Carbon Dioxide Emissions Inventory and Reduction in Fort Collins

Laura E. Witte, Colorado State University, Fort Collins, CO

Creative Climate Solutions

Recognizing the increasing need for widespread reduction of greenhouse gas (GHG) emissions, the Fort Collins City government has been performing biennial greenhouse gas (GHG) emission inventories since 1990 and has set numerous long- and short-term goals for reducing GHG emissions by conservation, waste reduction, and increased usage of renewable energy.[1] The most distant and ambitious goal established to date is to reduce GHG emissions 80% below the 2005 level (baseline) by 2050.[1]

Given the pressing nature of problems associated with energy overconsumption, a local environmental organization, The Fort Collins Sustainability Group (FCSG), is interested in accelerating the 2050 goal to the year 2030. In June 2009, FCSG established a list of more than 30 high priority tactics for emissions reduction called Creative Climate Solutions; this project deals with estimating the GHG emissions that would be avoided as a result of the implementation of some of these measures.[2]

Narrowing the Scope

Producing 43% of the 2.60 million metric tons CO_2e, electricity is of the highest importance

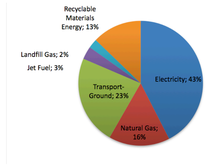


Figure 1. Fort Collins 2005 communitywide greenhouse gas emissions [3]

The residential sector is the most accessible and relevant sector to explore first

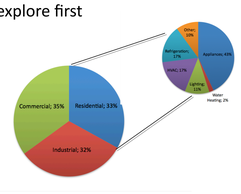


Figure 2. Fort Collins 2005 electricity usage by sector with residential end-use [4]

Inventory Methodology

Greenhouse gas	Major human sources	Avg. Atmospheric residence time, years	Global Warming Potential (GWP)	Estimated contribution to greenhouse warming, %
*Carbon dioxide (CO_2)	Combustion, deforestation	50—200	1	55
*Methane (CH_4)	Rice fields, livestock, landfills, petrol production	10	21	15
*Nitrous oxide (N_2O)	Fertilizer, acid synthesis, de-forestation	150	310	6
CFC-12 (CCl_2F_2)	Refrigeration compressor fluid	130	7100	11
CFC-11 (CCl_3F)	Plastic foam blowing solvent	65	3400	7

Table 1. Common anthropogenic GHGs.[5] GWPs, accounting for lifetime and reradiative properties, of starred gases are used to calculate carbon dioxide equivalent (CO_2e).[5] CO_2 is defined to be one.[5]

- Pounds CO_2e emitted per MWh electricity consumed: 1,698[3]
  - USEPA'seGrid output emission rates CO_2, CH_4, and N_2O specific to fuels burned in Colorado
  - Local power mix 73.5% coal, 19% hydro, 6% purchases, 1% renewables and < 1% natural gas

Figure 3. Rawhide Energy Station, Fort Collins [6]

Estimation Methodology

1. Select end-use proportion relevant to measure
2. Further divide into components
   - Based on EIA regional/national trends
3. Estimate extent to which measure already implemented
   - Based on market shares
4. Calculate new 2005 energy consumption and CO_2e emission after complete implementation
   - Apply new 2005 per capita/per household consumption to 2030 projections
5. Projections for 2030 energy consumption and CO_2e levels

Figure 4. Fort Collins, CO[8]

- Population: 183,256, based on annual 1.47% compound growth rate (2000—2005)[7,9]
- Housing: 111,999 units, based on annual 2.93% compound growth rate (2000—2005)[7]

Lighting

Figure 5. Incandescent replacement[12]

- More than 80% of lighting energy used for incandescents[10]
- Compact fluorescent lights 4 x more efficient[11]
- After 100% replacement of incandescents in 2005
  - 23,500 tonnes of CO2e conserved

Consumption parameter	2005 value, kWh	2030 total, MWh	CO_2e emission, tonnes
Per capita	151.25	27,718.39	21,348.70
Per household	347.21	38,887.72	29,951.31

Table 2. Projected 2030 energy consumption and CO_2e emissions by 2005 post-implementation per capita and per household consumption rates

Appliances

Appliance	Usage proportion	Avg wattage, W	Yearly hours of use per hh	Yearly consumption per hh, kWh	Total, kWh
Dishwasher (load/day)	0.62[13]	1,201.00[15]	426.31	512.00[14]	17,656,965.12
Washing machine (load/ day)	0.79[14]	1,808.00[15]	186.00	336.29[15]	14,702,053.44
Others	N/A	N/A	N/A	N/A	162,891,081.44
				Total, kWh	195,250,100.0[4]

Table 3. 2005 clothes and dishwasher energy usage

Table 4. Projected 2030 consumption and CO_2e emissions

- Energy efficient models use approx. 1/2 the energy of traditional models[16]
- After replacement of traditional dish and clothes washing machines in 2005:
  - 13,000 tonnes CO_2e conserved

Consumption parameter	2005 value, kWh	2030 total, MWh	CO_2e emission, tonnes
Per capita	1,400.14	256,583.69	195,758.57
Per household	3,214.10	359,975.96	274,640.91

Refrigeration

- After replacement of traditional refrigerator/freezers and standalone freezers in 2005:
  - 27,000 tonnes CO_2e conserved

Table 5. Projected 2030 consumption and CO_2e emissions

Consumption parameter	2005 value, kWh	2030 total, MWh	CO_2e emission, tonne
Per capita	331.32	60,716.10	46,322.89
Per household	760.56	85,182.09	64,989.03

Figure 6. An Energy Star qualified refrigerator/freezer[17]

Conclusions

Figure 7. Actual CO_2e emissions from residential lighting, appliances, and refrigeration as portions of total 2005 emissions[3,4]

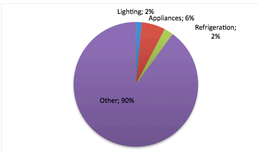
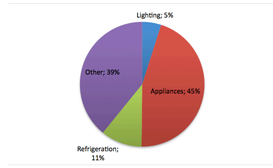


Figure 8. Projected CO_2e emissions from residential lighting, appliances, and refrigeration as portions of total 2030 emissions



Comparing figures 7 and 8 suggests that residential lighting, appliance, and refrigeration consumption must be significantly less than the projected consumption derived from these three energy-saving measures for Fort Collins to realistically meet the 520,000 CO_2e goal by 2030.

This brief study of GHG emission estimation reinforces what FCSG already recognizes about widespread GHG reduction, that it can be achieved only through a combination of pervasive actions, such as: conservation, creation of new and implementation of existing energy-saving technology, and increased usage of renewable energy. The above figures make clear the insufficiency of trying to address GHG emission reduction with only one type of action.

Continuing Work

Figure 9. Earth and its inhabitants, the motivation for reducing GHG emissions[18]

The estimations completed thus far represent a small fraction of both the number of and variety of FCSG's Creative Climate Solutions. The next topics in the estimation process include residential HVAC and weatherization and ground transportation.

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