Ouray and San Miguel County Greenhouse Gas Emissions Inventory & Sustainable Energy Benchmarking and Actions 2010

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Center for Sustainable Infrastructure Systems
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Towns of Telluride, Mountain Village, Norwood, Ophir, Ridgway, City of Ouray

Other Organizations:
Montrose Regional Airport
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Amerigas
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"Sustainable development is development that meets the needs of the present [generation] without compromising the ability of future generations to meet their own needs."
— THE BRUNDTLAND COMMISSION, UNITED NATIONS 1983

EXECUTIVE SUMMARY

Background

At the beginning of 2011, Ouray County (OC) and San Miguel County (SMC) partnered with the University of Colorado Denver (UCD) and the Colorado Municipal League (CML) through a generous donation from the Wal-Mart Foundation to begin the process of quantifying energy and materials consumption. This process has grown out of concern about the availability of increasingly scarce non-renewable natural resources, rising energy costs, and the adverse effects of burning fossil fuels. The Counties of Ouray and San Miguel have recently been exploring ways to address these concerns.

Inventory Objective

The objective of this Greenhouse Gas (GHG) emissions inventory is to establish a community-wide baseline from which future emission and energy reduction goals can be set.

Inventory Method

This inventory covers the three main greenhouse gases: carbon dioxide (CO_2), methane (CH_4), and nitrogen oxides (N_2O). The unit of measure used throughout this report is metric tons of CO_2 equivalent (abbreviated mt-CO_2e), in order to express total emissions of all three GHG gases in one comparable unit.

This report assesses 2010 GHG emissions for Ouray and San Miguel Counties, Colorado, using a hybrid demand-center life cycle assessment methodology developed by Ramaswami et al. (Ramaswami, Hillman, Janson, & Thomas, 2008). The method uses the standard Local Government Operations Protocol (LGOP) released by ICLEI[1]-Local Governments for Sustainability to report GHG emissions from in-boundary activities. Out-of-boundary activities critical to a community such as the provision of food, water, fuels and dwellings are added to the in-boundary activities to yield an expanded inventory that becomes a more comprehensive "carbon emissions footprint".

1 ICLEI is the International Council for Local Environmental Initiatives, an international membership association of local governments dedicated to climate protection and sustainable development.

Inventory Results

In 2010, the population of the Ouray and San Miguel Counties was estimated at 11,795 people. The activities of the population 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 2010, electricity and natural gas consumption from the *residential and commercial sectors* made up about 216 thousand mt-CO_2e, or 63% of the total community-wide GHG emissions. Emissions from transportation (gasoline and diesel from surface travel and jet fuel from air travel) resulted in 70 thousand mt-CO_2e or 20% of total community-wide GHG emissions. Finally, key urban materials such as food, cement, fuel production, water fugitive emissions, and waste emitted 61.2 thousand mt-CO_2e or 17% of total community-wide GHG emissions. In 2010, emissions totaled 346 thousand mt-CO_2e for the entire two county community and the per capita emissions of 29.3 mt-CO_2e.

Figure ES-1 Greenhouse Gas emissions summary by sector for Ouray & San Miguel County, 2010

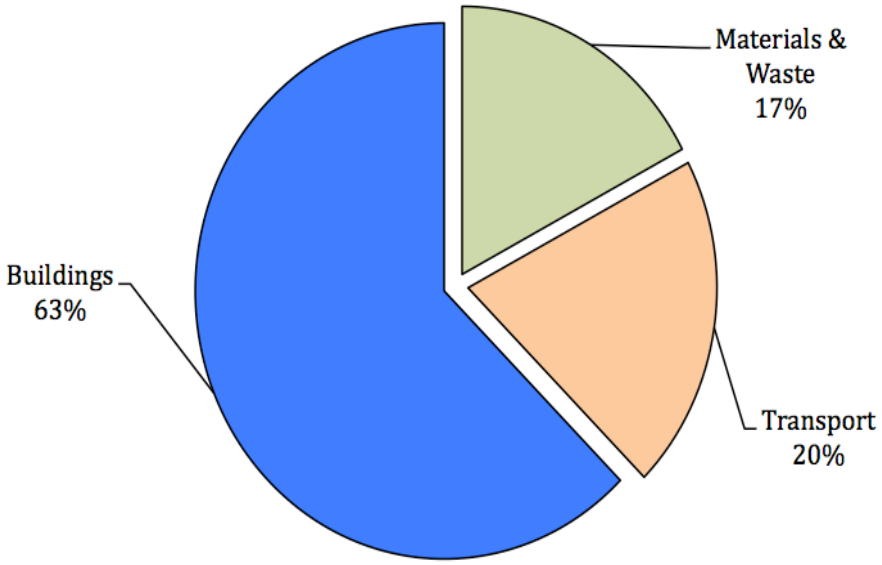
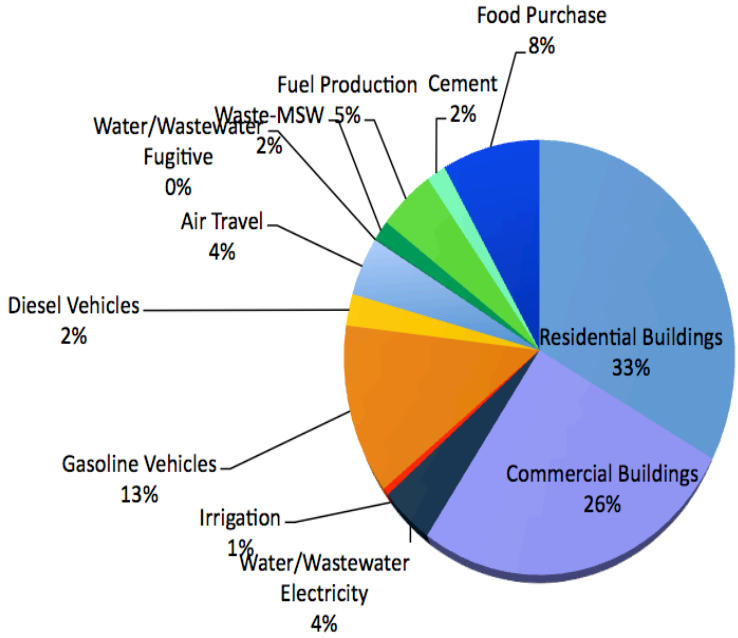


Figure ES-2 2010 greenhouse gas emissions summary by source type; Community-wide Emissions: 346 thousand mt-CO_2e; Per-Capita Emissions: 29.3 mt-CO_2e



2010 total GHG emissions = 346 thousand metric tons of CO_2e

Comparisons with Other Counties

In order to compare one community to another, it is useful to compare "per capita emissions" as opposed to "total emissions". Per capita emissions bring conceptually difficult numbers (i.e., millions or billions of tons) into line and establish a common standard of comparison. For example, if two countries, "A" & "B", have the same total emissions of 20 billion tons each, but country "A" has three times the population, then per capita emissions in country "A" will be 1/3 that of the country "B". There could be many reasons for the per capita differences, including more or less development or prosperity, warmer versus colder climate, different urban planning policies, or higher renewable versus fossil-fueled power generation.

Key Findings

Ouray and San Miguel County GHG emissions are compared with national data; the State of Colorado; Denver CO; Eagle County, CO; the Town of Vail, CO; and the City of Montrose. Since all of these areas have different populations and services, GHG emissions can be compared on a per capita basis. The national average emissions in 2010 were estimated at 25.2 mt-CO2e/capita, while the State of Colorado emitted 24.5 mt-CO2e/capita, Eagle County emitted 27.0 mt-CO2e/capita in 2009, the Town of Vail emitted 16.3 mt-CO2e/capita in 2009, and the City of Montrose emitted 23.6 mt-CO2e/capita in 2008. Ouray and San Miguel Counties may have higher per capita, 29.3 mt-CO2e/capita, emissions due to higher residential energy and natural gas use and higher commercial energy use intensity from larger buildings.

Table ES-1 Ouray & San Miguel County GHG emissions compared to the State of Colorado average, and other cities and counties

Sector Being Benchmarked	U.S Average[2] (2010)	CO State (2007)	Eagle County, CO (2009)	Town of Vail, CO (2009)	Montrose, CO (2008)	Ouray & San Miguel, CO (2010)	Units of Measurement (*source*)
Avg. Home Sq.Ft (people/home)	- -	-- (2.53)	2,040 (2.75)	3,607 (2.8)	1,699 (2.3)	2,707 (2.15)	Sq.Ft (ppl/hh) *OC &SMC*
Avg. Residential Electricity Use	888	674	966	609	980	1,380	kWh/hh/mo *SMPA*
Avg. Residential Natural Gas Use	58	47	37	59	118	111	therms/hh/mo *SourceGas*
Avg. Commercial Buildings Energy Use Intensity	138	104*	151	106	899[4]	98	kBTU/ft^2/yr *OC & SMC, SMPA*
Vehicle Miles Traveled (VMT)	27	24.5	32**	36.7	31.5	26.2**	VMT/person/d *Vehicle Registration/ CDOT*
Water[1]	-	154	118.5	168	113	173	gal/person/day (*OC & SMC*)
Municipal Solid Waste (MSW)	5	6.3	11.5	6.6	11.6	2.3!!!	lbs/person/day (OC & SMC)
Air Travel Efficiency -local airport2	22	--	12.7	12.7	21.2	20.4	Gal/enplaned passenger[5]
Food (1997$) $/hh/yr	$4,841	--	$2,356	$1,205	$2,930	$3,662	West region CES
Cement Use/Capita	0.36	0.53	0.43	0.43	0.50	0.50	mt/person/yr (Economic Census)
GHG Emissions/resident	**25**	**24.5**	**27.0 (19.2)**	**16.3**	**23.6**	**29.3 (24.2)**	**mt-CO2e/ resident/yr**

* This number applies to mountain regions in the State only.
** Visitor and worker travel not included
[1] Includes Residential, Commercial and industrial
[2] Data published 2010
[4] May be so high if the commercial square footage is not calculated correctly
[5] Per percent travelers that go to Telluride - Montrose, Telluride, Cortez & Durango airports
!!! This number is not representative of the current situation due to lack of data

Business as Usual Projection

Current consumption patterns and the counties' 2020 estimates for population were used to project countywide emissions to 2020. From 2010-2020 the average annual population growth rate in Ouray and San Miguel is expected to be 2.5% based on data from the Colorado Department of Local Affairs. Using the assumption that per capita emissions stay constant, Ouray and San Miguel County community-wide emissions are expected to increase by 24% by 2020, reaching nearly 500 thousand mt-CO_2e.

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 policies from the 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.

Sustainability Actions Recommendations

Local governments can greatly influence their communities' greenhouse gas emissions by exercising key powers over land use, transportation, building construction, waste management and, in many cases, energy and water supplies and management. While it is important that Ouray and San Miguel create a action plan based on input from the community, a Sustainability Actions Matrix provides measures to reduce the community-wide GHG emissions. Measures were identified based on a preliminary assessment of the counties' existing conditions and projected growth as well as the goals from the "Collaborative Sustainability Action Plan and Implementation Methodology".

Vehicles for implemented measures suggested in the Sustainability Actions Matrix include: Local government sponsored outreach (e.g. education campaigns), County-funded programs, partnerships with state-funded programs, and County mandates. See Table ES-2 for a summary of the strategies included in the Sustainability Actions Matrix

Table ES-2 Summary of Sustainability Actions Matrix

	County-sponsored outreach	County-funded program	State-funded program	Mandate
Pursue DSM	❍			
Energy Display Meters	❍			
Time of Sale upgrades				❍
Insulate & Seal	❍		❍	
ENERGY STAR building code for new residential				❍
Replace inefficient refrigerators	❍	❍	❍	
Renewable Energy Purchases	❍			

Based on the preliminary assessment of Ouray and San Miguel Counties' existing conditions and the projected growth, several specific measures, with their impacts, were suggested in this report. The following is a brief description of most viable actions:

Commercial Demand Side Management (Voluntary)

Voluntary participation (100%) by Ouray and San Miguel commercial electricity customers in Tri-State Generation & Transmission's Demand Side Management (DSM) Program could potentially result in savings of 2,054 mt-C02$_e$ or 0.421% decrease from 2020 business as usual scenario.

Commercial Green Power

In 2010, commercial power accounted for 4.4% of total commercial energy purchased. Striving to raise this number, through education and outreach, to 10% of the total commercial energy purchased by 2020, it could lead to 7,259 mt-CO_{2e} or 1.69% savings in emissions from the business as usual level.

Residential Green Power (Voluntary)

In 2010, residential green power accounted for 2.1% of total energy purchased in the OC &

SMC. Educational campaigns and incentive programs aimed at increasing the green purchase power to 8% of total energy used in the area by 2020, could result in saving of 10,091 mt-CO_{2e} or 1.61% decrease from the 2020 business as usual levels.

Residential Natural Gas DSM (Voulntary)

Voluntary participation of Ouray and San Miguel residents in SourceGas's demand side management program could lead to savings of 9,303 mt-CO_{2e} or 1.87% from the 2020 business as usual level.

Home Energy Meter (Mandate)

Home Energy Information Display Meters are simple device that are proven to decrease energy use in households between 6%-12%. If a mandatory program were implemented to install energy meters in homes within Ouray and San Miguel Counties, with a resulting participation of 100% of all homes between 2010-2020, the two-county region could save 8,508 mt-CO_{2e} or 1.71% of the 2020 business as usual levels.

Individualized Travel Marketing Program (Voluntary)

Individualized Travel Marketing Program is a method used to increase awareness of transportation modes alternative to car travel. This method is based on targeted, personalized, and customized marketing approach that empowers people to change their traveling behavior. It is assumed that this method will be developed and utilized as a one-time program in 2012. If the current trends continue, Ouray and San Miguel could see an increase in total Vehicle Miles Traveled (VMT) by 5%. An Individualized Travel Marketing Program has a potential to affect 10% of the total VMT and result in a 7% decrease in the affected (10%) VMT. Success of this program could result in savings of 334 mt-CO_{2e} or 0.07% of the total 2020 business as usual scenario.

Pay-as-you-throw (Voluntary)

Ouray and San Miguel have an opportunity to promote a Pay-as-you-throw trash services to its

residents. This program charges users of the service directly on the basis of the amount of the trash they throw away. Therefore, the program has a potential to encourage the users to recycle more and reduce waste production. EPA estimates 15-28% reduction in the total municipal waste generation from this program and its implementation in Ouray and San Miguel Counties could result in 1,579 mt-CO_{2e} or 0.3% savings of the total 2020 business as usual scenario.

Zero Waste (Voluntary)

A voluntary program aimed waste prevention, re-use and recycling could result in 7% reduction in waste generation by 2020 and consequently prevent 502 mt-CO_{2e} or 0.10% from being emitted in the business as usual scenario.

Green Concrete for New Construction (Policy)

Green concrete, based on fly ash, can significantly contribute to reduction of greenhouse gas emission. Since it uses a by-product of power plants, it helps reduce the amount of new cement made and therefore offsets GHG emissions. Developing a policy requiring all new development to utilize at least 25% of green concrete in the construction process can save 1,887 mt-CO_{2e} or 0.38% of the total business as usual scenario.

Biomass Co-firing in Coal-Fired Boilers

Ouray and San Miguel have an opportunity to develop and utilize biomass co-firing process of developing electricity. Co-firing is a fuel diversification strategy and it is utilized as method to decrease the cost of electricity, not to save energy. Biomass used as a fuel source can result in greenhouse gas emissions savings equivalent to burning 20% less coal. And, based on the projected electricity use in Ouray and San Miguel, this could equate to saving of 35,429 mt-CO_2e or 7.32% of business as usual scenario.

Small- & Pico-Hydro Power Production

Small-hydro

Ridgway Dam project is expected to produce 22.6 gigawatt-hours of electricity per year at an installed capacity of 7 MW. Allocation of the entire electricity production to Ouray and San Miguel area could potentially offset 4.53% or 22,553 mt-CO_2e.

Pico-hydro

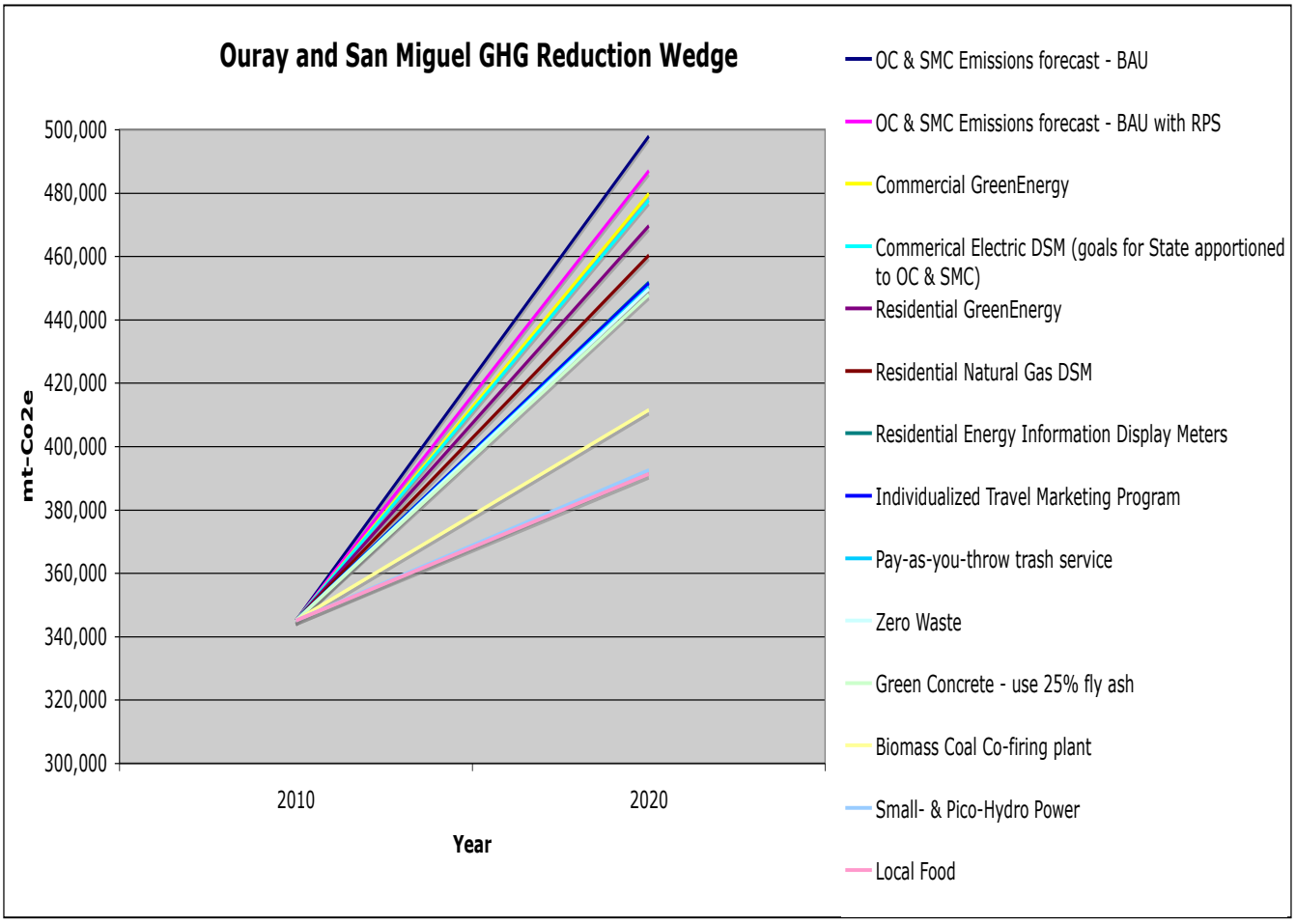
Pico-hydro is electricity production on a small, individual household, level. If 5% (274) of current homes in Ouray and San Miguel were to install such power generators, it could potentially lead to 0.74% or 3,666 mt-CO_2e savings from 2020 levels.

Local Food

Creating opportunities and programs to promote local food production to substitute at least 25% of the current food demand, Ouray and San Miguel could save up to 10% or 1,271 mt-CO_{2e} of the business as usual scenario.

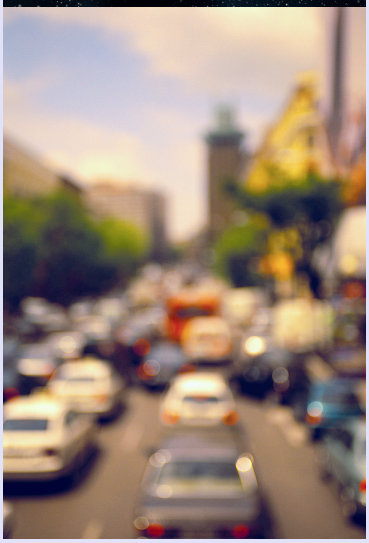
Greenhouse Gas Emissions Wedge

Combining the recommended calculations for Ouray and San Miguel can be visually presented as a reduction wedge:


Ouray and San Miguel GHG Reduction Wedge
500,000
480,000
460,000
440,000
420,000
400,000
380,000
360,000
340,000
320,000
300,000
mt-Co2e
2010
2020
Year
OC & SMC Emissions forecast - BAU
OC & SMC Emissions forecast - BAU with RPS
Commercial GreenEnergy
Commerical Electric DSM (goals for State apportioned to OC & SMC)
Residential GreenEnergy
Residential Natural Gas DSM
Residential Energy Information Display Meters
Individualized Travel Marketing Program
Pay-as-you-throw trash service
Zero Waste
Green Concrete - use 25% fly ash
Biomass Coal Co-firing plant
Small- & Pico-Hydro Power
Local Food

ABBREVIATIONS AND ACRONYMS

CACPS	Clean Air Climate Protection Software
CAPPA	Climate & Air Pollution Planning Assistant (ICLEI Software)
CDPHE	Colorado Department of Public Health and the Environment
CFL	Compact Fluorescent Light
CH_4	Methane
CML	Colorado Municipal League
CO_2	Carbon Dioxide
DSM	Demand Side Management
EECBG	Energy Efficiency and Conservation Block Grants
EIA	Energy Information Administration
EPA	Environmental Protection Agency
GEO	Governor's Energy Office (State of Colorado)
GHG	Greenhouse Gases
GREET	Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation model
GWh	Gigawatt hour
HH	Household
IGERT	Interdisciplinary Graduate Education Research Traineeship
kWh	kilowatt hour
LCA	Life Cycle Assessment
LGOP	Local Government Operations Protocol
MSW	Municipal solid waste
mt-CO_2e	Metric tons of carbon dioxide equivalents
N_2O	Nitrous Oxide
NREL	National Renewable Energy Laboratory
P2W	Pump-to-Wheels
RMA	Rocky Mountain Airport
UCD	University of Colorado Denver
VMT	Vehicle miles travelled
WARM	Waste Reduction Model
WRI	World Resources Institute
W2P	Wells-to-Pump



SECTION 1 - INTRODUCTION TO SUSTAINABLE ENERGY PLANNING

Sustainability is widely understood to encompass 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 Sustainability

There has been interest nationally, within the State of Colorado and in many 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 fuel energy. The global/local impacts from using fossil fuels 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 (GHG) emissions. The global impacts of GHG emissions are projected to have local impacts in Colorado, affecting snow pack, water supplies (local and regional) and agriculture. Looking toward a future with increased cost and reduced availability of fossil fuel 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 Greenhouse Gases and Greenhouse Gas Accounting

The U.S. EPA defines greenhouse gases as those that trap heat in the atmosphere. Some GHGs, such as carbon dioxide, occur naturally and are emitted into the atmosphere through natural processes and human activities (e.g. carbon dioxide and methane). Other GHGs (e.g. fluorinated gases) are created and emitted solely through human activities.

Greenhouse Gases (GHGs)

The principal greenhouse gases that enter the atmosphere as a result of human activities are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and several industrial compounds called "chlorofluorocarbons." The first three GHGs: CO_2, CH_4, and N_2O, account for more than 98% of GHGs emitted nationally and are the focus of this report (U.S. Environmental Protection Agency, 2009).

Almost every facet of modern life emits greenhouse gases. Carbon dioxide, the largest contributor to global warming, is emitted wherever and whenever fossil fuels are burned including when we drive our cars, heat our houses, and generate our electricity. Most methane emissions come from waste decomposition (naturally or in landfills) and from farms that raise the animals for food production. Nitrous oxide is emitted primarily from landfills and wastewater treatment plants, usually as fugitive emissions. Factories that produce the products we use in our daily lives emit greenhouse gases and the trucks that transport these items to our cities emit more still.

The various GHGs have different global warming potentials, or ability to trap heat in the atmosphere. For example, one ton of methane can trap 25 times as much heat in the atmosphere as one ton of carbon dioxide. Therefore 1 mt-CH_4 is equal to 25 mt-CO_2e. In order to compare the emissions and energy consumption, greenhouse gases are reported together on a common standardized basis as metric tons of carbon dioxide equivalents (mt-CO_2e). Greenhouse gases are a good way to compare the full impact of energy use across many different sectors. Comparing gasoline consumption to electricity consumption to food consumption can be difficult without one common unit. Carbon dioxide equivalents provide this common unit to compare energy across

different scales. Table 1-1 shows the top three greenhouse gases in the atmosphere and their global warming potentials.

Table 1-1 Global warming potentials of Greenhouse gases

Greenhouse gas	Chemical Formula	Global Warming Potential
Carbon Dioxide	CO_2	1
Methane	CH_4	25
Nitrous Oxide	N_2O	298

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

Greenhouse Gas Accounting

Greenhouse gas accounting calculates GHG emissions within a defined boundary (anything from a single home to an entire country) and those emitted on behalf of the area within that boundary (for example, electricity that is produced in a neighboring county but used in the county of interest). The end product is a greenhouse gas emissions footprint specifying how many (mt-CO_2e) were emitted in a given year, broken down by sector and source and expressed in simple terms that are comparable over time. The purpose of local GHG inventories is to identify the most promising reduction opportunities and set goals for the future.

GHG emissions inventories are a useful tool for policymakers. If it is apparent which sector of a community is producing the majority of emissions, policies can be targeted at specific sectors where easy improvements can be made with little investment; inventories can help to identify the "low-hanging fruit." Each sector can be compared on a per-user basis (per household, per capita, per square foot, etc) to the same sector in a nearby region having similar demographics and climate in order to identify if there are specific local practices that can be modified or if there are even any improvements to be made. Once policies have been implemented, their effectiveness can be tracked over time by performing a new inventory every year or two and comparing the results. It is important that any organization interested in reducing its environmental impact have a "baseline" inventory to compare to in the future.

1.3 Climate Change Mitigation

International Measures

The most widely known international response to mitigate climate change is the Kyoto Protocol, a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC),

which seeks to reduce six greenhouse gases[2]. The Kyoto Protocol was adopted on December 11, 1997 and calls for a 5.2% reduction from 1990 emission levels by 2012. As of November 2009, 187 countries have signed and ratified the protocol.

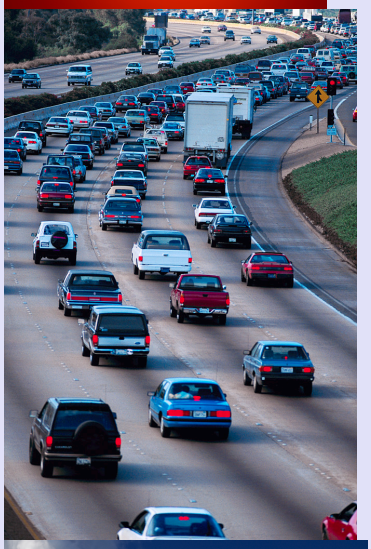
U.S. Measures

The U.S. did not ratify the Kyoto Protocol and is therefore not bound by the Protocol's objectives. Currently, there is no Congressionally approved federal policy regarding greenhouse gas emissions reductions in the U.S. although climate legislation passed in the House in 2009 and separate legislation is currently being debated in the Senate. Many states however, have initiated statewide greenhouse gas reduction goals. Colorado Governor Bill Ritter issued a Climate Action Plan in 2007. It set a goal of reducing the state's greenhouse gas emissions 20% below their 2005 levels by 2020 and 80% by 2050.

In 2005, a coalition of U.S. mayors created the U.S. Mayor's Climate Agreement, establishing a city-scale response to the Kyoto protocol, aiming for a 10% per capita reduction in GHG from 1990 levels by 2012. To date, 1,017 U.S. Mayors have joined the U.S. Mayor's Climate Agreement including Denver, Fort Collins, and Westminster, Colorado.

More and more communities are realizing that reducing GHG emissions can provide not only global environmental benefits, but also local economic benefits from energy efficiency measures, business competitiveness in an era of oil market volatility, as well as health and other societal benefits. Local actions can have a global impact, while the quest to reduce global GHG emissions can have a corresponding beneficial local impact.

2 Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Sulfur hexafluoride (SF_6), Perfluorocarbons (PFCs).



SECTION 2 - GHG INVENTORY AND PROJECTION

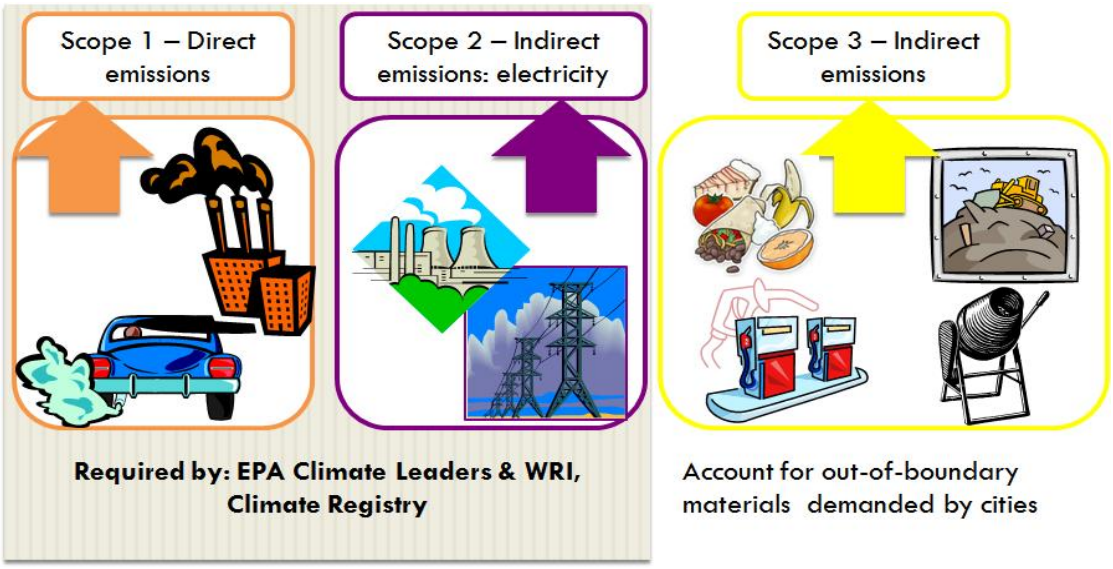
2.1 Method and Scopes

Spatial scale and boundary effects complicate GHG accounting at the scale of individual cities (Ramaswami, Hillman, Janson, & Thomas, 2008). National-scale accounting for GHG emissions (IPCC, 2006) primarily focuses on emissions that occur within the geospatial boundary of a country, which include: the accounting of total energy supplied at the national scale - electricity and natural gas for buildings and industry sectors; petroleum (gasoline, diesel, jet fuel, etc.) for surface and airline transport and industrial operations; as well as waste decay and other biological processes. Scaling down national GHG accounts to the county-scale is challenging, because county-scale GHG accounts primarily focus on the demand for energy and materials exerted by cities.

The Ramaswami inventory-footprint method for GHG accounting was pioneered by the University of Colorado Denver along with the City and County of Denver in 2008, building on previous in-boundary GHG accounting at the city-scale by incorporating six key cross-boundary activities which were found sufficient to yield a holistic GHG emission footprint (Hillman & Ramaswami, 2010). Since the success of the Denver inventory, the method has been utilized by other cities such as Portland, Oregon; Seattle, Washington; Arvada, Colorado; Austin, Texas; and Minneapolis, Minnesota and many other Colorado communities. The method uses the standardized Local Governments Operations Protocol (LGOP) to report GHG emissions from in-boundary (within jurisdictional boundary) activities and therefore, it can be applied to any jurisdictional level, such as the Ouray and San Miguel county

region. LGOP provides a protocol for the quantification and reporting of GHG emissions for cities Scopes 1, 2, and 3. See Figure 2-1.

Figure 2-1 Inventory scopes



Scope 1 emissions include emissions from in-boundary activities, such as on-site combustion of fuels, Scope 2 emissions are out-of-boundary emissions from purchased electricity consumed within the municipality, and Scope 3 emissions include other "optional" out-of-boundary activities crucial for a community such as water, food, fuels, and shelter. When activities such as airline transport, oil refining, cement production, and food production, activities that largely occur outside of the boundaries but appear in national inventories, are mapped to a jurisdiction based on demand, challenges associated with truncation at the spatial boundary of a jurisdiction are mitigated (Hillman & Ramaswami, 2010). This inclusion of additional out-of-boundary activities (World Resource Institute [WRI] Scope 3) is highly recommended by EPA's Climate Leaders Program (WRI and World Business Council for Sustainable Development, 2004).

2.1.1 In-Boundary Activities

The following energy uses are considered "in-boundary" and are required to be reported as per LGOP and World Resources Institute (WRI) protocols:

- **BUILDINGS ENERGY USE** – Use of electricity, natural gas, and propane in residential, commercial and industrial sectors in a community.
- **TRANSPORTATION ENERGY USE** – Includes tailpipe emissions from operating personal and commercial vehicles associated with a community.
- **EMISSIONS FROM WASTE DISPOSAL AND WASTEWATER TREATMENT** – In LGOP, emissions from waste disposal by residential and commercial sectors are also included in the in-boundary accounting as well as fugitive emissions from wastewater treatment.

Formally, the GHGs emitted directly from burning natural gas in buildings and gasoline and diesel fuels in vehicles are termed "Scope 1". Since electric power plants are typically located outside the spatial boundaries of most US cities, city-scale accounting procedures include methods to spatially allocate emissions that result due to demand (or consumption) within the city but occur outside the city's boundary. Therefore, emissions from power plants to produce electricity consumed within the community are termed "Scope 2".

2.1.2 Out-of-Boundary Activities

WRI designates all emissions not included in Scopes 1+2 as Scope 3. The inclusion of these emissions is optional but highly recommended by the EPA and results in an expanded GHG inventory, called a carbon emissions footprint. Including Scope 3 is necessary for per-capita comparison to national data. Additionally, communities that use a comprehensive inventory including all scopes are more likely to make greater reductions over time.

The following out-of-boundary, or trans-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** – The energy use and associated GHG emissions from producing key urban materials such as water, fuels, and food, necessary to support life in cities. Some inventories, including OC & SM's, also include concrete.

- **Waste and Water Treatment –** Emissions relating to the collection, processing, and storage of solid and liquid wastes, including the operation of landfills and water and wastewater treatment plants and direct emissions from the waste/water itself, if such activities happen outside the boundary.

- **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.

2.2 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** – GHG emissions from residential, commercial, and government buildings and industrial facilities.
- **Transport Sector** – GHG emissions from operating cars, trucks and airplanes, termed Pump-to-Wheels (P2W) emissions.
- **Materials Sector** – GHG emissions from producing critical urban materials (food, water, cement) and fuel production (termed Wells-to-Pump, W2P) and from landfilling and water and wastewater treatment.

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

- *Annual Materials or Energy Consumption* – Total kWh of electricity consumed annually, total water consumed annually, total natural gas use, etc. The annual Material/Energy Flow Analysis indicates how much is consumed in a community. Benchmarking these consumption data on a per-person or per-household basis represents how efficient the community's consumption patterns are.
- *GHG Emission Factors* – GHG emissions factors express how much CO_2e is emitted per unit of energy or material consumed. For example: kilograms of carbon dioxide equivalent emitted per kilowatt-hour of electricity consumed, or kg-CO_2e/kWh.

Total emissions are computed as the product of how much is consumed and the GHG emissions per unit of the product consumed, using the following simple equation:

∑[Material/Energy Flow Analysis (MFA) x Emission Factor (EF)] = Total Emissions

In the next section, consumption data and emission factors for all three sectors are reported and an overall community-wide GHG inventory and footprint is developed.

This section reports energy (or materials) consumption data and associated GHG emissions factor for the year 2010 (or most recent data available), for the three main sectors:

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

This baseline inventory can be referenced to measure OC and SMC's progress in the coming years. For each sector, raw consumption data are presented, the data are normalized and compared with benchmarking metrics, and emission factors are quantified. The total GHG emissions from each sector are consolidated and reported as an overall community-wide summary in Table 2-4. GHG emissions are reported in metric tons (mt) of carbon-dioxide equivalent, mt-CO_2e.

2.2.1 Buildings Sector

The buildings sector energy use reports electricity and natural gas consumed in residential, commercial, and industrial facilities. The GHG Inventory revealed that buildings in OC and SMC account for 63% of the two counties' total emissions, higher than the national average of 38% of total emissions (U.S. Green Building Council, 2010). Data were obtained from San Miguel Power Association (SMPA), which supplies electricity consumed within the two counties in 2010. SourceGas, the primary natural gas provider to the OC and SMC, supplied data for natural gas consumption. Amerigas and Ferrel provided propane data. Electricity used in the counties accounted for 77% of buildings sector emissions with the 21% attributed to natural gas and 2% propane use.

Data were obtained from San Miguel Power Association (SMPA), which supplies electricity consumed within the two counties in 2010. SourceGas, the primary natural gas provider to the OC and SMC, supplied data for natural gas consumption. Amerigas and Ferrel provided propane data. Electricity used in the counties accounted for 77% of buildings sector emissions with the 21% attributed to natural gas and 2% propane use.

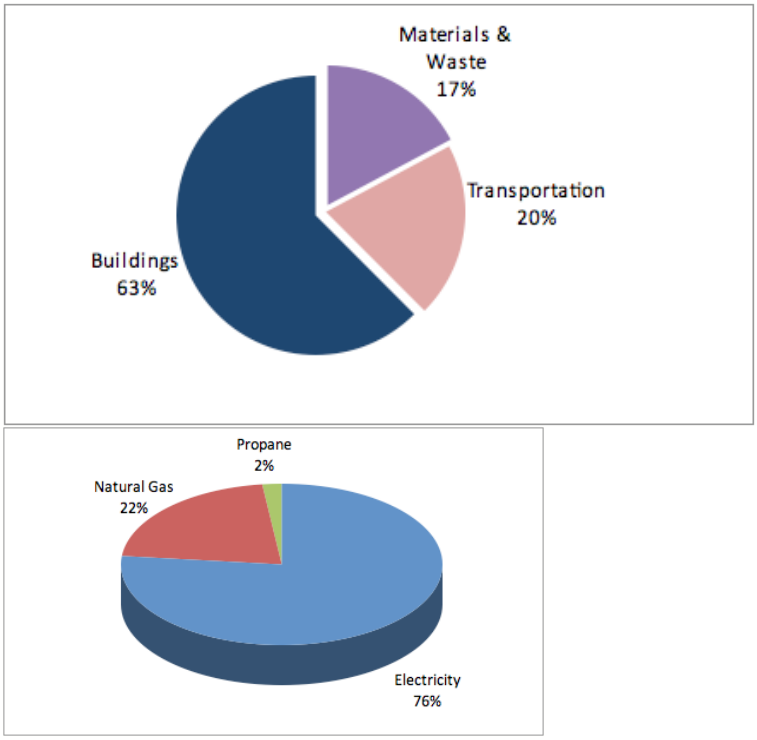


Figure 2-2: Sector Emissions Breakdown

As illustrated in Table 2-1, 116 thousand mt-CO_2e or 54% of total buildings emissions are attributed to the residential sector with the remaining 45% (98 thousand mt-CO_2e) from commercial and 2% (1.8 thousand mt-CO_2e) from industrial energy use. In order to normalize residential buildings energy use data, it is useful to express residential consumption by average monthly kWhs and therms per household. While this provides a benchmark for regional comparison, it is also useful to determine per capita emissions associated with buildings energy use. Per capita emissions associated with total building energy use is 18.3 mt-CO_2e per capita per year.

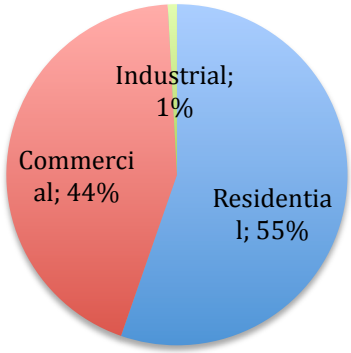


Figure 2-3: Electricity by Type of Building

Buildings Energy Use Intensity

Using the number of households and the square footage of commercial spaces in OC and SMC (data from the assessor's office) energy use intensity (EUI) can be computed in

terms of electricity and natural gas use per household, and kBtu used per commercial square foot. Calculated energy intensity for commercial buildings in is benchmarked with energy intensity metrics reported by the Energy Information Administration (EIA) in the Rocky Mountain region and national data. The Rocky Mountain region reports an average of 104 kBtu/sf/yr in commercial buildings while national data reports an average of 90 kBtu/sf/yr. OC and SMC energy use intensity is in line with the national average at 97.7 kBtu/sf/yr while Denver has an EUI of 179 kBtu/sf/yr. Contrary to the commercial EUI in the OC and SMC region, the residential benchmark value is higher, at 1330 kWh/hh/mo, than that of the national average and most of the surrounding municipalities (see Table ES-1 and Table 2-1).

Table 2-1 Summary of Building Energy Use in Ouray and San Miguel Counties, CO

A. Residential Energy	**2010**
Total Number of Populations	11,795
Total Number of Households	5,476
Total Grid Electricity Used	87,372
Electricity/household/month (kWh/hh/mo)	1,380
Total Number of Customers (Natural Gas)	3,507
Total Natural Gas Used (million therms)	4.7
Natural Gas/household/month (therms/hh/mo)	111
Propane Consumption (million gallons)	0.68
Total Residential GHG emissions (thousand mt-CO_2e)	**116.3**
B. Commercial-Industrial Energy	
Total Commercial Area (million square feet)	1,007,216*
Total Electricity Used (MWh)	74,513
Total Natural Gas (million therms)	3.7
Total energy use per square foot (kBtu/sf)	95.1*
Total Commercial GHG Emissions (thousand mt-CO_2e)	**94.7**

Data Source: Energy data from SMPA and SourceGas. GWh = Giga Watt-hours of electricity = 1 million kWh. Both electricity and natural gas use can be combined and represented as kBtu (1 kWh = 3.412 kBtu; 1 therm = 100 kBtu).
* Ouray County only data

Emission Factors for Electricity & Natural Gas

The GHG emissions factor for electricity use was provided by SMPA as 1.0 kg-CO_2e/kWh. SourceGas is the main company that provides pipelined natural gas to Ouray and San Miguel Counties and the emissions factor is reported as 5.4 kg-CO_2e/therm. Data for propane use was obtained from Amerigas and Ferrel gas companies and the emission factor is reported as 5.74

CO_2e/gallon. These emission factors are in line with the factors reported by the Environmental Protection Agency (EPA) and EIA (U.S. Environmental Protection Agency, 2010). To yield the total GHG emissions in mt-CO_2e, the total consumption of electricity, natural gas, or propane is multiplied by the emissions factor.

2.2.2 Transportation Sector

The transportation energy use in OC & SMC includes two main modes of transport:

1. **Personal and Commercial Motor Vehicles:** Cars and trucks, modeled for the counties, were separated to assign estimated vehicle miles traveled of personal and commercial traffic attributable to OC & SMC.
2. **Airline Transport:** Energy use associated with jet fuel and fleet operations at the Montrose Regional Airport in 2010 attributable to OC & SMC and at the Telluride Regional Airport in 2010.

The transportation sector accounted for 20% of the two county total emissions, and it is well below the national average of 30% of total emissions (Shuford, Rynne, & Mueller, 2010). A summary of the miles traveled, fuel consumed and GHG emissions for both modes of transport are presented in Table 2-2.

Table 2-2 Transport Distances, Fuel Use (P2W) and GHG Emissions by Modes of Transport

A. Personal & Commercial Motor Vehicles	**2010**
Annual Vehicle Miles Traveled (million VMT)	106
VMT/person/day	26.2
Annual Fuel Use	
Gasoline (million gallons)	5
Diesel (million gallons)	0.8
Total GHG Emissions from Personal and Commercial Motor Vehicle Transport (thousand mt-CO_2e)	53.9
B. Airline Travel	
Enplaned Passengers	**76.132**
Jet Fuel and Aviation Fuel (million gallons)	1.5
Total GHG Emissions for Airline Travel	16
Total GHG Emissions from Transportation Sector (thousand mt-CO_2e)	70

Surface Miles Traveled

To calculate the surface miles traveled for the Ouray and San Miguel region two different methods were utilized: vehicle registration and average daily traffic counts. Average number of the two methods was used to calculate the total vehicle miles traveled (VMT). Vehicle registration data, from the Colorado Department of Revenue, allows estimation of the total number of VMT by multiplying the number of registered vehicles by the national average 12,000 miles per year. While, the data on average daily traffic of select roadway segments, provided by the Colorado Department of Transportation, allows estimation of the total VMT by multiplying the number of vehicles on predefined roadway segments by 342 days/yr (number of working days in a year). The two methods average to 105 million VMT/yr for Ouray and San Miguel region.

The VMT intensity can be defined as the total amount of VMT in Ouray and San Miguel per resident of the Ouray and San Miguel. To determine the VMT intensity, the total VMT is divided by the population.

Normalizing the total annual VMT results for personal and commercial vehicles per Ouray and San Miguel County resident allowed the data to be compared with regional and national transportation data[3]. As

Table **2-3** indicates Ouray and San Miguel's VMT intensity (per person/per day) is in line with both regional and national data.

Table 2-3 OC & SMC VMT compared to the National average, State of Colorado, and other cities

Description of Benchmark	**US National (2007)**	**CO State (2007)**	**Denver (2007)**	**Arvada (2006)**	**OC & SMC (2010)**	**Units**
Vehicle Miles per person per day	27.0	24.5	25.0	12.3	26.2	VMT/person/day

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

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

economies as reported in ICLEI CACP software. Fuel consumption was computed by dividing the total annual VMT by the average fuel economy (ICLEI-Local Governments for Sustainability, 2009)[4].

Airline trips

Energy use associated with jet fuel and fleet operations of Ouray and San Miguel in 2010 was allocated to the two counties using the data from the Montrose Regional Airport and Telluride Airport. In 2010, 65% of the total jet fuel consumed at Montrose airport and 100% of the jet fuel consumed at Telluride airport was attributed to the two-county region.

Emission Factors for Diesel, Gasoline and Jet Fuel

Diesel and gasoline emissions factors were obtained from ICLEI calculations (ICLEI-LGOP, 2008) and jet fuel emission factors were obtained from the Energy Information Administration. 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, 9.7 kg-CO_2/gallon for jet fuel (Jet A) and 8.3 kg-CO_2/gallon for AvGas (California Air Resources Board, California Climate Action Registry, ICLEI - Local Governments for Sustainability, The Climate Registry, 2008). The emissions factors for transportation fuels were multiplied by the total demand for transport to compute the total transport sector tailpipe emission. Table 2-**4** shows the consumption or material flow of gasoline, diesel, and jet fuels, emission factors associated with each fuel type, and GHG emissions associated with transportation. In 2010 OC & SMC emitted 69 thousand mt-CO_2e from transportation. Details are provided in Table 2-4.

4 Fuel economy data from ICLEI-CACP.

Table 2-4 Consumption and emission factors for gasoline, diesel, and jet fuels

Sector/Use	Community-wide annual urban material/energy flows, MFA		GHG emission factor (EF)		Total GHG emitted = MFA x EF	
Surface Vehicle Miles Traveled, VMT	105	Million VMT		P2W kg-CO2e/gal	54	thousand mt-CO2e
	20.1	Avg. fuel economy in mpg (gasoline)	9.1			
	6.3	Avg. fuel economy in mpg (diesel)	10.2			
Airline Travel P2W	1,552	Thousand gallons jet fuel	9.9	P2W kg-CO2e/gal	15	thousand mt-CO2e
Total					69	thousand my-CO2e

The Materials and Waste Sector accounts for 17% of GHG emissions in OC & SMC

2.2.3 Materials and Waste Sector

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

Sources for Annual Consumption of Key Materials

The consumption of food was tracked in terms of money spent on food expenditures as reported in the Consumer Expenditure Survey for residents ($3,662 per home as 1997$) (Consumer Expediture Survey, 2009). Cement use per person was obtained using the Colorado Economic Census data. Water treatment direct emissions were not obtained but were calculated based on assumed parameters, while the indirect emissions were captured in the electricity use data. While the wastewater emission were estimated based on the theoretical fugitive emissions and the population numbers of the curbside trash pickup to residential accounts within a target market, which included detached, paired and certain attached homes. This limited service would not be a good proxy for estimating total trash generation within the area because trash volumes may substantially deviate in the commercial sector and other types of residential. Consequently, municipal solid waste volumes were estimated from the regional data of waste management and Bruin Waste 2010 to an average of 2.30 pounds per person per day.

Emission Factors for Well-to-Pump

This inventory also included emissions from producing the fuel, which includes the energy for production and the energy in transporting the fuels to the pump. The GHG emissions factors for

producing transport fuels were obtained from the GREET[5] model, well-to-pump (W2P) analysis as 2.3 kg-CO_2e/gallon for gasoline, diesel, and jet fuels. OC and SMC emitted 45 thousand mt-CO_2e from gasoline fuel production, 9 thousand mt-CO_2e from diesel fuel production and 15 thousand mt-CO_2e from jet fuel production.

Water and Wastewater Emissions

Emissions from treating water and wastewater at water treatment plants servicing the area have been included in the countywide electricity data. Water and wastewater treatment accounted for 1% of electricity emissions, each.

Most of Ouray and San Miguel emissions associated with wastewater and water treatment that were included in the materials sector, 240 mt-CO_2e, for 2010 were attributed to the fugitive emissions from the treatment process.

Cement in Urban Concrete

Cement is included in GHG inventories because of its high use in daily municipal operations. It is usually imported in large amounts and for every metric tonne produced about 1-mt-CO_2e is emitted. When cement is made, the reaction with the limestone produces carbon dioxide, which can comprise about 3% of a city's/county's total GHG emissions. The flow of cement was determined based upon consumption data collected from the 2007 Colorado Economic. The per capita cement consumption for Ouray and San Miguel Counties was determined by multiplying the total expenditure of cement products in the Denver-Aurora area by the cost of cement per kilogram ($/2.32kg). The kilograms of cement attributed to the two-county region population were calculated by taking the proportion of the total Colorado population. 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) (NREL, 2001)[6]. It is estimated that Ouray County and San Miguel County, in 2010, emitted 5,897 mt-CO_2e from cement.

Food Consumption

Food is another product that is usually not produced within municipal limits and is brought in from

5 GREET refers to Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model developed by the U.S. Department of Energy's Transportation Technology R&D Center, Argonne National Laboratory.

6 The U.S. Life-Cycle Inventory (LCI) database contains data modules that quantify the material and energy flows into and out of the environment for common unit.

thousands of miles away. The embodied energy from food and food packaging was determined from "food consumed at home" for the two-county area. Food expenditures were determined on a per-household basis from the Consumer Expenditure Survey (U.S. Census Bureau, 2009). Total expenditure is determined using a bottom-up method for the households in Ouray and San Miguel. The average food expenditures in Ouray and San Miguel was estimated to $3,662 per household per year, with the total estimate of $20 million for the region (all figures are in 1997 dollars). Using an emission factor for food of 2 kg-CO_2e/$1, the total GHG emissions from food production in Ouray and San Miguel Counties in 2010 were 20,000 mt-CO_2e (Carnegie Mellon University Green Design Institute, 2011)[7].

Municipal Waste and Recycling

Ouray and San Miguel's waste generation was calculated based on the information provided by the Waste Management of the Greater Montrose Area and Bruin Waste. The total annual waste generation was estimated using the percent of customers served in Ouray and San Miguel and multiplied by the total annual handled by the Greater Montrose Area Waste Management. The same procedure was used to calculate the total waste generated from Bruin waste management data. In 2010 Ouray and San Miguel generated 4,868 short tons of waste, averaging to approximately 2.3 lb of waste per person per day, resulting in 5 thousand mt-CO2e. It is important to note that 2.3 lb of waste/person/day does not provide a clear situation on municipal solid waste generation in Ouray and San Miguel due to lack of appropriate data and large discrepancy among the data that was provided. While the primary set of data suggested 2.3 lb/person, a secondary data set indicated 20.42 lb/person. The lower estimate is below the regional and national average, while the second number is several times above the regional and national average. In order to address this issue of discrepancy, an appropriate data collection needs to be developed. More representative data regarding waste generation, will allow for development of appropriate actions that will help mitigate the future waste generation and greenhouse gas emissions related to such activities.

Total Urban Materials Emissions

Total emissions from fuel production, water, wastewater, cement, food production, and municipal

7 Emission factor derived from: Economic Input-Output Life Cycle Assessment (EIO-LCA) tool which estimates the materials and energy resources required for, and the environmental emissions resulting from, activities in the U.S. economy.

solid waste and recycling are shown in Table 2-5.

Table 2-5 GHG Emissions from manufacture of key urban materials consumed in Ouray and San Miguel

	2010	
Material	Annual Material Flow	GHG Emissions, thousand mtCO2e
Fuel Production (W2P for all fuels)		
Gasoline (million gallons)	4.9	11.47
Diesel (million gallons)	0.8	1.93
Jet fuel (million gallons)	1.6	3.75
Water (million gallons)	-	-
Wastewater (million gallons)	-	0.24
Cement in Urban Concrete (thousand mt)	5.8	5.9
Food & Packaging ($ million)	$20	30.08
Municipal Solid Waste (thousand mt /year)	4.4 !!!	5
Recycling per person-day (lb/person/day	N/A	N/A
Total GHG Emissions for Key Urban Materials		59

2.3 Community-Wide and Per Capita GHG Emissions Footprint

Table 2-6 presents a comprehensive tally of GHG emissions from the buildings, transportation, and material sectors. The table includes materials flows, tracking metrics (in parenthesis after each consumption figure), and emissions factors as well as the total GHG emissions. The total community-wide emissions for the Ouray and San Miguel Counties in 2010 were 345 thousand mt-CO_2e. The per-capita emissions (population of 11,795) were 29.3 mt-CO_2e/person.

Table 2-6 Comprehensive Scope 1-2-3 GHG Emissions for Ouray and San Miguel County, 2010

	Sector/Use	Community-wide annual urban material/energy flows, MFA		GHG emission factor (EF)		Total GHG emitted = MFA x EF	
Scopes 1 + 2 + Waste	Buildings Electricity Use	166	GWh	1.00	kg CO_2e/kWh	166	thousand mt-CO_2e
	Buildings Natural Gas	8	Million therms	5.4	kg CO_2e/kWh	46	thousand mt-CO_2e
	Buildings Propane	0.7	Million gallons	5.7	kg CO_2e/gallon	4	thousand mt-CO_2e
	Surface Vehicle Miles Traveled, VMT	105	Million VMT		P2W kg-CO2e/gal	54	thousand mt-CO2e
		20.1	Avg. fuel economy in mpg (gasoline)	9.1			
		6.3	Avg. fuel economy in mpg (diesel)	10.2			
	Water/Waste Water	-	Million gallons	Varies		-	thousand mt-CO_2e
	Municipal Solid Waste	4,868	short tons/year	1.15	mt-CO2e/mt-waste	6	thousand mt-CO_2e
Scope 3	Airline Travel PTW	1.6	Jet and Aviation Fuel (thousand gallons)	9.9	PTW kg-CO2e/gal	15	thousand mt-CO2e
	Fuel Production (WTP)	1.6	Jet and Aviation Fuel (million gallons)	2.3	Gasoline WTP (kg CO_2e/gal)	1	thousand mt-CO2e
		0.8	Diesel fuel (million gallons)	2.3	Jet fuel WTP (kg-CO_2e/gal)		
		5.0	Gasoline fuel (million gallons)	2.3	Diesel fuel WTP (kg-CO2e/gal)		
	Cement Use	5,897	Mt-cement	1.0	mt-CO_2e per mt cement	17	thousand mt-CO2e
	Food Purchases	$20.1	Million (1997 $)	1.5	kg-CO_2e/$ (1997 $)	6	thousand mt-CO2e
Total Community Wide Emissions:						**345.6**	**thousand mt-CO_2e**
Community wide per capita emissions						**29.3**	**mt-CO_2e/ capita**
Community wide per capita emissions w/ Visitors						**24.2**	**mt-CO_2e/ capita**

SECTION 3: SUSTAINABILITY ACTION RECOMMENDATIONS

3.1 Business as usual 2020 Projection

From 2000 to 2010, the two-county area saw an average annual growth rate of 2.5%. If the population continues to grow at this rate between 2010 and 2020, the population will increase by 5223 for a total 2020 population of 17,018.

Using the assumption that per capita emissions stay constant, Ouray and San Miguel County community-wide emissions are expected to increase by 24% by 2020, reaching nearly 500 thousand mt-CO_2e.

The suggested strategies for reduction of greenhouse gas emissions are based on voluntary and mandated compliance that encourage investment in renewable energy and energy conservation.

3.1.1 Demand-Side Management Program (Electricity)

Demand Side Management (DSM), is an energy conservation effort put forth voluntarily by utility companies and targets the reduction of peak demand by providing incentives for conservation and efficiency. A utility uses a DSM program to circumvent having to build additional power plants or use expensive fuel sources such as natural gas to supply electricity during peak periods. DSM programs can be designed for either commercial or residential customers and employ various strategies that either 1) shift peak demand; or 2) reduce total energy load demand. The result of a successful DSM is a win-win situation, the customer is rewarded either through an energy efficiency rebate or a reduction on their bill and the utility avoids utilizing a more expensive power source to meet peak demand.

Tri-State Generation and Transmission Association's Demand Side Management program characterizes energy efficiency programs through three potentials: technological, economic and achievable. The technological potential is described as a potential savings if the entire technology base is replaced with the most efficient technology, while the economic potential is described as potential monetary savings from installation of the new technologies. A study completed on behalf of Tri-State has shown that the greatest savings in electricity consumption can be achieved in the residential sector through technological implementation, followed by economic incentive. In the 2008-2009 energy efficiency program initiative, Tri-State has expanded the demand side management program to include several energy efficient technologies: Premium efficiency electric

motors and ENERGY STAR appliances, LED lighting, and low temperature heat pumps and energy efficient heating systems. In 2008, Tri-State paid out in excess of $1.8 million under the EEC Program, and since inception, the program has resulted in the reduction of approximately 73 MW in demand and saved 80,000 MWh in energy in the Tri-State service area. The technology-oriented programs go along with, Tri Sate initiated, Load Management Programs that focus on altering consumer energy consumption behavior. The programs target peak load consumption and encourage end-users to shift use of energy to a different part of day. These programs are among several others aimed at reducing the overall energy consumption and energy load through energy efficiency and have a cost–effectiveness of $0.047/KWh. Tri-State Generation & Transmission's DSM Program could potentially result in savings of 2,054 mt-C02$_e$ or 0.421% decrease from 2020 business as usual scenario.

3.1.2 Demand-Side Management Program (Gas)

SourceGas is the main supplier of natural gas for the Ouray and San Miguel residents and the two-county area constitutes 5.25% of the total customer demand. SourceGas is anticipating 1% increase in annual consumption and currently has developed a demand side management (DSM) program. If the program is fully implemented it has a potential to create significant savings in for Ouray and San Miguel residents by 2020. It is estimated that a proper DSM could save up to 33% of the projected natural gas consumption in the area and therefore contribute to greenhouse gas emissions reduction by 1.87% or 9,303 mt-CO_2e.

3.1.3 Residential GreenPower

Energy produced from renewable energy such as wind, solar, or hydro does not generate air or water emissions and does not produce hazardous waste. Additionally, renewable energy does not deplete natural resources such as coal or petroleum.

Green Blocks is a voluntary renewable energy program offered by San Miguel Power Association (SMPA). Green Blocks customers have the option of purchasing 100-kilowatt-hour (kWh) blocks for $1.00 per block.

SMPA provides Ouray and San Miguel customers with electricity and therefore many residents could conceivably participate. In 2010, residential green power accounted for 2.1% of total energy purchased in the OC & SMC. Educational campaigns and incentive programs aimed at increasing the

green purchase power to 8% of total energy used in the area by 2020 could result in saving of 8,000 mt-CO_2e.

Ouray and San Miguel can facilitate an education campaign on the benefits of renewable energy to encourage more purchases. Without any additionally incentives the City of Denver realized a 60% increase in Windsource® kWh blocks, a similar program to GreenPower, purchased from 2005 – 2007 due to education alone (Mayor's Greenprint Denver Advisory Council, October 2007).

3.1.4 Audit and Install with Attic Insulation

The GEO partners with local Colorado organizations to offer rebates directly to qualifying homeowners for the installation of insulation and air sealing measures through the Insulate Colorado program. The program provides a rebate to homeowners that insulate and air-seal their attics and exterior walls to the recommended R-Values presented in the 2006 International Energy Conservation Code (Insulate Colorado).

Homeowners can qualify for incentives and insulations after an authorized technician has completed a proper audit. The auditor evaluates the quality of the building structure and appliances used on a daily basis, and provides information regarding the upgrade costs and how much the owner should expect to save with the new technology in place.

The precedent cases have shown that an average home can save as much as 5.4% of an average home's electricity and 13.6% of natural gas consumption for an audit and install program (Energy $avings Partners). If 3% of Ouray and San Miguel households participate in this program, community-wide GHG emissions would be reduced by approximately 0.07% or approximately 360 mt-CO_2e.

3.1.5 Advanced Home Upgrade

Advanced home upgrade is a voluntary action by homeowners who wish to raise their home's energy performance to higher standards. Reaching these standards, however, can be a higher cost as well, up to $10,000 per home. Few cities have their own funding for rebates and subsidies, and typically coordinate with State-level funds and, more recently, the federal block grants. Participation rates for voluntary adoption of incentives for higher cost whole home upgrades, such as energy efficient windows, solar panels, solar water heaters etc., are often very low. Denver, CO, case studies have presented evidence that the participation rates for this type of voluntary action are in

the 0.1% level.

Depending on the upgrades, advanced home upgrades can reduce greenhouse gas emissions by 1.7 mt-CO_2e per home. If 0.1% of Ouray and San Miguel homes participated in this energy efficiency program, it could result in 0.034% of total GHG emissions reduction.

3.1.6 Energy Display Meter Distribution

The "Meter", is an easy-to-use plug-in device that allows for real time tracking/viewing of energy use based on kWh and/or on cost to the house. This $100 device accurately measures energy consumption of home and office electronics and appliances instantaneously and over time.

The U.S. Department of Energy reports that 20% of our electric bills come from items that are left plugged in when they are not in use, or items that are in standby mode. When an item is plugged into the Meter, the efficiency of that item (kilowatt per hour of energy) is displayed. The Meter can help households determine which items are costing the most to run and promote a user to use less energy by replacing energy inefficient items or reducing use and being more aware of consumption. Pilot studies have found that the Meter can help consumers reduce their energy consumption by up to 20% (Wood & Newborough, 2003).

The method of GHG reduction would be based on mandatory participation. If 100% of Ouray and San Miguel residents were required to use a Meter to monitor energy consumption, 1.71% or 8,500 mt-CO_2e would be saved.

The cost for Ouray and San Miguel would not exist if obtaining the meter were mandated in every home, similar to the mandate of having a carbon monoxide or smoke detector. Much of the cost would lie in enforcing the mandate with residents.

3.1.7 LEED Silver for New Construction

To earn the LEED Silver rating, a home or a commercial entity must meet guidelines for energy efficiency set by the Leadership in Energy and Environmental Design (LEED), making them 20–30% more efficient than standard homes and commercial buildings. LEED Silver certification for New Construction requires attaining between 50 and 59 points from the seven topics below:

- Sustainable Sites (SS)

- Water Efficiency (WE)

- Energy and Atmosphere (EA)

- Materials and Resources (MR)

- Indoor Environmental Quality (IEQ)

- Innovation in Design (ID)

- Regional Priority (RP)

LEED[8] certification guidelines are simple to follow and easy to implement, making them an attractive alternative for communities that want to implement a green building code.

If the LEED Silver level is mandated for all new construction in the Ouray and San Miguel counties, it could significantly decrease the levels of energy use and therefore the levels of GHGs emitted. A 76% participation of all new commercial construction and 76% of all new residential construction, the two-county region could realize 0.47% and 1.08% reduction of the total GHG emissions and result in $0.63/sq.ft and $0.24/sq.ft savings, respectively. The total potential savings from LEED Silver for new construction could reach approximately 7700 mt-CO_2e.

3.1.8 Individualized Travel Marketing Program

Individualized Travel Marketing Program is a method used to increase awareness of transportation modes alternative to car travel. This method is based on targeted, personalized, and customized marketing approach that empowers people to change their traveling behavior. It is assumed that this method will be developed and utilized as a one-time program in 2012. If the current trends continue, Ouray and San Miguel could see an increase in total Vehicle Miles Traveled (VMT) by 5%. An Individualized Travel Marketing Program has a potential to affect 10% of the total VMT and result in a 7% decrease in the affected VMT (which is about 10% of total VMT). Success of this program could result in savings of 334 mt-CO_2e or 0.07% of the total 2020 business as usual scenario.

3.1.9 Pay-as-you-throw

8 LEED (Leadership in Energy and Environmental Design) is a standard for green building design established by the USGBS U.S. Green Building Council. (2010). *LEED for New Construction*. From U.S. Green Building Council: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220.

Ouray and San Miguel have an opportunity to promote a pay-as-you-throw trash services to its residents. The program charges users of the service directly on the basis of the amount of trash they throw away. Therefore, the program has a potential to encourage the users to recycle more and reduce waste. EPA estimates 15-28% reduction in the total municipal waste generation from this program and its implementation in Ouray and San Miguel Counties could result in 1,579 mt-CO_2e or 0.3% savings of the total 2020 business as usual scenario. *Note: effectiveness of this action are directly related to the validity and reliability of municipal solid waste data. See 3.1.9.*

3.1.10 Zero Waste

A voluntary program aimed at waste prevention, re-use and recycling could result in 7% reduction in waste generation by 2020 and consequently prevent 251 mt-CO_{2e} or 0.06% from being emitted in the business as usual scenario. *Note: effectiveness of this action are directly related to validity of municipal solid waste data. See 3.1.9.*

3.1.11 Municipal Solid Waste Production - Data Collection

Data regarding municipal solid waste (MSW) production in Ouray and San Miguel was included in this report, however it was not considered adequate representative of the current MSW situation and the potential impacts related to it. While the initial data suggested that 2.3 lbs of waste per person per day are being generated in the area, those directly involved in the making of this report concluded that this number is not truly representative of the behavior in Ouray and San Miguel and that most likely could be higher. Secondary data set was regarding was production was provided and it indicated 20.4 lb of waste/person/day production. This number is several times the national average and double the amount of waste generated by similar communities in the region. The high discrepancy in numbers related to waste production resulted in this action proposal: To better understand the impacts of MSW production in the Ouray and San Miguel area, Ouray and San Miguel must make efforts to develop an action plan to better capture information/data regarding waste production. Accompanying this document are two greenhouse gas inventory spreadsheets that present the situation of the difference in data and its impacts on greenhouse emissions in the Ouray and San Miguel area and the influence it could have on the decision making process and future action plans related to greenhouse gas mitigation.

3.1.12 High Performance Green Concrete

The production of cement used for concrete contributes to GHG emissions; green concrete uses a percentage of fly ash, a byproduct from power plants. Using this recycled material also has proven to be more durable and higher strength than traditional materials and is also less expensive.

If Ouray and San Miguel Counties used green concrete with 25% of fly ash included in the mix instead of traditional concrete for its flatwork and paving by 2020, this would reduce emissions from cement by 25%, or 1887 mt-CO_2e, 0.38% of total GHG emissions.

3.1.13 Biomass Co-firing in Coal-Fired Boilers

Ouray and San Miguel have an opportunity to develop and utilize biomass co-firing process of developing electricity. The term biomass refers to materials derived from plant matter such as trees, grasses, and agricultural crops. The main difference between biomass and fossil fuel as sources of carbon is that biomass contains carbon that is currently part of the atmospheric cycle, while carbon from fossil fuel has been out of this cycle for millions of years. Therefore, use of biomass does not contribute to the overall levels of greenhouse gas emissions. Co-firing is a fuel diversification strategy and it is utilized to decrease the cost of electricity, not to save energy. Also, when burned with coal, biomass can provide multiple benefits: lower fuel costs, avoidance of landfills and associated costs, and reduction in sulfur-dioxide emissions.

Currently, there are two power plants in the Ouray and San Miguel area that could potentially utilize the coffering technology: Craig and Nucla. There is a direct relationship between use of biomass and greenhouse gas emissions. For example, using biomass to replace 10% of coal can reduce the net greenhouse emissions by 10%. If Craig and Nucla were to utilize 50/50 (coal/biomass) mix *(depending on biomass availability),* such fuel use could result in greenhouse gas emissions savings equivalent to burning 20% less coal. And, based on the projected electricity use in Ouray and San Miguel, this could equate to saving of 35,429 mt-CO_2e or 7.32% of business as usual scenario.

In order to achieve all of the potential benefits of the co-firing plant multiple conditions need to be present. Since biomass has a lower heating value, to generate the same amount of heat to for the turbines, the amount of fuel (biomass) needs to be increased, in some instances twice the volume of previously used coal. Therefore, best opportunities for economically attractive co-firing are in the areas where: local or facility-generated biomass supplies are abundant, coal prices are high, annual use of coal is significant and the infrastructure for extracting and delivering biomass is present. If all of above and other elements, such as power plant management and community support, are in place, the implementation of biomass co-firing can reduce power plant operating expenses by 20% and at the same time contribute to greenhouse gas emissions reduction.

Figure 3-1. Biomass example economics.

Boiler Type	Example Plant Size (MW)	Heat from Biomass (%)	Biomass Power (MW)	Unit Cost ($/kW)[1]	Total Cost for Cofiring Retrofit ($)	Net Annual Cost Savings ($/yr)[2]	Payback Period (years)	Production Cost, no Cofiring (¢/kWh)[3]	Production Cost, with Cofiring (¢/kWh)[3]
Stoker (low cost)	15	20	3.0	50	150,000	199,760	0.8	5.25	5.03
Stoker (high cost)	15	20	3.0	350	1,050,000	199,760	5.3	5.25	5.03
Fluidized bed	15	15	2.3	50	112,500	149,468	0.8	5.41	5.24
Pulverized coal	100	3	3.0	100	300,000	140,184	2.1	3.26	3.24
Pulverized coal	100	15	15.0	230	3,450,000	700,922	4.9	3.26	3.15

Notes:

[1]Unit costs are on a per kW of biomass power basis (not per kW of total power).

[2]Net annual cost savings = fuel cost savings – increased O&M costs.

[3]Based on data obtained from EPRI's Technical Assessment Guide, 1993, EIA's Costs of Producing Electricity, 1992, UDI's Electric Power Database, EPRI/DOE's Renewable Energy Technology Characterizations, 1997, coal cost of $2.10/MBtu, biomass cost of $1.25/MBtu, and capacity factor of 70%.

Example economics adopted from Federal Technology Alert: Biomass Co-firing in Coal-Fired Boilers, 2004. Biomass vs. 100% coal.

3.1.14 Small- & Pico-Hydro power production.

Small-hydro

Try-County Water Conservancy District operates and maintains Ridgway Dam for the Bureau of Reclamation. The District plans to build a hydropower facility at the Ridgway Dam to produce 22.6 gigawatt-hours of electricity per year at an installed capacity of 7 MW (4.9 and 2.1 MW turbine and generator). If the entire Ridgway Dam electricity production was to be distributed to Ouray and San Miguel, it could potentially offset 4.53% or 22,553 mt-CO_2e. The cost of this project will be approximately $18,000,000.

Pico-hydro

Pico-hydro is electricity production on a small, individual household, level. The types of turbine and generator used have on average 60% efficiency and can typically have 2.5kW capacity. With a constant availability of water this type of generator can produce 13,408 kWh/home/year. If 5% (274) of current homes in Ouray and San Miguel were to install such power generators, it could potentially lead to 0.74% or 3,666 mt-CO_2e savings from 2020 levels. Cost of an individual pico-hydro power generator can exceed $10,000.

3.1.15 Local Food

Local food reduces costs and GHG emissions through reductions in

transportation; local meals have been shown to reduce emissions by 33% per plate. Local food has the added benefit that it supports 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 1,271 mt-CO_2e, or 0.26% of total GHG emissions when only looking at the avoided miles of transportation. There needs to be additional analysis on local food production and how the food growing practices influence greenhouse gas emissions.

Alternate Strategies for Future Consideration

There are several other high-impact feasible actions that would increase sustainable energy and emissions reductions. The actions in this analysis are by no means exhaustive, however they are meant to help Ouray and San Miguel Counties add to their portfolio of current actions and also to prioritize what areas to target in the near term.

Alternative potential future actions:

Buildings:

- Energy efficiency financing/mortgages (market-based)
- Carbon tax (policy)
- Tiered rate on electricity (policy)
- Business recognition program (voluntary)

Transportation:

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

Materials and Waste:

- E-waste collection (voluntary)

There are other factors to take into consideration when creating policies, such as political and economic feasibility. For example, a pay-as-you-throw solid waste mandate could be an option if the Town implemented a single-hauler strategy.

CONCLUSION

Ouray and San Miguel GHG inventory establishes 2010 as the baseline from which future emission reduction goals can be set to reduce the region's carbon emissions footprint.

This GHG inventory revealed that the buildings sector contributed to 63% of total emissions in the two-county area, the largest source of emissions. Fifty-seven percent of buildings sector emissions were attributed to residential energy use. It is projected that 2020 residential energy consumption will increase by 10% based on estimated population growth and current consumption patterns. Of the three sectors: buildings, transportation, and materials, energy consumption attributed to the buildings sector is often the most accessible for local governments to impact since transportation and materials cross jurisdictional boundaries.

Sustainability is often defined as a balance of the environment, the economy, and social equity. This report suggested pathways to sustainability and provided a matrix of suggested actions to serve as a guide to Ouray and San Miguel as the counties embark on sustainability planning. The matrix proposes practical actions to mitigate GHG emissions associated with residential buildings to be considered. Strategies in the matrix promote energy efficiency and energy conservation to Ouray and San Miguel residents. Additionally, many of these strategies can provide economic opportunities for the businesses in the area. For example, the both counties can partner with local retailers that sell ENERGY STAR appliances, Energy Meters and LEDs to promote energy efficiency and conservation.

Other cities both nationally and internationally have demonstrated that GHG emissions at the local scale can be reduced through a combination of incentives, mandates, and voluntary outreach. As Ouray and San Miguel continue to grow, absolute emissions in the two-county area will continue to rise along with the mounting risks of climate change. However, the opportunities to reduce emissions are abundant. Through innovation, leadership and public involvement, the community can benefit significantly both now and in the future from climate protection actions. This endeavor will require a staunch commitment and participation by all community sectors and forward-thinking leadership by the government. It is important for the Ouray and San Miguel to take action now to ensure that Ouray and San Miguel can continue to meet the needs of today's citizens without diminishing the opportunity for future generations to be afforded the same high standard of living.

SECTION 3 – OURAY COUNTY AND SAN MIGUEL COUNTY SUSTAINABILITY ACTIONS MATRIX

	Item Description	Cost per home	Annual Energy Savings/HH	Participation Rate	Community-wide GHG Savings (CO_2e)	Total Cost to the County	Engagement Vehicle
EDUCATION CAMPAIGNS	**GreenPower Residential** **GreenPower Commercial**	$1 premium-100 kWh block	100% GHG emission savings (0kg CO_2e/kWh)	Quadruple 2010 residential purchase (from 2.0% to 8.0%) Double 2010 commercial purchase (from 4% to 8%)	10,091 mt-CO_2e 7,259 mt-CO_2e	Program administrative costs only	San Miguel Power Association Program
	Tri-Sate Demand Side Management	Varies $0.047/kWh	24 kWh/HH/mo	100% Xcel customers	2,054 mt-CO_2e	Program admin costs only $0.047/kWh to TSGA	Tri-Sate Generation and Transmission Association
	SourceGas Demand Side Management		284 therms/home	Calculation based on SourceGas DSM plan. No specific participation rate.	9,300 mt-CO_2e	Program admin costs $0.70/therm to SourceGas	SourceGas

	Item Description	Cost per home	Annual Energy Savings/HH	Participation Rate	Community-wide GHG Savings (CO_2e)	Total Cost to County	Engagement Vehicle
	Audit and Install with Attic Insulation	Up to $2,800	5.4% of Electricity Use per home 13.6% of Natural gas use per home	3% of current stock (164 homes)	350 mt CO_2e	Program admin costs only	State Program
	Advanced Home Upgrade	$10,000 or more	1.7 mt CO_2e/hh	0.1% of current stock	9.8 mt CO_2e	Program costs for providing loans only	Coordinated program b/w State, County and NGO
MANDATE	**Energy Display Meters**	$100/unit	10% per meter	100% HH (5476 HH)	8,508 mt- CO_2e	Program admin costs only	Mandate
MANDATE	**Date Certain Residential** **Date Certain Commercial**	Varies	5.4% of Electricity Use per home 13.6% of Natural gas use per home	100% of homes sold	12,000 mt-CO_2e 8,462 mt-CO_2e	Program admin costs only	Mandate
BEHAVIOR CHANGE	**Individualized Travel Marketing Program (one year implementation)**	TBD	7% VMT decrease from participating VMT	10% of 2012 VMT	334 mt- CO_2e	$24,000 for 2012 IMT Program	County Program

	Item Description	Cost per home	Annual Energy Savings/HH	Participation Rate	Community-wide GHG Savings (CO_2e)	Total Cost to County	Engagement Vehicle
Consumption/Behavior Change	**Pay-as-You-Throw**	Varies	-	100%	1,579 mt- CO_2e	Program admin costs only	Marketing
	Zero Waste	Varies	-	100%	502 mt- CO_2e	TBD	County Program
	Green Concrete	Save 1$ per ton purchased	-	25% of fly ash/ton cement	1, 887 mt- CO_2e	TBD	Marketing
	Local Food	No Data	10% of energy used in food production	25% increase in local food consumption	963 mt- CO_2e	TBD	County Program
Alternative Electricity Generation	**Biomass Co-fired Power Plants**	No Data	0.00	2 power plants: Craig & Nucla	34,000 mt- CO_2e	$112,000-$3,450,000 (depending on boiler type)	Local Government
	Small-Hydro	$3,200	0.00	Ridgway Dam Project	22,500 mt- CO_2e	$18,000,000	Local Government
	Pico-Hydro	$10,000+	0.00	5% of existing homes	3,600 mt- CO_2e	-	Marketing

TECHNICAL APPENDIX

Emissions from Water and Wastewater Treatment

Table A-1 Annual Methane Emissions from Wastewater Treatment Plant

Variable	Description	Value
P	Population served by the WWTP with anaerobic digesters user input	11,795
Digester Gas	Cubic feet of digester gas produced per person per day [ft^3/person/day]	1.0
F CH4	Fraction of CH_4 in biogas	0.65
ρ(CH4)	density of methane [g/m^3]	662
DE	CH_4 Destruction Efficiency	.99
0.0283	conversion from ft^3 to m^3 [m^3/ft^3]	0.0283
365.25	conversion factor [day/year] 365.25	365.25
10^{-6}	conversion from g to metric ton [metric ton/g]	10^{-6}
25	Global Warming Potential	**240 mt-CO_2e**

Source: (U.S. EPA, 2008)

Emissions from Municipal Solid Waste

The EPA has developed a Waste Reduction Model (WARM) to aid municipalities in calculating the emissions associated with solid waste and recycling (U.S. EPA, 2009). 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.

BIBLIOGRAPHY

2008 ENERGY STAR Appliance Retail Sales Data . (2009 йил 16-September). From ENERGY STAR: http://www.drintl.com/HtmlEmail/2008FinalSalesData2009_09_16.xls

Blasnik, M. (2006). *Colorado Energy $avings Partners - Impact Evaluation Report.* Governor's Energy Office Management and Conservation.

California Air Resources Board, California Climate Action Registry, ICLEI - Local Governments for Sustainability, The Climate Registry. (2008). *Local Government Operations Protocol For the quantification and reporting of greenhouse gas emissions inventories.*

California Air Resources Board, California Climate Action Registry, ICLEI - Local Governments for Sustainability, The Climate Registry.

Carnegie Mellon University Green Design Institute. (2008). *Economic Input-Ouput Life-Cyle Assessment (EIO-LCA), US 1997 Industry Benchmark model*. From http://www.eiolca.net

City Light Twist & Save. (n.d.). From Seattle Climate Now: http://www.seattlecan.org/resources/home_energy/city_light_twist_save.html

City of Austin, Texas. (2008 йил 6-November). Energy Conservation Ordinance.

City of Fort Collins Climate Action Plan.

Colorado Department of Public Health and the Environment (CDPHE). (2008). *Hazardous Materials and Waste Management Division - Solid Waste Report*. From http://www.cdphe.state.co.us/HM/swreport/swreport.htm

DRCOG. (2007). *2007 Population & Household Estimates.* From DRCOG: Denver Regional Council of Governments: http://www.drcog.org/documents/Final%200607PopTableByCounty.pdf

EERE State Activities and Parternships. (2008 йил 25-June). *Electric Power and Renewable Energy in Colorado.* From U.S. Department of Energy: Energy Efficiency & Renewable Energy: http://apps1.eere.energy.gov/states/electricity.cfm/state=CO

Energy Rating. (2009 йил 2-February). From http://www.energyrating.gov.au/rfl.html

Energy Star. (n.d.). From http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW

ENERGY STAR - New Homes. (n.d.). From ENERGY STAR: http://www.energystar.gov/index.cfm?c=new_homes.hm_index

ENERGY STAR Refrigerator Retirement Savings Calculator. (n.d.). From http://www.energystar.gov/index.cfm?fuseaction=refrig.calculator&which=4&rate=0.0988&rconfig=Top+Freezer&screen=4&manu=1980-1989&tvol=19.0-21.4+Cubic+Feet&model=&submit.x=103&submit.y=12

Federal Technology Alert. (2004). Biomass Co-firing in Coal Fired Boliers.

Hillman, T., & Ramaswami, A. (2010). Greenhouse Gas Emission Footprints and Energy Use Benchmarks for Eight U.S. Cities. *Environmental Science Technology , 44*, 1902-1910.

Hillman, T., Janson, B., & Ramaswami, A. (2009). Spatial Allocation of Transportation Greenhouse Gas Emissions at the City-Scale. *Journal of Transportation Engineering , 1* (1), 88.

ICLEI-Local Governments for Sustainability. (2009). *ICLEI-CACP (Clean Air & Climate Protection Software)*, V2.2.1. From http://www.icleiusa.org/action-center/tools/cacp-software

Insulate Colorado. (n.d.). From State of Colorado Governor's Energy Office:

http://www.colorado.gov/energy/index.php?/residential/category/insulate-colorado/
IPCC. (2007). *Intergovernmental Panel on Climate Change, Climate Change 2007: The Physical Science Basis.* Cambridge, UK: Cambridge University Press.
Mayor's Greenprint Denver Advisory Council. (October 2007). *City of Denver Climate Action Plan.* City of Denver.
NREL. (2001 йил 1-May). *National Renewable Energy Labroratory (NREL)*. From U.S. Life-Cycle Inventory Database: http://www.nrel.gov/lci/database/default.asp
Ramaswami, A., Hillman, T., Janson, B., & Thomas, G. (2008). A Demand-Centered, Hybrid Life-Cycle Methodology for City-Scale Greenhouse Gas Inventories. *Environmental Science Technology , 17* (42), 6455-6461.
Residential Energy Conservation Ordinance (RECO). (2010). From San Francisco Planning + Urban Research Association:
http://www.spur.org/publications/library/report/critical_cooling/option1
Residential: Renewable Energy: Windsource: Pricing, Terms and Conditions. (2009). From Xcel Energy:
http://www.xcelenergy.com/Colorado/Residential/RenewableEnergy/Windsource_/Pages/PricingTermsandConditions.aspx
(2003-2004). *Selected western metropolitan statistical areas: Average annual expenditures and characteristics, Consumer Expenditure Survey, 2003-2004.* United States Department of Labor, Bureau of Labor Statistics (BLS).
Shuford, S., Rynne, S., & Mueller, J. (2010). *Planning for a New Energy and Climate Future.* Chicago: American Planning Association.
Southwest Energy Efficiency Project. (2010). *Southwest Green Building Initiatives*. From Southwest Energy Efficiency Project:
http://www.swenergy.org/programs/buildings/greenbuilding/initiatives.htm
State of Colorado Governor's Energy Office. (n.d.). From Low Income Weatherization Assistance Program: http://www.colorado.gov/energy/index.php?/residential/category/free-energy-services/
Summary Profile Report: Xcel Energy Custom Efficiency (DSM). (n.d.). From Best Practices Benchmarking for Energy Efficiency Programs:
http://eebestpractices.com/pdf/SummaryProfileReport_NR52.PDF
U.S. Census Bureau. (2005 йил 12-October). From 2002 Economic Census - Manufacturing - Denver-Aurora, CO Metropolitan Statistical Area:
http://www.census.gov/econ/census02/data/metro1/M1974031.HTM#N327
U.S. Environmental Protection Agency. (2010 йил 18-March). *Technology Transfer Network*. From Clearinghouse for Inventories & Emissions Factors:
http://www.epa.gov/ttn/chief/efpac/index.html
U.S. Environmental Protection Agency. (2009). *U.S. Greenhouse Gas Inventory Report.* From http://www.epa.gov/climatechange/emissions/usinventory.html
U.S. EPA. (2008). *EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006.* Environmental Protection Agency.
U.S. EPA. (2009 йил November). *WAste Reduction Model (WARM)*. From http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html
U.S. EPA: Climate Change - Greenhouse Gas Emissions. (2010 йил 9-March). Retrieved 2010 йил 17-March from U.S. Environmental Protection Agency:
http://www.epa.gov/climatechange/emissions/

U.S. Green Building Council. (2010). *LEED for New Construction*. From U.S. Green Building Council: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220
United States Department of Energy. (2007). *Refrigerators 2007 Partner Resource Guide.* From Energy Star: http://www.energystar.gov/ia/partners/manuf_res/downloads/2007Refrigerator_prg.pdf
Wood, G., & Newborough, M. (2003). Dynamic energy-consumption indicators for domestic appliances: environment, behaviour and design. *Energy and Buildings* (35), 821–841.
World Resources Institute and World Business Council for Sustainable Development. (2004). *A Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard.* Washington D.C.: World Resources Institute.
Xcel Energy. (2009 йил 20-February). *2009/2010 Biennial Demand-Side Management Plan - Residentia Segmentl* . From Xcel Energy: http://www.xcelenergy.com/SiteCollectionDocuments/docs/DSMBiennialPlan_ResidentialSegment.pdf