ROUTT COUNTY

Greenhouse Gas Emissions Inventory

&

Sustainable Energy Benchmarking and Actions

2005

Center for Sustainable Infrastructure Systems

July 2010

UNIVERSITY OF COLORADO DENVER
DOWNTOWN CAMPUS

Prepared by:

Alison Culpen, Sustainability Outreach Project Coordinator and
Dr. Anu Ramaswami, Director
Center for Sustainable Infrastructure Systems
University of Colorado Denver

With Tim Winter, Routt County; Mike Zopf, Routt County; Steven Hoots, Steamboat Springs; Angela Ashby, President, Yampa Valley Sustainability Council

Prepared for: Routt County, Colorado and the City of Steamboat Springs, CO

Acknowledgements

We would like to thank the employees of Routt County and Steamboat Springs and other organizations for assisting with gathering the data necessary to conduct this inventory.
Routt County:
Tim Winter, Routt County
Mike Zopf, Routt County
Steamboat Springs:
Steven Hoots, Steamboat Springs
Other Organizations:
Angela Ashby, Chair, Yampa Valley Sustainability Council
Robert Peterson
Yampa Valley Regional Airport
Steamboat Springs Airport
Atmos Energy
Yampa Valley Electric Association
Oak Creek Electric

For further information on the data, appendices, or the report, please contact:

Alison Culpen
Center for Sustainable Infrastructure Systems, University of Colorado Denver
Ph: 303-556-4676
Email: alison.culpen@ucdenver.edu

Dr. Anu Ramaswami
Center for Sustainable Infrastructure Systems, University of Colorado Denver
Ph: 303-556-4734
Email: Anu.Ramaswami@ucdenver.edu

Tim Winter
Routt County
Ph: 970-870-5309
Email: twinter@co.routt.co.us

Executive Summary

At the end of 2009, Routt County (the County) and the City of Steamboat Springs 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 sustainability. Routt County has recently been exploring ways 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 County's emissions, the University of Colorado Denver conducted a greenhouse gas (GHG) inventory for 2005, 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 County to develop a baseline starting in 2005, establish goals into the future, and track the progress along the way.

This report assesses the 2005 GHG emissions for Routt County, Colorado using a hybrid demand-center life cycle assessment methodology developed by Ramaswami et al (2008). This method treats the County as a demand center and accounts for buildings electricity and natural gas, surface and air transportation, agricultural activity, and the embodied energy of key urban materials and waste. The inventory and this report should be updated about every three to five years to track the progress of greenhouse gas emissions and general sustainability in Routt County. This report also includes example tailored actions that the County can add to its current list to further a sustainability and action plan for the community.

Background

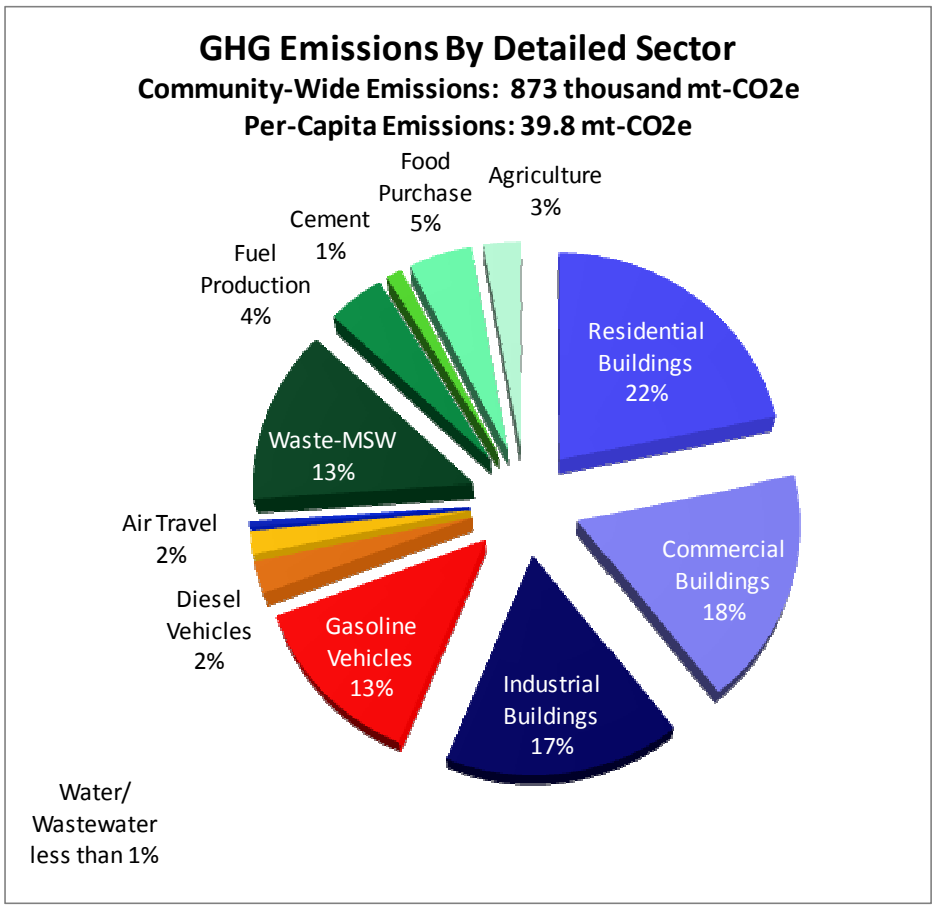
Greenhouse gases are emitted almost exclusively from the burning of fossil fuels, such as coal, natural gas, gasoline and diesel. Greenhouse gases are important because they trap heat in the atmosphere, which over many years causes climate change worldwide. Greenhouse gases include carbon dioxide (CO_2), 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 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 Routt County in 2005; Figure ES.1 shows these results split up by the main GHG emitting sectors in the community.

Figure ES.1: Routt County 2005 GHG Emissions by Detailed Sector



Results

In 2005, the population of Routt County was estimated to be 21,917 people[1]. 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. In 2005, the residential, commercial, and industrial sectors (electricity, natural gas, and propane consumption) about equally made up about 491 thousand mt-CO_2e, or 56% of the total community-wide GHG emissions. Emissions from transportation (gasoline, diesel from surface travel and jet and aviation fuel from air travel) resulted in 151 thousand mt-CO_2e or 17% of total community-wide GHG emissions. Emissions from agriculture and key urban materials such as food, cement, fuel production,

1 Source: Department of Local Affairs, 2005

water, and waste emitted 232 thousand mt-CO_2e or 27% of total community-wide GHG emissions. In 2005, the total emissions from the three sectors totaled 873 thousand mt-CO_2e for Routt County and the per capita emissions were 39.8 mt-CO_2e/capita for the resident community and 31.5 mt-CO_2e/capita including visitors who traveled to Routt County in 2005 (see Section 2.2).

Routt County's 2005 GHG emissions are benchmarked with the State of Colorado; Denver, CO; Chafee County, CO (as another County); and the Town of Eagle, CO (as another ski area). Since all of these areas have different populations, activities, and services, GHG emissions can only be relatively compared on a per capita basis. Routt County emitted 39.8 mt-CO_2e/capita in 2005 (31.5 mt-CO_2e/capita including visitors), the State of Colorado emitted 24.5 mt-CO_2e/capita in 2007, the City of Denver emitted 25.3 mt-CO_2e/capita in 2007, the Town of Eagle emitted 25.2 mt-CO_2e/capita in 2005, while Chafee County emitted 27.1 mt-CO_2e/capita in 2007. Routt County may have higher per capita emissions due to higher vehicular travel, the existence of agricultural activity, and higher commercial and industrial activity due to its large tourism industry.

Without understanding where greenhouse gas 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 Routt County 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 this report, including energy efficiency, green building, zero waste, and local food to help the County identify and prioritize high-impact actions.

Table of Contents

List of Tables and Figures

Abbreviations and Acronyms

CACP	Clean Air Climate Protection software
CDPHE	Colorado Department of Public Health and 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	Well-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[2]. 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),

2 2008 U.S. GHG Inventory, U.S. EPA

enteric fermentation (livestock), and from fugitive emissions in natural gas pipelines. Nitrous oxide can be emitted during wastewater treatment and agricultural soil and manure management. 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 suite of actions that can be taken 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;
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, Routt County and the City of Steamboat Springs 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 complete the first two steps mentioned

above:

- Conduct an inventory of community wide CO_2e emissions, to understand fossil fuel use and associated GHG emissions in the main activity sectors in Routt County;
- Develop a tailored suite of 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 updates.

2.1 Background on Routt County

Routt County was named after John Long Routt, the first Governor of Colorado and former Mayor of Denver; the City of Steamboat Springs is the County seat of Routt County. The County is situated in the northwest quadrant of the State, along U.S. Route 40 and is relatively rural with over 50,000 acres serving as harvested cropland. The County has two airports, Steamboat Springs Airport and Yampa Valley Regional Airport. Routt County, and Steamboat Springs in particular, is a tourist destination as it is home to Steamboat Ski Resort and Routt National Forest. Routt County has approximately 2,368 square miles of area and in 2005 had an estimated population of 21,917; however on any given day in the summer and winter, the population of Routt County can increase by up to 13,000-15,000 visitors due to tourism. The County enjoys hundreds of acres of open space and miles of trails for outdoor activities. It also has many public parks and venues for shopping, dining and entertaining. Routt County has close to 4,000 businesses employing just over 14,000 people in 2005. Residents of Routt County are proud of their community and seek to be leaders in sustainability.

2.2 Tourism Effect on Population

The impact of tourism on Routt County's population is significant. In order to take visitors into account, Routt County analyzed information on lodging. During the winter and summer of 2005 Routt County hosted about 1.3 million visitors, and about 795,000 visitors, respectively. In order to adjust the population according to these numbers, average seasonal visitor numbers were added to the resident population using a weighted average; this added an additional 5,780 people to Routt County's population, for a total population of 27,697 in 2005, including visitors. Where appropriate, this adjusted population will also be used to compare per capita emissions and consumption estimates so that it can be noted where typical estimates may be higher due to tourism.

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 propane 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, 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 and propane 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 can appear as out-of-boundary emissions, particularly when the airport is outside jurisdictional boundaries (note in Routt County the airports are within boundaries and all emissions are appropriated to Routt County).

- AGRICULTURAL ACTIVITY: Routt County differs from other communities because there is significant agricultural activity within the County. Animal agriculture can have a large impact on GHG emissions due to the digestive process of livestock as well as manure management, so this inventory will include a component not relevant to most inventories. Note agricultural activity is included in Scope 3 because it is not a required inventory sector.

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, propane, 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 emission from producing critical urban materials (food, transport fuels, water, cement) and waste disposal. Emissions from raising livestock (agriculture) are also lumped in here as a Scope 3 source.

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. Routt County 2005 Community-Wide Energy and GHG Emissions Inventory Analysis

4.1 Reporting Year

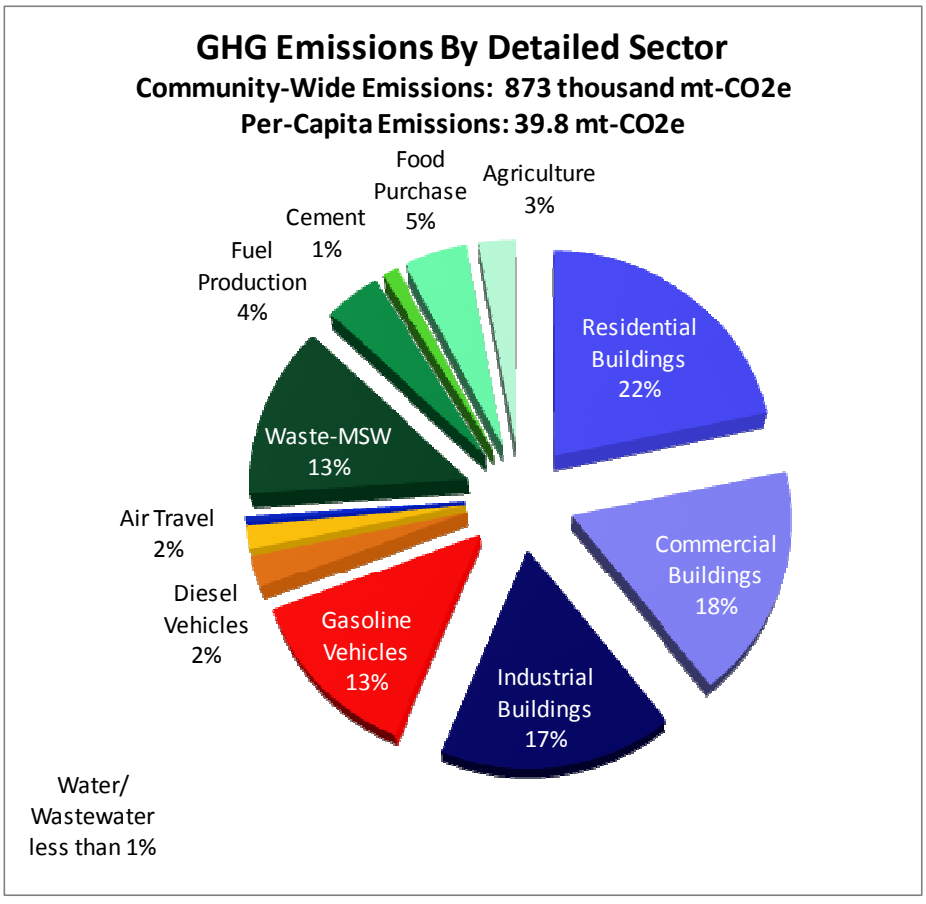
This section reports energy (or materials) consumption data and associated GHG emissions factors for the year 2005, for the three main sectors:

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

This 2005 baseline inventory can be referenced to measure Routt County'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. GHG emissions are reported in terms of metric tons (mt) of carbon-dioxide equivalent, shown as mt-CO_2e.

Total community-wide greenhouse gas emissions for Routt County in 2005 amounted to 873 thousand mt-CO_2e and 39.8 mt-CO_2e/capita (31.5 mt-CO_2e/capita using the visitor adjusted population). Figure 1 shows the GHG emissions from each detailed sector. The following sections explain the calculations and assumptions for each sector.

Figure 1: Results of Routt County 2005 GHG Emissions Inventory



4.2 Buildings Sector

4.2.1 Buildings Energy Consumption and Energy Use Intensity

The buildings sector energy use reports electricity, natural gas, and propane consumed in residential, commercial (including public), and industrial facilities. Data were obtained from electricity providers Oak Creek and Yampa Valley Electric Association and natural gas provider Atmos Energy for the year 2005. Residential propane consumption data were collected from the County Assessor's Office and derived from the number of units that heat their residence with propane gas and the total and average square feet of these units; a vacancy rate of 30% was also factored in, as reported by the U.S. Census Bureau. Based on the number of households and the square footage of commercial spaces in Routt County (obtained from the Assessor's Office), energy use intensity can be computed in terms of electricity and natural gas use per home, and kBTU used per commercial square foot. Calculated energy intensity for buildings in Routt County can be benchmarked with energy intensity metrics reported by the Energy Information Administration (EIA) in the Rocky Mountain region and national data. See Table 8 and Section 4.6 for more detail and for Routt County results.

4.2.2 Emissions from Electricity and Natural Gas

The GHG emissions factors for electricity were provided by the utilities. Oak Creek reported 0.76 kg-CO_2e/kWh and Yampa Valley Electric Association's emissions factor was calculated based on its grid mix and associated emissions factors provided, resulting in an emissions factor of 1.11 kg-CO_2e/kWh. The national default emissions factors for natural gas and propane were used (which do not generally change according to region etc.), or 5.4 kg-CO_2e/therm and 5.74 kg-CO_2e/gallon, respectively (ICLEI). These emissions factors are in line with the factors reported by the Environmental Protection Agency (EPA)[3] and the Energy Information Associate (EIA). The total consumption of electricity, natural gas, and propane is multiplied by the appropriate emissions factors to yield the total GHG emissions for residential, commercial, and industrial buildings, or 491 thousand mt-CO_2e. See Table 2 and Figures 2 and 3 for a detailed breakdown of buildings emissions.

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

Table 2: Summary of Routt County 2005 Energy Use and GHG Emissions from Residential Buildings, Commercial & Industrial Facilities

A. Residential Energy	**2005**
Total Population	21,917
Total Number of Households	10,242
Total Number of Customers (electricity)	13,710
Total Grid Electricity Used (MWh)	137,410
Electricity/household/month (kWh/hh/mo)	835
Total Number of Customers (natural gas)	6,233
Total Natural Gas Used (million therms)	5.8
Natural Gas/household/month (therms/hh/mo)	79
Propane (million gallons)	1.2
Total Residential GHG emissions (thousand mt-CO_2e)	**189**
Total Residential per capita GHG emissions (mt-CO_2e per person)	8.6
B. Commercial Energy	
Total Number of Customers	3,969
Total Commercial Area (million sf)	9.9
Total Electricity Used (MWh)	115,106
Total Number of Customers (natural gas)	1,010
Total Natural Gas Used (million therms)	5.2
Total Public Customers	7
Total Public Electricity Used (MWh)	699
Total commercial energy use per square foot (kBtu/sf)	91
Total Commercial GHG emissions (thousand mt-CO_2e)	**156**
C. Industrial Energy	
Total Number of Customers (electricity)	14
Total Electricity Used (MWh)	131,871
Total Industrial GHG emissions (thousand mt-CO_2e)	**146**
D. Total Buildings and Facilities GHG Emissions (thousand mt-CO_2e)	**491**

Data Source: Energy data from Oak Creek, Yampa Valley Electric Association, and Atmos Gas. 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 Emissions by Building Type

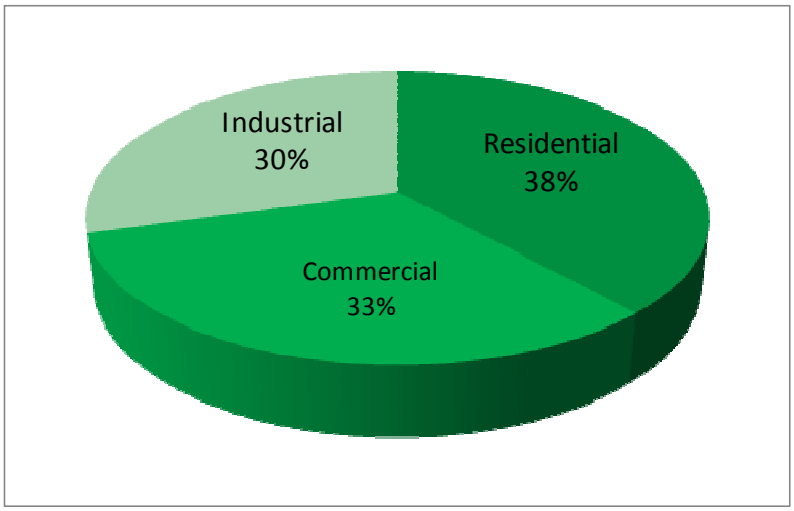
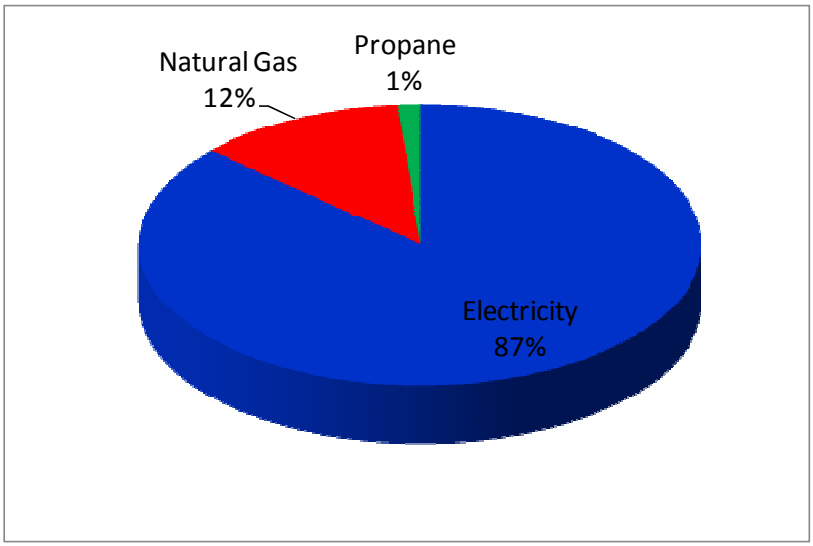


Figure 3: Breakdown of Buildings Emissions by Energy Source



4.3 Transportation Sector

The transportation energy used in 2005 in Routt County includes two main modes of transport:

1. **Personal and Commercial Motor Vehicles:** Cars and trucks, modeled for the County through traffic counts and vehicle registration, were used to assign the miles of personal and commercial traffic attributable to Routt County[4].
2. **Airline Transport:** Energy use associated with jet and aviation fuels and fleet operations at the Steamboat Springs and Yampa Valley Regional airports.

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

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

4.3.1 Surface Travel Miles and Travel Intensity

Annual vehicle miles traveled (VMT) for Routt County were computed using the hybrid demand-center life cycle assessment methodology (Ramaswami, et al. 2008) from traffic counts as well as vehicles registered in the County. Consistent with modeling the community as a demand center for travel, these two methods were used, amounting to an average of 264 million annual VMT. GHG emissions from personal and commercial motor vehicles transport totaled 135 thousand mt-CO_2e.

To calculate VMT, traffic counts provided by an analysis done by Routt County were multiplied by road segment lengths; to check this method Routt County 2005 vehicle registration for vehicles used for personal transport and an average miles traveled per vehicle estimate (12,000 miles per vehicle, per EPA) was used to calculate VMT. The average of these two 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 County. 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 Environment (CDPHE); 95% gasoline-powered cars and 5% diesel-powered vehicles, with average fuel economies as reported by CDPHE. Fuel consumption was computed by dividing the total annual VMT by the average fuel economy.

The VMT intensity is the total annual VMT allocated to Routt County per resident of the County. VMT intensity was determined by dividing Routt County's annual VMT by the 2005 population. Normalizing the total annual VMT results for personal and commercial vehicles per Routt County resident allowed the data to be compared with national and other transportation data. National data for 2005 yielded 25 VMT/person/day, 25 VMT/person/day for the State and for Denver (2007), and 36.7 VMT/person/day for the Town of Eagle. Except for Eagle, these averages are all slightly lower than the 35.3 VMT/person/day obtained for Routt County, demonstrating that the daily VMT/person in the County are not comparable with travel behaviors observed regionally and nationally but are similar to other mountain/resort communities.[5] To compare, VMT/person/day using the visitor adjusted population is equal to 27.9 VMT/person/day. Routt County has limited mass transit options and has many tourists traveling in and out; for both of these reasons VMT is higher than in other more urban and connected areas.

4.3.2 Air Travel

Energy use associated with jet and aviation fuel and fleet operations at Steamboat Springs and Yampa Valley Regional airports in 2005 was allocated in full to Routt County, as both are within the jurisdictional boundaries and are used by residents for travel. In 2005, 11 thousand

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

passengers were enplaned at Steamboat Springs Airport, while 141 thousand passengers were enplaned at Yampa Valley Regional Airport. In 2005, 57 thousand gallons of jet fuel and 53 thousand gallons of aviation gasoline were consumed at Steamboat Springs; 1.4 million gallons of jet fuel and 21 thousand gallons of aviation gasoline were consumed at Yampa Valley Regional Airport, resulting in a total of 15 thousand mt-CO_2e from air travel.

4.3.3 Emissions from Diesel, Gasoline and Jet Fuel

Diesel, gasoline, jet fuel and aviation gasoline 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, 9.9 kg-CO_2/gallon for jet fuel, and 8.32 kg-CO_2/gallon for aviation gasoline (TCR, 2008). The emissions factors for transportation fuels were multiplied by the total fuel consumption for each fuel to get total GHG emissions. Routt County emitted 151 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 Routt County

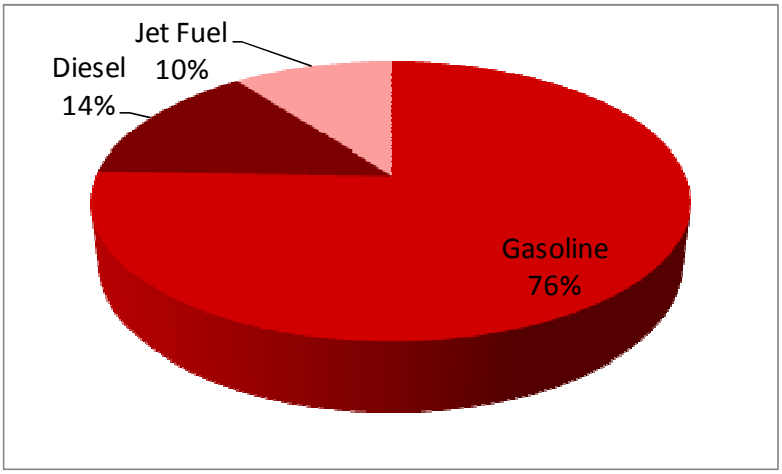
A. Personal & Commercial Motor Vehicles	**2005**
Annual Vehicle Miles Traveled (million VMT)	264
VMT/person/day*	35.3
Annual Fuel Use	
Gasoline (million gallons)	12
Diesel (million gallons)	2
Total GHG Emissions from Personal and Commercial Motor Vehicle Transport (thousand mt-CO_2e)	**135**
B. Airline Travel	
Annual Fuel Use	
Jet Fuel and Aviation Gasoline (million gallons)	1.5
Total GHG Emissions from Airline Travel (thousand mt-CO_2e)	**15**
C. Total GHG Emissions from Transportation Sector (thousand mt-CO_2e)	**151**

A. Data Source: VMT for personal-commercial vehicles obtained from UCD analysis with Routt County as a demand center (from Routt County traffic study and Colorado Department of Revenue for vehicle registrations). Vehicle loading and fuel economy data from CDPHE to calculate VMT and fuel use.

B. Data Source: Fuel data for Airport operations provided by Steamboat Springs Airport and Yampa Valley Regional Airport.

*Miles traveled are normalized to the County'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 Emissions

The materials sector comprises several sources of GHG emissions including cement, water and wastewater, fuel production, food production, agriculture, and municipal solid waste (MSW). (See Table 6 for a summary of materials and waste inputs and associated emissions).

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 money spent on food expenditures as obtained from State averages from the Economic Census (for money spent on food in the home). State average cement use per person from Consumer Expenditure Surveys for the State of Colorado was used. Water and wastewater flow, energy, and emissions data were obtained from Routt County. Agricultural activity data were measured in terms of number of livestock head and were obtained from Routt County. Municipal solid waste and recycling estimates for Routt County were also obtained from County analysis.

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. Routt County emitted 29 thousand mt-CO_2e from gasoline fuel production, 4.8 thousand mt-CO_2e from diesel fuel production, and 3.6 thousand mt-CO_2e from jet and aviation fuel production.

4.4.3 Water and Wastewater Emissions

In 2005, Routt County treated and transported a total of about 600 million gallons each of water and wastewater through its community water and wastewater systems; electricity usage from these activities amounted to just under 4 thousand mt-CO_2e and was subtracted from total

commercial energy, as reported by the utilities, to avoid double counting.

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). Routt County has two centralized advanced treatment wastewater treatment plants (Steamboat Springs and Morrison Creek) and five community aerated lagoon systems. Since wastewater treatment plants in Routt County do not use anaerobic lagoons for treatment and the County does not have emissions data on their smaller septic systems (less than 2,000 gallons/day), minimal methane and nitrogen emissions from processing wastewater were included in the inventory. Table 4 describes wastewater treatment emissions in more detail.

Table 4: 2005 GHG Emissions from Routt County Wastewater Treatment

Emissions	Value
Population served by centralized wastewater treatment plants	11,652 people
Population served by aerated lagoon wastewater treatment systems	3,583 people
Stationary CH_4 emissions from the incomplete combustion of digester gas (centralized treatment plant)	13 mt-CO_2e
Process N_2Oemissions from a treatment plant without a nitrification/denitrification system (centralized treatment plant)	11 mt-CO_2e
Process N_2O emissions from effluent discharge to environment (all systems)	6 mt-CO_2e
Total	**30 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 2002 Colorado Census Data[6] for the State. The per capita cement use for Routt County 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 County population by taking its proportion of the total Colorado population, or around 10, 200 metric tons of cement.

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

The emissions factor for cement is about 1 mt-CO_2e/mt-cement from the National Renewable Energy Laboratory's (NREL) Life Cycle Inventory Database (LCI)[7]. In 2005, Routt County emitted 10 thousand mt-CO_2e from cement.

4.4.5 Food Consumption Emissions

Food is another product that is usually not produced within County 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 Routt County. In the absence of local data on food, food expenditure estimates were derived from the 2005 Census information published in the Consumer Expenditure Survey[8] on a per-household and per-person basis. Using these average estimates, Routt County food expenditures were $3,297 per household per year, and the total estimate for the County is $27.7 million (all figures are in 1997-$ in order to use the Carnegie-Mellon Economic Input-Output model). The emissions factor for food is 1.5 kg-CO_2e/1997-$; total GHG emissions from food production in Routt County in 2005 were 42 thousand mt-CO_2e (Carnegie-Mellon 2009).

4.4.6 Agricultural Emissions

Agricultural activities, specifically animal agriculture, emit a large amount of greenhouse gases. Livestock emit methane during the digestive process (referred to as "enteric fermentation"), and their wastes release additional methane and nitrous oxide while being collected, stored, and treated. Please note that this sector will include only emissions directly related to livestock and not from farm operations, which are already covered in buildings energy and transportation fuel sections.

The head of livestock in each category were obtained from the County. Emissions factors were derived from the Agriculture Chapter in the International Panel on Climate Change (IPCC)'s manual[9] as well as the Food and Agriculture Organization's report "Livestock's Long Shadow."[10] GHG emissions from livestock totaled 23,964 mt-CO_2e in 2005. The data supporting these calculations are shown in Table 5.

[7] http://www.nrel.gov/lci/database/default.asp
[8] http://www.bls.gov/data
[9] http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch4ref1.pdf
[10] ftp://ftp.fao.org/docrep/fao/010/a0701e/a0701e12.pdf

Table 5: Emissions Factors and GHG Emissions in the Agricultural Sector

Type	Number	Enteric Fermentation (kg-CH_4/animal/year)	Manure Management (kg-CH_4/animal/year)	GHG Emissions (mt-CO2e/year)
Dairy Cattle	7	100	51	26.4
Other Cattle	14,807	50	9.5	22,025
Sheep & Goats	750	5	0.23	98.1
Horses	3,501	18	2.10	1,759.3
Swine	92	1	22.7	54.5
Poultry	452	n/a	n/a	n/a
			Total GHG Emissions from Agricultural Activity:	**23,964**

4.4.7 Municipal Waste and Recycling Emissions

Since Routt County has its own landfill, estimating the amount of solid waste sent to Milner Landfill from Routt County was possible (many communities have to use State averages because they have multiple waste haulers and a landfill outside of their boundaries). In 2005, Routt County sent 37,000 tons of solid waste to landfill[11] and diverted about 1,850 tons of waste through recycling efforts for a 5% recycling rate for the community.

The EPA has developed a Waste Reduction Model (WARM)[12] to aid municipalities 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, 37,000 short tons of solid waste were disposed of in Milner Landfill (that does not flare the methane) which produced 115 thousand mt-CO_2e; recycling 1,850 short tons of mixed recyclables reduced emissions by 5,315 mt-CO_2e.

4.4.8 Total Urban Materials and Waste Emissions

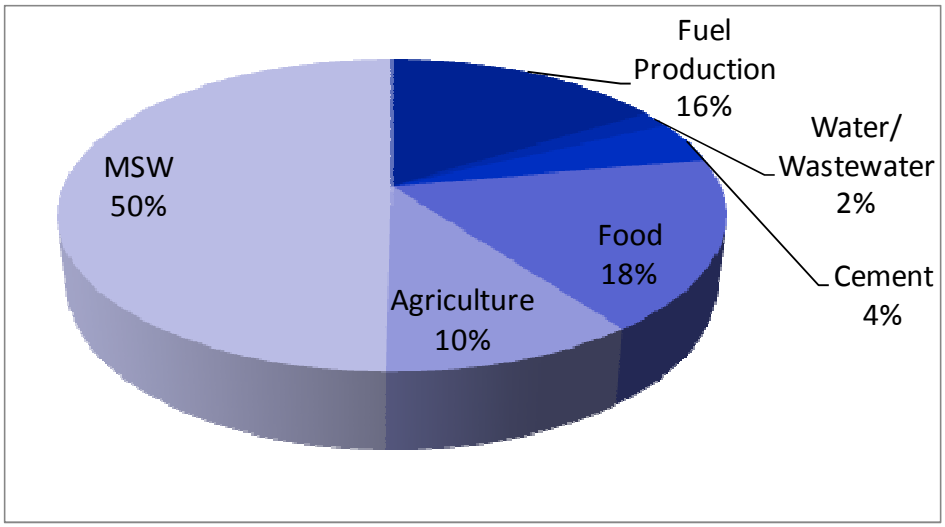
Total emissions sources and associated emissions from fuel production, water, wastewater, cement, food production, and municipal solid waste and recycling are shown in Table 6 and in Figure 5.

[11] Note this includes both compacted (50%) and loose waste (50%) indicating this number most likely includes waste other than municipal solid waste (MSW).
[12] http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

Table 6: 2005 GHG Emissions from Manufacture of Key Urban Materials and Solid Waste in Routt County

Material	Annual Material Flow	GHG Emissions (thousand mt-CO_2e)
Fuel Production (WTP for all fuels)		
Gasoline (million gallons)	12.5	28.7
Diesel (million gallons)	2.1	4.8
Jet fuel (million gallons)	1.6	3.6
Water Consumed (million gallons)	613	0.56
Wastewater Treated (million gallons)	571	3.44
Energy Used to Treat Wastewater	-	*3.41*
Wastewater-Stationary Methane Emissions (mt-CH_4)	-	*0.01*
Wastewater-Process Nitrous Oxide Emissions (mt-N_2O)	-	*0.02*
Cement in Urban Concrete (thousand mt)	10.2	10.2
Food & Packaging ($ million)	$27.8	41.6
Agriculture (# livestock head)	19,609	23.9
Municipal Solid Waste (thousand tons/year)	37	114.7
Recycling per person-day (lb/person/day)	0.5	-
Total GHG Emissions for Producing Key Urban Materials		**232**

Figure 5: Breakdown of Materials and Waste Emissions



4.5 Community-Wide and Per Capita GHG Emissions Footprint

Table 7 presents a comprehensive tally of GHG emissions from the buildings, transportation, and materials and waste sectors. The table includes materials flows, tracking metrics (in parenthesis after selected consumption figures), emissions factors, as well as the total GHG emissions. Total community-wide emissions for Routt County in 2005 were 873 thousand mt-CO_2e. The per-capita emissions were 39.8 mt-CO_2e/person and 31.5 mt-CO_2e/person with the visitor adjusted population.

Table 7: Comprehensive Scopes 1-2-3 2005 GHG Emissions for Routt County [13]

	Sector/use	Community-wide 2005 urban material/energy flows (MFA)		GHG emissions factor (EF)	Total GHG emitted = MFA x EF (thousand mt-CO_2e)
Scopes 1 & 2 plus waste	Buildings Electricity Use	389 GWh (835 kWh/hh/mo)		0.76 kg CO_2e/kWh (OC) 1.11 CO_2e/kWh (YVEA)	425
	Buildings Natural Gas Use	11 million therms (79 therms/hh/mo)		5.4 kg-CO_2e/therm	60
	Buildings Propane Use	1.2 million gallons		5.7 kg-CO_2e/gal	7
	Surface Vehicle Miles Traveled (VMT)	14.5 million gallons 264 million VMT Average Fuel Econ. = 20.1 mpg (gasoline) 6.3 mpg (diesel) (CDPHE)		9.1 kg-CO_2e/gal Gasoline PTW 10.2 kg-CO_2e/gal Diesel PTW	135
	Water/Wastewater	600	Million gallons	Varies	4
	Municipal Solid Waste	37,000	short tons/yr	3.1 mt-CO_2e/short ton	115
Scope 3	Airline Travel (PTW)	1.5	Jet Fuel (million gallons)	9.9 kg-CO_2e/gal Jet fuel PTW	15
	Fuel Production (WTP)	1.6	Jet Fuel (million gallons)	2.3 kg-CO_2e/gal Jet fuel WTP	37
		2.1	Diesel (million gallons)	2.3 kg-CO_2e/gal Diesel WTP	
		12.5	Gasoline (million gallons)	2.3 kg-CO_2e/gal Gasoline WTP	
	Cement Use	10,269	Mt-cement	1 mt-CO_2e per mt-cement	10
	Agriculture	19,609	Head of livestock	varies	24
	Food Purchases	$27.8	Million (1997-$)	1.5 kg-CO_2e/$ (1997 $)	42
Total 2005 Community Wide Emissions:				**873**	**thousand mt-CO_2e**
Community wide per-capita emissions:				**39.8** (31.5)	**mt-CO_2e per capita**

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

Table 7 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 2005 Routt County population. Finding the per capita emissions is beneficial to compare the County's emissions across communities, 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 Routt County, Scope 3 emissions accounted for almost a third of the total GHG emissions as seen in Figure 6. Including Scope 3 emissions allows for more innovative policies and solutions to reduce greenhouse gas emissions. Figure 7 shows GHG emissions by main sector.

Figure 6: GHG Emissions by Scope

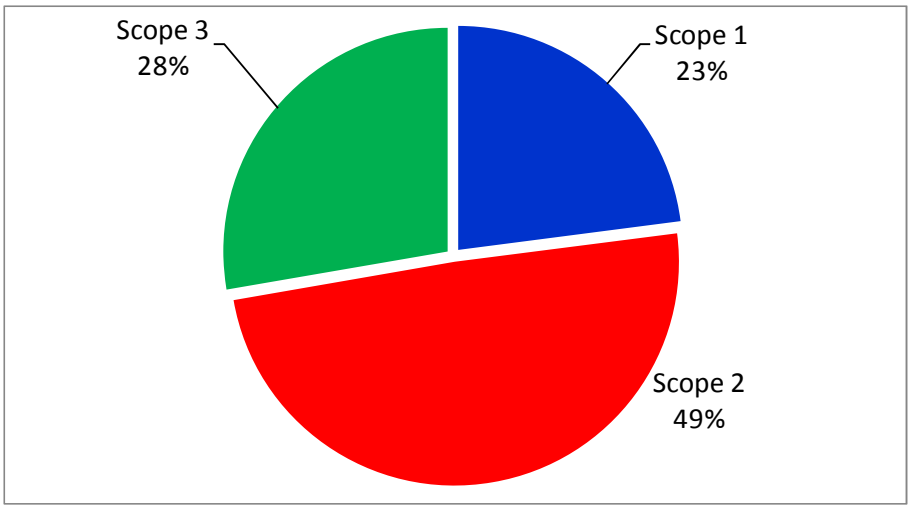
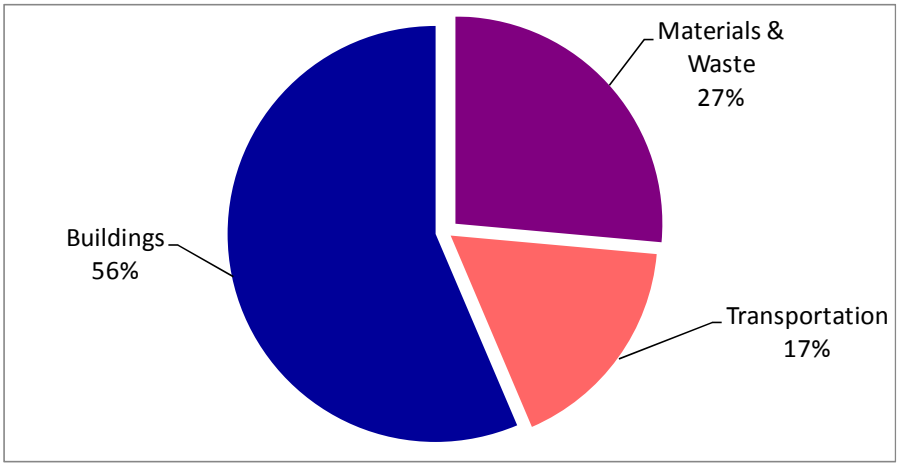


Figure 7: GHG Emissions by Sector



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 communities, states, and nations. Routt County was benchmarked next to the Nation, the State of Colorado; Denver, CO; Chafee County, CO (as another County); and the Town of Eagle, CO (as another ski area) (see Table 8). Routt County matches more closely with the National benchmarks, and has noticeably higher energy use intensity in homes and lower commercial energy use intensity than other Colorado jurisdictions. In addition, VMT and waste numbers are also higher on a per-capita basis; again, these numbers are benchmarked with resident population and are lower when the visitor adjusted population is used.

Table 8: Benchmarks

Description of Benchmark	U.S. National (2005)	CO State (2007)	Denver, CO (2007)	Chaffee County (2007)	Eagle, CO (2005)	Routt County (2005)	Units of Measurement
Average Residential Electricity Use	888	674	528	665	609	835	kWh/hh/mo
Average Residential Natural Gas Use	58	47	65	45	59	79	therms/hh/mo
Average Commercial Buildings Energy Use Intensity	90	104	179	137	106	91	kBTU/ft^2/yr
Vehicle Miles Traveled	27	24.5	25	n/a	36.7	35.3	VMT/person/day
Water/Wastewater	100	154	168	n/a	168	110	gallons/person/day
Municipal Solid Waste (MSW)	4.62	6.3	6.9	5.40	3.1	9.3	lbs/person/day
GHG Emissions	**25.2**	**24.5**	**25.3**	**27.1**	**25.2**	**39.8 (31.5)**	**Mt-CO_2e/person/yr**

5. Inventory Conclusion

This part of the report is meant to be a baseline inventory of the emissions in Routt County in 2005. The technical data in the report will also be used to provide the County with background information on the current emissions from activity in Routt County. The County 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 action steps for the Yampa Valley Sustainability Council, City of Steamboat Springs, and the County Commissioners to adopt in a Sustainability or Climate Action Plan. As Routt County continues to pursue a direction towards a sustainable community, the County can continually update the greenhouse gas emissions inventory report to track the progress the community has made in reducing its greenhouse gas emissions.

6. Sustainable Energy Actions

This section of the report addresses actions that Routt County can take to increase sustainability in the community and leverage multiple economic, environmental, and health benefits. The strategies proposed include a few of the County's current community actions as well as 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 County about which actions make the most sense for Routt County and how to prioritize these actions against existing actions and future goals.

6.1 Background on Current Community Actions and Next Steps

As part of a community-wide effort to create a more environmentally sustainable community, the area established the Yampa Valley Sustainability Council (YVSC) in early 2008. Input from citizens, YVSC, and City and County government officials helped identify several community actions, outlined below along with next steps in the process.

Current Community Actions:

Green Buildings

- City and County have initiated performance contracting to evaluate energy efficiency in existing buildings
- City/City Green Team is developing green purchasing program
- City/County green building program which includes Energy Star for new homes
- Governor's Energy Office - Energy Star for New Homes, Community Marketing Grant (Outreach/Education in partnership with Yampatika and Yampa Valley Partners to educate about energy efficiency, renewable energy, sustainable building), ReCharge Colorado, high performance building
- Home energy meters - possible checkout system through library
- Greening the MLS
- Green Building Committee/Green building tour this fall in conjunction with ASES Solar home tour
- Sustainable Steamboat Business Program

Transportation

- City has purchased two hybrid buses and has plans for expansion
- County Department of Environmental Health purchased two hybrid vehicles
- South Routt Vanpool
- Bicycle friendly designation and focus on biking industry/tourism

Materials/Waste

- Zero Waste Initiative-Recycling, Compost (turning end product back into community, closing the loop)
- Deep Roots – local foods effort

- City and Mt. Werner Water Conservation Program

Other

- ReTree Colorado – Reforestation – planted 12,000 trees in one day
- Outreach and Education – Talking Green, youth education
- Collaboration with other organizations and networking sessions such "Every Day is Earth Day" this May
- EcoGuide – resource for community, visitors, businesses, organizations, etc.

Next Steps

- Gather stakeholders
- Form committee
- Monthly meetings (this fall)
  - establish action items
  - set goals
  - develop strategies
  - re-inventory
- Develop Climate Action/Sustainability Plan
- Local entity GHG emissions inventories

Understanding the Following Pages

Each of the following pages contains a strategy for mitigating GHG emissions. 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)

6.2 Actions Rationale and Assumptions

As mentioned in the inventory section of this report, buildings energy use makes up over half of GHG emissions, with only 14 industrial consumers contributing 17% of total GHG emissions from energy use. With this in mind, the majority of the suggested actions address the buildings sector which is also the least difficult and the most cost-effective sector to implement actions in, such as energy efficient appliances.

There are a few overall assumptions for the actions analysis. First, actions are analyzed in terms of reductions in GHG emissions by 2020, a potential target year for Routt County that is in line with the State of Colorado. Second, 2.2% annual population/job growth (obtained from the Department of Local Affairs estimates) is applied to all emissions sector growth from 2005-2020 (the business as usual emissions forecast, or BAU). Second, the emissions factors for 2020 Yampa Valley Electric Association (YVEA) electricity consumption (2005) is decreased by 20% due to the renewable portfolio standard for electric cooperatives (RPS - 10% by 2015, so almost 20% by 2020 is assumed).

6.3 Renewable Portfolio Standard

Emissions Reductions from State Policy

In addition to local action, reductions in GHG emissions can be also attributed to requirements put on utility providers to include a certain percentage of renewable energy sources in their grid mix. In Colorado these standards require electric cooperatives to use 10% renewables by 2015. As mentioned previously, the following actions assume that YVEA will be on track to meet these requirements by 2015 and will also increase renewables to 20% by 2020 which would in turn decrease the emissions factor to 0.89 kg CO_2e/kWh (from 1.11 kg CO_2e/kWh in 2005); this reduced emissions factor is used in 2020 projections. This policy alone reduces total GHG emissions by 9% 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.

6.4. Commercial/Industrial Sector

Lighting Replacement

Lighting accounts for about 35% of total electricity used in commercial buildings. Electronic T8 ballasts are 30% more efficient and can easily replace less efficient T12 ballasts used for overhead lighting, at low cost. In addition, electronic ballasts can provide better quality light without flicker.

In 2005, commercial and industrial buildings in Routt County used close to a total of 250 GWH of electricity, increasing to close to 350 GWH in 2020. If 50% (assuming 5% over 10 years) of the electricity used in commercial and industrial buildings was replaced with energy efficient lighting this would reduce energy use by about 30%, or over 18 GWH by 2020. Total GHG emissions would be reduced by 15,957 mt-CO_2e in 2020, or close to 2% of total GHG emissions. If full participation was realized (so 100% of businesses and industry) by 2020, this would reduce GHG emissions by an additional 50%, or close to a 4% total reduction.

Total cost for this action to consumers would be $0.06/square foot. Cost savings would be $0.27/square foot with a payback of 0.2 year. The lifecycle cost effectiveness of this action is a low $2.82/mt-$CO_2$e.

Greenhouse Gas Emissions Reduction

1 globe = 1,000 mt-CO2e/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

6.5. Residential Sector

Compact Fluorescent Light Giveaway

Compact Fluorescent Lights (CFLs) are up to 75% more efficient than regular incandescent light bulbs, according to the Department of Energy. Many communities are encouraging local residents to change a few older bulbs to more efficient bulbs, while at the same time increasing awareness and education on energy efficiency and how small actions can add up to a larger impact. Promotional giveaways often include CFLs and can be coupled with other low cost energy efficiency and savings programs such as weatherization.

If Routt County provided two CFLs to 60% of the community by 2020 (average participation ranges from 40-50% however increased education and outreach increases participation to 60%), the County would reduce electricity by almost one million kWh, resulting in a GHG emissions reduction of 869 mt-CO_2e in 2020, or 0.1% of total GHG emissions. If full participation was realized (so 100% of households by 2020), this would reduce GHG emissions by an additional 579 mt-CO_2e, or close to a 0.2% total reduction.

Total cost for this action to consumers would be zero; costs to the County would be close to $30,000. Cost savings to the household would be $0.06/kWh or close to $100,000 annually for the community. The lifecycle cost effectiveness of this action is a low $7.36/mt-$CO_2$e.

Greenhouse Gas Emissions Reduction
1 globe = 1,000 mt-CO2e/year

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

Payback Period *(none)!*

Home Energy Meters

This action offers residences the opportunity to install Home Energy Meters, or Visible Energy Information Meters. The visible meter helps consumers to monitor electricity use and associated costs in real time, in turn causing behavioral change by reducing electricity use; case studies have shown it can reduce electricity by 10-20% per household per month.

Typical voluntary participation rates for this program are around 3%, however this can be increased by 10% with education and outreach. If 13% of homes installed home energy meters by 2020, this would reduce GHG emissions by 2,145 mt-CO_2e or 0.3% of total GHG emissions. If participation increased by 87% to 100% by 2020, this would reduce GHG emissions by an additional 14,355 mt-CO_2e in 2020, or close to a 2% reduction in total GHG emissions.

Total cost for this action to consumers would be $100 per meter with a one year payback. Cost savings would be $0.10/kWh/household; the lifecycle cost effectiveness of this action is $16.10/mt-$CO_2$e.

Greenhouse Gas Emissions 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

6.6. Residential and Commercial Sector

Residential and Commercial Natural Gas Demand-Side Management

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 investor-owned and regulated public and cooperative utilities (in this case, Atmos 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 for the community. 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). Atmos Energy is involved in a natural gas utilities collaborative called "Excess is Out"; a few examples of residential and commercial natural gas programs include energy audits, insulate and seal, HVAC and lighting upgrades, etc.

In order to estimate the potential from DSM for natural gas in Routt County, State-wide Atmos Energy natural gas DSM annual expenditure goals and savings (based on a percentage of their expenditure target) are extended out to 2020 and scaled down to Routt County residential and commercial natural gas demand (~12% of total Atmos Energy natural gas demand in Colorado). The County's proportion of Atmos's natural gas cumulative DSM 2020 goal equates to about a 5% reduction in natural gas use. To be more liberal, we assumed that combining education and outreach would increase this by 10% to a 15% reduction in natural gas use which would result in a reduction of 27,087 mt-CO_2e in 2020, or 3% of total GHG emissions.

Greenhouse Gas Emissions Reduction

1 globe = 1,000 mt-CO_2e/year

Note all associated costs of the program are costs to the utility unless you add in consumer incentives and rebates for specific technologies.

Residential and Commercial Green Building

As pointed out in the inventory section of this report, the buildings sector is the largest contributor to GHG emissions in Routt County in 2005, and thus has the largest opportunity for reductions. The County has already begun to encourage new homes to adopt green building standards, and continuing this effort to commercial construction as well as existing buildings would result in significant energy and GHG emissions reductions in the future. Green building is a holistic way to approach environmental performance and also has many co-benefits such as increasing comfort, productivity, and the health of building occupants.

Typical voluntary participation rates for green building programs is around 5%, however this can be increased by 10% with education and outreach. If 15% of all new and existing residential and commercial buildings adhered to green building standards by 2020, this would reduce GHG emissions by 13,983 mt-CO_2e or 1.2% of total GHG emissions. 15% of these GHG emissions reductions would be from new residential green building construction (current policy), 12% would be from new commercial green building construction, and 73% would be from retrofitting existing residential and commercial buildings to green building standards. If participation increased by 85% to 100% by 2020, this would reduce GHG emissions by close to an additional 80,000 mt-CO_2e in 2020, or about a 10% reduction in total GHG emissions. Note for this action, only electricity use was analyzed so as not to double count this effort in conjunction with the previous natural gas DSM program.

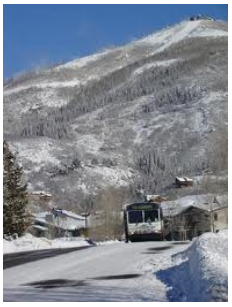
Greenhouse Gas Emissions Reduction

1 globe = 1,000 mt-CO_2e/year

On average, high performance buildings do not cost more than typical buildings.

6.7. Transportation Sector

Increase Ridership on Regional Commuter Bus



Commuter buses reduce the number of people commuting in their car alone to work and can significantly reduce vehicle miles traveled annually and associated gas consumption, saving energy, costs, and reducing GHG emissions.

Currently, Routt County has bus service from Craig to Steamboat Springs, four trips per day (two for the morning commute, two for the evening commute). The buses are not full for each trip, and so we assumed that if by 2020 ridership increased 25% this would save over 100,000 gallons of gasoline annually and reduce GHG emissions by 1,412 mt-CO_2e, or close to 0.2% of total GHG emissions.

Greenhouse Gas Emissions Reduction

1 globe = 1,000 mt-CO_2e/year

Total cost savings (from reduced gasoline consumption) for this action is over $300,000 or over $5,000 per extra rider annually.

Switch Regional Commuter Buses to Biodiesel Fuel

Switching commuter buses from using regular diesel fuel to using biodiesel, made from renewable sources such as vegetable or cooking oil, is an easy way to reduce GHG emissions. Most diesel buses do not have to be converted to use biodiesel, and so upfront costs are lower to switch to biodiesel than to a hybrid bus. In addition, biodiesel can be made locally or from cooking oil which reduces emissions from transportation even further. For this analysis, we assumed that biodiesel is a popular B20 mix which is 20% biodiesel and 80% petroleum diesel.

If both regional commuter buses were switched from diesel to biodiesel by 2020, this would reduce GHG emissions by 37 mt-CO_2e, or less than 0.1% of total GHG emissions.

Cost effectiveness for the lifetime of this action is close to $20/ mt-$CO_2$e.

Greenhouse Gas Emissions Reduction

1 globe = 1,000 mt-CO_2e/year

6.8. Materials and Waste Sector

Zero Waste

Routt County, the City of Steamboat Springs, and YVSC have already kicked off a zero waste initiative by increasing the number of zero waste events and working with the Ski Corps on zero waste efforts. Zero waste includes recycling and composting, thus closing the loop; in addition, the area is developing a compost market so compost can be easily reused for planting, etc.

According to the report "Stop Trashing the Climate" published by the Institute for Local Self-Reliance, Eco-cycle, and Gaia, we would need to reduce emissions from waste by 7% by 2030 in order to achieve the GHG emissions reductions from waste needed to stabilize the climate. For this action, we assumed that a goal for 2020 could be half of that goal, or to reduce emissions from waste by 3.5% through zero waste (diversion, composting and recycling efforts). This would mean reducing waste generation by 1% per year and diverting 90% of waste from the landfill by 2020; resulting GHG emissions reductions would be 5,564 mt-CO_2e, or 0.6% of total GHG emissions.

Greenhouse Gas Emissions Reduction

1 globe = 1,000 mt-CO_2e/year

Local Food

Routt County, the City of Steamboat Springs, and YVSC have also begun a local food effort in the area. Local food reduces costs and GHG emissions through reductions in transportation; local meals have been shown to reduce emissions by 33% per plate. In addition, most local food is organic and less processed so it is healthier for local consumers while also supporting the local economy.

For this action, we assumed that a goal for 2020 could be to increase local food by 25%. This would result in GHG emissions reductions of 4,760 mt-CO_2e, or 0.5% of total GHG emissions.

Greenhouse Gas Emissions Reduction

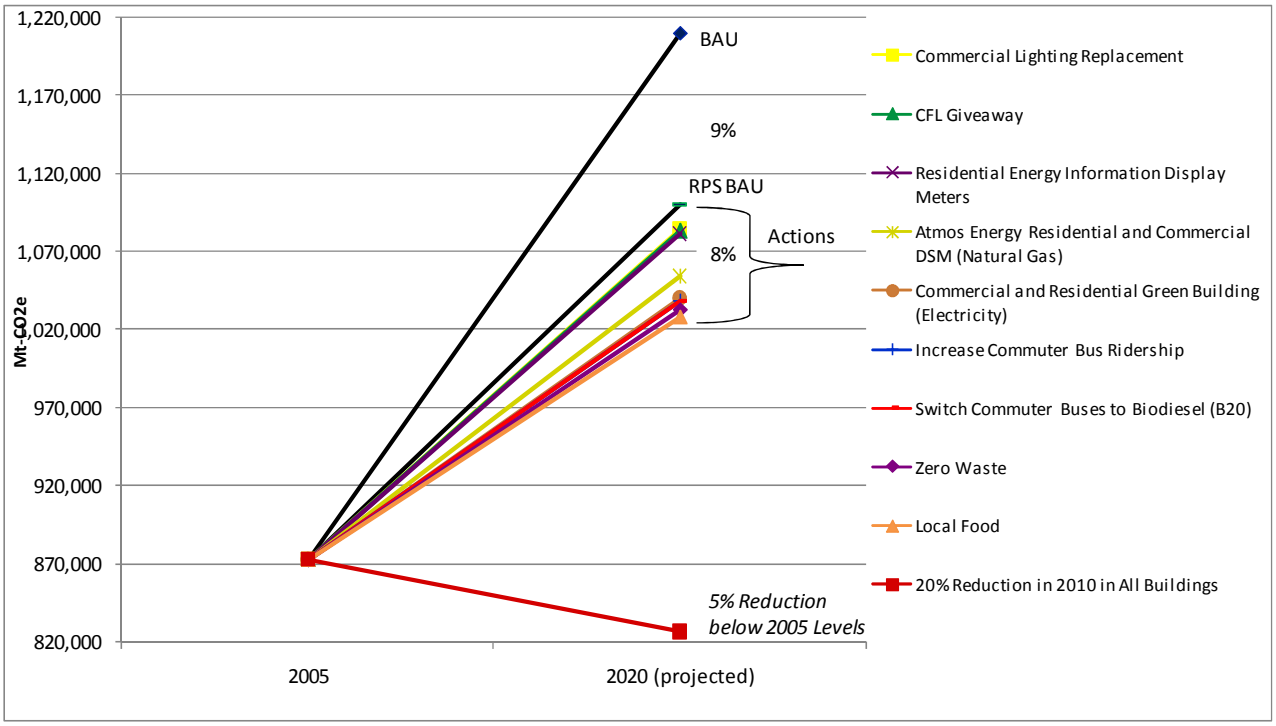
1 globe = 1,000 mt-CO_2e/year

Summary of Greenhouse Gas Emissions Reductions and Recommendations

The purpose of this section of the report was to analyze high impact actions and provide Routt County with a few strategies that are feasible to consider while also being in line with previously established programs. To summarize, the GHG emissions inventory breakdown is as follows: buildings - 56%, transportation – 17%, materials and waste – 27%. The GHG emissions inventory made it clear where there are opportunities for actions that will have large outcomes; in this case, mainly in the buildings sector. Of course, looking at the other sectors is also important and smaller actions can certainly add up to a larger sum.

Figure 8 provides a graphic summary of the actions described above and the associated GHG emissions reductions. The business as usual forecast (BAU) reflects a GHG emissions forecast if no actions were implemented and the Renewable Portfolio Standard (RPS) BAU reflects a GHG emissions forecast if only the RPS was enforced with no other actions. As you can see, the RPS (9% reduction), commercial lighting replacement (2%), and the natural gas demand-side management program (3%) were a large part of the overall percent reduction if all actions were implemented (17% reduction from forecasted 2020 GHG emissions); the other actions added up to about 3% of total GHG emissions reductions. With full participation, the emissions reductions from these actions could double. Alternatively, the last line represents what GHG emissions would look like in 2020 if everyone reduced emissions today from 2010 by 20% in all buildings – a GHG emissions reduction of 5% below 2005 levels! This goal could be achieved through performance contracting and other energy efficiency measures. Looking at emissions reductions in this way allows a comparison of the magnitude of each action and, along with cost and other indicators, helps the County to prioritize actions.

Figure 8: GHG Emissions Reduction Wedge



It is also worth noting that there is no silver bullet action, as a portfolio of strategies is needed to achieve savings anywhere close to the Colorado Climate Action Plan goal (20% emission reductions by 2020 from 2005 levels) and the various goals the County has and will lay out in the future. 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 participation in the implementation of the proposed actions is critical. A compelling story on Routt County saving money, improving energy security, creating new industries and jobs, conserving scarce water and other resources, and leaving our children a fair and equitable legacy could all be useful messages for action.

Alternate Strategies for Future Consideration

Per the County'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 Routt County add to its portfolio of current actions and also to 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 (in addition to the current actions listed previously) that could be analyzed in the future that would address additional goals and sectors of the inventory.

Alternative potential future actions:

Buildings:

- Energy efficiency financing/mortgages (market-based)
- Time of sale ordinance (market-based)
- Carbon tax (policy)
- Tiered rate on electricity (policy)

Transportation:

- Travel offsets (voluntary)
- Pay-as-you-drive auto insurance (market-based; according to SWEEP can decrease VMT by 10%)
- Gas tax (policy)
- Parking fees (policy)

Materials and Waste:

- Green concrete (voluntary)
- Pay-as-you-throw (market-based)

There are other factors to take into consideration when creating policies, such as political and economic feasibility; for this reason, mandatory ordinances were not included as an immediate actions but could be considered in the future as infrastructure and other factors change, alleviating the economic and political burden on these policies.

Finally, we would be remiss to exclude noting that the current actions that Routt County, the

City of Steamboat Springs, and YVSC are taking will be reflected in real data and reductions in the inventory over the coming years, such as its green building and zero waste efforts; these are very commendable actions that can be expanded upon in the future.

Financing Options

There are financing options available for energy and resource conservation and GHG emissions reductions 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 called "Recharge Colorado". In addition, Federal tax credits are available; GEO's website has a large resource section that is worth exploring. Taking advantage of these financing opportunities will decrease the payback periods and increase outreach for the energy efficiency recommendations in this report.
GEO: http://www.rechargecolorado.com/

As mentioned in this report, Atmos Energy recently began a new "Excess is Out" demand-side management (DSM) program collaborative. The program targets residential and commercial/industrial natural gas customers, offering rebates for a variety of energy efficiency and weatherization measures as well as low-income assistance.
Atmos Energy: http://excessisout.com/atmosenergy

In addition, for more information on how to buy wind energy from **Yampa Valley Electric Association** or on their net metering program go to: http://www.yvea.com/

References

Argonne National Laboratory. *The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model.* Vers. 2.7. 2007. http://www.transportation.anl.gov/modeling_simulations/GREET/index.html (accessed December 2009).

Brundtland, Gro. *Our Common Future: The World Commission on Enviornment and Development.* Oxford: Oxford University Press, 1987.

Carnegie-Mellon. *Input-Output Life Cycle Assessment (EIO-LCA) tool.* 2009. http://www.eiolca.net (accessed October 2009).

EPA. "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006." 2008.

Hillman, T, and A Ramaswami. "Greenhouse Gas Emission Footprints and Energy Use Metrics for Eight U.S. Cities." *Environmental Science and Technology*, no. 44 (2010): 1902-1910.

ICLEI. *Clean Air and Climate Protection Software (CACPS).* 2009. http://www.icleiusa.org/action-center/tools/cacp-software (accessed December 2009).

ICLEI. "Local Government Operations Protocol." v.1 September 2008.

Ramaswami, Anu, Tim Hillman, Bruce Janson, Mark Reiner, and Gregg Thomas. "A Demand-Centered, Hybrid Life-Cycle Methodology for City-Scale Greenhouse Gas Inventories." *Environmental Science and Technology* 42, no. 17 (2008): 6455-6461.