



CITY & COUNTY OF
Broomfield
COLORADO



Sustainable Energy Benchmarking and Greenhouse Gas Accounting for Broomfield, Colorado

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Motivation

- City scale becoming important for sustainability
 - Growing populations
 - Finite water, energy and land resources
 - Uncertainty about Climate Change impacts
- US Mayors Climate Protection Agreement
 - More than 800 US Cities have signed on to meet Kyoto Protocols at the city-scale
- Local actions suited to local culture, geography
 - Most effective with state- and federal support
 - Green Jobs
 - Money Savings and efficiency
 - Leadership in sustainable energy

What are Greenhouse Gases (GHG)?

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 - **Carbon Dioxide (CO₂)**: Fossil Fuel Burning for energy in buildings, transport and industrial production, cement production
 - **Methane (CH₄)**: Waste disposal, natural gas leaks, COWS
 - **Nitrous Oxide (N₂O)**: Fertilizers, combustion
 - Plus three CFC replacements (usually negligible in cities without these factories)
 - Aggregated in terms of global warming potential as *metric tonnes of CO₂e* (Carbon dioxide equivalents)

How much is 1 metric ton CO₂e?

- 1 mt of CO₂ gas would fill a 30-foot diameter balloon
- In one year, the average individual in the U.S. produces 15 of these balloons



... would stretch from goal line to goal
... times

... the carbon in GHG emissions of
... imagine a 9.5
... , woman, and



Why Do GHG Accounting?

Yields a CO₂e aggregate number that:

- Summarizes how efficiently we use energy and materials in each of our sectors
 - Buildings
 - Transport
 - Materials & Waste
- Shows how clean the energy is that we use in all sectors
- Allows benchmarking our efficiency in consumption with our “peers” in individual sectors and overall
 - Ex: water use, waste generation, miles traveled

Baseline GHG Accounting

- Tells us where we are now in terms of sustainable energy
- Helps set sustainable energy goals for the future
- Helps plan most effective pathways to the future
- Helps get credit/recognition for early action

Accounting Protocols: WRI, EPA Climate Leaders and ICLEI

- Scope 1 + Scope 2: GHG Emissions from End Use of Energy Within Boundary + Direct Waste emissions.
 - Tailpipe emissions from vehicles (Scope 1)
 - Emissions from burning natural gas in-boundary (Scope 1)
 - Direct release of methane from waste disposal (Scope 1)
 - Powerplant Emissions from electricity use by the organization, even if powerplant is “outside” (Scope 2)
- Scope 3 Emissions: Other Out Of Boundary Emissions; Relevant upstream emissions
 - Travel: Airline Travel, Commuter Travel
 - Embodied Energy of Critical materials for functionality: Food, fuel, cement and water use in cities

EPA Climate Leaders & WRI, Climate Registry

- Scope 1 + Scope 2 are required reporting
- EPA and WRI recommend reporting on a few relevant Scope 3 emissions
 - Optional but important
 - Creates win-win climate actions: green concrete
 - Shows trade-off between activities: airline vs telepresence
 - Prevents shifting impacts outside: Hydrogen
- Full Scope 1-2-3 Accounting yields an expanded inventory that becomes a “Carbon Footprint”

Public Understands Emissions by Three Major Sectors

Buildings Energy Use



Transportation: Tail- Pipe



Materials & Waste



Master Equation

$$\begin{aligned} & \text{[Material or Energy Use]} \\ & \quad \times \\ & \text{CO}_2\text{e Emission Factor for that Material} \\ & \quad = \\ & \text{Total CO}_2\text{e Emissions} \end{aligned}$$

Data Sources

- Consumption Data

Demographics:	DRCOG
Transportation:	DRCOG model
Building Energy:	Xcel Energy, United Power
Cement:	US Economic Census

Water:	CCB
Wastewater:	CCB
Waste:	CDPHE
Food:	Consumer Expenditure Survey

- Emissions Factors

Electricity:	Xcel Energy (<i>0.75 kg CO₂e/kWh</i>), United Power (<i>0.82 kg CO₂e/kWh</i>)
Natural Gas:	Xcel Energy (<i>5.4 kg CO₂e/therm</i>)
Gasoline, Diesel, Jet Fuel (PTW):	ICLEI (<i>9.3 kg CO₂e/gal, 9.5 kg CO₂e/gal, 9.4 kg CO₂e/gal, respectively</i>)
Fuel Processing (WTP):	GREET (<i>Gasoline 2.5 kg CO₂e/gal, Diesel/Jet Fuel 2.0 kg CO₂e/gal</i>)
Cement:	NREL (<i>0.92 mt CO₂e/mt cement</i>)

Water:	CCB
Wastewater:	CCB
Waste:	EPA WARM
Food:	Carnegie-Mellon EIO-LCA

Benchmarking Buildings Energy Efficiency



- Residential

	Broomfield	Denver	Colorado
Electricity: kWh/hh/mo	723	568	674
Natural Gas: therms/hh/mo	65	63	47

- Commercial

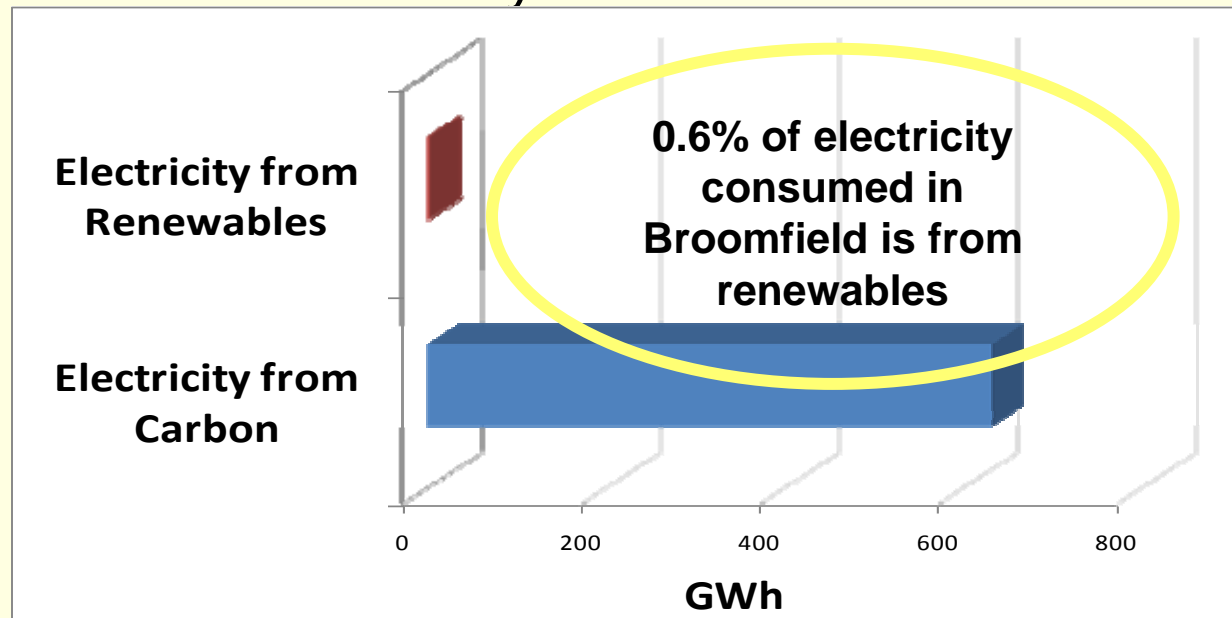
	Broomfield	Denver	Rocky Mtn Region
Electricity: kWh/sf/yr	27	21.7	15
Natural Gas: therms/sf/yr	0.56	0.86	1.3
Energy Use Intensity: kBtu/sf/yr	148	160	181

Building Sector Insights

- Broomfield's residential average monthly electricity use is higher than Denver and Colorado's average
 - Could be due to larger home size (1,900 sq ft average)
- Broomfield's average commercial electricity use is a little higher compared to Denver and the Rocky Mountain Region
- Commercial Natural Gas is more efficient in Broomfield
 - Could be explained by newer, more efficient buildings
- **Overall Buildings Sector Contribution**
 - Electricity: 633 GWh, **475 thousand mt-CO₂e**
 - Nat Gas: 23 million therms, **124 thousand mt-CO₂e**

Renewable Energy Purchases in Broomfield

- Residential
 - % of HH = 3.6%
 - % of total electricity = 2%
- Commercial
 - % of commercial premises = 0.32%
 - % of total electricity = 0.06%



Transportation Sector Efficiency Benchmarks



- Motorized Vehicle Miles Traveled (VMT) per person per day

	Broomfield	Denver	U.S.
VMT/person/day	22	23	23.4

- Airline Travel
 - Air travel at DIA was allocated to Broomfield based on proportion of trips from Broomfield to DIA (1.24%)
 - Rocky Mountain Airport was not included

Transportation Sector Insights

- Broomfield's per capita VMT's are in line with state averages
- VMT's are a function of employment intensity in the DRCOG region
- **Overall Transportation Sector Contribution**
 - Surface Travel: **288 thousand mt-CO₂e**
 - Air Travel: **49 thousand mt-CO₂e**

Benchmarking Materials Efficiency, per person

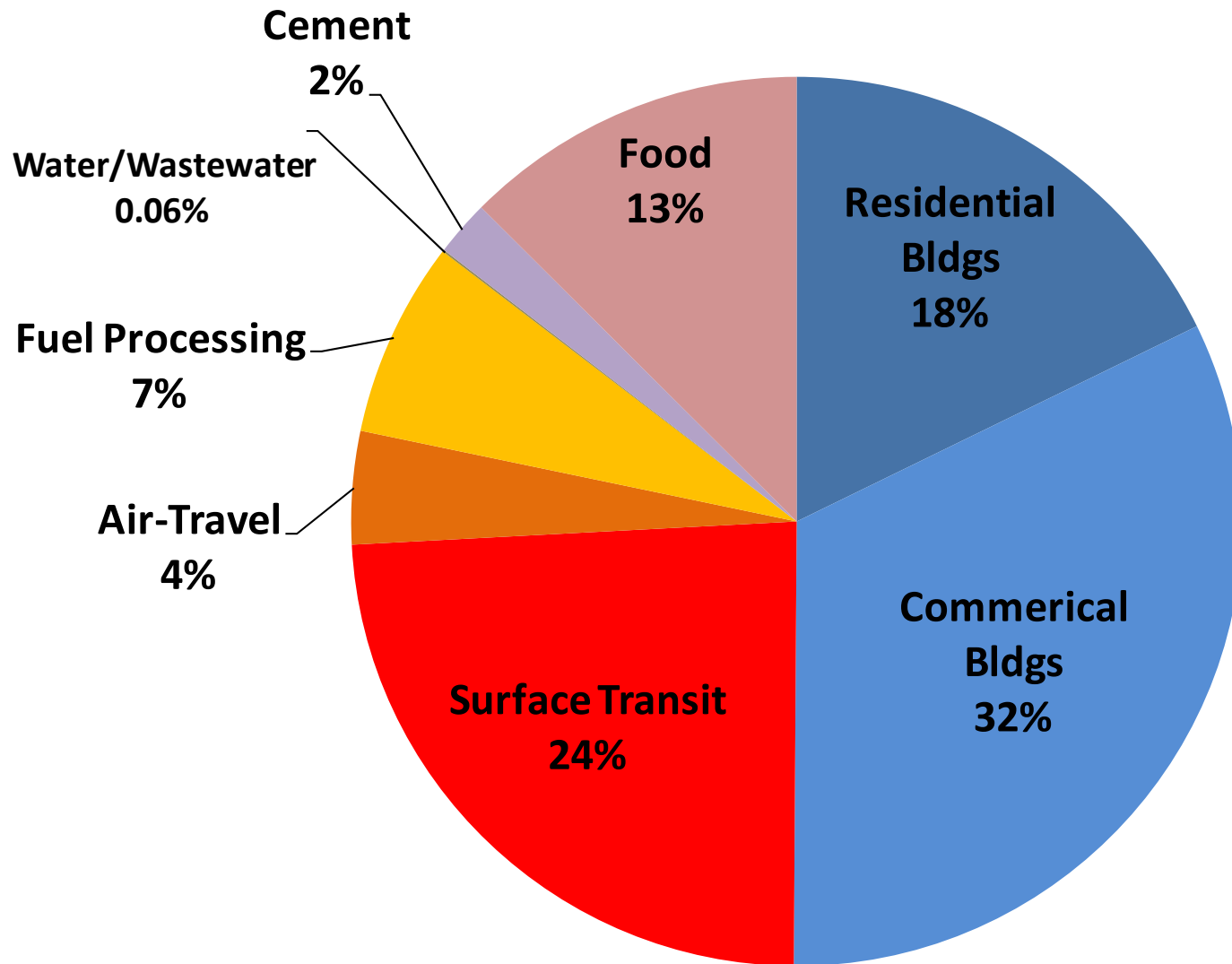


Material	Broomfield	Denver	Colorado
Water	178 gallons/day	168 gallons/day	154 gallons/day
Cement	0.5 mt/year		
Food	\$1,762 /year		
Fuel Production	670 gallons/year	800 gallons/year	604 gallons/year
Waste/End-of-life	7.2 lb/day	4.5 lb/day	6.21 lb/day

Insights form Materials and Waste

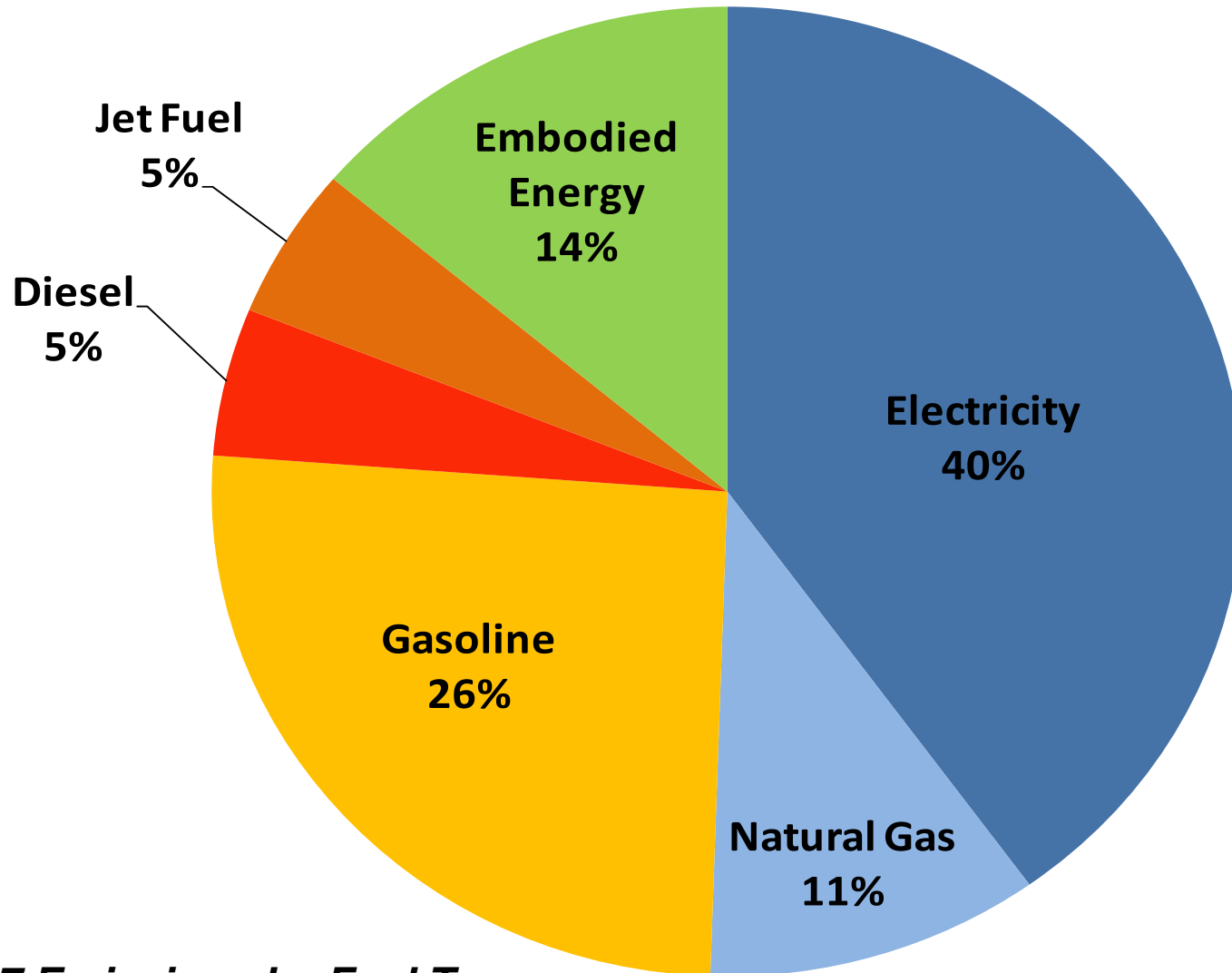
- Broomfield consumes more water per capita on average than Denver and Colorado
- Broomfield residents generate more waste on average than Denver and Colorado
- **Overall Materials Sector Contribution**
 - Materials Emissions: **249 thousand mt-CO₂e**

Per Capita Footprint = 22.1 mt-CO₂e / person
Total Footprint = 1.19 million mt-CO₂e



** 2007 Emissions by Sector*

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** 2007 Emissions by Fuel Type*

Conclusions

- Total community wide GHG's are 1.19 million mt-CO₂e
- Per capita emissions are 22.1 mt-CO₂e per Broomfield residents
 - Close to state average (*25.2 mt-CO₂e per person*)
- Building sector contributed most at 51%
- Residential energy use per home is higher in Broomfield compared to state
- Sector by sector action analysis should be done to move towards sustainable energy: efficiency strategies, and renewable energy strategies