BOULDER'S CLIMATE COMMITMENT

Rising to the climate challenge, powering a vibrant future.

DRAFT MAY 2016

City of Boulder, Colorado
May 2016

Dear Neighbors,

Boulder has long understood the importance of local climate action. Boulder's residents and businesses were among the first in the country to implement programs like the Climate Action Plan Tax (CAP Tax) and a host of other energy efficiency and conservation programs. Some of these, including EnergySmart and SmartRegs, are being replicated elsewhere as they also begin to achieve the full benefits of their implementation locally. Others, like the Boulder Building Performance Ordinance and the possible creation of a local electric utility to change our energy supply from fossil fuels to renewable sources, are still taking shape.

Over our years of work, however, one thing has become increasingly clear: climate change is happening, and the scale of the challenge is even greater than we originally understood. Scientists now tell us that we need to reduce greenhouse gas emissions by at least 80 percent by 2050 to stop the trend of warming – and slow the impacts already underway. Successfully addressing this challenge will require bold, broad measures. This document outlines the areas of action that we in your local government plan to focus on in the years ahead. We believe that city leadership in these key areas is critical to success. But we can't do it alone. Community-wide participation, innovation and action are essential to fully address this challenge.

With so many other challenges and demands on your time, why should this be a priority for you? Well, as is often the case, challenges also present opportunities. For those in our community drawn to Boulder's entrepreneurial spirit, creating new approaches to renewable energy generation, storage and management—and being able to test those approaches here in Boulder—are leading to unprecedented business opportunities. For those concerned about how we'll withstand the impacts of climate change, these innovations also enable us and to build resilience in our critical infrastructure, as well as support vulnerable populations that are disproportionately stressed during emergencies. And for the average household, being able to use less energy, generate it yourself, and intelligently plan for home system upgrades can add up to significant cost savings. Rather than sending over $300 million each year out of our community to pay for fossil fuels we simply burn up, we can reinvest those dollars in energy systems that could last a lifetime or more.

This is a critical time for our environment and our community--but it is also an exciting time. Once again, our community is positioned to be a leader. We are eager to hear your thoughts about our planned focus areas and your ideas for how each of us can play a role in achieving our goals. We're up to the challenge. We hope you are, too.

Sincerely,
Matt and Jane

Boulder's Climate Commitment

The Challenge

The combustion of coal, gas and petroleum is warming the earth's atmosphere and changing our climate. The current trajectory, left unchecked, will lead to human-induced warming of 4 degrees Celsius, or higher. Such an increase in global temperatures will be catastrophic. To change this trajectory, we must achieve dramatic near-term reductions in greenhouse gas emissions.

The Opportunity

Transformation of our energy system is essential if we are going to stop burning fossil fuels. It is also an unparalleled opportunity. Technology, innovation and collective action have the potential to create a world in which the fuel to power our lives is clean, abundant, free and accessible to all. We need to redirect our energy system investments, making them more decentralized and resilient in the process.

Our Commitment

Boulder will rapidly transition to a clean energy economy and lifestyle through innovative strategies, products and services that dramatically reduce greenhouse gas emissions, enhance our community's resilience, and support a vital and equitable economy.

Our Goal

To rise to the climate challenge, and power a vibrant future, we will reduce Boulder's greenhouse gas emissions at least 80% below 2005 levels by 2050.

The pages that follow outline major parts of the actions we all need to be a part of in the next five years to set us on the path to this unprecedented change.

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History and Accomplishments To Date

City Council passes Kyoto Resolution to lower GHGs to 7 percent below 1990 levels by 2012.

City launches first voluntary energy efficiency programs.

First city greenhouse gas (GHG) inventory published.

Voters pass nation's first Climate Action Plan (CAP) Tax to reduce GHGs.

City Council adopts *Smart Regs* Ordinance to help improve energy performance in rental properties.

Second city GHG inventory published.

Residential and Commercial *Energy Smart* Programs begin.

Voters pass a five year CAP Tax extension.

Accelerated Net-Zero Energy Code adopted requiring new and remodeled residential and commercial buildings meet net-zero emissions by 2031.

Boulder achieves Solar Friendly Community Platinum Designation

The *Universal Waste Ordinance* passes.

City Council approves the commercial & industrial *Boulder Building Performance Ordinance*.

2002 2004 2006 2008 2010 2012 2014 2016

14 miles per resident per day driven.

11 miles per resident per day driven.

1st home enrolls in Energy Smart & 1st rental unit receives compliance certificate.

Energy Smart advised 7,500 homes and 1,600 businesses. 6,500 rental units are Smart Regs compliant.

About 50 solar photovoltaic (PV) installs; 1 megawatt of solar capacity; $0 for local solar development.

2,000 solar installs; 12 megawatts of solar; $200,000 in grants for local solar development.

Voters approve potential creation of a city-run electric utility.

City Council formally approves creation of a city electric utility.

Judge rules the city has the right to establish its own municipal electric utility. City files application with state regulators and continues planning.

Vision Into Action

Vision

Boulder becomes a world leader in the development, implementation and export of renewable energy and emissions reductions programs that create local economic opportunities, enhance community well-being and resilience, and inspire and enable other communities to participate in reducing carbon emissions and stabilizing the climate.

Goal

Boulder will reduce its energy-related emissions by 80 percent or more below 2005 levels by 2050.

Action Areas

- **Energy**—Rapidly transition to an energy system and economy that is powered 80 percent or more by renewable clean energy with 50 percent or more of that produced locally.[1]
- **Resources**—Reduce the emissions impacts caused by the use of goods and services by maximizing the productivity of all resources used and making purchasing decisions that support responsible resource use.
- **Ecosystems**—Enhance the ability of urban, wildland and agricultural ecosystems to capture and stabilize atmospheric carbon and provide critical buffering against climatic extremes.

Emissions Reduction Targets [2]

	TARGET AREA	2020	2030	2050
ENERGY	Buildings	6%	15%	20%
	Mobility	3%	8%	16%
	Electricity Source	25%	60%	80%
RESOURCES	Waste	1%	1.5%	2%
	Water	Methodologies for evaluating emission reduction impacts and targets under development		
	Food			
ECOSYSTEMS	Urban			
	Wildland			
	Agricultural			
	TOTAL	20%	43.5%	81%

[1] The current methodologies for calculating community-wide greenhouse gas emissions account primarily for energy-related sources. Recognizing the important role that both resource use and ecosystem management play in emissions reduction, the city is working on incorporating methods for quantifying the impacts of actions in these areas.

[2] Relative to 2005 emissions baseline.

The Climate Change Challenge

Our understanding of the causes, dynamics and consequences of human-induced climate change continues to evolve. But what is completely clear: climate change is not a hypothetical possibility. It is a current reality that could become significantly more difficult to address if we delay taking critical actions.

The accumulated impacts of over a century of rapidly escalating CO2 emissions have already caused changes in the climate, with noticeable and significant impact. Globally, temperatures are setting seasonal and annual records. According to NOAA, the last 12 months have been the hottest on record, with June 2015 being the warmest month ever recorded.[1]

An associated consequence of increased temperatures is an increase in the amount of moisture in the atmosphere. This combination adds both energy and precipitation potential to every weather event. Many climate scientists now believe these factors are contributing to the increasing intensity of many extreme weather events. Increased global temperatures are also accelerating polar ice melt, raising sea levels, increasing ocean acidity, and accelerating species loss.

Locally, average annual temperatures are already over a degree Celsius (two degrees Fahrenheit) warmer. While this may not sound like much, it is having significant impacts: increasing the risk of high intensity wildfires; increasing the number of "high heat" days we experience; and impacting the types of plants that can grow here. The USDA Plant Hardiness Zone Map informs which plants are suitable for a given region (zone) using average annual extreme minimum temperature range to differentiate zones. That map shows Boulder has already shifted from Zone 4, a -25 to -20 plant hardiness range to Zone 5, -20 to-15 range, in less than 20 years. At current rates, Boulder's growing environment may shift in the near future to a Zone 6 or a -10 to -5 range.[2] As temperatures continue to increase, our natural landscape will change and many species currently native to the area will no longer find suitable conditions.

The causes and consequences of a changing climate are well documented and there is growing global consensus that significant action is needed now. But even as that consensus grows, so too does worldwide investment in the exploration, extraction and combustion of fossil fuels. These investments perpetuate our dependence on an energy system and lifestyles that are having increasingly devastating consequences.

[1] http://www.climatecentral.org/news/12-months-warmest-on-record-19010

[2] http://planthardiness.ars.usda.gov

Climate Change on the Front Range

In a recent analysis of past and future climate conditions along the northern Front Range, CU's Western Water Assessment team constructed a temperature history and projections. This analysis shows a clear warming trend since 1950, with temperatures already nearly 2 degrees F above average. This is in part responsible for fire seasons that are now nearly five weeks longer than the 1970s and average flowering dates for plants that are one to two weeks earlier than 20 to 30 years ago. By 2050, temperatures are projected to rise by a minimum of 2 degrees with a possible increase as high as 6 degrees. At 2 degrees, Boulder's climate would resemble Pueblo, Colorado. At 6 degrees, the closest comparison would be Albuquerque, New Mexico.

Already nearly 2 degrees F above average.

Fire seasons nearly five weeks longer.

Flowering dates for plants are one to two weeks earlier.

Projected to be 2 to 6 degrees F warmer by 2050.

What's this look like for Boulder?

+2° Fahrenheit

+6° Fahrenheit

"The answer to the oft-asked question of whether an event is caused by climate change is that it is the wrong question. All weather events are affected by climate change because the environment in which they occur is warmer and moister than it used to be."

-Kevin Trenberth, CU climate scientist

[1] Kevin Trenbreth, "Framing the way to relate climate extremes to climate change", Climatic Change (2012) 115:283–290. Published by Springerlink.com

We Need to Change the System, Not Just the Light Bulbs

Boulder launched its first formal climate action efforts in 2002. Since that time, the city has been at the forefront of innovation in working to reduce climate impacts: adopting the country's first carbon tax, developing a national model for delivering energy efficiency services, enacting the country's most stringent energy code for new buildings, and much more.

During the past dozen years, we've made progress, and learned lessons. In recent years, we have integrated climate action strategies within relevant planning efforts, such as the Transportation Master Plan and the Boulder Valley Comprehensive Plan, and developed better tools for analyzing and tracking progress. We are working on a wide array of policies, programs and projects to reduce emissions and realize other important community outcomes. We know that long-term success will require better feedback loops, honest assessment, persistence and collective action.

Perhaps most important, it has become clear that while energy efficiency and related investments are essential to long-term impact, we need to fundamentally transform our energy system—not just in electricity, but also natural gas and transportation fuels.

DID YOU KNOW?

Currently, Boulderites spend over $300 million a year on energy (electricity, natural gas, and gasoline combined). Nearly all of this money leaves the community, and most of it goes to buy fuel that is then burned.

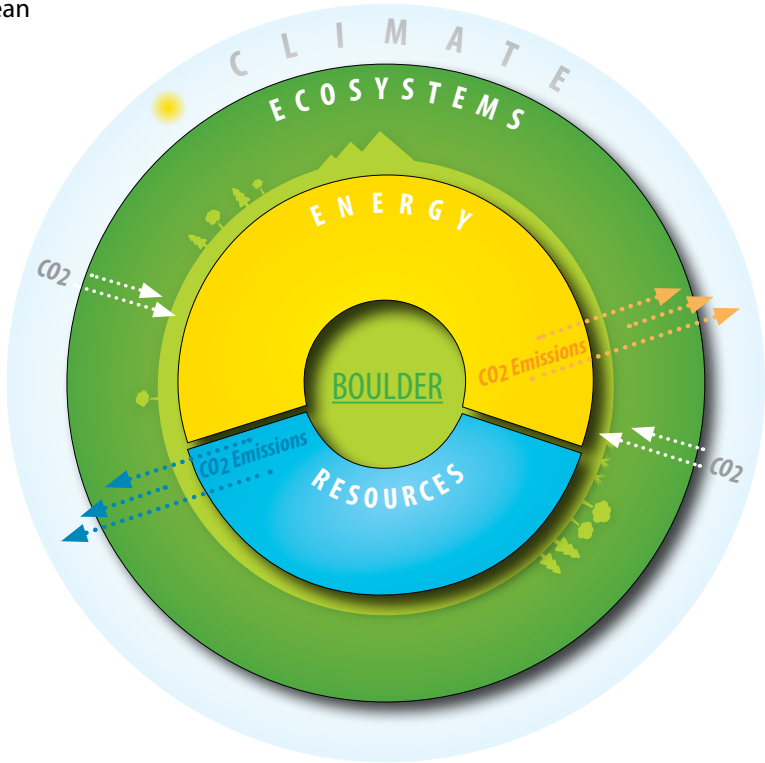
It is this realization—grounded in extensive analysis, affirmed through engagement with numerous experts, and reflected in industry and technology trends—that led the city to explore municipalization of its electric utility in recent years. Grounded in the principles of "Decarbonize, Democratize, and Decentralize" and guided by our vision for the "Utility of the Future" (described in detail at BoulderEnergyFuture.com), Boulder's municipalization effort is a key step toward energy system transformation and achieving the community's climate goals. That's not to say our current utility couldn't be a valued partner in leading a transformation, but to date there's been no commitment to go beyond what is required under state law.

As described in this document, and demonstrated in the municipalization analyses, not only is transformation of our energy system essential to our long-term health and sustainability, it is a better economic proposition as well. The International Energy Agency estimates that emission reduction activities represent a $10 trillion global marketplace. Boulder's research infrastructure, start-up culture, and venture capital resources provide the building blocks for a climate solutions engine that can support local action as well as an export economy for this emerging marketplace.

The economic benefits of climate action also translate into health cost savings due to reduced pollution levels. In an assessment of transportation emissions alone, Fort Collins projected that deep emission reductions could save local residents over $17 million in health care costs between now and 2030. An analysis conducted by The Solutions Project for a Colorado-wide clean energy system estimated annual health savings of more than $7.4 billion.

The Climate Emissions System

The three main areas of Boulder's Climate Commitment are shown in this diagram. A more simplified icon (see page 8) is used throughout this document to help designate whether the specific section relates to Energy, Resources or Ecosystems.



Organizing for Action

Recognizing the need for a comprehensive strategy, Boulder's Climate Commitment is divided into three areas: Energy, Resources and Ecosystems. Of these, energy has been and remains the primary near-term focus due to the critical importance of reducing fossil fuel combustion. Simultaneously, the city and community continue to explore ways to address the impact that resource use has on emissions, and how ecosystem management can enhance the emission-minimizing services provided by natural systems.

Energy—Nationally, close to 90% of GHG emissions are generated by energy-related activities. Locally, over 95% of the emissions tracked through Boulder's 2012 inventory were from burning fossil fuels. The three areas of action within Energy are High Performance Buildings, Clean Mobility, and Clean Energy Sources.

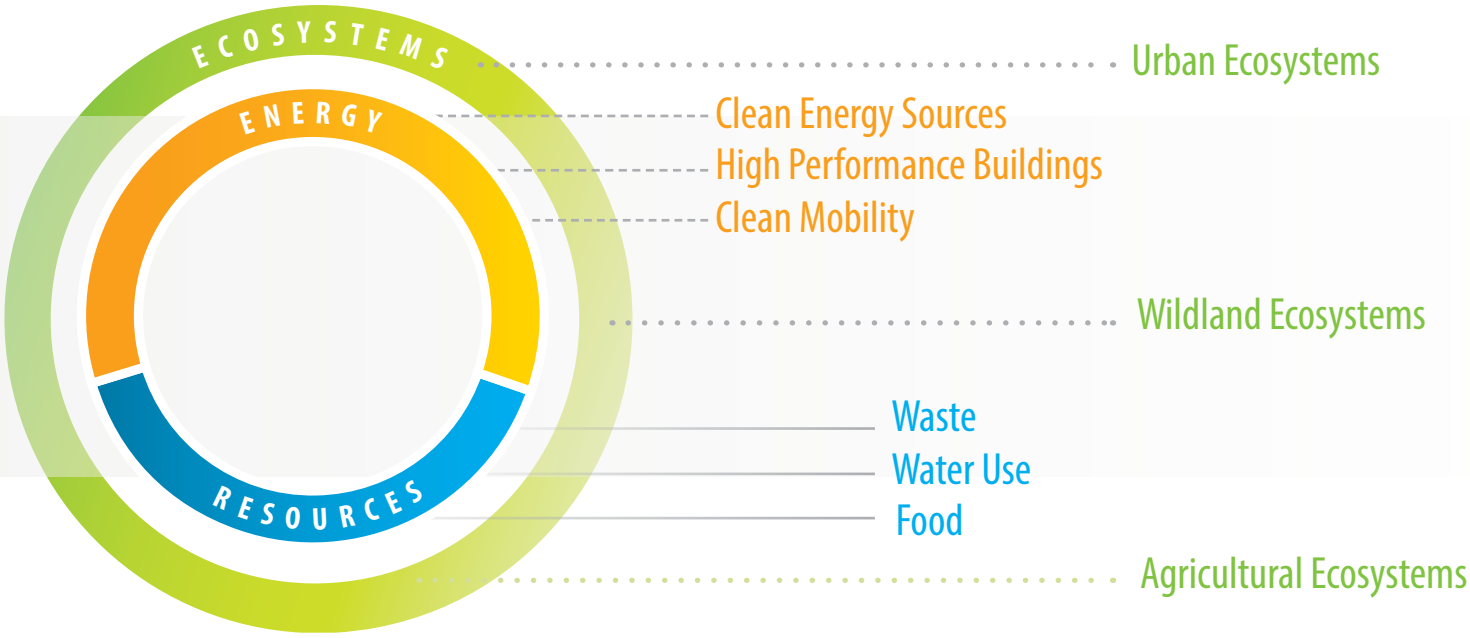
Resources—Boulder is also responsible for emissions related to the production, distribution and disposal of resources in the goods and services we consume. This includes the acquisition of raw materials and the energy used to transform those materials into useful products and services. The majority of these products and services are produced outside Boulder and are not included in Boulder's emissions inventory, though they are part of our carbon footprint. The three areas of action within Resources are Water, Food and Waste.

Ecosystems—The unseen regulators of CO_2 emissions are the different natural ecosystems that can reduce emissions and even remove or "sequester" CO_2 out of the atmosphere. Trees, for example, capture atmospheric carbon while also providing temperature buffering and moisture retention. The three areas of action within Ecosystems are Urban Ecosystems, Wildland Ecosystems, and Agriculture.

Act Locally, Impact Globally

In 2014 Boulder was invited to join 16 other vanguard cities committed to deep carbon reductions. The Carbon Neutral Cities Alliance—representing a diversity of cities such as London, New York, Copenhagen, Yokohama, and San Francisco—is a learning and innovation network that seeks to develop and test new approaches to accelerated climate action. The Alliance also helps ensure a stronger voice for cities in global climate discussions, and recognizes that urban centers are the innovation labs where the world's climate solutions will be pioneered. Boulder is also active in climate and sustainability work with International Council for Local Environmental Initiatives (ICLEI), National League of Cities, the Compact of Mayors and other venues.

The Climate Emissions System



ENERGY

SECTION I

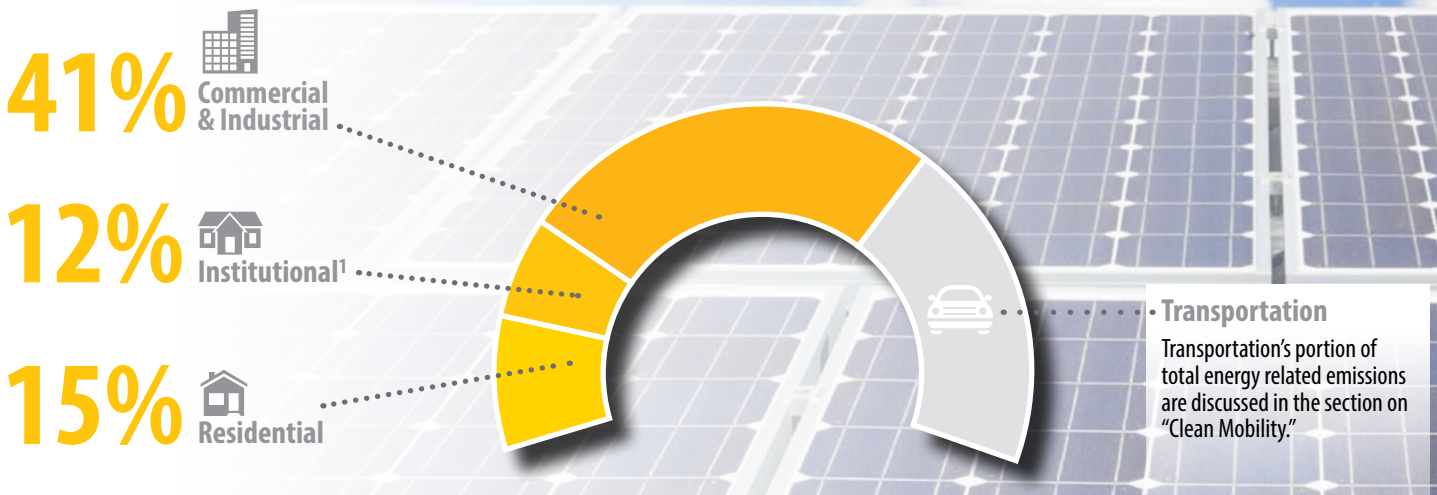
Rapidly transition to an energy system and economy that is powered 80 percent or more by renewable clean energy with 50 percent or more of that produced locally.

HIGH PERFORMANCE BUILDINGS

By 2050, all buildings in Boulder will be high performance, with air-tight and insulated building envelopes that reduce the need for heating and cooling; highly efficient equipment, lighting and appliances; on-site renewable energy generation and storage where possible; and smart, automated energy management systems that ensure building comfort, efficiency and livability.

Boulder's Buildings Today

Boulder has approximately 44,000 residential dwelling units and 3,700 commercial and industrial buildings. Together the energy used to maintain these buildings and the activities taking place within them use over two-thirds of the total energy consumption in the community. Currently over 90 percent of this energy comes from the burning of fossil fuels. As a consequence, buildings and the energy uses within them contribute approximately 68 percent of the city's overall energy-related greenhouse gas emissions. These emissions can be further divided into three major building use sectors: residential, commercial/industrial, and institutional (city organization, Boulder County, Boulder Valley School District, University of Colorado).



Targets & Timeframe[2]

Energy Efficiency - Energy Use Reductions	2020	2030	2050
Residential Electricity Savings[3]	10%	27%	70%
Residential Natural Gas Savings	5%	15%	40%
Commercial/Industrial Electricity Savings[4]	(0%)	3%	20%
Commercial/Industrial Natural Gas Savings	7%	13%	30%
Commercial Energy Use Intensity (kBtu/sqft-yr)[5]	85	70	65

[1] Includes the City, CU, BVSD, and Boulder County. Data from the federal labs is still being researched but could add several percentage points to the institutional category that would be subtracted from the Commercial & Industrial sector.

[2] Relative to 2005 baseline.

[3] Residential electricity savings include the projected increase in installed rooftop solar. This on-site generation results in reduced energy purchased from the grid and is therefore a "savings" of energy not needed from a utility energy system.

[4] Commercial & industrial energy use is projected to decline below 2005 levels by 2025 as the city's new Building Performance Ordinance takes full effect.

[5] Energy Use Intensity Targets only apply to buildings covered by the Building Performance Ordinance (BPO).

20%

REDUCTION IN OVERALL EMISSIONS BY 2050

DID YOU KNOW?

Enhancements to city buildings have already reduced the city organization's emissions by 22 percent and save the city almost $700,000 each year.

HIGH PERFORMANCE BUILDINGS

City Buildings Lead The Way!

In 2010 the City of Boulder hired McKinstry and Associates to conduct a comprehensive energy assessment and develop an emissions reduction strategy. Based on this assessment, the city invested over $11 million in energy efficiency measures and the installation of renewable energy. Through these efforts, the city improved energy performance in 43 buildings, changed out over 10,000 light fixtures, and installed new building controls and other mechanical systems.

These measures reduced the city's facility emissions by over 22 percent—over 8,000 metric tons of greenhouses gases—and saves the city almost $700,000 per year in energy costs. The city is now exploring a next stage of opportunities in energy efficiency and renewable energy generation to achieve the goal of reducing emissions 80 percent or more by 2050.

How to Make Buildings Better

Achieving high performance buildings throughout Boulder will require significant investment. But the good news is: over the next 30 years, significant investment will happen regardless, as property owners and businesses replace outdated systems, new buildings are built, and old buildings are remodeled. It's not so much that we need to make new investments; it's that we need to make different investments. And while sometimes those investments may cost more up front, they will invariably save money over time, as less energy is needed to achieve the same outcomes. The three key areas of action to make this happen are outlined below.

Reduce

Reduce the energy needed to operate buildings and power the activities within them through deep energy efficiency retrofits, "net zero" energy codes, and improvements in the energy performance of appliances and other equipment.

Replace

Replace all building systems that rely on fossil fuels, particularly heating and cooling systems and water heating. In other words, switch from natural gas systems to either electric (assuming a shift to a clean electricity supply) or other clean, renewable energy systems (e.g., ground source heating and cooling).

Redesign

Redesign building codes and community systems to create "net zero" or "net positive" buildings and neighborhoods, integrating systems at the district scale and incorporating local generation of clean energy.

The community has installed enough solar panels to power over 3,000 homes

Whole Energy Systems Change—For Your Home!

As part of its effort to support community-generated innovation, the City of Boulder sponsored the Boulder Energy Challenge in 2014. Among the exciting projects selected for funding is an exciting initiative developed by a local company—SNUGG Home—to create innovative financing strategies to support local households in securing a complete clean energy system makeover…at about the same cost as maintaining an existing fossil-fuel dependent system. This exciting initiative is already helping Boulder households map out a strategy to deep emissions reduction—often 80 percent or more—while making their homes more comfortable, lowering energy costs, and creating the energy needed to drive around on solar power!

BOULDER ENERGY CHALLENGE

2015-2020 City Action Priorities

Improving the energy performance of buildings has been a key area of focus in Boulder over the past decade, particularly in the residential sector, but increasingly in the commercial and industrial sectors as well. But there is a long way to go.

While shifting Boulder's energy source to clean and renewable "fuels" like sun and wind will make a significant contribution to deep emission reductions, achieving much higher levels of energy efficiency is critical to a cost-effective energy transition. This will require changes not only in how buildings are built (and renovated), but also in the choices each of us makes when purchasing new appliances and equipment, or when managing our daily energy use at home and work. Over the next five years, aggressive action is needed to set us on the path to our community's climate commitment. To support community action, the city plans to prioritize the following:

REDUCE

Voluntary Education, Services and Incentives for Building Owners

- Continue to provide information, incentives and support for deep efficiency retrofits through energy advising programs like EnergySmart and Partners for a Clean Environment (PACE).
- Support the use of newly developed clean energy financing mechanisms such as the Boulder County property-assessed clean energy financing program.

Building Efficiency Standards and Requirements

- Implement the Building Performance Ordinance that requires the largest commercial and industrial buildings to track and report energy use – and eventually to implement specific energy efficiency actions.
- Achieve 100 percent compliance in residential efficiency requirements for rental housing by 2019 (SmartRegs).
- Explore the potential for time-of-sale energy efficiency requirements for owner-occupied housing.

Piloting New Programs and Services

- Implement programs such as the Community Power Partnership (piloted in 2014) that provide households and businesses with enhanced information about their energy use and access to customized efficiency and energy management services.
- Pilot integrated approaches to energy efficiency, solar energy installation and electric vehicle acquisition to create deep emission reduction pathways for Boulder households such as those being tested in two Boulder Energy Challenge funded projects (SNUGG Home pilot project, Solar +Storage pilot project).

Energy Efficiency and Demand Side Management as Priorities of Municipal Utility

- Ensure that investments in aggressive energy efficiency measures are a core part of the resource planning, services plan and business model for a new municipal electric utility.

REPLACE

Infrastructure Assessment & Transition Planning

- Assist building owners in identifying clean energy alternatives to existing systems dependent on natural gas and create a retirement and replacement plan consistent with the normal replacement cycles of these systems.
- Use city facilities and other leading edge businesses and institutions to develop and test new clean energy systems and develop the technical and financial information needed to support broader scale adoption.

Roof-top Solar

- Provide residences and businesses with solar capacity information for every building in the city through the current Mapdwell solar capacity analysis to encourage and facilitate more widespread installation of rooftop solar.

REDESIGN

Clean Energy Future Design for New Buildings

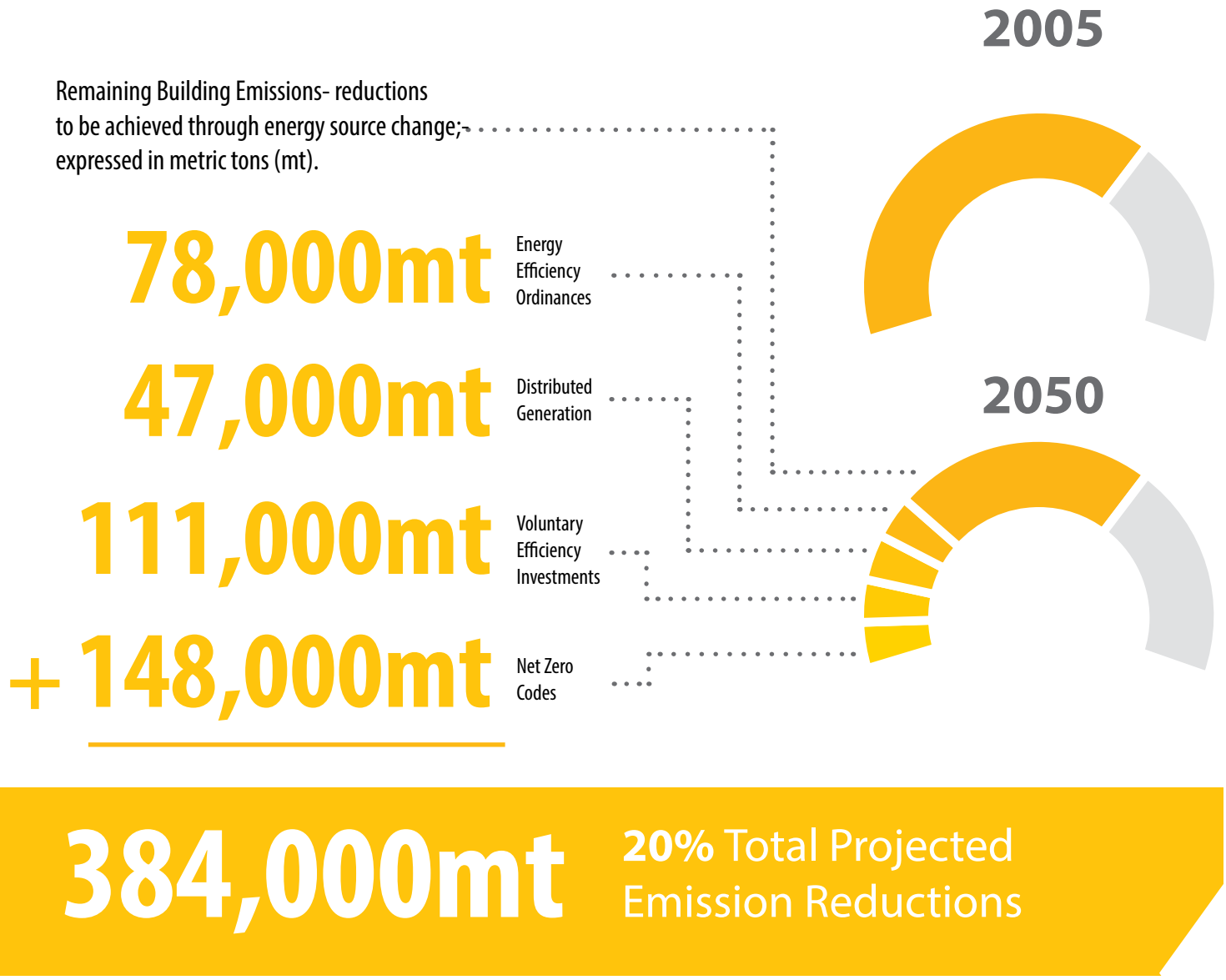
- Manage and refine implementation of the Net Zero Building code compliance pathway with the goal of all new buildings achieving net zero emissions by 2031.

HIGH PERFORMANCE BUILDINGS

Making it Happen: The Path to 2050

The figure below summarizes projected emission reductions that can be achieved through investments in high performance buildings, based on current information and assumptions. Taken as a whole, these efforts would result in a reduction of 500,000 metric tons by 2050, a 26 percent reduction from estimated 2005 baseline year emissions. The remainder of emissions reductions related to energy use in buildings must be achieved through changes to our energy sources as discussed in the "Clean Energy Sources" section that follows.

The ability to hit these long-term targets requires a utility partner committed to deep efficiency, with capabilities for on-bill financing of efficiency investments, net metering and rate structures that are consistent with an overall goal of reducing energy use, rather than selling more electricity. The chart also shows the expected impact of energy efficiency in city buildings and other institutions, like CU, federal labs and local schools, which are not subject to city codes and requirements.



Measuring Success

The city has developed an extensive set of performance measures to evaluate our community's progress towards achieving high performance building objectives. A link to the full set of metrics and targets for building performance and the city's other energy related initiatives can be found in the References and Resources section of this document. Much of the information necessary to monitor this progress will depend on the willing participation and engagement of the community's energy providers, particularly electricity and natural gas. These efforts will also depend on the investments and actions of other leading community institutions.

Building Partnerships

Boulder is fortunate to have many progressive organizations working hard to meet our community's climate goals.

The University of Colorado plans to continue its long-term commitment to investing in clean energy improvements. The Board of Regents has approved $50,000,000 in spending authority to be awarded through Energy Performance Contracting. Energy efficiency upgrades have been proposed in 7 facilities thus far, with projected annual energy savings of over $1.3 million and an estimated annual reduction of emissions of 11,400 metric tons.

Boulder County has been the lead partner in administration of both the Energy Smart residential energy efficiency program and the Partners for a Clean Environment (PACE) commercial and industrial energy efficiency program. More than 7,000 households and 3,000 businesses have been served through these programs since 2010, stimulating over $12 million in private investment in energy efficiency on less than $3 million in public incentives. Seventy-five percent of homeowners in contact with the program implement some form of efficiency, 3 times the national average.

Boulder Valley School District completed its Sustainable Energy Plan in 2013 calling for a 20 percent reduction in overall energy use by 2019, with a long term goal of being net zero energy by 2050. As part of its recently passed bond measure, it has targeted many of its facilities for significant upgrades including eight buildings with deep retrofits (less than 50 percent energy use reduction) and many more that will receive renovations and mechanical system retrocommissioning. The bond also includes constructing four new zero net energy capable buildings (buildings that have the ability to produce as much energy as they consume).

Boulder's 14 **federal labs** have also been leaders in implementing President Obama's recently issued executive order to improve federal building efficiency standards, which mandated a 40 percent improvement in building energy efficiency over the next five years. As a major presence in Boulder, the federal labs' efforts will substantially efforts will substantially contribute to Boulder's reduction in GHG emissions.

CLEAN MOBILITY

By 2050, people and goods will travel around Boulder generating little or no carbon emissions. This will include walking and biking as well as shared transportation like transit, car share, and van pools. The personal and work vehicles that remain will use clean energy sources such as renewably produced electricity and alternative fuels such as hydrogen or fuel cells.

How We Move Today

Boulder has over 63,000 vehicles registered to residents. Tens of thousands of additional vehicles enter and depart from Boulder every day carrying employees, students, goods, and visitors. While Boulder has one of the highest per capita percentages of hybrid and EV ownership, we also have one of the highest per capita proportions of SUVs, bringing Boulder's average fuel efficiency to 21.4 MPG, a little higher than the state average. Together, this ground transportation accounts for 21percent of the city's recorded emissions. An additional 11 percent is added for Boulder's share of the regional air travel out of Denver International Airport.

Targets & Timeframe

SECTOR	METRIC	2020	2035[1]	2050[2]
Passenger	miles/resident/day	10	7	4
SOV mode share	residents all trips	32%	20%	8%
SOV mode share	non-resident work trips	75%	60%	45%
Transit mode share	residents all trips	6%	10%	14%
Bicycle mode share	residents all trips	22%	30%	38%
Electric & Alternative Vehicles	percent owned	15%	not calculated	75%

Transportation Share of Emissions

Buildings

The proportion of total emissions from buildings and their related energy sources are discussed in the section on "High Performance Buildings."

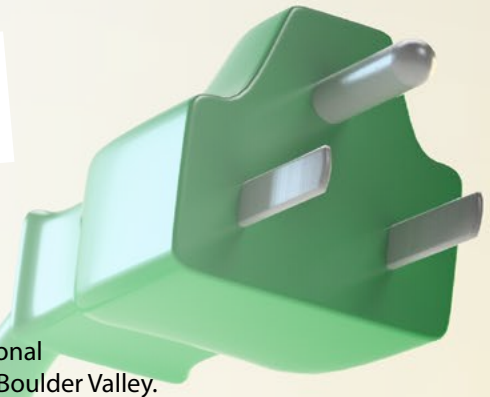
[1] Transportation Master Plan (TMP) Adopted Objectives set long-term goals using a 2035 timeframe.

[2] Projected levels based on simple linear extrapolation of TMP objectives out to 2050. Continued reductions between 2035-2050 will require additional investment, innovations and community land use changes beyond those in the TMP. Targets will continue to be refined over time.

A Boulder Success Story: Holding the Line on Vehicle Miles Traveled

In 1996, Boulder's Transportation Master Plan (TMP) established a goal of holding VMT steady to 1994 levels. Now 20 years later, while most other communities on the Front Range have seen vehicle miles traveled increase by 113 percent, Boulder has been able to keep its VMT from growing, despite growth in population and employment.

To help meet the new 2050 GHG reduction goals, the 2014 TMP Update established a goal to reduce vehicle miles traveled (VMT) by 20 percent by 2035. Together, the VMT reduction programs and strategies outlined in the TMP are projected to achieve close to a quarter of the transportation emissions reduction goal by 2050.



The Many Benefits of a Low Carbon Transportation System

A low emissions transportation system has many community benefits in addition to helping reduce climate change. Boulder's 20-year success in managing vehicles miles traveled has avoided an estimated 1.9 million additional daily vehicle miles of travel around the Boulder Valley. This has kept a significant amount of pollutants out of the air, even as VMT and related emissions have nearly doubled in the Denver metro region. The city has also enhanced pedestrian, bike and transit systems providing transportation options to all members of the community, saving transportation costs and supporting forms of mobility that improve our health. The city's support of RTD's Eco Pass program has had significant impact on travel behavior and GHG emissions as residents with Eco Passes emit 45 percent less transportation related GHGs than residents without access to the annual unlimited use transit pass. The city also continues to integrate more diverse and connected neighborhoods. This, combined with the city's goal to make all areas accessible by walking and biking, minimizes the miles we have to travel by vehicle and the distance we have to travel when we do use our cars.

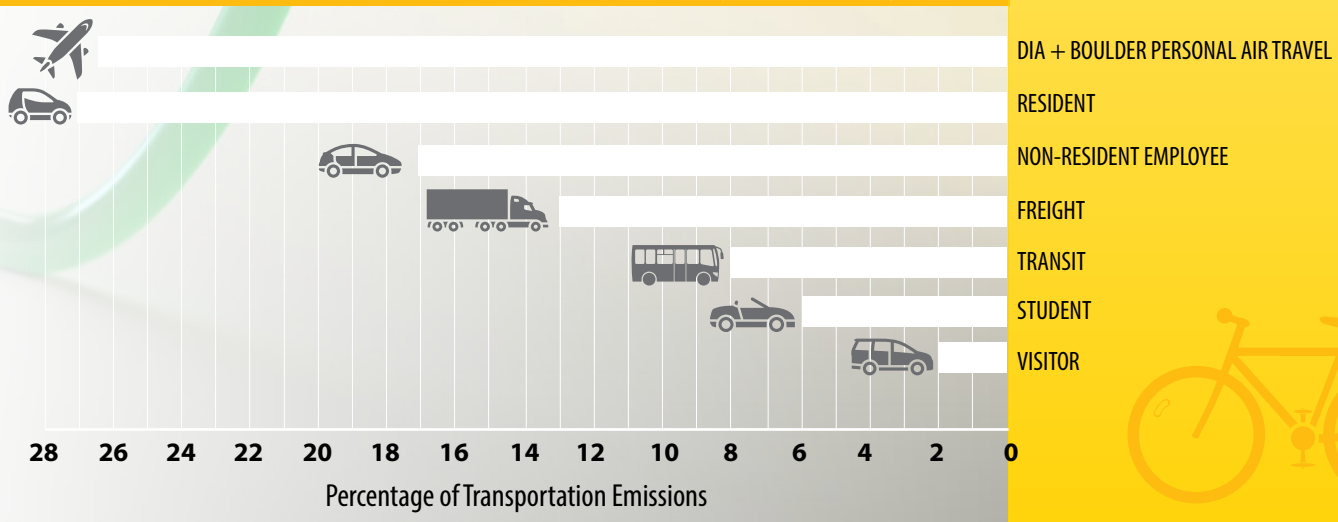
16%

REDUCTION IN OVERALL EMISSIONS BY 2050

DID YOU KNOW?

Approximately 70,000 Boulder residents and employees have access to an Eco Pass; RTD's discounted unlimited ride annual transit pass.

2012 Transportation Emissions By Travel Type



CLEAN MOBILITY

2015-2020 City Action Priorities

Similar to the actions described for the building and related energy use sectors, there are three broad areas of action within which the city has initiated programs.

REDUCE

Create multiple mobility options

· Expand access to transit including implementation of a community-wide EcoPass and expansion of Bus Rapid Transit routes.

· Expand ride share programs by adding additional incentives and support for expanded carpool/vanpool.

· Enhance bike and pedestrian travel options through creating protected bike lanes on key travel corridors and improved pedestrian efficiency through mobile route mapping.

Use digital technology to maximize our transportation efficiency

• Pilot and promote telework and other no-travel work options.

• Create enhanced mobility tools through development of new mobile applications for trip planning.

Create incentives to explore new mobility options

• Use parking management to encourage other travel options by creating financial incentives that reward commuters who don't require daytime parking.

REPLACE

Support the adoption of electric vehicles and other non-fossil fuel mobility options for personal vehicles

• Collaboratively expand regional electric vehicle (EV) charging infrastructure.

• Implement electrification of city vehicle fleet.

• Co-organize Workplace Charging Challenge with other leading employers.

• Develop employee EV commuting pilot project.

Catalyze the development of non-fossil fuel transit systems

· Promote electrification/clean fuel options for the Regional Transportation District (RTD) transit fleet.

· Pilot clean energy transit on select local routes, especially the city's "HOP" route.

REDESIGN

Develop parking management systems that stimulate adoption of high efficiency mobility options

• Encourage parking management systems using the city's "SUMP" (Shared, Unbundled, Managed, & Paid) principles.

• Create parking districts with enhanced mobility options e.g. car share, bike share, transit hubs.

Integrate mobility enhancements in land use planning

• Continue complete streets planning to provide safe and convenient travel options.

• Integrate mixed use development close to neighborhoods to provide walkable destinations for daily needs (15 minute neighborhoods).

Movers and Shakers

Creating a clean mobility system requires a collective effort. Boulder is fortunate to have many leaders and partners working together to achieve transformative change.

The University of Colorado has an extensive program to significantly reduce the use of single occupancy vehicles and provide viable options in transit, biking and walking. The University provides full service bus passes to all 30,000 of its students through student fees along with over 13,000 bike parking spaces (more than cars!), has a vanpool service for employees and is actively planning for the development of an EV charging infrastructure for both staff and students.

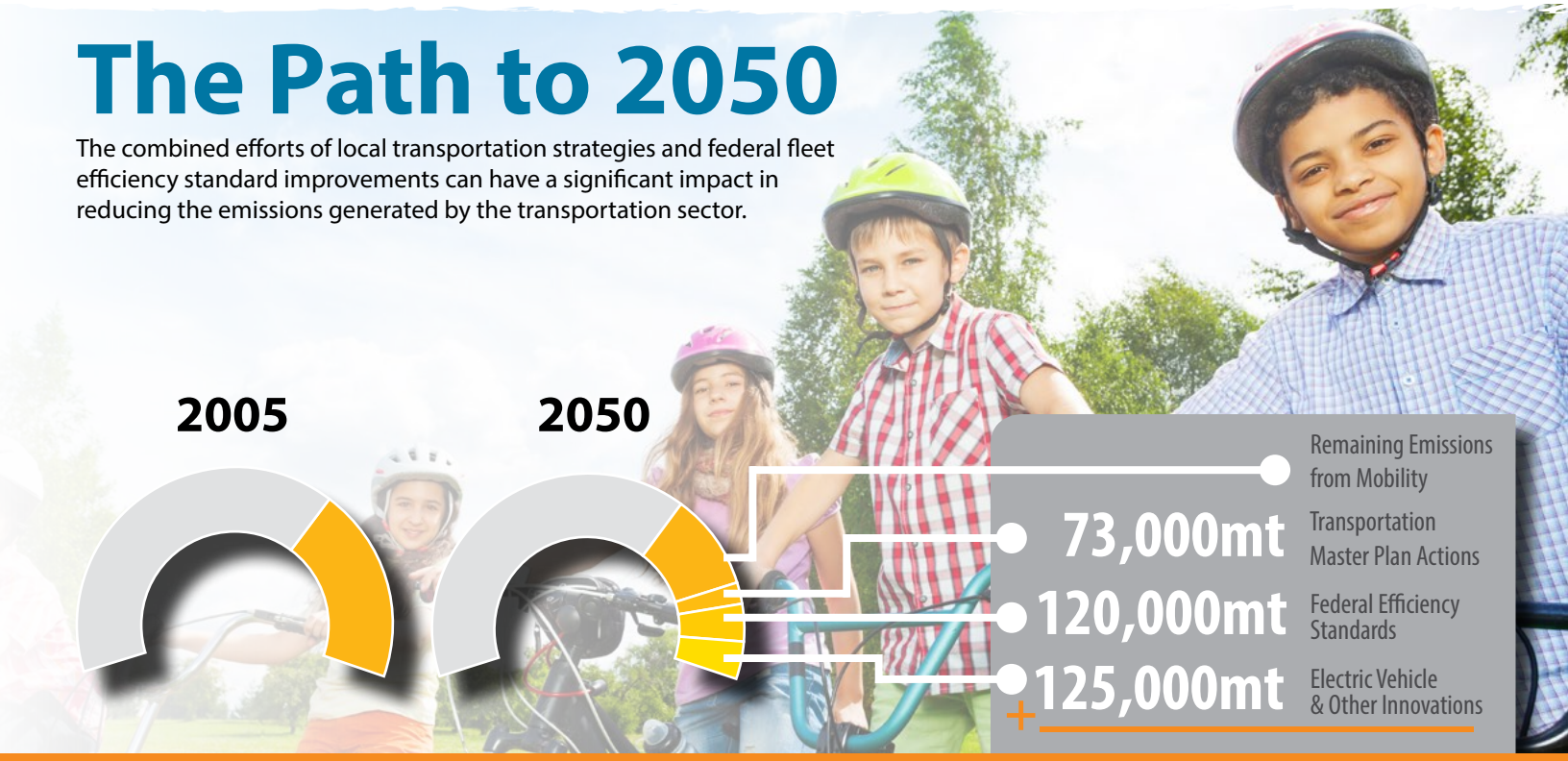
Boulder County has invested in low-emissions transportation alternatives throughout the county, and was lead sponsor, along with the City and CU, in a countywide electric vehicle adoption assessment. That assessment explored electric vehicle charging infrastructure needs as well as how building codes, transportation programs and employee commuting incentives could promote EV ownership. The County is currently helping to coordinate the Boulder County Electric Vehicle Workplace Charging Challenge to encourage other employers to actively support EV adoption by the over 50,000 daily in-commuters to Boulder and Boulder County.

Boulder Valley School District has initiated a wide range of programs to reduce emissions from its bus and administrative fleet, including initiatives to increase walking, biking, transit and carpooling as well as efforts to lower emissions through hybrid buses, alternative fuels and efficient routing schedules. Through an internally developed "Trip Tracker," over 2,000 participating students in 17 schools cut an estimated 75,000 car trips in a single school year. The District is also exploring the expansion of its current EV fleet and charging infrastructure to provide more opportunities for both students and staff to use EVs.

The University Corporation for Climate Research (UCAR) and its other federal lab partners in the Boulder area provide van pool and ride sharing support for employees, and free bicycle check outs, complementary Bike Share membership, and EcoPasses for all employees. Recently, the labs secured funding to install an EV charging network for employees, and has been an active partner with the City, County, CU, and BVSD in developing a community-wide EV adoption plan.

The Path to 2050

The combined efforts of local transportation strategies and federal fleet efficiency standard improvements can have a significant impact in reducing the emissions generated by the transportation sector.



Total Projected Emissions Reduction = **318,000mt or 16%**

CLEAN ENERGY SOURCES

By 2050, Boulder will be powered by 100 percent clean electricity, and natural gas and petroleum use will be significantly reduced. The majority of residents and businesses will have the opportunity to participate in the production of this clean electricity, and in so doing, share in the prosperity, well-being and resilience of our entire community.

Targets & Timeframe

GOAL	METRIC	TARGETS [1]		
		2020	2030	2050
Clean Electricity	% Renewable Electricity	35%	100%	100%
80% Reduction in Natural Gas	% of 2005 Usage	5%	25%	80%
80% Reduction in Petroleum	% of 2005 Usage	50 MW	100 MW	175 MW
Local Renewable Energy	% of Total Energy Use	12%	25%	50%

The Current Energy System

Like most communities, the majority of Boulder's energy and emissions comes from burning fossil fuels. Figure 1 illustrates that roughly half of these emissions come from burning coal and natural gas to produce electricity (53 percent of Boulder's emissions), another 15 percent is generated by burning natural gas for heat and other process uses (cooling, manufacturing), and another 31 percent is generated through the use of petroleum for transportation. Based on the city's 2012 greenhouse gas inventory, this means roughly 8 to 10 percent of the community's current overall energy use came from clean, renewable sources in 2012[2]. Figure 2 shows the breakdown of our current energy portfolio by generation type.

Figure 1 - Emissions by Energy Source-2012

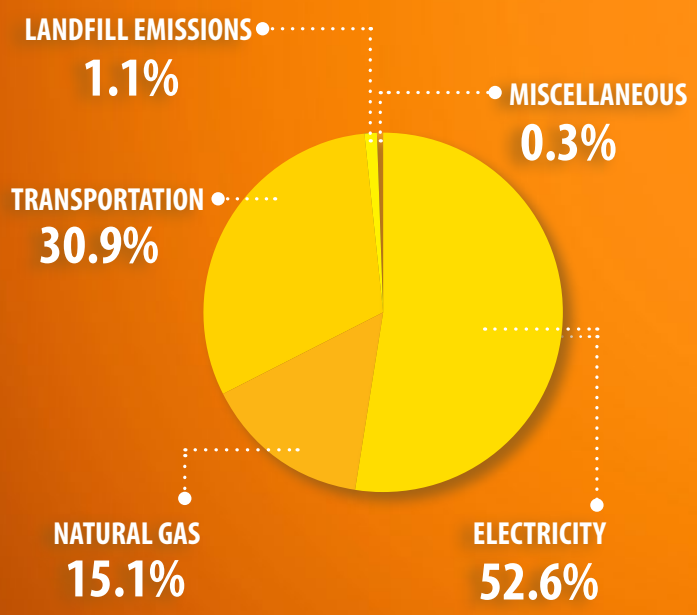
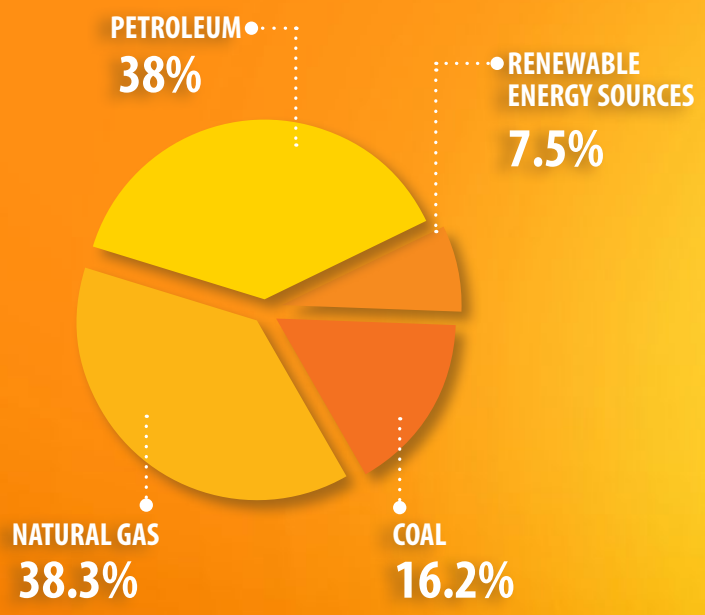


Figure 2 - Boulder All Energy Sources-2012[3]



[1] All targets are measured using 2005 as the base year.

[2] Between 2012 and 2014, community residents and Xcel Energy have continued to add renewable energy generation. This is projected to have increased the community's renewable energy from 7.5 percent in 2012 to 8.2 percent in 2014).

[3] While approximately 25 percent the community's electricity sources are currently generated by renewable sources, electricity is only half of the total energy used (and emissions generated) when combined with natural gas and petroleum.

ENERGY
SOURCES

43%
REDUCTION IN EMISSIONS BY 2050

DID YOU KNOW?

In 2007 there were less than 100 solar systems in Boulder. By 2014, nearly 2,000 systems had been approved representing over 15 MW of solar capacity— enough energy for approximately 3,000 of Boulder's 44,000 homes!

CLEAN ENERGY SOURCES

Clean Renewable Energy—How Much Do We Need?

There is growing agreement that the most viable path to deep emission reductions in the next 20 to 30 years is the conversion of 80 percent or more of all energy use—in buildings, transportation and business processes—to electricity generated from clean, renewable energy sources.

Using the extensive analyses conducted for establishing a community-owned electric utility, the city has been able to estimate total energy use across all sectors of the community. Using standard energy conversions, it's then possible to estimate the amount of clean, renewable electricity needed to replace current fossil fuel combustion, as summarized below.

ENERGY TYPE	TOTAL NEEDED
Electricity	200-250 Megawatts (current usage)
Natural Gas (converted to electricity)	35-50 Megawatts
Petroleum (converted to electricity)	50-80 Megawatts
TOTAL ELECTRICITY NEEDED	~285-380MW

These estimates are based on 2012 energy consumption. With the substantial efficiency measures implemented across the building and transportation sectors, the total electricity requirement could be reduced by 20 to 30 percent by 2050.

Building a Rooftop Solar Tool

With more than 300 days of sunshine per year, Boulder is the perfect place to take advantage of solar. In fact, since 2007, Boulder has seen the installation of approximately 15 MW of solar in the city, helping to avoid 69,000 metric tons of GHG emissions (equivalent to taking 14,500 cars off the road). To assist residents, businesses and property owners in understanding their unique rooftop potential, the City of Boulder, in conjunction with Mapdwell, LLC, has created a Rooftop Solar Tool to:

- Determine how much electricity can be produced from a solar photovoltaic (PV) system and what system layout may work best on every rooftop within city limits
- Estimate system cost and payback time based on local energy costs and financial incentives
- Help residents or community members better visualize how use of renewable energy impacts the environment

Solar potential of city building at 11th and Spruce

Discover your rooftop solar potential at www.mapdwell.com

Is There Enough Clean Energy to Meet Boulder's Needs?

Boulder, like most communities, has substantial clean, renewable energy resources. With currently available technology, Boulder can rapidly transition to energy that is abundant, environmentally sustainable, and economically viable. Boulder's goals for clean energy include a mix of localized generation such as solar, combined heat and power, and other technologies, as well as larger scale grid-based renewables, implemented through an integrated strategy that balances customer benefits, resilience and affordability. While issues of storage and load balancing must be addressed to deal with intermittency, there are significant local renewable resources that can be tapped:

Solar—The city recently completed the first stage of a community-wide solar assessment of the generation capacity of just rooftop area. This assessment indicates the potential for over 500 megawatts of rooftop generation capacity. Substantial additional capacity is possible in parking lots and other non-building spaces.

Wind— According to the American Wind Energy Association, as of September 2014, Colorado ranked tenth for installed wind power capacity with 2,332 MW. Colorado generated 13.8 percent of its power from 1,530 wind turbines in 2013. A recent Department of Energy (DOE) Study determined that Colorado has the potential to install 387,220 MW of additional wind power generation—more than 160 times current production!

Earth—Using the same technology that enables our refrigerators to make ice from room temperature air, ground source and air source heating systems can draw on the latent heat in the earth and air to derive the majority of the energy we need for heating and cooling. For every kilowatt of electricity used, a ground source heat pump can produce 2X that value in heating or cooling. If the electricity source is solar or wind, it is 4X!

Boulder's Energy Future: Guiding Principles

There are multiple potential paths to achieving a clean energy future. The choices made in how this new energy system is created—and who gets to make those choices—will significantly affect who benefits from this transition and who will pay its costs. Boulder's exploration and development of its clean energy future have been guided by principles that have been developed and refined through community conversations and council direction over the past several years. These principles include:

1. **Ensure affordable, clean, reliable and secure energy**—The first priority is ensuring community access to energy that is affordable, clean, reliable and secure. This includes investments in system enhancements that enable energy services to withstand local and regional disruptions—both community wide and at individual household, business and institutional levels

2. **Prioritize a rapid transition from fossil fuels**—Rapidly retiring fossil fuels reduces GHG emissions. It also insulates the community from fossil fuel price and supply volatility while protecting and restoring local environmental health.

3. **Invest in our local economy**—Fostering rapid development of local renewable energy resources enables the community to keep a growing share of its energy expenditures local, thereby sustaining the local economy, supporting existing businesses, creating new jobs and expanding business opportunities.

4. **Design a marketplace for innovation**—Central to achieving these principles is the creation of a marketplace that fosters innovation and the development of new energy products and services, responding to local needs, and then exporting solutions to regional, national and international markets.

CLEAN ENERGY SOURCES

Clean Energy Source Change—Making the Transition

Achieving a clean, renewable energy system will require sustained, multi-decade action to:

Reduce
Maximize the productivity and efficiency of existing energy uses to minimize the scale and cost of developing new generation.

Replace
Replace existing fossil fuel energy sources and the equipment that depends on them with clean energy sources and clean energy ready equipment (furnaces, boilers, water heaters, personal vehicles, etc.).

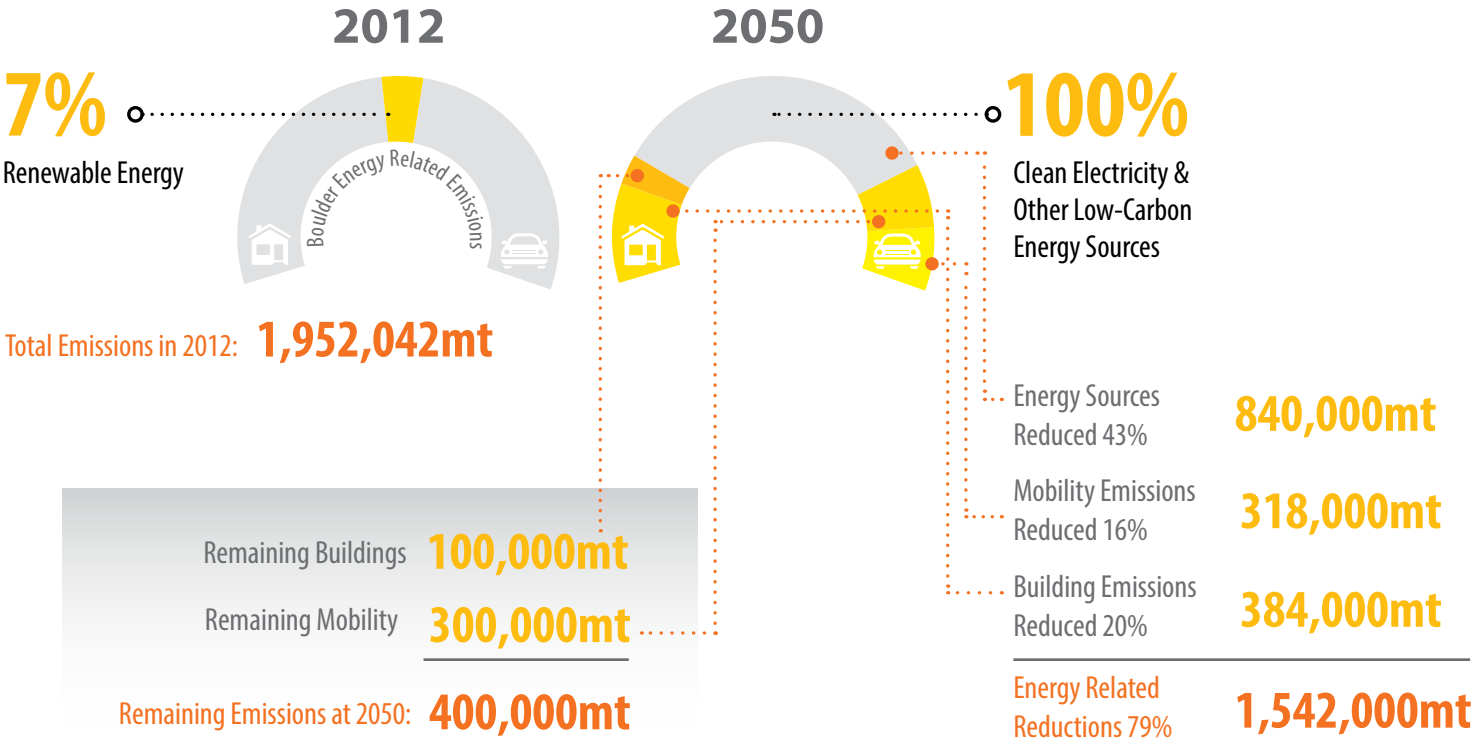
Redesign
Design our energy delivery and management infrastructure to maximize energy security and resilience and create maximum opportunities for local generation of energy.

WHAT'S A MEGAWATT?

A megawatt (MW) is one way to measure the flow of electricity—similar to measuring the flow of water through a pipe. Each megawatt flowing through Boulder's electrical grid can power around 200 average sized homes doing normal operations (heating, cooling, lighting, computers, TVs, etc).

The Path to 2050

In 2013, the city analyzed clean energy options as part of the analysis for establishing a municipal utility. This analysis indicated that the city could immediately source more than 60 percent of community electricity needs from renewable energy sources at the same cost as existing coal and natural gas generated electricity.[1] Given the challenges in reducing emissions in sectors like air travel and heavy transport, achieving the full 80 percent emissions reduction by 2050 will require that electricity production achieve at or near 100 percent renewable energy sourcing by 2050. In achieving this goal, a core consideration will be to prioritize the development of locally based renewable energy sources, in keeping with our community's energy future guiding principles.



[1] See Boulder City Council Memo July 23, 2013; https://documents.bouldercolorado.gov/weblink8/0/doc/121330/Electronic.aspx

Boulder Clean Energy Future: 2015—2020 City Action Priorities

The next five years will be a dynamic period in Boulder's energy-related efforts. After nearly five years of analysis and preparation, the city continues to work towards operation of its own locally-owned electric utility. Simultaneously the city will continue to work with both residents and business to identify and develop cost effective strategies to reduce energy use and rapidly transition current fossil fuel uses to clean, renewable, local energy alternatives. The following section highlights key parts of the city's five year action plan.

REDUCE

Expansion of Energy Services

- Expand pilot projects funded through the Boulder Energy Challenge to create enhanced energy service offerings for residents and businesses which can integrate efficiency with on-site generation and natural gas and petroleum replacement strategies.

- Provide expanded demand side management services through implementation of the municipal utility.

Expansion of On-site Solar

- Work with Boulder County and other public institutions to launch group solar acquisition programs designed to lower the costs of ownership through collective purchase agreements. This expansion in residential and commercial on-site solar will help reduce the overall demand for electricity and the scale of renewable energy assets or purchases necessary to achieve emissions reductions.

REPLACE

Municipalization

- Assume operational authority and begin operations of an electric utility by early 2018. Explore opportunities to create financing mechanisms that support both energy efficiency and renewable generation development. These mechanisms could include on-bill financing and on-site generation incentives.

Local Generation Analysis

- Conduct a second stage analysis of additional on-site generation opportunities, including combined heat and power, heating/cooling district analysis and energy storage infrastructure development.

Natural Gas and Petroleum Replacement

- Evaluate options for replacing existing natural gas uses and infrastructure with renewable energy alternatives.

- Partner with Boulder County, BVSD, CU and the Federal labs to design and implement a comprehensive electric vehicle charging infrastructure that fosters larger scale adoption and use of electric vehicles as an alternative to petroleum-based transportation.

REPLACE

Nanogrid and Microgrid Development

- Work with both institutional and private sector partners to pilot projects integrating local energy system designs with alternative electricity distribution systems (Direct Current circuitry) to reduce energy use and costs and increase energy resilience.

Energy Resilience Capacity Building

- Map critical community infrastructure and operations and identify opportunities to develop and deploy energy system upgrades that enable these sites to sustain operations during periods of power grid disruption. Create additional "safe haven" sites to ensure access to basic services for the entire community during periods of power system failure.

CLEAN ENERGY SOURCES

Powerful Partnerships

The University of Colorado (CU) is focusing on three initiatives to upgrade campus infrastructure while reducing energy consumption. Its new athletic facility will be built to be net zero greenhouse gas emissions including a nearly one megawatt array of solar on its roof. CU is also making substantial upgrades to its existing cogeneration system as an alternative energy source, and expanding its renewable energy resources for campus operations. There is currently over 1.2 MW of total solar capacity installed on campus, with another 850 kW in construction.

Boulder County has been a national leader in the support and development of renewable energy systems. In 2013, the County became the first in Xcel's Colorado service territory to host a community solar garden. This 500kW array is enough to support approximately 100 residences, with a second 500kW array recently added to this site. The County has also sponsored several rounds of pooled solar purchase contracts which have significantly lowered solar acquisition and installation costs for County employees and residents. The County and a consortium of seven other public entities and municipalities (including Adams County, Denver, Louisville, Lafayette and Boulder) are currently finalizing plans for one of the largest solar collective purchase contracts ever awarded in the State of Colorado.

Boulder Valley School District has taken substantial steps to integrate renewable energy into its buildings and teaching programs. Between 2008 and 2014, the District installed close to 2 megawatts of solar on 28 schools. These systems are providing 15-30 percent of these schools' energy needs and 8 percent of the District's overall energy needs. Many of the schools have associated websites showing live data from the solar panels, and real time energy consumption. These schools also received and are using materials provided by the National Energy Education Development Project and Solar City, to incorporate lessons about renewable energy and efficiency into curriculum. The District has also installed a wind turbine in the Nederland middle/senior school and two geothermal systems, one providing over 90 percent of the Casey School's heating and cooling needs.

Boulder Housing Partners has been a leader in the integration of renewable energy into its affordable housing projects. BHP's groundbreaking Red Oaks development features 140kW of rooftop solar throughout the development and a 10kW system on the shared community center. BHP is currently working with the City of Boulder to explore integrating solar, battery backup storage and microgrid networks in its new developments to achieve both zero net emissions and the capacity to provide energy "safe havens" for residents and surrounding neighborhoods during periods of grid power disruption.

RESOURCES

SECTION II

Reduce the emissions impacts caused by the use of goods and services, maximizing the productivity of all resources used, and leveraging purchasing decisions to support responsible resource use.

WASTE

By 2050, Boulder will be a place where residents, business owners, employees and visitors have all the tools they need to generate zero waste. The community will minimize hazardous and solid waste through conscious consumption choices and reuse opportunities, and will be able to recycle, compost or reuse any waste materials that are produced.

Targets & Timeframe

	2014	2020	2030	2050
Pounds of Waste/Person/Day[1]	6.76	4.50	3.50	2.50
Landfill emissions (% of Boulder GHGs)	2.3%	1.5%	1%	.5%
Diverted from Landfill (%):	34%	60%	90%	90%
Total Recycled:	25,946	25,319	26,009	18,729
Total Composted:	17,237	28,551	39,014	28,093
Total Diverted:	43,183	53,870	65,023	46,822
% of Total Diverted That Is Recycled	60%	50%	40%	40%
% of Total Diverted That Is Composted	40%	50%	60%	60%

The Waste-Climate Connection

Most community greenhouse gas inventories typically only measure the greenhouse gas emissions associated with methane generated from the organic wastes delivered to landfills. For Boulder, this represented approximately two percent of the community's recorded emissions inventory in 2012.

However, the resources we use and the waste that is generated from this consumption of products and food are responsible for a significantly larger share of emissions, many of which impact areas outside of Boulder's boundaries. According to the US Environmental Protection Agency, approximately 42 percent of U.S. greenhouse gas emissions are associated with the energy used to produce, process, transport, and dispose of the resources we use. This includes the extraction or harvest of materials and food, production and transport of goods, provision of services, reuse of materials, recycling, composting, and disposal.[2]

[1] Reduced overall waste per person will also result in reductions of recycled and composted materials.

[2] http://www.epa.gov/climatechange/climate-change-waste/#statistic

Systems-Based GHG Inventory
U.S. Resource-based Emissions[2]

2%
REDUCTION IN OVERALL EMISSIONS BY 2050.

DID YOU KNOW?

In 2014, Boulder residents and businesses recycled and composted more than 43,000 tons of waste that would otherwise have gone to the landfill. This avoided more than 91,000 MTCO2e in 2014, the equivalent of taking more than 19,000 cars off the road.

WASTE

2015-2020 Action Plan Priorities

As part of Boulder's recently adopted Zero Waste Strategy, a new set of strategies are being deployed to both track and manage a larger set of factors that can help reduce the community's waste related emissions impacts. These include:

R E D U C E

Recycle (Reducing Trash)

2015:

- Deliver expanded multifamily housing assistance program to increase recycling and composting.
- Implement the Universal Zero Waste Ordinance, requiring all property owners to provide recycling and compost collection services and requiring businesses to use these services.
- Expand business assistance and advising.
- Negotiate with local partners to provide cost-effective and convenient composting operations for all area organics haulers.
- Support state legislative efforts to encourage recycling and reuse.

Next one to three years:

- Expand the reach of multifamily residential assistance program.
- Expand community-wide educational efforts on available services, incentives, and facilities as well as proper recycling/ composting/source reduction methods.
- Support improvements to the Boulder County Recycling Center to facilitate processing of additional materials.

R E U S E

Source Reduction- Replacing Disposables with Reusable Materials

2015:

- Expand community-wide educational efforts on reuse and source reduction opportunities.

Next two to three years:

- Strengthen the Disposable Bag Fee ordinance to further reduce bag use.
- Explore consumption-based accounting method to track and measure GHG emissions from products and packaging produced outside of Boulder but consumed locally.
- Include GHG emission reductions from recycling and composting in climate accounting (using WARM model), based on avoided manufacturing emissions; track by total and per person.
- Reduce food waste and improve opportunities to re-purpose leftover food to people, animals or energy.

R E D E S I G N

Changes in Community Wide Infrastructure or System Strategies

2015:

- Support product stewardship and other legislative efforts at a state and federal levels to reduce the creation of waste.

Next one-three years:

- Support shifts in business practices that result in more sustainable purchasing, separating recyclable and compostable materials, and avoiding waste.
- Perform a programming exercise to further investigate/analyze future uses of 6400 Arapahoe site to support zero waste goal, including the expansion of CHaRM and ReSource.
- Collaborate with Boulder County and other partners on developing a regional construction/ demolition recycling facility.

Tracking the Emissions Benefits of Recycling and Composting

The emission reduction benefits of recycling and composting are currently unrecognized in most conventional emissions inventory systems including the one developed for the City of Boulder. To quantify these benefits and improve the tracking and management of this information, the city's ZeroWaste team is building greenhouse gas (GHG) accounting capabilities into the new waste hauler reporting tool, Re-Trac Connect, based on the EPA's Waste Reduction Model (WARM). The Re-TRAC tool will enable city staff to obtain more detailed information from haulers on materials being discarded in our community. This, in turn, can be used to calculate municipal solid waste emissions (predominantly methane, CH4) and avoided emissions from the diversion of recycling and compost materials from the landfill. This information will both improve the visibility of these benefits and enable the city and community to continue to improve its programs to maximize these benefits.

Reuse Reduces Emissions: Boulder ReSource

Repurposing used building materials reduces GHG emissions by avoiding the energy used to extract and manufacture new materials. Raising the national recycling rate for construction and demolition (C&D) materials from 30 percent to 80 percent would save 91 million MTCO2e per year. Locally, ReSource reclaimed more than 3.3 million pounds of building materials in 2014 while creating jobs, conserving natural resources and reducing pollution. The ReSource Tool Library also helps reduce per capita GHG emissions by promoting shared ownership of products. The library rents to more than 800 electrical, plumbing, landscaping and general construction tools.

Zero Waste Partners

Eco-Cycle operates the Center for Hard-to-Recycle materials (CHaRM), keeping tons of large appliances and other difficult to recycle materials out of the landfill. It also organizes the community and volunteers in support of zero waste initiatives, including a network of block leaders throughout the community.

Western Disposal partners with the city to provide yard and wood waste drop-off centers. It is also an active collaborator with the city on pilot projects and innovation solutions, such as the launch of bear resistant trash cans and compost carts.

Boulder County owns and manages regional facilities, including Boulder County Recycling Center, the primary sorting and distribution for the community's recycling materials. It also operates the Hazardous Materials Management Facility which diverts thousands of pounds and gallons of otherwise toxic materials out of our landfills. The County also jointly supports (with city of Boulder) the Partners for a Clean Environment (PACE) service, providing zero waste services to Boulder businesses.

The Center for ReSource Conservation operates ReSource, which sells reclaimed building materials and runs a community tool lending library. In 2014, ReSource reclaimed more than 3.3 million pounds of building materials.

University of Colorado is an important waste management partner with city by providing outreach to the student community through its student staffed "green teams". These teams provide face-to-face information and education to thousands of students each year, discussing both energy efficiency and waste reduction.

WATER USE

In 2050, water will be managed as a critical resource in reducing GHG emissions and supporting the stabilization of the climate. Water will be used to both produce and store clean renewable energy, and it will maintain natural ecosystems that are critical to moderating climatic extremes and sequestering excess carbon in the atmosphere.

Targets & Timeframe

	METRIC	2000	2050
Total Water Use	acre feet	23,820[1]	22,500[1]
Water Use Per Capita	gallons per capita day	186[2]	149[3]
Total Electricity Generation-Hydro[4]	megawatt hours (MW)	39,068[5]	52,015[6]

REDUCE EMISSIONS. SAVE WATER.

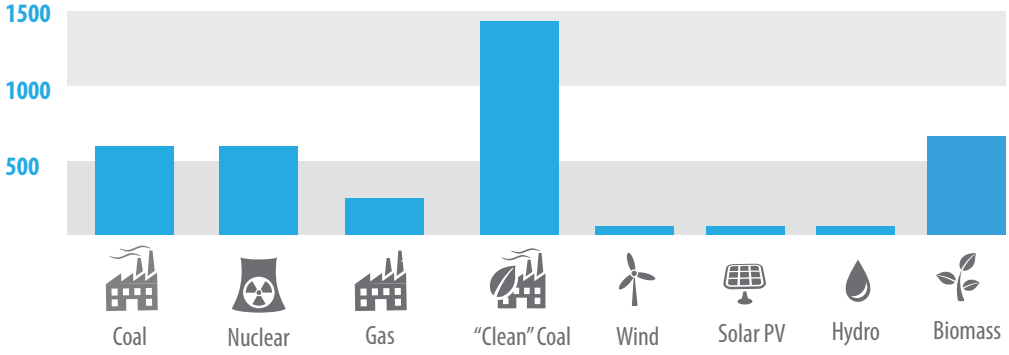
Renewable energy sources often are less water-intensive to produce and reduce GHG emissions when compared to non-renewable resources.

The Climate-Water Connection: The Power of Water

The water-energy-climate nexus is well established. It takes energy to heat, treat and pump water and it takes water to produce energy. Since energy sources, especially those dependent on fossil fuels, result in GHGs, renewable energy sources like solar and wind energy not only reduce climate impacts but also use significantly less water to generate energy. Hydroelectricity, for example, requires little to no water consumption, creates a clean energy source and offsets carbon emissions.

In Boulder, the city's collective hydropower facilities across all water resources produce 52 million kilowatt hours of electricity each year, enough energy to power 4,932 homes and offset over 26,000 metric tons of carbon. It should be noted that precipitation, system demand, and water supply are significant factors in the city's ability to maximize hydropower. For example, decreased water use or water storage can reduce hydroelectric production.

Gallons of Water Used per Megawatt Hour of Energy Production[7]



FILLING UP: WATER USED FOR GAS

It takes 5 gallons of water to make 1 gallon of gasoline which means every full tank of gas uses about 60 gallons of water.[8]

[1] Values from the upcoming draft Water Efficiency Plan; scheduled to be updated in 2016.
[2] Value recorded in the 2011 Water Utilities Master Plan; references the 2000 Water Conservation Futures Study (WCFS) which used 1996-1999 as a baseline.
[3] This is the water conservation goal for build-out set in the 2000 Water Conservation Futures Study.
[4] Hydroproduction in any given year is water and weather dependent; max capacity may not be achievable in any given year.
[5] Extrapolated based on past production using 2004 hydroelectric production.
[6] Uses 2014 City of Boulder hydroelectric production; additional hydropower from the city's Colorado-Big Thompson water supply is owned/operated by the Department of Interior.
[7] Graph is modified from the original which appears courtesy of Western Resource Advocates *Water Use for Energy* webpage.
[8] Comprehensive Evaluation of Impacts from Potential, Future Automotive Fuel Replacements; Kreider and Curtiss; University of Colorado; 2007.

2015-2020 Action Plan Priorities

In 2000, the city's Water Conservation Future Study set a goal to reduce total city water use by 10%. To date, the city has met and exceeded this goal. However, climate change, population growth and other factors can increase the city's future water use. To coincide with drought planning and state reporting requirements, the city will be reevaluating these factors in the 2016 Water Efficiency Plan update. The Water Efficiency Plan must be submitted to the Colorado Water Conservation Board every 7 years.

Specific water management strategies that support emissions reductions include:

- Expand water conservation programs that focus on outdoor irrigation which may also support better identification of water-related carbon sequestering opportunities such as using soil amendments, native grasses and proper tree watering.
- Promote measures that reduce the energy needed to heat, treat and transport water including continued evaluation of new hydroelectric opportunities.
- Evaluate opportunities for real-time water and energy metering that may help customers better understand and reduce their water and energy consumption.

Partnerships

Boulder Valley School District (BVSD) has worked with the city to promote wise water use in schools- both indoors and outdoors. For example, the city works with BVSD to install refillable water bottle stations in schools to better promote drinking tap water, reducing waste from plastic water bottles and recognizing that bottled water consumes 2000 times more energy than tap water.

Boulder Housing Partners has worked with the city to install new low-flow toilets, water efficiency sprinkler heads and other water-saving features. The city and BHP are also working on a submetering pilot to help find system leaks. At one property BHP was able to identify a leak that wasted 8,640 gallons per day; that's 6 gallons per minute!

EPA WaterSense initiatives, like Fix-a-Leak-Week are supported by the city and helped win the city a 2013 WaterSense Excellence Award.

Center for ReSource Conservation (CRC) offers multiple city supported programs from low-cost xeriscape gardens to low-flow toilet installs. The CRC also promotes energy efficiency in BVSD schools through the "Renew Our Schools" challenge.

Boulder County's EnergySmart Program helps support wise water and energy use by coordinating low-flow shower head retrofits. Partners for A Clean Environment provides free water conservation and energy assessments to businesses.

CLEAN ENERGY AND WISE WATER USE

DID YOU KNOW?

Every year the city's hydroelectric power production offsets the equivalent GHG emissions created by the average passenger vehicle driving 85,372,981 miles.

FOOD

By 2050, the choices in the food we eat, grow and raise in Boulder will include consideration of the climatic impact of those decisions, both with regard to the resources used in their production and distribution as well as the carbon sequestration realized by associated agricultural practices.

The Food Climate Connection

The foods that sustain humans have a variety of impacts on the climate—both those we eat directly and those raised to feed animals (cows, chickens, sheep etc) whose meat we in turn rely on for food. According to research by the Environmental Protection Agency[1], agriculture accounts for 20 percent of the greenhouse gas emissions in the United States. Livestock and manure management account for the greatest amount of emissions within agriculture, at 33 percent and 12 percent respectively. While these resource impacts are often felt far from Boulder, food choices we make here contribute to these impacts. These impacts also vary considerably depending on a variety of factors including:

- how low on the food chain it is—foods derived from plants typically generate fewer emissions per calorie than those from animals
- how water is used to produce the food
- how much energy is required to cultivate, tend, harvest and process that food
- how far the food has to travel before it gets to the table

Deciding to consume and produce food locally can be associated with decreased impacts on the climate, increased sequestration and improved awareness about where our food comes from and the associated impacts of how we choose to feed ourselves. In an effort to foster and grow these benefits of local food choices, a broad collaboration of groups including the city, Boulder County, the Boulder Valley School District, Transition Colorado, the University of Colorado, and others have formed a local initiative called "Making Local Food Work." Among their efforts was the recent launch of a local/regional food awareness campaign branded as "The Shed: Boulder County Foodshed." Among the activities contemplated by this initiative is the development of marketing materials and support for local food producers who are pioneering new approaches to sustainable, climate-friendly food production, distribution and preparation

Measuring Success

Tracking the connection between food, especially local food, and climate, is still a new and emerging field of interest. Over the next 3-5 years, the city and its community partners will be evaluating a number of approaches to begin understanding and monitoring these connections. These initiatives may include:

- Assessing the total water utilized in producing local foods.
- Tracking the "carbon miles" from farm to table for local foods.
- Tracking the number of acres certified in organic production or other sustainable production monitoring systems.

Local Food Achievements

- From 2004-2014, Boulder County Farmers' Market sales increased by 98 percent.
- The "Harvest Bucks" program was implemented in 2014, which increased SNAP purchases at the Boulder County Farmers' Market from $12,500 in 2013 to $23,455 In 2014.
- As of 2015, Boulder County is known to have more than 12 community gardens.

[1] http://epa.gov/climatechange/ghgemissions/sources/agriculture.html

Livestock, Land Use and Soil Sequestration

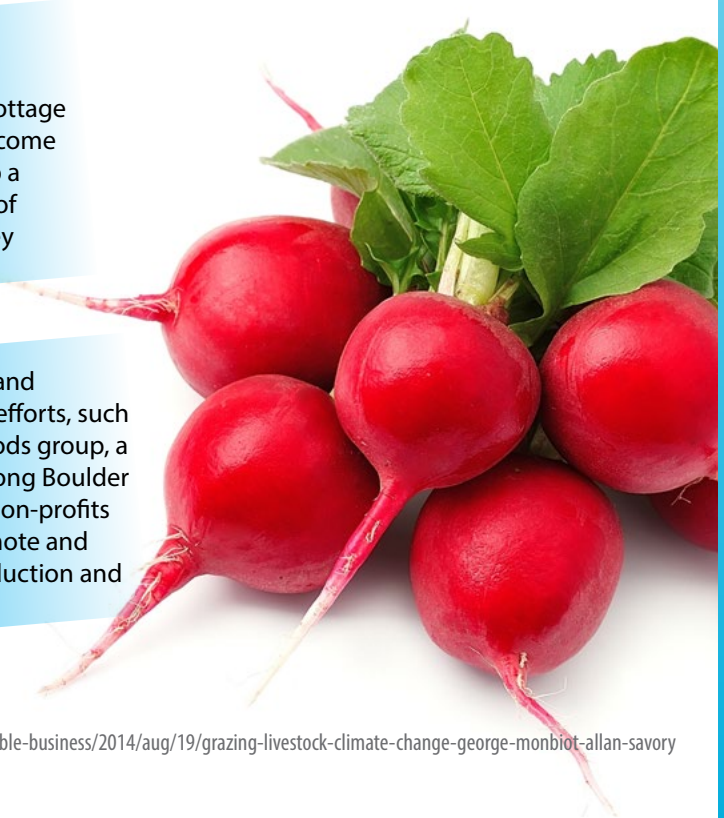
The already frequently debated topic of eating meat has recently added climate impacts to its list of issues raised in this dispute. In Boulder and Boulder County, a significant amount of the agricultural land is not well suited to the production of vegetables and grain crops. Consequently, much of the 15,000 acres of agricultural land owned by the city—nearly 80 percent—is used as grazing land for livestock. Emerging research indicates that both perspectives are right: many conventional livestock management practices contribute significant amounts of carbon emissions, in large part due to impacts to the soil. In contrast, a growing movement of ranchers and range managers have begun using livestock rotation and management techniques that mimic natural processes of wild grazers. These techniques have been shown to actually improve the health of the soil and foster enhanced sequestration of carbon out of the atmosphere.[2] To be successful, these progressive land managers need positive support from a marketplace of food buyers that ask for—and in some cases are willing to pay a premium for—the meat products that come from these operations. Many of Boulder County's farmers that direct the market use practices such as these that sequester greenhouse gases or reduce their emissions (see Agricultural Ecosystems section on page 43).

2015-2020 Action Plan Strategies in Development: Climate-Friendly Food

The City of Boulder's 2010 Comprehensive Plan outlines broad goals and objectives for local food and agriculture, including support for local food production, sustainable agricultural practices, urban gardening and access to locally produced foods. In 2015, a cross-departmental staff team was formed to begin exploring additional actions the city could take in support of these objectives. Specific strategies being explored or under development include:

Encouraging sales of residentially-produced vegetables, fruits and cottage foods (when people become producers they develop a greater understanding of the impacts of what they consume).

Continued leadership and investment in regional efforts, such as the Making Local Foods group, a collaborative effort among Boulder County governments, non-profits and businesses to promote and support local food production and consumption.



SUPPORT LOCAL FOOD, DECREASE CLIMATE IMPACTS

DID YOU KNOW?
From 2004-2014, Boulder County Farmers' Market sales increased by 98 percent.

[2] http://www.theguardian.com/sustainable-business/2014/aug/19/grazing-livestock-climate-change-george-monbiot-allan-savory

ECOSYSTEMS

SECTION III

Enhance the ability of urban, wildland and agricultural ecosystems to capture and stabilize atmospheric carbon and provide critical buffering against climatic extremes.

URBAN ECOSYSTEMS

In 2050, Boulder's urban landscape will be fully planted with trees and vegetation selected to moderate climate extremes, reduce energy and water usage, improve water quality and enhance the beauty and livability of Boulder's urban environment.

Targets & Timeframe

	2020	2030	2050
Unoccupied Planting Spaces[1]	75%	60%	40%
Urban Tree Canopy (% canopy closure)	27%	30%	37%
Number of Trees Planted Annually	1,000	1,200	1,500

The Climate-Urban Ecosystem Connection: The Power of Trees

Research indicates that healthy trees can mitigate a range of environmental impacts: stormwater runoff, poor air quality, temperature extremes. Trees also provide significant energy use reductions associated with both cooling and heating. The density and placement of trees in an urban environment is typically measured by the percentage of area covered by the trees during full foliage—the urban tree canopy (UTC). Cities with higher UTCs are typically able to reduce temperature extremes—often referred to as the "urban heat island" effect. These reductions can be significant.

The City of Boulder's urban forest and ecosystems are an integral part of its living infrastructure. The city has over 650,000 trees—approximately 6.7 trees per capita. However, given the significant open space in the community, this results in a canopy closure of less than 25 percent. Achieving the long term goal of over 35 percent canopy closure level considered necessary to achieve full emissions and environmental benefits, the community will need to utilize the available planting sites on both public and private property, ideally in ways that also support rooftop solar access.

Trees, Energy and Emissions

According to the Environmental Protection Agency, a mature tree can reduce peak summer temperatures between 2°F to 9°F! Trees properly placed around buildings can reduce air conditioning needs by 30 percent and can save 20 to 50 percent in energy used for heating and by reducing wind exposure. This reduction in energy usage, particularly during high energy use periods such as hot summer days, translates directly into reducing carbon emissions where the energy being reduced would otherwise have been produced by a fossil fuel source (coal, natural gas).

Emerald Ash Borer

Boulder has the unwelcome distinction to be the first western community to experience an infestation of the Emerald Ash Borer.
This small green beetle has swept through the Midwest causing complete mortality in untreated ash tree species. As much as one-fifth of Boulder's urban forests are comprised of ash including many spectacular trees on Boulder's iconic Pearl Street Mall. While climate change is not the cause of this outbreak, the increased plant stress it causes already appears to be accelerating the pace of the spread of the infestation. This loss of up to 20 percent of the urban tree canopy over the next 5 to10 years will have a significant impact on the many environmental, aesthetic and economic benefits provided by the urban canopy. It also provides an opportunity to replace the ash with diverse species that are well suited to the hotter conditions expected as a result of climate change. Species selection and planting locations can also address other objectives, such as coordination with optimizing rooftop solar capture capacity.

[1] Unoccupied planting spaces' refers to locations suitable for planting trees along roads and public areas that are currently unoccupied.

HEALTHY TREES FOR A VIBRANT FUTURE

Trees In Jeopardy: Climate Change and Exotic Pests

Climate change is beginning to exacerbate the stresses urban trees are already facing, including temperature extremes, drought stress, infestation and disease, adding to the urgency to create effective protection and restoration strategies. Effects include:

- Hotter summers are stressing young trees and increasing external watering needs.
- Milder winters enable a proliferation of pests and increase susceptibility to premature budburst and subsequent freeze damage to new growth.
- Extreme temperature fluctuations can stress or kill trees. During 2014, a November temperature drop from 64° to -11° in 48 hours created substantial local damage and dieback.
- Increased water stress will also make trees more susceptible to a wide range of insects and disease that attack low vigor trees. Boulder is currently experiencing a number of these threats, most notably the likely eradication of Green Ash due to the Emerald Ash Borer.

2015-2020 Action Plan Priorities

The city of Boulder's Urban Forestry workgroup manages all city trees in parks and street right of ways in Boulder. Under the guidance of the 2014 Parks and Recreation Master Plan, staff is now preparing to develop the city's first Urban Forest Strategic Plan. Key action items anticipated as part of its workplan over the next five years include:

- Review and revise parking lot shading guidelines and enforcement of increased canopy cover.
- Conduct a comprehensive urban forest inventory.
- Monitor the urban forest using both on-the-ground and remote sensing technologies to document how it is responding to climate change and establish ongoing monitoring protocol.
- Increase the diversity of urban tree species to improve overall urban forest resilience.
- Review and improve strategies for responding to pest and disease invasions.
- Review and refine park and natural space plans to minimize damage from the impacts of increased use and warmer conditions.
- Explore the establishment of a partner non-profit urban forest foundation to leverage additional financial and community support for the urban forest.

DID YOU KNOW?

A mature tree can reduce peak summer temperatures between 2°F to 9°F!

WILDLAND ECOSYSTEMS

In 2050, the city will continue to be surrounded by vibrant, diverse natural ecosystems. The city and a broad consortium of partners are engaged in stewardship and restoration activities that enhance the resilience of these systems enabling them to continue to thrive and provide the wide range of climate buffering services the community enjoys.

The Climate-Wildland Ecosystem Link

Wildland ecosystems—from forests and grasslands to alpine and desert—are integral parts of the climate system. Each ecosystem has a unique interaction with the climate depending on its geography, moisture profiles, seasonal characteristics and a host of other factors. In Boulder, the extensive wildland buffers that surround and weave through Boulder's landscape have important roles in moderating local climate conditions, sequestering and holding carbon (especially forests) and maintaining the complex network of species that support a vast array of biological functions—each essential to a stable environment. A changing climate will alter this balance, with potentially dramatic impacts on biodiversity and ecosystem services, as well as the ecological processes that link the two.

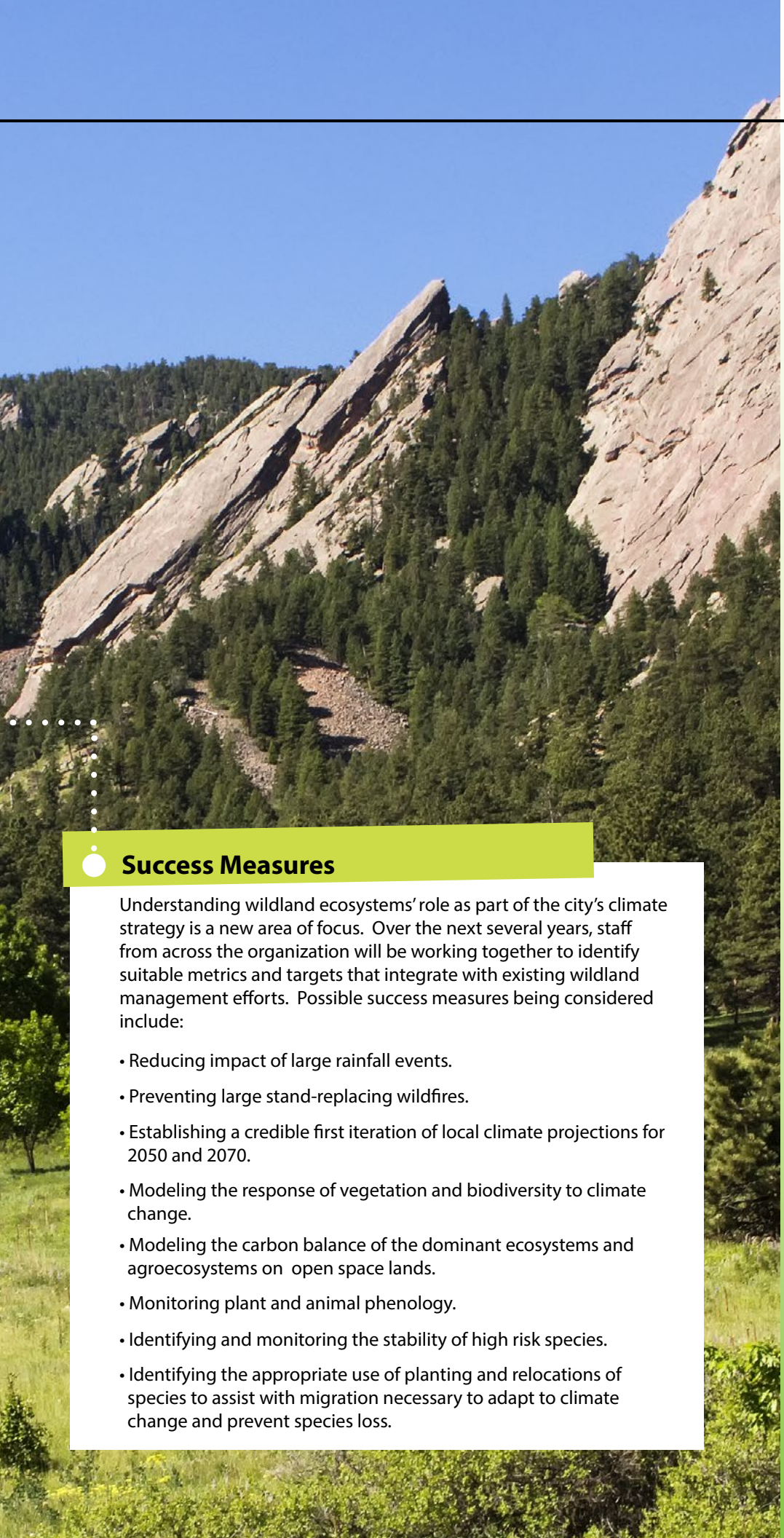
Summary of Current Conditions

Over the last 50 years, Boulder has experienced a steady increase in temperature and precipitation. Looking forward, all climate models predict that temperatures will continue to rise; predictions for precipitation are less certain. The ecological effects of climate change in Boulder are understudied, but we may anticipate increased fire and flood frequency, declines of snow pack, increased drought, altered seasonal water flows, upslope shifts in the distribution of plants and animals, earlier arrival of migratory birds, advanced blooming time of plants, increased spread of invasive species, and even the local extinction of some species.

2015-2020 Action Plan Priorities

Protecting and sustaining wildland ecosystems is essential to address the city's emissions reduction objectives and its climate adaptation and resilience strategy. In many ways, these strategies are closely integrated. To maintain the climate stabilizing services provided by wildand ecosystems, the city will need to manage their adaptation to the changing climatic conditions already underway, particularly species conservation. To this end, it will be necessary to convene a multidisciplinary team that includes hydrologists, conservation planners, geographers, and biologists. Ongoing strategies should include:

- Incorporating climate change into all levels of planning. In particular, invest in scenario planning, focusing on novel future conditions so that recommendations for land management reflect the best available and most current science and potential range of impacts.
- Manage landscapes to support ecosystem transitions.
- Identify multiple biological indicators of climate change sensitivity and response; specifically, identify high risk assets for monitoring or intervention.
- Develop downscaled future climate layers and use them to predict the return interval of extreme events.



RESILIENT ECOSYSTEMS SUPPORTING THE CLIMATE

Success Measures

Understanding wildland ecosystems' role as part of the city's climate strategy is a new area of focus. Over the next several years, staff from across the organization will be working together to identify suitable metrics and targets that integrate with existing wildland management efforts. Possible success measures being considered include:

- Reducing impact of large rainfall events.
- Preventing large stand-replacing wildfires.
- Establishing a credible first iteration of local climate projections for 2050 and 2070.
- Modeling the response of vegetation and biodiversity to climate change.
- Modeling the carbon balance of the dominant ecosystems and agroecosystems on open space lands.
- Monitoring plant and animal phenology.
- Identifying and monitoring the stability of high risk species.
- Identifying the appropriate use of planting and relocations of species to assist with migration necessary to adapt to climate change and prevent species loss.

DID YOU KNOW?

The city is beginning to evaluate the ability of more than 1,500 local species to adapt to projected increases in local temperatures due to climate change.

AGRICULTURAL ECOSYSTEMS

In 2050, agricultural operations on city lands will be recognized for maximizing the fertility and climate stabilizing capacity of the soil and associated ecosystems. The city's agricultural lands will continue to provide local foods and support the critical ecological services these agricultural lands provide.

The Climate-Agriculture Link

The inclusion of agricultural land management as a consideration in the city's emissions and climate action strategy is a new area of consideration and development. While agricultural-based emissions are not currently captured under the emissions protocol used by Boulder and most cities, the importance of agriculture as both an emissions source and a possible emissions reduction strategy is a rapidly emerging field of study. According to the US EPA, agriculture is responsible for approximately 9% of all greenhouse gas emissions nationally[1]. The sources of these emissions include livestock, soil and crop management, and the equipment and operations associated with agricultural operations.

Emissions from agriculture have been increasing since 1990 and are projected to continue to increase if current management practices and food preferences are maintained. However, agricultural practices can also be used to reduce carbon emissions and sequester carbon out of the atmosphere. A hopeful new movement referred to as "Carbon Farming" has demonstrated encouraging progress in developing land management practices that can sequester carbon in soils and contribute to climate stabilization, while maintaining or enhancing agricultural production and land health.

The city of Boulder through its Open Space and Mountain Parks Division currently leases almost 15,000 acres of agricultural lands, 80% of which is used for livestock grazing. Close to 500 acres are currently leased to farms focusing on locally-marketed food products, including beef, lamb, honey and fresh produce. OSMP has a variety of initiatives designed to maintain and improve land health including support for farmers utilizing organic and other sustainable farming practices, including rotational grazing systems, reduced tillage, and other soil stabilization and conservation practices.

2015-2020 Action Plan Priorities

1. Continue the development of Best Management Practices for Soil Sequestration--Soil sequestration of carbon is a new science and Best Management Practices for our local climate and soils are still being developed. The city is working on developing soil organic matter sampling procedures to set standards for acceptable conditions and work towards increasing soil organic matter and soil health on city-owned agricultural lands.

2. Implement soil protection actions—Work with agricultural lessees and university researchers to adopt soil conservation systems such as reduced tillage, cover cropping and longer crop rotations.

3. Identify suitable sites to run pilot projects for soil sequestration of carbon—Explore collaboration opportunities between the city and Boulder County, as well as private farms which are already using many soil carbon sequestration methods, to provide opportunities for testing various soil sequestration strategies.

4. Explore Opportunities to Incentivize "Carbon Farming"—Identify and assess opportunities to incentivize sequestration management through both local carbon offset funding or the development of external carbon market incentives such as the Carbon Trade Exchange[3].

5. Initiate a public information campaign to encourage Soil Sequestration of Carbon by homeowners, farmers, and on public lands. Carbon can be sequestered in lawns, mulched flower beds, vegetable gardens, farm fields, rangelands and forest lands. Partnerships with public or private entities can amplify the campaign's effectiveness.

Carbon Farming: Agriculture as a Carbon Sequestration Technology

A growing movement of agriculturalists, soil scientists, permaculturists and others interested in land stewardship have been engaged in both formal and informal research on the potential for using agriculture as a part of strategies to stabilize the climate. The Marin Carbon Project has begun publishing findings from a range of on-farm pilot projects intended to use agricultural practices to sequester carbon. In one study, UC Berkeley researchers found that a single application of 1 ton/hectare of composted green waste increased carbon sequestration by an average 25-70% while also increasing forage production by as much as 50%.[2] Given the growing recognition that stabilizing the climate will require both reducing emissions and finding ways to recapture much of the carbon now released, approaches to augmenting sequestration are critical. Careful research and testing is necessary before widespread use of these techniques is implemented. This research should be directed towards highly modified landscapes only, such as tilled agricultural fields and previous industrial sites

[1] http://www.epa.gov/climatechange/ghgemissions/sources/agriculture.html
[2] http://www.marincarbonproject.org/science/land-management-carbon-sequestration
[3] http://ctxglobal.com/

SUPPORTING AGRICULTURE, SEQUESTERING CARBON

DID YOU KNOW?

One ton of composted green waste per hectare increases the carbon sequestration capacity of annual grasslands by up to 70% while increasing forage up to 50%.[2]

COMMUNITY

"**Communities are going to be at the forefront** of deciding how to adapt to and manage climate change risks. We know enough now to say climate is changing, and to see the opportunity for innovating our public dialogue, our policy institutions, and our scientific processes. Our success in navigating the challenge of climate change will no doubt require skillful engagement in all three."

-**Lisa Dilling**
Director of the Western Water Assessment

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* External Resource
** Organization

Long-term success will require better feedback loops, honest assessment, persistence and collective action.