Warren Wilson College
Greenhouse Gas Emissions Inventory
and Fuel Use Survey

2006-2007 Academic Year

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Executive Summary

The 2006-2007 Warren Wilson College Greenhouse Gas Inventory marks the third consecutive inventory compiled by Warren Wilson College (WWC) students under the supervision of Environmental Studies faculty and Environmental Leadership Center staff. These inventories provide WWC with the trend data necessary to understand the institution’s contribution to climate change, and discover effective means to reduce energy use and greenhouse gas emissions.

In 2006, WWC joined the ranks of signatories to the American College and University Presidents Climate Commitment (ACUPCC) as a Leadership Circle member (college and university presidents who have agreed to help lead the initiative, promote it, and recruit colleagues to join). Signatories to this commitment pledge to engage in climate change action as demonstrated by this pledge excerpt: We believe colleges and universities must exercise leadership in their communities and throughout society by modeling ways to minimize global warming emissions, and by providing the knowledge and the educated graduates to achieve climate neutrality. To put this belief statement into action, signatory institutions are required to institute a series of initiatives including producing a greenhouse gas inventory: 1b. Within one year of signing this document, complete a comprehensive inventory of all greenhouse gas emissions (including emissions from electricity, heating, commuting, and air travel) and update the inventory every other year thereafter.

Currently, WWC’s inventory measures the impact of the following sectors; electricity, natural gas, international flights, student and staff driving, campus vehicle fleet use, solid waste, farm operations, blacksmith coke, used motor oil boiler, and propane. Chelsea Maier (class of ‘09) compiled the 2006-2007 data for these sectors and produced the current inventory. Her findings illustrate significant trends over the past three academic years:

- Campus population (students and staff) grew by 5.3% and building square footage by 4.5%. When looking on a per capita, per square foot basis during the same time period, WWC’s overall greenhouse gas emissions fell by 2.2%. This reduction in emissions jumps to 44% when we considering the 4.4 million KWh of electricity (100% annual usage) offset through the purchase of renewable energy credits (REC) beginning in 2006.
- This decrease in total greenhouse gas emissions per capita per square foot was in spite of a 1.5% increase in electricity use, a 9.3% increase in natural gas use and a 22% increase in on campus vehicle fuel use overall.
- The costs incurred for all energy sectors have risen disproportionately to use showing an overall 26% increase.
- The built environment continues to be the largest contributor to greenhouse gas emissions monitored accounting for 68% of total emissions (electricity and natural gas) followed by international study abroad flights accounting for 11%.
- Solid waste related emissions (5% of total campus GGE) increased 18% per capita and campus vehicle fleet emissions (also 5% of total) increased 15.6% per capita.
The three most notable institutional changes contributing positively to the three year trends are (1) the purchase of REC (99% wind and 1% solar) to offset 100% of campus electricity use, (2) the construction of three buildings to LEED Gold standard (2 dorms, 1 office) and renovation of two buildings— including the campus’ primary academic building— to LEED Gold standards, and (3) the existence of an on-campus compost operation that offsets a significant amount of solid waste related methane emissions.

This inventory shows how the impact of each energy sector and of each greenhouse gas varies. At WWC, carbon dioxide is clearly the gas of most concern accounting for 92% of total greenhouse gas emissions. Because of the distinctive character of the College (farm operation and solid waste management program in particular) it is important to include methane and nitrous oxide emissions sources in the inventory even though these gasses only account for 8% of emissions. By looking at all three gas emissions across each contributing sector, WWC attains a clear picture of the problem, and opportunities for continued solution implementation.

The information presented in this inventory is assisting WWC’s presidential appointed Greenhouse Gas Emissions Reduction Task Force to research and propose institutional goals for energy use and emissions reductions, identify the most economically viable areas to invest in pursuit of these goals, and establish targeted behavior change campaigns. Once initiated, these proposals will ensure the WWC continues to make strides towards the broader climate change goals outlined in the ACUPCC pledge. Subsequent annual greenhouse gas inventories will quantify the effect of WWC’s ongoing climate change initiatives.
Introduction:

The Greenhouse Gas Emissions Inventory 2006-2007 for Warren Wilson College is the third annual emissions inventory the college has completed to date. With these three inventories, energy use, cost, and emission trends can be made and Warren Wilson College is able to use these trends to better understand the current impact that the college has on its surrounding environment. Also, these trends can be used to set goals for emissions and energy use reductions to strive for in the future.

The inventory also provides a unique opportunity for a student to not only compile a greenhouse gas emissions inventory but also to apply networking skills to ascertain the appropriate information from other individuals within the Warren Wilson community.

The inventories include sectors of Electricity, Natural Gas, Campus Vehicle Fleet Fuel Use, International Flights, Solid Waste, Staff and Faculty driving, Student driving, Agriculture, and Miscellaneous (propane, used motor oil, and coke). Carbon dioxide, methane and nitrous oxide emissions were calculated for all of these sectors.

Carbon dioxide, methane, and nitrous oxide have different molecular structures and thus absorb different amounts of solar radiation and contribute to the greenhouse gas effect with different intensities. In order to compare overall effect of the three greenhouse gases measured in this inventory, the mass of nitrous oxide and methane emitted were converted to a mass of carbon that would have the equivalent effect on global warming.

1 lb of methane has the equivalent impact of 21 lb of carbon dioxide
1 lb of nitrous oxide has the equivalent impact of 310 lb of carbon dioxide

In this inventory, the overall sum of these emissions in terms of carbon dioxide are expressed as total Greenhouse Gas Emissions (GGE). This was done not only to compare the three greenhouse gases to one another but also to put the total emissions in a term that the public is more familiar with, carbon dioxide.
Overall Emissions:

A three year trend for GGE at Warren Wilson College is shown in the Table 1.1.

Table 1.1

<table>
<thead>
<tr>
<th></th>
<th>Carbon Dioxide Emission (lb)</th>
<th>Methane Emission (lb)</th>
<th>Methane GGE (lb)</th>
<th>Nitrous Oxide Emission (lb)</th>
<th>Nitrous Oxide GGE (lb)</th>
<th>Total GGE (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-2005</td>
<td>10,054,109</td>
<td>39,417</td>
<td>827,761</td>
<td>323</td>
<td>100,193</td>
<td>10,982,064</td>
</tr>
<tr>
<td>2005-2006</td>
<td>11,519,479</td>
<td>44,900</td>
<td>942,902</td>
<td>380</td>
<td>117,760</td>
<td>12,580,140</td>
</tr>
</tbody>
</table>

From academic years 2004-2005 to 2006-2007 the overall emission at Warren Wilson College increased by about 8%, but from academic year 2005-2006 to academic year 2006-2007 the overall emissions decreased by about 6%. The overall increase is due most likely to the inclusion of more sectors in the inventory and the establishment of Village A and Village B dormatories. Also, the surveying for fuel consumption and the emissions produced from that burned fuel may be inaccurate because of the nature of the survey. In addition, the miles per gallon used to calculate total gas use was not the same for all surveys.

Methane and nitrous oxide have greater global impact than carbon dioxide and Warren Wilson College is an emitter of all three of these gases. Figure 1.1 shows the composition of the overall emissions that Warren Wilson College produces.

Figure 1.1
Again, the graph above displays the contribution of each greenhouse gas in terms of GGE, however nitrous oxide and methane represent much smaller contributions when comparing by weight emitted as shown in Table 1.1.

Using the data gathered for this inventory, the sources for each gas can be separated out to see which source is the highest emitter for each individual gas, this is shown in Figure 1.2, 1.3, and 1.4.

Figure 1.2

![Carbon Dioxide Emission by Source](image)

Figure 1.3

![Methane Emission by Source](image)
The major source of carbon dioxide is electricity usage, the major source of methane at WWC is solid waste and the major source of nitrous oxide is agriculture. The overall GGE by source is shown in Figure 1.5.

Electricity is the main source of emissions, natural gas usage is the secondary emitter, and International Flights is the thirdly emitter. Together they account for 79% of the total GGE. Emissions from Student Driving represent 6% of the total GGE. Together Campus Vehicle Fleet and Solid Waste represent 10% of the overall GGE and Agriculture, Staff & Faculty Driving and the Miscellaneous sectors represent 5% of the overall GGE.
Overall, Warren Wilson College has increased emissions by 864,395 lb of GGE from 2004-2005 to 2006-2007 which is a 7.9% increase overall as shown in Figure 1.6

Figure 1.6

However, Warren Wilson started purchasing Renewable Energy Credits for electricity from Sterling Planet in the later part of academic year 2005-2006. These Renewable Energy Credits replace every kilowatt-hour Warren Wilson College uses from the finite electricity grid with a kilowatt-hour produced from a renewable energy source, mostly wind power. With the renewable energy credits Warren Wilson is buying, WWC has a net emission of 0 lb from electricity usage and when this statistic is factored into the three year trend, there is an overall reduction of 4,260,900 lb GGEs which is a 39% reduction in emission. Figure 1.7 shows the emission trend in which the renewable energy credits are considered.

Figure 1.7
From 2004-2005 to 2006-2007 the total population (staff, faculty and students) and the total square-footage increased. In 2004-2005, the total population was 986 staff, faculty and students and the buildings totaled 616,571 square-feet. The population increased to 1,038 staff, faculty and students and the square-footage increased to 644,454 square-feet by 2006-2007. A more accurate way to look at the Warren Wilson College’s energy usage and resulting emission is by distributing the total usage and emissions per capita and per square-footage as shown in Figure 1.8.

*Figure 1.8*

![GGE Emission per Capita per SqFt](image)

Overall, there was a 2.2% decrease in GGE at Warren Wilson College from 2004-2005 to 2006-2007. If the renewable energy credits are considered, there is a 44% decrease in emissions as shown in Figure 1.9.

*Figure 1.9*

![GGE Emission per Capita per SqFt Including Renewable Energy Credits](image)
Figure 1.10 shows the total carbon emissions trend from 2004-2005 to 2006-2007 and Figure 1.11 shows the total carbon emission trend with the renewable energy credits considered.

**Figure 1.10**

![CO₂ per Capita per Squarefoot](image)

**Figure 1.11**

![CO₂ Emission Trend Per Capita per Square Foot with Renewable Energy Credits](image)
**Total Costs:**

The annual cost for electricity, natural gas, and the fuel used by the Campus Vehicle Fleet for 2006-2007 was $628,153, which is a 26% increase from 2004-2005 with a total monetary increase of $128,559. However all three of these sectors energy supplies have increased in cost, so this increase in total annual cost is not necessarily from extra energy consumption from year to year. Figure 1.12 shows the total cost trend for the past three years.

*Figure 1.12*
The Three Major Users and Emissions Sectors

Electricity:

Electricity at Warren Wilson College is the largest contributor to total GGE. Warren Wilson College purchases its electricity from Progress Energy and the calculated emissions from Warren Wilson College’s electricity usage is attributed to the generation of electricity from Progress Energy. In order to calculate emissions from electricity, the methods of generation must be known. The electricity generation from 2005-2006 to 2006-2007 did not change, but Warren Wilson College did start purchasing renewable energy credits in this year, which drastically decreases the net greenhouse gas emission. Figure 2.1 shows the relative percent of the total electricity generation from each type of power plant used by Progress Energy.

![Figure 2.1](image)

Using the Clean-Air Cool Planet Carbon Calculator for the Virginia/Carolinas region, one kilowatt-hour of electricity was calculated as producing 1.16 lbs. of carbon dioxide, 0.00001 lbs. of methane, and 0.00002 lbs. of nitrous oxide. Table 2.1 shows the three year trend of electricity use, associated costs and resulting emissions.

Table 2.1

<table>
<thead>
<tr>
<th>Electricity Use by Warren Wilson College</th>
<th>Total Use (kWh)</th>
<th>Costs</th>
<th>Carbon Dioxide Emission (lbs)</th>
<th>Methane Emission (lbs)</th>
<th>Nitrous Oxide Emission (lbs)</th>
<th>Total GGE(lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-2005</td>
<td>4,337,732</td>
<td>$298,831</td>
<td>5,020,608</td>
<td>45.49</td>
<td>87.94</td>
<td>5,048,825</td>
</tr>
<tr>
<td>2005-2006</td>
<td>4,333,775</td>
<td>$311,186</td>
<td>5,016,028</td>
<td>45.45</td>
<td>87.86</td>
<td>5,044,219</td>
</tr>
<tr>
<td>2006-2007</td>
<td>4,403,183</td>
<td>$342,123</td>
<td>5,096,362</td>
<td>46.17</td>
<td>89.27</td>
<td>5,125,295</td>
</tr>
</tbody>
</table>
Overall the electricity use at Warren Wilson College has shown a slight increase from 2004-2005 to 2006-2007 of about 1.5% and cost increased by about 14.5% or $43,292. The increase in electricity usage and the subsequent emissions is most likely due to the establishment of Village A and Village B dormitories. Figure 2.2 shows the top emitting buildings.

Figure 2.2

Devries is the largest user of electricity and accounts for about 16% of the total electricity usage. Gladfelter a/c is another top user as well as the Hamill Science Center. The dormitory that has the largest usage is Sunderland, and this is to be expected because it has the largest occupancy of all the dormitories.

Warren Wilson College had an overall increase in electricity usage of 65,451 kWh from 2004-2005 to 2006-2007 which is a 1.5% increase, shown in Figure 2.3 below.

Figure 2.3
However, the electricity use declined if we look at per capita usage. This decrease in usage is about 3.6% less than the electricity usage in 2004-2005, This decrease is shown in Figure 2.4 below.

**Figure 2.4**

![Graph showing Electricity GGE per Capita](image)

**Figure 2.4**

Carbon dioxide emission per capita show a 3.6% decrease from 2004-2005 to 2006-2007 also, this is shown in Figure 2.5.

**Figure 2.5**

![Graph showing CO₂ Emission from Electricity per Capita](image)
The total costs for electricity for 2006-2007 was $342,123, and this was a 14.5% increase from 2004-2005. A cost trend for electricity is shown in Figure 2.6.

**Figure 2.6**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
<td>$298,831</td>
<td>$311,186</td>
<td>$342,123</td>
</tr>
<tr>
<td>$50,000</td>
<td>$300,000</td>
<td>$300,000</td>
<td>$300,000</td>
</tr>
<tr>
<td>$100,000</td>
<td>$350,000</td>
<td>$350,000</td>
<td>$350,000</td>
</tr>
<tr>
<td>$150,000</td>
<td>$400,000</td>
<td>$400,000</td>
<td>$400,000</td>
</tr>
<tr>
<td>$200,000</td>
<td>$450,000</td>
<td>$450,000</td>
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<tr>
<td>$250,000</td>
<td>$500,000</td>
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<td>$300,000</td>
<td>$550,000</td>
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<td>$350,000</td>
<td>$600,000</td>
<td>$600,000</td>
<td>$600,000</td>
</tr>
<tr>
<td>$400,000</td>
<td>$650,000</td>
<td>$650,000</td>
<td>$650,000</td>
</tr>
</tbody>
</table>

**Natural Gas:**

Natural gas is the second largest emission producing energy source for Warren Wilson College and approximately 25% of the total GGE produced by Warren Wilson College is from the use of natural gas.

Table 3.1 shows the trend of natural gas usage, the subsequent costs and emissions for natural gas. Therms is the unit of energy for natural gas and it is equivalent to 100,000 BTUs and is equivalent to burning 100 cubic feet of natural gas.

**Table 3.1**

<table>
<thead>
<tr>
<th>Natural Gas Use by Warren Wilson College</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Use (Thersms)</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>2004-2005</td>
</tr>
<tr>
<td>2005-2006</td>
</tr>
<tr>
<td>2006-2007</td>
</tr>
</tbody>
</table>

Total usage increased by 21,116 therms from 2004 to 2007 which is about a 9.3% overall increase. Subsequent emissions increased by 246,421 lb GGE which is again a 9.3% overall increase, but per square-foot this increase is only 4.6%. 

15
The trends of energy costs at WWC show an increase significantly greater than the increase in actual usage. This is due to continually rising energy costs, and demonstrates an added value of instituting energy conservation technologies and practices.

Figure 3.1 shows the top users of natural gas at Warren Wilson.

Figure 3.1

The Boiler Room is disproportionately high in usage because there are many different buildings that run from that meter. The Boiler Room meter is responsible for monitoring Carson, Spidel, Ogg, the Ransom House, the Recycling Complex, the greenhouses, the Garden Cabin, the Blacksmith shop, Witherspoon, Morse, Bannerman, the Library, Gladfelter, Dodge, the Log Cabin, the Farm Office and the Pig Barn. Because all these building are monitored on the same meter, it is impossible to know how much natural gas each building is using. However if we treat the total square footage of all of these builds as one large building that is responsible for using the amount of natural gas that the Boiler Room is said to use, then the boiler room is no longer the largest user of natural gas per square footage. The pool is the largest user of natural gas per square footage, this is shown in Figure 3.2.
Figure 3.2

From 2004-2005 to 2006-2007 the total GGE from natural gas increase by 21,116 therms or 9.3%. Figure 3.3 shows this trend.

Figure 3.3

Natural gas is primarily used for heating buildings and when the natural gas use is divided by the total square-footage at Warren Wilson College there is a lesser increase than the overall of 4.6%. Warren Wilson College built Village A and Village B dorms in the year 2005-2006 and were put online starting in 2006-2007. Figure 3.4 shows the natural gas GGE per square-foot trend.
Figure 3.4

Similar trends for carbon dioxide emissions from natural gas are shown in Figures 3.5 and 3.6.

Figure 3.5

Figure 3.6
The total cost of natural gas for 2006-2007 was $209,162 which is $55,216 more than 2004-2005 and this is about a 36% increase in costs. Figure 3.7 shows the cost trend for natural gas.

Figure 3.7

International Flights:

International Flights are Warren Wilson’s third largest greenhouse gas emitters. The International Flights arise from Warren Wilson’s WorldWide program, in which students take a class during the semester dealing with various issues and then travel to other countries or within the US to further study the subject. Many students a year participate in the WorldWide program and some of the cost for this program is included in the year tuition. It is a privilege to go on these trips, however the subsequent emissions from the international travel ranks these trips as the third largest source of GGEs at Warren Wilson College. In 2006-2007 Warren Wilson students, staff and faculty members made a total of 6 trips, which are listed in Table 4.1 along with the number of passengers for each trip and the total round trip mileage.
Table 4.1

<table>
<thead>
<tr>
<th>Destination</th>
<th>Number of WWC Passengers</th>
<th>Miles Round Trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everglades, Florida</td>
<td>7</td>
<td>1,260</td>
</tr>
<tr>
<td>Frankfurt, Germany</td>
<td>15</td>
<td>8,762</td>
</tr>
<tr>
<td>Santiago, Chile</td>
<td>18</td>
<td>9,778</td>
</tr>
<tr>
<td>Mexico City, Mexico</td>
<td>8</td>
<td>3,318</td>
</tr>
<tr>
<td>Edinburgh, Scotland</td>
<td>10</td>
<td>8,324</td>
</tr>
<tr>
<td>Hong Kong, Thailand</td>
<td>15</td>
<td>20,842</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>73</strong></td>
<td><strong>52,284</strong></td>
</tr>
</tbody>
</table>

The round trip mileage was multiplied by the number of passengers to determine passenger miles. Passenger miles were then used to calculate the subsequent emissions from the trips. For 2005-2006 and 2006-2007 a different emissions factor of 1.71 lb of CO$_2$/passenger mile was used to calculation emissions where as for 2004-2005 an emissions factor of 0.61 lb of CO$_2$/passenger mile.$^4$ The U.S. Department of Transportation provided these emission factors.

Table 4.2 shows the total passenger miles per year and the subsequent emissions from those miles traveled.

Table 4.2

<table>
<thead>
<tr>
<th>Warren Wilson College International Flights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>2004-2005</td>
</tr>
<tr>
<td>2005-2006</td>
</tr>
<tr>
<td>2006-2007</td>
</tr>
</tbody>
</table>
Passenger miles traveled decreased by 34%, and this was mostly due to the lesser number of International trips taken in 2006-2007. Figure 4.2 shows this trend.

**Figure 4.2**

![Passenger Miles Travelled Per Year](image)

Figure 4.3 shows the total GGE resulting from international travel, with a total decrease of 665,062 lbs or 34% from 2004-2005 to 2006-2007.

**Figure 4.3**

![GGE from International Travel](image)
The Remaining Five Sectors

Faculty, Staff and Student Fuel Use:

Fuel used by students, staff and faculty at Warren Wilson College was estimated by a survey. Surveys were sent through the campus mail system to staff, faculty and day students and surveys were given to Resident Directors to distribute to on-campus students at the time of the first dormitory meetings. These surveys asked individuals to report the type of car driven and the miles per week they drove on average. The total gallons of fuel was calculated from the estimated miles traveled per week and an estimated average miles per gallon for small trucks and SUVs and for sedans was used to find the total gallons of fuel consumed. The percentage of staff, faculty and students was found and then the total gallons calculated was then divided by the percent of surveyed to find the overall gallons used by the entire student and staff and faculty bodies. Table 5.1 shows gas use and subsequent emissions.
Table 5.1

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>7,007</td>
<td>108.44</td>
<td>432,606</td>
<td>85.11</td>
<td>28.54</td>
<td>443,240</td>
</tr>
<tr>
<td>Staff</td>
<td>15,331</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resident Students</td>
<td>15,317</td>
<td>22.43</td>
<td>294,306</td>
<td>60.61</td>
<td>20.20</td>
<td>301,839</td>
</tr>
<tr>
<td>Day Students</td>
<td>20,864</td>
<td>132.05</td>
<td>403,753</td>
<td>79.78</td>
<td>26.74</td>
<td>413,687</td>
</tr>
</tbody>
</table>

Because the fuel use is directly related to population size, total fuel consumption was divided per capita to create a more accurate depiction of the primary users of fuel at Warren Wilson College. Day students consumed the most fuel, 132 gallons per student every year. Resident students used the least, only about 22 gallons per year. Faculty and staff use about 108 gallons per year. This is shown in Figure 5.1.

Figure 5.1

![Per Capita Fuel Consumption](image-url)
Student Driving:

Student’s overall fuel use increased a total of 13,225 gallons (diesel and gasoline is included in this total) and this is about a 58% increase from 2004-2005 to 2006-2007. Per capita, student fuel use increased by about 50% as shown in Figure ES.21.

Figure 5.2

![Fuel Use per Student](image)

The large increase in fuel use may be due to surveying differences. A higher percentage of the student body was surveyed for 2006-2007 statistics than the other two years. Also, in past surveys, a specific gas mileage was assigned to each type of car instead of using an average gas mileage for small trucks and SUVs and sedans. This could have contributed to the large rise in fuel consumption.

Figure 5.3 shows the total GGE trend per student.

Figure 5.3

![GGE per Student](image)
Figure 5.4 shows the carbon dioxide emission from Student Driving.

**Figure 5.4**

![CO₂ Emission from Student Driving](image)

Warren Wilson started a “Hitching Post” for students to catch rides with other students going to town. This was an effort to reduce fuel use and also to build community. On the student fuel use survey, students were asked if they had ever used the Hitching Post. The results are shown in Figure 5.5.

**Figure 5.5**

![Hitching Post Survey: "Have you Ever Used the Hitching Post?"](image)

Most students, 66% of respondents, had not used the Hitching Post. And 15% said that they had used it with success.
Staff and Faculty Driving:

Staff and Faculty driving decreased by a total of 8,111 gallons or 23% from 2004-2005 to 2006-2007. Figure 5.6 shows the staff and faculty fuel use trend.

Figure 5.6

Per Staff and Faculty persons, there was an even larger decrease in fuel use of about 27% from 2004-2005 to 2006-2007, as shown in Figure 5.7.

Figure 5.7
Figure 5.8 shows the GGE per Staff and Faculty persons, which also has decreased 27% from 2004-2005 to 2006-2007.

**Figure 5.8**

![GGE per Staff and Faculty](image)

Figure 5.9 shows the carbon dioxide emissions resulting from Staff and Faculty Driving.

**Figure 5.9**

![CO₂ Emission per Staff and Faculty](image)
Campus Vehicle Fleet Fuel Use:

The Campus Vehicle Fleet is the seventh largest emitter of greenhouse gases at Warren Wilson College. This sector consists of all the vehicles used by Warren Wilson College; for work crews, service-learning, academics, and athletics. Motorpool is the pool of vehicles that Warren Wilson’s Staff, Faculty and Students can reserve to use for school related driving needs. Table 6.1 summarizes the total gallons used, subsequent costs and emissions from the Campus Vehicle Fleet for all three years.

Table 6.1

<table>
<thead>
<tr>
<th>Campus Vehicle Fleet Use by Warren Wilson College</th>
<th>Total Gallons Gas and Diesel</th>
<th>Cost</th>
<th>Carbon Dioxide Emission (lb)</th>
<th>Methane Emission (lb)</th>
<th>Nitrous Oxide Emission (lb)</th>
<th>Total GGE (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004-2005</td>
<td>24,352</td>
<td>$46,817</td>
<td>477,261</td>
<td>87</td>
<td>30</td>
<td>488,273</td>
</tr>
<tr>
<td>2005-2006</td>
<td>25,985</td>
<td>$66,999</td>
<td>508,357</td>
<td>94</td>
<td>32</td>
<td>520,200</td>
</tr>
<tr>
<td>2006-2007</td>
<td>29,608</td>
<td>$76,868</td>
<td>580,626</td>
<td>106</td>
<td>36</td>
<td>593,978</td>
</tr>
</tbody>
</table>

Figure 6.1 shows the Top Ten Fuel Users at Warren Wilson.

Motorpool unsurprisingly was the largest user of fuel at Warren Wilson. Farm and Landscaping followed closely.
There was an overall increase in fuel use of 5,256 gallons or about 22% from 2004-2005 to 2006-2007, as shown in Figure 6.2.

**Figure 6.2**

The large increase in fuel consumption may be due to calculation methods. For 2006-2007 total miles were estimated and then subsequent fuel consumption was calculated. In past years, only work crews, service-learning trips, and athletic game trips were estimated, so this may not have included all the same areas of fuel consumption.

When the fuel consumption is distributed across Warren Wilson’s total population, there is a 15.6% increase in fuel use per capita as shown in Figure 6.3.

**Figure 6.3**
Motorpool and the Campus Vehicle Fleet emission from fuel use increased by again 15.6% per capita as shown in Figure 6.4.

**Figure 6.4**

This sector was compiled and analyzed differently than the 2004-2005 and 2005-2006 inventories. For 2006-2007, the individual gas logs for each of the crews were compiled and Motorpool was found by using total mileage traveled by all the Motorpool vehicles. For the past two years, fuel purchases from the Autoshop were used to extrapolate fuel use. These differences could account for some differences in calculated total fuel use between the 3 years.

Total cost increase by 64% from 2004-2005 to 2006-2007 totaling a monetary increase in cost of $30,051. The cost trend for fuel use is shown in Figure 6.5.

**Figure 6.5**
Solid Waste:

Disposal of solid waste produces methane through the decomposition process that the waste undertakes after being buried in the county landfill. Through composting some of Warren Wilson’s waste, Warren Wilson College is able to lessen the amount of methane produced because composting does not release methane as a by-product. Methane produced from WWC solid waste was not flared in 2004-2005, 2005-2006, or 2006-2007. Flaring reduces the methane emission. Table 7.1 shows the waste stream at Warren Wilson from all three years the inventory has been conducted.

Table 7.1

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>to landfill:</td>
<td>Trash</td>
<td>357.6</td>
<td>310.7</td>
<td>286.35</td>
</tr>
<tr>
<td></td>
<td>Recycling</td>
<td>137.1</td>
<td>134.9</td>
<td>165.66</td>
</tr>
<tr>
<td>diverted from landfill:</td>
<td>Reusables</td>
<td>3.0</td>
<td>2.1</td>
<td>3.02</td>
</tr>
<tr>
<td></td>
<td>Compost</td>
<td>0.0</td>
<td>56.9</td>
<td>37.41</td>
</tr>
<tr>
<td>TOTAL</td>
<td>497.7</td>
<td>504.6</td>
<td>492.44</td>
<td></td>
</tr>
</tbody>
</table>

Solid Waste at Warren Wilson College is the largest emitter of methane and this sector only emits methane. When this is converted into GGE equivalents, solid waste is the sixth largest emitter overall for total GGE. Warren Wilson implements a composting system that offsets the methane emission from solid waste because composting theoretically emits no methane. There was no composting in 2004-2005, however there was composting in both 2005-2006 and 2006-2007 and this reduced the total amount of methane produced from the waste at Warren Wilson College.

Methane production shows an increase of 24% from 2004-2005 to 2006-2007 when the offsets from composting are not taken into account. However, when the offsets are factored into the overall methane production resulting from solid waste, there is an overall decrease in methane production by 20%. This comparison is shown in Figure 7.1.
Figure 7.1

Figure 7.2 shows the poundage of methane produced over the past three years and there is a 20% reduction overall.

Figure 7.2

Per capita GGE from solid waste shows an increase of about 18%. Figure 7.3 shows GGE from solid waste per capita.
Agriculture:

Agricultural emission from Warren Wilson College result from methane produced from solid waste of the animals and the fertilizers used on the hay and corn crops. Nitrous oxide and methane are produced from these sources, however carbon dioxide is not. Both methane and nitrous oxide have a larger global warming potential than carbon dioxide.

Horses, pigs, cattle, chickens and goats were included in this inventory. Figure 8.1 shows the GGEs from the farm animals and fertilizer used on Warren Wilson’s farm.
The nitrous oxide produced from WWC’s farm is 0.26% of the total GGE produced by Warren Wilson and the methane produced from WWC’s farm is 2.6% of the total GGE produced by Warren Wilson.

The total GGE produced from agriculture decreased by 8.5% or a total of 31,997 lb from 2004-2005 to 2006-2007, as shown in Figure 8.2.

**Figure 8.2**

Methane production decreased by 3.4% from 2004-2005 to 2006-2007, shown in Figure 8.3.

**Figure 8.3**

And nitrous oxide decreased by 40.5% from 2004-2005 to 2006-2007, and this large decrease was due to the fact that fertilizer was not used to fertilize the hay fields in 2006-2007. The nitrous oxide trend is shown in Figure 8.4.
Miscellaneous:

The Miscellaneous emissions sector at Warren Wilson consists of emissions produced by Used motor oil burned in the Autoshop furnace for heating, propane used by landscaping, and coke used by the blacksmithing shop. This sector is the lowest emitter of all sectors however it is significant. Only used motor oil was included in the 2004-2005 inventory. Table 9.1 summarizes the use and emissions for these sources for 2006-2007.

Table 9.1

<table>
<thead>
<tr>
<th>Source</th>
<th>Total Use</th>
<th>Carbon Dioxide Emission (lb)</th>
<th>Methane Emission (lb)</th>
<th>Nitrous Oxide Emission (lb)</th>
<th>Total GGE (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used Motor Oil (Furnace)</td>
<td>1,600 gal</td>
<td>34,921</td>
<td>5.13</td>
<td>0.72</td>
<td>35,252</td>
</tr>
<tr>
<td>Propane (Landscaping)</td>
<td>773.2 gal</td>
<td>9,205</td>
<td>17.98</td>
<td>0.09</td>
<td>9,609</td>
</tr>
<tr>
<td>Coke (Blacksmith)</td>
<td>1.5 tons</td>
<td>6,329</td>
<td>0.71</td>
<td>0.10</td>
<td>6,375</td>
</tr>
</tbody>
</table>

These sources only account for 0.43% of the total GGE from Warren Wilson College. From 2004-2005 to 2006-2007 the emissions produced by these energy sources decreased by 42%. This is shown in Figure 9.1.
Figure 9.1

![GGE from Miscellaneous Sources](image)

Figure 9.2 shows the carbon dioxide emissions resulting from the burned motor oil, coke from the blacksmithing shop and propane.

Figure 9.2

![CO₂ from Miscellaneous Sources](image)

42%
Conclusion

Producing an annual greenhouse gas inventory allows WWC to track change over time for key emissions indicators. The table below summarizes the percent change from 2004-2005 to 2006-2007 by sector:

<table>
<thead>
<tr>
<th>Sector</th>
<th>Change from 2004-2005 to 2006-2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increase</td>
</tr>
<tr>
<td>Overall GGE</td>
<td>44% per Capita per Sqft (including RECs)</td>
</tr>
<tr>
<td>Electricity GGE</td>
<td>3.6% per Capita</td>
</tr>
<tr>
<td>Natural Gas GGE</td>
<td>4.6% per Square Foot</td>
</tr>
<tr>
<td>Campus Vehicle Fleet GGE</td>
<td>15.6% per Capita</td>
</tr>
<tr>
<td>Staff and Faculty Fuel GGE</td>
<td>27% per Staff and Faculty</td>
</tr>
<tr>
<td>Student Fuel GGE</td>
<td>50% per Student</td>
</tr>
<tr>
<td>Worldwide Flight GGE</td>
<td>34% overall</td>
</tr>
<tr>
<td>Agriculture GGE</td>
<td>8.5% overall</td>
</tr>
<tr>
<td>Solid Waste GGE</td>
<td>18% per Capita</td>
</tr>
<tr>
<td>Miscellaneous GGE</td>
<td>42% overall</td>
</tr>
</tbody>
</table>

Though all of the above sectors are important to understand, additional sectors need to be brought into the fold. Hence, WWC is initiating two important processes that will help broaden and deepen the College’s inventory:

1. A faculty and student led process will determine the carbon sequestering potential of the College’s mixed-stand, multi-age 750 acre forest, and inform the inventory process by providing forest-type specific data.
2. The new presidential appointed Local Food Task Force will begin looking at food miles and emissions accrued through dining services.

While these processes get underway, the presidential appointed Greenhouse Gas Emissions Reduction Task Force will propose institutional goals for energy use and emissions reductions identify the most economically viable areas to invest in pursuit of these goals, and establish targeted behavior change campaigns. This work effectively takes the information gathered by the inventory process and puts it to use in a positive feedback loop that will- if successful- result in measurable energy use and emissions reduction.
Areas for Improving the Inventory

The primary area for improving the inventory is the record keeping. Having a much tighter, more easily accessible data for the inventory would increase the rate of completion and also improve the accuracy of the energy use and emissions calculated for each sector. In addition, the following is recommended:

- Sub metering the boiler room meter so that each individual building was being monitored for natural gas would help Warren Wilson understand the usage of each building and unveil energy saving opportunities.
- Including other sectors such as on campus staff and faculty housing, carbon sequestration by the Warren Wilson forest, food commodity emissions, sewage treatment and disposal of refrigerants containing hydro fluorocarbons.
- Using more accurate emissions factors for each campus fleet vehicle would improve the accuracy of the emissions calculated as a result of the fuel used by these vehicles.

Finally, because energy use and emissions inventories are being conducted on a national and international basis, a universal emissions inventory style and emission factor could be used. This would speed up the process of conducting and producing and inventory for all institutions and also make the inventories more comparable to one another.
In Detail Methods and Data by Sector

Electricity Inventory Methods and Data

Methods:
Electricity data was gathered from the Progress Energy website, which provides monthly bills for all 58 on-campus electricity meters. In order to access the web site, located at www.progressenergy.com, the password and E-mail ID must be obtained from the Accounting Office. Once at the site, follow links to large commercial/industrial/governmental section for the Carolinas. Then follow the link to Energy Resource Center. Here the website prompts the user for a E-mail ID and a password. The data was then pulled off Progress Energy’s website and formatted to summarize individual building electricity consumption as well as the resulting emissions from the electricity consumption.

Data:
The first two charts display the total usage, percent of total use, total cost and emissions from 2006-07 electricity use. The last table shows the emissions factors and calculations used for each greenhouse gas.