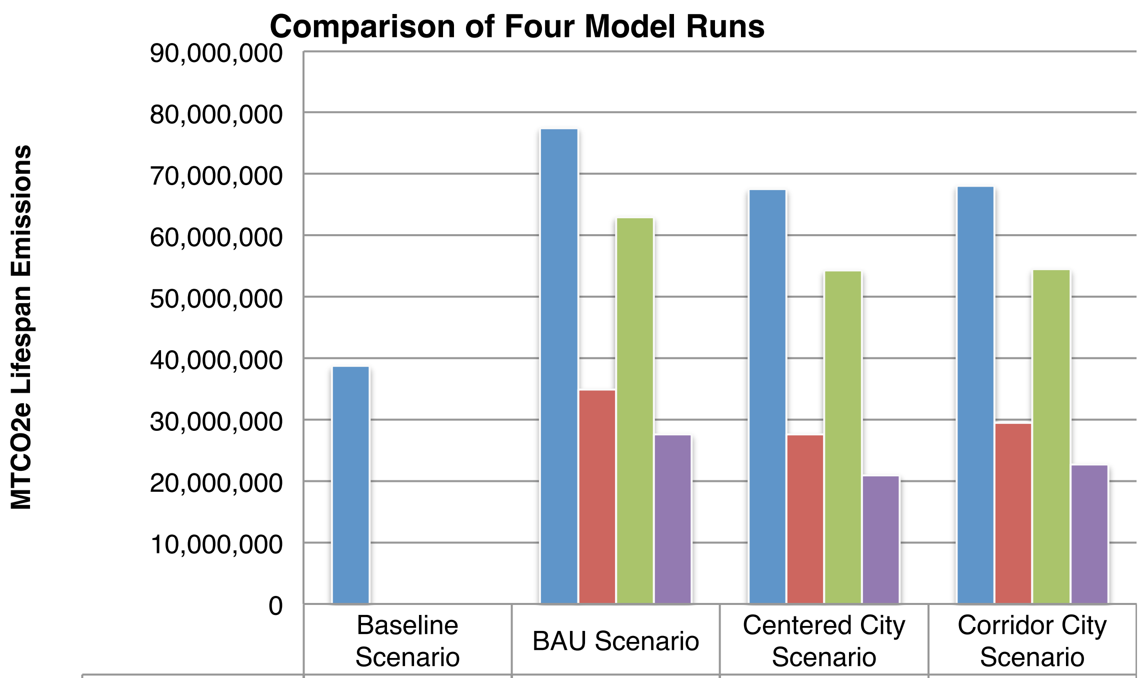
The centred city scenario with comprehensive demand and supply-side mitigation strategies is the highest performing, reducing lifespan emissions 40% below the baseline city.

The modelling of scenarios assumed the same reduction percentages for transportation and energy. The low-density development patterns of the BAU are not likely to deliver the same level of transit ridership or energy-efficient buildings as the centred and corridor scenarios. However, reductions in the CO2e content in the grid and more fuel-efficient vehicles can benefit the BAU scenario. To a lesser degree, more energy efficient construction will also benefit the BAU.

The performance of mitigated scenarios demonstrates the importance of regional, state, and federal-level policies. In particular, rules for vehicle fuel efficiency, reductions in CO2e in the power grid, and building codes significantly reduce emissions. The dynamics of local, state, and federal influence on meeting city GHG emission targets is discussed further in section 6.6.

Figure 6.12

Modelling Results Comparing Four Model Runs



	Baseline Scenario	BAU Scenario	Centered City Scenario	Corridor City Scenario
Land Use	38,726,063	77,449,508	67,517,377	68,038,946
Demand		34,878,352	27,598,033	29,491,995
Supply		62,965,146	54,275,532	54,463,660
Comprehensive		27,636,171	20,977,110	22,704,353

Note: The low-density development patterns of the BAU will not deliver the same level of transit ridership as the centred and corridor scenarios. Therefore, BAU reductions are overstated when applying the same reduction assumptions in the mathematical model.

6.5.2 Land Use Strategy Results

The first model run tests the benefits of land use and transit patterns strategies.

Land Use Assumptions

The first model run assumes demand and supply-side mitigation strategies are not implemented (Table 6.11). It measures only the benefits of compactness, building types, and resulting reductions in paving, VMT, and building energy-efficiency.

Run 1 Results

Centred and corridor city scenarios' land use programs have lower CO2e lifetime emissions compared to the BAU by 10.0 M and 9.5 M MTCO2e respectively. There is also about a 13% reduction in per capita annual MTCO2e for the two smart growth scenarios. The smart growth scenarios have reductions in embodied, energy, and transportation emissions. The most prevalent reductions are from reduced amounts of roadway and site paving and VMT.

Table 6.11

Model Run 1: Land Use

	Baseline Scenario	**BAU Scenario**	**Centre City Scenario**	**Corridor City Scenario**
TOTAL	**38,726,063** MTCO2e Lifespan Emissions	**77,449,508** MTCO2e Lifespan Emissions	**67,517,377** MTCO2e Lifespan Emissions	**68,038,946** MTCO2e Lifespan Emissions
Per Capita Annual MTCO2e	**12.70**	**12.70**	**11.11**	**11.17**
Embodied	3%	3%	2%	3%
Energy	47%	47%	49%	50%
Transportation	37%	37%	41%	37%
Paving	13%	13%	8%	10%

6.5.3 Demand-Side Strategy Results

The second model run tests the benefits of demand reduction strategies with a focus on the two highest GHG emissions sectors–electricity generation and transportation.

Energy and Embodied CO2e Assumptions

The second model run increases the energy efficiency of both new and existing buildings. This includes a 50% improvement in building energy use and 30% reduction in embodied energy compared to the baseline and BAU scenarios.

Building energy improvements assumptions include a 70% reduction in energy use in new buildings and 30% improvements in existing buildings over the baseline and BAU scenarios. This results in a weighted average overall reduction of about 50%.

Embodied CO2e emissions assume a combined 30% reduction for new construction and existing buildings. The existing building stock has the embodied emissions of the baseline city and is assumed to refresh at the new building rate as it is replaced.

Transportation Efficiency Assumptions

Transportation emission reductions come from a combination of lower VMT and improved vehicle fuel efficiencies and mix. VMT reductions due to density and infill are built into the land use model. Improved transit service and citywide parking management policies are assumed to reduce VMT another 30%.

Table 6.12

Model Run 2: Demand-Side Mitigation Strategies

	Baseline Scenario	**BAU Scenario**	**Centre City Scenario**	**Corridor City Scenario**
TOTAL	**38,726,063** MTCO2e Lifespan Emissions	**34,878,352** MTCO2e Lifespan Emissions	**27,598,033** MTCO2e Lifespan Emissions	**29,491,995** MTCO2e Lifespan Emissions
Per Capita Annual MTCO2e	**12.70**	**5.66**	**4.48**	**4.79**
Embodied	3%	4%	3%	4%
Energy	47%	52%	60%	58%
Transportation	37%	14%	17%	15%
Paving	13%	30%	19%	23%

Run 2 Results

Table 6.12 summarizes the results for the demand-side strategy model run. Demand-side strategies significantly reduce CO2e emissions. The centred and corridor city scenarios are 20% and 15% below the mitigated BAU scenario using the same reduction strategies and 64% and 62% below the unmitigated BAU scenario. All the scenarios are below the baseline scenario lifespan MTCO2e emissions, even the BAU. The centred city scenario annual per capita is 4.48 MTCO2e, 65% below baseline annual per capita emissions.

The demand-side strategies emphasize reducing building energy use and transportation efficiencies, shifting an increased percentage of lifespan emissions towards paving and embodied emissions. The BAU has 30% of lifespan emissions resulting from paving compared to 19% in the centred city scenario.

6.5.4 Supply-side Strategy Results

The third run tests the benefits of employing supply-side strategies in renewable energy.

Supply-side Assumptions

Supply-side strategies assume reductions in the amount of CO2e in the electric energy supply by 40% using a combination of RPS grid sources and on-site renewable sources.

Table 6.13

Model Run 3: Supply-Side Strategies

	Baseline Scenario	BAU Scenario	Centre City Scenario	Corridor City Scenario
TOTAL	**38,726,063** MTCO2e Lifespan Emissions	**62,965,146** MTCO2e Lifespan Emissions	**54,275,532** MTCO2e Lifespan Emissions	**54,463,660** MTCO2e Lifespan Emissions
Per Capita Annual MTCO2e	**12.70**	**10.37**	**8.98**	**8.99**
Embodied	3%	3%	3%	3%
Energy	47%	35%	37%	37%
Transportation	37%	46%	51%	47%
Paving	13%	17%	10%	13%

Run 3 Results

Table 6.13 summarizes the results for the supply-side strategy model run. Supply-side strategies reduce CO2e emissions less than the demand-side reductions. The centred and corridor city scenarios are 14% and 13% below the BAU scenario using the same reduction strategies and 30% below the unmitigated BAU scenario. The centred city and corridor city scenarios' annual per capita are 8.98 and 8.99 MTCO2e, 29% below baseline annual per capita emissions.

The supply-side strategy shifts the percentage of lifespan emissions towards transportation and paving.

6.5.5 Comprehensive Approach

The fourth run tests the benefits of employing fully mitigated scenarios combining both demand-side and supply-side strategies.

Comprehensive Approach Assumptions

This model run describes the benefits of the cumulative strategies and potential outcomes. It includes both the demand-side and supply-side strategies.

Run 4 Results

Table 6.14 summarizes the results for the comprehensive strategy model run. The comprehensive strategies significantly reduce CO2e emissions. The centred and corridor city scenarios are 24% and 18% below the BAU scenario using the same reduction strategies and 73% and 72% below the unmitigated BAU scenario. All the scenarios are below the baseline scenario lifespan MTCO2e emissions. The centred city scenario annual per capita is 3.42 MTCO2e, 73% below baseline annual per capita emissions.

Table 6.14

Model Run 3: Comprehensive Strategies

	Baseline Scenario	**BAU Scenario**	**Centre City Scenario**	**Corridor City Scenario**
TOTAL	**38,726,063** MTCO2e Lifespan Emissions	**27,636,171** MTCO2e Lifespan Emissions	**20,977,110** MTCO2e Lifespan Emissions	**22,704,353** MTCO2e Lifespan Emissions
Per Capita Annual MTCO2e	**12.70**	**4.50**	**3.42**	**3.70**
Embodied	3%	5%	5%	5%
Energy	47%	39%	47%	45%
Transportation	37%	18%	23%	19%
Paving	13%	38%	25%	30%

The comprehensive scenario strategies emphasize on building energy use and transportation. This shifts an increased percentage of lifespan emissions towards paving and embodied emissions, demonstrating the impacts of low-density patterns on emissions from paving. The low-density patterns of the BAU do not support transportation and building efficiencies gained from higher-density scenarios. Therefore, the BAU scenario is not as likely to achieve the percentage reductions assumed for the other scenarios.

6.5.6 Effectiveness: Goals, Strategies, and Outcomes

The modelling results indicate significant improvements in CO2e reduction beyond implementing smart growth land use patterns when used in concert with other mitigation measures. Cities' CAPs have targets that identify strategies and actions to meet goals.

Effectiveness of Mitigation Strategies

Figure 6.13 compares the lifespan CO2e baseline, unmitigated BAU, unmitigated centred city, and mitigated (comprehensive) centred city scenarios. The mitigated centred city scenario reduces the lifespan emissions more than others modelled. Its land use patterns provide an 18% advantage over the BAU. However, to make significant progress towards meeting aggressive targets, the land use strategies should be complemented with other local, state, and federal actions. The mitigated centred city version is approximately 42% below the baseline emissions and 73% below the BAU scenario. Smart growth land use patterns only seem to be a down payment in terms of meeting steep reductions required to meet 2050 targets.

Goals and Outcomes

Table 6.15 contains goals, strategies, and worksheet results for reductions for land use, demand-side, and supply-side strategies for the centred city scenario. The assumed target is 40% below baseline lifespan emissions requiring a 54.3 tgCO2e reduction of the BAU lifespan emissions. The percentage goals are used in the worksheet to calculate the reductions to demonstrate how mitigated strategies could reduce emissions below the target in the mitigated centred city scenario.

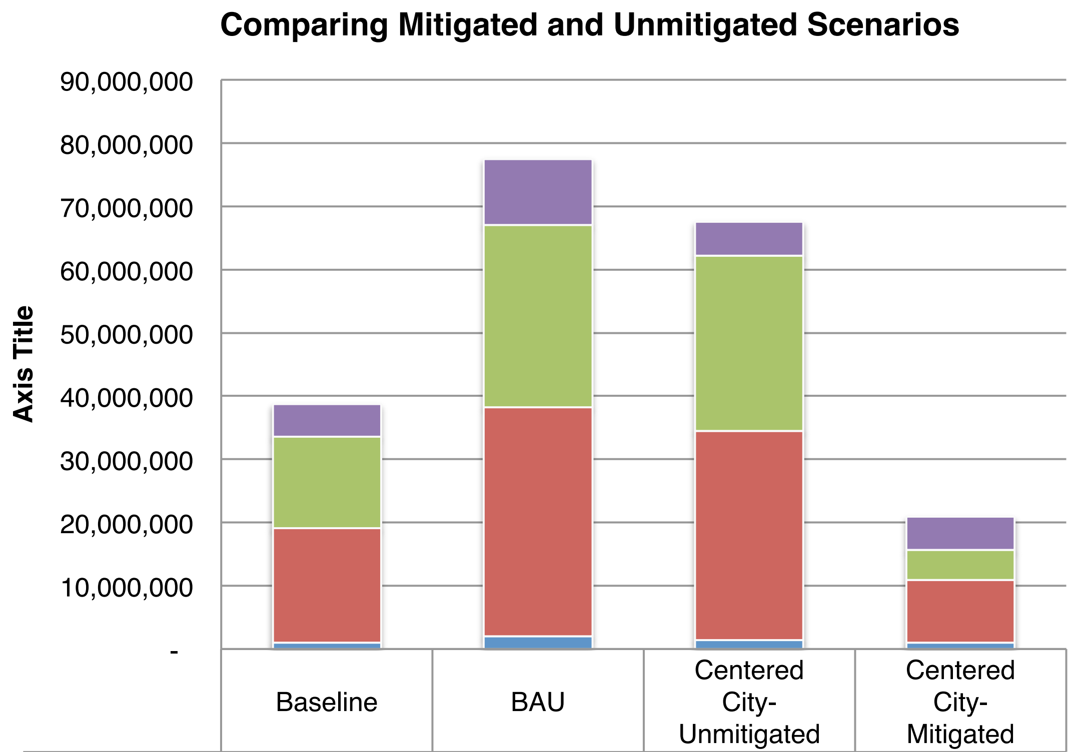
The mitigated centred city scenario is calculated to be about 42% below the baseline. The worksheet results indicate:

- About 18% of reductions come from smart growth land use features in the centred city scenario, including reduced VMT, more energy-efficient buildings, and reduced amounts of new roads.
- Approximately 64% of the CO2e reductions are from demand-side strategies, including energy efficient-buildings, reduced VMT, better vehicle fuel efficiency and fuel mix, and reduced embodied CO2e in new construction and renovation.

- The mitigated centred city scenario includes reducing of CO_2e in the power supply through on-site, local and regional solutions. About 18% of the overall reduction in CO_2e would come from these supply-side strategies.

Figure 6.13

Comparing Baseline, BAU, Unmitigated Centred City and Mitigated Centred City Scenarios



	Baseline	BAU	Centered City-Unmitigated	Centered City-Mitigated
Paving	5,197,076	10,393,863	5,285,792	5,285,791
Transporation	14,428,488	28,855,543	27,749,038	4,795,380
Energy	18,105,867	36,210,905	33,104,613	9,931,383
Embodied	994,630	1,989,196	1,377,933	964,533

Table 6.15

Comparative Benefits of Strategies for Centred City Scenario

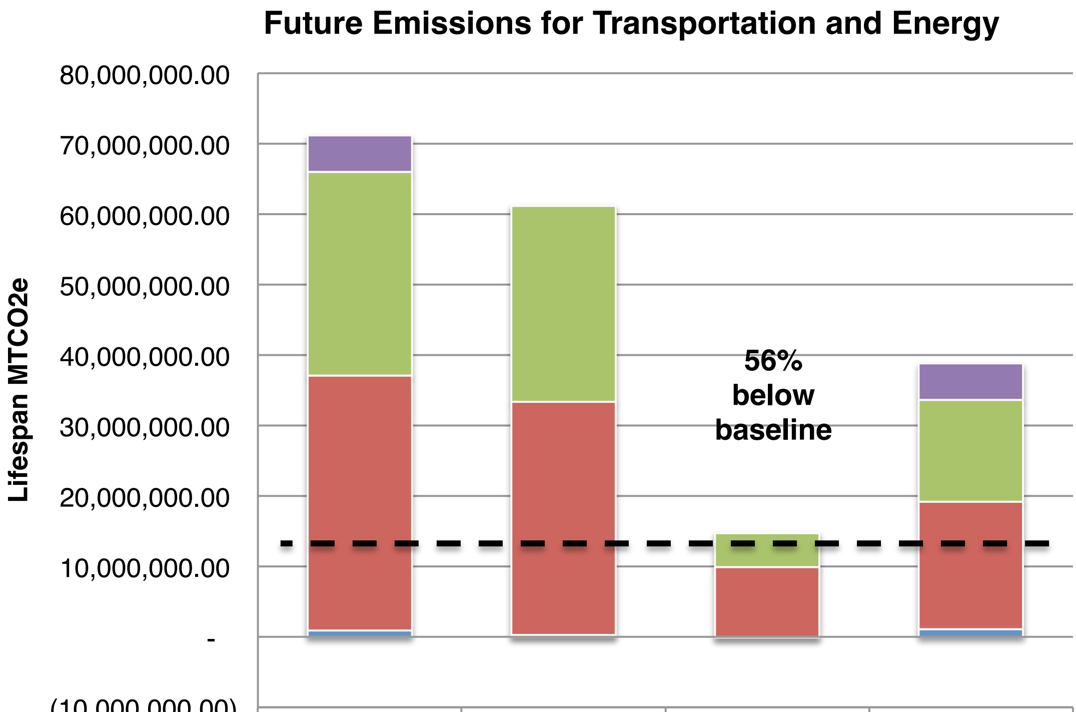
	Goals	Strategies Top strategies from Study 2 CAP City Survey	Worksheet Results Reductions in CO_2e of BAU	State and Federal Influence
Land Use	15% reduction in VMT CO_2e from land use compactness due to transportation (VMT) and building energy reductions 50% reduction in CO_2e from paving (uses existing roads)	• Make cities more compact, concentric, and centred with a higher "passive performance"-- walking and biking. • Reinforce and influencing city commitments to developing in and adjacent to downtowns. • Emphasize increasing density and transit-oriented development.	18% (10.1 gtCO_2e)	Transit funding
Demand-side Mitigation	50% reduction of CO_2e from buildings 30% reduction in embodied CO_2e 30% reduction in VMT 400% improvement in vehicle fuel economy and fuel mix	• Pursue higher energy-efficiency standards for buildings. • Reduce parking requirements and expanding transit services.	23% (13.0 gtCO_2e) 1% (0.6 gtCO_2e) 11% (6.2 gtCO_2e) 29% (16.4 gtCO_2e)	Building codes Vehicle fuel efficiency standards
Supply-side Mitigation	40% reduction in CO_2e from power generation	• Provide incentives for renewable energy.	18% (10.2 gtCO_2e)	State RPS policies
Target Reductions 40% below Baseline 54.3 tgCO_2e in reductions			**100%** **(56.5 gtCO_2e lifespan emissions, 42% below baseline)**	

Discounting Existing Embodied and Paving Emissions

Figure 6.14 compares lifespan emissions for the baseline, BAU, centred city land use-only scenario, and centred city mitigated scenario but omits *existing* paving and embodied lifespan MTCO_2e. This results in a measurement of *future* lifespan emissions for the mitigated centred city that are 56% below the baseline compared to about 40% if embodied and road construction are included. As an annualized comparison, the overall reduction is still about 56% below the annualized baseline emissions.

Figure 6.14

Scenario Comparison without Existing Paving or Embodied CO2e

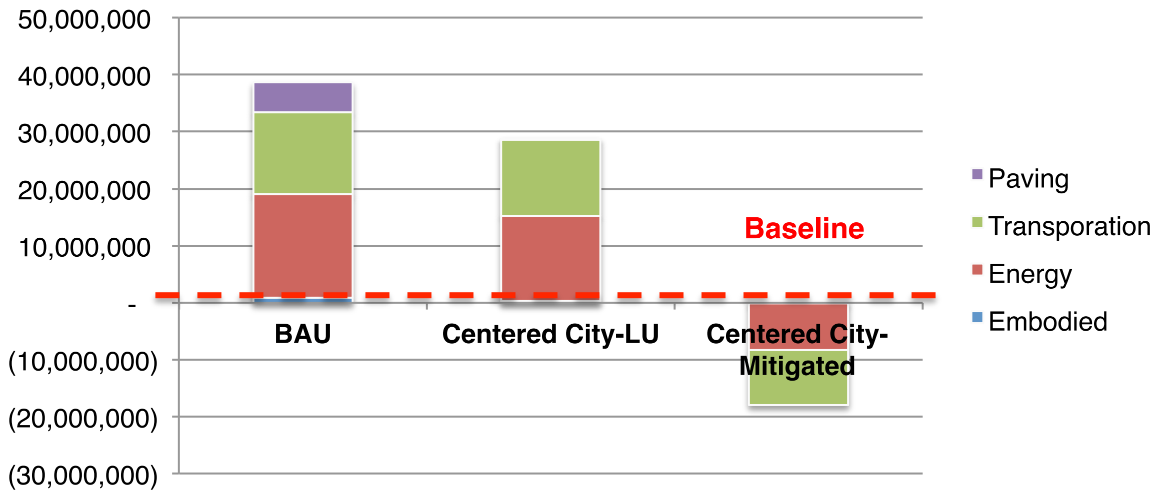


	BAU	Centered City-LU	Centered City-Mitigated	Baseline
Paving	5,196,787.00	88,716.00	88,715.00	5,197,076.00
Transporation	28,855,543.00	27,749,038.00	4,795,380.00	14,428,488.00
Energy	36,210,905.00	33,104,613.00	9,931,383.00	18,105,867.00
Embodied	905,836.00	294,573.00	(118,827.00)	1,083,360.00

Omitting embodied CO2e from *existing* buildings and paving can have a significant effect on a GHG emission accounting. The baseline scenario has 13% of its lifespan MTCO2e embodied in buildings and developed roads (paving). Even though the mitigated centred city scenario has significantly less emissions from roads and paving, it proportionally rises to 29% when omitting exiting buildings.

Figure 6.15

Future Emissions: Unmitigated BAU and Mitigated Centred City Lifespan MTCO2e



Demonstrating the Need for Early Mitigation Actions

Smart growth land use concepts can reduce VMT, improve building energy efficiency, and reduce emissions from road and utility infrastructure construction and maintenance. Land use patterns take time to change. Therefore, a variety of other early actions must be taken to meet targets. Delay has global and local implications.

Waiting is Expensive

Delay increases costs and impacts. Extreme weather events in the U.S. cost each taxpayer $1,100 in 2012. Hurricane Sandy losses in New York and New Jersey alone were an estimated $80 billion. The NRDC has proposed spending $4 billion per year reducing CO2e emissions from power plants 26% by 2020. This investment would ultimately save and an estimated $25-$60 billion per year in reduced property damage (Kennedy & Meek, 2013).

Besides the global costs and impacts, local governments that delay may not be able to finance the number of required high-performing projects all at once. Instead, they will need to build mitigation and adaptation investments into their capital improvement programs.

Moving Towards Net Zero

Figure 6.15 compares the *future emissions* of the unmitigated BAU scenario with the unmitigated and mitigated centred city scenario. Their lifespan MTCO2e are compared to the baseline. This *future only* graph illustrates the importance of early implementation of mitigation actions other than land use in meeting reduction targets below the baseline. It also indicates the importance of early implementation of climate mitigation actions to meet targets because new development and investment must effectively move towards net zero performance to reduce emissions below the CAP baseline.

Partner Early

Table 6.15 identifies other potential actors that should be involved in early funding, development, and regulatory actions. Three of the most effective strategies for reducing emissions include vehicle fuel efficiency and mix, CO2e reductions in the energy supply, and energy-efficient buildings. The federal CAFÉ standards for fuel efficiency can triple or quadruple fleet mpg by 2050. Federal emission standards for power generation can reduce emission from power plants and encourage development of renewable energy. State and local building codes can reduce energy demand in new and retrofitted construction. State and federal governments have significant influence over meeting GHG reduction goals.

6.5.7 Comparing Results with Other Research

Two studies prepared by the Urban Land Institute (ULI) explored how compact and transit-oriented development could reduce GHG emissions. The first study, Growing Cooler, concluded that VMT could be reduced 20-40% and GHG emissions 7-10% by 2050 (Ewing, Bartholomew, Winkelman, Walters, & Chen, 2007, pp. 4, 9). The follow up study, Moving Cooler, concluded that investing in transit and pedestrian facilities could reduce GHG emissions by 4-18% and even up to 24% under a "maximum deployment" scenario by 2050 (Cambridge Systems, Inc., 2009, p. 5).

The unmitigated centred city scenario is 13% less GHG emissions than the BAU (Table 6.16). Another 23% reduction in GHG is accomplished by implementing the 2025 CAFÉ standards (54.4mpg by 2025). The total 36% reduction is at the high end of the combined ULI study results that also take into account exurban areas. The cumulative low end of the two ULI reports for smart growth and transit investments is 11%, and the high end is a 28-42% reduction.

The Transportation Research Board (TRB) estimated that smart growth could reduce GHG emissions between 1% and 11% by 2050, depending on the scenario. Their review of literature suggests doubling of residential densities could reduce household VMT by 5-12%, up to 25% with other qualitative improvements including good mix of uses, accessibility, and a well-designed environment (Transportation Research Board, 2009, pp. 4, 153).

Table 6.16

Growth Management Scenarios Compared to BAU and ULI and TRB Studies

	Unmitigated	With 2025 CAFÉ Standards	Total (1)
Centred City Scenario	13%	23%	36%
Corridor City Scenario	12%	21%	33%
ULI Growing Cooler	7-10% reduction in GHG emissions by 2050		11%-28% (42% under "maximum deployment")
ULI Moving Cooler	4-18% reduction in GHG emissions by 2050 and up to 24% under "maximum deployment"		
Transportation Research Board: Special Report 298	5-12% reduction in VMT GHG emissions by 2050 and up to 25% VMT reduction with other improvements		1-11% total GHG reductions by 2050

(1) Total GHG reductions compared to BAU

6.5.8 Summary of Modelling Results

The four modelling runs of the baseline, BAU, centred city, and corridor city scenarios describe how demand-side strategies are especially effective at reducing GHG emissions. Most reductions will come from increasing the energy efficiency of buildings, reducing CO2e in the grid, and implementing CAFÉ standards for cars and trucks. Traditional smart growth land use strategies of centred, compact, and connected patterns are an important down payment for meeting CAP targets. They form the chassis for a CAP strategy where cites have the most control. The scenario modelling suggests that traditional smart growth planning can provide a reduction in emissions due to reduced VMT, less paving and infrastructure, and more energy-efficient building types.

6.6 VALIDATION: ANALYSIS CASE STUDY

The worksheet tool was selected and modified to describe the performance of scenario cities under "laboratory conditions." The mathematical modelling allows control over variables representing the types of actions taken by cities in the context of state and federal actions. The validation study tests the modified worksheet tools' potential applications in real world conditions.

Study goal: Validate the worksheet tool effectiveness for measuring existing and predicting future GHG emissions at a citywide, district-scale, and block-scale.

6.6.1 Validation Case Method

A single case study is used as a sensitivity analysis of the worksheet model outputs. This study considers how scenario and worksheet approach for determining lifespan embodied, energy, and transportation categories supports a traditional top-down CAP approach and bottom-up district and site-scale approach.

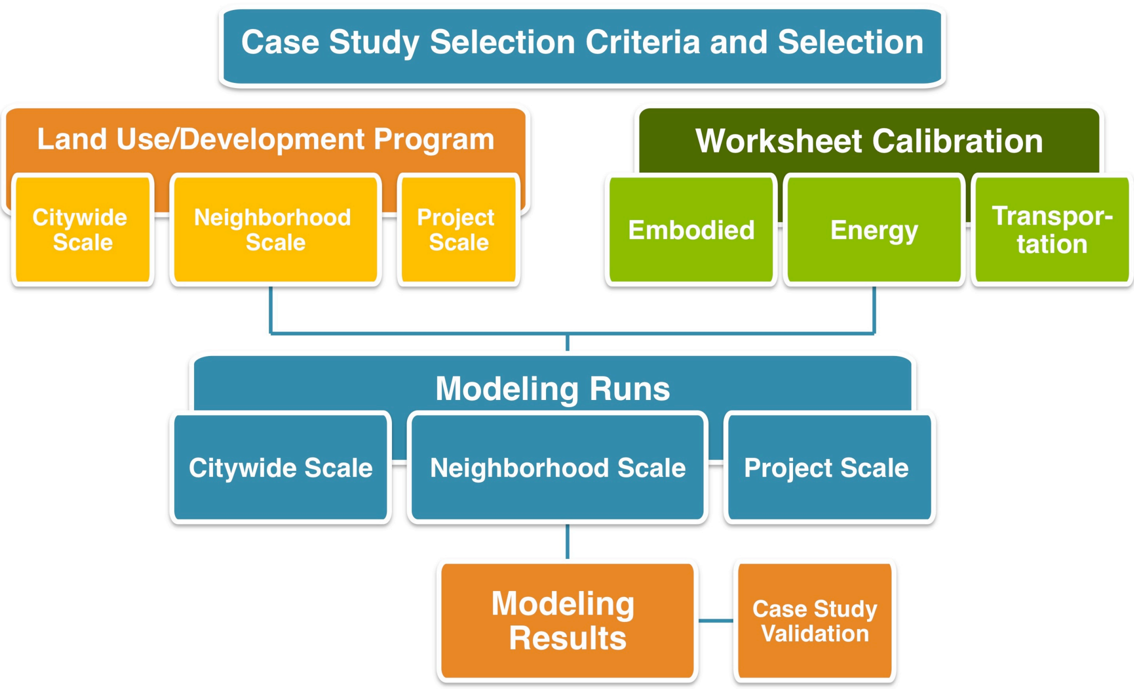
Five-Step Method

The validation case study method includes five steps (Figure 6.16):

1. Case study selection
2. Land use and development program
3. Worksheet calibration
4. Model runs
5. Summary of comparison results

Figure 6.16

Validation Case Study Method



Modelling Three Scales

A case city is used to test the performance of the worksheet tool at three scales:

- Citywide scale (future and existing development)
- Neighbourhood (new development)
- Block scale (new development)

Case Selection

Case selection criteria for the case assumes a city:

- With a completed GHG inventory and CAP
- With a comprehensive plan
- In the 50,000 to 100,000 population range and growing
- In a climate zone different from the national average the worksheet is based on to test its adaptability

6.6.2 Case City: Merced, CA

The City of Merced, California is used as the case city. The city completed a CAP in 2012 and updated its comprehensive plan in 2012. It has a population of about 80,000 and is expected to grow to about 107,500 by 2020. It is located in the arid San Joaquin Valley and has the advantage of California's lower regional eGRID CO2e emissions.

Merced Context

Merced is located in California's hot and dry San Joaquin Valley. The Valley is expected to grow by over three million people by 2040. The Valley has a diverse population that is 46% Hispanic. The San Joaquin is the most important agricultural region in the United States, and agriculture represents nearly two-thirds of the regional economy. As a result, one of the primary challenges for the Valley has been a seasonal unemployment rate of over 20%.

Environmental health and dietary health are additional challenges for the Valley. The San Joaquin air basin is the most polluted in the country with high amounts of soot and dust (PM10 and PM2.5). In 2005, one in three children in Fresno County were diagnosed with asthma. During the winter of 2011-2012, over 37 days in the Valley violated federal health standards (Grossi, 2012). The region also has a higher rate of diabetes and children eligible for the school lunch program.

Merced is a fast-growing, diverse city facing fiscal and environmental challenges that typify Valley communities. In 2010, Merced's population was about 80,000 and is expected to grow to 115,000 by 2025 (Economic & Planning Systems, Inc, 2004). The Merced CAP assumes 107,500 as the 2020 population.

The Merced CAP 2008 baseline inventory identifies 405,748 MTCO2 or about 5.1 MTCO2e per capita. Merced's low per capita CO2e is a result of being in a climate with a low number of heating degree-days. In addition, California's CAMX eGRID has one half the national average of CO2e lb/MWh.

Merced Compared to the Baseline Scenario

Merced's population is about 80,000 compared to 50,000 for the baseline scenario. The worksheet baseline scenario's 12.73 MTCO2e and the mitigated centred city annual per capita 3.81 MTCO2e. Merced's 2008 baseline annual emission is 5.1 MTCO2e per capita. The climate is hotter and dryer than the U.S. average baseline scenario.

Merced CAP Targets, Goals, Strategies, and Actions

Merced, as most cities, employs a top-down methodology for establishing baseline and BAU inventories and projections; establishing broad targets and developing reduction goals by emissions category; and defining a set of actions to meet the reduction goals. Merced GHG emission categories reflect protocols and areas that are within their jurisdictional control. The following figures and tables are derived from the City of Merced, California CAP.

Figure 6.17

Merced GHG Baseline Inventory Pie Chart

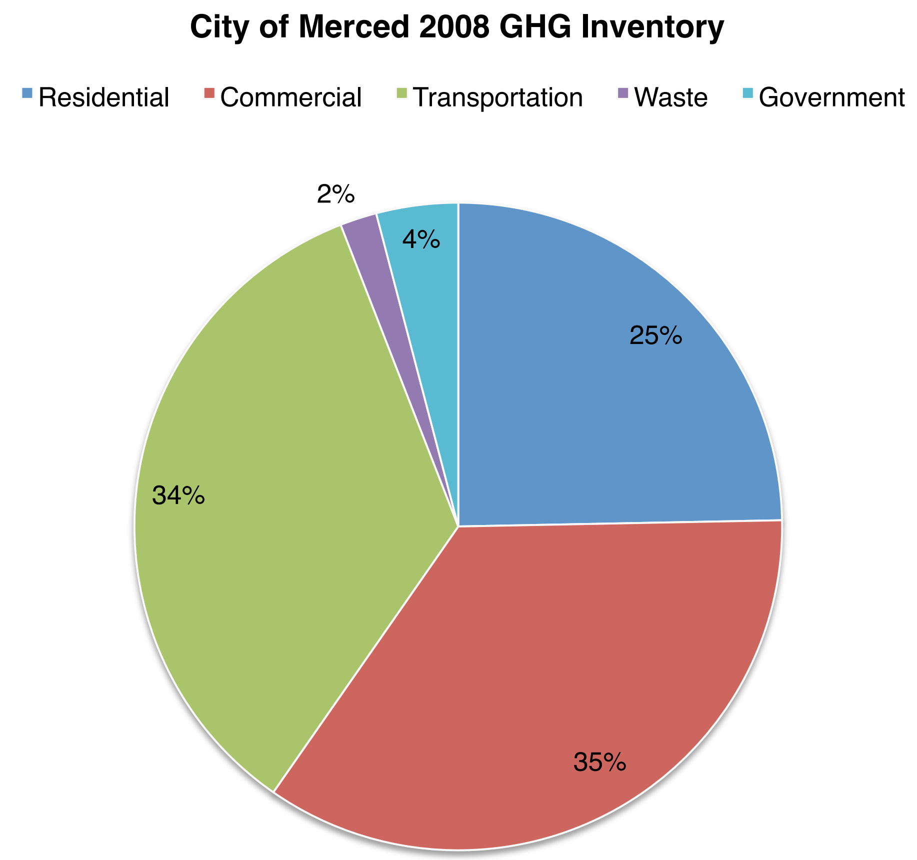
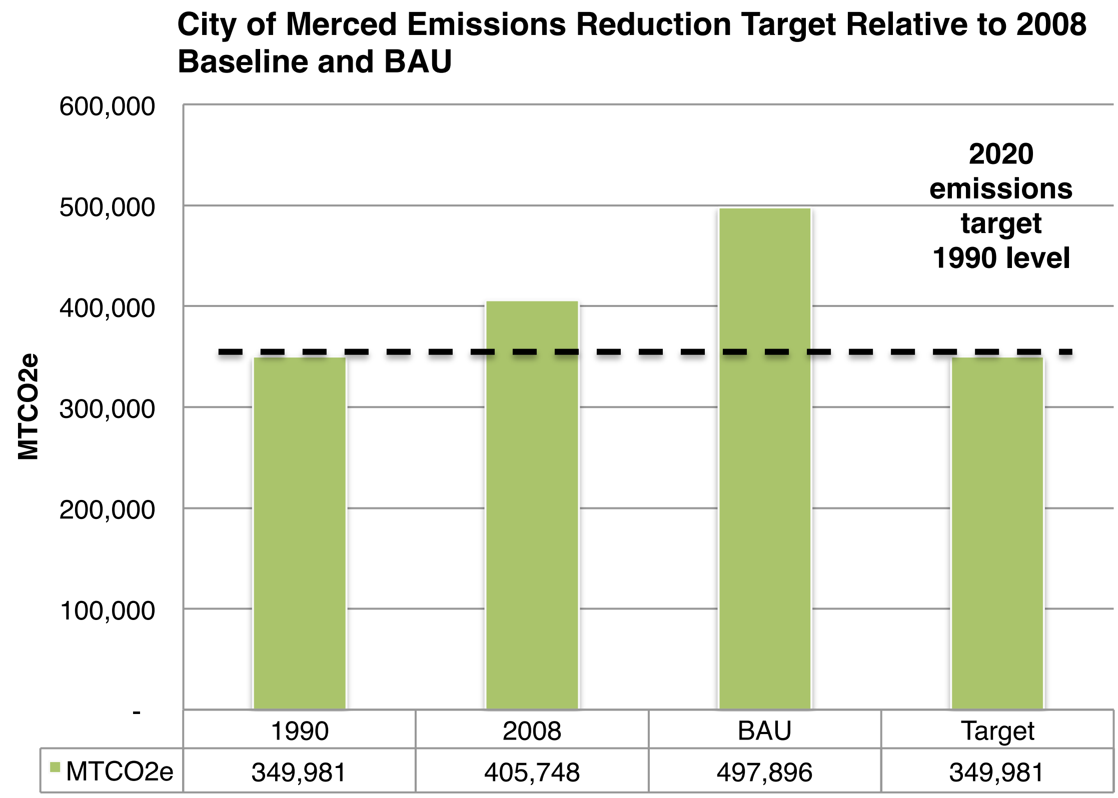


Figure 6.17 is the GHG emission baseline from the City of Merced, California CAP (City of Merced, 2012). The categories of emission are determined by CARB protocols and align with California's CAP inventory.

Figure 6.18 illustrates Merced's target of reducing CO2e emission to 1990 levels by 2020. Merced has set broad targets. The CAP uses a top-down approach to establish a set of strategies and actions that work towards meeting targets.

Figure 6.18

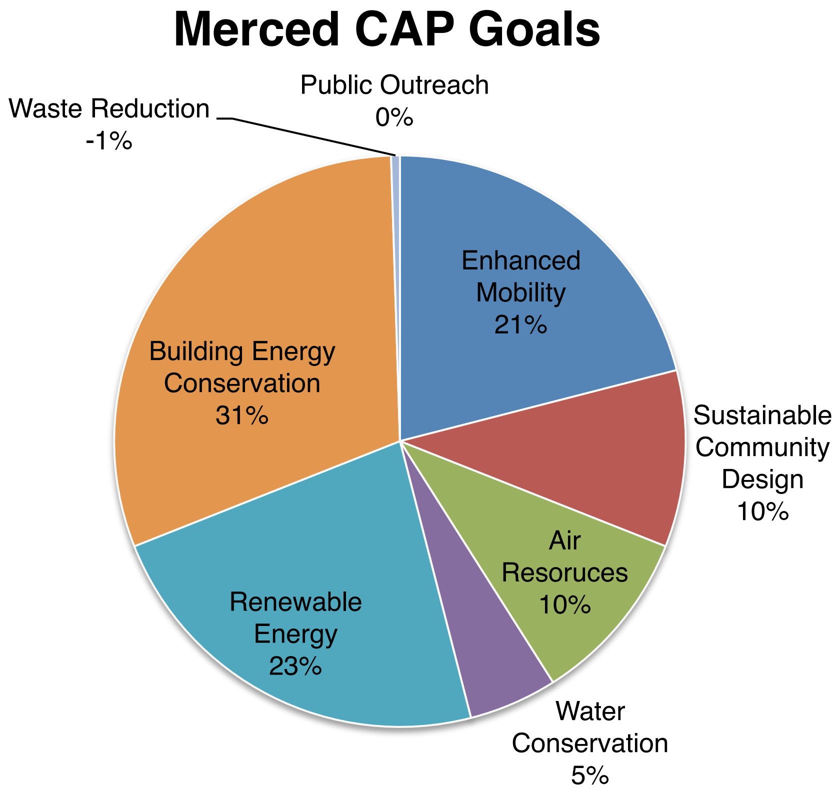
Merced Overall Emissions Reduction Target



The Merced CAP's top four goals include improving buildings' energy conservation, providing renewable energy, enhancing mobility, and implementing sustainable community design. The goals are supported by strategies and actions. For example, enhanced mobility have has five strategies and 20 actions for reaching mobility goals to reduce GHG emissions by 30% before 2020. Merced's CAP also includes a set of public outreach strategies and actions. These are common supporting actions for CAPs and may have other metrics rather than GHG reductions. Figure 6.19 summarizes Merced's 2020 reduction strategy goals by action areas.

Figure 6.19

Merced CAP Emission Reduction Goals



6.6.3 Assessing Citywide CAP: Worksheet Calibration

Calibrating the worksheet baseline interprets available information. To approximate Merced's 2008 baseline requires preparing an existing land use program; updating energy inputs to reflect the CAMX eGRID; changing transportation data to reflect California's vehicle fleet fuel efficiency; and energy efficiency improved to reflect California more demanding codes.

Land Use Program

The available land use information provides housing program information. The non-residential program requires estimating.

The Housing Element indicates 28,004 DUs of housing for Merced:

- Detached DUs 15,771
- 2-4 DUs 5,374
- 5-19 DUs 3,865
- 20+ DUs 1,707
- Mobile Homes 1,287

The Land Use Element in the comprehensive plan indicates the amount of land zoned for various uses, but not the actual developed building or site area.

An estimate of the non-residential program uses two methods: land use data and employment data. Both methods interpret available information that is incomplete or out-dated.

Non-residential–Land Use Method Program Estimate

The first method estimates percentage of zoning build out by reviewing the zoning map and aerial to estimate percentage build out based on spot-checking land use categories. The employment method resulted in an estimated non-residential program of 17,981,000 GSF on 1,448 acres in the worksheet (Table 6.17).

Table 6.17

Estimate of Zoning Build-Out

	Acres	Build-out	Acres	FAR	1,000s GSF
Public/Gov.	535	40%	214	.05	466
Industrial	2,692	20%	538	.20	4,690
Business Park	631	20%	126	.25	1,374
Business Park Reserve	328	0			
Commercial	1,759	40%	704	.25	7,662
Schools (Education)	731	40%	292	.15	1,911
TOTAL Non-residential					**16,103**

Non-residential–Employment Method Program Estimate

The employment method updates 2000 employment data for Merced by 10% reflecting population growth and using the worksheet employees per 1,000 GSF in the transportation calculations. The Merced General Plan contains tables with existing land use information. The land use/zoning inventory in 2007 included 44% single-family residential (5,600 acres), 7% multifamily (917 acres), 15% industrial (1,900 acres), 17% commercial and office (2,200 acres), and 17% open space (2,100 acres).

The land use zoning method results in an estimate of non-residential 16,103,000 GSF on 1,465 acres in the worksheet (Table 6.18).

Comparing Non-residential Program Results

The zoning method and employment method are within 7% of each other in terms of total employment. The employment data method was chosen because has a more accurate mix of building space, not just building area. The employment was allocated to building types using national census data prepared for creating the baseline scenario (Table 6.6). For example, education and health extrapolated based on per capita national data:

In-patient Health	80,000 pop. X 6.07GSF per capita = 485,600 GSF
Out-patient Health	80,000 pop. X 0.92GSF per capita = 73,600 GSF
Education	80,000 pop. X 10.42GSF per capita = 833,600 GSF

These building area calculations are converted to number of employees by dividing them by the multipliers in the worksheet.

Table 6.18

Estimate of 2007 Employment

	2000	2007	empl/1,000 GSF	1,000 GSF
Ag/Forestry	1,173	1,290	0.25	322
Construction	1,272	1,399	0.25	350
Manufacturing	2,387	2,625	2.0	1,313
Wholesale	691	760	2.0	.38
Retail	2,466	2,713	0.8	3,391
Transp./Warehousing/Utl.	923	1,015	0.6	1,692
FIRE	954	1,049	1.9	552
Rec./Food Service	1,695	1,865	1.8	1,036
Professional	1,859	2,045	1.9	1,076
Ed./Health/Soc. Srvcs.	5,624	6,186	1.2	5,155
Other Services	989	1,088	0.9	1,209
Public Admin.	1,323	1,455	1.2	1,212
TOTAL	22,267	24,494		**17,308**

Baseline Worksheet Assumptions and Results

In addition to land use program, the worksheet has data inputs that must be set to better reflect local conditions. For example, the California building codes have been a trendsetter nationally regarding energy efficiency since 1978. This will reduce energy efficiency for buildings by an estimated 40%. Other important assumptions include reducing the eGRID by 50% and improving fuel efficiency for cars and trucks based on California's leadership in setting higher standards. Table 6.19 summarizes the worksheet calibration assumptions.

In addition, the method for estimating the baseline inventory in the Merced CAP is based on activities and does not include embodied emissions or paving. To reflect those types of assumptions, the worksheet paving and embodied emissions calculators are turned off.

The total lifespan emission for the Merced baseline worksheet using the employment-based build-out estimates is 26.9 tGCO2e. The annual emissions are 451,592 MTCO2e compared to 405,748 MTCO2e in the CAP 2008 baseline inventory, about 10% higher that the CAP baseline inventory prepared using ICLEI's CAPPA software that has built-in multipliers and assumptions.

Table 6.19

Worksheet Calibration Assumptions Compared with U.S. Averages

Embodied	10% reduction in embodied CO2e (1)	
Energy	40% reduction based on Title 24 and CA building codes (2)	50% reduction in CO2e in the energy supply (CAMX eGRID compared to national average) (3)
Transportation	27 mpg fuel efficiency (4)	
Paving	None	

Notes:

(1)(2) California building codes reinforce reduction in waste and design for lower embodied energy and higher energy performance
(3) CAMX eGRID has 661.2 lb/MWh CO2e versus 1,222.29 lb/MWh CO2e for the U.S. average
(4) California has already implemented higher fuel standards, raising fleet efficiency from 23mpg to 27mpg

Calculating Merced's 2020 Target

The worksheet and new baseline are now used to calculate the percentage reductions identified in the CAP. Table 6.20 includes both the percentage reductions in the CAP and the anticipated amount of CO2e reduction.

The Merced CAP assumes the city will grow about 34.5% by 2020 to 107,500 people. The development program assumes jobs and housing will grow proportionally. The amount of GHG emissions reduction is to equal 1990 levels. The 2020 target is 55,767 MTCO2e below the 2008 baseline.

Table 6.20

Merced 2020 GHG Emissions Goals and Reduction Below 2008 Baseline

	Percentage Total Goal	Anticipated reduction MTCO2e by 2020 (against 2008 Baseline)
Enhanced Mobility	21%	11,771
Sustainable Community Design	10%	5,577
Air Resources	10%	5,577
Water Conservation	5%	2,788
Renewable Energy	23%	12,826
Building Energy Conservation	31%	17,288
Waste Reduction	1%	558
Public Outreach	0%	-
TOTAL	**100%**	**55,767**

Assumptions for running a 2020 estimate of annual MTCO2e for Merced include translating Merced goals into percentage reductions in the worksheet. The assumptions are summarized in Table 6.21.

Table 6.21

2020 Worksheet Calibration Assumptions

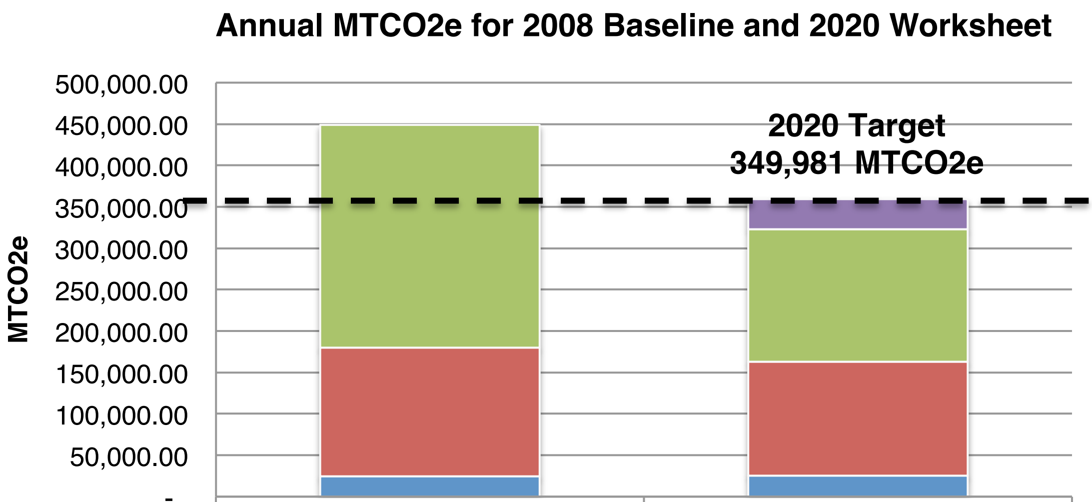
Land Use/Sustainable Community Design	Approximately 30% increase in non-residential density due to infill	Increased percentage of multifamily housing from 20% to 24% with emphasis on high-density infill
Embodied	30% reduction in embodied CO2e (1)	
Energy	50% reduction based on Title 24 and CA building codes and Merced's added 31% goal	60% reduction in CO2e in the energy supply based on CAMX eGRID compared to national average and Merced 23% renewable energy goal
Transportation	48 mpg fuel efficiency based on 2025 CAFÉ standards progress	21% reduction in VMT based on Merced's goal
Paving	Reductions due to higher density and infill	Subtracts baseline paving from 2020 for new added paving

Worksheet Results for 2020 Goals

The 2020 worksheet assumptions resulted in a 2020 GHG emissions reduction to the 2008 Baseline approximately equal to the 1990 target (Figure 6.20). The 2020 worksheet annual total is 359,064 MTCO2e, about 3% higher than the 1990 levels and the target of 349,981 MTCO2e. However, in order to meet the goal, the housing count and land use assumptions are made different than the Merced General Plan projections. The uses are denser. Adding multifamily units with fewer persons per unit raises the number of units from 35,866 DUs to 37,700 DUs. The commercial density was increased about 30% above the assumptions for the 2008 baseline.

Figure 6.20

Merced CAP Worksheet 2020 Compared to Merced Worksheet Baseline and Target



	2008 Merced Baseline	2020 Worksheet
Paving	-	36,258.36
Transporation	269,142.35	159,912.40
Energy	155,621.99	137,761.51
Embodied	24,209.03	25,132.32

6.6.4 District and Neighbourhood-scale Analysis

Using the worksheet on a neighbourhood-scale program illustrates the benefits of density and compactness. The worksheet is used to compare a Merced BAU low-density neighbourhood and a land-efficient neighbourhood with the same population. The BAU is run with the same assumption as the Merced CAP 2008 Baseline, and the compact neighbourhood uses Merced mitigation goals.

Comparing BAU (2008 Baseline) and Compact Neighbourhoods

Table 6.22 summarizes the two programs. The worksheet results indicate that new neighbourhoods developed more compactly and applying Merced strategies and goals will have 48% less CO2e than the 2008 Baseline. The 2008 Merced baseline neighbourhood would have 5.74 MTCO2e per capita reduced to 2.98 MTCO2e in the compact neighbourhood.

Table 6.22

Comparative 10,000 Population Neighbourhood Development Program

	Residential Program	Non-residential Program	Paving
BAU (2008 Merced Baseline)	**956 acres** 3,245 DUs Single-Family 310 DUs Multifamily 3,555 DUs Total	**1,544 acres** 163,400 GSF Education 130,700 GSF Commercial Services 294,100 GSF Total	**17,191 SF**
Compact	**552 acres** 2,560 DUs Single-Family 1,350 DUs Multifamily 3,910 DUs Total	**837 acres** 163,400 GSF Education 130,700 GSF Commercial Services 294,100 GSF Total	**10,691 SF**

6.6.5 Block-scale Analysis

The objective for using the worksheet on a block-scale program is to illustrate the benefits of infill density and building types. The worksheet is used to compare a downtown Merced block with the same number of units. The higher-density development assumes a vertical mixed-use development in a corridor building, and the mid-rise assumes a horizontal development with storefront commercial buildings and narrow urban townhouses. The worksheet uses the 2008 Baseline mitigation assumptions.

Comparing Mixed-use Blocks

Table 6.23 summarizes the two programs. The worksheet results indicate that new infill mixed-use development in Merced with 60 stacked flats and 8,000 SF of retail has 638 MTCO2e in emissions annually. The same number of units and retail in townhouses and storefront buildings generates 726 MTCO2e emissions annually, about 12% more than a vertical mixed-use development.

Table 6.23

Comparative Block Development Program

	Residential Program	Non-residential Program	Paving
Vertical Mixed-use	**53,000 SF (1.2 acres)** 60 DUs Multifamily 850 GSF/DU 114 Residents	**Same block** 8,000 GSF Retail	**15,880 SF**
Horizontal Mixed-use	**87,120 SF (2.0 acres)** 60 DUs Townhouses 1,390 GSF/DU 114 residents	**10,000 SF (0.23 acres)** 8,000 GSF Retail	**39,600 SF**

6.6.6 Summary of Validation Case Study

The CAP for Merced, CA is used as a case study to test the worksheet as a tool for measuring, planning, and guiding CAP strategies at city, neighbourhood, and block scales.

Using the Worksheet at a Citywide Scale

The worksheet was originally developed for tracking and informing implementation of CAPs at a project scale. The worksheet requires program details that may not be available at a city scale, making it harder to use for preparing inventories. It is a bottom-up tool with some top-down features added to it. As currently developed, it is better suited for measuring and planning future land use strategies at a city scale rather than preparing GHG inventories that require extensive data collection and input. The worksheet does not have the capacity to calculate water and waste mitigation strategies.

Using the Worksheet at a Neighbourhood Scale

The worksheet is a better tool for informing and tracking emissions from larger district and neighbourhood planning, particularly greenfield projects with significant amounts of new paving. Used at the neighbourhood scale, the worksheet shows clear advantage of density and mitigation policies and can be used for planning and monitoring future large-scale developments. It also can be used to establish parameters or environmental performance standards for implementing new projects.

Using the Worksheet at a Block Scale

The worksheet is a good tool for comparing scope and program of infill development and can be used to set parameters for implementation. The worksheet can also be used to establish performance standards for block typologies.

Conclusions

The worksheet works best as a research tool supporting a mathematical modelling of scenarios and calculating the future emissions from proposed development. It is difficult to calibrate at city scale unless detailed land use and development program information exists for a city.

The worksheet can be modified further to add new capabilities, such as waste and water, annual scheduling, and trending analysis features. This is not in the scope of this research study and thesis but would be an effort for a later date.

6.7 SUMMARY: Effectiveness of Growth Management Strategies

Study 3 demonstrates the effectiveness of popular land use, demand-side, and supply-side strategies being employed by CAP survey cities. The land use scenarios represent simplified models of smart growth strategies. The enhanced worksheet was an effective mathematical modelling tool for comparing scenarios and describing their effectiveness.

The development of land use scenarios and the worksheet describes the effectiveness of smart growth and demand-side and supply-side mitigation in reducing GHG emissions. Study 3 provides the research findings that address the three questions resulting from Study 2's survey.

Q6A-Land Use Strategies: How effective is increasing density, compactness, and centeredness of communities in reducing GHG emissions?

The four modelling runs of the baseline, BAU, centred city, and corridor city scenarios describe how demand-side strategies are especially important in meeting targets and how smart growth strategies are an important down payment for a meeting CAP targets. They form the chassis for a CAP strategy where cites have the most control. The scenario modelling suggests that smart growth planning can provide up to 13% reduction in emissions compared to BAU due to reduced VMT, less paving and infrastructure, and more energy-efficient building types.

Q6B-Demand-side Strategies: How effective are demand-side strategies, such as increasing energy efficiency of buildings and improving mobility services, in reducing GHG emissions?

The bulk of reductions in CO2e come from increasing energy efficiency of buildings, reducing CO2e in the grid, and most importantly, implementing CAFÉ standards for cars and trucks. Modelled demand-side strategies suggest they can reduce lifespan CO2e by up to 64% below the BAU scenario. These strategies are dependent on state and federal actions and regulations. The scenarios demonstrate the need for cities' efforts to be complimented by states and the federal government.

Q6C-Supply-side Strategies: How effective are common demand-side strategies in combination with supply-side strategies?

Reducing in the amount of CO2e in the grid and using of renewable onsite sources are assumed to provide up to a 30% reduction in emissions below the BAU scenario. In reality, this varies from state to state depending on the CO2e content in the eGRID region. The Merced validation case study demonstrates steep supply-side reductions compared to the national average. Cities with low CO2e in the grid and located in a climate with fewer heating degree-days have a distinct advantage.

CAPs combine land use, demand-side, and supply-side goals and strategies. The scenarios that apply the full suite of strategies reduced emissions by up to 73% below the BAU scenario and over 40% below the baseline. For the average U.S. city, this appears to be a promising result.

Conclusion

Many CAP city long-term targets are to be 80% below 1990 GHG emissions levels by 2050. However, the mitigated scenarios included informed assumptions about how much demand-side and supply-side reductions could be expected by mid century. Meeting 80% below 1990 targets will require added innovation and intergovernmental cooperation.

The enhanced passive-performance of cities with walk-first neighbourhoods that reduce VMT, energy use, water, and waste by design is an important down payment for a low-carbon future. The cities with growth polices focused on compact, centred and connected development patterns, energy-efficient construction and retrofit of existing buildings, seem to be on the right track. Complemented with federal CAFÉ standards, these actions make:

- The centred city scenario 64% below the baseline;
- A 10,000-person neighbourhood in Merced 38% below the citywide 2008 per capita baseline and 48% below a 10,000-person BAU low-density suburban neighbourhood; and
- A 60-unit mixed-use downtown infill project in Merced 65% below the lifespan CO2e emissions of a new 60-unit suburban subdivision and commercial pad.

Validity of Scenarios as Research Tools

The scenarios were developed as simplified land use mathematical models with popular smart growth features. The clarity of the scenarios allowed the study to control variables and explore the effectiveness of strategies and their dynamic relationships.

The comparison of unmitigated BAU, centred city, and corridor city scenarios demonstrates how traditional smart growth land use strategies contribute to reducing lifespan GHG and annual emissions. By introducing similar mitigations strategies and goals, the scenarios illustrated how important demand-side and supply-side actions are regardless of city form and how city form also amplifies their effectiveness.

6.8 VALUE OF STUDY

The development of a worksheet that can support bottom-up and top-down mitigation strategies is a significant contribution from Study 3. The new tool is sensitive strategy evaluation worksheet that can test and compare embodied, energy, and transportation emissions for various land use patterns and transportation scenarios.

The study includes simplified scenarios allowing the examination and comparison of land use, demand-side, and supply-side strategies used by U.S. cities to reduce GHG emissions. The study provides a clear distinction between strategies and a method that can describe their effectiveness.

The mathematical modelling of popular smart growth strategies identified in Study 2's survey of CAP cities makes further contributions to our understanding about their effectiveness for an average U.S. city that doubles its population by 2050. The study makes three important contributions. First, we now know that smart growth strategies can contribute to about 13% of reductions compared to BAU while facilitating other strategies. Secondly, demand-side strategies can result in the greatest reductions in

GHG emissions, greater than land use and supply-side strategies combined. Thirdly, almost a fifth of GHG reductions can come from supply-side mitigation strategies. Combined strategies reduced the 2050 future 40% below the study's baseline and about 73% below the BAU.

Chapter 7

SUMMARY AND CONTRIBUTIONS

7.1 OVERVIEW OF REMAINING CHAPTER

Chapters four, five, and six present methods and results from three research studies, which represent the core research completed for this thesis. Chapter 7 discusses how the studies' findings relate to existing knowledge and contributions. Chapter 8 draws theoretical and practice conclusions, and suggests topics for further research.

7.2 SUMMARY OF STUDY FINDINGS

The findings summary is organized by research aims, description of the relationship between the studies, and a summary of findings organized by research question.

7.2.1 Summary of Thesis Aims

To better understand how climate action planning is changing the form of cities, the thesis examines the motivation for communities to prepare climate action plans, exemplar processes and tools used, and common GHG mitigation and adaptation strategies employed by cities and how those strategies are integrated into planning and policy systems.

The research addresses three aims:

AIM 1: Assess Motivation and Process of Local Government

AIM 2: Identify the types of CAP tools and processes used by cities

AIM 3: Assess how CAPs shape city form

7.2.2 Overview of the Relationship Between Studies

The thesis employed three studies sequenced to inform the central focus of the research–how CAPs are changing the form of cities. Study 1 provided case studies that are the footings for the second and third studies. The case study summary included hypotheses used to design Study 2's national survey of cities that have completed CAPs. The survey results identified popular GHG mitigation strategies used by cites that have completed CAPs. Study 3 modelled the effectiveness of popular CAP strategies. The modelling corroborated results from case studies and survey responses.

Collectively, the three studies fulfil the aims of the thesis by advancing our understanding of what is motivating cities to prepare CAPs, the types of tools they are using, the strategies employed, and how those strategies are becoming policies that are reshaping U.S. cities. In addition, Study 3 tells us the effectiveness of popular strategies and stimulated the development of an innovative emissions calculator.

Because the thesis aims and questions are broader than studies discovered in the literature review process, the thesis bridges those contributions providing the most comprehensive overview of state-of-the-art CAP preparation and implementation to date.

7.3 RESEARCH FINDINGS, CONTRIBUTIONS, AND RELATIONSHIP TO EXISTING LITERATURE

The primary findings from the three studies support and strengthen our existing knowledge regarding how CAPs are changing the form of U.S. cities. The literature research did not discover national surveys or comprehensive analysis of the state-of-the-art in city CAPs. Much of the discovered research included comparative case studies of varying depth, involved a small(er) sample of cities, and addressed a narrow set of questions. The literature contains guidance. There are fewer studies expanding our understanding of what cities are actually doing in their CAPs and how actions and policies respond to their fundamental (circumstances).

The literature review discovers regional surveys of CAP cities. No national longitudinal study of CAP cities has examined the relationship between fundamental attributes of cities (political context, regional differences in climate, adaptation needs and eGRID, and community values), the actions they take, and the policies they adopt.

This section is organized by research aim and research questions. Subsections include the thesis's contribution, related literature (what we knew), and findings (what we know now) from the studies.

7.3.1 Motivation and Process of Local Government Related to Literature

This subsection summarizes how the findings about motivation and CAP processes relate to existing knowledge.

Q1-Motivation: Why are cities preparing CAPs?

Contribution: We now understand the motivation for CAP preparation is primarily coming from local elected officials, secondarily from local advocates, and thirdly as an extension of a local sustainability tradition.

Related Literature

Krause compared 960 cities whose mayors were signatories of the Mayors Climate Protection Agreement (MCPA) to 14 local and state independent variables in order to understand potential influence of: state-level policies on local adoption of related climate change policies; and cities' motivations, strengths, barriers, and resources (Krause, 2010). The results indicated a strong correlation between MCPA membership and local characteristics. The study suggests MCPA membership seems to be motivated locally. The study only identifies MCPA membership and does not consider which cities prepared climate action plans.

In 2011 Krause conducted a survey of 425 U.S cities with populations over 50,000 to explore connections between climate actions and co-benefits (Krause, 2012). The survey had 255 responses. The three highest "single most important" co-benefits for pursuing a climate program include:

- *Achieving energy and cost savings for the city Government (31.3%)*
- *The preferences and priorities of particular city official(s) (19.7%)*
- *State government requirements or legislation (14.2%)* (Krause, 2012, p. 12)

As with the earlier survey, Krause's survey population did not focus on cities that have completed a CAP. The 2011 survey only included cities with populations over 50,000.

Adam Millard-Ball (2011) of McGill University studied California cities that have completed CAPs. He finds little evidence that climate action plans "play any causal role" in reducing GHG emissions. He claims, "citizens' environmental preferences appear to be a more important driver of both the adoption of climate plans and the pursuit of specific emission reduction measures. Thus, climate plans are largely codifying outcomes that would have been achieved in any case" (p. 289).

Findings from Studies

Study 2 is the first national survey of cities that have prepared a CAP. It asks CAP cities about what motivated them to take climate actions. Study 2's survey of this thesis had 143 responses (within the ± 5% margin of error). Of those, 90% had completed or were in the process of completing a CAP and/or MCAP. There were 143 survey responses to the question about city motivation for preparing a CAP (Table 7.1). The leading three responses included local political leadership, local citizen advocates, and policy extension of local sustainability tradition. Under the *other* category, there were 28 written in responses. None of those included cost saving or a financial motivation.

Table 7.1

Study 2 Survey Results: Motivation for Preparing CAP

Q1.8 MOTIVATION: What motivated your city to prepare a CAP? (select all that apply)

1 Local citizen advocates	66	46%
2 Local political leadership	90	63%
3 Policy extension of local sustainability tradition	51	36%
4 Mission of external CAP funder (such as a foundation or state agency)	14	10%
5 Required by State	13	9%
6 Other	31	22%

Q2-Policy Context: How are cities responding to state and federal policy context regarding preparing CAPs?

Contribution: We now know that state and federal policies do influence city climate actions but are not considered the primary motivation for preparing CAPs. Most cities acknowledge state and federal influence. Fewer than 3 in 10 CAP cities feel their state does NOT have some type of influence on local climate change mitigation or adaptation policies. Yet, despite this, 63% credit local elected leadership as the PRIMARY driver for preparing a CAP, even in California where state polices require climate action by cities.

Related Literature

As of October 2011, all but 12 states (in the Mountain West, South and Midwest) have prepared, or are in the process of preparing climate action plans (Center for Climate and Energy Solutions, 2011). These state CAPs range from Lead by Example (LBE) efforts where states are trying to influence local government by setting a good example, such as Florida, or states that have legal and regulatory requirements for local governments, such as California.

Fifteen states have completed climate adaptation plans, four are in progress, and seven others (including the District of Columbia) have one recommended in their climate action plans (Center for Climate and Energy Solutions, 2013). Some states are requiring cities to plan for adaptation and supporting those efforts with priority funding for implementation of projects that improve their resilience.

State CAPs include several common strategies for mitigating GHG emissions, including generating and distributing renewable energy; adopting more stringent building codes; increased investment in transportation infrastructure; and facilitating or requiring local governments to prepare CAPs. A 2010 study by William Drummond found that states requiring higher energy standards for commercial construction (indicated by LEED certification requirements) and higher efficiency standards for transportation produced slightly lower per capita GHG emissions. More importantly, Drummond (2010) found that states categorized as "sprawl states" had nonindustrial energy GHG emissions 1.273 metric tons per capita more than "rural states" and over 3 metric tons per capita more than "compact urban states" (p. 426). The results suggest that state policies supporting compact development patterns would reduce GHG gas emissions.

California, Washington, and Massachusetts treat GHG emissions as an environmental impact and require measurement and mitigation planning for GHG emissions. Comprehensive planning requiring environmental review includes feedback loops for evaluation and inclusion of mitigation alternatives.

Similarly, the National Environmental Protection Act (NEPA) review requires exploration of alternatives for projects that are administered by federal agencies. This includes transportation projects with federal funding, such as roads and transit.

The 2010 NEPA guidelines from the Obama administration advises Federal agencies to scope NEPA review to examine the direct and indirect GHG emissions from their actions (Sutley, 2010). The guidelines also stipulate the methods of evaluation and how they should measure cumulative effects in an Environmental Impact Study (EIS).

Findings from Studies

Most CAP cities surveyed are located in states that are actively pursuing climate change policies. Only 27% of the cities in the survey are located in states respondents felt were NOT influencing their climate change mitigation or adaptation policies. Over a third the cities are located in states that: lead by example with their own CAP (38%), have renewable portfolio standards (55%), use incentives (45%), have state energy efficiency regulations (53%), and air quality regulations (56%). Many of the cities surveyed are in states that regulate GHG emissions (33%) and have climate adaptation policies or regulations (22%).

However, state or federal policies were not identified as the primary driver in the CAP process. One third (33%) of the survey cities in Study 2 are located in the CAMX eGRID. In California, state legislation has required cities to plan for lower GHG emissions, yet a relatively small percentage of survey cities cite state requirements as primary motivators for preparing a CAP. Only 33% of the cities in the CAMX eGRID cite the state's requirements as motivation. Even in California, 63% of the of the survey cities credit local leadership for preparing their CAP.

Q3-Process: How are cities approaching preparation of CAPs?

Contribution: We now know that cities are using customized community outreach processes that reflect political and GHG emissions context. In addition, Study 2 survey results tell us that six in ten CAP survey cities have prepared both a MCAP and CCAP, 46% of cities have participated in regional CAP effort, and 30% collaborated in preparing their GHG inventory.

Related Literature

The CAP process for a city requires preparing GHG inventories, identifying benchmarks against their historical emissions, and identifying actions and timelines to achieve emission reduction targets (ICLEI, 2008). The scope and process of a CAP is developed out in front of the effort to manage resources, expand community outreach, and meet legal or policy requirements. In some cases, cities want to, or are required to report their emissions to a third party such as the Climate Registry.

Cities use the Local Government Operations Protocol to calculate emissions from municipal operations (MCAPs). The Local Government Operations Protocol was coordinated by ICLIE for the California Air Resources Board and has become the national standard endorsed by the U.S. EPA (ICLIE, 2012). In California, the protocols for GHG emission inventory for local government operations was prepared by the California Resources Board in cooperation with the California Climate Action Registry and ICLIE.

Cities that do not use ICLEI's software tools, or only use them for developing their GHG emissions inventory, may combine or add steps to reflect their local policy-making and action-planning context. Interviews with CAP managers from Berkeley, CA, Chicago, IL, Boulder, CO, and Austin, TX revealed cities that designed their CAP processes to suit local political and strategic planning conditions.

Findings from Studies

In Study 1 case study CAP managers discussed how their cities are developing community outreach and process variations reflecting their local political and GHG emissions context.

Most of the cities in the survey have prepared both a Community CAP and Municipal CAP (59%). Of the respondents, 4% have only completed a CCAP and 16% a MCAP. Some of the cities have draft CAPs (11%) that are in the approval process, and (10%) have not completed or prepared CAPs.

Case study cities in Study 1 are divided into three categories in terms of how they integrate their CAP plans into their comprehensive plans. Categories include cities that

- Fully integrate their CAPs into their comprehensive plans;
- Use their CAPs as a strategic planning effort; or
- Have not integrated their CAPs.

The survey responses reflect the various planning systems and degrees of CAP integration categories identified in Study 1 case studies. Nearly nine in 10 (87%) survey cities have comprehensive plans, 40% have sections required by state law, 36% use a strategic planning method, and 39% participate in some sort of regional planning. Sixty-two of 116 survey cities (53%) did not participate in a regional effort in preparing their CAP. The rest of the cities collaborated in GHG inventory preparation (30%), have common mitigation or adaptation strategies (12%), and shared responsibility and actions (11%).

7.3.2 Types of CAP Tools and Processes Related to Literature

This subsection summarizes how the findings about CAP tools and processes relate to existing knowledge.

Q4-CAP Tools: Why do communities choose certain tools to inform the CAP process?

Contribution: We now know the types of tools being used by cities in various steps in the CAP process. Most cities use ICLEI or other software provided by non-profit organizations/agencies for preparing GHG inventories (61%), customized tools or spread sheets for testing mitigation strategies (56%) and monitoring CAP progress (54%).

Related Literature

A study regarding the percentage of the types of tools cities use in each step of the CAP process is not found in the literature. However, an increasing number of tools and resources are available embodying protocols developed by international, federal, state and non-profit agencies and organizations. Cities in a few states recognize GHG emissions as an environmental impact, which must meet requirements and protocols.

California, in particular, has made GHG emissions inventory and mitigation necessary in the EIR process for large-scale projects and city planning. The CARB and air pollution control districts have provided tools and protocols to help track the impacts of projects. State air pollution control districts developed the California Emissions Estimator Model (CalEEMod) to meet CARB requirements (CAPCOA, 2013).

ICLEI offers a popular tool for GHG inventory, strategy evaluation, and monitoring. ICLEI's recommended process has five-milestones and is supported by their CAPC software. Many ICLEI membership cities have used this software, and others have developed their own custom spreadsheets. The future of CAP tools seems to also include commercially developed and marketed software that has additional implementation, monitoring, and communication capabilities.

Findings from Studies

The surveys showed 61% of cities use packaged software from a non-profit, such as ICLEI's CAPPA software, for developing their GHG emissions inventory. In addition, 13 cities specifically identify software from ICLEI in the "other" category for inventorying emissions. For testing mitigation strategies, 56% of surveyed cities use custom spreadsheets, 41% of cities use packaged software from a non-profit, and six cities specifically referred to ICLEI tools for this step in the "other" category for testing mitigation strategies. Further, 54% of survey cities use custom spreadsheets developed by staff or consultants for managing and monitoring progress, and 41% use packaged software from a non-profit. Four cities also mentioned they are using ICLEI software.

7.3.3 How CAPs are Influencing the Future Form of Cities Related to Literature

This subsection summarizes about how CAP are reshaping U.S. cities relate to existing knowledge.

Q5-CAP Strategies: How are CAP strategies integrated into urban planning policies?

Contributions: We now know that CAP cities have a tradition of comprehensive planning and are integrating their CAPs into their comprehensive plans. Findings show 87% of CAP cities have comprehensive plans, 36% cities have already fully integrated their CAP throughout their comprehensive plan's goals and policies, and 39% have not yet but intend to integrate their CAP strategies into their comprehensive plans. Only 7% of CAP cities have no plans of adding CAP strategies to their comprehensive plan.

Relationship to Literature

To various degrees, cities are moving their climate actions and strategies into their comprehensive plans, where they are implemented through policy and capital improvements planning. In California, New Jersey, and Florida, cites are required to prepare comprehensive plans. In California cities are also required to make their capital improvement plans (CIPs) consistent with their general (comprehensive) plan (Godeschalk & Anderson, 2012, p. 52).

Cities employ a variety of methods for tracking the success of the sustainability policies in their comprehensive plan. These include identifying indicators, benchmarks, and targets, as in the Marin County, California General Plan. Other methods include developing baseline data to measure progress against, defining indicators, creating data books of inventories, using report cards, and establishing procedures for policy tracking (Godeschalk & Anderson, 2012, pp. 60-61).

Findings from Studies

Study 2 identifies the intent and status of cities' efforts in migrating and integrating CAP strategies and actions into comprehensive plans. To date, 39% of CAP cities have not yet, but plan to include strategies in their comprehensive plan. Cities that have already moved their CAP actions into their plan are integrating them in several ways: 36% have expressed their strategies throughout the plan's goals and policies; 23% have added new sections or elements emphasizing environmental and climate change policies; 18% have added or modified a few new goals and policies; and 11% has added implementation policies. Only 7% have no plans of adding CAP strategies to their comprehensive plan.

<u>*Q6-Influencing Patterns:* How are CAP strategies changing the form of cities?</u>

Contributions: We now understand what actions and strategies identified in CAPs can influence the future form of cities. In addition, we know what climate actions reinforce existing policies and which have influenced development of new policies. CAP cities are employing a comprehensive combination of traditional smart growth land use, demand-side, and supply-side strategies.

Relationship to Literature

The 40-city 2010 study *Moving Agenda to Action* was the most comprehensive discovered in the review of literature. The research addressed six questions including: "What actions have local jurisdictions taken to mitigate and adapt to climate change, and which strategies received the greatest and least attention?"

The study yielded "indicators of performance" data, including the percentage of cities that adopted land use and transportation policies: 65% of the cities have adopted mixed-use land use policies, 60% have green building and infrastructure policies, 37.5% have policies regarding infill and brownfield sites, and 35% have polices about growth controls. The study also identified transportation-related policies adopted by CAP cities: 80% of cities increased alternative transportation, 77.5% of the cities included TODs and transit corridor policies, 72.5% implemented ped-bike policies, and 65% committed to adjusting existing parking standards (Tang Z. , Brody, Quinn, Chang, & Wei, 2010, pp. 52-53).

Findings from Studies

The studies tell us new information about how cities are following through on implementation of strategies. This includes common land use, demand-side, and supply-side strategies.

Land Use Strategies and Policies: Cities are employing traditional smart growth strategies including the "three Cs": centred, compact, and connected development.

Centred development: The survey showed 63% cities' CAP strategies support existing policies regarding centring development around their downtown, and 39% said their CAP resulted in new policies about downtown-oriented development.

Compact development: Among responding CAP cities, 41% have strategies supporting existing policies for higher density residential development, and 32% have added policies allowing higher-density residential development.

Connected development: CAP strategies are influencing cities' transit-land use policies: 48% are improving transportation services; 37% are increasing the number or density of TODs; 46% support or require increased density or infill development near transit; 38% allow or require higher-density commercial development near transit; and 49% allow or require reduced parking standards near transit. Further, 84% of CAP cities have strategies about walking and biking, and 65% have bike and pedestrian infrastructure policies influenced by their CAP.

Common demand-side strategies: The leading demand-side strategies used by the CAP cities include reducing VMT and improving building energy efficiency: 70% have strategies that reduce energy use in buildings, 48% have adopted higher energy efficiency standards, and 66% have strategies for reducing VMT.

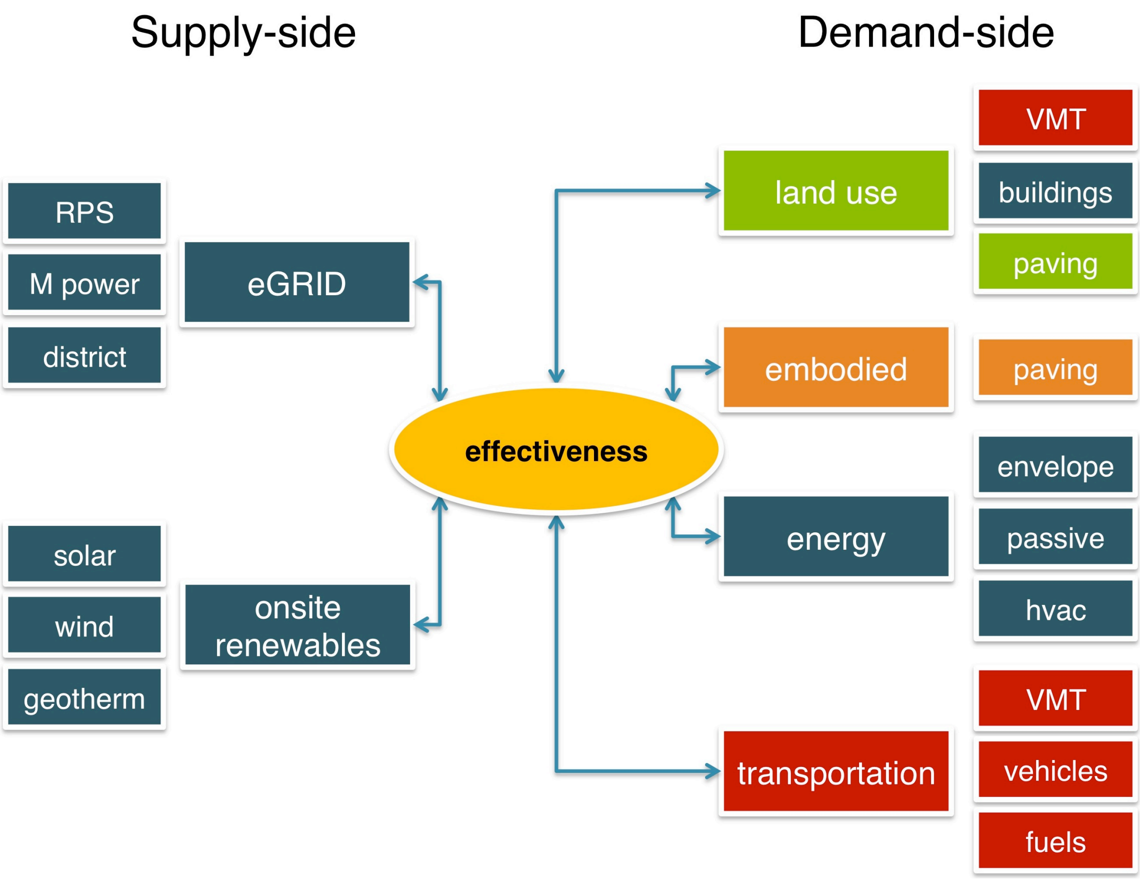
Common supply-side strategies: Over half of responding CAP cities offer some kind of incentives or other measures that encourages local efforts to increase the use of renewable energy. More specifically, 44% of cities have incentives for solar and 14% for wind energy.

7.3.4 Effectiveness of CAP Strategies

The effectiveness of common CAP strategies identified in Study 2 is compared using a mathematical model. Business-as-usual, compact-centred, and transit-corridor city land use scenarios are compared to an average U.S. 2015 baseline city of 50,000. The baseline scenario is constructed from U.S. Census and Bureau of Labour Statistics data. Each land use scenario is modelled at a 2050 population of 100,000 to test and describe the added effectiveness of demand-side strategies (reduction of embodied energy in buildings, improve energy-efficient buildings, and reduction in VMT) and supply-side strategies (reduction of CO2e in the grid and expand use of onsite renewables) (Figure 7.1).

Figure 7.1

Measuring Effectiveness



<u>*Q6A-Land Use Strategies:* How effective are increasing community density, compactness, and centeredness in reducing GHG emissions?</u>

Contributions: We now know that land use GHG emissions mitigation strategies can contribute up to 13% reductions in an average U.S. city that doubles its population by 2050.

Relationship to Literature

Two studies prepared by the Urban Land Institute (ULI) explored how compact and transit-oriented development could reduce GHG emissions. The first study, *Growing Cooler,* concluded that VMT could be reduced by 20-40% and GHG emissions by 7-10% by 2050 (Ewing, Bartholomew, Winkelman, Walters, & Chen, Growing Cooler: Evidence on Urban Development and Climate Change, 2007, pp. 4, 9). The follow-up study, *Moving Cooler*, concluded that investing in transit and pedestrian facilities could reduce GHG emissions by 4-18% and even up to 24% under a “maximum deployment” scenario by 2050 (Cambridge Systems, Inc., 2009, p. 5).

The Transportation Research Board (TRB) estimated that smart growth could reduce GHG emissions between 1% and 11% by 2050, depending on the scenario. Their review of literature suggests doubling residential densities could reduce household VMT by 5-12%, and up to 25% with other qualitative improvements such as good mix of uses, accessibility, and a well-designed environment (Transportation Research Board, 2009, pp. 4, 153).

Findings from Studies

Study 3 includes four modelling runs of the baseline, BAU, centred city, and corridor city scenarios to describe how demand-side strategies are especially important to meeting targets and smart growth strategies as an important down payment for meeting CAP targets. They form the foundation for a CAP strategy where cites have the most control. The scenario modelling suggests that smart growth planning can provide up to 13% reduction in emissions due to reduced VMT, less paving and infrastructure, plus more energy-efficient building types.

The unmitigated centred city scenario produces 13% less GHG than the BAU (Table 7.2). Another 23% reduction in GHG is accomplished by implementing the 2025 CAFÉ standards (54.4 mpg by 2025). The total 36% reduction is at the high end of the combined ULI study results that also consider exurban areas. The cumulative low end of the two ULI reports for smart growth and transit investments is 11% and the high end is a 28-42% reduction.

Study 3 tests compression by modelling cities with fixed, determined, and flexible boundaries. The more compression, the higher modelled performance. By constraining or fixing growth boundaries, the centred city scenario has the highest density, most infill, and lowest GHG emissions. The corridor city model assumes a determined boundary that confines development expansion along a higher-density corridor. The lower-performing BAU scenario has a flexible boundary, allowing low densities outside the existing baseline boundary.

Table 7.2

Growth Management Scenarios Compared to BAU and ULI and TRB Studies

	Unmitigated	With 2025 CAFÉ Standards	Total
Centred City Scenario	13%	23%	36%
Corridor City Scenario	12%	21%	33%
ULI Growing Cooler	7-10% reduction in GHG emissions by 2050		11%-28% (42% under “maximum deployment”)
ULI Moving Cooler	4-18% reduction in GHG emissions by 2050 and up to 24% under “maximum deployment”		
Transportation Research Board: Special Report 298	5-12% reduction in VMT GHG emissions by 2050 and up to 25% VMT reduction with other improvements		1-11% total GHG reductions by 2050

Q6B-Demand-side Strategies: How effective are demand-side strategies, such as increasing energy efficiency of buildings and improving mobility services, in reducing GHG emissions?

Contributions: We now know that demand-side strategies can result in GHG emission reductions greater than land use and supply-side strategies combined. The average U.S. city in Study 3 that doubles its population by 2050 can reduce GHG emissions up to 55% by implementing demand-side energy-efficiency strategies for buildings and vehicles.

Relationship to Literature

Electrical generation and transportation are the two largest GHG emission sectors in the United States. Demand-side reduction strategies that focus on these sectors can have a significant reduction in GHG emissions. Trends and policies regarding increased energy efficiency for cars and buildings suggest that states and cities can realize large reductions in CO2e if they continue to follow through on their implementation.

The 2010 U.S. EPA national inventory of GHG sectors indicates that industry, transportation, commercial, and residential sectors combines for 58% of emissions (U.S. EPA, 2012). Electricity accounts for 34%, 70% of which is used by buildings (Architecture 2030, 2011). In 2011, 28% of GHG emissions came from the transportation sector and 33% from electric power generation (U.S. EPA, 2013).

The Architecture 2030 Challenge calls for net zero carbon new construction and 50% reduction in CO2e from existing buildings by 2030. These 2030 reduction targets have been adopted by federal agencies, states, cities and counties.

The American Institute of Architects has adopted "The AIA 2030 Commitment," where members reduce energy of their firms' operations and prepare a firm action plans that reduces their projects' GHG emissions to zero by 2030. Participating firms prepare annual progress reports (American Institute of Achitects, 2013).

International building codes show a supporting effort for 2030 carbon neutrality. Over 30 states have adopted the 2009 or 2012 International Energy Conservation Code (IECC) has been adopted been adopted by over 30 states (Department of Energy, 2013). The IECC has been reducing energy use by 30% every six years, with the goal of reaching net zero by 2030.

In 2007, Congress passed the Energy Independence and Security Act (EISA), which mandates increasing CAFE standards for cars and small trucks from 34.1 MPG in 2010 to 54.5 in 2025 to meet a 40% reduction goal in CO2e (Center for Climate and Energy Solutions, 2013). This will have a significant benefit and lead to reductions well beyond 40% by 2050.

Findings from Studies

The bulk of demand-side reductions in CO2e come from increasing energy efficiency of buildings and implementing CAFE standards for cars and trucks. Modelled demand-side strategies suggest these can reduce lifespan CO2e by up to 55% in the BAU scenario. The demand-side strategies bring the Centred City scenario 64% below the BAU. These strategies depend on state and federal actions and regulations. The scenarios demonstrate the need for cities' efforts to be complemented by state and federal governments.

Q6C-Supply-side Strategies: How effective are common demand-side strategies in combination with supply-side strategies?

Contributions: We now know that supply-side GHG emissions mitigation strategies can contribute up to 19% of reductions in the Study 3 BAU scenario for an average U.S. city that doubles its population by 2050. The centred city land use scenario that combines supply and demand-side strategies can reduce GHG emissions up to 73% in GHG reductions below the BAU scenario and 40% below baseline scenario.

Relationship to Literature

Strategies for reducing CO2e on the supply-side include reducing CO2e in the grid and adding local/onsite renewables such as distributed solar. Trends indicate that states and consumers are pursuing energy solutions that will lower CO2e.

Most states have committed to a Renewable Portfolio Standard (RPS) that sets targets for reduction of CO2e in their power supply. All but 13 states have RPS goals or standards. A summary of state RPS programs indicates targets range from 12.5% by 2025 for Ohio to 33% by 2020 by California (North Carolina Solar Center, 2013).

Green Tech Media research indicates, "more than two-thirds of America's distributed PV (everything except for utility-scale projects) has been installed since January 2011. And by 2015, the country's distributed PV market is expected to jump by more than 200 percent" (Lacey, 2013).

Findings from Studies

CAPs integrate a combination of land use, demand-side, and supply-side goals and strategies. The centred city scenario with the full suite of strategies reduced emissions by 73% below the BAU scenario and over 40% below the baseline scenario. GHG emissions reductions for the BAU employing supply-side strategies reduced emissions by 19%.

7.3.5 Modelling Tool as Contribution

Study 3 tested existing software tools used by cities to complete inventories, test strategies, and monitor progress. The need to find or develop a calculator that could be used to evaluate urban form and land use and other mitigation strategies lead to significant modification and calibration of a new policy research tool.

Contribution: Study 3 provides a worksheet that can support bottom-up and top-down mitigation strategies is a significant contribution from Study 3. The new tool is sensitive strategy evaluation worksheet that can test and compare embodied, energy, and transportation emissions for various land use patterns and transportation scenarios.

Relationship to Literature

Four types of software were reviewed and tested for use in Study 3. These included ICLEI's CACPA software and 2009 Clean Air and Climate Protection (CACP) software; the California Emissions Estimator Model (CalEEMod) developed by ENVIRON International Corporation in collaboration with California Air Districts

(2011); and Version 1.7 (2011) King County Department of Development and Environmental Services SEPA GHG Emissions Worksheet. All of the tools are based on spread sheets and do not require spatial data inputs.

Findings from Study

The mathematical model tool was an effective way to evaluate popular smart growth strategies. Development of the worksheet tool can be calibrated to test land use strategies effectiveness in achieving GHG reductions while facilitating other strategies. The modelling also indicated how demand-side strategies result in the greatest reductions in GHG emissions, greater than land use and supply-side strategies combined.

7.4 CONTRIBUTION SUMMARY

The central hypothesis of this dissertation asserts ***if U.S. cities prepare a climate action plans and translate climate actions into land use policies, then there will be a measurable change in their urban form***. The case studies and survey demonstrate CAP cities are employing form-changing land use and transportation GHG emission mitigation strategies and incorporating them into their comprehensive plans. The modelling of popular strategies in Study 3 tells us that these strategies are also effective. The thesis research findings have significant theoretical and practical implications regarding CAPs influence on the future form of U.S. cities.

Chapter 8

CONCLUSIONS: THEORETICAL AND PRACTICAL IMPLICATIONS

Chapter 8 discusses theoretical implications for CAPs that arising from the research process. Areas of discussion are organized by research aim:

8.1 Motivation vs. Control: Study 1 case study interviews and Study 2 survey of cities underscore the importance of local leadership as the primary motivation for preparing a CAP. Study 3 illustrates how important federal and state regulations and polices are in supporting cities meeting their targets.

8.2 Implications of Universal Protocols and Tools: Study 1 interviews and Study 2 survey results indicate that cities are increasingly customizing tools and processes to meet their needs. There is an international effort underway to provide protocols and tools for cities.

8.3 CAP Influence on the Future Form of Cities: Review of CAPs and their policy contexts in Study 1 and identification of common strategies used by cities in Study 2 survey indicate cities are using similar smart growth tools to reduce GHG emissions. The unique economic, political, and ecological context of each city is resulting in a wide variety of urban design outcomes.

Chapter 8 concludes with three suggested areas for future research.

8.1 MOTIVATION vs. CONTROL

Conclusion: Cities credit their political leadership for their motivation to prepare a CAP. Yet, their success is largely dependent on the actions of state and federal actions. This affects how cities define emission reduction targets, assign funding responsibilities, and determine regulatory controls.

Section 8.1 discusses the theoretical and practical implications of federal and state actions on CAPs prepared by cities. Theoretical discussion includes thesis research indicating the necessity of state and federal actions. Discussion of practical implications includes examples and best practice recommendations.

8.1.1 Theoretical Discussion of Federal and State Actions

Research included in this thesis demonstrates the importance and necessity of state and federal actions for cities to successfully meet GHG emission targets. The results of Study 2 indicate the important role city elected leadership plays in pursuing climate-friendly city policies. Study 3 illustrates that without national and state-level actions cities may not meet targets.

Study 3 Indicates the Need for Federal and State Standards and Funding

Study 3 modelling demonstrates the importance of demand-side GHG reduction strategies in meeting targets. Demand-side reductions in the model cities are greater than land use and supply-side strategies combined.

The model scenarios have a reduction target of 40% below the baseline. Of the total GHG reductions, only about 40% are assumed to be due to local policies. The rest of GHG reductions are fully or partially influenced by federal and state policies and regulations. Internationally, cites create 70% of GHG emissions. If U.S. cities are responsible for 70% of GHG emissions and control 40% of emissions, they could potentially only accomplish 28% of their reduction goals without federal and state action.

Figure 8.1 indicates the centred city scenario actions percentage contribution to meeting the GHG reduction target of 40% below a 2015 baseline.

Figure 8.2 is a conceptual break down of responsibility or influence of local and state or federal responsibilities. It assumes land use actions are local while state and federal actions influence building and energy codes, transit service and transportation infrastructure, fuel efficiency standards for vehicles, and green power generation.

Importance of CAFÉ Standards

Over half the reductions in GHG in the Study 3 centred city scenario come from increased fuel efficiency for vehicles. This is because federal CAFÉ fuel efficiency standards will require cars and small trucks to have an average fuel efficiency of 54.5MPG by 2025. The modelling assumes an average of 80MPG by 2050, facilitated by improved technology and diversification of fuel sources. This represents a 400% increase in vehicle fuel efficiency. Lowering the CO2e from transportation meets 29% of the total 2050 GHG reduction goal for the centred city scenario (Table 6.15 and Figure 8.1).

Figure 8.1

Centred City Scenario: Percentage Strategy Contribution Towards 2050 Target of 40% Below 2015 Baseline

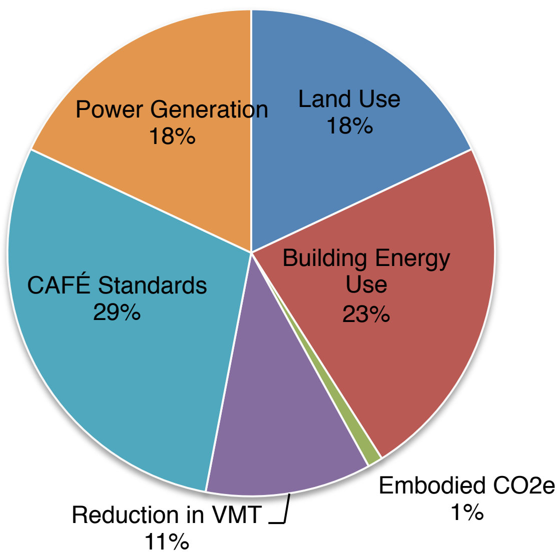
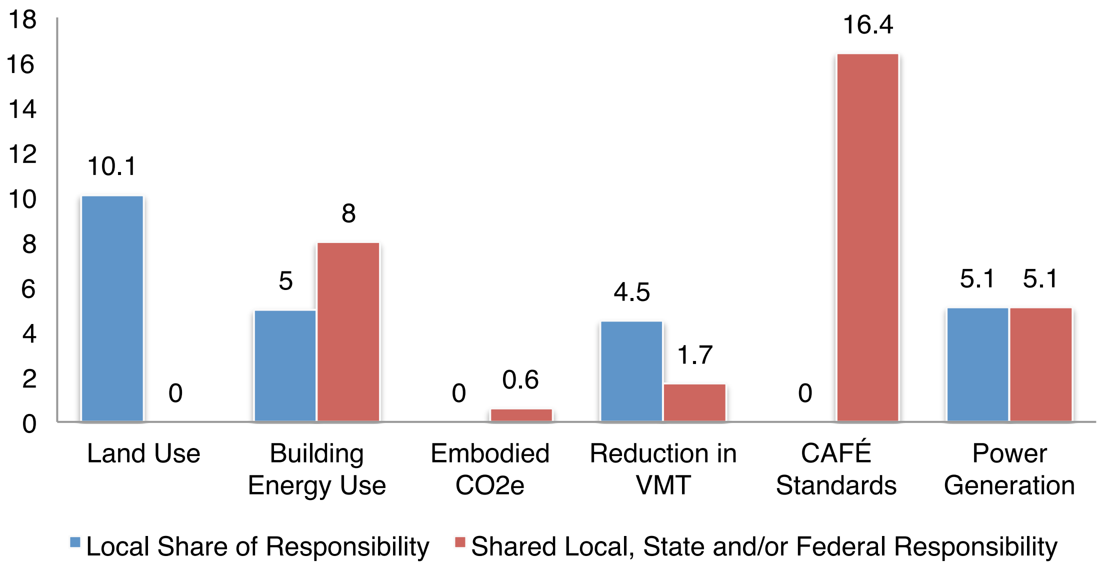


Figure 8.2

Assigning Local and State or Federal Responsibility to Meeting Target for Centred City Scenario Reductions in tgCO2e



Importance of Building and Energy Codes

States' building and energy efficiency codes set a minimum standard. States adopting the International Energy Conservation Code (IECC) are using a code system that is pursuing net zero energy policies for buildings by 2030. States updating the IECC will help cities meet energy goals for buildings.

Federal and state tax incentives for weatherization and retrofit programs improve the performance of the existing building stock. Incentives can include renewable energy tax credits, energy efficiency tax credits, and rebates for energy efficient windows and equipment.

The modelling in Study 3 assumes buildings will use 50% less energy and represents 23% of the 2050 CO2e reduction target total for the centred city scenario (Figure 8.1).

Federal and State Transportation Funding Support for Smart Growth

Federal and state funding are used to support local policies for smart growth land use and transportation patterns. In the U.S. only about 36% of transportation funding is from local government. The balance of funding is from state (43%) and federal (21%) sources (American Association of State Highway and Transportation Officials, 2014).

Greening of the Grid

Greening the grid will require local, state, and federal action. States can use their influence to meet and exceed their RPS goals. Federal regulations for power generation can reduce CO2e in the eGRID. Cities can implement local projects either as feed-in tariffs or more assertive actions. For example, Boulder, Colorado created a local energy/CO2e tax to fund green power and Austin, Texas has been greening its own municipal power company.

Study 3 modelling assumes a 40% greener grid and Figure 8.2 assumes cities will be responsible for meeting half the power generation reduction goal.

8.1.2 Best Practice Recommendations for Integration of Federal and State Actions into CAPs

Best practice recommendations for responding to state and federal climate actions include examples of cities that have implemented similar policies. CAP cities should identify federal, state, and regional actions that reduce Scope 1, 2, and 3 GHG emissions, plus supply-side strategies reflecting control of how much CO2e is in the grid serving the city.

CAPs reflect state and federal contributions

The technical definition of a BAU is a future that does not reflect policy or technical intervention. Yet, cities are preparing CAPs in a shifting state and federal policy and regulatory environment. CAPs should incorporate benefits of future policy and technical intervention from states and federal actions in their BAUs and clearly distinguish between local and others' actions in their planning.

In California, cities are operating within a set of state legislative targets and standards to reduce GHG to 80% below 1990 levels by 2050. The most recent generation of California city CAPs acknowledge the role of state and federal regulations in reducing GHG emissions. For example, the CAP for Sunnyvale, California reduces the BAU for 2035 by more than 23% due to CAFÉ standards, California's RPS, CalGreen and Title 24 energy standards for buildings, and other regional transportation actions (PMC, 2011, pp. 3.34-3.36). This adjusted BAU reflects the influence of state and federal regulations. The Sunnyvale CAP focuses on actions that are mostly under their local control to meet their 2020 target (15% below 2008 baseline).

Sunnyvale's CAP strategies rely heavily on local supply-side actions of on-site power generation and purchasing off-site green power. Their supply-side strategies are very aggressive, representing 54% of their total 2020 and 2035 reduction goals. Cities like Sunnyvale with aggressive supply-side solutions should acknowledge supporting policies and programs at the federal and state levels, even in California where there is a policy commitment to RPS.

Establish realistic supply-side strategies

CAPs should model and validate supply-side strategies and make contingencies. This includes anticipating the actions of others, including electric power companies and state's performance on meeting RPS goals.

Boulder, Colorado's CAP emphasizes energy efficiency and conservation measures for buildings and transportation. In 2007, Approximately 74% of all local GHG emissions was from buildings and about 22% were from transportation (City of Boulder, 2009). The City was identifying and implementing demand-side strategies.

The 2008 assessments indicate GHG emissions were declining but not fast enough to meet 2012 targets. The community's goals were on the *demand-side* of energy. Xcel Energy built one new coal-powered power plant that increased Boulder's coal-source energy from 56% to 65%, but the *supply-side* losses wiped out the CAP's gains. Despite Colorado's 30% RPS goal by 2020, the City was still held hostage by Xcel's coal-powered portfolio. The City Council made a tough decision to switch from an incentive-based to a regulatory approach to implementation to meet 2012 targets (Koehn, 2010). Also in 2009, Boulder increased its carbon tax was increased to the maximum allowed by the voters in 2009, and the City successfully pursued municipal power options in a 2011 referendum (Koehn, 2010).

The City funds implementation of a municipal power program that uses renewable energy. The City placed an energy tax on Xcel Energy that will replace a $4M/year income stream from rights-of-way franchises in the city that currently goes to the General Fund. The City now brokers deals with Xcel to purchase green power and explores other ways to implement locally developed and distributed power (Koehn, 2010).

8.2 IMPLICATIONS OF UNIVERSAL PROTOCOLS AND TOOLS

Conclusion: There is an international effort underway to provide universal protocols and tools for cities. However, Study 1 interviews and Study 2 survey results indicate that U.S. cities are customizing CAP tools and processes to meet their needs, particularly in the strategy and monitoring phases. The best tools and protocols will meet GHG accounting requirements while supporting the need for customization, innovation, education, and communication in the CAP process.

Section 8.2 of this thesis discusses these countervailing trends about the future of CAP process and supporting software tools. This includes theoretical discussions, practical implications, and best practice recommendations for international protocols and software tools used in U.S. cities.

8.2.1 Theoretical Discussion of International Protocols for U.S. Cities

C40 cities in conjunction with WRI, ICLEI, and other partners, have prepared protocols for community-scaled CAPs with a primary objective of aligning local with national GHG inventories. Discussed are considerations for establishing boundaries, identifying direct and indirect GHG sources, aligning GHG inventory with best practice protocols, and focusing strategies on areas where a city has the most control. A brief review of C40 pilot cities is included to examine how they are using the international protocols in a local context. Finally, there is a discussion about the need for CAP tools to create accurate reports, support community education and communication.

CAP Boundaries and Scope of Emissions

Cities prepare CAPs to address GHG emissions that fall within their jurisdictional boundaries. These are called direct emissions. Cities should also track indirect emissions, which are a consequence of activities inside their boundaries but occur outside the city.

WRI and WBCSD GHG Protocol identifies three scopes of emissions:

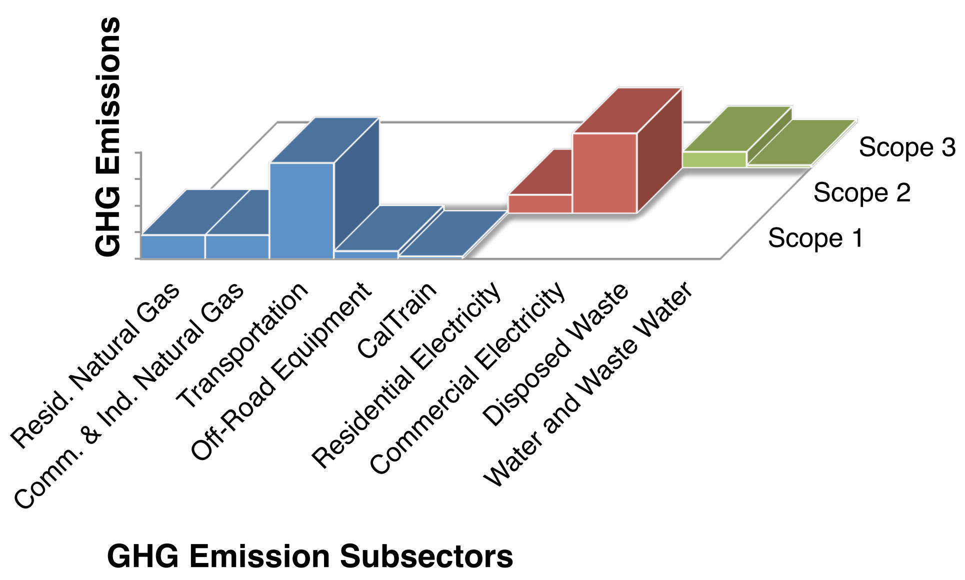
- *Scope 1: All direct GHG emissions.*
- *Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.*
- *Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g. T&D losses) not covered in Scope 2, outsourced activities, waste disposal, etc.* (Greenhosue Gas Protocol, 2012)

Role of Cities Identifying Scope of Emissions

Scope 2 and 3 GHG emissions are harder for cities to identify and calculate. For example, the GHG inventory for Portland's 2009 CAP focuses on power generation emissions. It does not include industrial processes, agriculture, forestry, air travel, and consumed goods (City of Portland, 2009, pp. 65-66). Whereas, Sunnyvale, California's CAP identifies GHG emissions by scope (Figure 8.3). About 57% of the GHG emission are direct (Scope 1) and fall within the city limits of Sunnyvale. Scope 2 emissions include power for Sunnyvale's residential and commercial buildings generated outside the city limits. Scope 3 emissions include waste disposal and electricity required for water and wastewater treatment (PMC, 2011, pp. A-7).

Figure 8.3

Sunnyvale GHG Subsectors by Scope



International Protocols and City GHG Inventories

WRI, C40, and ICLEI collaborated with the World Bank and others to prepare a framework for developing GHG inventories that better aligns local CAP protocols with those used by the IPCC. *The Global Protocol for Community-Scale Greenhouse Gas Emissions (v1)* (GPC) is being piloted by 33 international cities (Fong & Sotos, 2013).

GPC Objectives

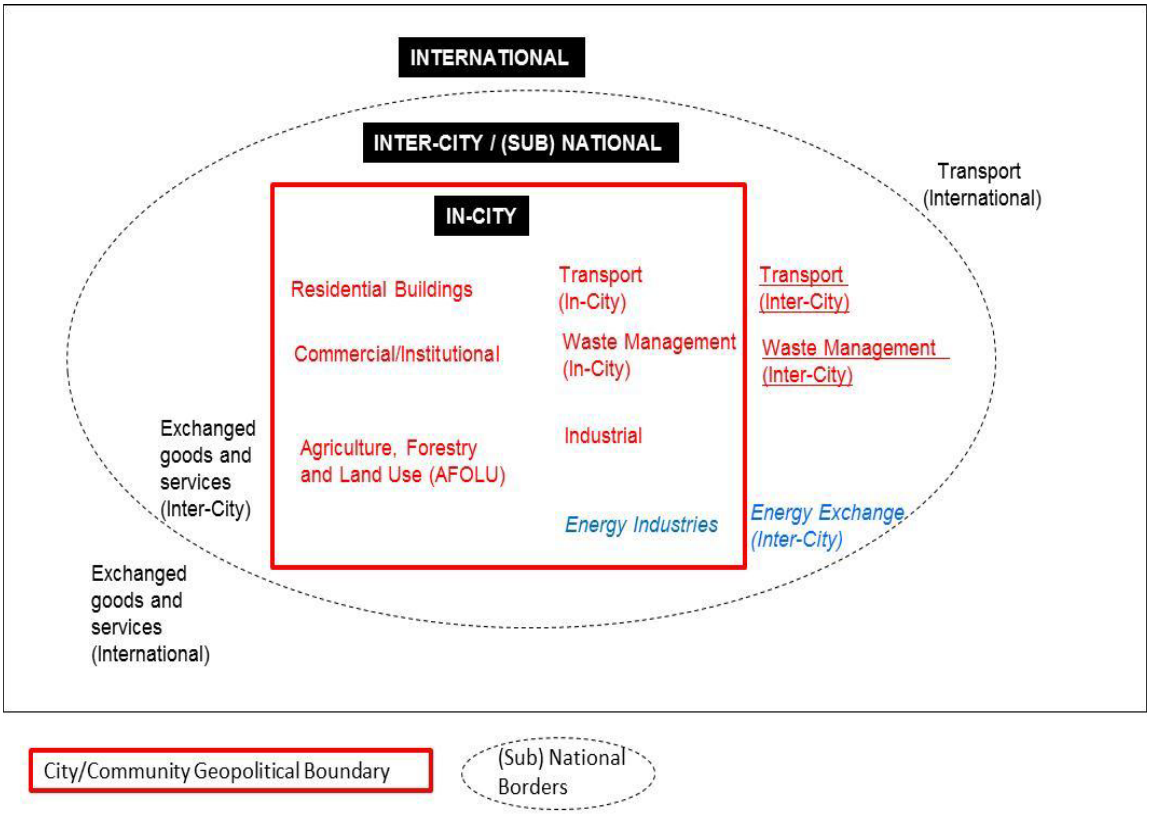
The primary objectives for the protocols is to provide an accounting and reporting standard, sync local inventories and actions with international treaties and national actions, and provide a process for updating the protocol in the context of continuous improvements to methods (C40 & ICLEI, 2012, pp. 1-2).

The GPC includes the *2012 Accounting and Reporting Standard* that "measures single-process emissions from end-use activities associated with the community. Global cities have different capacities and levels of experience in GHG inventorying. Therefore, the emissions sources listed in the 2012 Standard reflect the minimum accounting and reporting requirements necessary to achieve comparability between cities and relevancy for local policy development" (C40 & ICLEI, 2012, p. 13).

Figure 8.4 illustrates the GPC sources and boundaries of community-scale emissions associated with the city and thereby prevents double counting emissions in another jurisdiction (C40 & ICLEI, 2012, p. 12).

Figure 8.4

Schematic Representation of Sources and Boundaries of Community-scale GHG Emissions



GPC Limitations

The GPC report includes a list of limitations of the *2012 Standard*. Three of the limitations may be applicable to U.S. cities. These include: embodied emissions in materials and goods that move between communities (Scope 3), accounting for agriculture and forestry as a land use, and access to emissions data (pp. 17-18).

Implications of International Protocols

Examining international, U.S., state, and local CAP protocols for developing GHG inventories reveals the diversity of approaches. Table 8.1 compares IPCC, C40, CARB, Sunnyvale, and Portland GHG inventory sectors. The comparison indicates that each is using an approach to scoping emissions sources and boundaries that aligns with their mandates and what is under their operational control (government operations), policy control (building codes, energy-efficient appliances), and policy influence (street design, public transportation, recycling).

Table 8.1

Comparison of Inventory Protocol GHG Sectors

	IPCC (2012)	**GPC–C40/WRI/ICLEI (2012)**	**California Air Resource Board (CARB, 2010)**	**Sunnyvale, CA (PMC, 2011)**	**Portland, OR (City of Portland, 2009)**
Purpose	International protocols for global leaders	International protocols for cities	Implement AB32 Global Warming Solutions Act of 2006	Community Climate Action Plan	Community Climate Action Plan
Scope Features	National–Comprehensive	More closely aligns city-scale CAPs with IPCC protocols	State of California CAP	Reflects overall emission categories found in ICLEI CAPC software	County/City GHG inventory with a strong focus on energy
Inventory GHG Sectors	1. Energy supply 2. Transport and related infrastructure 3. Residential and commercial buildings 4. Industry 5. Agriculture 6. Forestry 7. Waste management	1. Stationary units (buildings) 2. Mobile units (transport) 3. Waste 4. Industrial process and product use 5. Agriculture, forestry, and land use 6. Other indirect emissions	1. Transportation 2. Electricity 3. Industry 4. Commercial and residential 5. Agriculture 6. High GWP (GHG sources other than CO2) 7. Recycling and waste	1. Transportation 2. Commercial and industrial 3. Residential 4. Waste 5. Other	1. Buildings (homes, commercial, industrial) 2. Transportation 3. Consumption and solid waste 4. Food 5. City and County operations

Brief Review of C40 Pilot Cities

Review of CAPs from three of the 33 pilot cities using the GPC accounting and reporting framework suggests North American Cities are using the protocols in a variety of policy contexts. There are two U.S. pilot cities. These include Los Altos Hills, California and Minneapolis, Minnesota. Vancouver, British Columbia is listed as a pilot city but has not yet published an updated GHG inventory.

The 2013 CAP for Los Altos Hills 2005 baseline community emissions inventory uses six sectors: on-road transportation, residential energy, commercial energy, off-road equipment, waste disposal, and water and wastewater (PMC, 2013, p. 14). The same consulting firm used similar sectors in preparing the Sunnyvale CAP.

Minneapolis, Minnesota has also appears to have used the GPC protocols (City of Minneapolis, 2013, p. 7). Their GHG sectors in the baseline community inventory are the same as Los Altos Hills. In addition, Minneapolis includes air travel, as Sunnyvale included Caltrain (commuter rail) as a Scope 1 emission.

Vancouver, British Columbia's CAP is integrated into a community sustainability plan. As of 2013, the GHG inventory update reflecting the C40 protocol had not been completed or made available. Vancouver's 2008 baseline community emissions inventory sectors include light duty vehicles, 1 and 2 family homes, light-industrial buildings, multi-unit residential buildings, solid waste, and heavy-duty vehicles (City of Vancouver, 2012, p. 24).

Vancouver's 2008 inventory does not align with that of the Province or GPC. British Columbia produced protocols for community-scale GHG emissions that include buildings, vehicles, solid waste, and other emission sources (wastewater, agriculture, land use change, air transportation, marine transportation, rail transportation, and non-energy industrial process) (Community Energy Association; British Columbia, 2008, p. 9). British Columbia's 2006 baseline emissions inventory uses the following sectors: transportation, residential and commercial, other industry, agriculture, waste, electricity, net deforestation, and fossil fuel production (p. 2).

Aligning Federal and State Protocols with Local Priorities

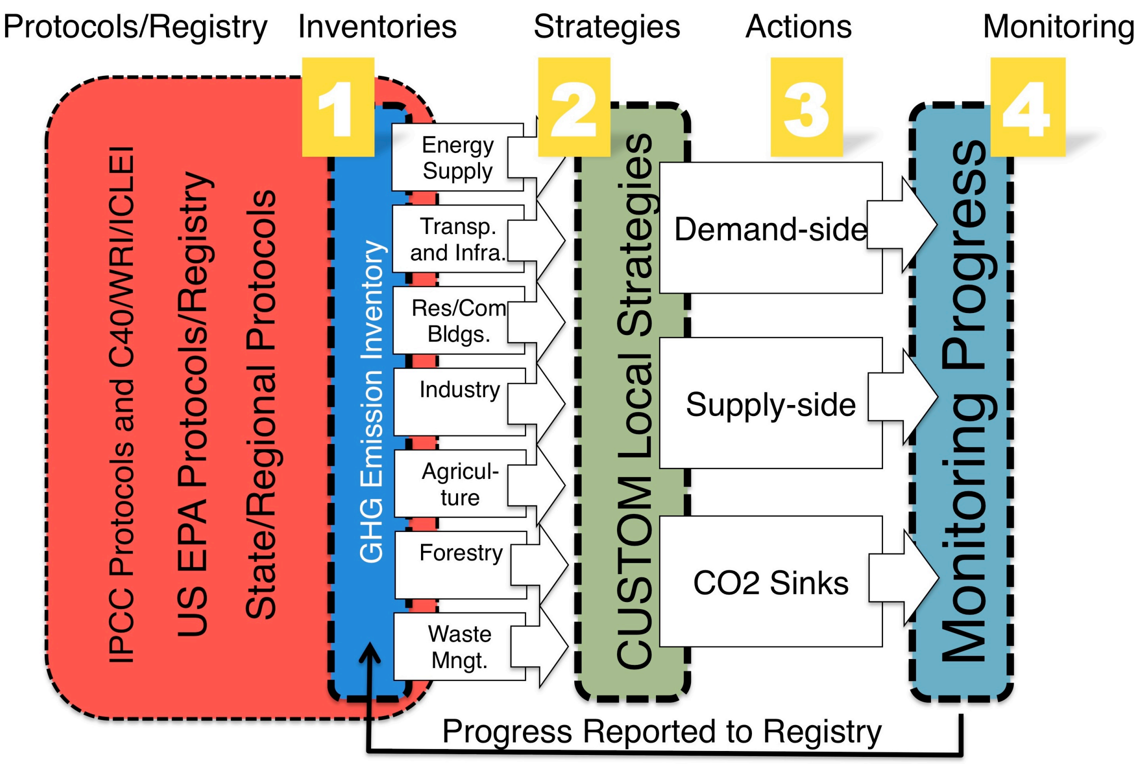
Review of IPCC, C40, state, and city protocols used in developing inventories reflects the policy challenge of aligning responsibilities for Scope 1, 2, and 3 emissions. U.S. C40 pilot cites seem able to create CAPs that reflect both their local aspirations and GHG emission mitigation challenges while using the GPC. Now federal and state regulations must support city CAP processes with an "ecosystem" of protocols that allows them to leverage local capabilities to meet local, state, and federal targets.

Need for Flexible, Transparent, and Educational Tools

Figure 8.5 illustrates four key steps where software tools are used in the CAP process. These include preparing the GHG inventory baselines and BAUs, exploring effectiveness of strategies, testing effectiveness of actions, and monitoring reporting progress. Studies 1 and 2 indicate within these steps, cities desire to tailor their tools to support a transparent and educational process.

Figure 8.5

CAP Process Diagram



Transparency, Customization, and Education

Study 1's interviews and Study 2's survey indicate cities are looking for CAP software tools that are open book (transparent) and can be used to test and measure local actions and policies. Most U.S. cities are using ICLEI's CAPC software or similar tool provided by a non-profit for preparing their GHG inventories. For the CAP strategy-making and monitoring phases, cities are increasingly using customized spreadsheets and tools that reflect their local policies and actions.

CAP managers interviewed were concerned about the "black box" nature of proprietary software. They preferred more open book tools that allowed them to better understand underlying assumptions and structure. ICEI's CAPC software and their participation with C40 cities leverage their years of experience. The GPC identifies transparency as a guiding principle.

CAP tools and processes are integral to informing stakeholders about choices that are unique to their community. The review of literature makes a connection between how informed a community is and the quality of their CAP.

8.2.2 Best Practice Recommendations for Universal Software Tools

Best practice recommendations for CAP tools and protocols include expanding their abilities to support educational and communications goals and support innovation. Study 2 indicates cities are moving away from software that imbeds protocols after they develop their initial baseline GHG emission inventory. CAP managers interviewed in Study 1 were looking for software that could help them communicate and track progress in real time, prepare and test strategies unique to their community, and is based on improving science and metrics.

Expand tool performance to enhance education and communication

Software that is developed to meet protocols should support other CAP process needs. This includes education in the inventory phase, access to interactive exploration of alternatives in the strategies and actions phase, and real time information about CAP implementation progress.

New CAP commercial tools use social media and online interactive software to document the process, inform the community, and provide real time feedback. The C40 and ICLEI tools developed to meet the protocol needs are spread sheets. There is a considerable communications and interactive performance gap between the protocol tools and what cities are looking for.

Protocols and tools supporting innovation

Protocols and tools for CAPs should satisfy accounting requirements and support policy innovation. They should allow cities to test and explore strategies reflecting opportunities unique to their community.

Protocols slowly emerge out a collaborative process that requires building consensus among stakeholders. Innovation can also emerge from collaboration. Many innovations in preparing CAPs have come from cities themselves and interactions with peer communities. CAP tools and protocols cannot be passive obstructions to innovation.

Protocols guiding high-performance cities

CAP protocols and tools should provide optional prescriptive and performance-based methods for developing GHG mitigation strategies.

New trends in energy and building codes can inform development of CAP protocols. For example, the International Energy Conservation Code (IECC) and California's CALGreen building code have optional prescriptive and performance-based methods for compliance. The prescriptive method uses detailed standards for design components. The performance standards rely on the designers' innovation to meet energy goals. The best CAP tools will provide the same type of science-based emission reporting while supporting innovation.

8.3 CAP INFLUENCE ON THE FUTURE FORM OF CITIES

Conclusion: Despite the number of common strategies being used, the unique economic, political, and ecological context of each city is resulting in a wide variety of urban design outcomes. The effectiveness of those strategies depends on the degree cities are prepared to compress growth into walkable nodes, corridors, neighbourhoods, and districts.

Section 8.3 discusses the theoretical and practical implications of compression, connection, and adaptation as core CAP strategies. This includes theoretical reflection on the universal experience of cities, what contributes their uniqueness, and how layers of CAP strategies contribute to their urban form. Section 8.3 concludes with best practice recommendations.

8.3.1 Theoretical Discussion of CAPs' Influence on the Form of U.S. Cities

CAPs inform planning policies directing land use patterns, mobility systems, and services supporting low-carbon lifestyles. Best practice CAPs respond to a city's unique attributes. Their strategies have a cumulative effect, reshaping cities over time by compressing development into transit-oriented, walkable communities. They have urban design features that are commonly seen in low-carbon cities.

Universal Experiences and Unique Circumstances of Cities

With so many cities employing similar smart growth policies in CAPs, will cities start to take on a similar form? In *The City Shaped* (1991), Geographer Spiro Kostof discusses the universal experience of cities. He claims cities are artefacts of their birthplace, form, and makers. Every city has a unique physical circumstance, exists as part of a cluster, and possesses an identifiable monumental framework.

Cumulative Effect of CAP Strategies

CAP strategies have a cumulative effect on city form, and those for reducing GHG that affect urban form has various timeframes. Retrofitting buildings and districts within a city can have near-term benefits. Changing travel and energy infrastructure will take longer and may have midterm benefits. In the long term, these strategies can begin to shift overall patterns of development.

Framework of Community Design Construct Strategies

The following constructs provide a schematic of how CAP smart growth land use strategies influence the overall pattern of development in cities.

Compression Strategy

The *construct of compression* activates many urban form policies being adopted by CAP cities. Strategies are concentrating high-density infill developments, reducing outward expansion, and protection of natural areas contiguous to cities. This combination of centring and concentrating development while reducing horizontal expansion is compressing cities, improving their passive energy and mobility performance.

Boundaries–Study 3 tests compression by modelling cities with fixed, determined, and flexible boundaries. The more compression, the higher modelled performance. By constraining or fixing growth boundaries, the centred city scenario has the highest density, most infill, and lowest GHG emissions. The corridor city model assumes a determined boundary that confines development expansion along a higher-density corridor. The lower-performing BAU scenario has a flexible boundary, allowing low densities outside the existing baseline boundary.

Polycentric Regions–As Kostof (1991) reminds us, cities exist in clusters. The simple models in Study 3 would likely be located in polycentric regions of centres, satellites, balanced suburbs, and bedroom communities. Extending similar compression strategies to constrain and determine urban patterns will improve the performance of individual communities and regions.

Nodal Development–Even within cities, compressing development into nodes served by transit has similar benefits, supporting walking and transit for development nodes and contiguous areas. Nodal (constrained boundary) development connected by corridor (determined boundary) development will result in a more land-efficient city.

Connection Strategy

The *construct of connection* is based on incorporating CAP transportation strategies into city comprehensive plans. Transportation is the greatest emissions source identified by CAP survey cities. As a result, cities are developing walking and bike systems, enhancing transit services, and incentivizing low-carbon lifestyles.

Walk-first Cities–Every trip begins and ends as a pedestrian experience. Improving the walking experience will encourage more people to walk. This is a central strategy for Portland, Oregon's neighbourhoods. The 20-minute neighbourhood concept provides residents' daily needs within a 20-minute walk, which considers the destinations, distance, and walk quality.

Enhanced Transit Services–Half of CAP cities are expanding transit services and requiring or allowing reduced parking standards. By providing mobility choices, these cities are promoting compactness and continuity of a walk-first city.

Adaptation Strategy

Climate change impacts entire regions and requires a regional design response. Yet, only 12% of CAP survey cities collaborated at a regional scale on mitigation or adaptation strategies.

At a local level, CAP cities are addressing a variety of climate change impacts. These actions will make them more resilient to climate events; make their interface with wildlands and water more natural and safer; improve water conservation and better manage stormwater; and result in greener and cooler environments by protecting and enhancing existing landscape and trees cover.

Visible Indicators of a Low-Carbon City

Research outcomes in this thesis provide a set of urban design indicators for a low-carbon city. A low-carbon city is a:

Walking City–The greenest cities will be the best walking cities. This will be a product of compression creating the type of density that also supports transit.

Energy City–Cities will be climate responsive with demand-side GHG reductions from passive heating and cooling and non-motorized transport. Cities will be activated by visible green power sources.

Adapting City–The adapting city will use landscape to reduce heat and moderate stormwater. It will have edges that respond to increasingly extreme weather events in interface zones with wildlands, wetlands, rivers, and oceanfront.

Table 8.2 provides examples of the types of visible features we will see in low-carbon cities resulting from passive and active strategies. Many of the passive design features are found in historic cities. They were designed to be seasonably comfortable and take advantage of local resources and materials. Active strategies include technological and engineering solutions that close the gap in reaching GHG reduction targets.

Table 8.2

Examples of Visible Evidence of Passive and Active Strategies

	Passive Strategies	Active Strategies
Walking city	Crowded streets designed for walking, transit, and less driving Green with comfortable walking pace Indoor and outdoor transitional spaces Hierarchy of pedestrian spaces–scale, privacy, and activity Buildings oriented towards public streets and spaces Buildings using local materials	Shared transit–rail, bus, cars, bikes Municipal and private outdoor lighting–efficient, reduction in light pollution
Energy city	Buildings and blocks organized for breezes and sun access Buildings with passive solar and day lighting features Landscape that cools open spaces and streets Light building materials to reduce heat	PV, small power wind on every building Geothermal in open spaces Regional green power generation–wind, solar
Adapting city	Dual-use open spaces used for stormwater and recreation Street tree canopy and landscaping Natural wildland, wetland, and oceanfront buffers	Grading or walling for flooding Grey infrastructure for peak weather events Hardening construction in zones vulnerable to climate events

8.3.2 Comparing Theoretical Implications of Research with APA and C2ES Recommendations

The research in this thesis is compared to popular sustainability and smart growth principles from the APA and C2ES and used to describe the visible features of a low-carbon city.

<u>APA's Smart Growth Principles</u>

In 2011, the American Planning Association's Board adopted six Smart Growth Principles where outcomes help cities meet GHG mitigation goals. Table 8.3 compares

APA smart growth outcomes to construct strategies of compression, connection, and adaptation. The research in this thesis demonstrates effectiveness of selected APA's Smart Growth Principles.

Table 8.3

APA Smart Growth Principles' Relationship to Construct Strategies

	Construct 1: Compression	Construct 2: Connection	Construct 3: Adaptation
APA Smart Growth Outcomes (American Planning Association, 2011)			
Sufficient residential density to support multiple modes of transportation	•••	•••	•
Proximity of land uses that encourage walking and bicycling	•••	•••	••
More energy-efficient building types and unit sizes	••	•	••
Provision of public open space that substitutes for more energy-intensive private open space, such as lawns	••	•	••
Less land consumed for development	•••	••	•
More efficient (and more energy-efficient) provision of public services, such as streets and utilities	•••	••	••

Key: ••• High, •• Medium, • Low contribution to construct strategy

Compression Construct Strategies Reinforced (Highly Effective)

Most APA outcomes result from a compression strategy for cities. More efficient land use is a shared theme in the outcomes. Compression also introduces more space and energy-efficient building types, pushing usable open space outside the property line as a shared community resource. Study 3 modelling demonstrates the benefits of compression as a strategy. The unmitigated centred city scenario reduces overall emissions 13% less than the BAU scenario.

Connection Construct Strategies Reinforced (High-Medium Effective)

The connection construct strategy supports APA outcomes. It enhances relationships between transit and land use, thereby reducing unmitigated centred city scenario transportation emissions 5% below the BAU, reducing the mitigated centred city scenario transportation emissions 83% below the BAU, and reducing emissions from paving 51% below the BAU.

Adaptation Construct Strategies (Medium-Low Effective)

The link between adaptation and compression is conceptually clear. There is an adaptation benefit to reducing expansion into environments susceptible to flooding, sea level rise, and wildland fires. Compression strategies reduce the amount of impervious paving and lower stormwater impacts.

The CAP cities adaptation strategies address heat islands (29%), flooding (28%), and drought (26%). To a lesser extent, cities were preparing for wildland fires (11%) and sea level rise (9%), likely reflecting the number of cities in a geographic context that would require those types of actions.

C2ES–*Towards a Climate-Friendly Built Environment*

In 2005 the Pew Centre (now C2ES) published a paper from the Oak Ridge National Laboratory about how to prepare cities for climate change. This often-cited paper is comprehensive and defines the challenges and solutions for climate change. The report states that higher-density mixed-use development will reduce GHG emissions due to complementary effects (Brown, Southworth, & Stovall, 2005, p. 39).

Table 8.4

C2ES Complimentary Effects of Higher-Density Mixed-use Development Relationship to Construct Strategies

Pew Centre for Global Climate Change–now Centre for Climate and Energy Solutions (C2ES)			
	Reduced per-unit-area consumption of district energy for cooling, heating, and power generation	Reduced municipal infrastructure requirements, including the reduced need for construction of streets and electric, communication, water, and sewage lines, and other services	Reduced VMT, including shorter freight and person trips, as well as the substitution of these trips with public transit, walking, and cycling
Construct 1: Compression	•••	•••	•••
Construct 2: Connection	•	••	•••
Construct 3: Adaptation	•	••	••

Key: ••• High, •• Medium, • Low contribution to construct strategy

Modelling in Study 3 validates the benefits described by the Oak Ridge team. The unmitigated and mitigated centred city scenario has a distinct reduction in GHG emissions from energy, transportation, and paving. It compresses growth and increases density thereby reducing VMT and shifting building types into more compact and energy-efficient forms. The amount of infrastructure and paving greatly reduces embodied energy, operational costs, and stormwater run-off.

Table 8.4 compares complimentary effects of high-density mixed-use to construct strategies in thesis section 8.3.1.

8.3.3 Cities that are Moving Theory into Practice

The comprehensive plans and CAPs of three California cities are reviewed to test the implications of compression strategies pertaining to land use and transit strategies. These include: Napa, CA with a *fixed boundary* and future commuter rail station planned adjacent to downtown; Elk Grove, CA a city with the fastest growing public school system with a reputation for land intensive low-density development with a *flexible boundary*; and San Jose, CA a city that was designed as an auto-oriented suburb that has new policies that *determine boundaries* for growth around transportation systems.

Napa–Fixed Boundary

Napa has held the urban-rural since 1976 (Figure 8.6) to protect world-renown wineries from encroaching development (City of Napa, 1998, 2010, pp. 1-1). The city's population will grow from 76,600 (2005) to 84,000 by 2020 (Table 8.5). The comprehensive plan treats every project as an infill development. The city prepared design guidelines to improve the fit of new projects into existing neighbourhoods. There is also an emphasis on development of new housing in and adjacent to downtown. As a result, the projects are higher density and better connected via an in-town pedestrian and bicycle system.

Napa's CAP Targets

The City of Napa's GHG inventory and targets were developed as part of Napa County's CAP process. Napa's GHG emission target is a 15% reduction below the BAU by 2020 (Napa County, 2009). This will reduce the 5.94 MTCO2e per capita from a 2005 baseline to 4.60 MTCO2e in 2020. As most California cities, Napa County's GHG emissions inventory largest sector is transportation (53%). Infill and transportation strategies are to reduce transportation emissions.

Napa's Adaptation Strategies Implication on Urban Form

The Napa County CAP identifies five climate change impacts of concern for Napa Valley cities. These include the impact of rising sea levels and related flooding events on the Napa River; increased drought and heat on agriculture; impact of invasive species on native plants and wildlife; decreasing depth of the sierra snowpack and related shortages of domestic water; drought, flooding, and wildfires; and potential impacts on human health. No specific recommendations or policies are made that influence the future form as it pertains to adaptation.

Figure 8.6

Napa, CA: Fixed Boundary City

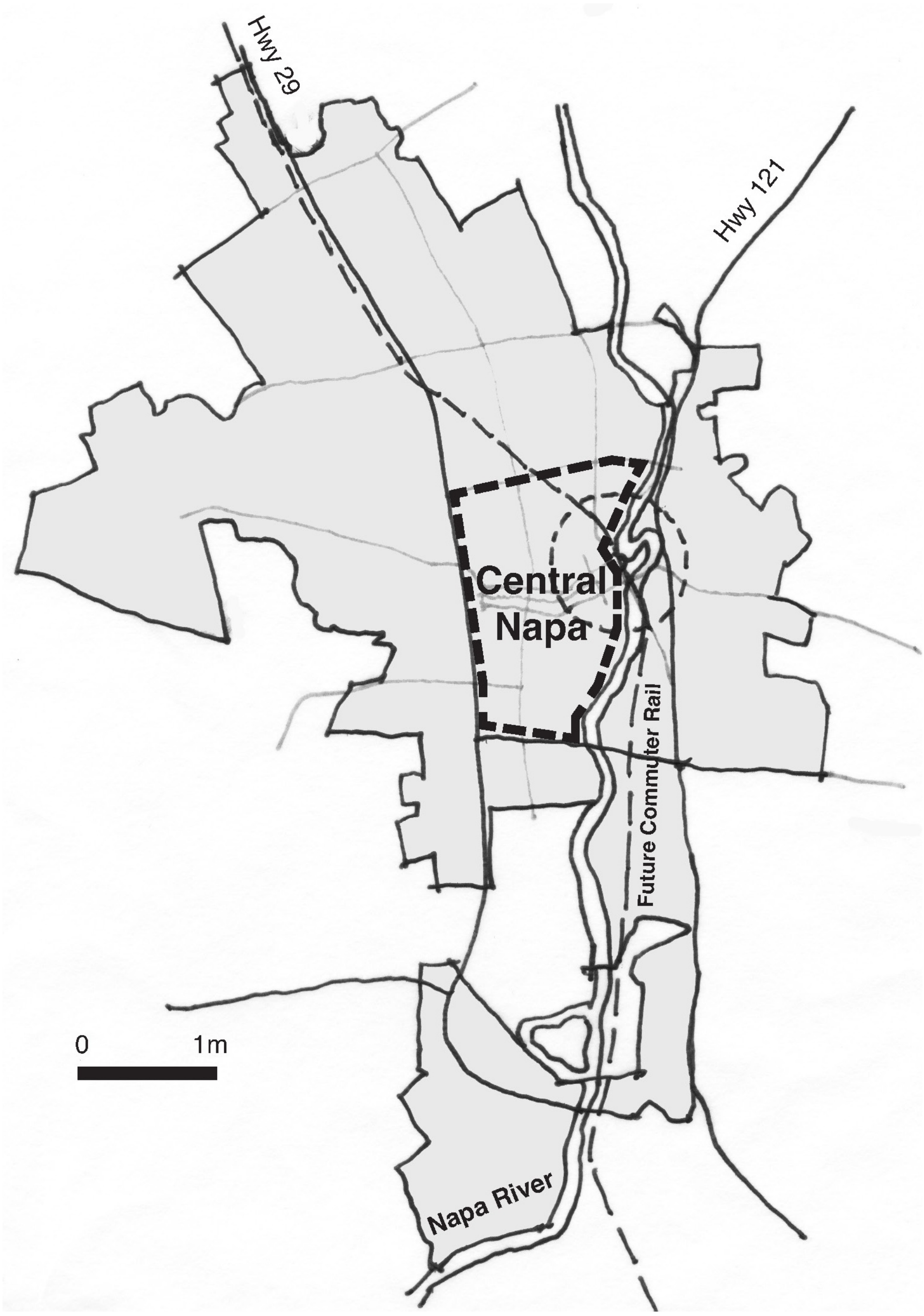


Table 8.5

Napa Population Growth and CAP Projections

2005 Base Line **455,062**	2020 BAU **544,572**	2020 Target **386,803**
	Percent Above 2005 Baseline **20%**	Percent Below 2020 BAU **-15%**
2005 SM **18.15**	2020 SM **18.15**	
2005 Population **76,600**	2020 Population **84,000**	
2005 Pop/SM **4,220**	2020 Pop/SM **4,628**	
2005 Baseline Per Capita MTCO2e **5.94**	2020 BAU Per Capita MTCO2e **6.48**	2020 Target Per Capita MTCO2e **4.60**

Note: CAP target highlighted

Napa: Comparing BAU and Infill

Table 8.6 compares emissions for housing for 2020 population as two scenarios:

- Scenario 1: Infill within the fixed boundary of Napa at medium density (22 du/a) reflecting the existing plan policy
- Scenario 2: Outside the boundary of Napa as low density (4 du/a) to illustrate implications of allowing housing to be developed in the valley

The worksheet developed in Study 3 is used to compare GHG emissions from the housing in each scenario. Non-residential uses are not included. The infill policy scenario has 62% less lifespan GHG emissions than the ex-urban expansion policy.

Table 8.6

Napa: Comparison of Urban Form Policy Scenarios for Housing

	Added Population	Density Assumptions	MTCO2e Lifespan
Scenario 1: Urban Infill (1)	**7,400** **2,960 DUs at 2.5 per household**	**22 du/a**	**1.08 MMTCO2e**
Scenario 2: Ex-urban Expansion (2)	**7,400** **2,960 DUs at 2.5 per household**	**4 du/a**	**2.83 MMTCO2e**

(1) Assumes 60% better than California energy codes (Napa County CAP target), 25% reduction in VMT (Napa County CAP target), no new streets required
(2) Assumes California energy codes, new streets required

Elk Grove: Flexible Boundary

Elk Grove is a fast growing suburb of Sacramento. The city was incorporated in 2000 and grew almost 90% in its first decade (Census Viewer, 2012). The city's population will grow from 113,083 (2005) to 183,438 by 2025 (Table 8.7). The comprehensive plan continues to promote low-density and auto-oriented development spanning between two highways (I-5 and Hwy 99). The city recently had an annexation proposal for 19,500 acres (30.5 square miles) turned down by the Local Agency Formation Organization (LAFCO).

The regional transportation system includes a future lightrail transit line that is to pass through Elk Grove and terminate on its southern boundary. The comprehensive plan does not emphasis higher densities around future LRT stations (Figure 8.7).

Table 8.7

Elk Grove Population Growth and CAP Projections

2005 Base Line **737,838**	2025 BAU **1,125,691**	2025 Target **627,000**
	Percent Above 2005 Baseline **53%**	Percent Below 2005 Baseline **-15%**
2005 SM **42.24**	2025 SM **54.74**	
2005 Population **113,083**	2025 Population **183,438**	
2005 Pop/SM **2,677**	2025 Pop/SM **3,351**	
2005 Baseline Per Capita MTCO2e **6.52**	2025 BAU Per Capita MTCO2e **6.14**	2025 Target Per Capita MTCO2e **3.42**

Note: CAP target highlighted

Elk Grove's CAP Target

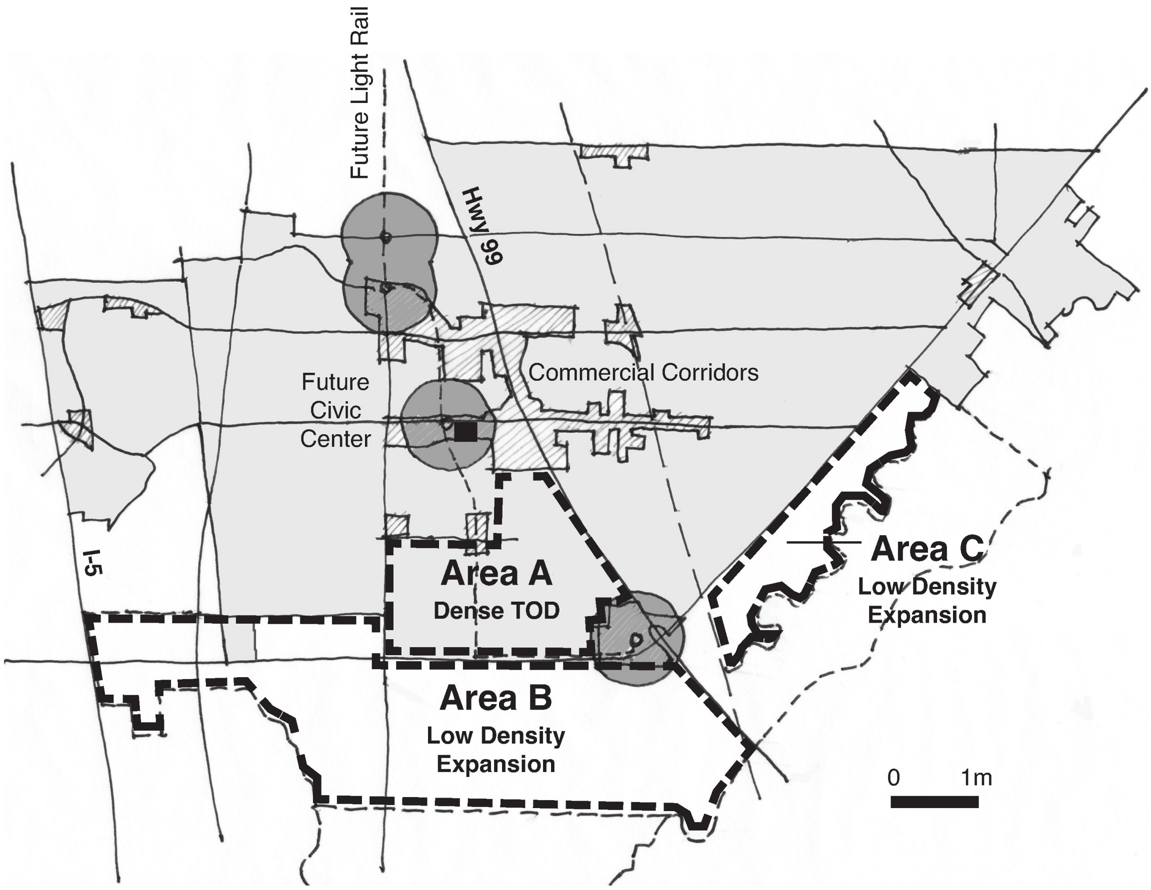
Elk Grove's GHG emission target is a 15% reduction below the BAU by 2025 (City of Elk Grove, 2013). This will reduce the 6.52 MTCO2e per capita from a 2005 baseline to 3.42 MTCO2e in 2020. As most California cities, Elk Grove's GHG emissions inventory largest source on-road vehicles (48%). The CAP emphasizes energy efficient construction and energy conservation strategies, many of which are being required by the State of California. The CAP does not emphasize land use or form-changing mitigation strategies.

Elk Grove CAP Adaptation Strategies

The Elk Grove CAP acknowledges the drought and flood impacts on local creeks. The CAP calls for city department budgets to reflect on-going investments in resilient infrastructure. The CAP does not include any other adaptation actions that will alter the form of the city.

Figure 8.7

Elk Grove, CA: Free or Flexible Boundary City



Elk Grove: Comparing Annexation and TOD

Table 8.8 compares emissions for housing for 2020 population as two scenarios:

- Scenario 1: Infill development compressed at medium densities (22 du/a) into a fixed boundary within Elk Grove near future LRT stations (Area A) as an alternative to the expansion policy

- Scenario 2: Outside the boundary of Elk Grove as low density (4 du/a) ex-urban neighbourhoods in buildable portions of proposed annexation (Areas B and C) as proposed in the annexation request

The worksheet developed in Study 3 is used to compare GHG emissions from the housing in each scenario. Non-residential uses are not included. The modelling indicates that a TOD policy scenario would have 50% less lifespan emissions from housing than the ex-urban annexation policy.

Table 8.8

Elk Grove: Comparison of Urban Form Policy Scenarios for Housing

	Added Population	Density Assumptions	MTCO2e Lifespan
Scenario 1: Urban Infill TOD (1)	**70,000 28,000 DUs at 2.5 du/a**	**22 du/a**	**12.30 MMTCO2e**
Scenario 2: Ex-urban Expansion (2)	**70,000 28,000 DUs at 2.5 du/a**	**4 du/a**	**24.41 MMTCO2e**

(1) Assumes 21% better than California energy codes (CAP target for Built Environment), 25% reduction in VMT (assumed for TOD), some new streets required
(2) Assumes 21% better than California energy codes (CAP target for Built Environment), new streets required

<u>San Jose–Determined Boundary</u>

San Jose is preparing a CAP as part of the 2040 comprehensive planning process. The city grew quickly in the 1970s and 80s as the hub of electronics technology innovation and manufacturing. San Jose grew southward down the Santa Clara Valley along highways. In the 1990s, the San Jose and other South Bay cities realized their land intensive growth was unsustainable and began to increase employment and housing densities. There was also an effort to extend and capitalize on existing CalTrain commuter rail and BART systems and develop a new lightrail transit (LRT) system. San Jose is now using a diverse-mode public transportation system and compression strategies as a way to reduce GHG emissions.

Because San Jose is an employment centre, their CAP focuses on reducing the GHG emissions for its "service population." This includes the daytime resident and employment populations (Table 8.9). The comprehensive plan treats every project as an infill development. The 2005 service population was 1,355,000 and the 2035 projection is 2,150,000 (City of San Jose, 2011).

San Jose Adaptation Planning

The comprehensive plan acknowledges the impacts of sea level rise on San Francisco Bay. The City requires review of project mitigation measures for location and design for the lifespan of new structures. In addition, the City is to prepare a Storm Drainage Master Plan that provides infrastructure that accommodates a 10-year storm event. This includes a monitoring and determining adaptive management actions (City of San Jose, 2007).

Table 8.9

San Jose Population Growth and CAP Target

2008 Base Line **7,610,000**	2035 BAU **14,500,000** Percent Above 2008 Baseline **91%**	2035 Target **13,450,000** Percent Below 2035 BAU **77%**
2008 SM **180**	2035 SM **180**	
2008 Service Population **1,355,000**	2035 Service Population **2,150,000**	
2008 Serv. Pop/SM **42,278**	2035 Serv. Pop/SM **80,556**	
2008 Baseline Per Capita MTCO2e **5.62**	2035 BAU Per Capita MTCO2e **6.74**	2035 Target Per Capita MTCO2e **6.26**

Note: CAP target highlighted in yellow

San Jose CAP Target

The city is preparing an update of the comprehensive plan and the CAP concurrently. San Jose's 2035 GHG emission target is a 6.26 MTCO2e per capita (service population). San Jose's 2020 target is to be at or below 6.6 MTCO2e per capita service population to meet the overall state goal. Nearly 45% of GHG emissions in the 2008 baseline inventory are from transportation (City of San Jose, 2011).

San Jose Urban Form Strategies

The San Jose GHG emission mitigation strategies are integrated into the city's comprehensive plan. *Envision San Jose 2040* includes 12 overall strategies. Key urban form strategies include creating a form-based plan that focuses urban growth, maintaining the cities “greenline” growth boundary, centring growth in downtown, creating transit-oriented urban villages, and improving pedestrian facilities. The plan includes sustainability metrics to measure progress (City of San Jose, 2007).

Figure 8.8

San Jose, CA: Determined Boundary City

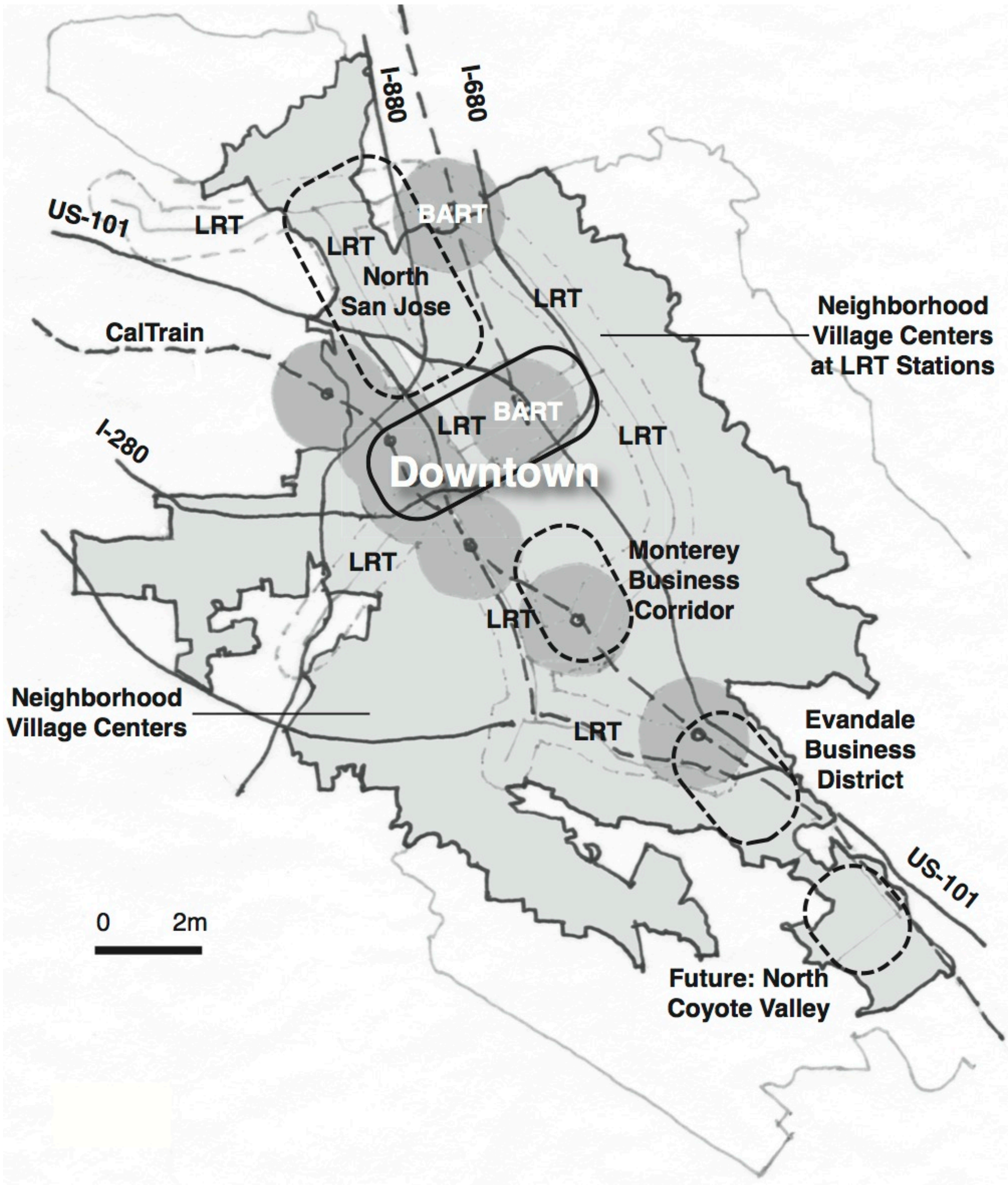


Figure 8.8 shows the variety of transit modes and related defined growth areas in *Envision San Jose 2040*. The comprehensive plan compresses the city within a growth

boundary. Growth policies centre development in downtown and support it with BART, CalTrain, and LRT transit systems. The plan intensifies employment development in North San Jose and other established business parks adding BART access in the north and lightrail and CalTrain in the south. Neighbourhood centres are connected with lightrail and established corridors on the west side are intensified and accessible by bus.

Table 8.9

San Jose: Comparison of Urban Form Policy Scenarios for Housing

	Added Population	Density Assumptions	MTCO2e Lifespan
Scenario 1: Urban Infill TODs (1)	**418,300 167,325 DUs at 2.5 du/a**	**44 du/a**	**61.9 MMTCO2e**
Scenario 2: Ex-urban Expansion (2)	**418,300 167,325 DUs at 2.5 du/a**	**11 du/a**	**101.9 MMTCO2e**

(1) Assumes 20% better than California energy codes (CAP target for Built Environment), no new streets required, 25% reduction in VMT (assumed for TOD), new streets required
(2) Assumes 20% better than California energy codes (CAP target for Built Environment), new streets required

San Jose: Comparing Flexible vs. Determined Boundaries Policies

Table 8.9 compares emissions for housing for 2035 population as two scenarios:

- Scenario 1: Infill within the fixed boundary of San Jose and around transit stations at higher density (44 du/a) as proposed in *Envision San Jose 2040*
- Scenario 2: Allow suburban growth outside the boundary of San Jose as low to medium density (11 du/a) to illustrate the implications of allowing the city to sprawl down the valley

The worksheet developed in Study 3 is used to compare GHG emissions from the housing in each scenario. Non-residential uses are not included. The existing infill policy scenario has 40% less lifespan GHG emissions than the suburban expansion policy would have.

Comparing Effectiveness of Napa, Elk Grove and San Jose Boundary Policies

The three cities provide examples of fixed (Napa), flexible (Elk Grove), and determined (San Jose) approaches to establishing boundaries that compress development. Modelling policy scenarios for the three cities indicate the mitigation benefits of compressing housing development rather than expanding cities.

- By developing at modest infill densities of 22 du/a to accommodate 2020 population growth rather than allowing low-density housing to grow into the Valley, Napa has reduced future lifespan emissions by 63%.
- If Elk Grove were to compress 2025 residential growth into a 22 du/a TOD neighbourhood rather than expanding into agricultural land at 4 du/a, lifespan GHG emissions would be cut in half.
- San Jose is compressing growth into the city boundary and transit corridors and station areas. If San Jose were to continue to grow southward down Santa Clara Valley at 11 du/a rather than developing at higher transit-oriented densities of 44 du/a, lifespan emissions of 2035 population growth would be 40% higher.

None of the cities had adaptation strategies that will greatly changing their form. San Jose requires design review for project location regarding sea level rise and flooding and design and Elk Grove is to review budgets for capital projects to address resiliency design responses. However, each CAP does recommend cooperating with regional agencies and communities to address impacts of climate change.

Practical Implications for Shrinking Cities

Compression is an important strategy for U.S. cities that are losing population, such as Detroit, Youngstown, and Cleveland. Shrinking cites are using demolition as an economic and municipal service survival strategy that is compressing the remaining population into more compact patterns.

Detroit has lost over one million people and is tearing down entire blocks to reduce service costs. Previous residents abandoned buildings, infrastructure, and streets to build less efficient cities on farmland that once fed Detroit. Across much of the Rust Belt the story is repeated. The 1950 population shrunk as much as 60% in some cities, spreading municipal, infrastructure, and energy emissions across a smaller and poorer population.

Plans call for development to shrink around transit corridors that act as fingers of development radiating out from downtown (City of Detroit, 2013). This is a compression strategy. The *Detroit Future City Plan* is fixing, constraining, and determining boundaries for existing and future development around transit. A by-product of the revitalization strategy will be reduced GHG emissions from more efficient construction and VMT reduction.

District-Scale Applications

Eco-districts and university campuses are demonstrating some of the benefits of holistic GHG emissions strategies. They are planning and managing district-scale energy infrastructure, stormwater systems, waste reduction, and transportation systems. They are offering a glimpse of what cities will look like in the future as compressed, connected, and adapted places.

The first generation of eco-districts in the U.S. are taking advantage of unique circumstances of public property control, enlightened developers, and infrastructure to act as pilot projects, demonstration projects, and early phase CAP implementation. These plans and projects have comprehensive and integrated ecological design features. Portland has been a leader in development of eco-districts. The city has nine districts. Each is unique, reflecting their history, mission, and assets.

In 2012, The University of California Merced Campus Long Range Development Plan was the first plan (rather than building) to receive an AIA National COTE Top Ten Green Project Award (American Institute of Architects, 2014). The plan is a comprehensive road map to developing a net-zero energy, GHG, and waste campus by 2020. The campus is designed for walking and has very high passive performance goals for building. Renewable energy sources include solar, wind, and plasma gasification.

Ball State University in Indiana has the largest ground-source geothermal project in the United States. Replacing its aging coal-fired steam system, the project heats and cools 47 buildings and saves the university over $2 million per year in energy costs (Ball State University, 2013).

8.3.4 Community Design Best Practice Recommendations

This thesis has comprehensively explored operational and design strategies CAP cities are using to mitigate GHG solutions. Three key concepts have emerged as key to developing climate-friendly cities: compression, connection, and regional adaptation.

Compression design strategies are primary

Climate Action Plans should compress development into patterns that can efficiently support walking, transit, energy-efficient buildings, and urban infrastructure. Compression should be the primary design strategy.

Density and compactness are often referred to as important features of a low-carbon city. Unless a city has natural boundaries, such as San Francisco or Manhattan, density and compactness are a result of a compression strategy. Cities should establish boundaries that are fixed, constrained, or determined to optimize development patterns for walking, transit, urban infrastructure, and building energy efficiency. Compression strategies can be applied at the regional, city, district, corridor, and site scale.

Design the walk-first city

City planning should focus on making districts and neighbourhoods walkable, safe, and interesting. Connection should be the primary strategy supporting compression.

High passive performance of cities begins with the ability to walk. A city without sidewalks, interesting destinations, and services within walking distance will not reduce their GHG emissions related to VMT.

Transportation is the largest source of GHG emissions identified by CAP cities in Study 2. Two-thirds of CAP survey cities have strategies to reduce VMT and encourage higher-density compact development. CAP cities are foremost planning and investing in walking and biking infrastructure.

Adaption requires a regional perspective

CAPs should address adaptation planning at the regional and local scale. Planning should focus on edge conditions in communities and make adaptation strategies an extension of compression strategies.

CAP cities are addressing a variety of climate change impacts to improve their resilience. They are using strategies to improve the interface of wildlands-urban edges, water conservation, and stormwater management. These strategies create greener and cooler environments by protecting and enhancing existing landscape and trees cover.

Climate change often affects entire regions and requires a regional design response. Yet, only 12% of CAP survey cities collaborated at a regional scale on mitigation or adaptation strategies.

8.4 FURTHER RESEARCH NEEDED

The review of literature indicates knowledge gaps regarding how cities are activating their CAPs in their policy documents, the implications of CAP protocols on growth management and land use mitigation strategies in the U.S, and comprehensive district-scale strategies.

8.4.1 Longitudinal Study of U.S. CAP Cities

Existing surveys of CAP cities are limited because they are regional, include small samples, or do not sample cities that have completed CAPs. There is an opportunity to fill this gap with a national longitudinal study of CAP cities that examines the relationship between fundamental attributes of cities (political context, regional differences in climate, adaptation needs and eGRID, and community values), the actions they take, and the policies they adopt.

Study objectives:

- Provide on-going assessment of CAP cities' actions and adopted policies
- Expand the survey participation to new cities
- Add and refine research questions

Conducting the survey with the same variables over time will indicate climate action and policy trends, and allow studying regional or policy cohorts cities. Cohorts can include the early adopter cities (first 1%) in the original survey and later joiners, plus cities with various fundamentals (independent variables).

8.4.2 Protocols for CCAPs

ICLEI and C40 Cities Climate Leadership Group have drafted international protocols for CCAPs that facilitate developing effective policy, compare GHG emissions between communities, inform development and consumption policies, and simplify aggregating data at regional and national levels (Yunis, 2012, pp. 7-8).

The 76-page report offers a framework for scoping CAPs in terms of boundaries and sectors used for GHG emission inventories. The scoping protocols tier GHG emissions at a local in-city, inter-city (sub national), and international scale. The in-city emission sectors include residential buildings; commercial/institutional buildings; agriculture, forestry, and land use; transport (in-city); waste management (in-city); industrial; and energy industries (Yunis, 2012, p. 12).

Review of three of the 33 pilot cities using the C40 protocol looks promising. Further research still requires vetting of how the protocols are working within the U.S.

land use law and planning system. CAP managers interviewed in Study 1 case studies and literature review suggest cities develop inventories that reflect what they can affect at a local level. This explains the variety of approaches cities are taking to emission inventory. Chicago uses a building-centric approach (higher CO2e eGRID and emissions in building sectors), and Portland emphasizes transportation and 20-minute neighbourhood strategies (higher percentage of GHG emissions in transportation sector).

Further research efforts could explore how these new scoping protocols align with the diversity of policy and energy contexts throughout the United States.

Study objectives:

- Study protocols' compatibility with (comprehensive) planning practice
- Review availability of GHG emissions sector data at a local level
- Analyse compatibility with municipal planning law

8.4.3 Research Regarding District-scale Low Carbon Implementation

Ecodistricts.org is a non-profit located in Portland, OR with a mission to "To bring together city builders and entrepreneurs, policymakers and innovators to create vibrant neighbourhoods and smart cities" (EcoDistricts, 2013). The organization has been working on eco-district plans and energy studies in Portland, providing national case studies, and convening conferences. They have become a national leader in the pursuit of district-scale low carbon development.

However, a review of EcoDistrict's plans does not indicate the type of GHG emissions inventory, land use, demand-side, and supply-side strategies measured in Study 3. The worksheet developed for Study 3 could be modified to compare the effectiveness of strategies at a district scale.

Study objectives:

- Calibrate the emissions worksheet for district-scale use
- Define neighbourhood-scale GHG mitigation strategies
- Measure and compare their effectiveness

8.5 THE FUTURE OF CLIMATE ACTION PLANNING FOR CITIES

The findings in this thesis make a significant contribution towards the goal of understanding the benefits of the city design in climate action planning. Research identifies smart growth actions being used by cities for mitigation of GHG emissions and their relative effectiveness. The results should be of interest to cities, state and federal agencies, and other researchers in their efforts to cerate, inform, support, and implement climate action plans.

U.S. cities surveyed in this thesis are pioneers at the forefront of climate change leadership and innovation. The research captures this first generation of CAP cities in early phases of implementing climate strategies. Their mitigation and adaptation actions include land use strategies that are being incorporated into their comprehensive plans, thereby improving their performance and changing investment patterns.

Research underscores the importance of urban design as a tool in the CAP toolbox. The need to optimize the passive performance of cities requires constant improvement of the public realm. Despite use of common smart growth strategies, cities will look different. Kostof (1991) reminds us, cities are artefacts of their birthplace, form, and makers. Every city has a unique physical circumstance, exists as part of a cluster, and possesses an identifiable monumental framework.

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APPENDIX A

STUDY 1: Case Study Interview Notes

Key West, FL
Bozeman, MT
Annapolis, MD
Boulder, CO
Berkeley, CA
Portland, OR
Austin, TX
Chicago, IL

Case Study Questions

Annalise Mannix, Environmental Projects Manager, City of Key West (retired civil engineer)
Phone: 305-797-0463, Email: amannix@aol.com

11-12-10 interview

<table>
<tr><th colspan="2">Questions</th><th>Notes</th></tr>
<tr><td>Q1-

Why did your city prepare a climate action plan?</td><td>Degree to which motivation is based on local values:

O O O O X
Low High</td><td>Motivation for CAP:
• Only reason City Commission and Mayor supported CAP process and plan was community advocacy
• Community advocates (name) selected and promoted candidates
• Completed both municipal and community CAP</td></tr>
<tr><td>Q2-

How has your city responded to state and federal policy regarding preparing the climate action plan?</td><td>Degree to which motivation is based on state-level policies:

X O O O O
Low High</td><td>Voluntary contents of CAP:
• Key West was an early adopter - - was out in front of the State
• At the time, Fla had not completed CAP or RPS requirements.
• HB763(?) requires cities and towns to include metrics for sea level change and GHG emissions
• These requirements will influence Key West's future plan updates

Mandated contents of CAP: in the future
• Metrics for sea level rise and GHG emissions
• Now requires RPS</td></tr>
<tr><td>Q3-

How did you choose GHG inventory and modeling software tools?</td><td>Degree which an off-the-shelf vs. customized tool kit was used:

X O O O O
Off-the shelf High

Degree which an off-the-shelf process vs. customized was used:

X O O O O
Off-the shelf High</td><td>(See Jody Smith Williams' interview - - used ICLEI tools and process)

Types of GHG INVENTORY TOOLS:

Types of STRATEGY FORMATION TOOLS:

Types of ACTION PLANNING TOOLS:

Types of IMPLEMENTATION AND MONITORING TOOLS:

• Action plan was prepared by Annalise identifying actions and responsible staff - - is sent to the Commission in monthly reports
• Economic slowdown has impacted implementation - - staff reduced from 14 to 7 and there is not budget for implementation</td></tr>
<tr><td>Q4-

In the future, how will the climate action planning influence the form of your city?</td><td>Degree to which CAP is integrated into a comprehensive plan or sustainability plan:

O O X O O
Low High

Degree to which CAP influences the future physical form of the city:

O O X O O
Low High</td><td>Ways in which the CAP is integrated into comprehensive or sustainability planning:

CAP strategies that influence:

• land use patterns and densities: adaptation strategies

• infrastructure design: scope of waste planning and scope and location of public improvements - - will it have a 50 year life due to rising sea level?

• transportation planning: scope of transportation studies

Other CAP strategies that impact the future shape of the city:</td></tr>
</table>

		• Currently used in preparing a citywide Strategic Plan • Influenced technical studies related to implementation actions - - transportation and solid waste planning • Sea level rise is a difficult issue to discuss with the community - - could see 75% of Key West under water by 2100 • CAP was used to promote policies • Adaptation Plan is used by Commission and funding requests - - not for promotion because it acknowledges the impact on real estate value
Q5- Why were certain software tools and related processes effective?	Degree to which CAP tools were effective (easy to use, informative and flexible/customizable): O O X O O Low High	(See Jody Smith Williams' interview - - used ICLEI tools and process) Strongest features in CAP tools: Weakest features in CAP tools:

Interviewed:

Case Study Questions
KEY West, FL

Interviewed: Jody Smith Williams, Consultant (and local advocate/activist) that Prepared GHG Inventory with ICLEI

Oct. 28, 2010

<table>
<tr><th colspan="2">Questions</th><th>Notes</th></tr>
<tr><td>Q1-

Why did your city prepare a climate action plan?</td><td>Degree to which motivation is based on local values:

O O O O X
Low High</td><td>Motivation for CAP:

All part of planning for the future
Political motivation - - lead by mayor and endorsed by council
Activist started to lobby the City in 2007 to prepare a CAP
Discussion at GLE (Green Living & Energy Education) (http://www.keysglee.com/index.cfm/about-glee/) with all 6 communities on the Keys
One of the first communities in FLA to do a CAP and join ICLEI
Part of quality of life planning</td></tr>
<tr><td>Q2-

How has your city responded to state and federal policy regarding preparing the climate action plan?</td><td>Degree to which motivation is based on state-level policies:

X O O O O
Low High</td><td>Voluntary contents of CAP:

No state mandate at the time
Inspired by other communities, not the state

Mandated contents of CAP:</td></tr>
<tr><td>Q3-

How did you choose GHG inventory and modeling software tools?</td><td>Degree which an off-the-shelf vs. customized tool kit was used:

O O O O X
Low High

Degree which an off-the-shelf process vs. customized was used:

O O O O X
Low High</td><td>Used ICLEI tools and process

Types of GHG INVENTORY TOOLS: ICLEI

Types of STRATEGY FORMATION TOOLS: ICLEI? Ask Annnalise

Types of ACTION PLANNING TOOLS: ICLEI? Ask Annnalise

Types of IMPLEMENTATION AND MONITORING TOOLS: ICLEI? Ask Annnalise</td></tr>
<tr><td>Q4-

In the future, how will the climate action planning influence the form of your city?</td><td>Degree to which CAP is integrated into a comprehensive plan or sustainability plan:

O O X O O
Low High

Degree to which CAP influences the future physical form of the city:

O O O O O
Low High</td><td>Ways in which the CAP is integrated into comprehensive or sustainability planning: ONGOING

CAP strategies that influence:
• land use patterns and densities: Being used now by Strategic Planning Committee, Sustainability Advisory Board - - “as a reminder”
• infrastructure design: above
• transportation planning: Used to guide mixed-mode planning in city “traffic study”

Other CAP strategies that impact the future shape of the city:
City hall project planned and programmed to support objectives</td></tr>
<tr><td>Q5-</td><td>Degree to which CAP tools were effective (easy to use, informative</td><td>Strongest features in CAP tools:
Good model to follow, full package and technical support for</td></tr>
</table>

Why were certain software tools and related processes effective?	and flexible/customizable): O O X O O Low High	small cities without resources Weakest features in CAP tools: Some calibration problems, particularly with solid waste calcs - - these have been patched by successive software updates. ICLEI was working on a web-based tool, and that would have been handy. Version compatibility for early modeling - - lost data entries ICLEI software was developed by consultants. ICLEI staff could not always answer questions ISSUE: Besides sea level rise, the Keys have their trash and recyclables hauled 200 miles. It has a big carbon footprint. Cities records for energy use were poorly maintained (overlapping accounts, lack of awareness- - a lot of assumptions had to be made. On the plus side, the process improved record keeping of energy use and awareness about measuring progress OTHER: Annalise did the strategy and policy work (now retired). She can answer those questions better. Terry Johnston on the City Commission would be a good policymaker to talk to. Check the website for her contact info.

Case Study Questions

Hattie Baker, Consultant
Bozeman Sustainability Coordinator
Phone: (406) 209-4719
Email: climateprotection@bozeman.net
Natalie Meyer, Grants and Climate Coordinator, City of Bozeman
Phone: (406) 582-2317
Email: nmeyer@bozeman.net
11-4-10 interview

Questions		**Notes**
Q1- Why did your city prepare a climate action plan?	Degree to which motivation is based on local values: O O O O X Low High	Motivation for CAP: • Bozeman signed onto Mayors Climate Protection Agreement • Citizen-driven effort • Still wrestling with communications - - website not up and running and do not have a systematic approach to educating the community - - requires staff time and budget
Q2- How has your city responded to state and federal policy regarding preparing the climate action plan?	Degree to which motivation is based on state-level policies: X O O O O Low High	Voluntary contents of CAP: • Municipal and Community CAPs • MCAP had 15 member taskforce met once/month over the year - - three working groups • CCAP organized as four working groups - - each met last year four times • Taskfroce was appointed by Commission (stakeholders identified in grant) • One year process time limit based on grant - - needed more time - - took three months just to do the inventory • Have new two-year grant and almost complete Mandated contents of CAP: • The grant mandated some aspects of participation • Not aware of any state requirements
Q3- How did you choose GHG inventory and modeling software tools?	Degree which an off-the-shelf vs. customized tool kit was used: O O O X O Low High Degree which an off-the-shelf process vs. customized was used: O X O O O Low High	Types of GHG INVENTORY TOOLS: ICLIE • Used ICIE process and tools (80% - - modified about 20% of ICLIE to fit Bozeman) • ICLIE provided tech support - - but not enough - - not as much help as hoped - - took a long tme to hear back from ICLIE Types of STRATEGY FORMATION TOOLS: ICLIE • The inventory was not used enough in the stratgy-making step • Did not lead to a comprehensive work plan • Hard to validate ICLEI model - - BLACK BOX, opeque • Forced city to start tracking energy use Types of ACTION PLANNING TOOLS: NA • Been more oportunistic than strategic - - based on funding • Ued for grant writing Types of IMPLEMENTATION AND MONITORING TOOLS:

		• Communications effort is the big challenge now • Getting people to take action through peer presure • The MCAP does connect with the CIP - - this is a updated annually and all expenditures over $10k are evaluated on a scale of 1 to 5 interms of meeting objectives in the MCAP
Q4- In the future, how will the climate action planning influence the form of your city?	Degree to which CAP is integrated into a comprehensive plan or sustainability plan: O O O O O Low High Degree to which CAP influences the future physical form of the city: O O O O O Low High	Ways in which the CAP is integrated into comprehensive or sustainability planning: • Recently updated Comprehensive Plan • Referred to CAP enough to justify having a sustainability section • Already using some "smart growth" polices • CAP does reinforce some popular policies • Inventory was not used enough for policymaking CAP strategies that influence: • land use patterns and densities: • infrastructure design: • transportation planning: Other CAP strategies that impact the future shape of the city: • 88 recommendations were shortened down to 20 leading ones
Q5- Why were certain software tools and related processes effective?	Degree to which CAP tools were effective (easy to use, informative and flexible/customizable): O O O O O Low High	Strongest features in CAP tools: ICLIE • ICLIE good for a start-up effort for cities w/out expertise ot resources • ICLIE network - - learned from networking w/ other communities (Boulder, Bellingham, WA were helpful) • Did force city to start tracking energy use Weakest features in CAP tools: ICIE • Opeque, black box • Had to customize some of it to work • Not enough tech help

Interviewed:

Case Study Questions
Rob Savage, Environmental Coord.
410-263-7946
City of Annapolis, MD
12-8-10

Questions		**Notes**
Q1- Why did your city prepare a climate action plan?	Degree to which motivation is based on local values: O O O O X Low High	Motivation for CAP: • The former mayor and City Council took the lead with the administration - - with a lot of community support • Mayor signed on to Mayors Climate Protection Agreement and joined ICLEI • A lot of community involvement - - 2 larger meetings (with 50+ people) and a dozen smaller outreach meetings to community organizations • Motivation by sea level change - - hurricanes, higher tides • Received grant funding for emissions inventory from DNR and other grants for sea level rise study
Q2- How has your city responded to state and federal policy regarding preparing the climate action plan?	Degree to which motivation is based on state-level policies: O X O O O Low High	Voluntary contents of CAP: • ICEI approach all voluntary - - supported with Council resolutions Mandated contents of CAP: • None - - comp plans do have state regulations that are dealt with by the Planning Department
Q3- How did you choose GHG inventory and modeling software tools?	Degree which an off-the-shelf vs. customized tool kit was used: O O O O X Low High Degree which an off-the-shelf process vs. customized was used: O O O O O Low High	Types of GHG INVENTORY TOOLS: • ICLEI CACP software Types of STRATEGY FORMATION TOOLS: Types of ACTION PLANNING TOOLS: Types of IMPLEMENTATION AND MONITORING TOOLS: • Creating annual "Score Cards" to track GHG emissions progress • Accounting software: ICLEI - - Climate & Air Pollution Planning Assistant (CAPPA)
Q4- In the future, how will the climate action planning influence the form of your city?	Degree to which CAP is integrated into a comprehensive plan or sustainability plan: O X O O O Low High Degree to which CAP influences the future physical form of the city: O X O O O Low High	Ways in which the CAP is integrated into comprehensive or sustainability planning: Mostly went into Chapter 7: Environment CAP strategies that influence: • land use patterns and densities: • infrastructure design: • transportation planning: Other CAP strategies that impact the future shape of the city: • CAP and Comp Plan process ran parallel and managed by

		different departments • Released around the same time • Could use added effort to integrate CAP strategies into the comprehensive planning
Q5- Why were certain software tools and related processes effective?	Degree to which CAP tools were effective (easy to use, informative and flexible/customizable): O O X X O Low High	Strongest features in CAP tools: • ICEI's CACP software is readily available, and comes with support and training • Good for bigger picture planning • Preparing the inventory helped the City better understand efficiency opportunities in municipal operations • Weakest features in CAP tools: • ICLEI tools not as useful for ongoing planning • Need for more customization - - this should be easier • EPA's Portfolio Manager software better for more detailed inventory and performance tracking - - may switch in the future • CAPPA used for implementation modeling but not as user friendly unless you are good with spreadsheets • Not used as much for Score Card • ICLEI was helpful in startup but now are providing services for a fee Other Issues: • Former mayor had inter-department "Green Team", this needs to be reestablished to better coordinate action plan implementation • No current discussion regarding updating the Comprehensive Plan, just discussing the Score Card • CIP is DPW's job, not sure how they are implementing the MCAP/CCAP recommendations • The MCAP is showing progress - - however, the CCAP is not. It is increasing - - there needs to be a way to encourage the community to purchase green power (through Maryland's green power programs, where it actually costs less) • Preparing the CAP inventory and Score Card efforts provide an opportunity for City departments to showcase their programs and efforts.

Interviewed:

Case Study Questions

Jonathan Koehn, staff to Environmental Advisory Board
Phone: 303-441-1915 cel: 303-396-4582
Email: koehnj@bouldercolorado.gov
Interview: 11-19-10

Questions		**Notes**
Q1- Why did your city prepare a climate action plan?	Degree to which motivation is based on local values: O O O O X Low High	Motivation for CAP: • Long tradition as sustainable community • First green building code in US • Has been willing to tax itself to implement GHG and sustainability polices (first local local carbon tax in US) • City adjusted - - switched from incentive-based to regulatory program to meet 2012 targets - - big policy decision
Q2- How has your city responded to state and federal policy regarding preparing the climate action plan?	Degree to which motivation is based on state-level policies: X O O O O Low High	Voluntary contents of CAP: • All of it Mandated contents of CAP: • State has RPS, but the trends are still towards coal (Xcel Energy)
Q3- How did you choose GHG inventory and modeling software tools?	Degree which an off-the-shelf vs. customized tool kit was used: x O O O O Low High Degree which an off-the-shelf process vs. customized was used: O O O O x Low High	Types of GHG INVENTORY TOOLS: • Alacarte - - all local effort, local company (WSP Environment and Energy) • ICLIE good programs but too cookie cutter Types of STRATEGY FORMATION TOOLS: Types of ACTION PLANNING TOOLS: Types of IMPLEMENTATION AND MONITORING TOOLS: • Incentive-based tools - - were not working well enough
Q4- In the future, how will the climate action planning influence the form of your city?	Degree to which CAP is integrated into a comprehensive plan or sustainability plan: O O O O x Low High Degree to which CAP influences the future physical form of the city: O O x O O Low High	Ways in which the CAP is integrated into comprehensive or sustainability planning: • Currently updating the comp plan • Repackaging plan around "triple bottom line" • Has a sustainability "underlay" • Work-papers for comp plan are on-line CAP strategies that influence: • land use patterns and densities: • infrastructure design: • transportation planning: Other CAP strategies that impact the future shape of the city: • Get "green points" and get density bonuses of 50-70% FAR • Efficiency programs for commercial projects - - $25M for "2-techs in a truck" program • Local improvement districts with granting and bonding

		capacity - - localized PACE program (Property Assessed Clean Energy)

Q5-
 	
Why were certain software tools and related processes effective?
	Degree to which CAP tools were effective (easy to use, informative and flexible/customizable):
	
	O O O x O
	Low High
		Strongest features in CAP tools:
		• Locally developed and informed
		
		Weakest features in CAP tools:
		• Depended on Xcel for energy data - - not always agregated in a useful way
		
		Other:
		• Tradition for demand supply programs - - smart grid (Xcel's "smart grid city"), building codes, energy audits, etc.
		• In order to meet GHG emision goals, new focus on supply side for energy including locally generated and distributed power - - one new coal plant developed by Xcel increased the coal-source energy for Boulder from 57% to 65%. Therefore, the city could not meet its emission goals - - in spite of State RPS goals of 30% GHG reduction by 2020 - - city still held hostage by Xcel's portfolio.
		• Very public process - - are trying to get ready to send proposal to the ballot box next fall
		• People see that cost of energy is going up - - will be economic impacts - - integrate more renewables, time-use pricing
		• Now evaluating options to Xcel in cluding a municipal energy solution:
		  o Xcel franchise for ROWs creates $4M/yr for general fund
		  o Proposed new energy tax on Xcel to replace the franchise fees
		  o May broker own energy deal or negotiate clean energy franchise with Xcel
		• Communicating data - - real time information
		• Requires SOCIAL MOBILIZATION
		• Message for every-day people - - data, information, intelligence with a feedback loop
		• Do not alienate the business community. Make sure they realize how vulnerable they are under the current energy model. Work with them. Implementing the CAP will require $460M in private investment, leveraged by $18M in public. Discuss economic growth, prosperity, and equity. Redefine sustainability as a business opportunity.

Interviewed:

Case Study Questions
Berkelely, CA

Timothy Burroughs
Climate Action Coordinator, Office of Energy & Sustainable Development, City of Berkeley
October 29, 2010
p 510.981.7437, tburroughs@cityofberkeley.info, www.cityofberkeley.info/climate
NOTE RE Timothy: former ICLEI staff in Oakland, did inventory in CA, at Berkeley for four years, coord efforts between departments, models and help communicate

Questions		**Notes**
Q1- Why did your city prepare a climate action plan?	Degree to which motivation is based on local values: O O O O X Low High	Motivation for CAP: • Measure G in 2006 - - over 80% approval, community demanded it. Drafted by mayor, city council, and citizens. Requires 80% below 1990 GHG levels by 2050. • Community concerned about environmental and social justice - - leadership around public policy (reputation for) • Focus on community participation. OK to contact Mayor's office: Nils Mo (nmoe@cityofberkeley.info)
Q2- How has your city responded to state and federal policy regarding preparing the climate action plan?	Degree to which motivation is based on state-level policies: O X O O O Low High	Voluntary contents of CAP: • CAP - - was prepared before AB32. • Not a regulation to prepare a CAP but do have to be accountable for GHG emissions. • Solar roofs - - property-based program FHFA stopped it (no leans before mortgage) - - State may do this • Mandated contents of CAP: • Added force and motivation and coordination with state and local government. • Updated General Plan (EIRs) take into account GHG impacts • New development is required to account for GHG impacts in EIR • SB375 adds clout - - cities need to plan for lower GHG emissions
Q3- How did you choose GHG inventory and modeling software tools?	Degree which an off-the-shelf vs. customized tool kit was used: O X O O O Low High Degree which an off-the-shelf process vs. customized was used: O O O O X Low High	Types of GHG INVENTORY TOOLS: • GHG inventory was done by Bay Area Air Quality Control District for Alameda County • ICEI tools a "giant calculator" Types of STRATEGY FORMATION TOOLS: • Custom built spreadsheet - - "less of a black box" Types of ACTION PLANNING TOOLS: • Custom approach to metrics and measuring results • Using software called "SEE IT" by Visible Strategies Co. • Presentation tools Types of IMPLEMENTATION AND MONITORING TOOLS: • New tools are better - - web-based, better presentation of data • Emphasis on communications - - website • Interdepartmental teams

		• Fund raising emphasis for unfunded CAP strategies • Staff time for management
Q4- In the future, how will the climate action planning influence the form of your city?	Degree to which CAP is integrated into a comprehensive plan or sustainability plan: O O X O O Low High Degree to which CAP influences the future physical form of the city: O O X O O Low High Adds clout to policies being pursued	Ways in which the CAP is integrated into comprehensive or sustainability planning: CAP strategies that influence: • land use patterns and densities: • reinforces policies Berkeley is already working on - - density and transit around BART stations, corridors (univ ave, san pablo ave) • infrastructure design: • transportation planning: Other CAP strategies that impact the future shape of the city: • Density around transit stations and corridors • On-going battle over neighborhood preservation, character, and generally against change
Q5- Why were certain software tools and related processes effective?	Degree to which CAP tools were effective (easy to use, informative and flexible/customizable): O O O X O Low High Customized but still hard to quantify benefits	Strongest features in CAP tools: • ICEI work well for smaller cities without resources • ICEI good to start-up the process Weakest features in CAP tools: • ICLEI is a Black Box - - wants more control over data and presentation • ICLEI does not do the strategy unless you contract them to do so • Hard to quantify benefits - - like bikes lanes

Interviewed:

Case Study Questions
Susan Anderson, Portland Bureau of Planning and Sustainability
Phone: 503 823-7222
Email: susananderson@ci.portland.or.us
November 5, 2010

<table>
<tr><th colspan="2">Questions</th><th>Notes</th></tr>
<tr><td>Q1-

Why did your city prepare a climate action plan?</td><td>Degree to which motivation is based on local values:

O O O O X
Low High</td><td>Motivation for CAP:
Stated to plan for climate change in the early 1990's - - saw it as a bigger issue, and cities have to take a proactive position
Other motivations: creates (green) jobs, reduces costs, results in healthier communities
Finally, in the past 3-5 years we can actually discuss climate change
Merged planning and sustainability functions of City into single department
Started in the 90's with a dozen cities from around the world (including Copenhagen and Dade County, FL, others)</td></tr>
<tr><td>Q2-

How has your city responded to state and federal policy regarding preparing the climate action plan?</td><td>Degree to which motivation is based on state-level policies:

O X O O O
Low High</td><td>Voluntary contents of CAP:
All voluntary - - however, Oregon's regional planning and growth management framework gives cities greater incentive to implement infill and smart growth projects
Regionally elected reps can work at a comprehensive approach
Mandated contents of CAP:</td></tr>
<tr><td>Q3-

How did you choose GHG inventory and modeling software tools?</td><td>Degree which an off-the-shelf vs. customized tool kit was used:

O O O O X
Low custom

Degree which an off-the-shelf process vs. customized was used:

O O O O X
Low custom</td><td>Types of GHG INVENTORY TOOLS:
Pre-ICLEI, used own customized framework
ICLEI good for smaller cities without resources
Portland needed a model that works
Types of STRATEGY FORMATION TOOLS:

Types of ACTION PLANNING TOOLS:

Types of IMPLEMENTATION AND MONITORING TOOLS:

** call Michelle Armstrong at Metro planning and ask about current tools - - new EPA approach</td></tr>
<tr><td>Q4-

In the future, how will the climate action planning influence the form of your city?</td><td>Degree to which CAP is integrated into a comprehensive plan or sustainability plan:

O O O O X
Low High

Degree to which CAP influences the future physical form of the city:</td><td>Ways in which the CAP is integrated into comprehensive or sustainability planning:
Currently updating comp plan - - first time in 25 years - - 20-30% complete
Using strategic plan for outreach and then supported with plan update
Greater focus on equity issues (social and economic)
Uses 20-minute neighborhood concept at its core
CAP is integrated into comp planning, even more so</td></tr>
</table>

	O O O O X Low High	rather than traditional focus on zoning and urban design - - and provides expanded tools - - statewide growth management relieves political pressure on locals • CAP has changed focus at local and regional scales - - overall • CAP strategies that influence: • land use patterns and densities: • infrastructure design: • transportation planning: Other CAP strategies that impact the future shape of the city:
Q5- Why were certain software tools and related processes effective?	Degree to which CAP tools were effective (easy to use, informative and flexible/customizable): O O O X O Low High	Strongest features in CAP tools: Weakest features in CAP tools: Going forward: • Need for tools that are science-based • Need for strong business and political champions • Focus on messaging and PR - - short, seven word sentences, simple ideas that people can take action on

Interviewed:

Case Study Questions
Austin, TX
Ester Matthews, Director,
Austin Climate Protection Program at City of Austin/Austin Energy
512-322-6041
November 22, 2010
(retiring in January 2011)

Questions		**Notes**
Q1- Why did your city prepare a climate action plan?	Degree to which motivation is based on local values: O O O O X Low High	Motivation for CAP: • Individuals with a longstanding commitment to sustainability took the lead on the CAP process - - former mayor became the Austin Energy department head • Mayor Wynn signed the Mayors Climate Protection Agreement • It was the mayors proposal to do the CAP, the council agreed and then the draft CAP was taken to the community • Currently doing charrettes in the Community Action Plan Process • Trying to convince the task force, it is NOT the City but the community doing this
Q2- How has your city responded to state and federal policy regarding preparing the climate action plan?	Degree to which motivation is based on state-level policies: X O O O O Low High	Voluntary contents of CAP: • Fully voluntary - - no state legislation forcing cities to do this • Austin is the only Texas city doing a CAP Mandated contents of CAP:
Q3- How did you choose GHG inventory and modeling software tools?	Degree which an off-the-shelf vs. customized tool kit was used: X O O O O Low High Degree which an off-the-shelf process vs. customized was used: O O O O X Low High	Types of GHG INVENTORY TOOLS: Types of STRATEGY FORMATION TOOLS: Types of ACTION PLANNING TOOLS: Types of IMPLEMENTATION AND MONITORING TOOLS: • Developed own tools • Inventory is a good start • Part of California Climate Registry - - hoping it becomes the national model • Helped with registry protocol - - 3 years worth of inventory • EPA - - now reporting to EPA, ICLEI too
Q4- In the future, how will the climate action planning influence the form of your	Degree to which CAP is integrated into a comprehensive plan or sustainability plan: X O O O O Low High Degree to which CAP influences	Ways in which the CAP is integrated into comprehensive or sustainability planning: • Lucia started in Sept as the overall coordinator - - climate is one small part of her portfolio • She will inherit Austin Energy - - already started community process, "what would you prefer?" and emissions discussion

city?	the future physical form of the city: O O X O O Low High	• Existing programs are already in baseline • There are staff teams • ISSUES with comp plan process - - • Alternatives are not that different from an emissions stand point - - not really a true variety of choices • Austin is spread out, limited transportation options, lacks a decent metro system, poor bus and LRT service • AH HA moments - - • Downtown housing 25,000 new residents, but many turned into second homes, so not so sustainable • University area has highest density and share cost of utilities • Close-in neighborhoods have revitalized CAP strategies that influence: • land use patterns and densities: • infrastructure design: • transportation planning: Other CAP strategies that impact the future shape of the city:
Q5- Why were certain software tools and related processes effective?	Degree to which CAP tools were effective (easy to use, informative and flexible/customizable): O O O O X Low High	Strongest features in CAP tools: Weakest features in CAP tools: Lessons learned: • Imbed energy efficiency into building codes - - using international building code and increasing efficiency requirements every three years • Developed and used own energy/emission inventory tools • Each city department has to make the commitment to reduce GHG emissions over the next 10 years - - includes incentives • Since 2003 - - hyping hybrid vehicles and planning for plug-ins • "point of sale" residential properties require energy audits OK for houses but 2 years to get MF and commercial property to provide documentation - - it is delayed and hard to report - - not a good tool •

Interviewed:

Case Study Questions
Joyce Coffee, Director of Project Development, Policy and Research
City of Chicago, Department of Environment
joycecoffe@cityofChicago.org, 312-742-0151
Nov. 12, 2010 interview

<table>
<tr><th colspan="2">Questions</th><th>Notes</th></tr>
<tr><td>Q1-

Why did your city prepare a climate action plan?</td><td>Degree to which motivation is based on local values:

O O O O X
Low High</td><td>Motivation for CAP:
• Push by the private sector
• Local advocates in and outside the City
• Several thousand people to part in process
• Focus on quality of life based on Field Museum study- - Quality of Life Plan, more relevant to average Chicagoan than climate change. Example:
  o Energy Action Network - - power “shut off protection” for residents (CETA)
  o CDCs office for energy action at the neighborhood level
  o Conservation Corps program offering five weeks of training, neighborhood projects and weatherization (17,000 homes completed)
• Funding
  o $100M in Fed stimulus funding
  o $20M from state
  o City $20M
  o Grants--$20M from Utls
  o $12M in private</td></tr>
<tr><td>Q2-

How has your city responded to state and federal policy regarding preparing the climate action plan?</td><td>Degree to which motivation is based on state-level policies:

O X O O O
Low High</td><td>Voluntary contents of CAP:

Mandated contents of CAP:
• Illinois RPS</td></tr>
<tr><td>Q3-

How did you choose GHG inventory and modeling software tools?</td><td>Degree which an off-the-shelf vs. customized tool kit was used:

O O O O X
Low High

Degree which an off-the-shelf process vs. customized was used:

O O O O X
Low High</td><td>CAP planning and GHG inventory:
• Center for Neighborhood Technology developed inventory tools (http://www.cnt.org/) and supported CAP process
• (CNT offers various downloadable spreadsheets - - http://www.cnt.org/toolbox)

FROM CNT website - - http://www.cnt.org/climate/:

Chicago Climate Report
CNT was the lead researcher for the climate change mitigation elements of Chicagoâ€™ s Climate Action Plan, advising the city by developing an emissions inventory and forecast for Chicago and the metro region, as well as researching, modeling and evaluating 33 different mitigation strategies.

Clinton Foundation Partnership
In conjunction with the William J. Clinton Foundation, CNT has designed an online tool for measuring greenhouse gas emissions in the world’s 40 largest cities,</td></tr>
</table>

		thus providing critical information to enable climate action. Types of GHG INVENTORY TOOLS: Types of STRATEGY FORMATION TOOLS: Types of ACTION PLANNING TOOLS: Types of IMPLEMENTATION AND MONITORING TOOLS: • Kresge Foundation Grant for "continuous improvements" • Carbonetworks - - new software vendor selected through competitive process • PSViews being used for presentation/graphic representation of data (Adobe Systems?)
Q4- In the future, how will the climate action planning influence the form of your city?	Degree to which CAP is integrated into a comprehensive plan or sustainability plan: X O O O O Low High Degree to which CAP influences the future physical form of the city: O O O O X Low High	Ways in which the CAP is integrated into comprehensive or sustainability planning: • CAP actions are implemented as projects and programs • "take easy steps" program did not connect to average Chicagoan – focus on quality of life and • Chicago has subarea plans - - no comp plan • Quality of Life Plan approaches CAP as a global problem CAP strategies that influence: • land use patterns and densities: • infrastructure design: • transportation planning: Other CAP strategies that impact the future shape of the city: • Chicago does not have a comprehensive plan but a set of district and neighborhood plans • The CAP gets implemented through programs and projects and aggressive monitoring

Q5-
 	
Why were certain software tools and related processes effective?
	Degree to which CAP tools were effective (easy to use, informative and flexible/customizable):
	
	O O O X O
	Low High
		Strongest features in CAP tools:
		
		Weakest features in CAP tools:
		
		CHICAGO CONTINOUS IMPROVEMENT THROUGH PERFORMANCE MEASURMENT
		
		• Currently working under Kresge Foundation Grant for "continuous improvement program".
		• Expected to share results and contribute to understanding and implementation of best practices.
		• Overall objectives include:
		  o Best practice
		  o Mitigated actions
		  o Measure performance
		  o Gather data in a comprehensive manner
		  o Measure GHG mitigation for specific CAP

		indicators - - environmental indicators for progress

Interviewed:

APPENDIX B

STUDY 2: Survey Results and Sample Tables

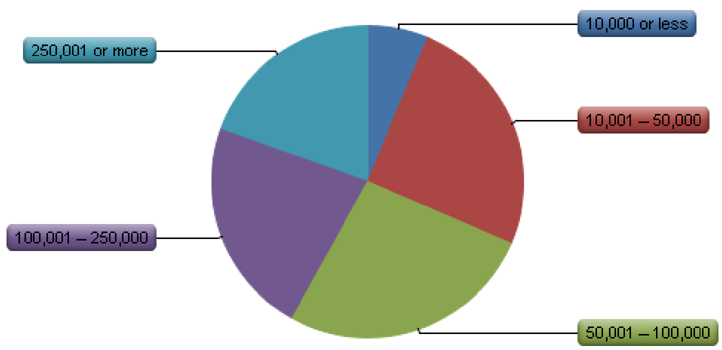
Survey Summary

Sample Tables

Initial Report

Last Modified: 05/09/2013

1. Q1.1 CITY POPULATION: What is your city's population? (select one)



#	Answer	Bar	Response	%
1	10,000 or less		9	6%
2	10,001 – 50,000		36	25%
3	50,001 – 100,000		38	27%
4	100,001 – 250,000		32	22%
5	250,001 or more		28	20%
	Total		143	

Statistic	Value
Min Value	1
Max Value	5
Mean	3.24
Variance	1.46
Standard Deviation	1.21
Total Responses	143

2. CLIMATE REGION: Use the map diagram to identifywhich cli...

#	Answer	Bar	Response	%
1	Northwest		15	10%
2	West		47	33%
4	Southwest		8	6%
3	Northern Rockies and Plains (West North Central)		3	2%
5	Upper Midwest (East North Central)		16	11%
6	Ohio Valley (Central)		15	10%
7	South		7	5%
9	Southeast		10	7%
8	Northeast		18	13%
10	Alaska		4	3%
11	Hawaii		0	0%
	Total		143	

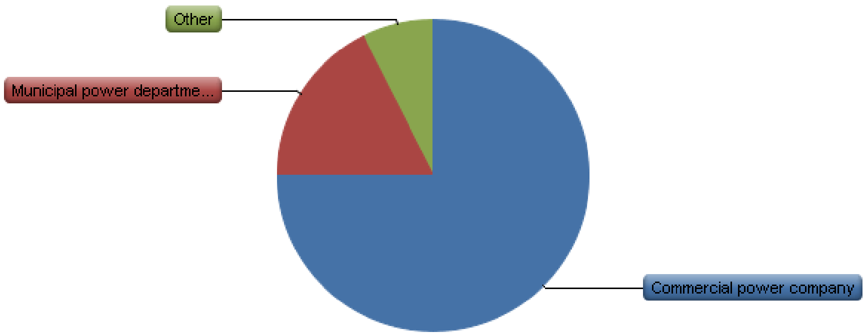
Statistic	Value
Min Value	1
Max Value	10
Mean	4.50
Variance	7.83
Standard Deviation	2.80
Total Responses	143

3. eGRID EMMISSION SUBREGION: Use the eGRID map toidentify ...

#	Answer	Bar	Response	%
14	CAMX		46	32%
15	NWPP		15	10%
16	AZNM		6	4%
17	RMPA		4	3%
18	MROW		8	6%
19	SPNO		2	1%
20	SPNO		1	1%
21	SPSO		1	1%
22	ERCT		3	2%
23	MROE		4	3%
24	SRMW		2	1%
25	SRMV		1	1%
26	RFCM		7	5%
27	RFCW		7	5%
28	SRTV		5	3%
29	SRSO		0	0%
30	FRCC		1	1%
31	NEWE		9	6%
32	NYUP		1	1%
33	NYLI		1	1%
34	NUCW		0	0%
35	RFCE		7	5%
36	SRVC		8	6%
37	AKMS		1	1%
38	AKGD		3	2%
39	HIOA		0	0%
40	HIMS		0	0%
	Total		143	

Statistic	Value
Min Value	14
Max Value	38
Mean	21.37
Variance	65.74
Standard Deviation	8.11
Total Responses	143

4. Q1.4 SOURCE OF ELECTRICAL POWER: What is the primary source of your community's electrical power? (select all that apply)



#	Answer	Bar	Response	%
1	Commercial power company		111	78%
2	Municipal power department/agency		26	18%
3	Other		11	8%

Other
PG&E
investor owned utility
public utility district
Federal Power Company (TVA)
NYSEG
Public Utility District
investor-owned electric utility
Regional buying cooperative
TVA
Power Cooperative
Commercial supplier but through a contract based on municipal aggregation

Statistic	Value
Min Value	1
Max Value	3
Total Responses	143

5. Q1.5 FORM OF LOCAL GOVERNMENT: What form of local government does your city have?(select one)

#	Answer	Bar	Response	%
1	Strong Mayor		20	14%
2	Weak Mayor		14	10%
3	Commission-Manager		8	6%
4	Mayor-Council		60	42%
5	Mayor-Commission		0	0%
6	Council Manager		27	19%
7	City Commission		1	1%
8	Other		13	9%
	Total		143	

Other
Modified Commission
Weak Mayor, No City Manager, It's Complicated
Not sure. Either Mayor-Council or Council Manager
MAYOR-COUNCIL-MANAGER
County Executive
City Manager / City Council
Weak Mayor, Commission, City Manager
City Manager
Council- City Manager
Council - City Manager
Mayor, Council, & City Manager
City Manger
Mayor-Council-Manager

Statistic	Value
Min Value	1
Max Value	8
Mean	4.09
Variance	4.00
Standard Deviation	2.00
Total Responses	143

6. Q1.6 COMPREHENSIVE PLAN REQUIREMENTS: How does your city approach comprehensive planning?(select all that apply)

#	Answer	Bar	Response	%
1	Do not have a comprehensive plan		4	3%
2	Have a comprehensive plan		123	86%
3	Part of a regional planning framework		55	38%
4	Use a strategic planning approach to inform planning policy		51	36%
5	Have elements or sections required by state law		57	40%
6	Other		5	3%

Other
General Plan, as required by CA State law
City has a General Plan and Climate Action Plan among many other department specific planning documents
Sustainability Plan
Sustainability Plan
comprehensive plan under development

Statistic	Value
Min Value	1
Max Value	6
Total Responses	143

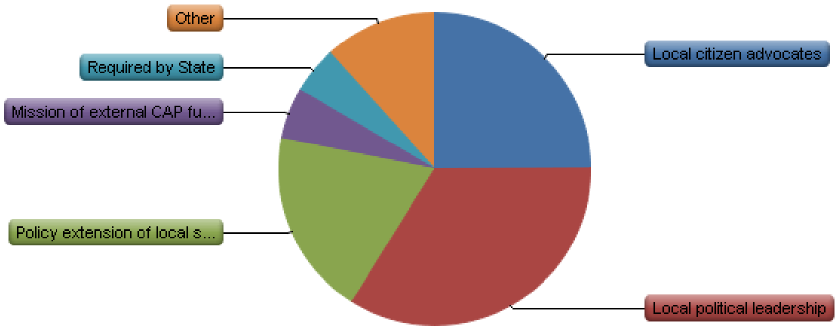
7. Q1.7 STATE CLIMATE CHANGE POLICIES: How does your state influence local climate change policy? (select all that apply)

#	Answer	Bar	Response	%
1	State does not influence local climate change mitigation or adaptation policies		38	27%
2	State Leads by Example (LBE) with State Climate Action Plan (CAP)		53	38%
3	State has a Renewable Portfolio Standard (RPS)		76	54%
4	Uses incentives		62	44%
5	State energy efficiency regulations		74	53%
6	State air quality regulations		78	56%
7	State Greenhouse Gas (GHG) emission regulations		46	33%
8	State adaptation policies/regulations		31	22%
9	Other		21	15%

Other
Vehicle and fuel standards
SB 375, land use and transportation legislation
State Comprehensive Energy Plan
Many CA policies/regs in place
GHG emissions targets
CEQA
Sustainable building and solar equipment tax rebates
sECTOR-SPECIFIC PROGRAMS
State GHG reduction targets, but no implementing regulations for local governments. For adapation, have recommended strategies and best practices, but no specific requirements
I am not certain about adaptation policies however we are considering adaptation at the local level for various reasons and are awaiting ongoing studies currently that will provide us information pertaining to the benefits of adaptation in conjunction with mitigation (CAP)
CEQA
State does not acknowledge GHG / climate change or lead with policy
Fed air quality regs
Mixed messages - climate change is politicized
Green Communities Program
State GHG reduction target
RGGI regional cap & trade
various
has a climate plan but has not implemented it
Legal framework allows for municipal aggregation of power contracts

Statistic	Value
Min Value	1
Max Value	9
Total Responses	140

8. Q1.8 MOTIVATION: What motivated your city to prepare a CAP?(select all that apply)



#	Answer	Bar	Response	%
1	Local citizen advocates		66	46%
2	Local political leadership		90	63%
3	Policy extension of local sustainability tradition		51	36%
4	Mission of external CAP funder (such as a foundation or state agency)		14	10%
5	Required by State		13	9%
6	Other		31	22%

Other
required by environmental review law
regional collaboration with other jurisdictions of similar size
CEQA streamlining
Adopted US Mayors Climate Protection Agreement in 2006
Stated in Sustainability Plan
City has no CAP
we don't have a CAP
Oregon SB 1059
STATE TARGETS; FUNDING AVAILABILITY
lawsuit and susequent settlement agreement
Required for EIR for General Plan Update
SVJV (Silicon Valley Joint Venture) brought a group together to form a public Climate Committee. Some of the members of this committee formed a subcommittee and we all worked together to draft the first CAP template for use by all cities within our county and region; a plug and play approach which has worked out very well for cash strapped communities that still are focused on climate change and understand the need to address this now- we also obtained funding through the local air district for the consultant work that was / is required and formed several groups including an advisory group to facilitate this process. This includes the funding of the tool that will track the CAP measures and results once implemented at the local and county level. Locally, we also obtained federal ARRA grant monies to fund various green initiatives including the drafting of our CAP with the use of the template and a citizens group
Compliance w/ AB32
We don't have a CAP.
Done as part of General Plan Update (req'd by State)
We don't have one
Does not have a CAP
ICLEI; staff initiative
We don't have a CAP but a Sustainability Plan with Mitigation and Adaptation targets and goals, including GHG emission reduction
do not have one
compliance with State regs
Sustainability Program initiated efforts as a revamp of the US Mayors Climate Protection Agreement
Staff
Recommended by State
don't have a "CAP"; use other long range plans to address issues
Grant funds!
City staff initiative, with Council approval
Recommended by State Legislation
Partnership for a Green City

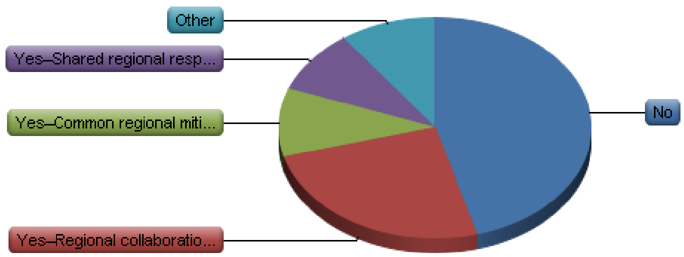
Statistic	Value
Min Value	1
Max Value	6
Total Responses	143

9. Q1.9 TYPE OF CAP: Has your city prepared a Climate Action Plan (CAP)? If so, what type?(select one)

#	Answer	Bar	Response	%
1	No		14	10%
2	In process or planning to prepare a CAP		16	11%
3	Yes–Municipal CAP (Governmental operations)		23	16%
4	Yes–Community CAP		5	3%
5	Yes–Both a Municipal and Community CAP		85	59%
	Total		143	

Statistic	Value
Min Value	1
Max Value	5
Mean	3.92
Variance	2.09
Standard Deviation	1.45
Total Responses	143

10. Q2.1 REGIONAL COOPERATION: Did your CAP process include regional collaboration in preparing a GHG inventory, common strategies, or actions? (select all that apply)



#	Answer	Bar	Response	%
1	No		64	54%
2	Yes–Regional collaboration for GHG inventory		35	30%
3	Yes–Common regional mitigation and/or adaptation strategies		14	12%
4	Yes–Shared regional responsibilities and actions		13	11%
5	Other		14	12%

Other
Retained shared consultant
citizen volunteers were from the region
Air district review and comment
CITY CAP PRECEDING PENDING REGIONAL PLAN
local CAP and Regional CAP
regional planning, drafting and review of CAP see previous answers
Surrounding counties participate on our Climate Protection Action Committee
Prior to passage of regional GHG legislation; other cities in county are now developing CAPs and Benicia is updating its existing CAP and it will reflect regional goals and policies.
Regional partners were brought to the table
Not known as CAP unfinished
not yet completed
same process with two other smaller communities in SE michigan
our first GHG inventory was community based, but our latest was municipal government.
Regional consultation on GHG inventory and strategies for carbon reduction and adaptation

Statistic	Value
Min Value	1
Max Value	5
Total Responses	118

11. Q2.2 LEADING GHG EMISSION SECTORS: Identify the three highest GHG emission sectors in your cityFIRST HIGHEST

#	Answer	Bar	Response	%
1	Energy		12	10%
2	Transportation		49	42%
3	Residential and commercial buildings		42	36%
4	Industry		2	2%
5	Agriculture		0	0%
6	Forestry		0	0%
7	Waste management		2	2%
8	Other		11	9%
	Total		118	

Other
Residential/Commercial Energy Use
University
Commercial
Materials (goods, food and services)- used a consumption-based approach for community GHG inventory
Commercial
Wastewater treatment
Residential
Potable Water Treatment
Materials - goods and foods
residential
University

Statistic	Value
Min Value	1
Max Value	8
Mean	2.93
Variance	3.47
Standard Deviation	1.86
Total Responses	118

12. SECOND HIGHEST

#	Answer	Bar	Response	%
1	Energy		15	13%
2	Transportation		46	39%
3	Residential and commercial buildings		40	34%
4	Industry		9	8%
5	Agriculture		0	0%
6	Forestry		0	0%
7	Waste management		1	1%
8	Other		6	5%
	Total		117	

Other
Wastewater Treatment Facility
commercial/industrial energy use
Water delivery
commercial/industrial energy use
Buildings & Facilities
commercial

Statistic	Value
Min Value	1
Max Value	8
Mean	2.72
Variance	2.34
Standard Deviation	1.53
Total Responses	117

13. THIRD HIGHEST

#	Answer	Bar	Response	%
1	Energy		15	13%
2	Transportation		20	17%
3	Residential and commercial buildings		18	15%
4	Industry		25	21%
5	Agriculture		0	0%
6	Forestry		0	0%
7	Waste management		30	26%
8	Other		9	8%
	Total		117	

Other
Municipal operations
Residential
Consumption
residential energy use
Residential
industrial and commercial are grouped together per ICLEI guidelines; residential is our third highgest
Commercial
residential energy use
various scope 3 emissions

Statistic	Value
Min Value	1
Max Value	8
Mean	4.20
Variance	5.54
Standard Deviation	2.35
Total Responses	117

14. Q2.3 SUPPLY-SIDE STRATEGIES: Does your city offer incentives or pursue other local measures to increase the use of renewable energy?(select all that apply)

#	Answer	Bar	Response	%
1	No		57	48%
2	Yes–solar		52	44%
3	Yes–wind		17	14%
4	Yes–Geo-thermal		9	8%
5	Yes–bio-mass		7	6%
6	Other		18	15%

Other
Researching CCA, Installing Municipal Solar
weatherization/ energy eff improvements
SMUD offers many incentives
Nearly all our power is hydroelectric
HYDROELECTRIC; CO-GENERATION PROJECTS; NON-PETROLEUM FUEL TRAVEL
biogas
Citizens also have access to incentives and technical assistance through Energy Trust of Oregon, funded through public purpose charge on investor-owned utilities, as well as access to state and federal tax credits
our CAP is in draft and will be adopted within the next few months. We are participants in what was once known as the PACE program, and do provide info to applicants / customers at various city counters regarding PGE incentive based programs and will support all programs that are regional or state wide and provide financial incentives to property owners to implement such programs. We will assess aggregate purchasing options for solar installations when we draft the environmental purchasing policy / ordinance once the CAP is adopted
Energy Efficiency
Facilitate utility EE incentives and state solar incentives
Expedited Permit Processing for solar projects
hydro
yes participation in energy provider conservation program
Electric vehicle discount
Nearly 100% hydro electricity
Electric Vehicle Infrastructure
We have an aggregate contract for residential eletrical power that sources 100% through RECs

Statistic	Value
Min Value	1
Max Value	6
Total Responses	118

15. Q2.4 DEMAND-SIDE STRATEGIES: What are your city's three leading strategies for reducing GHG emissions?(select all that apply)

#	Answer	Bar	Response	%
1	Compact and higher density development		77	65%
2	Decreasing vehicle miles traveled (VMT)		78	66%
3	Energy efficiency requirements for (new and remodel) construction		83	70%
4	Other		62	53%
5	Other		27	23%
6	Other		11	9%

Other	Other	Other
waste reduction programs	transit oriented development	
Curbside food waste collection	Purchasing green electricity	Waste diversion
Energy efficiency incentive programs	Increasing renewables through CCA and encouragement programs	
Energy retrofit financing		
Energy efficiency encouargement for residential	Green Business Challenge	
Home weatherization campaigns	Energy coordinator position	
Transition to increasing purchase of renewable energy	Investment in energy eff. upgrades for buildings and infrastructure	
Energy efficiency programs for existing buildings		
non motorized transportation investments		
voluntary residential energy efficiency programming	Voluntary sustainable business assessments	
rebates for upgrades	education	buying renewable energy
Increased Waste Diversion		
Incentives for energy efficiency (regional)		
Municipal PV installations	Low interes loan program for income-qualified homeowners for energy efficiency and solar energy installations	
Renewable energy	Energy efficiency retrofits	
renewable energy	alternative fuels	
WASTE REDUCTION	WATER CONSERVATION	VEGETATION/URBAN FOREST
Energy efficiency incentives		
Renewable energy		
local yard waste composting		
Low-maintenance landscaping		
transit	energy - efficiency and renewables	forests
Voluntary and incentive-based efficiency measures	Solid waste reduction and recycling	
.		
No local energy code, follow State energy code which is rather stringent, for construction		
TOD- as is possible	utilizing tracking / monitoring and reporting information from our ghg tool / database to inform us as to where we must direct our attention. Therre are fluctuations that we do not yet recognize in GHG production and will use the data we collect from managing our CAP programs to assess the current trends and revise our plan of action based on what we find- we are flexible and work close with the local community to account for and respond to ghg emission production	
electrical aggregatio and purchasing renewable energy		

Energy Efficiency Building Standards		
Solid Waste		
low-maintenance landscaping		
Education		
Energy, Water,and Waste analysese and retrofits for existing commercial/industrial buildings	Incentivizing on-site renewable energy generation (res./commercial)	Encouraging conversion to alt. fuel vehicles
Retrofits of existing residental structures	Education	
Building energy efficiency		
Energy Efficiency in Existing Buildings		
Residential energy efficiency programming	Education	
Transit Oriented Development		
Energy Efficiency from all sectors		
energy efficiency	vehicle efficiency	
Energy Efficiency in existing buildings	Cleaner electric generation	
Encouraging home owners to have energy audits which will lead to energy services such as insulation work	Completing energy efficiency projects in municipal buildings	
Renewable energy for power supply - 90%	Electrical usage energy efficiency	Energy efficeincy education
improving public transportation options	purchasing green power	
reduce waste disposal		
property tax abatement for residential investment wood, wind & solar		
City City operations & facilities		
Electric Vehicles		
renewables		
RECs		
waste	land preservation	providing resources to help community become more energy efficient
Energy efficiency volunteer programs		
improved infrastructure including LED lights, addition of street trees, increased recycling, etc.		
building energy disclosure policy	supporting energy efficiency retrofit programs	
incorporate GHG reductions into land use planning		
HOV lanes		
Utility GHG reduction from generation		
energy efficient streetlighting retrofit		
Municipal aggregation for electric power--contract stipulates that it's 100% RECs	Promoting sustainable transportation options (walking, cycling, public)	Residential weatherization programs
Green Electricity Aggregation	Food Waste Composting	Enhanced Recycling
Renewables		

promoting clean energy generation by our investor-owned utility & by the City		
energy efficiency at home and work		

Statistic	Value
Min Value	1
Max Value	6
Total Responses	118

16. Q2.5 ADAPTATION STRATEGIES: What climate change issues are addressed in your city's adaption strategies?(select all that apply)

#	Answer	Bar	Response	%
1	Rising temperatures		51	43%
2	Drought		45	38%
3	Flooding		53	45%
4	Wildlands interface (fires)		29	25%
5	Sea level rise		30	25%
6	Heat island effect		41	35%
7	Other		49	42%
8	Other		17	14%

Other	Other
We are currently updating our General Plan, which will include adaptation strategies related to flooding and sea level rise	
low Impact Development	building and energy
Erosion/landslides	Disproportionate impact on vulnerable populations
none of the above	
none	
Agriculture	Emergency Preparedness
Policy to begin analysis	
none	
Energy	Emergency Services
tree damage from high winds	
None	
Vegetation Management	
no adaptation policies adopted to date	
Impacts to local food production	water quantity and quality
AIR, WATER POLLUTION; BIO RESOURCES	LOCAL ECONOMIES; PUBLIC SERVICES
n/a	
Coastal errosion	River mouth flooding due to storms and SLR
n/a	
Severe weather	
We have no adopted strategies	
The above are not explicitly called out as climate adaptation strategies, but rather elements of required Natural Hazards Mitigation Plan and statewide land use planning program	
Although we do not have any defined adaptation strategies at the moment, we recognize through regional studies that are ongoing at the moment that the above mentioned are the primary focal points for us as a coastal community bordered by open space and wildlands on the east and the ocean on the west	
Public Health and Safety	Water Resources
N/A	
Public Health	Agriculture
More extreme storms	
task force	
Public Health & Safety	water resources
Adaption not addressed	
no adaptation plan	
n.a.	
none	
Glacial melt	
not yet determined	
Waste reduction; processing; recycling	reducing petroleum; maximizing use of hydro; firming hydro
Health effects of poor alr quality	economic impacts from loss of tourism and traditional forest and ecologically based businesses such as maple sugar
None yet	

none	
Don't do adaptation	
Air Quality	
unk	
lack of water	health impacts
we don't have adaptation strategies	
We have not yet formulated our adaptation strategies	
Water Quality	Biological Resources
none - we have not adopted adaptation strategies	
	CAP does not address adaption
	No adaptation strategies developed.

Statistic	Value
Min Value	1
Max Value	8
Total Responses	118

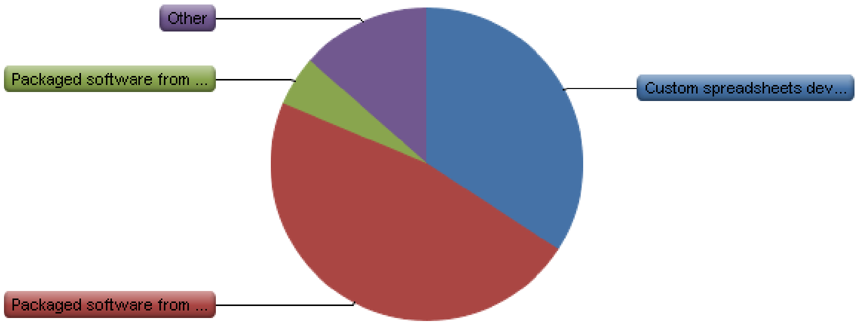
17. Q2.6 ECONOMIC INCENTIVES AND DISINCENTIVES: Does your city employ economic incentives to increase energy efficiency or implementing renewable energy?(select all that apply)

#	Answer	Bar	Response	%
1	No		52	44%
2	Yes–Tax or fee incentives		21	18%
3	Yes–Financing alternative energy		22	19%
4	Yes–Energy audits		36	31%
5	Yes–other		34	29%

Yes–other
Incentive for greater development floor area
We have provided temporary incentive programs for incentives and energy audits with grant funds when they are available
matching grants
energy efficiency rebates
grants for energy eff. upgrades
loan programs for building improvements
PACE financing for residential and commercial
Implemented Commercial PACE program
rebates for energy-efficient appliances
Rebate for upgrades
Streamlined development review process
forgivable loans for energy efficiency projects
Strong water conservation efforts (there is a strong water-energy connection)
Pace
Our Utility gives rebates
See Other under Q 2.3 in regard to Energy Trust of Oregon incentitives. No local incentives, though did offer when we had federal EECBG funds
We facilitate existing incentive based programs that offer free energy audits to a specified number of people, at the present time, we do not have the financial means to allocate dollars from the general fund to the funding of energy audits directly. If there were grant opportunities, we may consider applying for such independantly or aggregately as per City Councils direction
Mass. has robust utilty EE incentives & solar incentives (SRECs)
Education, RECs
not all offered by City itself
Energy efficiency rebates with limited funding
PACE program
conservation through municipal electric utility through state conservation laws
free post-audit energy advising for residential and commercial
rebates
rebates
Permit fee waiver; cash incentives
energy efficiency rebates
CYES Green House calls
Rebates for solar and energy efficiency upgrades
rebates
Residents who choose the municipal aggregation contract get lower rates than those paying for their electricity through individual accounts
Expedited processing
rebates & low-interest loans for energy efficiency enhancements to buildings

Statistic	Value
Min Value	1
Max Value	5
Total Responses	118

18. Q2.7.1 CAP TOOLS: What type of software tools has your city used to prepare GHG emissions inventory?(select all that apply)



#	Answer	Bar	Response	%
1	Custom spreadsheets developed by staff or consultants		53	45%
2	Packaged software from nonprofit		73	62%
3	Packaged software from commercial provider		8	7%
4	Other		21	18%

Other
ICLEI software has been used by a County organization, which prepared and recently updated inventories for interested cities
ICLEI
packaged software from regional agency
CACP
DOE calculators
ICLEI
Tools prepared by ICLEI
n/a
ICLEI's Cities for Climate Protection Campaign
we have one subscription service in place currently and are considering a second service at the present time from a for profit company.
Still working on this
ICLEI
ICLEI tools and resources
ICLEI
Web-based municipal energy tracking system
Software from ICLEI
ICLEI
None to date; have evaluated tree canopy cover with on line software (iTree)
Regional inventory serves as community inventory
ICLEI
ICLEI software

Statistic	Value
Min Value	1
Max Value	4
Total Responses	118

19. Q2.7.2 CAP TOOLS: What type of software tools has your city used to evaluate mitigation strategies?(select all that apply)

#	Answer	Bar	Response	%
1	Custom spreadsheets developed by staff or consultants		59	50%
2	Packaged software from nonprofit		49	42%
3	Packaged software from commercial provider		4	3%
4	Other		27	23%

Other
Have not evaluated the mitigation strategies
packaged software from regional agencies
Utility information and Software
none
None
ICLEI
n/a
ICLEI's Cities for Climate Protection Campaign
/
Still working on this
ICLEI
N/A
ICLEI tools
ICLEI
Staff analyses
n.a.
Has not been implemented.
ICLEI
noe
none
Don't do adaptation
unk.
not sure
none at this time
State Agency Manual

Statistic	Value
Min Value	1
Max Value	4
Total Responses	118

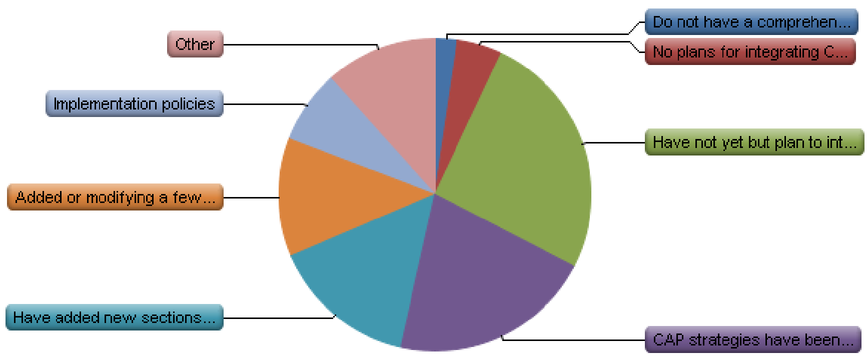
20. Q2.7.3 CAP TOOLS: What type of software tools has your city used to measure and monitor progress?(select all that apply)

#	Answer	Bar	Response	%
1	Custom spreadsheets developed by staff or consultants		60	54%
2	Packaged software from nonprofit		44	40%
3	Packaged software from commercial provider		10	9%
4	Other		21	19%

Other
CAP not yet adopted
Utility information and Software
Currently updating GHG inventory (consultants)
NA
Surveys
ICLEI
GHG inventory tools by ICLEI
n/a
N/A
Note our progress that is monitored is on municipal actions only at this time that have been implemented prior to our CAP being adopted. We are very motivated and have been directed by City Council to implement specific actions and activities and as they are in line with the CAP we are seeking approval for shortly, we are tracking the results of these actions.
none yet
Still working on this
Portfolio Manager
ICLEI
Have not adopted CAP yet
Has not been implemented
none
ICLEI software
To be determined - likely consultant or nonprofit software

Statistic	Value
Min Value	1
Max Value	4
Total Responses	111

21. Q3.1 DEGREE OF CAP AND URBAN PLANNING INTEGRATION: How has your city integrated CAP strategies into your comprehensive plan?(select all that apply)

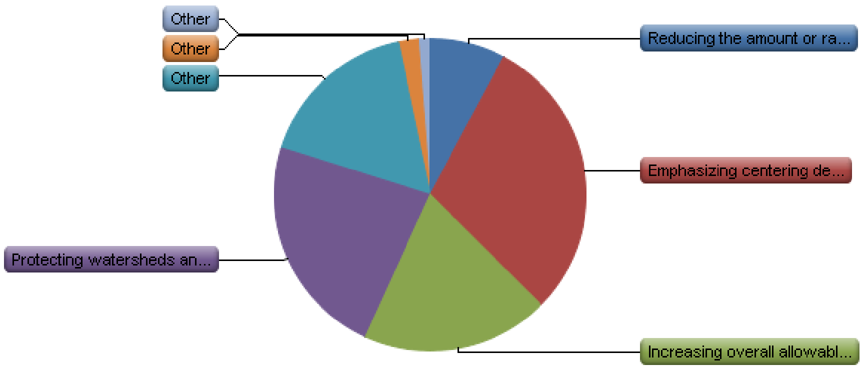


#	Answer	Bar	Response	%
1	Do not have a comprehensive plan		4	4%
2	No plans for integrating CAP strategies into the comprehensive plan		8	7%
3	Have not yet but plan to integrate CAP strategies into the comprehensive plan		44	39%
4	CAP strategies have been expressed throughout the comprehensive plan as goals and policies		36	32%
5	Have added new sections or elements emphasizing environmental or climate change policies		26	23%
6	Added or modifying a few existing goals and policies		21	18%
7	Implementation policies		13	11%
8	Other		20	18%

Other
Draft Land Use and Transportation Element of General Plan is coordinated with CAP and will be adopted concurrently
General Plan has Sustainability Element. CAP is a stand alone document.
Integration into comp plan currently in progress
comprehensive plan goals were used to inform climate change policies
CAP is implementation follow-up of General Plan
CAP is an implementation tool of the General Plan Air Quality and GHG Element
Alternative forms of transporation
Sections have not been adopted by voters - goes to vote in 2014
General plan update is underway and will incude summary of CAP strategies
Currently updating General Plan to add policies
Our comprehensive plan does not mention climate change. However, for many years our plans and regulations have addressed and implemented development patterns that promote compact and walkable development and redevelopment in areas served by transit; multi-modal transportation facilities; transit oriented development; higher densities in both downtown and in most residential neighborhoods; protection of environmentally sensitve areas and the urban forest; reduction of urban sprawl; and energy efficiency in government operations and facilities. The are done more for gool land use planning and economic sustainability, and not merely to hop on the climate change bandwagon. The fact that our land use and transportation strtegies support climate change goals is incidental to their primary purpose, which is good land use planning and stewardship of public financial resources.
Have not done yet
Comp Plan update is in progress, but climate and natural resouce related policies have not yet been approved by City Council. Existing comp plan policies are supportive of CAP strategies but don't explicitly mention (plan is from 1994)
Our GP is under update at the present time and as our CAP was under development during the same time, we have ensured that the two documents fully consider each other, and are complimentary in policy and goals pertaining to land use issues as they relate to climate change
Plan goes to the voters in 2014
Sustainablility Strategy plan is a separate document that is adopted by reference into the Comprehensivei Plan
Chapter on Sustainability focuses on CAP
Comp Plan references climate action plan and redcuing carbon footprint is a goal of the Comp Plan
Comp Plan already addresses a number of proposed CAP strategies.
Some strategies are already part of the comprehensive plan, and more will be integrated into it over time.

Statistic	Value
Min Value	1
Max Value	8
Total Responses	114

22. Q3.2.1 OVERALL DEVELOPMENT PATTERNS: How has your city's CAP SUPPORTED EXISTING POLICIES that influence overall development patterns? (select all that apply)



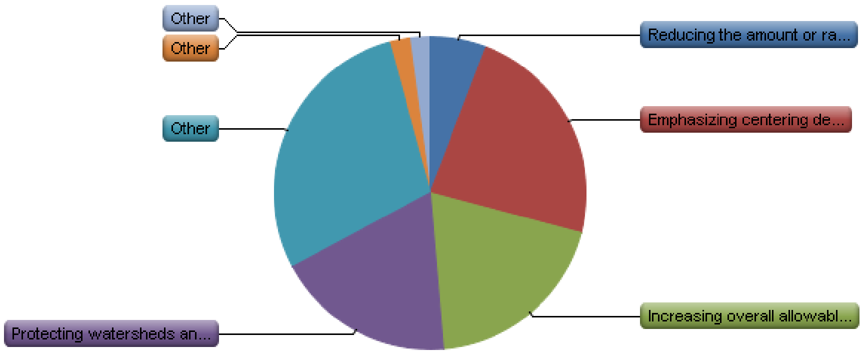
#	Answer	Bar	Response	%
1	Reducing the amount or rate of outward city expansion		19	17%
2	Emphasizing centering development in and around the city's downtown		72	63%
3	Increasing overall allowable residential densities		47	41%
4	Protecting watersheds and other natural systems in and/or adjacent to the city		56	49%
5	Other		41	36%
6	Other		5	4%
7	Other		3	3%

Other	Other	Other
has not influenced		
City is built-out - density is encouraged regardless of CAP goals		
Town has no commercial/downtown uses.		
Walkable neighborhoods		
preserving public parks and open space	incentivizing local economic development	
MOst are already GP policy		
Influenced the development of new program objectives		
CAP supports existing policy addressing all of the above		
Densiy bonuses in low income housing development		
protecting green space	restricting non-porous survaces	
Support TOD development		
Improve the City's jobs-housing balance to reduce VMT from commuting.	Support infill housing projects.	Incentivize mixed-use development.
energy efficiency and renewable measures in discretionary approvals		
No		
transit oriented development at BRT stations		
Built-out. Has no effect on development.		
Complete Streets Policies	water conservation	couldn't pick others because we are on an island...
Not at this time Draft CAP completed but not adopted		
TOD		
As in Q3.1, the above are desired and expressed in current and draft policies, but yet to be fully approved by City Council.		
OUr CAP fully supports our Green Building Ordinance which is the mechanism for mandating green building, as well as the MWELO and MRP (both water related mandates are considered from the CAP perspective)		
In process up updating General Plan		
Exploring District Energy		
your survey sucks. if you answer no to number one, you can't answer the next few questions.		
transit oriented development		
Consider transportation emissions in land use planning		

none - comp plan did these things first		
n.a.		
none		
Green building for residential		
dont know		
mixed use zoning		
Increasing the intensity of development through redevelopment		
Energy efficiency requirements		
it is nonbinding		
Encouraging transit oriented developments		
CAP will focus on City operations and facilities, not community. This is addressed in Comp Plan.		
N/A		
Traffic Managment Policies		
no influence yet		
		.

Statistic	Value
Min Value	1
Max Value	7
Total Responses	114

23. Q3.2.2 OVERALL DEVELOPMENT PATTERNS: How has your city's CAP INFLUENCED A CHANGE IN POLICIES that modified overall development pattern?(select all that apply)



#	Answer	Bar	Response	%
1	Reducing the amount or rate of outward city expansion		11	10%
2	Emphasizing centering development in and around the city's downtown		44	39%
3	Increasing overall allowable residential densities		37	32%
4	Protecting watersheds and other natural systems in and/or adjacent to the city		35	31%
5	Other		54	47%
6	Other		4	4%
7	Other		4	4%

Other	Other	Other
These policies were already in place before CAP developed		
has not influenced		
City is built-out - density is encouraged regardless of CAP goals		
No commercial zoning.		
These policies were all already in place, but the CAP provided additional rationale for pursuing them		
It has not influenced a change in policies, just the resolve to keep doing these things and another reason to do them.		
emphasis on MIxed Use- GP leads the way not CAP		
Requirement to reduce VMT for new development		
CAP supports existing policy addressing all of the above		
None - assembly has not responded		
no adopted yet - 2014		
NA - CAP too young to have influence at this time		
overbuilding in nearby urban area	protesting destruction of greenbelt	
Support TOD development		
Reduce barriers to production of secondary dwelling units (infill housing).		
No		
None yet		
No effect.		
green building standards	adaptation strategies	couldn't pick others because we are on an island...
CAP draft completed but not yet adopted		
No real policy influence from CAP		
N/A not complete yet		
none		
Emphasizes village centers near neighborhoods	More focused growth in change areas	More emphasis on design for bikability, walkability, and orientation to public transportation
CAP has not directly influenced a CHANGE in policies.		
As noted in other questions, CAP has not directly influenced; these policies have been in place as part of state-wide land use planning program.		
The CAP supports TOD and Smart Growth; both focus on infill development and more dense development and less sprawl		

In process up updating General Plan		
Not really		
improved gov't operational awareness		
your survey sucks. if you answer no to number one, you can't answer the next few questions.		
not applicable		
transit-oriented, dense development was already in progress		
none yet		
CAP has not been adopted yet		
reinforced, rather than changed generally		
not yet retified by voters		
none - comp plan did these first		
n.a.		
none		
implemented a more stringent energy efficiency building code		
dont know		
energy requirements		
Policies have not changed yet, focus on supporting existing policies		
n/a		
none		
See Q3.2.1		
N/A		
Our CAP was just adopted a couple of months ago, so it has not yet resulted in changes. We expect that it will, however.		
Traffic Managment Policies		
no influence yet		
		.
		none

Statistic	Value
Min Value	1
Max Value	7
Total Responses	114

24. Q3.3 TRANSPORTATION-LAND USE: How has your CAP strategies influenced land use and transportation policies? (select all that apply)

#	Answer	Bar	Response	%
1	Emphasizes walking and biking mobility and connectivity		95	83%
2	Includes expanded public transportation services		55	48%
3	Increasing the number or density of nodal, transit oriented developments		42	37%
4	Supports or requires increased density for infill development near transit		53	46%
5	Allows or requires higher density commercial development near transit		43	38%
7	Allows or requires reduced parking standards		56	49%
8	Increases the cost of parking		13	11%
9	Other		30	26%

Other
Provides direction to begin evaluatinghte cost of parking and collecting those costs
CAP includes all of the above; but most were already in place before CAP development
has not influenced
Increase ridership on regional public transit
Parking costs and reduced parking standards are addressed independently from the CAP
CAp Supports GP policy for th most of the above
CAP supports existing policy addressing all of the above
not adopted yet - 2014
public events to encourage active transport
Increase bicycle mode share and develop a downtown pedestrian plan.
CAP not yet adopted
N/A not complete yet
Again, as above, many of these policies are already in place as part of state-wide land use planning program. We do not have control over transit and have no paid parking...
Our CAP suggests that these actions listed above be taken; Council still must direct staff on which ordinances (measures in the CAP) will be drafted as a result of the adoption process and which (if any) will be stricken.
In process up updating General Plan
Increased electric vehicle infrastructure; conversion of City fleet to alt. fuel vehicles
your survey sucks. if you answer no to number one, you can't answer the next few questions.
car-sharing; bike sharing
CAP has not been adopted yet
n.a.
none
Future Transit Fleet purchases
Separates parking from real estate costs
Adopted Complete Streets Policy, but this was not in proposed CAP
N/A
we are about to enter into a code harmonization process
See answer to Q3.2.2.
no influence yet

Statistic	Value
Min Value	1
Max Value	9
Total Responses	114

25. Q3.4 INFRASTRUCTURE DESIGN: What parts of your city's public infrastructure has been influenced by your CAP strategies?(select all that apply)

#	Answer	Bar	Response	%
1	Water treatment		24	21%
2	Water distribution		24	21%
3	Storm water management		50	44%
4	Sanitary sewer		19	17%
5	Street, bike and pedestrian facility design standards		74	65%
6	Power distribution		15	13%
7	Other		37	32%
8	Other		6	5%
9	Other		3	3%

Other	Other	Other
potentially power portfolio		
replaced lightbulbs		
none, but CAP supports street/bike/ped design		
Water conservation (meters etc.)		
Energy efficient lighting installed	improved energy efficiency in buildings	
not adopted yet - 2014		
none		
Require new street designs to be "complete streets".	Research traffic congestion management techniques.	
Water supply plan	Municipal PV investment	Zero waste goal
none		
CAP not yet adopted		
N/A not complete yet		
wastewater	solid waste services	
as our CAP supports the MRP- and the local treatment plants NPDES permit, it supports a locally implemented lateral replacement program that requires laterals to be replaced at point of sale if they qualify as needing to be updated. This is not called out directly in our CAP however		
N/A Not yet complete		
your survey sucks. if you answer no to number one, you can't answer the next few questions.		
not applicable		
CAP has not been adopted yet		
Not yet ratified by voters		
Building of City Facilities		
none significantly		
n.a.		
none		
None to date		
potential district heating zone		
Public School System		
none		
not yet - plan adopted in 2012		
none at this time		
Building controls	Lighting controls	Street and outdoor lighting
See Q3.3		
N/A		
See answer to Q3.2.2.		
Beach & Park Managment		
none yet		

		none

Statistic	Value
Min Value	1
Max Value	9
Total Responses	114

26. Q3.5 BUILDING AND SITE DESIGN: Has your city adopted additional policies and/or regulations that require building or site design to be more energy efficient?(select all that apply)

#	Answer	Bar	Response	%
1	Adoption of higher energy efficiency standards		55	48%
2	Requirements for Net Zero GHG emission development		0	0%
3	Development standards or guidelines requiring climate-responsive building, site or block orientation		9	8%
4	On-site storm water management		53	46%
5	Other		53	46%

Other
Requirements for water efficient landscaping
These policies are in our CAP; but have yet to be implemented
Green building standards for new construction and renovations higher than State standards
NO - had on site storm water managment before CAP
cap goal is 15% above T-24 and 20 %reduction in water use. If not met, the project needs to demonstrate consistency with CAP
building energy benchmarking & disclosure ordinance
CAP supports existing policy addressing all of the above
None - staff is working that way but no policy was added
none
Adopted California Green Building Code Tier 2
Require new buildings to install energy-efficient appliances.
No requirements above state code
Green building code (includes embedded energy/GHG in materials, water conservation (saves energy too) and indoor air quality.
Density bonus for leed
density incentives to build LEED buildings
Nothing in excess of California Building Code
zero net by 2030
not yet, but will
for municipal buildings and additions to residential and non-residential buildings
No requirements from CAP
Adopted State CalGreen
none
.
Energy efficiency standards are by state code
GBO driven, MWELO driven, and MRP driven
LEED required in large new buildings
State has very strong energy code that we apply
Adopted State CalGreen
Not at this time
none yet
In October 2010, the City adopted by reference the CALGreen Code into the City's Development Code, Chapter 16.30.
storm water reqmts through state
no formal policies or regulations
We have not finished the CAP
no
solar ready development standards
working on weatherization and energy efficiency of buildings, public and private
Adopted a Sustainable Infrastructure Guideline Policy
None yet
Carbon neutral by 2030
Why is stormwater part of this survey, it has little impact on GHG emissions compared to other sectors?
no. CAP approved in 2012 - Comp plan revision underway.
Incentives for energy efficient buildings

local green building program and rating system
None
None at this time. We are starting out by taking an incentive and social/behavior approach.
none
none

Statistic	Value
Min Value	1
Max Value	5
Total Responses	114

27. Q3.6 ADAPTING TO CLIMATE CHANGE: How are climate change adaptation policies influencing the pattern of development in your city?(select all that apply)

#	Answer	Bar	Response	%
1	Heat-island and carbon sinks - - protecting and enhancing trees and landscaping		35	31%
2	Wildlands fires - - reducing or regulated development in wildland and urban interface areas		13	11%
3	Flooding - - limiting development in low-lying areas		33	29%
4	Sea level rise - - limiting development of critical infrastructure near sea level		10	9%
5	Drought - - requiring conservation or allowing use of recycled water		30	26%
6	Other		52	46%
7	Other		3	3%

Other	Other
CAP requires subsequent planning to regionally participate and evaluate sea level rise around hte San Francisco Bay	
Elevating residences to prevent flooding	
Not possible to see impact - too soon	
Flooding was already a concern.	
promoting infill and redevelopment	
adaptation policy development not formally pursued	
Most of the above policies already existed, CAP consolidated them	
Still TBD	
Analysis of adaptation strateigies only	
None-assembly has not acted	
working on our comprehensive adaptation plan at this time	
None	
Not yet but we're starting a climate adaptation strategy process shortly	
None yet	
none	
not yet...	
CAP not adopted	
Pending Adaptation Plan is expected to have more influence on site design than CAP, which is more mitigation focused.	
N/A not complete yet	
We do not have formal adaptation policies but do the actions identified above in part to adapt to changing climate.	
Again, as noted above, many of these policies have been in place are part of requirements under state-wide land use planning program.	
Through the General Plan Update, we will fully consider land use within the coastal zone as it relates to sea level rise and erosion. Additionally, development within or within a close proximity to floodplanes will be fully considered and responded to, this is in line with CAP policy and crosses over into adaptation and response but will be contained within the GP in my understanding	We do not have a heat island issue so to speak because of our existing level and types of development, however there is a strong effort to see that landscaping be enhanced and potentially regulated more stringently in response to the adoption of the CAP and as required by the final GP / zoning codes should they be revised
N/A	
your survey sucks. if you answer no to number one, you can't answer the next few questions.	
Vulnerability assessment in progress; CC preparedness plan to followin 2014	
not explicit	
CAP has not been adopted yet	
still analyzing vulnerability and adaptation options	
N/A	
none significantly	
no such policies	
none	
None to date	
dont know	
reduced parking standards	
energy conservation and efficiency in buildings and transportation	
None yet	

Flooding mitigation measures	
none	
don't do	You missed the biggest question, which is "is your CAP implemented" and you would likely get a big "NO" because there is little funding to get these things done and relying on planning that will take place in 2035 or 2050 will not meet 2020 goals. It is likely more programs will be needed to change behavior rather than planning.
no. CAP approved in 2012 - Comp plan revision underway.	
None	
no change at this time	
N/A	
we don't have climate change adaptation policies	
See answer to Q3.2.2.	
have not adopted climate adaptation policies	
	none

Statistic	Value
Min Value	1
Max Value	7
Total Responses	114

Climate Action Planning and the Form of Cities Cross Tabulation(1)

		Q1.1 CITY POPULATION: What is your city's population? (select one)					
		10,000 or less	10,001 – 50,000	50,001 – 100,000	100,001 – 250,000	250,001 or more	Total
Q2.1 REGIONAL COOPERATION: Did your CAP process include regional collaboration in preparing a GHG in...	No	5 8.33% 62.50%	13 21.67% 43.33%	15 25.00% 53.57%	19 31.67% 73.08%	8 13.33% 38.10%	60 100.00% 53.10%
	Yes–Regional collaboration for GHG inventory	1 2.86% 12.50%	11 31.43% 36.67%	11 31.43% 39.29%	4 11.43% 15.38%	8 22.86% 38.10%	35 100.00% 30.97%
	Yes–Common regional mitigation and/or adaptation strategies	0 0.00% 0.00%	5 35.71% 16.67%	4 28.57% 14.29%	1 7.14% 3.85%	4 28.57% 19.05%	14 100.00% 12.39%
	Yes–Shared regional responsibilities and actions	1 7.69% 12.50%	4 30.77% 13.33%	2 15.38% 7.14%	2 15.38% 7.69%	4 30.77% 19.05%	13 100.00% 11.50%
	Other	1 7.69% 12.50%	5 38.46% 16.67%	3 23.08% 10.71%	4 30.77% 15.38%	0 0.00% 0.00%	13 100.00% 11.50%
	Total	8 7.08% 100.00%	30 26.55% 100.00%	28 24.78% 100.00%	26 23.01% 100.00%	21 18.58% 100.00%	113 100.00% 100.00%

		Q1.1 CITY POPULATION: What is your city's population? (select one)
Q2.1 REGIONAL COOPERATION: Did your CAP process include regional collaboration in preparing a GHG in...	Chi Square	16.92*
	Degrees of Freedom	16
	p-value	0.39

**Note: The Chi-Square approximation may be inaccurate - expected frequency less than 5.*

Climate Action Planning and the Form of Cities Cross Tabulation(1)

		Q1.1 CITY POPULATION: What is your city's population? (select one)		
		10,000 or less, 10,001 – 50,000, 50,001 – 100,000, 100,001 – 250,000	250,001 or more	Total
Q2.1 REGIONAL COOPERATION: Did your CAP process include regional collaboration in preparing a GHG in...	No	52 86.67% 56.52%	8 13.33% 38.10%	60 100.00% 53.10%
	Yes–Shared regional responsibilities and actions, Yes–Common regional mitigation and/or adaptation strategies, Yes–Regional collaboration for GHG inventory, Other	43 76.79% 46.74%	13 23.21% 61.90%	56 100.00% 49.56%
	Total	92 81.42% 100.00%	21 18.58% 100.00%	113 100.00% 100.00%

		Q1.1 CITY POPULATION: What is your city's population? (select one)
Q2.1 REGIONAL COOPERATION: Did your CAP process include regional collaboration in preparing a GHG in...	Chi Square	1.89
	Degrees of Freedom	1
	p-value	0.17

APPENDIX 3

STUDY 3: Emission Modeling Summary Worksheets

Baseline

BAU–Land Use
BAU–Demand
BAU–Supply
BAU–Comprehensive

Centered City–Land Use
Centered City –Demand
Centered City –Supply
Centered City –Comprehensive

Corridor City–Land Use
Corridor City –Demand
Corridor City –Supply
Corridor City –Comprehensive

Merced–Baseline
Merced–2020
Merced–Neighborhood Scale
Merced–Project Scale

Development Summary: BASELINE

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population
Single-Family Home (4du/a)...........................	12,500	4	3,125	65%					20%	625	36,250
Single-Family Home (11du/a)..........................	-	11	-	0%					30%	0	-
ADU..	-	-	-	0%					0%	0	-
Multi-Family Unit in Large Building (44du/a) ...	-	44	-	0%					30%	0	-
Multi-Family Unit in Large Building (22du/a) ...	-	22	-	0%					30%	0	-
Multi-Family Unit in Large Building (20du/a) ...	2,885	20	144.25	15%					30%	43	5,482
Multi-Family Unit in Small Building (16du/a) ...	2,691	16	168.19	14%					30%	50	5,382
Mobile Home..	1,156	12	96.33	6%					20%	19	2,890
Education					521.00	0.16	3,256	74.75	15%	11	
Food Sales					250.00	0.25	1,000	22.96	50%	11	
Food Service					1,128.00	0.25	4,512	103.58	50%	52	
Health Care Inpatient					303.50	0.40	759	17.42	40%	7	
Health Care Outpatient					46.00	0.25	184	4.22	50%	2	
Lodging					469.00	0.35	1,340	30.76	40%	12	
Retail					1,566.50	0.25	6,266	143.85	50%	72	
Office (High Density))					-	0.80	-	-	40%	0	
Office (Low Density)					1,334.50	0.30	4,448	102.12	40%	41	
Public Assembly					25.00	0.20	125	2.87	50%	1	
Public Order and Safety					54.50	0.30	182	4.17	40%	2	
Religious Worship					325.00	0.20	1,625	37.30	30%	11	
Service					306.50	0.30	1,022	23.45	40%	9	
Warehouse and Storage					169.50	0.40	424	9.73	40%	4	
Manufacturing..					989.50	0.40	2,474	56.79	40%	23	
Vacant					-	0.03	-	-	40%	0	
	19,232		**3,534**	**100%**	**7,488.50**		**27,616**	**634**		**997**	**50,004**
Total Developed Land Area.......	**5,557**	**Acres**									
Pavement..................................					**103,942**		**Thousands of SF**				

Residential + Nonresidential + 25 % streets = Total Development Land Area...

Emissions Summary

Emissions Per Unit or Per Thousand Square Feet (MTCO2e)

Land Use	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)	52	645,606	658	8,231,039	674	8,429,181	17,305,826	58	51.6%	29.88	298,918.82
Single-Family Home (11du/a)	41	-	521	-	491	-	-	58	0.0%	0.00	-
ADU	10	-	156	-	543	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (44du/a)	14	-	350	-	442	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (22du/a)	8	-	350	-	550	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (20du/a)	23	67,060	350	1,009,917	566	1,634,182	2,711,158	58	8.1%	4.68	46,829.09
Multi-Family Unit in Small Building (16du/a)	23	62,686	504	1,355,569	607	1,634,716	3,052,971	58	9.1%	5.27	52,733.13
Mobile Home	22	25,092	276	319,239	478	552,401	896,731	81	2.7%	2.15	11,133.01
Education	38	19,797	618	321,891	286	148,916	490,604	81	1.5%	1.18	6,090.89
Food Sales	24	6,085	1,475	368,831	223	55,781	430,697	81	1.3%	1.03	5,347.14
Food Service	24	27,456	1,909	2,152,919	444	500,620	2,680,995	81	8.0%	6.44	33,284.80
Health Care Inpatient	37	11,278	1,855	562,890	461	139,780	713,948	58	2.1%	1.23	12,331.84
Health Care Outpatient	37	1,709	705	32,427	452	20,793	54,930	63	0.2%	0.10	878.23
Lodging	17	7,843	744	348,885	93	43,479	400,207	63	1.2%	0.75	6,398.52
Retail	24	38,130	552	865,453	195	305,902	1,209,484	63	3.6%	2.26	19,337.26
Office (High Density))	37	-	692	-	465	-	-	63	0.0%	0.00	-
Office (Low Density)	24	32,483	692	923,480	465	620,470	1,576,432	63	4.7%	2.94	25,204.04
Public Assembly	24	609	701	17,533	119	2,977	21,118	63	0.1%	0.04	337.64
Public Order and Safety	37	2,025	860	46,872	296	16,125	65,022	63	0.2%	0.12	1,039.58
Religious Worship	37	12,077	324	105,382	102	33,055	150,514	63	0.4%	0.28	2,406.42
Service	24	7,460	574	175,836	210	64,496	247,792	63	0.7%	0.46	3,964.68
Warehouse and Storage	19	3,149	336	57,033	144	24,338	84,521	63	0.3%	0.16	1,351.32
Manufacturing	24	24,085	1,224	1,210,672	203	201,278	1,436,034	63	4.3%	2.68	22,959.35
Vacant	19	-	155	-	37	-	-	63	0.0%	0.00	-
									100.0%		
Pavement							5,197,077			**61.66**	**84,283.52**
Total Project Emissions							**38,726,063**				**634,829**
		3%		47%		37%	13%				
Emission Category Subtotals (MTCO2e)		**994,630.69**		**18,105,867.15**		**14,428,488.33**	**5,197,076.74**				
Per Capita MTCO2e		**19.89**		**362.09**		**288.55**	**103.93**				**12.70**
Annual Per Capita		0.32		5.87		4.68	1.69				

Development Summary: BAU Land Use

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population
Single-Family Home (4du/a)...........................	25,000	4	6,250	65%					20%	1250	72,500
Single-Family Home (11du/a)..........................	-	11	-	0%					30%	0	-
ADU...	-	-	-	0%					0%	0	-
Multi-Family Unit in Large Building.................	-	44	-	0%					30%	0	-
Multi-Family Unit in Large Building	-	22	-	0%					30%	0	-
Multi-Family Unit in Large Building.................	5,770	20	288.50	15%					30%	87	10,963
Multi-Family Unit in Small Building.................	5,382	16	336.38	14%					30%	101	10,764
Mobile Home...	2,309	12	192.42	6%					20%	38	5,773
Education					1,042.00	0.16	6,513	149.51	15%	22	
Food Sales					500.00	0.25	2,000	45.91	50%	23	
Food Service					2,256.00	0.25	9,024	207.16	50%	104	
Health Care Inpatient					607.00	0.40	1,518	34.84	40%	14	
Health Care Outpatient					92.00	0.25	368	8.45	50%	4	
Lodging					938.00	0.35	2,680	61.52	40%	25	
Retail					3,133.00	0.25	12,532	287.70	50%	144	
Office (High Density))					-	0.80	-	-	40%	0	
Office (Low Density)					2,669.00	0.30	8,897	204.24	40%	82	
Public Assembly					50.00	0.20	250	5.74	50%	3	
Public Order and Safety					109.00	0.30	363	8.34	40%	3	
Religious Worship					650.00	0.20	3,250	74.61	30%	22	
Service					613.00	0.30	2,043	46.91	40%	19	
Warehouse and Storage					339.00	0.40	848	19.46	40%	8	
Manufacturing...					1,979.00	0.40	4,948	113.58	40%	45	
Vacant					-	0.03	-	-	40%	0	
	38,461		**7,067**	**100%**	**14,977.00**		**55,232**	**1,268**		**1,994**	**100,000**

Total Developed Land Area....... 11,114 Acres

Residential + Nonresidential + 25 % streets = Total Development Land Area...

Pavement.................................. 207,877 Thousands of SF

Emissions Summary

Emissions Per Unit or Per Thousand Square Feet (MTCO2e)

Land Use	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)	52	1,291,213	658	16,462,079	674	16,858,361	34,611,653	58	51.6%	29.88	597,837.64
Single-Family Home (11du/a)	41	-	521	-	491	-	-	58	0.0%	0.00	-
ADU	10	-	156	-	543	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building	14	-	350	-	442	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building	8	-	350	-	550	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building	23	134,120	350	2,019,833	566	3,268,363	5,422,316	58	8.1%	4.68	93,658.19
Multi-Family Unit in Small Building	23	125,371	504	2,711,138	607	3,269,433	6,105,941	58	9.1%	5.27	105,466.26
Mobile Home	22	50,119	276	637,649	478	1,103,368	1,791,136	81	2.7%	2.15	22,237.12
Education	38	39,593	618	643,782	286	297,832	981,207	81	1.5%	1.18	12,181.78
Food Sales	24	12,170	1,475	737,662	223	111,561	861,393	81	1.3%	1.03	10,694.28
Food Service	24	54,912	1,909	4,305,838	444	1,001,239	5,361,989	81	8.0%	6.44	66,569.61
Health Care Inpatient	37	22,557	1,855	1,125,780	461	279,559	1,427,897	58	2.1%	1.23	24,663.67
Health Care Outpatient	37	3,419	705	64,855	452	41,587	109,861	63	0.2%	0.10	1,756.45
Lodging	17	15,686	744	697,770	93	86,959	800,415	63	1.2%	0.75	12,797.05
Retail	24	76,259	552	1,730,905	195	611,803	2,418,968	63	3.6%	2.26	38,674.51
Office (High Density))	37	-	692	-	465	-	-	63	0.0%	0.00	-
Office (Low Density)	24	64,965	692	1,846,960	465	1,240,940	3,152,865	63	4.7%	2.94	50,408.08
Public Assembly	24	1,217	701	35,066	119	5,954	42,237	63	0.1%	0.04	675.28
Public Order and Safety	37	4,051	860	93,744	296	32,250	130,045	63	0.2%	0.12	2,079.16
Religious Worship	37	24,155	324	210,764	102	66,109	301,028	63	0.4%	0.28	4,812.85
Service	24	14,921	574	351,671	210	128,992	495,584	63	0.7%	0.46	7,929.35
Warehouse and Storage	19	6,299	336	114,067	144	48,676	169,041	63	0.3%	0.16	2,702.63
Manufacturing	24	48,170	1,224	2,421,343	203	402,556	2,872,069	63	4.3%	2.68	45,918.71
Vacant	19	-	155	-	37	-	-	63	0.0%	0.00	-
									100.0%		
Pavement							10,393,863			61.66	168,564.12
Total Project Emissions							**77,449,508**				**1,269,627**
		3%		47%		37%	13%				
Emission Category Subtotals (MTCO2e)		1,989,196.25		36,210,905.82		28,855,543.10	10,393,863.08				
Per Capita MTCO2e		19.89		362.11		288.56	103.94				12.70

Development Summary: BAU Demand

Emissions Summary

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population	Emissions Per Unit or Per Thousand Square Feet (MTCO2e): Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)...........................	25,000	4	6,250	65%					20%	1250	72,500	36	903,849	329	8,231,039	117	2,913,336	12,048,224	58	49.2%	28.49	208,105.69
Single-Family Home (11du/a)...........................	-	11	-	0%					30%	0	-	29	-	260	-	85	-	-	58	0.0%	0.00	-
ADU..	-	-	-	0%					0%	0	-	7	-	78	-	94	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (44du/a) ...	-	44	-	0%					30%	0	-	10	-	175	-	76	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (22du/a) ...	-	22	-	0%					30%	0	-	6	-	175	-	95	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (20du/a) ...	5,770	20	288.50	15%					30%	87	10,963	16	93,884	175	1,009,917	98	564,814	1,668,615	58	6.8%	3.95	28,821.52
Multi-Family Unit in Small Building (16du/a) ...	5,382	16	336.38	14%					30%	101	10,764	16	87,760	252	1,355,569	105	564,999	2,008,327	58	8.2%	4.75	34,689.29
Mobile Home..	2,309	12	192.42	6%					20%	38	5,773	15	35,083	138	318,824	83	190,676	544,583	81	2.2%	1.79	6,761.05
Education					1,042.00	0.16	6,513	149.51	15%	22		27	27,715	309	321,891	49	51,469	401,075	81	1.6%	1.32	4,979.39
Food Sales					500.00	0.25	2,000	45.91	50%	23		17	8,519	738	368,831	39	19,279	396,629	81	1.6%	1.30	4,924.19
Food Service					2,256.00	0.25	9,024	207.16	50%	104		17	38,439	954	2,152,919	77	173,027	2,364,384	81	9.7%	7.78	29,354.05
Health Care Inpatient					607.00	0.40	1,518	34.84	40%	14		26	15,790	927	562,890	80	48,311	626,991	58	2.6%	1.48	10,829.85
Health Care Outpatient					92.00	0.25	368	8.45	50%	4		26	2,393	352	32,427	78	7,187	42,007	63	0.2%	0.11	671.61
Lodging					938.00	0.35	2,680	61.52	40%	25		12	10,980	372	348,885	16	15,028	374,893	63	1.5%	0.96	5,993.79
Retail					3,133.00	0.25	12,532	287.70	50%	144		17	53,381	276	865,453	34	105,727	1,024,561	63	4.2%	2.62	16,380.71
Office (High Density))					-	0.80	-	-	40%	0		26	-	346	-	80	-	-	63	0.0%	0.00	-
Office (Low Density)					2,669.00	0.30	8,897	204.24	40%	82		17	45,476	346	923,480	80	214,450	1,183,405	63	4.8%	3.02	18,920.31
Public Assembly					50.00	0.20	250	5.74	50%	3		17	852	351	17,533	21	1,029	19,414	63	0.1%	0.05	310.39
Public Order and Safety					109.00	0.30	363	8.34	40%	3		26	2,835	430	46,872	51	5,573	55,281	63	0.2%	0.14	883.83
Religious Worship					650.00	0.20	3,250	74.61	30%	22		26	16,908	162	105,382	18	11,425	133,715	63	0.5%	0.34	2,137.84
Service					613.00	0.30	2,043	46.91	40%	19		17	10,445	287	175,836	36	22,291	208,572	63	0.9%	0.53	3,337.15
Warehouse and Storage					339.00	0.40	848	19.46	40%	8		13	4,409	168	57,033	25	8,412	69,854	63	0.3%	0.18	1,116.83
Manufacturing..					1,979.00	0.40	4,948	113.58	40%	45		17	33,719	612	1,210,672	35	69,567	1,313,957	63	5.4%	3.36	21,007.58
Vacant					-	0.03	-	-	40%	0		13	-	78	-	6	-	-	63	0.0%	0.00	-
	38,461		**7,067**	**100%**	**14,977.00**		**55,232**	**1,268**		**1,994**	**100,000**									100.0%		
Total Developed Land Area.......	**11,114**	**Acres**																				
Residential + Nonresidential + 25 % streets = Total Development Land Area...																						
Pavement..................................					**207,877**		**Thousands of SF**											10,393,863			**62.16**	**167,199.26**
Total Project Emissions																		**34,878,352**				**566,424**
													4%		52%		14%	30%				
Emission Category Subtotals (MTCO2e)													**1,392,437.38**		**18,105,452.91**		**4,986,598.54**	**10,393,863.08**				
Per Capita MTCO2e													**13.92**		**181.06**		**49.87**	**103.94**				**5.66**

Development Summary: BAU Supply

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population
Single-Family Home (4du/a)...........................	25,000	4	6,250	65%					20%	1250	72,500
Single-Family Home (11du/a)...........................	-	11	-	0%					30%	0	-
ADU..	-	-	-	0%					0%	0	-
Multi-Family Unit in Large Building (44du/a) ...	-	44	-	0%					30%	0	-
Multi-Family Unit in Large Building (22du/a) ...	-	22	-	0%					30%	0	-
Multi-Family Unit in Large Building (20du/a) ...	5,770	20	288.50	15%					30%	87	10,963
Multi-Family Unit in Small Building (16du/a) ...	5,382	16	336.38	14%					30%	101	10,764
Mobile Home..	2,309	12	192.42	6%					20%	38	5,773
Education					1,042.00	0.16	6,513	149.51	15%	22	
Food Sales					500.00	0.25	2,000	45.91	50%	23	
Food Service					2,256.00	0.25	9,024	207.16	50%	104	
Health Care Inpatient					607.00	0.40	1,518	34.84	40%	14	
Health Care Outpatient					92.00	0.25	368	8.45	50%	4	
Lodging					938.00	0.35	2,680	61.52	40%	25	
Retail					3,133.00	0.25	12,532	287.70	50%	144	
Office (High Density))					-	0.80	-	-	40%	0	
Office (Low Density)					2,669.00	0.30	8,897	204.24	40%	82	
Public Assembly					50.00	0.20	250	5.74	50%	3	
Public Order and Safety					109.00	0.30	363	8.34	40%	3	
Religious Worship					650.00	0.20	3,250	74.61	30%	22	
Service					613.00	0.30	2,043	46.91	40%	19	
Warehouse and Storage					339.00	0.40	848	19.46	40%	8	
Manufacturing..					1,979.00	0.40	4,948	113.58	40%	45	
Vacant					-	0.03	-	-	40%	0	
	38,461		**7,067**	**100%**	**14,977.00**		**55,232**	**1,268**		**1,994**	**100,000**

Total Developed Land Area....... **11,114** **Acres**

Residential + Nonresidential + 25 % streets = Total Development Land Area...

Pavement................................. **207,877** **Thousands of SF**

Emissions Summary

Emissions Per Unit or Per Thousand Square Feet (MTCO2e)

Land Use	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)	52	1,291,213	395	9,877,247	674	16,858,361	28,026,821	58	53.3%	30.86	484,099.64
Single-Family Home (11du/a)	41	-	312	-	491	-	-	58	0.0%	0.00	-
ADU	10	-	94	-	543	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (44du/a)	14	-	210	-	442	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (22du/a)	8	-	210	-	550	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (20du/a)	23	134,120	210	1,211,900	566	3,268,363	4,614,383	58	8.8%	5.08	79,702.98
Multi-Family Unit in Small Building (16du/a)	23	125,371	302	1,626,683	607	3,269,433	5,021,486	58	9.6%	5.53	86,734.77
Mobile Home	22	50,119	166	382,589	478	1,103,368	1,536,076	81	2.9%	2.35	19,070.53
Education	38	39,593	371	386,269	286	297,832	723,694	81	1.4%	1.11	8,984.73
Food Sales	24	12,170	885	442,597	223	111,561	566,329	81	1.1%	0.87	7,031.02
Food Service	24	54,912	1,145	2,583,503	444	1,001,239	3,639,654	81	6.9%	5.58	45,186.65
Health Care Inpatient	37	22,557	1,113	675,468	461	279,559	977,585	58	1.9%	1.08	16,885.55
Health Care Outpatient	37	3,419	423	38,913	452	41,587	83,919	63	0.2%	0.10	1,341.69
Lodging	17	15,686	446	418,662	93	86,959	521,307	63	1.0%	0.62	8,334.66
Retail	24	76,259	331	1,038,543	195	611,803	1,726,606	63	3.3%	2.05	27,605.01
Office (High Density))	37	-	415	-	465	-	-	63	0.0%	0.00	-
Office (Low Density)	24	64,965	415	1,108,176	465	1,240,940	2,414,081	63	4.6%	2.87	38,596.38
Public Assembly	24	1,217	421	21,040	119	5,954	28,210	63	0.1%	0.03	451.03
Public Order and Safety	37	4,051	516	56,246	296	32,250	92,547	63	0.2%	0.11	1,479.65
Religious Worship	37	24,155	195	126,459	102	66,109	216,723	63	0.4%	0.26	3,464.97
Service	24	14,921	344	211,003	210	128,992	354,916	63	0.7%	0.42	5,678.66
Warehouse and Storage	19	6,299	202	68,440	144	48,676	123,414	63	0.2%	0.15	1,973.15
Manufacturing	24	48,170	734	1,452,806	203	402,556	1,903,532	63	3.6%	2.26	30,433.71
Vacant	19	-	93	-	37	-	-	63	0.0%	0.00	-
									100.0%		
Pavement							10,393,863			61.34	169,443.84

	Embodied Subtotal	Energy Subtotal	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Annual Emissions (MTCO2e)
Total Project Emissions				**62,965,146**	**1,036,499**
	3%	35%	46%	17%	
Emission Category Subtotals (MTCO2e)	**1,989,196.25**	**21,726,543.49**	**28,855,543.10**	**10,393,863.08**	
Per Capita MTCO2e	**19.89**	**217.27**	**288.56**	**103.94**	**10.37**

Development Summary: BAU Comprehensive

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population
Single-Family Home (4du/a)...........................	25,000	4	6,250	65%					20%	1250	72,500
Single-Family Home (11du/a)...........................	-	11	-	0%					30%	0	-
ADU..	-	-	-	0%					0%	0	-
Multi-Family Unit in Large Building (44du/a) ...	-	44	-	0%					30%	0	-
Multi-Family Unit in Large Building (22du/a) ...	-	22	-	0%					30%	0	-
Multi-Family Unit in Large Building (20du/a) ...	5,770	20	288.50	15%					30%	87	10,963
Multi-Family Unit in Small Building (16du/a) ...	5,382	16	336.38	14%					30%	101	10,764
Mobile Home..	2,309	12	192.42	6%					20%	38	5,773
Education					1,042.00	0.16	6,513	149.51	15%	22	
Food Sales					500.00	0.25	2,000	45.91	50%	23	
Food Service					2,256.00	0.25	9,024	207.16	50%	104	
Health Care Inpatient					607.00	0.40	1,518	34.84	40%	14	
Health Care Outpatient					92.00	0.25	368	8.45	50%	4	
Lodging					938.00	0.35	2,680	61.52	40%	25	
Retail					3,133.00	0.25	12,532	287.70	50%	144	
Office (High Density))					-	0.80	-	-	40%	0	
Office (Low Density)					2,669.00	0.30	8,897	204.24	40%	82	
Public Assembly					50.00	0.20	250	5.74	50%	3	
Public Order and Safety					109.00	0.30	363	8.34	40%	3	
Religious Worship					650.00	0.20	3,250	74.61	30%	22	
Service					613.00	0.30	2,043	46.91	40%	19	
Warehouse and Storage					339.00	0.40	848	19.46	40%	8	
Manufacturing...					1,979.00	0.40	4,948	113.58	40%	45	
Vacant					-	0.03	-	-	40%	0	
	38,461		**7,067**	**100%**	**14,977.00**		**55,232**	**1,268**		**1,994**	**100,000**

Total Developed Land Area....... 11,114 Acres

Residential + Nonresidential + 25 % streets = Total Development Land Area...

Pavement.................................. 207,877 Thousands of SF

Emissions Summary

Land Use	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
	Emissions Per Unit or Per Thousand Square Feet (MTCO2e)										
Single-Family Home (4du/a)	36	903,849	198	4,938,624	117	2,913,336	8,755,808	58	50.8%	29.40	151,236.69
Single-Family Home (11du/a)	29	-	156	-	85	-	-	58	0.0%	0.00	-
ADU	7	-	47	-	94	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (44du/a)	10	-	105	-	76	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (22du/a)	6	-	105	-	95	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (20du/a)	16	93,884	105	605,950	98	564,814	1,264,648	58	7.3%	4.25	21,843.92
Multi-Family Unit in Small Building (16du/a)	16	87,760	151	813,341	105	564,999	1,466,100	58	8.5%	4.92	25,323.54
Mobile Home	15	35,083	83	191,295	83	190,676	417,054	81	2.4%	1.95	5,177.76
Education	27	27,715	185	193,135	49	51,469	272,319	81	1.6%	1.27	3,380.87
Food Sales	17	8,519	443	221,298	39	19,279	249,097	81	1.4%	1.16	3,092.56
Food Service	17	38,439	573	1,291,751	77	173,027	1,503,217	81	8.7%	7.02	18,662.58
Health Care Inpatient	26	15,790	556	337,734	80	48,311	401,835	58	2.3%	1.35	6,940.79
Health Care Outpatient	26	2,393	211	19,456	78	7,187	29,036	63	0.2%	0.11	464.23
Lodging	12	10,980	223	209,331	16	15,028	235,339	63	1.4%	0.85	3,762.60
Retail	17	53,381	166	519,272	34	105,727	678,380	63	3.9%	2.46	10,845.96
Office (High Density))	26	-	208	-	80	-	-	63	0.0%	0.00	-
Office (Low Density)	17	45,476	208	554,088	80	214,450	814,013	63	4.7%	2.95	13,014.47
Public Assembly	17	852	210	10,520	21	1,029	12,401	63	0.1%	0.04	198.26
Public Order and Safety	26	2,835	258	28,123	51	5,573	36,532	63	0.2%	0.13	584.07
Religious Worship	26	16,908	97	63,229	18	11,425	91,562	63	0.5%	0.33	1,463.90
Service	17	10,445	172	105,501	36	22,291	138,237	63	0.8%	0.50	2,211.80
Warehouse and Storage	13	4,409	101	34,220	25	8,412	47,041	63	0.3%	0.17	752.09
Manufacturing	17	33,719	367	726,403	35	69,567	829,689	63	4.8%	3.01	13,265.08
Vacant	13	-	47	-	6	-	-	63	0.0%	0.00	-
									100.0%		
Pavement							10,393,863			**61.89**	**167,946.60**
Total Project Emissions							**27,636,171**				**450,168**
		5%		39%		18%	38%				
Emission Category Subtotals (MTCO2e)		**1,392,437.38**		**10,863,271.75**		**4,986,598.54**	**10,393,863.08**				
Per Capita MTCO2e		**13.92**		**108.63**		**49.87**	**103.94**				**4.50**

Version 1.7 12/26/07

Development Summary: Centered Land Use

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population
Single-Family Home (4du/a)...........................	10,272	4	2,568	23%					20%	513.6	29,789
Single-Family Home (11du/a)..........................	-	11	-	0%					30%	0	-
ADU..	3,049	-	-	7%					0%	0	8,842
Multi-Family Unit in Large Building	8,480	52	163.08	19%					30%	48.92308	16,112
Multi-Family Unit in Large Building..................	16,771	30	559.03	37%					30%	167.71	31,865
Multi-Family Unit in Large Building	2,885	20	144.25	6%					30%	43	5,482
Multi-Family Unit in Small Building	2,691	16	168.19	6%					30%	50	5,382
Mobile Home..	1,012	12	84.33	2%					20%	17	2,530
Education					1,042.0	0.43	2,423	55.63	15%	8	
Food Sales					500.0	0.67	746	17.13	50%	9	
Food Service					2,256.0	0.67	3,367	77.30	50%	39	
Health Care Inpatient					607.0	1.07	567	13.02	40%	5	
Health Care Outpatient					92.0	0.67	137	3.15	50%	2	
Lodging					938.0	0.93	1,009	23.15	40%	9	
Retail					3,133.0	0.67	4,676	107.35	50%	54	
Office (High Density))					1,334.5	0.80	1,668	38.29	40%	15	
Office (Low Density)					1,334.5	0.67	1,992	45.73	40%	18	
Public Assembly					50.0	0.53	94	2.17	50%	1	
Public Order and Safety					109.0	0.80	136	3.13	40%	1	
Religious Worship					650.0	0.53	1,226	28.15	30%	8	
Service					613.0	0.80	766	17.59	40%	7	
Warehouse and Storage					339.0	1.07	317	7.27	40%	3	
Manufacturing...					1,979.0	1.07	1,850	42.46	40%	17	
Vacant					0.0	0.06	-	-	40%	0	
	45,160		**3,687**	**100%**	**14,977.00**		**20,976**	**482**		**1,037**	**100,001**

Total Developed Land Area....... **5,558** **Acres**

Residential + Nonresidential + 25 % streets = Total Development Land Area...

Pavement.................................. **105,716** **Thousands of SF**

Emissions Summary

Emissions Per Unit or Per Thousand Square Feet (MTCO2e)

Land Use	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)	52	530,534	658	6,763,939	674	6,926,763	14,221,236	58	22.9%	13.23	245,639.53
Single-Family Home (11du/a)	41	-	521	-	491	-	-	58	0.0%	0.00	-
ADU	10	31,102	156	476,201	543	1,654,470	2,161,773	58	3.5%	2.01	37,339.71
Multi-Family Unit in Large Building	14	120,536	350	2,968,490	420	3,560,162	6,649,188	58	10.7%	6.19	114,849.61
Multi-Family Unit in Large Building	8	138,568	350	5,870,819	499	8,366,106	14,375,492	58	23.1%	13.37	248,303.96
Multi-Family Unit in Large Building	23	67,060	350	1,009,917	566	1,634,182	2,711,158	58	4.4%	2.52	46,829.09
Multi-Family Unit in Small Building	23	62,686	504	1,355,569	607	1,634,716	3,052,971	58	4.9%	2.84	52,733.13
Mobile Home	22	21,966	276	279,472	478	483,590	785,028	81	1.3%	1.02	9,746.19
Education	38	39,593	618	643,782	229	238,555	921,930	81	1.5%	1.19	11,445.85
Food Sales	24	12,170	1,475	737,662	179	89,358	839,189	81	1.3%	1.09	10,418.62
Food Service	24	54,912	1,909	4,305,838	355	801,965	5,162,715	81	8.3%	6.68	64,095.60
Health Care Inpatient	37	22,557	1,855	1,125,780	369	223,919	1,372,257	58	2.2%	1.28	23,702.61
Health Care Outpatient	37	3,419	705	64,855	362	33,310	101,584	63	0.2%	0.10	1,624.12
Lodging	17	15,686	744	697,770	74	69,652	783,107	63	1.3%	0.79	12,520.34
Retail	24	76,259	552	1,730,905	156	490,037	2,297,202	63	3.7%	2.31	36,727.72
Office (High Density))	37	49,592	692	923,480	372	496,979	1,470,051	63	2.4%	1.48	23,503.21
Office (Low Density)	24	32,483	692	923,480	372	496,979	1,452,942	63	2.3%	1.46	23,229.67
Public Assembly	24	1,217	701	35,066	95	4,769	41,052	63	0.1%	0.04	656.34
Public Order and Safety	37	4,051	860	93,744	237	25,832	123,626	63	0.2%	0.12	1,976.54
Religious Worship	37	24,155	324	210,764	81	52,952	287,871	63	0.5%	0.29	4,602.49
Service	24	14,921	574	351,671	169	103,319	469,911	63	0.8%	0.47	7,518.58
Warehouse and Storage	19	6,299	336	114,067	115	38,988	159,353	63	0.3%	0.16	2,547.74
Manufacturing	24	48,170	1,224	2,421,343	163	322,436	2,791,949	63	4.5%	2.81	44,637.75
Vacant	19	-	155	-	30	-	-	63	0.0%	0.00	-
									100.0%		
Pavement							5,285,792			**61.45**	**86,022.86**

	Embodied Subtotal	Energy Subtotal	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Annual Emissions (MTCO2e)
Total Project Emissions				**67,517,377**	**1,110,671**
	2%	49%	41%	8%	
Emission Category Subtotals (MTCO2e)	**1,377,933.83**	**33,104,612.82**	**27,749,038.38**	**5,285,791.93**	
Per Capita MTCO2e	**13.78**	**331.04**	**277.49**	**52.86**	**11.11**
Annual Per capita	0.22	5.39	4.52	0.86	

Development Summary: Centered Demand

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population
Single-Family Home (4du/a)...........................	10,272	4	2,568	23%					20%	513.6	29,789
Single-Family Home (11du/a)..........................	-	11	-	0%					30%	0	-
ADU...	3,049	-	-	7%					0%	0	8,842
Multi-Family Unit in Large Building (44du/a) ...	8,480	52	163.08	19%					30%	48.92308	16,112
Multi-Family Unit in Large Building (22du/a) ...	16,771	30	559.03	37%					30%	167.71	31,865
Multi-Family Unit in Large Building (20du/a) ...	2,885	20	144.25	6%					30%	43	5,482
Multi-Family Unit in Small Building (16du/a) ...	2,691	16	168.19	6%					30%	50	5,382
Mobile Home..	1,012	12	84.33	2%					20%	17	2,530
Education					1,042.0	0.43	2,423	55.63	15%	8	
Food Sales					500.0	0.67	746	17.13	50%	9	
Food Service					2,256.0	0.67	3,367	77.30	50%	39	
Health Care Inpatient					607.0	1.07	567	13.02	40%	5	
Health Care Outpatient					92.0	0.67	137	3.15	50%	2	
Lodging					938.0	0.93	1,009	23.15	40%	9	
Retail					3,133.0	0.67	4,676	107.35	50%	54	
Office (High Density))					1,334.5	0.80	1,668	38.29	40%	15	
Office (Low Density)					1,334.5	0.67	1,992	45.73	40%	18	
Public Assembly					50.0	0.53	94	2.17	50%	1	
Public Order and Safety					109.0	0.80	136	3.13	40%	1	
Religious Worship					650.0	0.53	1,226	28.15	30%	8	
Service					613.0	0.80	766	17.59	40%	7	
Warehouse and Storage					339.0	1.07	317	7.27	40%	3	
Manufacturing..					1,979.0	1.07	1,850	42.46	40%	17	
Vacant					0.0	0.06	-	-	40%	0	
	45,160		**3,687**	**100%**	**14,977.00**		**20,976**	**482**		**1,037**	**100,001**
Total Developed Land Area.......	**5,558**	**Acres**									
Pavement..................................					**105,716**		**Thousands of SF**				

Residential + Nonresidential + 25 % streets = Total Development Land Area...

Emissions Summary

Emissions Per Unit or Per Thousand Square Feet (MTCO2e)

Land Use	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)	36	371,374	329	3,381,969	117	1,197,031	**4,950,374**	58	22.2%	12.84	85,506.47
Single-Family Home (11du/a)	29	-	260	-	85	-	-	58	0.0%	0.00	-
ADU	7	21,771	78	238,100	94	285,913	**545,785**	58	2.4%	1.42	9,427.19
Multi-Family Unit in Large Building (44du/a)	10	84,375	175	1,484,245	73	615,241	**2,183,861**	58	9.8%	5.67	37,721.23
Multi-Family Unit in Large Building (22du/a)	6	96,997	175	2,935,409	86	1,445,768	**4,478,174**	58	20.1%	11.62	77,350.28
Multi-Family Unit in Large Building (20du/a)	16	46,942	175	504,958	98	282,407	**834,307**	58	3.7%	2.16	14,410.76
Multi-Family Unit in Small Building (16du/a)	16	43,880	252	677,784	105	282,499	**1,004,164**	58	4.5%	2.61	17,344.65
Mobile Home	15	15,376	138	139,736	83	83,570	**238,683**	81	1.1%	0.86	2,963.27
Education	27	27,715	309	321,891	40	41,225	**390,832**	81	1.8%	1.41	4,852.21
Food Sales	17	8,519	738	368,831	31	15,442	**392,792**	81	1.8%	1.42	4,876.55
Food Service	17	38,439	954	2,152,919	61	138,590	**2,329,947**	81	10.4%	8.41	28,926.51
Health Care Inpatient	26	15,790	927	562,890	64	38,696	**617,376**	58	2.8%	1.60	10,663.77
Health Care Outpatient	26	2,393	352	32,427	63	5,756	**40,577**	63	0.2%	0.11	648.75
Lodging	12	10,980	372	348,885	13	12,037	**371,902**	63	1.7%	1.04	5,945.97
Retail	17	53,381	276	865,453	27	84,685	**1,003,519**	63	4.5%	2.81	16,044.28
Office (High Density))	26	34,714	346	461,740	64	85,884	**582,338**	63	2.6%	1.63	9,310.44
Office (Low Density)	17	22,738	346	461,740	64	85,884	**570,362**	63	2.6%	1.60	9,118.96
Public Assembly	17	852	351	17,533	16	824	**19,209**	63	0.1%	0.05	307.12
Public Order and Safety	26	2,835	430	46,872	41	4,464	**54,171**	63	0.2%	0.15	866.09
Religious Worship	26	16,908	162	105,382	14	9,151	**131,441**	63	0.6%	0.37	2,101.48
Service	17	10,445	287	175,836	29	17,855	**204,135**	63	0.9%	0.57	3,266.16
Warehouse and Storage	13	4,409	168	57,033	20	6,738	**68,180**	63	0.3%	0.19	1,090.06
Manufacturing	17	33,719	612	1,210,672	28	55,721	**1,300,112**	63	5.8%	3.64	20,786.22
Vacant	13	-	78	-	5	-	-	63	0.0%	0.00	-
									100.0%		
Pavement							**5,285,792**			**62.20**	**84,975.40**
Total Project Emissions							**27,598,033**				**448,504**
		3%		60%		17%	19%				
Emission Category Subtotals (MTCO2e)		**964,553.68**		**16,552,306.41**		**4,795,380.70**	**5,285,791.93**				
Per Capita MTCO2e		**9.65**		**165.52**		**47.95**	**52.86**				**4.48**

Development Summary: Centered Supply

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population
Single-Family Home (4du/a)...........................	10,272	4	2,568	23%					20%	513.6	29,789
Single-Family Home (11du/a).........................	-	11	-	0%					30%	0	-
ADU..	3,049	-	-	7%					0%	0	8,842
Multi-Family Unit in Large Building (44du/a) ...	8,480	52	163.08	19%					30%	48.92308	16,112
Multi-Family Unit in Large Building (22du/a) ...	16,771	30	559.03	37%					30%	167.71	31,865
Multi-Family Unit in Large Building (20du/a) ...	2,885	20	144.25	6%					30%	43	5,482
Multi-Family Unit in Small Building (16du/a) ...	2,691	16	168.19	6%					30%	50	5,382
Mobile Home...	1,012	12	84.33	2%					20%	17	2,530
Education					1,042.0	0.43	2,423	55.63	15%	8	
Food Sales					500.0	0.67	746	17.13	50%	9	
Food Service					2,256.0	0.67	3,367	77.30	50%	39	
Health Care Inpatient					607.0	1.07	567	13.02	40%	5	
Health Care Outpatient					92.0	0.67	137	3.15	50%	2	
Lodging					938.0	0.93	1,009	23.15	40%	9	
Retail					3,133.0	0.67	4,676	107.35	50%	54	
Office (High Density))					1,334.5	0.80	1,668	38.29	40%	15	
Office (Low Density)					1,334.5	0.67	1,992	45.73	40%	18	
Public Assembly					50.0	0.53	94	2.17	50%	1	
Public Order and Safety					109.0	0.80	136	3.13	40%	1	
Religious Worship					650.0	0.53	1,226	28.15	30%	8	
Service					613.0	0.80	766	17.59	40%	7	
Warehouse and Storage					339.0	1.07	317	7.27	40%	3	
Manufacturing..					1,979.0	1.07	1,850	42.46	40%	17	
Vacant					0.0	0.06	-	-	40%	0	
	45,160		**3,687**	**100%**	**14,977.00**		**20,976**	**482**		**1,037**	**100,001**

Total Developed Land Area....... **5,558** **Acres**

Residential + Nonresidential + 25 % streets = Total Development Land Area...

Pavement.................................. **105,716** **Thousands of SF**

Emissions Summary

Emissions Per Unit or Per Thousand Square Feet (MTCO2e)

Land Use	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)	52	530,534	395	4,058,363	674	6,926,763	11,515,660	58	23.5%	13.61	198,906.86
Single-Family Home (11du/a)	41	-	312	-	491	-	-	58	0.0%	0.00	-
ADU	10	31,102	94	285,721	543	1,654,470	1,971,292	58	4.0%	2.33	34,049.59
Multi-Family Unit in Large Building (44du/a)	14	120,536	210	1,781,094	420	3,560,162	5,461,792	58	11.1%	6.45	94,340.05
Multi-Family Unit in Large Building (22du/a)	8	138,568	210	3,522,491	499	8,366,106	12,027,165	58	24.6%	14.21	207,741.94
Multi-Family Unit in Large Building (20du/a)	23	67,060	210	605,950	566	1,634,182	2,307,191	58	4.7%	2.73	39,851.49
Multi-Family Unit in Small Building (16du/a)	23	62,686	302	813,341	607	1,634,716	2,510,743	58	5.1%	2.97	43,367.38
Mobile Home	22	21,966	166	167,683	478	483,590	673,239	81	1.4%	1.11	8,358.33
Education	38	39,593	371	386,269	229	238,555	664,418	81	1.4%	1.09	8,248.81
Food Sales	24	12,170	885	442,597	179	89,358	544,125	81	1.1%	0.89	6,755.36
Food Service	24	54,912	1,145	2,583,503	355	801,965	3,440,380	81	7.0%	5.66	42,712.64
Health Care Inpatient	37	22,557	1,113	675,468	369	223,919	921,944	58	1.9%	1.09	15,924.50
Health Care Outpatient	37	3,419	423	38,913	362	33,310	75,642	63	0.2%	0.10	1,209.36
Lodging	17	15,686	446	418,662	74	69,652	503,999	63	1.0%	0.64	8,057.95
Retail	24	76,259	331	1,038,543	156	490,037	1,604,840	63	3.3%	2.05	25,658.22
Office (High Density))	37	49,592	415	554,088	372	496,979	1,100,659	63	2.2%	1.41	17,597.36
Office (Low Density)	24	32,483	415	554,088	372	496,979	1,083,550	63	2.2%	1.38	17,323.82
Public Assembly	24	1,217	421	21,040	95	4,769	27,025	63	0.1%	0.03	432.08
Public Order and Safety	37	4,051	516	56,246	237	25,832	86,128	63	0.2%	0.11	1,377.02
Religious Worship	37	24,155	195	126,459	81	52,952	203,565	63	0.4%	0.26	3,254.60
Service	24	14,921	344	211,003	169	103,319	329,243	63	0.7%	0.42	5,267.89
Warehouse and Storage	19	6,299	202	68,440	115	38,988	113,727	63	0.2%	0.15	1,818.26
Manufacturing	24	48,170	734	1,452,806	163	322,436	1,823,412	63	3.7%	2.33	29,152.75
Vacant	19	-	93	-	30	-	-	63	0.0%	0.00	-
									100.0%		
Pavement							5,285,792			61.02	86,630.34

Total Project Emissions

	Embodied Subtotal	Energy Subtotal	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Annual Emissions (MTCO2e)
Total Project Emissions				**54,275,532**	**898,037**
	3%	37%	51%	10%	
Emission Category Subtotals (MTCO2e)	**1,377,933.83**	**19,862,767.69**	**27,749,038.38**	**5,285,791.93**	
Per Capita MTCO2e	**13.78**	**198.63**	**277.49**	**52.86**	**8.98**

Development Summary: Centered Comprehensive

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population
Single-Family Home (4du/a)...........................	10,272	4	2,568	23%					20%	513.6	29,789
Single-Family Home (11du/a).........................	-	11	-	0%					30%	0	-
ADU..	3,049	-	-	7%					0%	0	8,842
Multi-Family Unit in Large Building (44du/a) ...	8,480	52	163.08	19%					30%	48.92308	16,112
Multi-Family Unit in Large Building (22du/a) ...	16,771	30	559.03	37%					30%	167.71	31,865
Multi-Family Unit in Large Building (20du/a) ...	2,885	20	144.25	6%					30%	43	5,482
Multi-Family Unit in Small Building (16du/a) ...	2,691	16	168.19	6%					30%	50	5,382
Mobile Home..	1,012	12	84.33	2%					20%	17	2,530
Education					1,042.0	0.43	2,423	55.63	15%	8	
Food Sales					500.0	0.67	746	17.13	50%	9	
Food Service					2,256.0	0.67	3,367	77.30	50%	39	
Health Care Inpatient					607.0	1.07	567	13.02	40%	5	
Health Care Outpatient					92.0	0.67	137	3.15	50%	2	
Lodging					938.0	0.93	1,009	23.15	40%	9	
Retail					3,133.0	0.67	4,676	107.35	50%	54	
Office (High Density))					1,334.5	0.80	1,668	38.29	40%	15	
Office (Low Density)					1,334.5	0.67	1,992	45.73	40%	18	
Public Assembly					50.0	0.53	94	2.17	50%	1	
Public Order and Safety					109.0	0.80	136	3.13	40%	1	
Religious Worship					650.0	0.53	1,226	28.15	30%	8	
Service					613.0	0.80	766	17.59	40%	7	
Warehouse and Storage					339.0	1.07	317	7.27	40%	3	
Manufacturing...					1,979.0	1.07	1,850	42.46	40%	17	
Vacant					0.0	0.06	-	-	40%	0	
	45,160		**3,687**	**100%**	**14,977.00**		**20,976**	**482**		**1,037**	**100,001**

Total Developed Land Area....... **5,558** **Acres**

Residential + Nonresidential + 25 % streets = Total Development Land Area...

Pavement.................................. **105,716** **Thousands of SF**

Emissions Summary

Land Use	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
	Emissions Per Unit or Per Thousand Square Feet (MTCO2e)										
Single-Family Home (4du/a)	36	371,374	198	2,029,182	117	1,197,031	**3,597,587**	58	22.9%	13.27	62,140.13
Single-Family Home (11du/a)	29	-	156	-	85	-	**-**	58	0.0%	0.00	-
ADU	7	21,771	47	142,860	94	285,913	**450,545**	58	2.9%	1.66	7,782.14
Multi-Family Unit in Large Building (44du/a)	10	84,375	105	890,547	73	615,241	**1,590,163**	58	10.1%	5.87	27,466.45
Multi-Family Unit in Large Building (22du/a)	6	96,997	105	1,761,246	86	1,445,768	**3,304,011**	58	21.1%	12.19	57,069.27
Multi-Family Unit in Large Building (20du/a)	16	46,942	105	302,975	98	282,407	**632,324**	58	4.0%	2.33	10,921.96
Multi-Family Unit in Small Building (16du/a)	16	43,880	151	406,671	105	282,499	**733,050**	58	4.7%	2.70	12,661.77
Mobile Home	15	15,376	83	83,842	83	83,570	**182,788**	81	1.2%	0.94	2,269.33
Education	27	27,715	185	193,135	40	41,225	**262,075**	81	1.7%	1.35	3,253.69
Food Sales	17	8,519	443	221,298	31	15,442	**245,260**	81	1.6%	1.26	3,044.92
Food Service	17	38,439	573	1,291,751	61	138,590	**1,468,780**	81	9.4%	7.54	18,235.04
Health Care Inpatient	26	15,790	556	337,734	64	38,696	**392,220**	58	2.5%	1.45	6,774.71
Health Care Outpatient	26	2,393	211	19,456	63	5,756	**27,606**	63	0.2%	0.11	441.37
Lodging	12	10,980	223	209,331	13	12,037	**232,348**	63	1.5%	0.93	3,714.78
Retail	17	53,381	166	519,272	27	84,685	**657,338**	63	4.2%	2.62	10,509.53
Office (High Density))	26	34,714	208	277,044	64	85,884	**397,642**	63	2.5%	1.59	6,357.52
Office (Low Density)	17	22,738	208	277,044	64	85,884	**385,666**	63	2.5%	1.54	6,166.04
Public Assembly	17	852	210	10,520	16	824	**12,196**	63	0.1%	0.05	194.99
Public Order and Safety	26	2,835	258	28,123	41	4,464	**35,423**	63	0.2%	0.14	566.34
Religious Worship	26	16,908	97	63,229	14	9,151	**89,288**	63	0.6%	0.36	1,427.54
Service	17	10,445	172	105,501	29	17,855	**133,801**	63	0.9%	0.53	2,140.81
Warehouse and Storage	13	4,409	101	34,220	20	6,738	**45,367**	63	0.3%	0.18	725.32
Manufacturing	17	33,719	367	726,403	28	55,721	**815,843**	63	5.2%	3.25	13,043.72
Vacant	13	-	47	-	5	-	**-**	63	0.0%	0.00	-
									100.0%		
Pavement							**5,285,792**			**61.85**	**85,460.43**
Total Project Emissions							**20,977,110**				**342,368**
		5%		47%		23%	25%				
Emission Category Subtotals (MTCO2e)		**964,553.68**		**9,931,383.85**		**4,795,380.70**	**5,285,791.93**				
Per Capita MTCO2e		**9.65**		**99.31**		**47.95**	**52.86**				**3.42**
Annual Per Capita		0.16		1.61		0.78	0.85				

Development Summary: Corridor Land Use

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population
Single-Family Home (4du/a)...........................	11,688	4	2,922	30%					20%	584.4	33,895
Single-Family Home (11du/a)..........................	11,693	11	1,063	30%					30%	318.9	33,910
ADU..	812	-	-	2%					0%	0	2,355
Multi-Family Unit in Large Building (44du/a) ...	3,487	52	79	9%					30%	23.775	6,625
Multi-Family Unit in Large Building (22du/a) ...	4,979	30	226	13%					30%	67.89545	9,460
Multi-Family Unit in Large Building (20du/a) ...	2,885	20	144.25	7%					30%	43	5,482
Multi-Family Unit in Small Building (16du/a) ...	2,691	16	168.19	7%					30%	50	5,382
Mobile Home..	1,156	12	96.33	3%					20%	19	2,890
Education					1,042.00	0.30	3,473	79.74	15%	12	
Food Sales					500.00	0.48	1,042	23.91	50%	12	
Food Service					2,256.00	0.48	4,700	107.90	50%	54	
Health Care Inpatient					607.00	0.76	799	18.34	40%	7	
Health Care Outpatient					92.00	0.67	137	3.15	50%	2	
Lodging					938.00	0.48	1,954	44.86	40%	18	
Retail					3,133.00	0.48	6,527	149.84	50%	75	
Office (High Density))					-	0.80	-	-	40%	0	
Office (Low Density)					2,669.00	0.57	4,682	107.49	40%	43	
Public Assembly					50.00	0.38	132	3.02	50%	2	
Public Order and Safety					109.00	0.57	191	4.39	40%	2	
Religious Worship					650.00	0.38	1,711	39.27	30%	12	
Service					613.00	0.57	1,075	24.69	40%	10	
Warehouse and Storage					339.00	0.76	446	10.24	40%	4	
Manufacturing..					1,979.00	0.76	2,604	59.78	40%	24	
Vacant					-	0.03	-	-	40%	0	
	39,391		**4,699**	**100%**	**14,977.00**		**29,473**	**677**		**1,384**	**99,999**

Total Developed Land Area....... **7,168** **Acres**

Residential + Nonresidential + 25 % streets = Total Development Land Area...

Pavement.................................. **138,326** **Thousands of SF**

Emissions Summary

Emissions Per Unit or Per Thousand Square Feet (MTCO2e)

Land Use	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)	52	603,668	658	7,696,351	674	7,881,621	**16,181,640**	58	26.5%	15.33	279,501.05
Single-Family Home (11du/a)	41	477,979	521	6,086,522	491	5,742,061	**12,306,561**	58	20.1%	11.66	212,567.87
ADU	10	8,283	156	126,820	543	440,613	**575,716**	58	0.9%	0.55	9,944.19
Multi-Family Unit in Large Building (44du/a)	14	49,565	350	1,220,651	420	1,463,949	**2,734,165**	58	4.5%	2.59	47,226.49
Multi-Family Unit in Large Building (22du/a)	8	41,138	350	1,742,938	499	2,483,742	**4,267,818**	58	7.0%	4.04	73,716.86
Multi-Family Unit in Large Building (20du/a)	23	67,060	350	1,009,917	566	1,634,182	**2,711,158**	58	4.4%	2.57	46,829.09
Multi-Family Unit in Small Building (16du/a)	23	62,686	504	1,355,569	607	1,634,716	**3,052,971**	58	5.0%	2.89	52,733.13
Mobile Home	22	25,092	276	319,239	478	552,401	**896,731**	81	1.5%	1.18	11,133.01
Education	38	39,593	618	643,782	238	248,009	**931,384**	81	1.5%	1.23	11,563.22
Food Sales	24	12,170	1,475	737,662	186	92,899	**842,731**	81	1.4%	1.11	10,462.58
Food Service	24	54,912	1,909	4,305,838	370	833,746	**5,194,496**	81	8.5%	6.85	64,490.16
Health Care Inpatient	37	22,557	1,855	1,125,780	384	232,793	**1,381,130**	58	2.3%	1.31	23,855.89
Health Care Outpatient	37	3,419	705	64,855	376	34,630	**102,904**	63	0.2%	0.11	1,645.23
Lodging	17	15,686	744	697,770	77	72,412	**785,868**	63	1.3%	0.80	12,564.47
Retail	24	76,259	552	1,730,905	163	509,457	**2,316,621**	63	3.8%	2.37	37,038.20
Office (High Density))	37	-	692	-	387	-	**-**	63	0.0%	0.00	-
Office (Low Density)	24	64,965	692	1,846,960	387	1,033,348	**2,945,273**	63	4.8%	3.01	47,089.09
Public Assembly	24	1,217	701	35,066	99	4,958	**41,241**	63	0.1%	0.04	659.36
Public Order and Safety	37	4,051	860	93,744	246	26,855	**124,650**	63	0.2%	0.13	1,992.90
Religious Worship	37	24,155	324	210,764	85	55,050	**289,969**	63	0.5%	0.30	4,636.04
Service	24	14,921	574	351,671	175	107,414	**474,006**	63	0.8%	0.48	7,584.09
Warehouse and Storage	19	6,299	336	114,067	120	40,533	**160,898**	63	0.3%	0.16	2,572.45
Manufacturing	24	48,170	1,224	2,421,343	169	335,214	**2,804,727**	63	4.6%	2.87	44,842.04
Vacant	19	-	155	-	31	-	**-**	63	0.0%	0.00	-
									100.0%		
Pavement							**6,916,288**			**61.57**	**112,324.95**
Total Project Emissions							**68,038,946**				**1,116,972**
		3%		50%		37%	10%				
Emission Category Subtotals (MTCO2e)		**1,723,843.55**		**33,938,213.41**		**25,460,600.53**	**6,916,288.26**				
Per Capita MTCO2e		**17.24**		**339.39**		**254.61**	**69.16**				**11.17**

Development Summary: Corridor Demand

Emissions Summary

Emissions **Per Unit** or **Per Thousand Square Feet** (MTCO2e)

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)...........................	11,688	4	2,922	30%					20%	584.4	33,895	36	422,568	329	3,848,176	117	1,362,043	5,632,786	58	25.0%	14.45	97,293.57
Single-Family Home (11du/a).........................	11,693	11	1,063	30%					30%	318.9	33,910	29	334,585	260	3,043,261	85	992,300	4,370,146	58	19.4%	11.21	75,484.34
ADU..	812	-	-	2%					0%	0	2,355	7	5,798	78	63,410	94	76,143	145,352	58	0.6%	0.37	2,510.62
Multi-Family Unit in Large Building (44du/a) ...	3,487	52	79	9%					30%	23.775	6,625	10	34,695	175	610,326	73	252,989	898,010	58	4.0%	2.30	15,511.08
Multi-Family Unit in Large Building (22du/a) ...	4,979	30	226	13%					30%	67.89545	9,460	6	28,797	175	871,469	86	429,222	1,329,487	58	5.9%	3.41	22,963.87
Multi-Family Unit in Large Building (20du/a) ...	2,885	20	144.25	7%					30%	43	5,482	16	46,942	175	504,958	98	282,407	834,307	58	3.7%	2.14	14,410.76
Multi-Family Unit in Small Building (16du/a) ...	2,691	16	168.19	7%					30%	50	5,382	16	43,880	252	677,784	105	282,499	1,004,164	58	4.4%	2.58	17,344.65
Mobile Home..	1,156	12	96.33	3%					20%	19	2,890	15	17,564	138	159,619	83	95,462	272,645	81	1.2%	0.97	3,384.92
Education					1,042.00	0.30	3,473	79.74	15%	12		27	27,715	309	321,891	41	42,859	392,465	81	1.7%	1.40	4,872.49
Food Sales					500.00	0.48	1,042	23.91	50%	12		17	8,519	738	368,831	32	16,054	393,404	81	1.7%	1.40	4,884.15
Food Service					2,256.00	0.48	4,700	107.90	50%	54		17	38,439	954	2,152,919	64	144,082	2,335,439	81	10.3%	8.33	28,994.70
Health Care Inpatient					607.00	0.76	799	18.34	40%	7		26	15,790	927	562,890	66	40,230	618,910	58	2.7%	1.59	10,690.26
Health Care Outpatient					92.00	0.67	137	3.15	50%	2		26	2,393	352	32,427	65	5,984	40,805	63	0.2%	0.11	652.39
Lodging					938.00	0.48	1,954	44.86	40%	18		12	10,980	372	348,885	13	12,514	372,379	63	1.6%	1.03	5,953.60
Retail					3,133.00	0.48	6,527	149.84	50%	75		17	53,381	276	865,453	28	88,041	1,006,875	63	4.5%	2.79	16,097.94
Office (High Density))					-	0.80	-	-	40%	0		26	-	346	-	67	-	-	63	0.0%	0.00	-
Office (Low Density)					2,669.00	0.57	4,682	107.49	40%	43		17	45,476	346	923,480	67	178,575	1,147,531	63	5.1%	3.18	18,346.75
Public Assembly					50.00	0.38	132	3.02	50%	2		17	852	351	17,533	17	857	19,242	63	0.1%	0.05	307.64
Public Order and Safety					109.00	0.57	191	4.39	40%	2		26	2,835	430	46,872	43	4,641	54,348	63	0.2%	0.15	868.92
Religious Worship					650.00	0.38	1,711	39.27	30%	12		26	16,908	162	105,382	15	9,513	131,804	63	0.6%	0.37	2,107.28
Service					613.00	0.57	1,075	24.69	40%	10		17	10,445	287	175,836	30	18,562	204,843	63	0.9%	0.57	3,277.48
Warehouse and Storage					339.00	0.76	446	10.24	40%	4		13	4,409	168	57,033	21	7,005	68,447	63	0.3%	0.19	1,094.33
Manufacturing..					1,979.00	0.76	2,604	59.78	40%	24		17	33,719	612	1,210,672	29	57,929	1,302,320	63	5.8%	3.61	20,821.52
Vacant					-	0.03	-	-	40%	0		13	-	78	-	5	-	-	63	0.0%	0.00	-
	39,391		**4,699**	**100%**	**14,977.00**		**29,473**	**677**		**1,384**	**99,999**									100.0%		
Total Developed Land Area.......	**7,168**	**Acres**																				
Residential + Nonresidential + 25 % streets = Total Development Land Area...																						
Pavement..................................					**138,326**		**Thousands of SF**											**6,916,288**			**62.20**	**111,201.70**
Total Project Emissions																		**29,491,995**				**479,075**
													4%		58%		15%	23%				
Emission Category Subtotals (MTCO2e)													**1,206,690.49**		**16,969,106.70**		**4,399,910.03**	**6,916,288.26**				
Per Capita MTCO2e													**12.07**		**169.69**		**44.00**	**69.16**				**4.79**

Development Summary: Corridor Supply

Emissions Summary

Emissions Per Unit or Per Thousand Square Feet (MTCO2e)

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)...........................	11,688	4	2,922	30%					20%	584.4	33,895	52	603,668	395	4,617,811	674	7,881,621	13,103,100	58	27.6%	15.95	226,326.26
Single-Family Home (11du/a)..........................	11,693	11	1,063	30%					30%	318.9	33,910	41	477,979	312	3,651,913	491	5,742,061	9,871,952	58	20.8%	12.02	170,515.54
ADU...	812	-	-	2%					0%	0	2,355	10	8,283	94	76,092	543	440,613	524,988	58	1.1%	0.64	9,067.98
Multi-Family Unit in Large Building (44du/a) ...	3,487	52	79	9%					30%	23.775	6,625	14	49,565	210	732,391	420	1,463,949	2,245,904	58	4.7%	2.73	38,792.89
Multi-Family Unit in Large Building (22du/a) ...	4,979	30	226	13%					30%	67.89545	9,460	8	41,138	210	1,045,763	499	2,483,742	3,570,643	58	7.5%	4.35	61,674.74
Multi-Family Unit in Large Building (20du/a) ...	2,885	20	144.25	7%					30%	43	5,482	23	67,060	210	605,950	566	1,634,182	2,307,191	58	4.9%	2.81	39,851.49
Multi-Family Unit in Small Building (16du/a) ...	2,691	16	168.19	7%					30%	50	5,382	23	62,686	302	813,341	607	1,634,716	2,510,743	58	5.3%	3.06	43,367.38
Mobile Home..	1,156	12	96.33	3%					20%	19	2,890	22	25,092	166	191,543	478	552,401	769,036	81	1.6%	1.30	9,547.65
Education					1,042.00	0.30	3,473	79.74	15%	12		38	39,593	371	386,269	238	248,009	673,871	81	1.4%	1.14	8,366.17
Food Sales					500.00	0.48	1,042	23.91	50%	12		24	12,170	885	442,597	186	92,899	547,666	81	1.2%	0.93	6,799.32
Food Service					2,256.00	0.48	4,700	107.90	50%	54		24	54,912	1,145	2,583,503	370	833,746	3,472,161	81	7.3%	5.88	43,107.20
Health Care Inpatient					607.00	0.76	799	18.34	40%	7		37	22,557	1,113	675,468	384	232,793	930,818	58	2.0%	1.13	16,077.77
Health Care Outpatient					92.00	0.67	137	3.15	50%	2		37	3,419	423	38,913	376	34,630	76,962	63	0.2%	0.10	1,230.47
Lodging					938.00	0.48	1,954	44.86	40%	18		17	15,686	446	418,662	77	72,412	506,760	63	1.1%	0.67	8,102.08
Retail					3,133.00	0.48	6,527	149.84	50%	75		24	76,259	331	1,038,543	163	509,457	1,624,259	63	3.4%	2.14	25,968.70
Office (High Density))					-	0.80	-	-	40%	0		37	-	415	-	387	-	-	63	0.0%	0.00	-
Office (Low Density)					2,669.00	0.57	4,682	107.49	40%	43		24	64,965	415	1,108,176	387	1,033,348	2,206,489	63	4.6%	2.90	35,277.39
Public Assembly					50.00	0.38	132	3.02	50%	2		24	1,217	421	21,040	99	4,958	27,214	63	0.1%	0.04	435.10
Public Order and Safety					109.00	0.57	191	4.39	40%	2		37	4,051	516	56,246	246	26,855	87,152	63	0.2%	0.11	1,393.39
Religious Worship					650.00	0.38	1,711	39.27	30%	12		37	24,155	195	126,459	85	55,050	205,664	63	0.4%	0.27	3,288.15
Service					613.00	0.57	1,075	24.69	40%	10		24	14,921	344	211,003	175	107,414	333,337	63	0.7%	0.44	5,333.40
Warehouse and Storage					339.00	0.76	446	10.24	40%	4		19	6,299	202	68,440	120	40,533	115,272	63	0.2%	0.15	1,842.97
Manufacturing..					1,979.00	0.76	2,604	59.78	40%	24		24	48,170	734	1,452,806	169	335,214	1,836,190	63	3.9%	2.42	29,357.04
Vacant					-	0.03	-	-	40%	0		19	-	93	-	31	-	-	63	0.0%	0.00	-
	39,391		**4,699**	**100%**	**14,977.00**		**29,473**	**677**		**1,384**	**99,999**									100.0%		
Total Developed Land Area.......	**7,168**	**Acres**																				
Residential + Nonresidential + 25 % streets = Total Development Land Area...																						
Pavement..................................					**138,326**		**Thousands of SF**											**6,916,288**			**61.18**	**113,041.31**

	Embodied Subtotal	Energy Subtotal	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Annual Emissions (MTCO2e)
Total Project Emissions				**54,463,660**	**898,764**
	3%	37%	47%	13%	
Emission Category Subtotals (MTCO2e)	**1,723,843.55**	**20,362,928.05**	**25,460,600.53**	**6,916,288.26**	
Per Capita MTCO2e	**17.24**	**203.63**	**254.61**	**69.16**	**8.99**

Development Summary: Corridor Comprehensive

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population
Single-Family Home (4du/a)...........................	11,688	4	2,922	30%					20%	584.4	33,895
Single-Family Home (11du/a)..........................	11,693	11	1,063	30%					30%	318.9	33,910
ADU..	812	-	-	2%					0%	0	2,355
Multi-Family Unit in Large Building (44du/a) ...	3,487	52	79	9%					30%	23.775	6,625
Multi-Family Unit in Large Building (22du/a) ...	4,979	30	226	13%					30%	67.89545	9,460
Multi-Family Unit in Large Building (20du/a) ...	2,885	20	144.25	7%					30%	43	5,482
Multi-Family Unit in Small Building (16du/a) ...	2,691	16	168.19	7%					30%	50	5,382
Mobile Home..	1,156	12	96.33	3%					20%	19	2,890
Education					1,042.00	0.30	3,473	79.74	15%	12	
Food Sales					500.00	0.48	1,042	23.91	50%	12	
Food Service					2,256.00	0.48	4,700	107.90	50%	54	
Health Care Inpatient					607.00	0.76	799	18.34	40%	7	
Health Care Outpatient					92.00	0.67	137	3.15	50%	2	
Lodging					938.00	0.48	1,954	44.86	40%	18	
Retail					3,133.00	0.48	6,527	149.84	50%	75	
Office (High Density))					-	0.80	-	-	40%	0	
Office (Low Density)					2,669.00	0.57	4,682	107.49	40%	43	
Public Assembly					50.00	0.38	132	3.02	50%	2	
Public Order and Safety					109.00	0.57	191	4.39	40%	2	
Religious Worship					650.00	0.38	1,711	39.27	30%	12	
Service					613.00	0.57	1,075	24.69	40%	10	
Warehouse and Storage					339.00	0.76	446	10.24	40%	4	
Manufacturing..					1,979.00	0.76	2,604	59.78	40%	24	
Vacant					-	0.03	-	-	40%	0	
	39,391		**4,699**	**100%**	**14,977.00**		**29,473**	**677**		**1,384**	**99,999**
Total Developed Land Area.......	**7,168**	**Acres**									
Pavement.................................					**138,326**		**Thousands of SF**				

Residential + Nonresidential + 25 % streets = Total Development Land Area...

Emissions Summary

Land Use	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
	Emissions Per Unit or Per Thousand Square Feet (MTCO2e)										
Single-Family Home (4du/a)	36	422,568	198	2,308,905	117	1,362,043	**4,093,515**	58	25.9%	15.01	70,706.18
Single-Family Home (11du/a)	29	334,585	156	1,825,956	85	992,300	**3,152,841**	58	20.0%	11.56	54,458.17
ADU	7	5,798	47	38,046	94	76,143	**119,988**	58	0.8%	0.44	2,072.51
Multi-Family Unit in Large Building (44du/a)	10	34,695	105	366,195	73	252,989	**653,879**	58	4.1%	2.40	11,294.28
Multi-Family Unit in Large Building (22du/a)	6	28,797	105	522,881	86	429,222	**980,900**	58	6.2%	3.60	16,942.81
Multi-Family Unit in Large Building (20du/a)	16	46,942	105	302,975	98	282,407	**632,324**	58	4.0%	2.32	10,921.96
Multi-Family Unit in Small Building (16du/a)	16	43,880	151	406,671	105	282,499	**733,050**	58	4.6%	2.69	12,661.77
Mobile Home	15	17,564	83	95,772	83	95,462	**208,798**	81	1.3%	1.07	2,592.24
Education	27	27,715	185	193,135	41	42,859	**263,709**	81	1.7%	1.35	3,273.97
Food Sales	17	8,519	443	221,298	32	16,054	**245,872**	81	1.6%	1.25	3,052.52
Food Service	17	38,439	573	1,291,751	64	144,082	**1,474,272**	81	9.3%	7.52	18,303.22
Health Care Inpatient	26	15,790	556	337,734	66	40,230	**393,753**	58	2.5%	1.44	6,801.20
Health Care Outpatient	26	2,393	211	19,456	65	5,984	**27,834**	63	0.2%	0.11	445.01
Lodging	12	10,980	223	209,331	13	12,514	**232,825**	63	1.5%	0.92	3,722.41
Retail	17	53,381	166	519,272	28	88,041	**660,694**	63	4.2%	2.62	10,563.18
Office (High Density))	26	-	208	-	67	-	**-**	63	0.0%	0.00	-
Office (Low Density)	17	45,476	208	554,088	67	178,575	**778,139**	63	4.9%	3.08	12,440.90
Public Assembly	17	852	210	10,520	17	857	**12,229**	63	0.1%	0.05	195.51
Public Order and Safety	26	2,835	258	28,123	43	4,641	**35,599**	63	0.2%	0.14	569.17
Religious Worship	26	16,908	97	63,229	15	9,513	**89,651**	63	0.6%	0.36	1,433.34
Service	17	10,445	172	105,501	30	18,562	**134,508**	63	0.9%	0.53	2,152.13
Warehouse and Storage	13	4,409	101	34,220	21	7,005	**45,634**	63	0.3%	0.18	729.59
Manufacturing	17	33,719	367	726,403	29	57,929	**818,051**	63	5.2%	3.24	13,079.02
Vacant	13	-	47	-	5	-	**-**	63	0.0%	0.00	-
									100.0%		
Pavement.................................							**6,916,288**			**61.88**	**111,777.12**
Total Project Emissions							**22,704,353**				**370,188**
		5%		45%		19%	30%				
Emission Category Subtotals (MTCO2e)		**1,206,690.49**		**10,181,464.02**		**4,399,910.03**	**6,916,288.26**				
Per Capita MTCO2e		**12.07**		**101.82**		**44.00**	**69.16**				**3.70**

Development Summary: Merced Baseline (without existing pavement)

Emissions Summary

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population	Emissions Per Unit or Per Thousand Square Feet (MTCO2e): Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)...........................	15,771	8	3,943	56%					20%	788.55	48,890	52	814,549	230	3,634,728	493	7,779,253	12,228,530	58	45.0%	26.02	211,220.07
Single-Family Home (11du/a)..........................	5,374	11	489	19%					30%	146.5636	15,585	41	219,675	182	979,059	359	1,930,380	3,129,114	58	11.5%	6.66	54,048.33
ADU..	-	-	-	0%					0%	0	-	10	-	55	-	397	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (44du/a) ...	-	44	-	0%					30%	0	-	14	-	123	-	324	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (22du/a) ...	1,707	22	78	6%					30%	23.27727	3,585	8	14,104	123	209,142	402	686,572	909,817	58	3.3%	1.94	15,715.03
Multi-Family Unit in Large Building (20du/a) ...	-	20	-	0%					30%	0	-	23	-	123	-	414	-	-	58	0.0%	0.00	-
Multi-Family Unit in Small Building (16du/a) ...	3,865	16	241.56	14%					30%	72	9,663	23	90,033	176	681,437	444	1,717,440	2,488,910	58	9.1%	5.30	42,990.26
Mobile Home..	1,287	12	107.25	5%					20%	21	3,218	22	27,935	97	124,395	350	449,861	602,192	81	2.2%	1.78	7,476.27
Education					2,388.00	0.16	14,925	342.63	15%	51		38	90,738	216	516,385	209	499,277	1,106,399	81	4.1%	3.28	13,736.05
Food Sales					-	0.25	-	-	50%	0		24	-	516	-	163	-	-	81	0.0%	0.00	-
Food Service					-	0.25	-	-	50%	0		24	-	668	-	325	-	-	81	0.0%	0.00	-
Health Care Inpatient					-	0.40	-	-	40%	0		37	-	649	-	337	-	-	58	0.0%	0.00	-
Health Care Outpatient					-	0.25	-	-	50%	0		37	-	247	-	331	-	-	63	0.0%	0.00	-
Lodging					-	0.35	-	-	40%	0		17	-	260	-	68	-	-	63	0.0%	0.00	-
Retail					7,662.00	0.25	30,648	703.58	50%	352		24	186,498	193	1,481,573	143	1,094,452	2,762,523	63	10.2%	6.35	44,167.29
Office (High Density))					-	0.80	-	-	40%	0		37	-	242	-	340	-	-	63	0.0%	0.00	-
Office (Low Density)					1,374.00	0.30	4,580	105.14	40%	42		24	33,444	242	332,785	340	467,296	833,525	63	3.1%	1.92	13,326.42
Public Assembly					-	0.20	-	-	50%	0		24	-	245	-	87	-	-	63	0.0%	0.00	-
Public Order and Safety					582.00	0.30	1,940	44.54	40%	18		37	21,628	301	175,189	216	125,960	322,777	63	1.2%	0.74	5,160.57
Religious Worship					-	0.20	-	-	30%	0		37	-	113	-	74	-	-	63	0.0%	0.00	-
Service					-	0.30	-	-	40%	0		24	-	201	-	154	-	-	63	0.0%	0.00	-
Warehouse and Storage					-	0.40	-	-	40%	0		19	-	118	-	105	-	-	63	0.0%	0.00	-
Manufacturing...					4,690.00	0.40	11,725	269.17	40%	108		24	114,157	428	2,008,406	149	697,841	2,820,404	63	10.4%	6.48	45,092.68
Vacant					-	0.03	-	-	40%	0		19	-	54	-	27	-	-	63	0.0%	0.00	-
	28,004		**4,858**	**100%**	**16,696.00**		**63,818**	**1,465**		**1,623**	**80,939**									100.0%		
Total Developed Land Area.......	**8,430**	**Acres**																				
Residential + Nonresidential + 25 % streets = Total Development Land Area...																						
Pavement..................................					**0**		**Thousands of SF**											-			**60.47**	**-**
Total Project Emissions																		**27,204,192**				**452,933**
													0%		37%		57%	0%				
Emission Category Subtotals (MTCO2e)													**-**		**10,143,099.07**		**15,448,332.37**	**-**				
Per Capita MTCO2e													**-**		**202.86**		**308.97**	**-**				**9.06**

Development Summary: Merced CAP Paving

Emissions Summary

Emissions Per Unit or Per Thousand Square Feet (MTCO2e)

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population	Embodied	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)...........................	19,000	8	4,750	50%					20%	950	58,900	36	686,925	132	2,502,236	219	4,164,683	7,353,844	58	38.4%	22.22	127,020.94
Single-Family Home (11du/a)...........................	9,000	11	818	24%					30%	245.4545	26,100	29	257,527	104	936,949	160	1,436,605	2,631,080	58	13.7%	7.95	45,445.94
ADU..	-	-	-	0%					0%	0	-	7	-	31	-	176	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building (44du/a) ...	2,500	44	57	7%					30%	17.04545	4,750	10	24,875	70	175,029	144	359,502	559,405	58	2.9%	1.69	9,662.46
Multi-Family Unit in Large Building (22du/a) ...	2,500	22	114	7%					30%	34.09091	5,250	6	14,459	70	175,029	179	446,830	636,318	58	3.3%	1.92	10,990.94
Multi-Family Unit in Large Building (20du/a) ...	-	20	-	0%					30%	0	-	16	-	70	-	184	-	-	58	0.0%	0.00	-
Multi-Family Unit in Small Building (16du/a) ...	4,000	16	250.00	11%					30%	75	10,000	16	65,225	101	402,993	197	789,845	1,258,063	58	6.6%	3.80	21,730.17
Mobile Home...	1,000	12	83.33	3%					20%	17	2,500	15	15,194	55	55,232	155	155,328	225,754	81	1.2%	0.95	2,802.75
Education					1,120.00	0.20	5,600	128.56	15%	19		27	29,790	124	138,395	93	104,058	272,242	81	1.4%	1.14	3,379.91
Food Sales					-	0.25	-	-	50%	0		17	-	295	-	73	-	-	81	0.0%	0.00	-
Food Service					654.00	0.40	1,635	37.53	50%	19		17	11,143	382	249,647	144	94,347	355,137	81	1.9%	1.49	4,409.06
Health Care Inpatient					2,870.00	0.40	7,175	164.72	40%	66		26	74,657	371	1,064,576	150	429,656	1,568,889	58	8.2%	4.74	27,098.99
Health Care Outpatient					99.00	0.30	330	7.58	50%	4		26	2,575	141	13,958	147	14,546	31,080	63	0.2%	0.10	496.90
Lodging					-	0.35	-	-	40%	0		12	-	149	-	30	-	-	63	0.0%	0.00	-
Retail					4,560.00	0.30	15,200	348.94	50%	174		17	77,695	110	503,858	63	289,447	871,000	63	4.5%	2.84	13,925.57
Office (High Density))					1,000.00	0.80	1,250	28.70	40%	11		26	26,013	138	138,401	151	151,132	315,545	63	1.6%	1.03	5,044.95
Office (Low Density)					2,820.00	0.45	6,267	143.86	40%	58		17	48,048	138	390,291	151	426,191	864,530	63	4.5%	2.82	13,822.12
Public Assembly					-	0.20	-	-	50%	0		17	-	140	-	39	-	-	63	0.0%	0.00	-
Public Order and Safety					-	0.30	-	-	40%	0		26	-	172	-	96	-	-	63	0.0%	0.00	-
Religious Worship					-	0.20	-	-	30%	0		26	-	65	-	33	-	-	63	0.0%	0.00	-
Service					3,766.00	0.40	9,415	216.14	40%	86		17	64,167	115	432,103	68	257,595	753,864	63	3.9%	2.46	12,061.82
Warehouse and Storage					2,276.00	0.40	5,690	130.62	40%	52		13	29,603	67	153,166	47	106,228	288,996	63	1.5%	0.94	4,620.47
Manufacturing...					3,575.00	0.40	8,938	205.18	40%	82		17	60,912	245	874,816	66	236,379	1,172,107	63	6.1%	3.83	18,739.68
Vacant					-	0.03	-	-	40%	0		13	-	31	-	12	-	-	63	0.0%	0.00	-
	38,000		**6,072**	**100%**	**22,740.00**		**61,499**	**1,412**		**1,910**	**107,500**									100.0%		

Total Developed Land Area....... **9,978** **Acres**

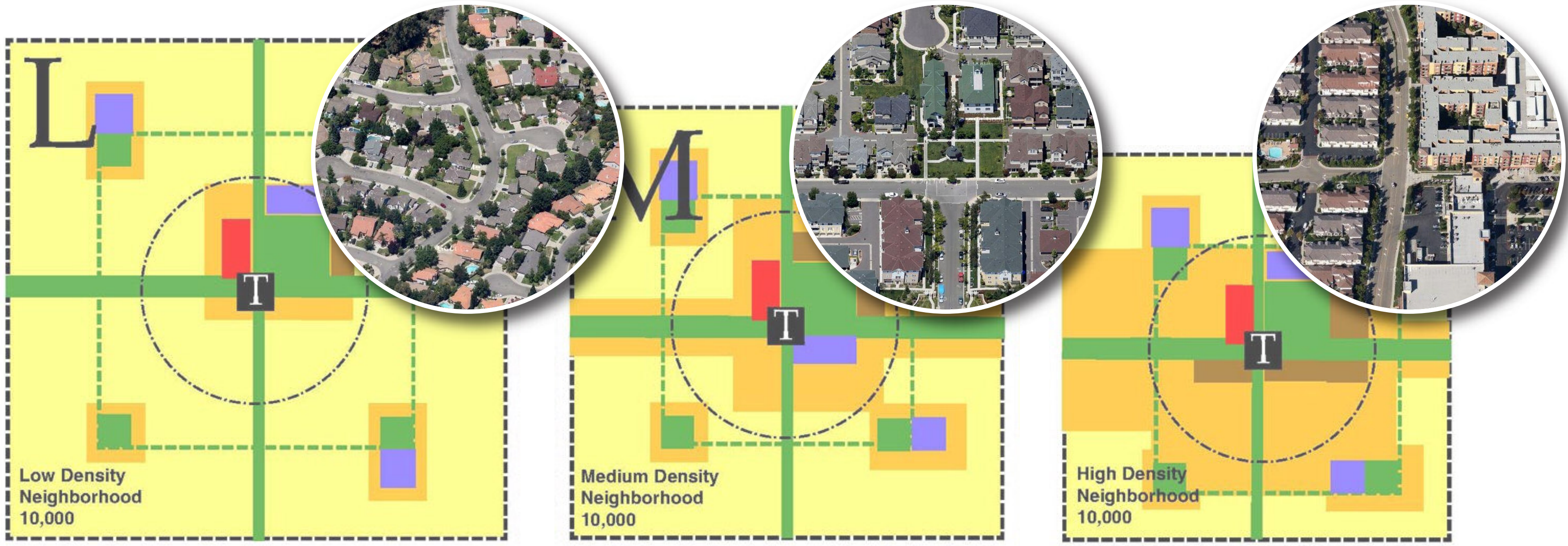
Residential + Nonresidential + 25 % streets = Total Development Land Area...

Total pavement - Baseline Pavement

	Square Feet (in thousands of square feet)		Embodied Subtotal	Energy Subtotal	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Weighted Average Year	Annual Emissions (MTCO2e)
Pavement.................................	**33,812**	**Thousands of SF**				1,690,619	**59.95**	**28,202.79**
Total Project Emissions						**20,848,473**		**349,455**
			7%	39%	45%	8%		
Emission Category Subtotals (MTCO2e)			**1,488,808.37**	**8,206,675.96**	**9,462,369.12**	**1,690,619.44**		
Per Capita MTCO2e			**29.78**	**164.13**	**189.25**	**33.81**		**3.25**

Neighborhood Typologies

Low 956 acres High 552 acres



Low Density Neighborhood
10,000 Population

Medium Density Neighborhood
10,000 Population

High Density Neighborhood
10,000 Population

Low 956 acres	High 552 acres
2008 Merced Baseline	**2008 Merced Baseline**
3.36 M MTCO2e Lifespan	2.87 M MTCO2e Lifespan
5.75 MTCO2e Per Capita Annual	4.91 MTCO2e Per Capita Annual
SMART BLOCK DEVELOPMENT	**SMART BLOCK DEVELOPMENT**
2.18 M MTCO2e Lifespan	1.75 M MTCO2e Lifespan
3.72 MTCO2e Per Capita Annual	2.99 MTCO2e Per Capita Annual

Targets: Below U.S. Average (Low 956 acres)

- **Demand-side**
  - Embodied 30% reduction
  - Energy 50% reduction
  - VMT 21% reduction
  - 23-48mpg
- **Supply-side**
  - 60% reduction in CO2e

Targets: Below U.S. Average (High 552 acres)

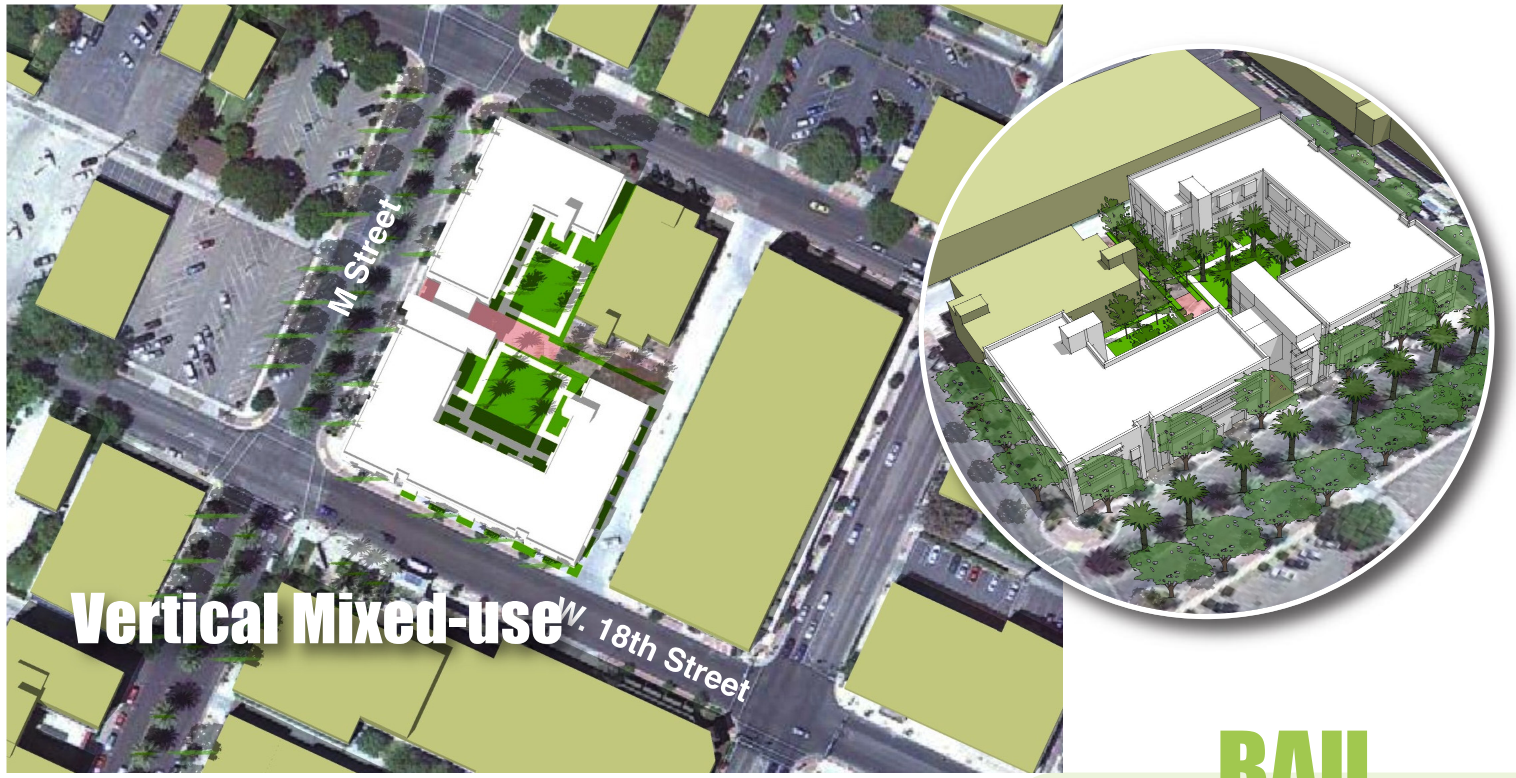
- **Demand-side**
  - Embodied 30% reduction
  - Energy 50% reduction
  - VMT 21% reduction
  - 23-48mpg
- **Supply-side**
  - 60% reduction in CO2e

Development Summary

Emissions Summary

Land Use	# Units	Dwelling Units per Acre (DU/a)	Residential Acre Land Area	Percentage of Housing Types	Square Feet (in thousands of square feet)	Floor Area Ratio (FAR)	Nonresid. SF Land Area	Nonresid. Acre Land Area	Percent On-site Paving	On-site Paving Area Acres	Population	Embodied (Emissions Per Unit or Per Thousand Square Feet (MTCO2e))	Embodied Subtotal	Energy	Energy Subtotal	Transportation	Transportation Subtotal	Lifespan Emissions (MTCO2e)	Life span	Percentage of Total Emissions	Weighted Average Year	Annual Emissions (MTCO2e)
Single-Family Home (4du/a)	660	4	165	17%					20%	33	1,914	36	23,862	132	86,920	219	144,668	255,449	58	21.0%	12.16	4,412.31
Single-Family Home (11du/a)	1,900	11	173	49%					30%	51.81818	5,510	29	54,367	104	197,800	160	303,283	555,450	58	45.7%	26.44	9,594.14
ADU	-	-	-	0%					0%	0	-	7	-	31	-	176	-	-	58	0.0%	0.00	-
Multi-Family Unit in Large Building	250	60	6	6%					30%	1.704545	475	10	2,487	70	17,503	144	35,950	55,941	58	4.6%	2.66	966.25
Multi-Family Unit in Large Building	800	30	36	20%					30%	10.90909	1,520	6	4,627	70	56,009	179	142,985	203,622	58	16.7%	9.69	3,517.10
Multi-Family Unit in Large Building (20du/a)	300	20	15.00	8%					30%	5	570	16	4,881	70	21,003	184	55,237	81,122	58	6.7%	3.86	1,401.19
Multi-Family Unit in Small Building (16du/a)	-	16	-	0%					30%	0	-	16	-	101	-	197	-	-	58	0.0%	0.00	-
Mobile Home	-	12	-	0%					20%	0	-	15	-	55	-	155	-	-	81	0.0%	0.00	-
Education					163.40	0.32	511	11.72	15%	2		27	4,346	124	20,191	93	15,181	39,718	81	3.3%	2.63	493.11
Food Sales					-	0.25	-	-	50%	0		17	-	295	-	73	-	-	81	0.0%	0.00	-
Food Service					-	0.25	-	-	50%	0		17	-	382	-	144	-	-	81	0.0%	0.00	-
Health Care Inpatient					-	0.40	-	-	40%	0		26	-	371	-	150	-	-	58	0.0%	0.00	-
Health Care Outpatient					-	0.25	-	-	50%	0		26	-	141	-	147	-	-	63	0.0%	0.00	-
Lodging					-	0.35	-	-	40%	0		12	-	149	-	30	-	-	63	0.0%	0.00	-
Retail					130.70	0.40	327	7.50	50%	4		17	2,227	110	14,442	63	8,296	24,965	63	2.1%	1.28	399.14
Office (High Density))					-	0.80	-	-	40%	0		26	-	138	-	151	-	-	63	0.0%	0.00	-
Office (Low Density)					-	0.30	-	-	40%	0		17	-	138	-	151	-	-	63	0.0%	0.00	-
Public Assembly					-	0.20	-	-	50%	0		17	-	140	-	39	-	-	63	0.0%	0.00	-
Public Order and Safety					-	0.30	-	-	40%	0		26	-	172	-	96	-	-	63	0.0%	0.00	-
Religious Worship					-	0.20	-	-	30%	0		26	-	65	-	33	-	-	63	0.0%	0.00	-
Service					-	0.30	-	-	40%	0		17	-	115	-	68	-	-	63	0.0%	0.00	-
Warehouse and Storage					-	0.40	-	-	40%	0		13	-	67	-	47	-	-	63	0.0%	0.00	-
Manufacturing					-	0.40	-	-	40%	0		17	-	245	-	66	-	-	63	0.0%	0.00	-
Vacant					-	0.03	-	-	40%	0		13	-	31	-	12	-	-	63	0.0%	0.00	-
	3,910		**395**	**100%**	**294.10**		**837**	**19**		**107**	**9,989**									100.0%		
Total Developed Land Area.......	**552**	**Acres**																				
Residential + Nonresidential + 25 % streets = Total Development Land Area....																						
Pavement.................................					**10,691**	**Thousands of SF**												534,567			58.73	9,102.12
Total Project Emissions																		**1,750,834**				**29,885**
													6%		24%		40%	31%				
Emission Category Subtotals (MTCO2e)													**96,797.23**		**413,868.10**		**705,601.13**	**534,567.19**				
Per Capita MTCO2e													**9.69**		**41.43**		**70.64**	**53.52**				**2.99**

MERCED



PROGRAM

Site Area	53,000 NSF (1.2 acres)
Resid.	1.2a @ 52 DU/a = 60 DUs
Commercial	8,000 SF (ground floor)

SMART BLOCK DEVELOPMENT

18,712 MTCO2e Lifespan
2.80 MTCO2e Per Capita Annual

4 % Embodied 28 % Energy 63 % Transportation 4% Paving

COMPACT DEVELOPMENT (2008 Merced CAP Baseline)

31,928 MTCO2e Lifespan
4.78 MTCO2e Per Capita Annual

3 % Embodied 25 % Energy 69 % Transportation 2 % Paving

Targets: Below U.S. Average
Demand-side
30% reduction 50% reduction 21% reduction
Supply-side
60% reduction

MERCED

BAU

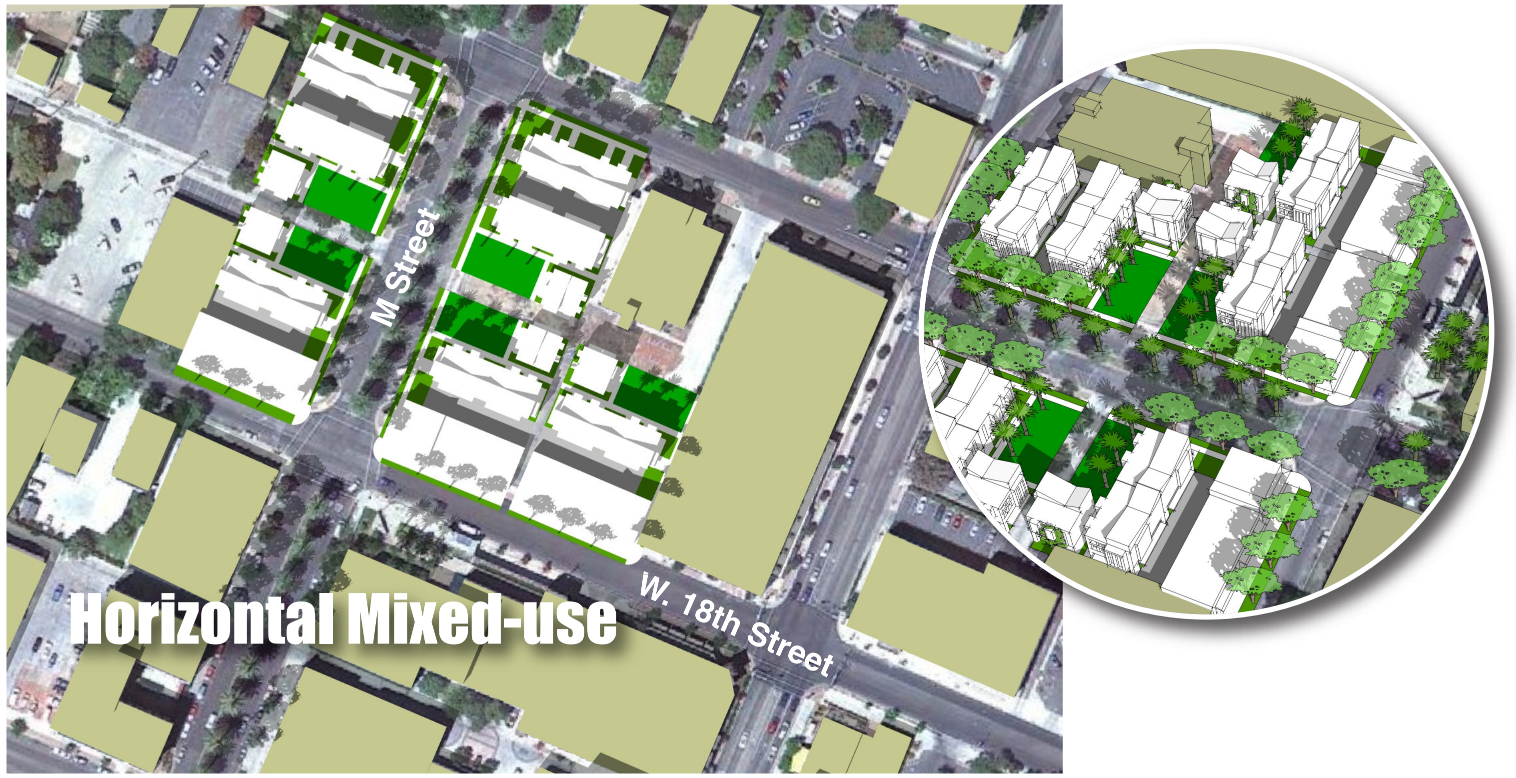
PROGRAM

Site Area:	20 Acres
Resid.	15A @ 4 DU/a=60 DUs
Commercial	8,000 SF (pad)

(2008 Merced CAP Baseline)

54,215 MTCO2e Lifespan
5.36 MTCO2e Per Capita Annual

2.9 X RMU Smart Block



PROGRAM

Site Area	87,120 NSF
Resid.	2a @ 30 DU/a = 60 DUs
Commercial	8,000 SF (single story storefront)

SMART BLOCK DEVELOPMENT

21,028 MTCO2e Lifespan
3.17 MTCO2e Per Capita Annual

2 % Embodied 24 % Energy 64 % Transportation 9% Paving

COMPACT DEVELOPMENT (2008 Merced CAP Baseline)

35,506 MTCO2e Lifespan
5.35 MTCO2e Per Capita Annual

2 % Embodied 21 % Energy 71 % Transportation 6 % Paving

Targets: Below U.S. Average
Demand-side
30% reduction 50% reduction 21% reduction
Supply-side
60% reduction