A Greenhouse Gas Inventory for Auraria Campus

September 1

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(Updated February, 2010)

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Significant Changes Contained in the updated February 2010 Version

- Updated natural gas, steam and electricity use values from the earlier report
- Of special note, natural gas use was significantly underreported in the December 2008 version due to a conversion error – only 42% of the actual value was reported
- Steam and electricity data were underreported (not significantly) in the earlier version
- Given the above revisions, the energy intensity values (energy per square footage) were corrected
- Gasoline use was underreported slightly (not significantly) in the earlier version
- Diesel use was not reported in the earlier version
- Comparisons to campus energy use in 1999-2005 contained in the earlier version were eliminated because those values (taken from a different 2006 report) could not be verified at this time
- Some figures and tables were modified and some additional figures were added to highlight differences in Scopes 1, 2, and 3 emissions and in order to make this version more useful for ACUPCC implementation

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Executive Summary

The Sustainable Urban Infrastructure Program at the University Of Colorado Denver (UC Denver) has teamed up with the Planning & Development Department and Facilities Management of the Auraria Higher Education Center (AHEC), Metropolitan State College of Denver and Community College of Denver to develop a baseline greenhouse gas (GHG) inventory for the Auraria Campus.

Methods and Inclusions

This inventory covers fiscal year 2007/2008 (July 2007 – June 2008) and uses the World Resources Institute (WRI) protocol to describe greenhouse gas emissions represented as metric tons of carbon dioxide-equivalents (mt-CO_2e). This methodology includes:

***In-boundary* activities** ("Direct emissions") designated by the WRI as Scope 1 & 2, and are required in all inventories. In-Boundary activities include:

1. Energy use in buildings and facilities, including electricity, natural gas, and steam.
2. Tailpipe emissions from university-owned vehicles.

***Out-of-boundary* activities** ("Indirect emissions") designated by the WRI as Scope 3, are optional in terms of their inclusion in an inventory, but "provide an opportunity to be innovative in GHG management" (World Resources Institute 2004). A limited number of relevant Scope 3 emissions are highly recommended by the EPA. These emissions should be chosen to reflect critical functions of the organization. The following SCOPE 3 items were included:

1. Commuter Travel: Tailpipe emissions of non-university-owned vehicles (students, faculty and staff) used for commuting to Auraria's facilities
2. Embodied energy of key materials purchased for/by Auraria Campus, including: water; fuel (upstream emissions from fuel production and transportation); electronics purchases/recycling; and solid waste/recycling

Data was unavailable for other relevant scope 3 inclusions that should be pursued with future research, which include: Campus-sponsored air travel for business trips; Campus purchases of Building materials (concrete); Campus purchases of office paper and food.

RESULTS:

Table 1: Total Community-wide GHG emissions per Institution and per inclusion method, in metric tons of carbon dioxide equivalents (mt-CO_2e)

Full-time Students on Auraria Campus		Inventory = In-boundary Activities (Scopes 1 & 2)	Footprint = Inventory + *Out-of-boundary* activities (Scopes 1,2,3)	Net Emissions = Inventory – Renewable Energy Credit Offsets/ Waste (Scopes 1 & 2 - ~25%)
Metro	52%	21,041	32,286	13,969
U C Denver	30%	12,139	18,626	8,059
CCD	18%	7,283	11,176	4,835
Total	**100%**	**40,463**	**62,088**	**26,863**
Per Student		1.46	2.23	0.97

Table 1: Annual community-wide GHG emissions by institution. Inventory (Scopes 1 & 2), Footprint (Scopes 1, 2 & 3), and Net Emissions (Scopes 1 & 2 – the renewable energy credits and waste / recycling benefits, in metric tons of carbon dioxide equivalents (mt-CO_2e) are listed. In-boundary *activities (Scope 1+2) are underlined.*

CONCLUSIONS

The campus-wide GHG emissions are normalized per Full-Time Equivalent (FTE) student on campus (27,781 FTEs), and on a per-1000-built square feet basis to provide a measure of the GHG intensity of activities on our campus (2,111,088 gross square feet). Taking all reported *in-boundary* activities (**Scope 1+2**) into account, the Auraria Campus and the three institutions that inhabit it operate at 1.46 metric tons of CO_2e per FTE per year and 19.17 metric tons of CO_2e per 1000 square feet per year.

Including the reported *out-of-boundary* activities (**Scope 3** items which are not required but highly suggested), the campus operates at 2.23 metric tons of CO_2e per FTE per year and 29.41 metric tons of CO_2e per 1000 square feet per year.

Table 2: Energy intensity normalized per Full-Time Equivalent (FTE) and per-1000-built square feet, with applicable benchmarks (ACUPCC 2008). *Both Central Washington University and Columbus State Community College were compared as commuter colleges. University of Colorado Boulder was compared as a regional example.*

	AHEC (UC Denver, Metro & CCD)		Central Washington University (2007)		University of Colorado – Boulder (2007)		Columbus State Community College (2007)	
	per FTE	per 1000 sqft	per FTE	per 1000 SQFT	per FTE	per 1000 SQFT	per FTE	per 1000 SQFT
Inventory = *In-boundary* Activities (Scope 1+2) ***40,463 mt-CO₂e***	**1.46**	**19.17**	1.9	4.8	4.7	14.6	1.2	25
Footprint = Inventory + *Out-of-boundary* activities (Scopes 1, 2 & 3) ***62,088 mt-CO₂e***	**2.23**	**29.41**	2.7	6.7	5.7	17.6	2.7	57.1
Net Emissions = Inventory – Renewable Energy Credit & Waste Credits (Scopes 1,2 & 3 - ~25%) ***26,863 mt-CO₂e***	**0.97**	**12.72**	2.7	6.7	5.5	16.9	2.7	57.1

As can be seen above, total GHG Inventory was between 1-2 mt-CO_2e per FTE and the total Footprint was between 2-3 mt-CO_2e per FTE, which is in-line with other commuter campuses. Readers should note that enrollment figures and Full-time equivalent calculations/definitions have tended to be inconsistent, preventing any reasonable comparisons to past inventories. Efforts should be made to keep these measurements more consistent in the future to allow more meaningful comparisons to be made.

WEAKNESSES / CONCERNS

1. The low response rate for the transportation survey made assumptions disproportionately influential in measuring commuter tailpipe emissions.

2. Some materials essential to operations on campus were not reported, such as food, air travel, and office paper, so their impact is not taken into account. Cement use, though not substantial in FY2007, will become increasingly so with the building of the new science building and the several projects to follow.

3. These numbers are very conservative, as they lack food purchases, office paper purchases, cement use and airline travel; all very relevant considerations for educational institutions.

4. Auraria Campus is a commuter campus; therefore, commuter fuel use is very significant in Auraria's overall emissions. A satisfactory commuter model was derived from the limited data for this report, but should serve only as a rough approximation until more comprehensive commuter data can provide more accuracy and confidence. Bike-sharing and car-sharing programs provide an emerging market to address this issue, while current car-pool behavior and EcoPass participation provides a clear direction for existing efforts. By involving the constituents of Auraria Campus in these efforts, a sense of ownership can provide the framework for increased "buy-in" by its participants, and the costs to maintain and enforce these new efforts will be outweighed by its benefits.

5. Auraria's energy intensity is seemingly reasonable compared to self-reported numbers of other commuter colleges. However, the disclaimer remains:

> Making fair comparisons between higher education institutions is always challenging due to the rich diversity of higher education. The unverified nature of the information in this database and unavailability of unbiased normalization metrics means such comparisons are even more difficult. Users should therefore approach direct institution to institution comparisons with caution and recognize that all comparisons between institutions are inherently biased (ACUPCC 2008).

1. Community of Auraria

With approximately 38,000 enrolled students (and nearly 28,000 full-time equivalent students) spanning 136 acres, AHEC is the largest campus by population in the state. In Colorado, one out of every five students in public higher education attends classes on the Auraria Campus (AHEC 2007). Auraria Campus houses the Community College of Denver (CCD), the Metropolitan State College of Denver (Metro State), and the University of Colorado Denver Downtown Campus (UC Denver). UC Denver maintains several other buildings separate from the Auraria Campus and these facilities were included in an emissions inventory by the University of Colorado Denver, along with Anschutz Medical Campus. AHEC's Facilities Management Division maintains and oversees all campus facilities and operations.

About one in every five students (21.5%) attending UC Denver represents an ethnic minority, compared with the state-wide institutional average of 17%. Metro State holds the largest number of ethnic minority students (at a four-year institution) in Colorado at 24%. CCD's enrollment saw more than 50% of minority enrollment (Auraria Library and Minority Campus Enrollments 2007: Three College Fact Sheet n.d.).

Total enrollment in 2007 was over 38,000 students across all three schools at Auraria Campus. When faculty and staff are included (as well as AHEC staff), the total population frequenting the campus is almost 42,000. Metro State holds 54%, UC Denver has 32%, and CCD has 13%. However, total full-time equivalent students (FTE) equaled almost 28,000. When added to faculty and staff, the total is over 31,000. Metro State's total decreases to 52%, UC Denver decreases to 30%, and CCD increases to 18%.

2. Project Background

AHEC has teamed up with the three institutions on Auraria Campus to assemble a comprehensive Greenhouse Gas Inventory as indicated by the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). This inventory is done using a demand-centered, hybrid life cycle-based methodology introduced by Dr. Ramaswami et al, in "A Demand-Centered, Hybrid Life Cycle Methodology for City-Scale Greenhouse Gas Inventories" published in the *Journal of Environmental Science & Technology* in 2008.

Figure 1: Campus map

Commitment to Renewable Energy and Sustainability

This methodology has been utilized in the GHG inventories of the City and County of Denver, the City of Arvada, and the University of Colorado Denver Health Sciences Center. This inventory is being done to help satisfy the requirements from the American College and Universities Presidents Climate Commitment (ACUPCC), which was signed by the Presidents of the Community College of Denver and Metropolitan State College of Denver, as well as the Chancellor of the University of Colorado Denver.

The Student Advisory Committee to the Auraria Board (SACAB), a committee of student representatives, started the Sustainable Campus Program. This program was implemented by a favorable vote by all of the student bodies on campus and includes an escalating student fee starting at $3.00 per semester and going up to $5.00 per semester in 2010. Its goal is to reduce Auraria's "dependence on fossil fuels and to reduce the ecological impact of this campus overall, while improving campus life for all students, faculty, and staff" (ASCP 2008). This report can serve as an integral step in measuring the progress to this goal.

In addition to installing several solar-powered lighting fixtures (such as several campus maps and the flagpoles at the King Center) and high-efficient lighting for many of the parking accommodations, larger scale efforts are also at work. In 2006, AHEC contracted to purchase renewable energy credits (RECs) equivalent to 17 million kilowatt hours of wind power a year for three years, with an option to re-sign every two years after that. This offset represents approximately 42% of the electricity purchased for the campus.

Construction on the new science building and the renovation of the existing science building has begun, and they both are expected to be certified as LEED Gold up on completion. LEED is a certification program that recognizes the sustainability of the design, construction and operation of new and existing buildings.

3. GHG Inventory: Goals and Methodology

Goals and Objectives: Energy use constitutes the single most comprehensive source of society-based CO_2 emissions, generated from the burning of fossil fuels (coal, petroleum products, natural gas and wood). Society relies on these fossil fuels for its buildings (in both its manufacture and the amenities it provides), transportation, and materials production (food, concrete, water, waste, etc.). Certainly natural sources can be a significant source of CO_2 emissions, such as forest fires, plant and matter decay, respiration, etc. However, our efforts concentrate solely on emissions that are a result of human activity.

Methane (CH_4) emissions are usually the result of leaking natural gas pipelines, landfill decomposition and/or wastewater treatment. Nitrogen oxides (NO_x) are emitted anytime nitrogen and oxygen interact at high temperatures, as in during combustion. Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) are all used as substitutes for more destructive chlorofluorocarbons (CFCs), and are released via leaks in refrigeration systems.

Methodology: In an effort for consistency, all of these gases are measured in carbon dioxide-equivalents (CO_2e). CO_2e calculates the impact of the other GHGs by their Global Warming Potential (GWP) compared to that of CO_2. The Global Warming Potential is the "ratio of the time-integrated radiative forcing from the instantaneous release of 1 kg of a trace substance relative to that of 1 kg of a reference gas" (*EPA GHG Inventory 2007*). For example, one metric ton (1000 kilograms) of CO_2 equals one metric ton of CO_2e; however, one metric ton of methane (CH_4) is equal to 21 metric tons of CO_2e.

Total CO_2e emissions are calculated by multiplying the Energy/Material Flow Analysis (E/MFA) by that energy/material's Emission Factor (EF) from its Life Cycle Assessment (LCA):

$$\textit{Total } CO_2e \textit{ emissions} = E/MFA * EF_{LCA}$$

where E/MFA represents the number of units of a material or energy (i.e. total kilowatt hours used) and EF_{LCA} represents the amount of CO_2e attributable to each (kilograms of CO_2e per kilowatt hour).

Emissions are separated into two categories: *In-boundary* (direct) emissions, such as those as a result of heating, cooling and providing electricity to the buildings on campus, tailpipe emissions of AHEC-owned vehicles, and on-site leakage of refrigerant; and *Out-of-boundary* (indirect) emissions, such as tail-pipe emissions of commuter traffic, and emissions produced from the production, packaging and transportation of goods, water, food, and fuel used by AHEC-owned vehicles.

Below is a summary of World Resources Institute's GHG Accounting Protocol, which served as the framework for this approach:

a. Goals:

1. To manage GHG risks and identify reduction opportunities
2. To facilitate public reporting and participation in voluntary GHG programs
3. To facilitate participation in mandatory reporting programs
4. To facilitate participation in GHG markets
5. To allow recognition for early voluntary action.

b. Accounting and reporting principles:

Relevance – This ensures that the data collected and the information harvested is of use to decisions makers, as opposed to just abstract measurements. This data has to be collected according to clearly defined boundaries based on financial and managerial influences that allow the company procedural control. The boundaries can be based on organizational structures, operational boundaries and/or the business context of the entities involved.

Completeness – The data collected can only be useful if it is done in a consistent, comprehensive manner.

Consistency – For the data to be useful, it needs to be consistent enough to be compared over time between and among similar companies. Consistency overtime is crucial. Unnecessary changes that would deem past measurements as unreliable should be avoided.

Transparency – For that data to be tracked and compared over time and across sectors, the methodologies, procedures and limitations must be highly visible. These processes must be clear and understandable to allow internal review and external verification.

Accuracy – Decision-makers need to be assured of the precision of the data in order to minimize uncertainty and to maximize benchmarking. This will lend greatly to the credibility of the information and the transparency of the methods used to get it.

c. Organizational boundaries:

1. Equity share – An organization is responsible for its economic share (usually a percentage of ownership) of an operation. This allows the risk of exposure of GHG emissions liability to mirror the financial rewards it reaps for the operations. Their responsibilities reflect closely to their financial accounting of any given project.

However, fixed asset investments are not included.
2. Control – Organizations are solely responsible for the operations under its control, either financially or operationally, regardless of interest owned. Financial control is defined as having a majority stake (of both risks and benefits) regardless of ownership status. For joint ventures, the equity share approach is used. Operational control is just that: an organization becomes responsible for the GHG emissions of an operation in which it has full authority to implement operational policies. Deciding between the two involves several criteria: the reflection of commercial reality, government regulations, liability, risk management, its alignment with financial accounting, management information, performance tracking, cost and completeness of reporting.
In the case of Auraria Campus, AHEC serves as a business park specifically tailored for educational institutions, which affects each tenant's abilities to implement policies in buildings that it essentially rents through a proportional cost-share. However, with the increased collaboration between AHEC and the three schools, this inventory will allow each school to take responsibility and ownership of their respective emissions, all under the umbrella of the Auraria Higher Education Center.
Therefore, our efforts would be best reflected through AHEC's *financial control*.

d. Operational Boundaries:

These boundaries are highlighted through the WRI Scopes to determine the extent of responsibility of an organization:

- Scope 1 accounts for direct GHG emissions: for Auraria, these are emissions produced from the operation of vehicles owned by AHEC and its constituents, direct emissions produced from heating (and cooling) the campus buildings, and fugitive emissions (such as leakage from refrigeration and air conditioning equipment).

- Scope 2 accounts for the GHG emissions produced from the electricity bought and used: for Auraria, this would constitute the electricity purchased for the campus and the emissions resulting from its production and delivery. While the first two scopes are required by the WRI, the third is optional, even if it can offer the greatest opportunity for mediation.

- Scope 3 accounts for commuting by students, faculty and staff to and from campus, and embodied energy in key materials purchased by/for Auraria Campus and its operations (such as fuel, water, electronic waste and solid waste).

Emissions from air travel were not considered in this report but certainly should be in future reports. However, since this information was included in the separate report prepared by/for the University of Colorado Denver, a balance needs to be struck in order to ensure it is counted for the Community College of Denver and Metropolitan State College of Denver.

Given the limited familiarity with WRI methods outside of the industry, these scopes will also be approached by sector: building; transport; and materials and waste.

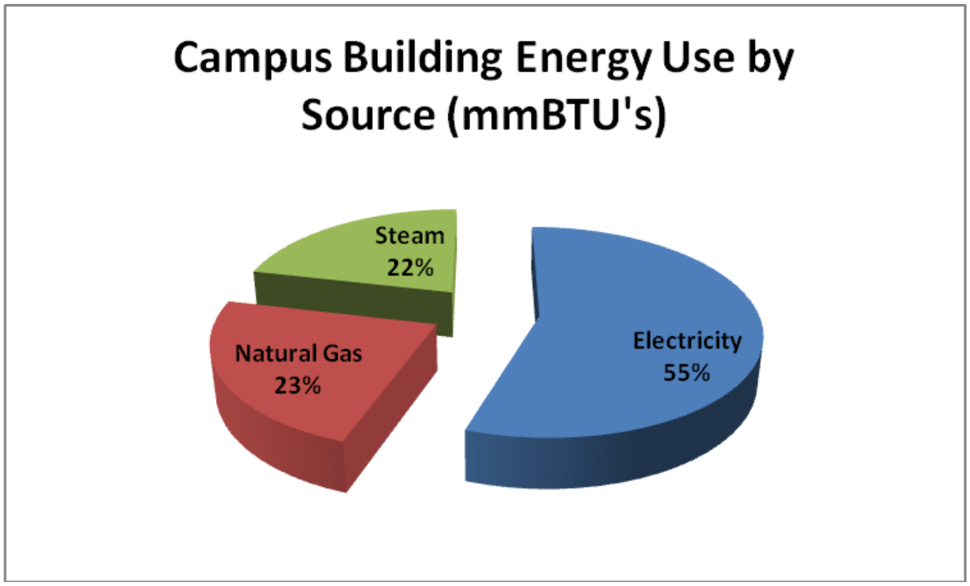
4. Inventory Results

4.1. Buildings Summary

Total emissions for Auraria's Buildings and Facilities sector totals 40,199 mt-CO_2e. The Renewable Energy Credit (REC) of 17 Megawatt hours (MWhs) mitigates nearly 40% of those emissions and therefore the net emissions total 26,599 mt-CO_2e.

Figure 2: Building Uses by Program

Figure 3: Energy Use by Source (MMBTUs)



4.1.1.1. Natural Gas Use

Natural gas use for the campus totaled 583,034 therms or 58,303 million BTUs (MMBTUs). Natural gas is used to heat many campus buildings and represents 23% of the energy used in campus buildings.

4.1.1.2. Steam Use

Steam use for the campus totaled 54,218,000 pounds, or 54,218 MMBTUs. Steam is used to heat many of the campus buildings, and in recent years Facilities Management has undertaken projects to improve the steam system by repairing or replacing steam traps campus-wide. Again, these numbers should be normalized per square foot heated by each source. Steam accounted for 22% of Auraria's energy consumption related to buildings.

4.1.1.3. Electricity Use

Electricity use for the campus totaled 40,433,156 kilowatt-hours or 137,958 million BTUs (MMBTUs). Given a gross square footage of 2,111,088, electricity efficiency equals 19.15 kWhs/GSF. The national average is 14.9 kWhs/GSF, with educational institutions averaging 11 kWhs/GSF and office buildings averaging 17.3 (EIA 2003).

4.1.2. GHG Emission Factors

4.1.2.1. Natural gas

Natural gas emission factors do not vary greatly from region to region and has been calculated as 56 kg of CO_2e/MMBTU (ICLEI, 2003).

Total GHG emissions from 58,303 MMBTUs of natural gas consumption amount to **3,298 mt-CO_2e** for fiscal year 2007 (July 2007-June 2008).

4.1.2.2. Steam

Emissions from steam generation are dependent on the efficiency of boilers at the steam plant. Xcel's steam plant averages a CO_2e intensity of 185 pounds (83.91 kgs) per pound of steam (Kutska 2008).

Total GHG emissions from over 54 million pounds of steam amount to **4,554 mt-CO_2e** for fiscal year 2007.

4.1.2.3. Electricity use

The emission factor for electricity use is calculated for each region by the mix of energy sources used to generate electricity for the grid, including transmission and line losses. In Colorado, coal and natural gas make up 57% and 37%, respectively. Renewable energy makes up 5% with wind generation and 1% with hydro (Xcel Energy 2007). The emissions factor for electricity in Colorado, given this mix, accounts for 0.8 kg of CO_2e/kWh. Colorado's emission factor is higher than the national average of 0.6 kg of CO_2e/kWh because of the lack of nuclear and hydroelectric power sources.

Total GHG emissions of 32,347 mt-CO_2e for fiscal year 2007 account for over 40 MWhs of purchased electricity. Renewable energy credits from purchased wind power total 13,600 mt-CO_2e (17 MWh), yeilding a total GHG emissions of **18,747 mt-CO_2e**.

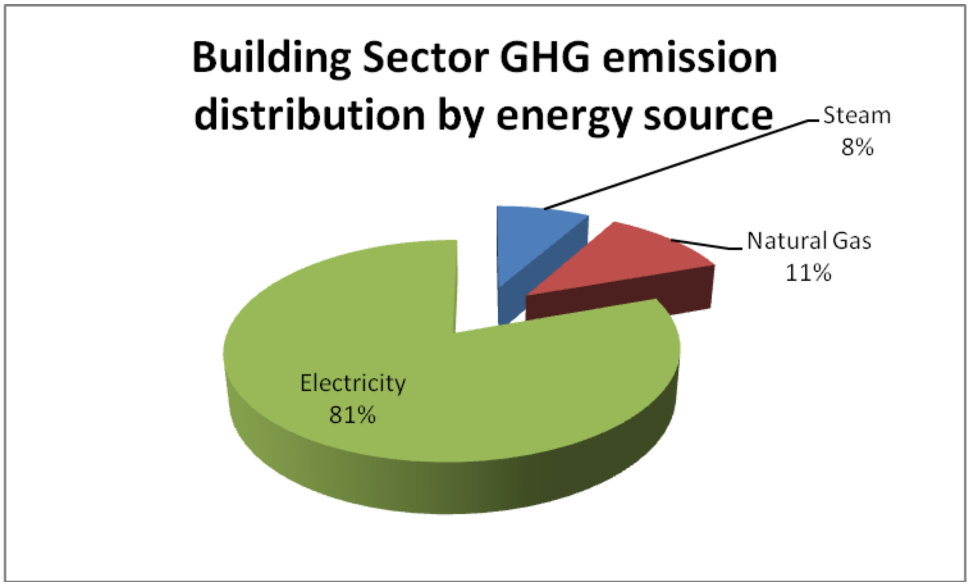
Table 3: ***AHEC Buildings and Facilities Energy Use CO_2e emissions, FY 2007***

Sector/use	Community-wide annual urban material/energy flows (MFA)	Data source for MFA	GHG emission factor (EF)	EF data source	Total GHG emitted = MFA x EF
Buildings Natural Gas Use	58,303 MMBTU	Xcel	56 kg-CO_2e /MMBTU	ICLEI	3,298 mt-CO_2e
Buildings Steam Use	54,218,000 lbs	Xcel	84 kg-CO_2e /1000 lbs	Xcel	4,554 mt-CO_2e
Buildings Electricity Use	40,433,156 kWh - 17,000,000 kWh* 23,433,156 kWh	Xcel	0.8 kg-CO_2e/kWh	Xcel	32,347 mt-CO_2e (- 13,600 mt-CO_2e)
TOTAL					**40,199 mt-CO2e**
Renewable Energy Offset Credit					**(- 13,600 mt-CO2e)**
TOTAL Scope 1 & 2 with credit					**26,599 mt-CO2e**

MMBTU = million BTU units = 1000 kBTU = Deca-therm;1 mt = 1000 kg

[1]Data source: AHEC Facilities Operations

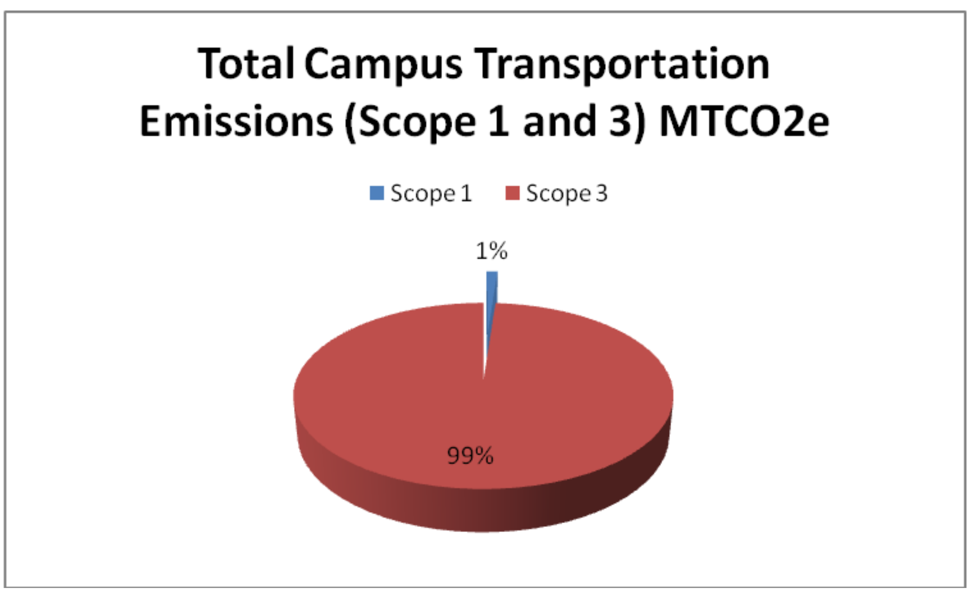
Figure 4: Building Sector GHG emission distribution by energy source



4.2. Transportation Summary

The scope 1 emissions resulting from tailpipe emissions of all AHEC vehicles equals 264 mt-CO_2e. This represents approximately one percent of the total campus transportation emissions (Scopes 1 and 3);

Figure 5: Total Campus Transportation Emissions (Scope 1 and 3) MTCO2e



When considering the total footprint (all emissions: scopes 1, 2, and 3), transportation was responsible for nearly half of all emissions at 22,692 mt-CO_2e. Ninety-nine percent of these emissions were a result of commuter traffic of students, faculty, and staff moving to and from campus in their own vehicles.

4.2.1. Campus-wide Fuel use

4.2.1.1. *In-boundary* activities

These activities include the tail-pipe emissions of vehicles owned and operated by AHEC, which are fueled by an on-site station which buys its fuel in bulk. A simple average of the 37 vehicles (33% of the total vehicles) allowing for standardized miles per gallon (MPG) measurements by the EPA came to 14.8 miles per gallon (MPG), assuming no highway miles were driven. Four of those vehicles with MPG data are used with a plow, which may have a significant effect on fuel efficiency. In future inventories, MPG can be calculated by odometer readings to reflect actual fuel use of each vehicle type.

The other vehicles, which included forklifts, mowers, and tractors designated as 'grounds equipment', are excluded from these MPG calculations. The vehicles excluded, which also included utility trucks and gasoline-powered golf carts, either lacked data at all or the data available varied widely according to the source. The three electric vehicles are accounted for under Building Energy Use.

AHEC purchased a total of 26,099 gallons of gasoline in order to fuel its fleet in FY2007. Diesel usage was 2,196, and while it constitutes a small percentage of total fuel use in Colorado (~5%), it should be pursued in future inventories.

4.2.1.2. *Out-of-Boundary* activities

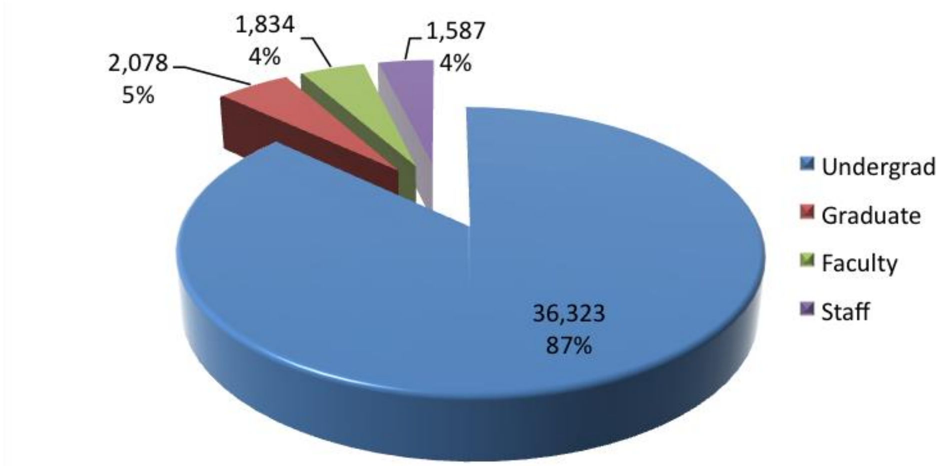
These activities include pump-to-wheels (tailpipe) emissions of commuter traffic from enrolled students, faculty and staff, which total 41,822 persons. Enrollment figures are used instead of FTE for emphasis on trips to campus instead of time spent on campus (but do not distinguish online students).

Emissions of commuter traffic are particularly important for the Auraria Campus as it is primarily a commuter campus with students, faculty and staff having to drive or take transit to reach the campus. Three student housing projects opened near the campus in 2006 that provide the opportunity of students living closer to campus. One of these projects provides a parking lot adjacent to the campus, another provides a shuttle service to and from campus, and the third is located in downtown Denver with some parking (although still located within walking distance of the campus).

Parking records for pay lots on the Auraria Campus reflect roughly 1.4 million vehicles paying for parking in fiscal year 2007, down 12% from 1.6 million in fiscal year 2006. This change coincides with the completion of RTD's TREX project. However, these numbers may be inflated due to the proximity of non-campus related functions (i.e. The Pepsi Center, etc.) and may not accurately commuter traffic to Auraria Campus.

A commuter survey was administered by AHEC to determine parking and transportation behaviors of its own staff, and the students, faculty and staffs of each of the three colleges in April of 2008. Of the 282 participants surveyed, only 25 (or 8%) were students, with the remaining being either faculty or staff. While it poorly represents the majority of the population (students at 87%), the survey still provides a reasonable picture of commuter behavior on campus.

Figure 6: Population by role on campus



Across all four institutions (by weighted average), 52% took either the bus or the light rail to Auraria Campus, 36% drove alone, 7% carpooled or were dropped off, and 5% walked or biked. UCD had the highest average of public transportation ridership with 61%; Metro State had 51%; CCD had 36%; and AHEC was roughly 33%

Similarly, AHEC had the largest proportion of commuters who drove alone to campus (~60%); CCD reported 49%; Metro State has 39% and UC Denver has 25%. Disparities between transportation behaviors reported *on the day* participants took the survey versus behavior reported “2 or more days a week” varied as much as 9%.

Figure 7: Composite commuter behavior by Institution

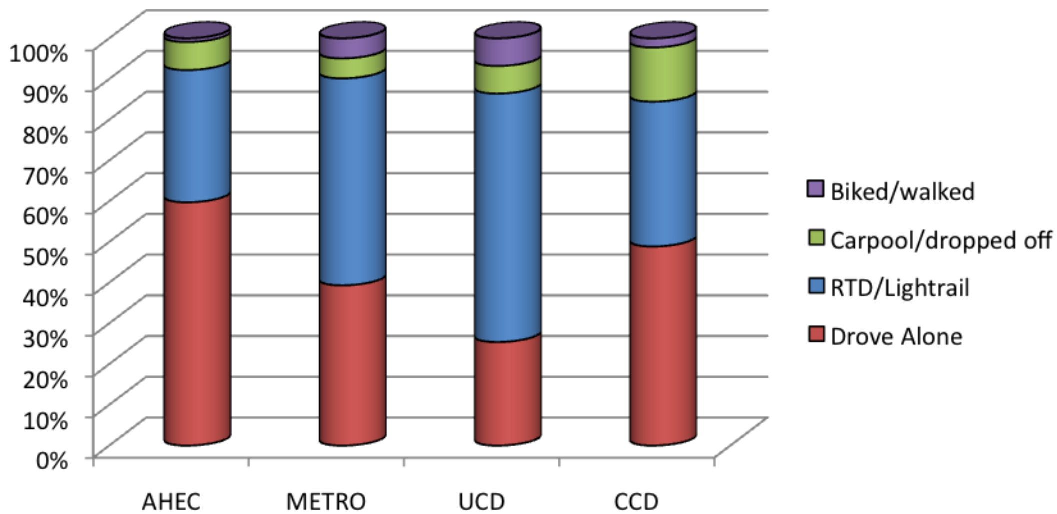


Table 4: Specific commuter behavior estimates of enrolled students, faculty & staff, based on survey.

	AHEC	Metro State	UC Denver	CCD
RTD/Light rail	115	11524	8207	1898
Drove Alone	212	8922	3420	2610
Carpool/dropped off	24	1115	912	712
Biked/walked	3	1115	912	119
Totals	355	22677	13451	5339

A composite per-capita model was multiplied by the behavior estimates shown opposite (Table). The per-capita model, based on the survey, computed:

a. an average commute of 14.2 miles one-way (or 7.1 miles if dropped off or carpooling);

b. the estimated weighted average miles-per-gallon for gasoline in Colorado of 16.8 mpg in 2006, (ICLEI 2003);

c. a reasonable number of days on campus each week (*assuming* students = 3, faculty = 4, and staff = 5 days per week),

d. and a reasonable number of weeks on campus per year (*assuming* students = 32, and both faculty and staff = 48 weeks per year).

Over 110 million gross vehicle-miles were traversed by 41,822 enrolled students, faculty and staff in fiscal year 2007. Over 31 million miles (56%) were travelled via bus or light rail by nearly 22,000 students, faculty and staff. Excluding public transportation, commuters burned over 1.4 million gallons of gasoline in order to travel nearly 24 million miles. Only one half of the gross vehicle-miles travelled were attributed to Auraria in order to avoid double-counting emissions claimed by the community in which each trip originates (Ramaswami, et al. 2007).

Figure 8: Reported mode of transportation to and from campus (2 or more days a week) by person

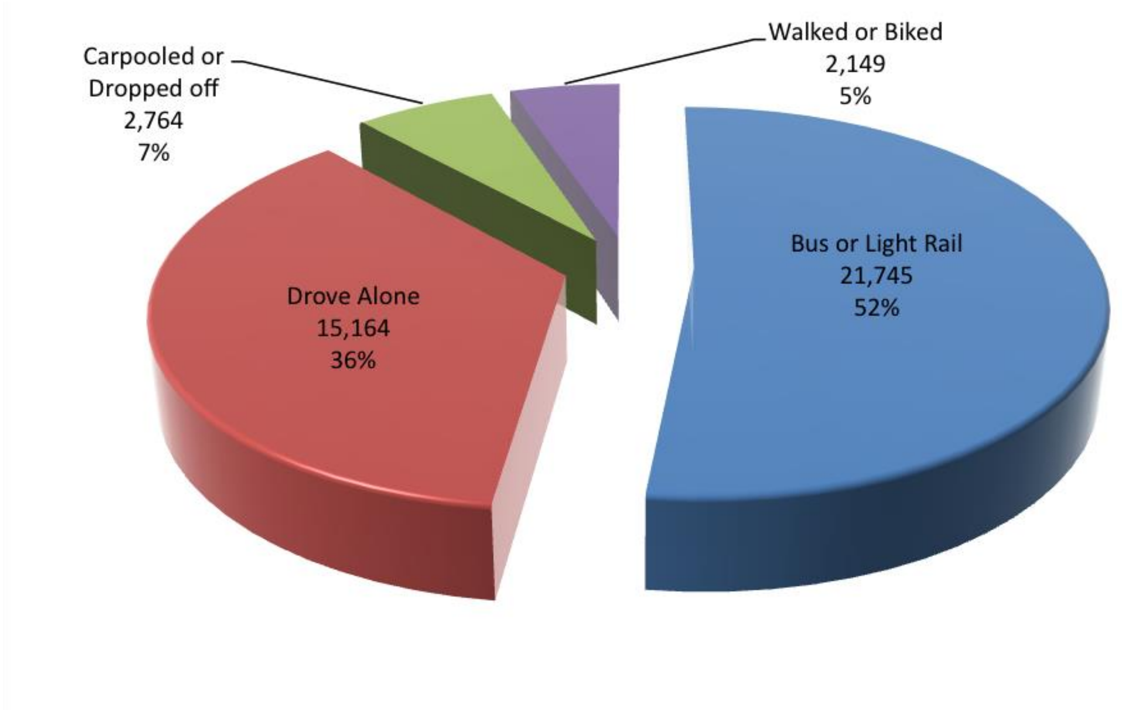


Figure 9: Distribution of Eco Pass Sales by Institution

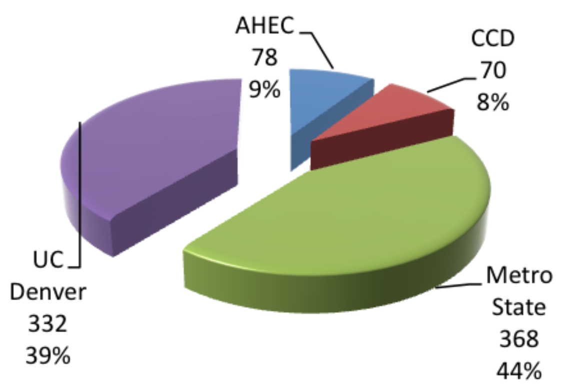
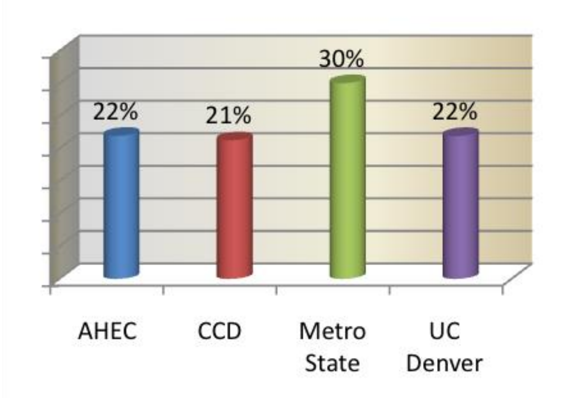


Figure 10: Percent of faculty/staff purchasing Eco Pass by Institution



4.2.2. GHG Emission Factors

According to GREET, the tail-pipe emissions for gasoline and diesel amount to 9.3 and 9.5 kg-CO_2e /gallon, respectively (GREET n.d.). These emissions are abbreviated *Pump-to-Wheels* (P2W). *In-Boundary* tailpipe emissions totaled **264 mt-CO_2e** and *Out-of-Boundary* emissions totaled **22,428 mt-CO_2e.**

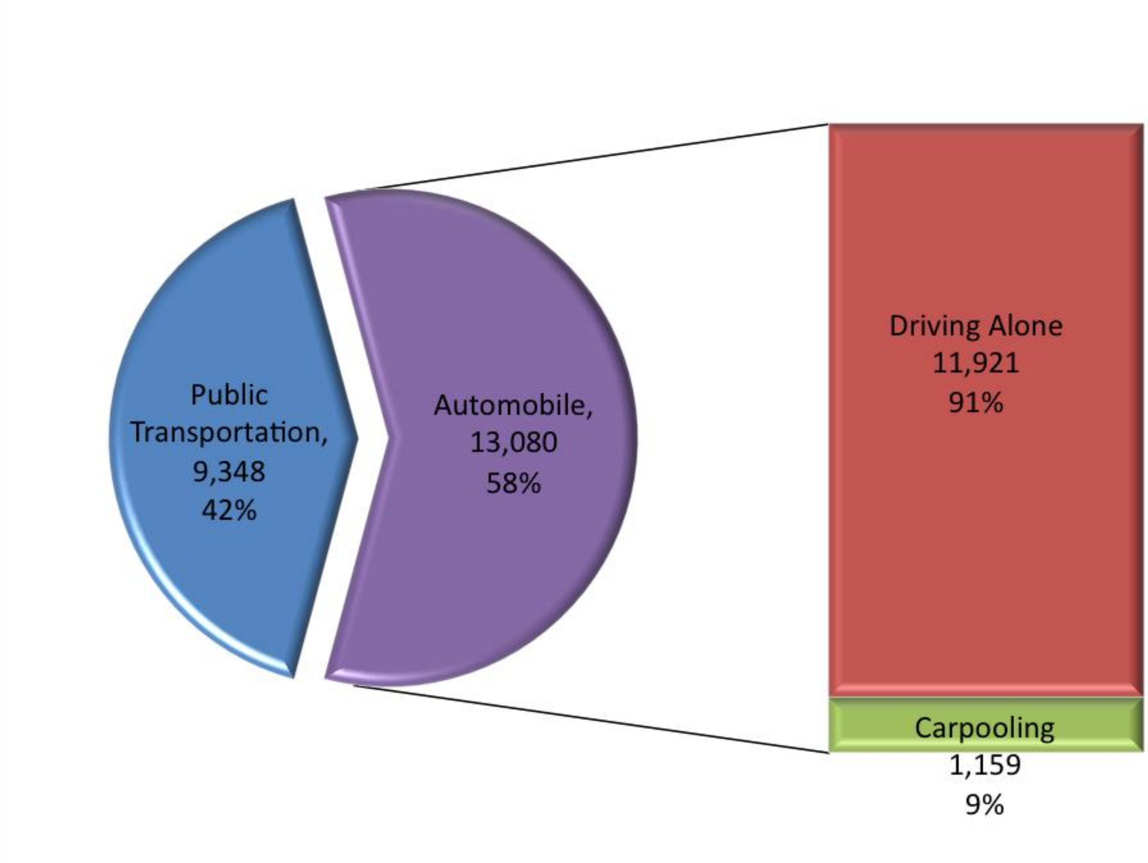
Table 5: Transportation Sector GHG Emissions (tailpipe)

Sector/use	Community-wide annual urban material/energy flows (MFA)	Data source for MFA	GHG emission factor (EF)	EF data source	Total GHG emitted = MFA x EF
AHEC Fuel Use (P2W)	Gasoline: 26,099 gallons	AHEC	Gasoline: 9.3 kg-CO_2e/gallon	GREET	264 mt-CO_2e
	Diesel: 2,196 gallons	AHEC	Diesel: 9.5 kg-CO2e/gallon		

P2W=Pump to Wheels, or tailpipe emissions.

[1]Sum of driving alone and carpool subsectors (Gasoline only)
[2]PMT = personal miles traveled using mass transit

Figure 11: Tailpipe Emissions from commuting in mt-CO_2e, by Mode


Public Transportation, 9,348 42%
Automobile, 13,080 58%
Driving Alone 11,921 91%
Carpooling 1,159 9%

4.3. Materials Summary: Fuel, Water/Wastewater, Municipal Solid Waste.

The sum of 89 mt-CO_2e emitted from the production and disposal of key materials fails to reflect the full impact of each institution's use of food, concrete and office paper. Waste and recycling were responsible for mitigating 899 mt-CO_2e.

4.3.1. Fuel

4.3.1.1. Energy Use

These activities include emissions associated with the production and transport of fuel (wells-to-pump) used by AHEC-owned vehicles.

4.3.1.2. Emissions Factor

On top of tailpipe (P2W) emissions, an additional 2.5 kg-CO_2e is emitted during the production and transport of each gallon of gasoline and 2 kg-CO_2e for each gallon of diesel and jet fuel (GREET n.d.). These emission are abbreviated *Wells-to-Pump* (W2P). The production and transport of fuel used by AHEC's fleet totaled **62 mt-CO_2e.**

Table 6: Fuel Production GHG Emissions

Sector/use	Community-wide annual urban material/energy flows (MFA)	Data source for MFA	GHG emission factor (EF)	EF data source	Total GHG emitted = MFA x EF
AHEC Fuel Production	Gasoline: 26,099 gallons	AHEC	Gasoline: 2.5 kg-CO_2e/gal	GREET	69 mt-CO_2e
(W2P)	Diesel: 2,196 gallons	AHEC	Diesel/Jet Fuel 2 kg-CO_2e/gal	GREET	
TOTAL					**69 mt-CO_2e**

W2P = Well to Pump, or emissions from production and transport.

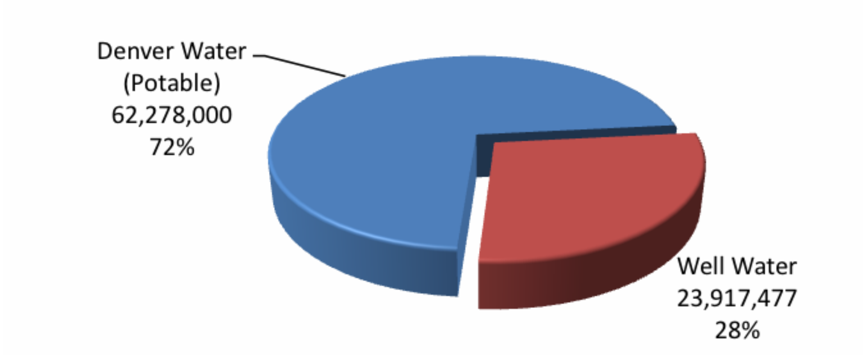
4.3.2. Water/ Wastewater

4.3.2.1. Energy Use

Auraria campus used 62,278,000 gallon from Denver Water over Fiscal Year

2007. Auraria also uses non-potable well water for most of the landscaping, totaling 23,917,477 gallons. Electricity used to pump the water from the well is covered under the Buildings sector.

Figure 12: Water use by source (gallons)



4.3.2.2. Emission Factor

Electricity used to transport the water from Denver Water to Auraria Campus was the chief constituent of CO_2e emissions, resulting in an emissions factor of 0.44 grams of CO_2e per gallon of potable water, or **27 mt-CO_2e.**

Table 7: Potable water GHG emissions

Material	Campus-wide Annual Material/Energy Flows [Benchmark]	Emission Factor [Xcel]	Total CO_2e emissions
Out-of-Boundary: Water (Potable)	62,278,000 gallons [68,474 MG/yr for Denver] 6.1 gallons per FTE per day*	0.00044 kg-CO_2e/gallon [Xcel /Denver water]	**27 mt-CO_2e (0.001 mt-CO_2e per capita)**

*where *per capita* = Full-time equivalent students + Faculty + Staff

4.3.3. Solid Waste & Recycling

4.3.3.1. Energy use

In FY 2007, the Auraria campus land-filled nearly 1,300 tons of solid waste. Auraria's single stream recycling totaled 70.1 tons, but since the single stream recycling program wasn't started until more than half way through the fiscal year (early 2008), recycling is expected to be significantly higher next year.

Auraria recycled nearly 60 CPUs, 91 CRT monitors, 2 LCD monitors, 13 laser printers, 7 televisions, and other miscellaneous items totaling over 6 tons. Auraria also recycled nearly 85 tons of office paper, 5 tons of mixed metals and 60 tons of mixed recyclables. Wastes not included in these calculations are biological waste, waste oil, and batteries, because of the negligible effect on emissions, or mandated recycling requirements.

4.3.3.2. Emission Factor

Waste Land-filled: The EPA's *Waste Reduction Model* (WARM) was used to calculate the emissions from solid waste and the benefits of recycling office paper, mixed metals and other recyclables.

According to WARM, organic waste land-filled in a facility with landfill gas capture avoids 0.3 kg-CO_2e/short ton from natural decomposition. Landfill Gas recovery and a default distance of 20 miles from the landfill were used in the model (EPA 2006).

Recycling: Had all waste been land-filled, *avoided* emissions would have totaled 462 mt-CO_2e. Since the recycling programs have been avoiding an additional 3.1 kg-CO_2e/short ton instead, an additional 425 mt-CO_2e were *avoided*, leading to a *net avoidance* of **887 mt-CO_2e**.

Electronic waste & Recycling: The EPA's *Durable Goods Calculator* (DGC) was used to calculate the weight of, and emissions from, electronic waste. The DGC did not allow calculations for certain specific items such as printers, docking stations or typewriters (EPA 2005).

According the DGC, had the electronic waste been land-filled, emissions would have totaled 0.24 mt-CO_2e. Since they were recycled instead, 11.84 mt-CO_2e were *avoided*, leading to a *net avoidance* of **11.59 mt-CO_2e**: the equivalent of not driving a passenger car for 2.5 years.

Table 8: GHG emissions for Solid Waste/Recycling

Material	**Campus-wide Annual Material/Energy Flows**	**Emission Factor**	**Total CO_2e *reductions***
Out-of-Boundary: Waste/Recycling	*Landfilled:* 1,291 tons [89 lbs per FTE] *Recycled* : 70 tons single stream 6 tons e-waste 85 tons office paper 5 tons of mixed metals	MSW: ~ -0.3 kg-CO_2e/ton Mixed recycling: ~ -3.1 kg-CO_2e/ton E-waste recycling: ~ -1.7 kg-CO_2e/ton	- 899 mt-CO_2e

5. Overall Results

Table 9: Annual community-wide material and energy flows with associated benchmarks and GHG emission factors (EF) for various sectors in the Auraria Campus. GHG emissions are reported in metric tons CO_2 equivalents (mt-CO_2e)[a]. Table is adapted from Ramaswami et al, 2008.

Sector/use	Community-wide annual urban material/energy flows (MFA)	Data source for MFA	GHG emission factor (EF)	EF data source	Total GHG emitted = MFA x EF
Buildings Natural Gas Use	58,303 MMBTU	Xcel	56 kg-CO_2e /MMBTU	ICLEI	3,298 mt-CO_2e
Buildings Steam Use	54,218,000 lbs	Xcel	84 kg-CO_2e /1000 lbs	Xcel	4,554 mt-CO_2e
Buildings Electricity Use	40,433,156 kWh - 17,000,000 kWh* 23,433,156 kWh	Xcel	0.8 kg-CO_2e/kWh	Xcel	32,347 mt-CO_2e (- 13,600 mt-CO_2e)
AHEC Fuel Use (P2W)	Gasoline: 26,099 gallons	AHEC	Gasoline: 9.3 kg-CO_2e/gallon	GREET	264 mt-CO_2e
	Diesel: 2,196 gallons	AHEC	Diesel: 9.5 kg-CO2e/gallon		
Waste & Recycling	MSW: ~1291 tons, Mixed Recyclables, etc:~166 tons, E-waste: ~6.3 tons	AHEC	MSW: ~ -0.3 kg-CO2e/ton, Mixed Recyclables: ~ -3.1 kg-CO2e/ton, E-waste: ~ -1.7 kg-CO2e/ton	EPA WARM / DRC	-899 mt-CO_2e
Commuter Fuel Use (P2W)	By Automobile: 2,812,843 gallons	AHEC	Gasoline: 9.3 kg-CO2e/gallon	GREET	22,428 mt-CO_2e
	By Public Transit: 62,321,196 PMT	CDPHE / ICLEI	Public Transit: 0.3 kg-CO2e/PMT	WRI	

AHEC Fuel Production	Gasoline: 26,099 gallons	AHEC	Gasoline: 2.5 kg-CO2e/gal	GREET	69 mt-CO2e
(W2P)	Diesel: 2,196 gallons	AHEC	Diesel/Jet Fuel 2 kg-CO2e/gal	GREET	
Water	62,278,000 gallons	Denver Water	0.00044 kg-CO2e/gallon		27 mt-CO2e
Airline Travel (P2W)	NR		Jet Fuel: 9.4 kg-CO2e/gal	EIA	
Cement Use	NR		0.97 - 1.05 mt-CO2e/ton	EPA *PCA*	
Office Paper	NR		Production: 1,180 kg-CO2e/mt	GWI	
Food Purchases	NR		2 kg-CO2e/$ (1997 $)	EIO-LCA	
Total Inventory (Scope 1 & 2)					**40,463 mt-CO2e**
Total Footprint (Scopes 1,2,&3)					**62088 mt-CO2e**
TOTAL Scope 1 & 2 with credit					**26,863 mt-CO2e**

Figure 13: Total Campus GHG Inventory (Scope 1 & 2) Emissions MTCO2e

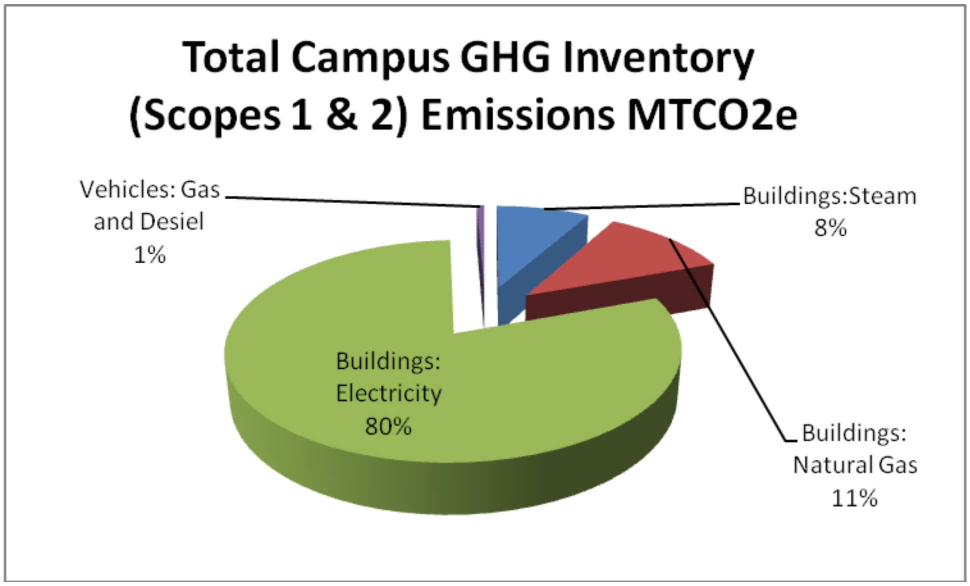
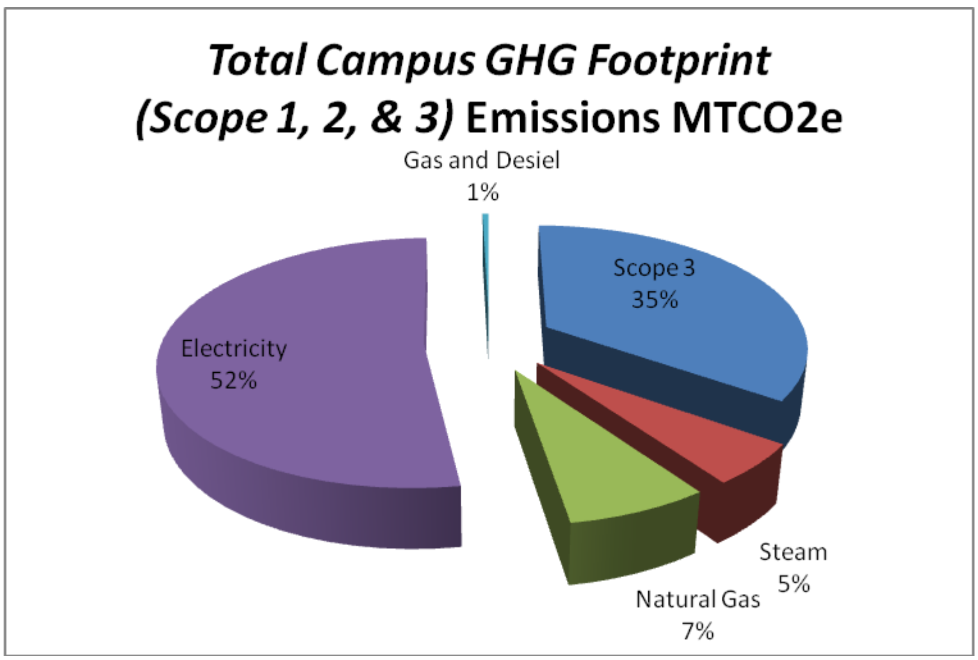


Figure 14: Total Campus GHG Footprint (Scope 1, 2, & 3) Emissions MTCO2e



6. Overall Recommendations and Next Steps

Building Data collection highlighted some opportunities for standardized procedures and collection methods. Occasional gaps and inconsistencies in energy use data were addressed by verifying figures from original utility bills, which proved to be disproportionately time consuming. The numbers included in the February 2010 version have been verified and can now be considered final.

Again, energy intensity is in-line with other commuter colleges, but it still leaves plenty of room for improvements. Discrepancies in the definition and use of FTE made comparison over time difficult and unreliable. Only with consistency and transparency in each institution's reporting will comparisons be useful and reliable

AHEC Fleet MPG calculations should be computed using fuel consumption and odometer readings of individual vehicles to reflect the efficiency of the fleet, instead of using global estimates.

Commuter data from the transportation survey suffered from a small sample size which may not have accurately represented the community of Auraria. The data we have suggests that the greatest impact lies in those who drive alone to campus and shifting them to carpool or public transportation. Exaggerating existing parking incentives for carpooling would be an inexpensive way to deter single passenger travel. Campus-wide faculty/staff participation is little more than 1 in 5, with the exception of Metro State, which garners nearly 1 in 3 (Figure). University of Denver provides Ecopasses to "fully benefited" faculty and staff. It's uncertain how they pay for it, but participation rates would easily jump if we were to institute an *opt-out* policy for Ecopass purchases, instead of opt-in.

Unfortunately, designing a survey with more than a miniscule response rate is no small feat. However, the World Resources Institute has spent years developing a commuter survey template for the employees (who helped create it) to garner a 60% response rate, which is astronomical when it comes to response rates. A sample of that template can be found at: http://www.safeclimate.net/calculator/.
A downloadable version can be found at:
http://www.ghgprotocol.org/downloads/calcs/Employee_Commuting_ServiceSector_v2.0_Final.xls

Data not reported such as jet fuel (from airline travel), food and paper consumption, which was either hard to come by or wasn't reported, highlights the need for a central (albeit inter-institutional) clearinghouse for all the relevant data that should be used in future inventories.

Auraria and its residents should aim to pool its resources with other regional institutions to maximize each others' mitigation plans and their effectiveness. The greatest opportunities lie within the products of these institutions: the students and faculty. One of those opportunities would involve outfitting all the exercise equipment in the Events Center/PE building with “parasitic” generators to leech the wasted energy that is a byproduct of pedaling a stationary bike in order to use it to light, heat and cool the same building (examples of which recently opened in Portland and Seattle).

But, more importantly, by being part of the Auraria Campus, students, faculty and staff may prove to be the most vested with tools to address these new challenges. Given the opportunity to give something back (besides tuition and such), reciprocity will result in an increased sense of ownership, and that can begin to be instilled with each new wave of constituents.

By developing voluntary programs in anticipation of policy, an honor system will develop itself into campus culture, relieving the pressure of constant enforcement. For example, an incremental pricing scheme for employee parking would entail both a “stick” and a “carrot”, in that employees of these institutions would be charged a little extra to park at work, but would be paid two or three times that much *not* to park at work.

The prices would start small, so as to prevent recruiting/retention disadvantages for any of the constituencies, and the “Charge + Cash-out” scheme would be slowly increase over time (ex. to $2/day and $4/day, respectively). Framed as a climate change issue, employees are made aware that the money made from parking charges are used only to pay those who don’t park. Employees self-report their parking behavior, with one such company asserting that “20% of employees are under-collecting the cash-out, validating that company's trust in its employees” (Raney 2008).

CH2M Hill has been using a variation of this concept for years: at one location, they began charging their employees $40 per month to park, but insisted on giving everyone a $40 travel allowance on their checks in order to cover it. This extra measure was enough to convince 25% of the staff to keep the money and leave their cars at home (Raney 2008). Given the intrinsic value inherent in the existing parking accommodations, these charges may have to be *in addition to* the existing cost structure, and it may become an unpopular suggestion.

As densification of the campus continues, parking should be displaced to promote true pedestrianization. With a long term goal of eliminating automobile traffic completely from the increasingly dense campus, which is an exceptional model for sufficient multi-modal transit, the prevalence and cohesion of the proposed pedestrian corridors will be a resource that can be taken full advantage of (studioINSITE, Sasaki Associates, Inc. and U3 Ventures 2007).

These approaches allow a major player in the city of Denver to aggressively address the current trend: 23% of Colorado’s greenhouse gas emissions are from transportation alone, and on-road gasoline use has grown 32% from 1990 to 2002. In Colorado, vehicle-miles travelled have increased by 69% since 1990, the 3rd highest increase in the U.S. (EnvironmentColorado.org 2007).

Automobile traffic surely cannot be immediately eliminated, but with circulators and mass transit taking advantage of designated priority corridors, the evolution of new personal/group transit modes become an attractive alternative. Until then, programs like *Freewheelin'* ensures that there is a serious demand for a bike-sharing programs: during the four days of the Democratic National Convention, over 26,000 miles were traveled by “shared” bicycles in downtown Denver (Freewheelin' All Over Denver 2008) (Duvall 2008). Car-sharing programs such as ZipCar® and ride-sharing programs like GoLoco.org™ can provide the convenience and reliability that current public transportation cannot yet provide.

Designing appropriate vehicle restrictions based on need and use will maximize the life of the existing infrastructure and allow the most flexibility for any future plans. Our campus needs not to be built for cars; it should be built for people.

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Acronyms