CITY OF GOLDEN

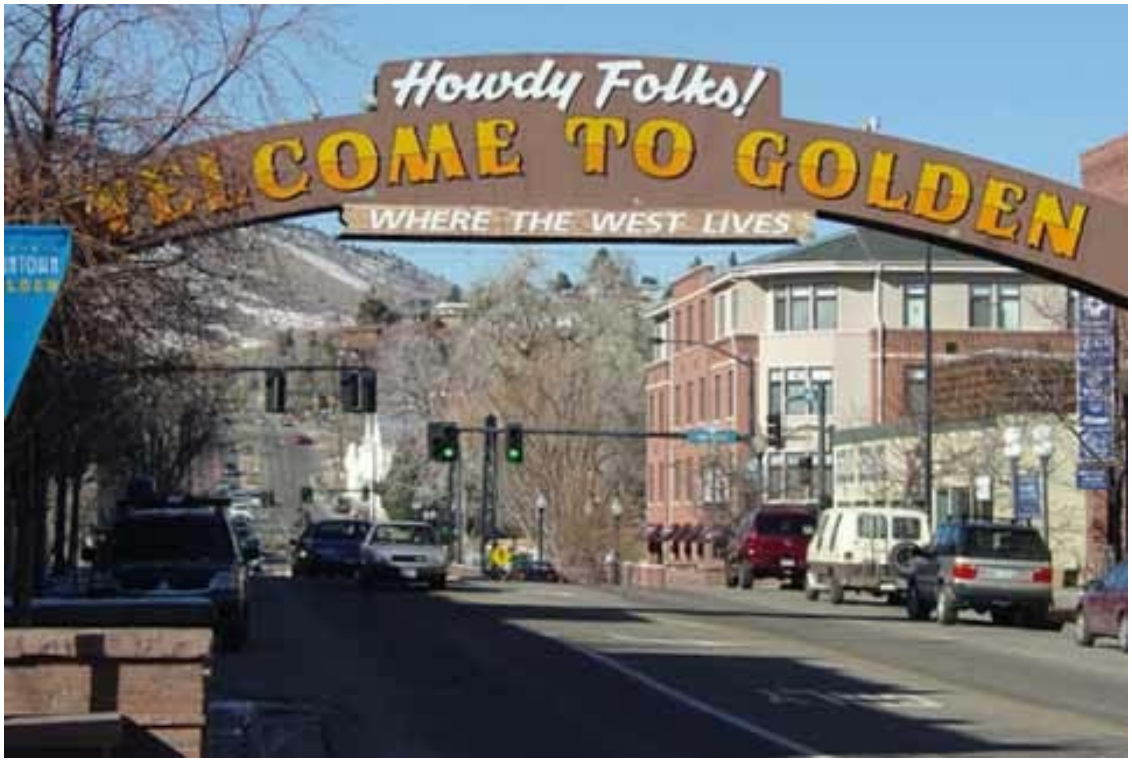
Greenhouse Gas Emissions Inventory

&

Sustainable Energy

Benchmarking and Actions

2007



Center for Sustainable Infrastructure Systems

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DOWNTOWN CAMPUS

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Executive Summary

Background

At the end of 2009, the City of Golden (Golden) partnered with the University of Colorado Denver (UCD) and the Colorado Municipal League (CML) through a generous donation from Wal-Mart to begin the process of quantifying a baseline for sustainability. The City of Golden has recently been implementing programs and policies to increase sustainability in the community and quantifying these efforts is an important next step. In order to inform the current and future conditions of the climate and the City's emissions, the University of Colorado Denver conducted a greenhouse gas (GHG) inventory for 2007, which is the baseline inventory for community-wide emissions. This inventory provides measureable data that can be tracked over time. While sustainability encompasses the environment, economics, and equity (social aspects), GHG accounting allows for the City to develop a baseline starting in 2007, establish goals into the future, and track the progress along the way.

This report assesses the 2007 GHG emissions for the City of Golden, Colorado using a hybrid demand-center life cycle assessment methodology developed by Ramaswami et al (2008). This method treats the City as a demand center and accounts for buildings electricity and natural gas, surface and air transportation, and the embodied energy of key urban materials and waste. The inventory and this report should be updated about every two years to track the progress of greenhouse gas emissions and general sustainability in the City of Golden. This report also includes a tailored sustainability matrix with examples of actions the City can add to its current list to further a Golden sustainability plan.

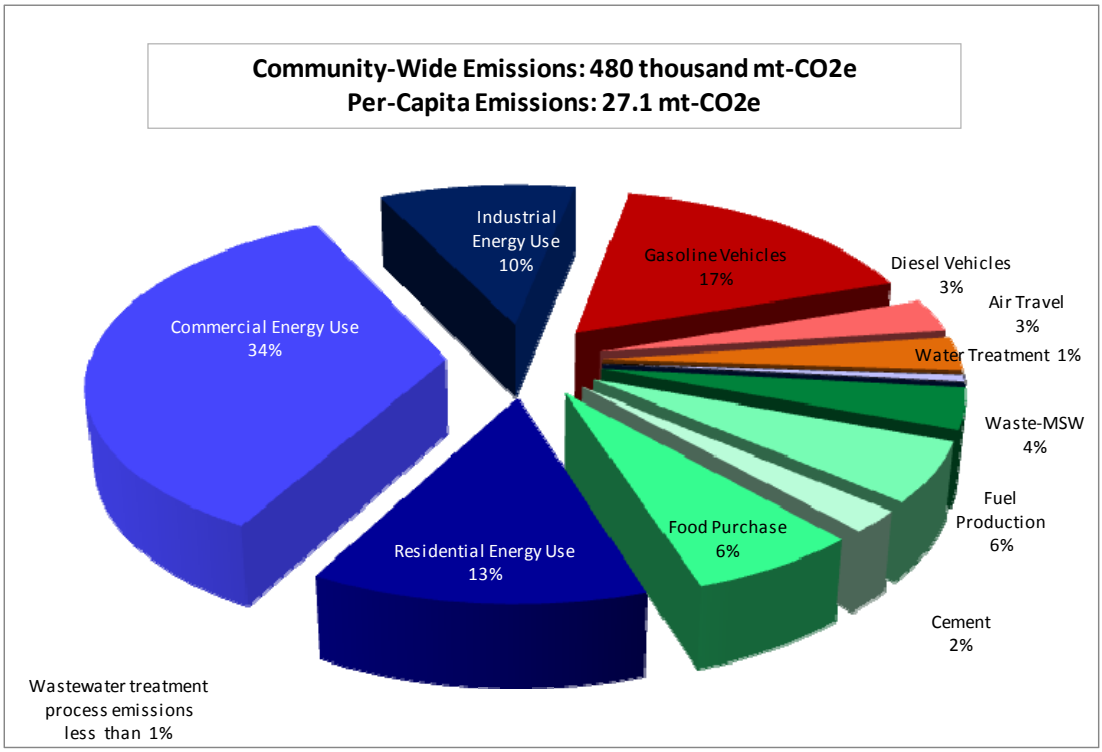
Greenhouse gases are emitted almost exclusively from the burning of fossil fuels, such as coal, natural gas, gasoline and diesel. Greenhouse gases are important because they trap heat in the atmosphere, which over many years causes climate change worldwide. Greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and three replacements for chlorofluorocarbons (HFCs, PFCs, SF_6). This report tracks CO_2, CH_4, and N_2O in the sectors of buildings, transportation and materials and waste for the entire community. Each of these gases has a different global warming potential. In order to compare the different gases, they are converted into carbon dioxide equivalents (CO_2e).
Tracking emissions is calculated with the following equation:

$$\sum[\text{Material Flow Analysis (MFA)} \times \text{Emissions Factor (EF)}] = \text{Total Emissions}$$

In other words, the emissions for each sector are found by multiplying the total consumption of a GHG emitting activity (e.g. kWh for electricity, therms for natural gas,

gallons of gasoline, etc) by the calculated emissions factor for that particular activity (e.g. kg-CO_2e/kWh; kg-CO_2e/gallon, etc.). The GHG emissions from each sector can be summed up to find the total community-wide greenhouse gas emissions for the City of Golden in 2007; Table 1 shows these results split up by the main GHG emitting sectors in the community.

Figure ES.1: City of Golden 2007 GHG Emissions by Detailed Sector



Results

In 2007, the population of the City of Golden estimated to be 17,701 was people. The activities of these people were summed together to find the total community-wide GHG emissions and the per capita emissions. There are many activities within the community that cause greenhouse gas emissions, the majority of which are easily tracked through economic, utility, and other public data. For the buildings sector in 2007, electricity and natural gas consumption from the residential sector made up about 62 thousand mt-CO_2e (13% of total GHG emissions), electricity and natural gas consumption from the commercial sector made up about 168 thousand mt-CO_2e (34%), and electricity and natural gas consumption from the industrial sector made up about 49 thousand mt-CO_2e, or 10% of the total community-wide GHG emissions. Emissions from transportation (gasoline and diesel from surface travel and jet fuel from air travel) resulted in 110 thousand mt-CO_2e or 23% of total community-wide GHG emissions. Finally, key urban materials such as food, cement, fuel production, water, wastewater and solid waste emitted

91 thousand mt-CO_2e or 20% of total community-wide GHG emissions. In 2007, the total emissions from the three sectors totaled 480 thousand mt-CO_2e for the entire Golden community; on a per capita basis, GHG emissions were 27.1 mt-CO_2e/capita.

The City of Golden's 2007 GHG emissions were benchmarked with Aurora, CO; Central City, CO; Denver, CO; the State of Colorado, and national data to show a variety of different per capita emissions by type of jurisdiction. Since all of these areas have different populations and different types of services, GHG emissions can be relatively compared on a per capita basis. The City of Golden emitted 27.1 mt-CO_2e/capita in 2007, the City of Denver emitted 25.3 mt-CO_2e/capita in 2007, the State of Colorado emitted 24.5 mt-CO_2e/capita, the nation emitted 25.2 mt-CO_2e/capita in 2005, while the City of Aurora emitted 15 mt-CO_2e/capita and Central City emitted 123 5 mt-CO_2e/capita. The City of Golden has slightly higher per capita emissions than Denver, the State, the nation and Aurora, and significantly fewer emissions than Central City; as is discussed in this report, this is due to slightly higher vehicular travel and commercial and industrial activity than other jurisdictions.

Without understanding where GHG emissions are coming from within the community, a strategy to reduce them cannot be established. Reducing these emissions will require a combination of personal lifestyle changes as well as help with policies from local governments in combination with the State and National government. As the community continues to strive towards sustainability, it can use greenhouse gas accounting as one way to measure how current and future efforts are progressing. In addition, a few tailored sustainability actions are included in the report, including energy efficiency, a commercial/industrial challenge, as well a home energy meter mandate, to help identify and prioritize high impact actions.

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Abbreviations and Acronyms

CACP	Clean Air Climate Protection software
CDPHE	Colorado Department of Public Health and the Environment
CH_4	Methane
CO_2	Carbon Dioxide
EIA	Energy Information Administration
EPA	Environmental Protection Agency
GHG(s)	Greenhouse Gas(es)
GREET	Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation model
MWh	Mega watt hours
ICLEI	ICLEI-Local Governments for Sustainability
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt hours
LCI	Life Cycle Inventory
LGOP	Local Government Operations Protocol
MSW	Municipal solid waste
mt-CO_2e	Metric tons of carbon dioxide equivalent
N_2O	Nitrous Oxide
NREL	National Renewable Energy Laboratory
P2W	Pump-to-Wheels
UCD	University of Colorado Denver
VMT	Vehicle miles traveled
WARM	WAste Reduction Model
WRI	World Resources Institute
WTP	Wells-to-Pump

1. Introduction to Sustainable Energy Planning

Sustainability is widely understood to encompass the three E's: Economics, Environment and Equity. In the context of the environment, sustainability refers to more efficient use of scarce natural resources such as water, energy and minerals. This includes reducing or avoiding emissions of toxic pollutants such as heavy metals, harmful pesticides, carcinogens, etc. Sustainability entails facilitating human activities that simultaneously promote economic development, environmental protection, and social equity in the present and into the future.

1.1 The Business Case for Sustainable Energy

There has been interest nationally, within the State of Colorado and in several Colorado communities, in developing sustainable energy plans. These plans are motivated by the projected increase in global demand for limited oil and gas resources, the increasing world-wide cost of fossil fuels, our dependence on foreign oil which impacts national energy security, and, our understanding of the global and local environmental impacts of using fossil energy. These impacts include local-scale air pollution from petroleum use in automobiles, which contributes to smog, local scale air pollution from coal-fired power plants, and global impacts of greenhouse gas emissions. The global impacts of greenhouse gas emissions are projected to have local impacts in Colorado, affecting snow pack, water supplies and agriculture. Looking toward a future with increased cost and reduced availability of fossil energy, communities are embarking on sustainable energy plans that save money through energy and resource conservation, generate jobs in the new green energy economy focused on energy efficiency and renewable energy, and promote community-wide economic development.

1.2 Sustainable Energy Planning and Greenhouse Gas Accounting

Since fossil fuel is used for almost all human activities – cooling and heating our buildings, transportation and industrial production – an accounting of GHG emissions, measured as CO_2 equivalent from burning fossil fuel promotes a comprehensive understanding of fossil energy use community-wide. In addition, such GHG accounting is also useful to represent human impact on climate.

1.3 Greenhouse Gases (GHGs)

Measured greenhouse gases (GHGs) include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and three replacements for chlorofluorocarbons (HFCs, PFCs, SF_6). The first three GHGs are dominant and account for more than 98% of GHGs emitted nationally[1]. Carbon dioxide is produced primarily from burning of fossil fuels and is the largest contributor to global warming. Methane is produced largely from waste decomposition (naturally or in landfills),

1 2008 U.S. GHG Inventory, U.S. EPA

enteric fermentation (cattle), and from fugitive emissions in natural gas pipelines. The last three GHGs may be omitted unless significant industrial production of these chemicals is occurring in the region of interest. The various GHGs have different global warming potentials, or ability to trap heat in the atmosphere. In order to compare the emissions from different sources, greenhouse gases are reported together on a common standardized basis as metric tons of carbon dioxide equivalent (mt-CO_2e). Table 1 shows the top three greenhouse gases in the atmosphere and their global warming potentials. Methane has 21 times more potential to trap heat than carbon dioxide while nitrous oxide has 298 times more potential to trap heat.

Table 1: Greenhouse Gases Global Warming Potentials

Greenhouse gas	Chemical Formula	Global Warming Potential
Carbon Dioxide	CO_2	1
Methane	CH_4	21
Nitrous Oxide	N_2O	298

Source: Intergovernmental Panel on Climate Change (IPCC), 2007.

1.4 Developing a Sustainable Energy Plan

A Sustainable Energy Plan for a community includes:

1. Conducting an inventory of CO_2e emissions, to understand fossil fuel use and associated GHG emissions in basic human activity sectors;

2. Developing a matrix of actions that can be taken in each of the sectors to promote energy efficiency, conserve resources, save money and/or create business opportunities while mitigating CO_2e emissions;

3. Choosing and prioritizing among the available action options based on local economics, culture, civic engagement and political support to develop a practical sustainable energy action plan suited for implementation;

4. Developing an implementation plan for the prioritized actions, with outcomes assessment protocols;

5. Re-inventorying emissions and assessing progress into the future.

Some communities are also focusing on adaptation strategies, or planning to adapt to the effects of climate change, i.e. water supply variation, peak oil prices, or other anticipated future trajectories.

2. Background

In December of 2009, the City of Golden contracted with the University of Colorado Denver (UCD), in partnership with the Colorado Municipal League (CML) through a generous donation from Wal-Mart to begin the process of quantifying sustainability. The objectives of the study were to:

- Conduct an inventory of community wide CO_2e emissions, to understand fossil fuel use and associated GHG emissions in the main activity sectors in Golden;

- Develop a matrix of tailored sustainable energy actions that can be taken to promote energy efficiency, conserve resources, save money and/or create business opportunities while mitigating CO_2e emissions;

- Create a simple, self-explanatory worksheet to assist with calculating and tracking metrics to facilitate regular inventory and climate action updates.

2.1 Background on the City of Golden

The historic City of Golden became incorporated in 1871, is a home-ruled municipality, and is the county seat of Jefferson County. Golden lies along Clear Creek at the eastern edge of the foothills of the Front Range of the Rocky Mountains, 20 miles west of Denver and 30 miles west of the Denver International Airport. The City is home to Coors Brewery, CoorsTek, City offices, the Jefferson County Campus, as well as the School of Mines; in addition, Golden is a hub of outdoor and cultural activity. As a result, the City has a lot of commuter and tourism traffic; approximately 2.5 million tourists come to Golden every year. Golden has approximately 9.1 square miles of area and in 2007 had an estimated population of 17,701 with an average growth rate of 0.5% per year. The City enjoys hundreds of acres of City-owned open space and miles of trails for outdoor activities. It also has many public parks and venues for shopping, dining, and entertaining. Golden has close to 23,000 employees working at over 900 businesses focused in professional services and manufacturing as well as Jefferson County Public Schools. Residents of Golden are proud of their community and have strived and succeeded in becoming leaders in sustainability and healthy lifestyle.

3. GHG Inventory Methodology

3.1 Method and Scopes

The GHG inventory is conducted using the advanced method developed by (Ramaswami, et al. 2008). The method uses the standardized Local Governments Operations Protocol (LGOP) (ICLEI v.1 September 2008) to report GHG emissions from in-boundary (within jurisdictional boundary) activities. LGOP provides a protocol for the quantification and reporting of GHG

emissions for communities Scopes 1, 2, and 3. Scope 1 emissions include emissions from in-boundary activities, such as on-site combustion of fuels, Scope 2 emissions are out-of-boundary emissions such as purchased electricity, and Scope 3 emissions includes other "optional" out-of-boundary activities crucial for a community (e.g. water, food, fuels, and shelter). This inclusion of additional out-of-boundary activities (World Resources Institute Scope 3) is highly recommended by EPA's Climate Leaders Program. The inventory method for GHG accounting was first pioneered in 2005 by UCD with the City of Denver, and since then it has been utilized by other communities in Colorado as well as other large national cities such as Portland, OR; Seattle, WA; Arvada, CO; Austin, TX and Minneapolis, MN. (Hillman and Ramaswami 2010).

3.2 In-Boundary Activities

In-boundary activities include the following energy uses and are required to be reported by all jurisdictions as per LGOP and World Resources Institute (WRI) guidelines.

- BUILDINGS ENERGY USE – Use of electricity, natural gas, and steam in residential, commercial and industrial sectors in a community.

- TRANSPORT OPERATIONS ENERGY USE – Includes tailpipe emissions from operating personal and commercial vehicles associated with a community.

- EMISSIONS FROM WASTE DISPOSAL – In LGOP protocol, emissions from waste disposal by residential and commercial sectors are also included in the in-boundary accounting.

Formally, the GHGs emitted directly from burning natural gas in buildings and gasoline/diesel in vehicles are termed Scope 1 emissions by WRI, while CO_2e emissions from power plants outside a jurisdiction's boundaries that produce electricity used within boundaries is termed Scope 2 emissions. Scope 1-2 plus waste emissions are included in the "in-boundary" activities and are required to be reported in a jurisdiction's GHG inventory as per LGOP.

3.3 Out-of-Boundary Activities

Out-of-boundary activities designated by the WRI as Scope 3 are optional, but are highly recommended by the EPA as they can lead to win-win strategies for GHG mitigation. Although a community may report a larger GHG footprint by including Scope 3 emissions, there may also be easier, more cost-effective actions that can be taken to reduce these Scope 3 emissions. The following out-of-boundary activities, when added to in-boundary activities, yield a more holistic account of a community's CO_2e footprint:

- EMBODIED ENERGY OF CRITICAL URBAN MATERIALS: This includes energy use and associated GHG emissions from producing key urban materials such as water, transport fuels, food, and shelter (cement for concrete), necessary to support life in communities.

- AIRLINE TRAVEL: Energy use for airline travel is important as it appears in national and statewide GHG inventories and in personal calculators. At the community-scale, these appear as out-of-boundary emissions, particularly when the airport is outside jurisdictional boundaries (as in the case of Golden).

3.4 Energy Use Sectors and Data

To better communicate a community's overall energy use and GHG emissions, classifying end-use of energy in three different sectors is more useful. In this report, we consistently report energy use and GHG emissions in the following three sectors:

- **Buildings Sector** – Energy use (electricity, natural gas, other fuels) in residential and commercial buildings and industrial facilities.

- **Transport Sector** – Energy (gasoline and diesel) used to operate personal vehicles, commercial trucks and airplanes, termed Pump-to-Wheels (P2W) energy use.

- **Materials and Waste Sector** – Energy use and associated GHG emissions from producing critical urban materials (food, transport fuels, water, cement) and waste disposal.

For energy (or materials use) in each sector, the following data were gathered:

- **Annual Materials of Energy Consumption Data**: Total kWh of electricity consumed annually, total water consumed annually, total natural gas use, etc. The annual Material/Energy Flow Analysis tells us how much is consumed as a community. By benchmarking these consumption data on per person, per household or other metric, the efficiency of the community can be determined.

- **GHG Emissions Factors:** GHG emissions factors represent how much CO_2e is emitted per unit of the product consumed. For example, kg-CO_2e emitted per unit kWh of electricity consumed.

Total emissions are computed as the product of how much is consumed and the GHG emissions per unit of the product consumed. The CO_2e emissions for each sector can be summed to find the total community-wide emissions. In the next section, consumption data and emissions factors for all three sectors are reported and an overall community-wide GHG inventory and footprint is developed.

4. 2007 Community-Wide Energy and GHG Emissions Inventory Analysis

4.1 Reporting year

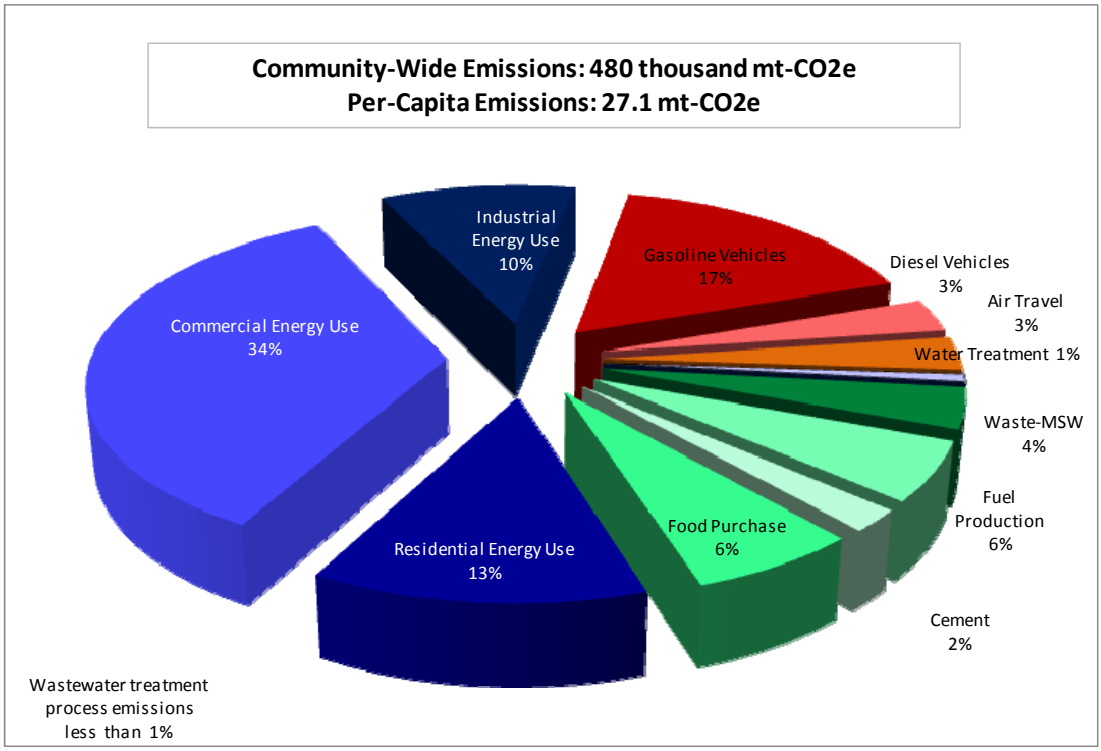
This section reports energy (or materials) consumption data and associated GHG emissions factors for the year 2007, Golden's adopted baseline year, for the three main sectors:

- Buildings
- Transport (tailpipe emissions)
- Materials and Waste

This baseline inventory can be referenced to measure Golden's progress in the coming years. For each sector, raw consumption data are presented, the data are normalized and compared with benchmarking metrics, and emissions factors are quantified. The total GHG emissions from each sector are consolidated and reported as an overall community-wide summary. Emissions are reported in terms of metric tons (mt) of carbon-dioxide equivalent, shown as mt-CO_2e.

The total community-wide greenhouse gas emissions for the City of Golden in 2007 amounted to 480 thousand mt-CO_2e and 27.1 mt-CO_2e/capita. Figure 1 shows the GHG emissions from each source. The following sections explain the calculations and assumptions for each sector.

Figure 1: Results of the City of Golden's 2007 GHG Emissions Inventory



4.2 Buildings Sector

4.2.1 Buildings Energy Consumption and Energy Use Intensity

The buildings sector energy use reports electricity and natural gas consumed in residential, commercial (which also includes public facilities), and industrial facilities. Data were obtained from electricity provider Xcel Energy for 2007. Based on the number of households (7,907) and the square footage of commercial spaces in Golden (obtained from the Assessor's Office) in 2007, energy use intensity can be computed in terms of electricity and natural gas use per home, and kBTU used per commercial/industrial square foot (only reported combined). Calculated energy intensity for buildings in Golden can be benchmarked with energy intensity metrics reported by the Energy Information Administration (EIA) in the Rocky Mountain region, national data, and other communities. The Rocky Mountain region reports an average of 104 kBTU/sf/yr in commercial buildings in 2007 (see Table 7 for benchmarks). Golden's commercial/industrial energy use intensity is 140 kBTU/sf/yr which is higher than State averages (104 kBTU/sf/yr) and also higher than Aurora (117 kBTU/sf/yr), but lower than Denver (179 kBTU/sf/yr) and Central City (231 kBTU/sf/yr). The City of Golden has a high ratio of commercial/industrial to residential electricity (~4, to compare, Denver is ~3); in addition, the average industrial electricity use is 11 GWh from only 6 entities (to compare, Denver ~6.6 GWh). This higher commercial/industrial energy use is important to note and could be a significant area of opportunity for emissions reductions, which will be addressed in the next section of this report. Of course, Central City's energy intensity is the highest as the casinos there make up most of the activity and are very energy intensive.

4.2.2 Emissions from Electricity, Natural Gas, and Propane

The GHG emissions factor for electricity was provided by Xcel Energy as 0.75 kg-CO_2e/kWh and the national default emissions factor for natural gas (which does not generally change according to region) was used as 5.4 kg-CO_2e/therm. These emissions factors are in line with the factors reported by the Environmental Protection Agency (EPA)[2] and the Energy Information Associate (EIA). The total consumption of electricity and natural gas is multiplied by the emissions factors to yield the total GHG emissions for residential, commercial, and industrial buildings, 279 thousand mt-CO_2e. See Table 2 and Figures 2 and 3 for a detailed breakdown of buildings emissions and indicator data.

[2] EPA Clearinghouse for Inventories and Emissions Factors, http://www.epa.gov/ttn/chief/efpac/index.html

Table 2: Summary of 2007 Energy Use and GHG Emissions from Residential Buildings and Commercial Facilities in Golden

A. Residential Energy	**2007**
Total Population	17,701
Total Number of Households	7,907
Total Number of Customers (electricity)	7,374
Total Grid Electricity Used including Windsource (MWh)	54,400
Total grid Electricity used from Windsource (MWh)	1,900
Number of premises buying electricity from Windsource	50
Electricity/household/month (kWh/hh/mo)	615
Total Number of Customers (Natural Gas)	5,677
Total Natural Gas Used (million therms)	4.2
Natural Gas/household/month (therms/hh/mo)	62
Total Residential GHG emissions (thousand mt-CO_2e)	**62.2**
Total Residential per capita GHG emissions (mt-CO_2e per person)	3.5
B. Commercial Energy	
Total Number of Customers (electricity)	1,397
Total Electricity Used including Windsource (MWh)	136,400
Total Electricity Used from Windsource (MWh)	97
Number of premises buying electricity from Windsource	6
Total Natural Gas (million therms)	11.8
Total Public GHG Emissions (thousand mt-CO_2e)	0.7
Total Commercial GHG emissions (thousand mt-CO_2e)	**166.8**
C. Industrial Energy	
Total Number of Customers (electricity)	6
Total Electricity Used (MWh)	65,300
Total Commercial/Industrial Area (million sf)	13.4
Total Industrial GHG emissions (thousand mt-CO_2e)	**50**
Total commercial-industrial energy use per square foot	140
D. Total Buildings and Facilities GHG Emissions (thousand mt-CO2e)	**279**

Data Source: Energy data from Xcel Energy. MWh = Mega Watt-hours of electricity = 1 thousand kWh. Electricity and natural gas use can be combined and represented as kBtu (1 kWh = 3.412 kBtu; 1 therm = 100 kBtu).

Figure 2: Breakdown of Buildings Energy Emissions by Building Type

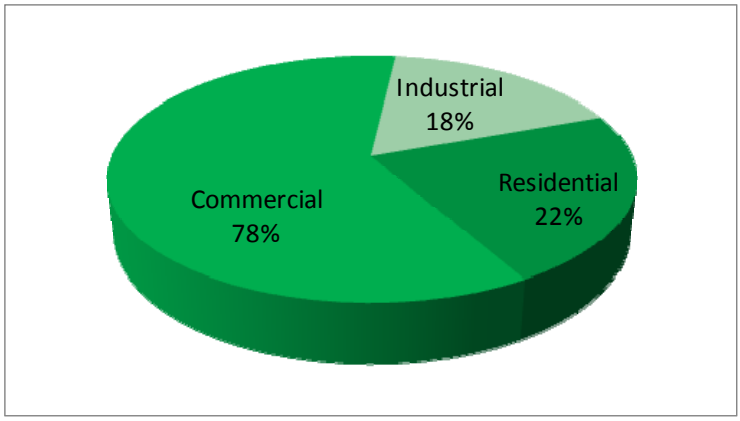
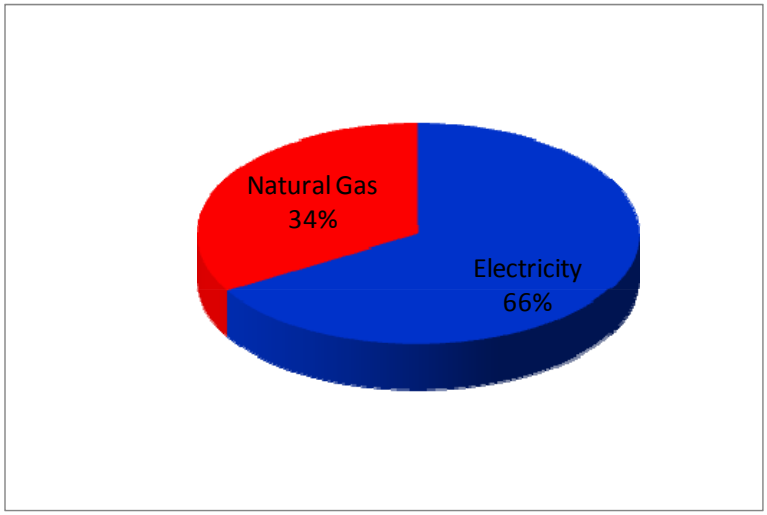


Figure 3: Breakdown of Buildings Energy Emissions by Source



4.3 Transportation Sector

The transportation energy used in 2007 in Golden includes two main modes of transport:

- **Personal and Commercial Motor Vehicles:** Cars and trucks, modeled for Golden through traffic counts and vehicle registration, were used to assign the miles of personal and commercial traffic attributable to Golden[3].

- **Airline Transport:** Energy use associated with jet fuel and fleet operations at the Denver International Airport (DIA) in 2007 attributable to Golden (0.36%).

[3] Mass transit trips were included in the personal and commercial motor vehicle sector.

Summary of the miles traveled, fuel consumed, and GHG emissions for both modes of transport are presented in Table 3.

4.3.1 Surface Travel Miles and Travel Intensity

Annual vehicle miles traveled (VMT) for the City of Golden were computed using the hybrid demand-center life cycle assessment methodology (Ramaswami, et al. 2008) from traffic count modeling (provided by the Colorado School of Mines) and vehicles registered in the City. Consistent with modeling the community as a demand center for travel, the average of those trips that took place on local roads in Golden and vehicles that were registered in Golden was used, amounting to an average of 187 million annual VMT[4].

To calculate VMT, analysis provided by work previously done for the City (by the Colorado School of Mines) were used in combination with a vehicle registration method; for this method, Jefferson County 2007 vehicle registration for vehicles used for personal transport were scaled down to Golden's population and an average miles traveled per vehicle (12,000, from EPA) was used to calculate annual VMT. The average of these methods was taken to account for discrepancies in each of the methods: the traffic count method includes some pass-through trips and the vehicle registration method includes some trips outside of the City. Fuel use (gasoline and diesel) was computed by allocating the annual VMT to an average State of Colorado Vehicle mix as reported by the Colorado Department of Public Health and the Environment (CDPHE); 95% gasoline-powered cars and 5% diesel-fueled vehicles, with average fuel economies as reported by CDPHE. Fuel consumption was computed by dividing the total annual VMT by the average fuel economy, and resulted in 95 mt-CO_2e (see Table 3).

The VMT intensity is the total annual VMT allocated to Golden per resident of Golden. VMT intensity was determined by dividing Golden's annual VMT by the 2007 population. Normalizing the total annual VMT results for personal and commercial vehicles per Golden resident allowed the data to be compared with national and other transportation data. State data for 2005 yielded 25 VMT/person/day, 25 VMT/person/day for Denver (2007), and 15 VMT/person/day for Aurora (2007), all slightly lower than the 31 VMT/person/day for Golden (2007), demonstrating that the daily VMT/person in Golden are not directly comparable with travel behaviors observed regionally and statewide.[5] Since the City of Golden has high employment intensity, or the ratio of employment to population (~1.2, compared with Denver, ~0.86), this means that more people are commuting to Golden than are living there which results in higher VMT. This makes sense based on the result from the previous section that there is a high ratio of commercial/industrial energy use to residential energy use. To compare

[4] Average daily surface VMT is based on average weekday travel. Annual VMT was determined by multiplying the daily surface VMT by 342 in order to normalize the data for yearly travel that includes weekends and holidays.

[5] Per person normalization distributes total miles equally across total population. This method does not correlate exactly with vehicle miles traveled per vehicle.

this to another community, the Denver Tech Center (Greenwood Village) which is made up of almost all commuters, has the highest employment intensity, at ~3.6.

4.3.2 Air Travel

Energy use associated with jet fuel and fleet operations at DIA in 2007 was allocated to Golden using a population ratio (City of Golden/Denver-Aurora MSA). From this model, Golden's regional ratio was determined to be 0.36%. In 2007, 423 million gallons of jet fuel were consumed at DIA and 24 million passengers were enplaned, of which, 0.36%, or 1.5 million gallons and 86 thousand passengers were attributable to the City of Golden.

4.3.3 Emissions from Diesel, Gasoline and Jet Fuel

Diesel, gasoline, and jet fuel emissions factors were obtained from The Climate Registry (TCR). The following emissions factors were used to calculate total transportation emissions: 9.1 kg-CO_2/gallon for gasoline fuel, 10.2 kg-CO_2/gallon for diesel fuel and 9.9 kg-CO_2/gallon for jet fuel (TCR, 2008). The emissions factors for transportation fuels were multiplied by the total fuel consumption for gasoline, diesel, and jet fuel. The City of Golden emitted 110 thousand mt-CO_2e from transportation. Detailed breakdown of emissions sources and associated emissions are provided in Table 3 and Figure 4.

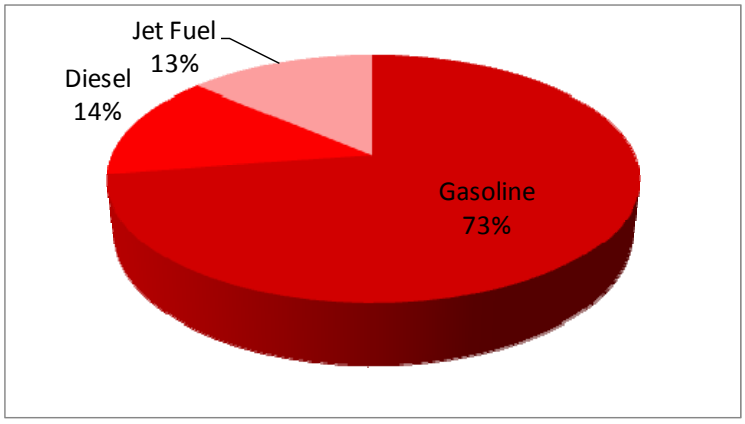
Table 3: Transport Distances, Fuel use and GHG Emissions by Modes of Transport in Golden

A. Personal & Commercial Motor Vehicles	**2007**
Annual Vehicle Miles Traveled (million VMT)	187
VMT/person/day*	31
Annual Fuel Use	
Gasoline (million gallons)	80
Diesel (million gallons)	15
Total GHG Emissions from Personal and Commercial Motor Vehicle Transport (thousand mt-CO_2e)	**95**
B. Airline Travel (0.36% allocation to Golden)	
Annual Fuel Use	
Jet Fuel (million gallons)	15
Total GHG Emissions from Airline Travel Allocated to Golden (thousand mt-CO_2e)	15
C. Total GHG Emissions from Transportation Sector (thousand mt-CO_2e)	**110**

Data Source: VMT for personal-commercial vehicles obtained from UCD analysis with Golden as a demand center (from School of Mines traffic study and Colorado Department of Revenue for vehicle registrations). Vehicle loading and fuel economy data from CDPHE to calculate VMT and fuel use.
Data Source: Fuel data for Airport operations provided by DIA.

*Miles traveled are normalized to Golden's entire population, including children, and therefore do not reflect actual average travel distances per driver or air traveler.

Figure 4: Breakdown of Transportation Emissions by Fuel Type



4.4 Materials and Waste Sector

The materials sector comprises several sources of GHG emissions including cement, water and wastewater, fuel production, food production, and municipal solid waste (MSW).

4.4.1 Sources for Annual Consumption of Key Materials

Consumption of transportation fuels was determined from travel demand computations as summarized in Table 3 and used to determine the emissions for producing the fuel. The consumption of food was tracked in terms of average money spent on food expenditures annually as obtained from the 2007 National Consumer Expenditure Survey[6]. For cement, state average cement use per person from Consumer Expenditure Surveys for the State of Colorado was used. Water flow data were obtained from the City of Golden, with 1.2 billion gallons treated annually at the Water Treatment Plant. Wastewater treatment data were attained from Coors Brewery, as this facility treats Golden's wastewater; only population served numbers were provided to estimate emissions from wastewater based on default values (no energy data were provided). Municipal solid waste and recycling estimates for Golden were estimated from State averages from the CDPHE.

4.4.2 Emissions from Well-to-Pump

The GHG emissions factors for producing transport fuels were obtained from GREET Well-To-Pump (WTP) analysis (Argonne National Laboratory 2007) as 2.3 kg-CO_2e/gallon for gasoline, diesel, and jet fuel. Golden emitted 20 thousand mt-CO_2e from gasoline fuel production, 3.4 thousand mt-CO_2e from diesel fuel production, and 3.5 thousand mt-CO_2e from jet fuel production.

[6] 2007 data available from the national BLS Consumer Expenditure Survey: http://www.bls.gov/cex/

4.4.3 Water and Wastewater Emissions

In 2007 the City of Golden treated a total of 1.2 billion gallons of water. The electricity and natural gas used to clean and transport this water amounted to 3.2 thousand mt-CO_2e; these energy data were provided by the City and was subtracted from total commercial energy data from Xcel.

According to LGOP, depending on the way a jurisdiction treats its wastewater, there can be stationary emissions (methane), process emissions (nitrous oxide), and fugitive emissions (methane). Since Golden's wastewater treatment plant (at Coors Brewery) does not use a lagoon for treatment, and the City does not have a septic system, minimal methane and nitrogen emissions from processing wastewater are included in the inventory. Table 4 describes the wastewater treatment emissions allocations in more detail.

Table 4: 2007 GHG Emissions from Golden Wastewater Treatment Plant

Emissions	**Value**
Population served by the wastewater treatment plant	17,300 people
Stationary CH_4 emissions from the incomplete combustion of digester gas at the centralized treatment plant	19.2 mt-CO_2e
Process N_2O emissions from a treatment plant without a nitrification/denitrification system	16.5 mt-CO_2e
Process N_2O emissions from effluent discharge to environment	7.4 mt-CO_2e
Total	**43 mt-CO_2e**

4.4.4 Cement in Concrete Emissions

Cement is included in GHG inventories because in order for a community to function, it imports large amounts of cement for new construction, remodels, etc. Producing cement emits about 1-mt-CO_2e for every 1 mt-cement. When cement is made, the reaction with the limestone produces carbon dioxide, which causes the emissions factor to approach one-to-one when factoring in transportation of the material. Depending on the size of a community, cement can comprise about 3% of total GHG emissions and is important to include in the inventory. The flow of cement was determined based upon financial data collected from the 2007 Colorado Census Data[7] for the State. The per capita cement use for Golden was determined by multiplying the total expenditure of cement products in Colorado by the cost of cement per kilogram ($/2.32kg), and then allocating the kilograms of cement to the Golden population by taking the proportion of the total Colorado population. The emissions factor for cement is about

[7] http://www.census.gov/econ/census02/data/metro1/M1974031.HTM#N327

1 mt-CO_2e/mt-cement from the National Renewable Energy Laboratory's (NREL) Life Cycle Inventory Database (LCI)[8]. In 2007, Golden emitted 10 thousand mt-CO_2e from cement.

4.4.5 Food Consumption Emissions

Food is another product that is usually not produced within City limits and is brought in from thousands of miles away. The embodied energy from food and food packaging was determined from "food consumed at home" for the City of Golden. Food expenditure estimates were derived from the 2007 Census information published in the Consumer Expenditure Survey[9] on a national per-household and per-person basis. Average food expenditures were $6,004 per household per year or about $2,682 per person per year, and the total estimate for Golden is $21.2 million (all figures are in 1997-$ in order to use the Carnegie-Mellon 2009 Economic Input-Output model). The emissions factor for food is 1.5 kg-CO_2e/1997-$, and total GHG emissions from food production in Golden in 2007 were 31.8 thousand mt-CO_2e.

4.4.6 Municipal Waste Emissions and Recycling

Since the City of Golden does not (yet) have a centralized solid waste collection service, estimating the amount of solid waste sent to landfills from Golden was impossible; state average waste data was used instead. Scaling down total MSW numbers for Colorado to Golden in 2007, the City sent about 29,000 tons of solid waste to landfill; recycling data were not provided.

The EPA has developed a Waste Reduction Model (WARM)[10] to aid jurisdictions and other organizations in calculating the emissions associated with solid waste and recycling. The emissions from solid waste are a result of the anaerobic breakdown of biodegradable material such as food waste, grass clippings, and paper. When such items are disposed of in landfills, methane emissions are produced. Based on the EPA's WARM Model, 29,000 short tons of solid waste were disposed of in a landfill (that does not flare the methane) which produced 19 thousand mt-CO_2e.

4.4.7 Total Urban Materials and Waste Emissions

Total emissions sources and associated emissions from fuel production, water, wastewater, cement, food production, and municipal solid waste are shown in Table 5 and in Figure 5.

[8] http://www.nrel.gov/lci/database/default.asp

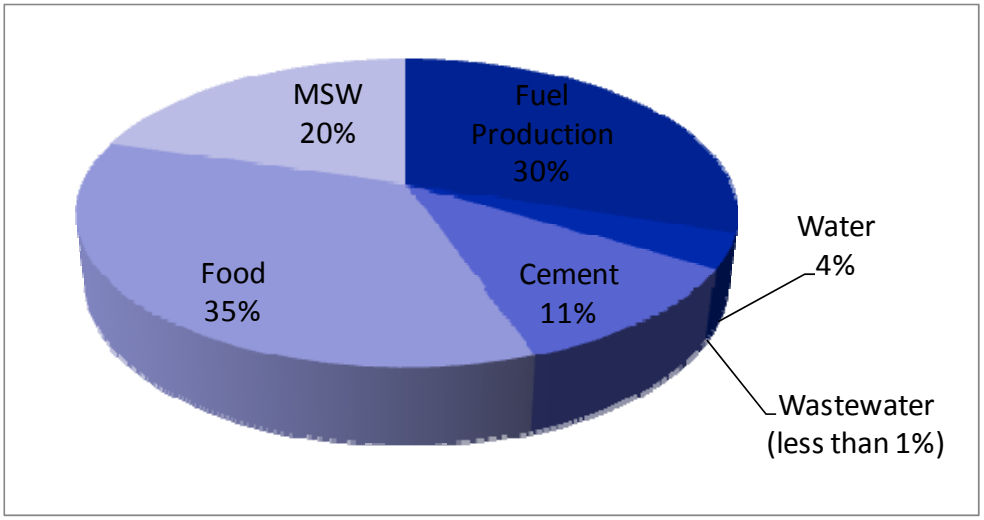
[9] http://www.bls.gov/data

[10] http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

Table 5: 2007 GHG Emissions from Manufacture of Key Urban Materials and Solid Waste in Golden

Material	Annual Material Flow	GHG Emissions (thousand mt-CO_2e)
Fuel Production (WTP for all fuels)		
Gasoline (million gallons)	11.8	27.2
Diesel (million gallons)	8.8	20.2
Jet fuel (million gallons)	1.5	3.4
Water (million gallons)	1,285	3.3
Wastewater Treated (million gallons)	N/A	
Wastewater-Stationary Methane Emissions (mt-CH_4)	-	0.02
Wastewater-Process Nitrous Oxide Emissions (mt-N_2O)	-	0.02
Cement in Urban Concrete (thousand mt)	10	10
Food & Packaging ($ million)	$21.2	31.8
Municipal Solid Waste (thousand tons/year)	29	18.5
Total GHG Emissions for Producing Key Urban Materials		**91**

Figure 5: Breakdown of Materials and Waste Emissions



4.5 Community-Wide and Per Capita GHG Emissions Footprint

Table 6 presents a comprehensive tally of GHG emissions from the buildings, transportation,

and materials and waste sectors. The table includes materials flows, select tracking metrics (in parenthesis after consumption figures), emissions factors, as well as the total GHG emissions. Total community-wide emissions for the City of Golden in 2007 were 480 thousand mt-CO_2e. The per-capita emissions (for a population of 17,701) were 27.1 mt-CO_2e/person.

Table 6: Comprehensive Scopes 1-2-3 2007 GHG Emissions for Golden [11]

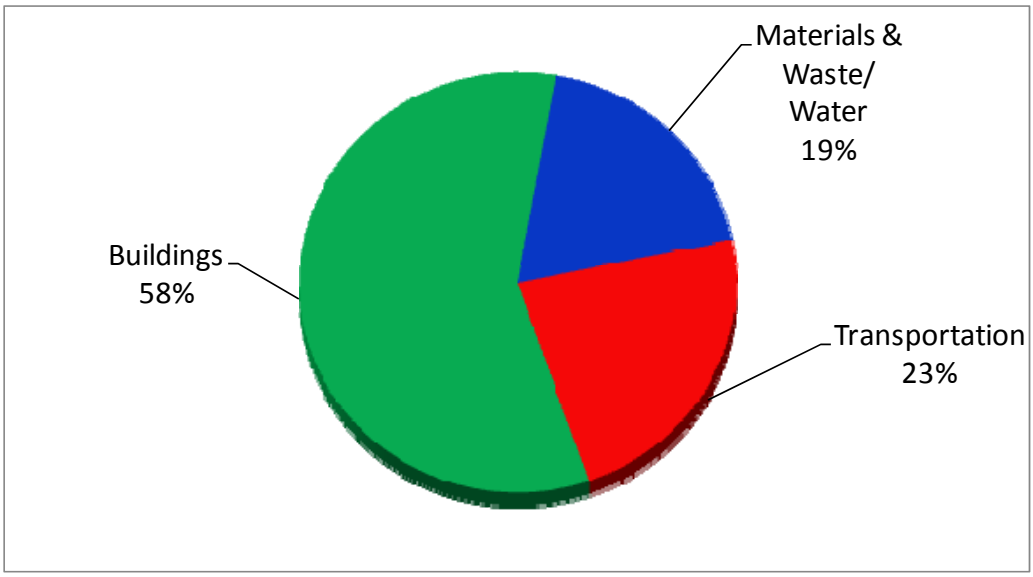
	Sector/use	Community-wide 2007 urban material/energy flows (MFA)		GHG emissions factors (EF)	Total GHG emitted = MFA x EF (thousand mt-CO_2e)
Scopes 1 & 2 plus waste	Buildings Electricity Use	255 GWh (615 kWh/hh/mo)		0.75 kg CO_2e/kWh	**192**
	Buildings Natural Gas	16 million therms (62 therms/hh/mo)		5.4 kg-CO_2e/therm	**87**
	Surface Vehicle Miles Traveled (VMT)	187	million VMT	9.1 kg-CO_2e/gal Gasoline PTW	**95**
		Average Fuel Economy = 20.1 mpg (gasoline), 6.3 mpg (diesel) (CDPHE)		10.2 kg-CO_2e/gal Diesel PTW	
	Water*	1,285	Million gallons	Varies	**3**
	Municipal Solid Waste	29,027	short tons/yr	0.64 mt-CO_2e/short ton (landfill w/flaring)	**19**
Scope 3	Airline Travel (PTW)	1,523	Jet Fuel (million gallons)	9.9 kg-CO_2e/gal Jet fuel PTP	**15**
	Fuel Production (WTP)	2	Jet Fuel (million gallons)	2.3 kg-CO_2e/gal Jet fuel WTP	**27**
		1.5	Diesel (million gallons)	2.3 kg-CO_2e/gal Diesel WTP	
		8.8	Gasoline (million gallons)	2.3 kg-CO_2e/gal Gasoline WTP	
	Cement Use	10.153	Mt-cement	1 mt-CO_2e per mt-cement	**10**
	Food Purchases	$21,207	Million (1997-$)	1.5 kg-CO_2e/$ (1997 $)	**32**
Total 2007 Community Wide Emissions:				**480**	**thousand mt-CO_2e**
Community wide per-capita emissions:				**27.1**	**mt-CO_2e per capita**

[11] Table is adapted from Ramaswami et al., 2008; numbers may be off due to rounding.

*Wastewater process emissions amount to 43 mt-C02e.

Table 6 demonstrates the simple method of multiplying the material flow by the emissions factor of carbon dioxide equivalence per unit of production. By summing the emissions in each sector the total community-wide GHG emissions can be determined. The per capita emissions were found by dividing total emissions by the 2007 Golden population. Finding the per capita emissions is beneficial to compare the City's emissions across cities, states, and nations. The sum of Scopes 1, 2, and 3 yield a GHG footprint, while Scopes 1 and 2 only yield a boundary-limited inventory. In the case of Golden, Scope 3 emissions accounted for about 20% of the total GHG emissions as seen in Figure 2. Including Scope 3 emissions allows for more innovative policies and solutions to reduce greenhouse gas emissions. See Figure 6 for a breakdown of emissions by sector.

Figure 6: GHG Emissions by Sector



4.6 Benchmarking

While determining the total emissions in a community may be important for tracking reduction progress, it is important to benchmark several descriptions of consumption to compare with other cities, states, and nations. Golden was benchmarked next to Colorado State, Denver CO, Central City, CO, and Aurora, CO in several consumption averages (see Table 7).

Table 7: Benchmarks

Description of Benchmark	CO State (2007)	Denver, CO (2007)	Central City, CO (2007)	Aurora, CO (2007)	Golden, CO (2007)	Units of measurement
Avg. Res. Electricity use	674	528	627	614	615	kWh/hh/mo
Avg. Res. Natural gas use	47	65	69	47	62	therms/hh/mo
Avg. Comm/ Ind./ Pub. Buildings Energy Use Intensity	104*	179	231	117	140	Kbtu/ft^2/year
Vehicle Miles per person per day	24.5	25	235	15	31	VMT/person/day
GHG Emissions	**24.5**	**25**	**123**	**15**	**27**	**Mt-CO_2e/person/year**

5. Inventory Conclusion

The GHG inventory portion of this report is meant to serve as a baseline inventory of the emissions in the City of Golden in 2007. The technical data in the report will also be used to provide the City with background information on the current emissions from activity in Golden. The City can use some of this information, along with current and proposed climate actions developed by the University of Colorado Denver's Center for Infrastructure Systems (see next section), to propose policies and actions for City Council to adopt in a Sustainability Plan. As the City of Golden continues to pursue a direction towards a sustainable community, the City can continually update the greenhouse gas emissions inventory report to track the progress the community has made in reducing its greenhouse gas emissions.

6. Sustainability Energy Actions

This section of the report addresses actions that the City of Golden can take to increase sustainability in the community and leverage multiple economic, environmental, and health benefits. The strategies proposed include many of the City of Golden's previously adopted sustainability goals and additional related actions that are either cost effective, politically feasible, and/or could be implemented in a reasonable time frame. This work is a result of numerous conversations with the City about which actions make the most sense for the City, and how to prioritize these actions against other existing actions and current goals.

Background on Current Golden Goals and Actions

As part of a City-wide effort to create a more environmentally sustainable community, the City of Golden established a Sustainability Advisory Board (SAB) in December 2007. Input from citizens, the SAB, and City government officials helped identify seven sustainability goals and thirteen priority areas. Golden's sustainability goals over the next 10 years (Resolution 1793) and priorities are outlined below, support the goal of 20% reduction in 2007 baseline GHG emissions inventory (as calculated in this report, and in-line with the State's goals) by 2017.

Golden's Sustainability Goals:

- *Buildings:* Improving the energy efficiency and reducing the environmental impact of new and existing buildings in Golden (90% of all new buildings and 50% of remodels are built to green building standards, revise land use code).
- *Economic Health:* Increasing business opportunities focused on energy efficiency and renewable energy and reducing the energy costs of all Golden businesses.
- *Community Awareness:* Encouraging community awareness and encouraging commitment to actively take part in sustainability as a public value that supports cultural, economic, and environmental health for all citizens.
- *Energy:* Increasing the community's energy efficiency and use of renewable sources of energy (reduce community energy use by 20% and increase use of renewable by 20%).
- *Waste:* Reducing solid waste stream contribution through expanded use of recycling programs, waste diversion programs, and other tools (reduce solid waste stream by 25%).
- *Transportation:* Increasing the ability of Golden residents and visitors to travel to and through Golden using alternative transportation (decrease VMT by 15%).
- *Water:* Ensuring that Golden sustains a clean, stable water supply into the future (reduce per-capita usage by 15% in 5 years).

Golden's Sustainability Priorities:

- Initiate an educational / promotional campaign for reducing solid waste, energy reduction (promote CFL use), alternative transportation and water consumption.

- Undertake a feasibility study of larger renewable energy projects that will result in more meaningful renewable energy production levels.
- Develop branding for a common look and feel for all sustainability efforts.
- Adopt LEED silver standards on all new City construction and implement U.S. Green Building Council's LEED EB (Leadership in Energy and Environmental Design for Existing Buildings) for all City renovations.
- Participate in the Insulate Colorado program.
- Establish incentives and education for energy audits.
- Waive all solar fees in the City, investigate decreasing other fees, and investigate other avenues to create incentives favoring sustainable projects.
- Adopt new building code changes for commercial and residential buildings that promote green construction.
- Work with Planning Commission to identify potential building code amendments to promote sustainability.
- Create a program to assist low or zero waste events.
- Establish recycling options in downtown and all city parks.
- Identify need and potential location for bike storage and lockers (at 10th and Washington bus stop for example).
- Establish a working group of citizens to help establish a community garden.

Understanding the Following Pages

Each of the following pages contains a strategy for mitigating GHG emissions. Actions are either voluntary, market-based, or mandate. These strategies are ranked by three criteria: The amount of GHG emissions reduced (the globe), the initial cost (the dollar sign), and the time it will take to pay it back (the clock). Each globe represents a savings of 1,000 metric tons of CO_2e per year, and each clock represents one year. Initial costs vary greatly so each dollar sign doesn't represent a specific dollar amount, but the pictures should give you a general idea of the overall cost of implementing each strategy.

 = Community GHG Mitigated (1,000 mt-CO_2e)

 = Low Initial Cost Per Unit (Less than $100)

 = Medium Initial Cost Per Unit (Less than $1,000)

 = High Initial Cost Per Unit (More than $5,000)

 = Payback Time (1 year)

Actions Rationale and Assumptions

As mentioned in the inventory section of this report, commercial and industrial energy make up close to half of the GHG emissions, with only 6 industrial consumers contributing 10% of total GHG emissions from energy use. Including residential energy use brings the total to almost 60% of total GHG emissions; with this in mind, the majority of the proposed actions are large impact actions that target the buildings sector, and in particular, commercial and industrial energy use.

There are a few overall assumptions for the actions analysis. First, actions are analyzed in terms of reductions in GHG emissions by 2017, a target year for the City of Golden. Second, 0.5% annual population growth (obtained from the City) is applied to all sector growth from 2007-2017 (the business as usual emissions forecast, or BAU). Second, the emissions factors for 2017 Xcel Energy electricity consumption (2007) is decreased by 20% due to the new renewable portfolio standard (RPS - 30% by 2030, so almost 20% by 2017 is assumed).

Renewable Portfolio Standard: Emissions decreases from State policy

In addition to local action, reductions in GHG emissions can be also attributed to requirements put on utility providers to use a certain percentage of renewable energy sources. In Colorado these standards require Xcel Energy to use 30% renewables by 2030. As mentioned previously, the following actions assume that Xcel will be on track to meet these requirements by 2017 and a 20% decreased emissions factor (0.63 kg CO_2e/kWh) is used in 2017 projections. This policy alone reduces total GHG emissions by 7% from the BAU GHG emissions forecast and is an example of how the greatest reductions can be achieved with combined action at the State, national, and local levels.

6.1. Residential Sector

Purchasing Residential WindSource Energy (voluntary)

Xcel Energy, the energy provider for the City of Golden, offers a WindSource program wherein consumers opt to pay a small amount more for their electricity ($2 per 100 kWh) and Xcel guarantees that the funds will be used to purchase electricity from providers who use wind turbines. The program is certified by a third-party organization, and since the emissions factor for wind is zero, any electricity from wind has zero emissions.

In 2007 residential customers in Golden purchased 1.9 GWh of Windsource® electricity, or 3.7% of total electricity purchased. Potential GHG emissions reductions were calculated based on increasing Windsource® purchases to 10% increase in 2017. As a precedent, the City of Denver increased WindSource purchases by 60% from 2005

to 2007. Avoided GHG emissions from this action would be 3,490 mt- CO_2e, or a 0.7% decrease in total GHG emissions in 2017.

Total cost for this action to consumers would be $2 in incremental cost per 100 kWh of electricity from WindSource, or about $14/month/household (for 10% households). The cost effectiveness of this action is $31/mt- CO_2e.

Greenhouse Gas Reduction
1 globe = 1,000 mt-CO_2e/year

Initial Cost
1 dollar sign (less than $100/unit) to 3 dollar signs (more than $5,000/unit)

Payback Period
1 clock = 1 year

None!

Residential Demand-Side Management (voluntary-energy efficiency)

Demand-Side Management (DSM) is a program that has gained acceptance as more communities work with their utilities toward increasing energy efficiency. The fundamentals of DSM are that private regulated utilities (in this case, Xcel Energy) are required by the Public Utilities Commission (the regulatory agency) to invest a fraction of annual revenue into energy efficiency installations, resulting in annual energy savings. Typical investments into DSM programs across the nation are three percent, while the energy savings from those investments are one percent; the lifetime of the measures installed is typically eight to eleven years (SWEEP, 2008). A few examples of residential natural gas programs include energy audits, insulate and seal, CFL distribution, water heater and boiler upgrades, low-flow shower heads, etc.

In order to estimate the potential from DSM for natural gas in Golden (natural gas use is most energy-intensive in homes as 75% goes to heating), State-wide Xcel Energy natural gas DSM

annual expenditure goals and savings (based on a percentage of their expenditure target) are extended out to 2017 and scaled down to Golden residential natural gas demand (0.3% of total Xcel natural gas demand). Golden's proportion of Xcel's natural gas DSM goal for 2020 are about a 1.2% reduction in natural gas use, compared to Golden's goal of a 20% reduction by 2017. To be more conservative, we assumed a reduction of 5% in natural gas use (quadrupling Golden's DSM savings proportion) which resulted in a reduction of 1,193 mt-CO_2e in 2017, or 0.2% of total GHG emissions.

Cost effectiveness = $72/mt-$CO_2$e (cost to Xcel, does not include rebates to consumers, etc.)

Greenhouse Gas Reduction
1 globe = 1,000 mt-CO_2e/year

Initial Cost
1 dollar sign (less than $100/unit) to 3 dollar signs (more than $5,000/unit)
Depends on costs and rebates of technology or program implemented

Payback Period
1 clock = 1 year
Depends on technology or program implemented

Home Energy Meters (mandate)

This is a mandate for all residences to install Home Energy Meters, or Visible Energy Information Meters. The visible meter helps consumers to monitor use in real time, in turn, causing behavioral change by reducing electricity use; case studies have shown it can reduce emissions by 10-15% per household per month. The goal is a one hundred percent mandatory adoption of these meters for all homes in Golden. If this goal could be achieved by 2017, it would reduce GHG emissions by 3,617 mt-CO_2e or 0.8% of total GHG emissions.

Cost Effectiveness: $30/ mt-CO2e

Greenhouse Gas Reduction
1 globe = 1,000 mt-CO_2e/year

Initial Cost
1 dollar sign (less than $100/unit) to 3 dollar signs (more than $5,000/unit)

Payback Period
1 clock = 1 year

6.2. Commercial Sector

Commercial/Industrial Awards Program (voluntary)

As was pointed out in the inventory section of this report, the commercial and industrial sectors are the largest contributors to GHG emissions and thus have the largest opportunity for reductions.

A commercial/industrial awards program is a good way to incentivize businesses and industry to participate in energy and emissions reductions programs they wouldn't normally participate in. The three programs recommended in this overall award program include: increasing Windsource participation/purchases, increasing Xcel DSM program participation (energy efficiency), and finally, expanding commuter benefits by participation in the "Best Workplaces for Commuters" program. Documentation of carbon mitigation that occurs via the above pathways will be established for annual corporate competitions and awards.

Windsource
Similar to the Residential Windsource, the Commercial Windsource program is offered by Xcel Energy as a way for commercial consumers to voluntarily purchase energy from zero emissions wind sources. In 2007, commercial customers in Golden purchased 97 MWh of Windsource®

electricity. Potential GHG savings were calculated based on increasing participation in Windsource® from 0.5% to 10% in 2017 (with 50% participation, so ~5%). If this goal is met, GHG emissions would be reduced by 6,773 mt-CO_2e, or 1.4% of total GHG emissions.

Cost Effectiveness: $31/ mt-CO2e

Greenhouse Gas Reduction
1 globe = 1,000 mt-CO_2e/year

Initial Cost
1 dollar sign (less than $100/unit) to 3 dollar signs (more than $5,000/unit)

Payback Period
1 clock = 1 year

None!

Demand-Side Management (energy efficiency)

Similar to Residential DSM, Xcel Energy also offers numerous commercial/industrial energy efficiency programs that businesses and industry can adopt to reduce electricity (the largest contributor to GHG emissions from commercial and industrial customers). A few examples of commercial/industrial electricity programs include energy audits, insulate and seal, HVAC and lighting upgrades, etc.

In order to estimate the potential from DSM for commercial/industrial electricity in Golden, State-wide Xcel Energy electricity DSM projected expenditure goals and savings for 2020 were scaled down to Golden commercial/industrial demand (1.3% of total Xcel commercial/industrial electricity demand). Golden's proportion of Xcel's DSM goals for 2020 are equivalent to about a 6.5% reduction in electricity, compared to Golden's goal of a 20% reduction by 2017. Although this is an aggressive goal, because there are 6 industries that emit 10% of total GHG emissions alone (all from electricity), Golden can target these entities immediately, as well as other commercial businesses in the City. If a 20% electricity reduction were attained by 2017, this would result in a GHG emissions reduction of 26,933 mt-CO_2e in 2017, or 5.6% of total Golden GHG emissions.

Cost effectiveness: $40/mt-$CO_2$e (cost to Xcel, does not include rebates to consumers etc)

Greenhouse Gas Reduction
1 globe = 1,000 mt-CO_2e/year

Initial Cost
1 dollar sign (less than $100/unit) to 3 dollar signs (more than $5,000/unit)
Depends on costs and rebates of technology or program implemented

Payback Period
1 clock = 1 year
Depends on technology or program implemented

Best Workplaces for Commuters

Best Workplaces for Commuters (BWFC) is a program initiated by the Department of Transportation and the U.S. EPA and is now run by the National Center for Transit Research at the University of San Francisco. The program is a membership recognition program that outlines guidelines for recognition including: 1 primary and 3 supporting commuting benefits (such as free or low cost bus passes and vanpool fares and strong telework programs); the entity receives recognition through this program if they meet these requirements and have 14% of employees commuting by another method other than driving alone within 18 months.

Currently, the City of Golden has zero entities enrolled in this program. However, if Golden could engage the top three employers – Coors Brewery, Jefferson County, and CoorsTek, this would automatically enroll 7,500 employees in the program. According to previous evaluations done by the BWFC, each employee enrolled decreases emissions by 0.5 mt-CO_2e. If the top three employers in Golden joined and were recognized in this program by 2017 (or some combination of employers that resulted in a similar amount of employees enrolled), this would decrease emissions by 3,750 mt-CO_2e or 0.8% of total GHG emissions.

Cost Effectiveness: $10/ mt-CO2e

Greenhouse Gas Reduction
1 globe = 1,000 mt-CO_2e/year

Initial Cost
1 dollar sign (less than $100/unit) to 3 dollar signs (more than $5,000/unit)
Depends on number of employees enrolled and type of commuter benefits

Payback Period
1 clock = 1 year
Depends on number of employees enrolled and type of commuter benefits

6.3. Transportation Sector

The burning of gasoline and diesel fuel for personal transportation makes up over 20% of the City's GHG emissions inventory. The new light rail and FasTracks expansion will aid the City of Golden in cutting down on emissions from vehicular travel, however this is a difficult area to address. An effective idea to reduce traffic, emissions, and improve air quality is outlined below.

Individualized Travel Marketing Program (voluntary)

An individualized travel marketing program is when someone goes around to homes and gives personal advice on transportation options; to start, residents get a free one month transit pass and from there they help outline a personal plan to alleviate commuting alone every day, as most people do. A successful pilot study was performed in Perth, Australia by Socialdata which found that this strategy reduced VMT by 10-15% per household.

Taking into account an annual 0.5% growth in households to 2017 (which is equivalent to an increase of ~400 households), if VMT was reduced by 10% in every household (Golden's goal is a 15% reduction in VMT – 10% is a conservative estimate), this would reduce GHG emissions by 8,022 mt-CO_2e, or 1.7% of total GHG emissions.

Total costs to City would be around $44/household, or the price of a transit pass

Cost Effectiveness: $45/ mt-CO2e

Greenhouse Gas Reduction
1 globe = 1,000 mt-CO_2e/year

Initial Cost
1 dollar sign (less than $100/unit) to 3 dollar signs (more than $5,000/unit)

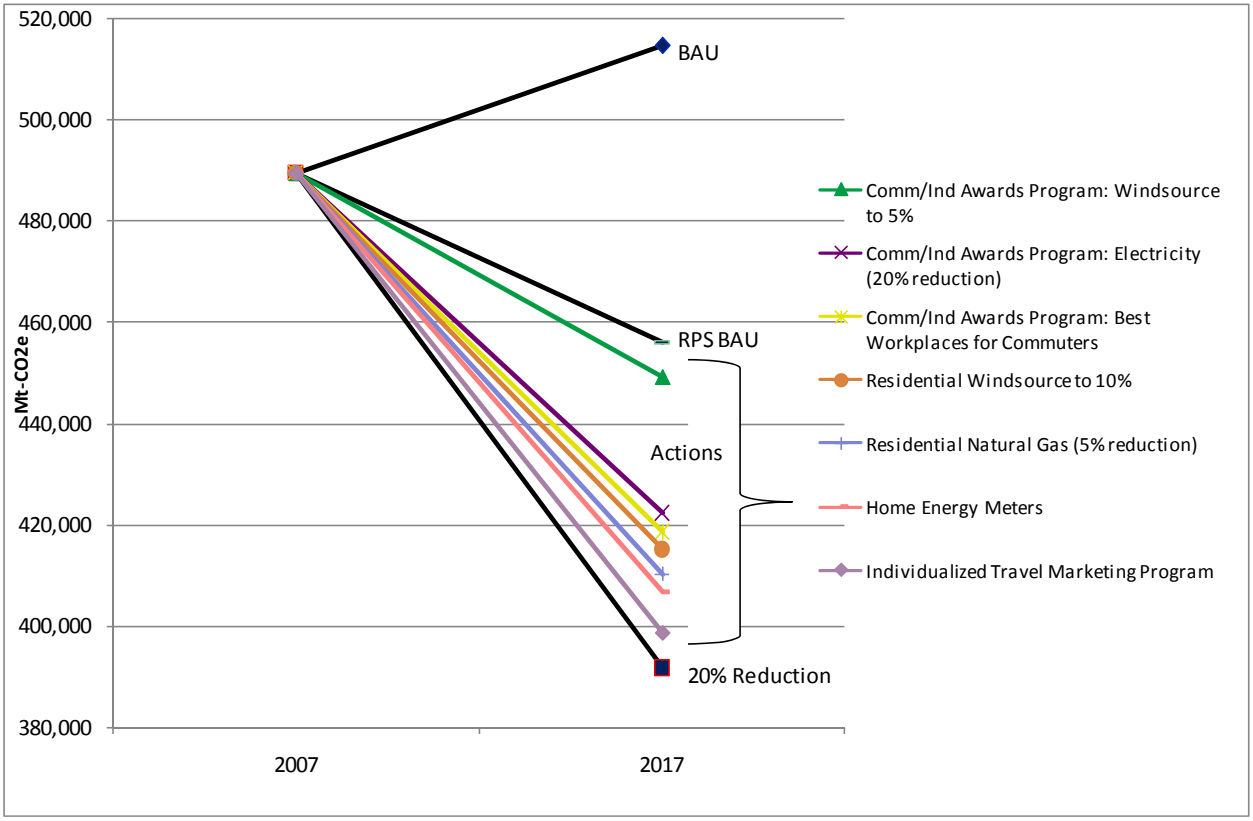
Payback Period
1 clock = 1 year
Varies

Summary of Greenhouse Gas Emissions Reductions and Recommendations

The purpose of this section of the report was to analyze high impact actions and provide the City of Golden with a few strategies that are feasible to consider while also being in line with previously established goals. To summarize, the GHG emissions inventory breakdown is as follows: buildings - 57%, transportation – 23%, materials and waste – 20%. The GHG emissions inventory made it clear where there are opportunities for actions that will have large outcomes; in this case, the commercial and industrial building sector. Of course, looking at the other sectors is also important and smaller actions can certainly add up to a larger sum.

Figure 7 provides a graphic summary of the actions described above and the associated GHG emissions reductions. As you can see, the RPS standard (7% reduction) and the commercial/industrial challenge (8%) were a large part of the overall percent reduction if all actions were implemented (18%); residential actions and transportation actions each added up to about 2% of total GHG emissions reductions. Looking at emissions reductions in this way allows us to compare the magnitude of each action and, along with cost and other indicators, helps the City to prioritize actions.

Figure 7: GHG Emissions Reduction Wedge



It is also worth noting that there is no silver bullet action, as a portfolio of strategies are needed to achieve savings anywhere close to the Colorado Climate Action Plan goal (20% emission reductions by 2020 from 2005 levels) and the various Golden Sustainability Goals. While some of the largest reductions may occur due to changes in the energy grid (i.e. the Renewable Portfolio Standard), additional measures will be needed, and individual and community-wide interest in the implementation of the proposed actions is critical. A compelling story on Golden saving money, improving energy security, creating new industries and jobs, conserving scarce water resources, and leaving our children a fair and equitable legacy could all be useful messages for action.

Alternate Strategies for Future Consideration

Again, per the City of Golden's request, this study investigated a short list of high-impact feasible actions to increase sustainable energy and emissions reductions. The actions in this analysis are by no means exhaustive, however they are meant to help the City add to its portfolio of current actions and also prioritize what areas to target in the near-term. This is not to say other goals are not important; in fact, there are a number of other actions (varying from voluntary to market-based to policy) that could be analyzed in the future that would address additional goals and sectors of the inventory.

Alternative potential future actions:

Buildings:

- Residential energy conservation outreach (voluntary)
- Energy efficiency financing/mortgages (market-based)
- Time of sale ordinances (market-based)
- Carbon tax (policy)
- Tiered rate on electricity (policy, Xcel Energy)

Transportation:

- Travel offsets (voluntary)
- Pay-as-you-drive auto insurance (market-based; according to SWEEP can decrease VMT by 10%)
- Transit-oriented development (policy; 0.2% GHG emissions reduction for 50% of new development by 2020)
- Retrofitting (policy; e.g. hybrid school buses)
- Gas tax (policy)
- Parking fees (policy)

Materials and Waste:

- Green concrete (voluntary; 20% fly ash, ~0.4% GHG emissions reduction)
- Water conservation (voluntary; ~0.2% GHG emissions reduction)
- Local food production (voluntary; ~0.8% GHG emissions reduction)
- Biofuels (voluntary; emissions factors close to zero)
- Waste minimization (policy)
- Pay-as-you-throw (market-based)

It is also important to note that there are some actions that Golden could consider but are not as viable. For example, solar panels use the energy from the sun to provide electrical power. Under current policy, they are not useful for offsetting greenhouse gas emissions as Xcel Energy receives the credit, not the consumer.

There are other factors to take into consideration when creating policies, such as political and economic feasibility; for this reason, increasing parking rates downtown was not recommended as an immediate action but parking management could be considered in the future as infrastructure and other factors change, alleviating the economic burden on this policy. A pay-as-you-throw solid waste mandate could be an option once the City implements its single-hauler strategy which is currently underway (this action could divert up to 17% of waste, per EPA analysis).

Finally, we would be remiss to exclude noting that current actions that the City is taking that will be reflected in real data and reductions in the inventory over the coming years, such as its aggressive green building targets and solid waste reduction and recycling goals.

Financing Options

There are financing options available for energy conservation at both the local and national level.

In Colorado, the Governor's Energy Office (GEO) offers grants and incentives for energy efficiency and renewable energy measures. GEO also recently launched a rebate program for energy efficiency measures. There are also federal tax credits available for weatherization and window upgrades as well as other measures; GEO's website has a great resource section that is worth looking at. Taking advantage of these financing opportunities will decrease the payback periods for the energy efficiency recommendations.
GEO: http://www.rechargecolorado.com/

As mentioned in this report, Xcel Energy recently began a new $60 million demand-side management (DSM) plan for 2020. The electric portion of the plan is designed to save 2,350 GWh in 2020 and Xcel is also establishing natural gas goals. The program targets residential and commercial customers, offering rebates for a variety of energy efficiency measures. Additional support for weatherization upgrades is available for low-income families who qualify through a partnership with the Governor's Energy Office.
Xcel Energy:
http://www.xcelenergy.com/Colorado/Company/Environment/Pages/Environment.aspx

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