CALVIN

College

Carbon Neutrality Project

Biology 354 and Engineering 333

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December 14, 2007

Objective:

The students of Calvin College's Engineering 333 and Biology 354 classes were given the task of determining "What would it take to make Calvin College Carbon Neutral?" At first glance, it would not appear that classes on Advanced Thermal System Design and Investigations in Plant Ecology would have much in common. However, the biology and engineering students comprising these classes banded together to tackle the problem. Coming to a satisfactory conclusion would require:

- Creating an inventory of Green House Gas (GHG) emissions and sequestration potential
- Coming up with detailed solutions to achieve Carbon Neutrality
- Working out a practical schedule to implement those solutions, and
- Developing a realistic plan to finance the process of achieving Carbon Neutrality

Approach:

In order to tackle this semester-long project, the students subdivided into five groups, each targeting a specific area to inventory GHG emissions and sequestration. The five groups, taking a cue from Calvin College's Statement of Sustainability[1], investigated the following five areas:

- Energy Use and Purchasing
- Land Use and Waste Water Management
- Recycling and Solid Waste Management
- Construction and Renovation
- Transportation

While creating the inventory, each group also researched potential solutions to the problem of GHG emissions. For the sake of consistency, all groups reported results in Metric Tons Carbon Dioxide Emitted per year, abbreviated MTCE.

During the course of the project, it became clear that some areas of study contributed far more to Calvin's carbon footprint than others. The two groups working on land use and waste water management and recycling and solid waste management wrapped up their investigations and focused on the financial aspect of the project. All groups had been encouraged to brainstorm solutions, both frivolous and realistic. The students working on Finance filtered through these suggestions, selecting projects and objectives that were both feasible and marketable. Once these had been selected, a financial plan; which took into account inflation, the time-value of money, and the college's total budget, was drawn up.

Results:

Achieving Carbon Neutrality is possible but quite a challenge. And it will remain that way as long as we burn fossil fuel to produce heat and electricity and to power our vehicles. Figure 1 shows the results of the Emissions and Sequestration inventory.

[1] http://www.calvin.edu/admin/provost/environmental/

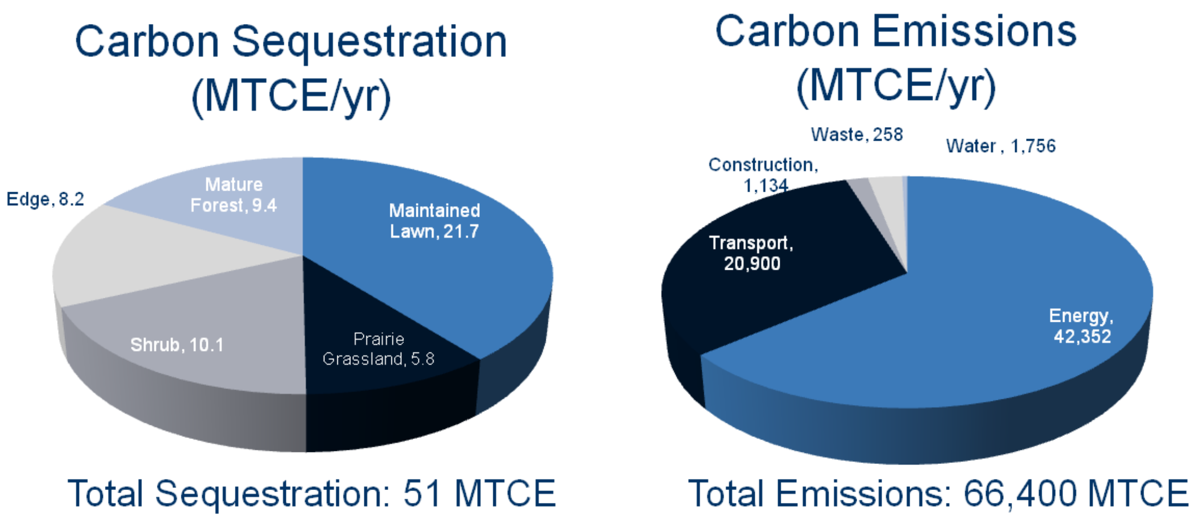

Figure 1: Results of the Inventory

Because Calvin's sequestration potential is so much lower than it emissions, reducing Calvin's Carbon footprint to zero required creativity. Ultimately, it is not currently feasible to become Carbon Neutral without looking off campus. Calvin can reduce its emissions by reducing consumption, increasing efficiency, using renewable power and finally making up the difference by purchasing Carbon offsets from a third party. Details on methods to reduce consumption and increase efficiency on campus can be found in the following appendices.

The main thrust of the proposed plan to achieve Carbon Neutrality centers around the installation of wind turbines on property owned by Calvin. These wind turbines would generate clean, renewable energy and reduce Calvin's dependence on electricity generated by burning fossil fuels. The rest of Calvin's footprint would be countered by purchasing Carbon Offsets from a third party such as TerraPass.com. Other projects, such as Calvin-owned bikes, would play into the overall plan, doing a small part to decrease emissions and playing a significant role in raising public awareness.

This plan outlined here and explained in greater detail in the appendices, could be achieved by dedicating 1.16% of Calvin's $86 million budget each year for 11 years toward a Green Energy Fund. Any monetary savings resulting from campus improvements would be deposited back into this Green Energy Fund to provide capital for future carbon reduction projects.

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Appendix A: Energy Use and Purchasing

Introduction

As a part of the Calvin College Neutrality Project, the Energy Use and Purchasing group was responsible for 4 tasks. First, determine Calvin's carbon footprint due to energy use on campus. Second, determine and validate different energy conservation methods that would offset Calvin's carbon footprint. Third, explore possible renewable energy options that would as well reduce the carbon footprint. Fourth, develop a plan to bring carbon emissions due to energy use on campus to zero. How these four tasks were accomplished is explained in the following report.

Carbon Footprint

The carbon foot print due to energy use on campus is a significant part of the overall carbon emitted by Calvin. Carbon emission are incurred by Calvin College due to energy use through two ways, natural gas combustion used for heating campus, and production methods used to create the electricity Calvin uses. Table 1 presents the composition of energy production used to generate the electricity that Calvin purchases, and its respective emission carbon emission.

Table 1: Energy Composition and Carbon Emission

Energy Composition	Percent of Energy	Carbon Emission [lbm/kWh]
Coal	0.57	2.117
Gas	0.18	1.314
Renewable	0.035	2.015
Nuclear	0.2	0
Wind	0.015	0

Current Carbon Footprint

Currently on average Calvin purchases 16000 mmBTU of natural gas, and 21,500,000 kW-hr annually. Do to the warming climate in Michigan in recent years there has been a trend of decrease natural gas use, and increasing electricity use. This energy purchasing and use results in 43,000 MTCE per year.

New Field House Complex and Boilers

This year Calvin began construction the new field house complex, and replaced two boilers in the science division power plant for more efficient ones. GMB engineers have calculated that the new field house complex will increase electricity use by 100%, and natural gas use by 50%. This has a serious impact on increasing the carbon emission that Calvin is responsible for. It was believed that boiler replacement would result in a "wash", but it was found that was not the case. A model was developed to best imitate the complex use of Boilers on campus. The estimates calculated by this model for the MTCE by the field house complex addition and more efficient boiler swap out are presented in Table 2 (see appendix 4 for calculations):

Table 2: Boiler System Model Results

Existing Infrastructure [kg]	482331
New Boilers Swap [kg]	470952
New Boilers + Additional Load [kg]	643211
Additional MTCE	1332

Future Carbon Emission Estimation

A mathematical model was developed to account for the new field house complex, and electricity and gas use escalation. We assumed positive escalation rate for electricity and gas use because Calvin continues to purchase properties, and there is an ever increasing use of technology needing electricity (e.g. computers). See appendix 5 for this model.

Carbon Reduction Options

Several methods of reducing Calvin's carbon emissions were considered. These included using wind turbines as a non-fossil fuel source of energy, lowering heating levels in campus buildings to reduce energy use, and purchasing carbon offset credits to mitigate the rest of the energy use which could not be accounted for. Wind turbines, though not a perfect solution, would allow Calvin to produce much of its own electrical energy (depending on the number of turbines installed), which is otherwise a major source of carbon emissions. Reducing heat loads in campus buildings would allow the campus to save both money and carbon emissions, just by a simple operational change. On the other hand, it might require some behavioral changes on the part of the occupants of the buildings; for example, it may become necessary for some occupants to wear a sweater indoors. Finally, many of the college's carbon emissions simply cannot be cut out without drastic impacts on the lives of those at the college, which would be intolerable for many of them. As such, it becomes necessary to mitigate the remaining carbon emissions. One of the easiest and best ways to accomplish this is with the use of carbon offset credits. Purchasing these credits from a certified supplier essentially pays for them to make an investment which will reduce carbon emissions relative to the status quo (See Appendix 2). By purchasing enough such credits to offset its remaining emissions, the college could legitimately claim carbon neutrality. A possible solution could incorporate any or all of these options, though a combination of several strategies is typically found to be most effective.

Carbon Neutrality Plan

Our group has developed a plan which yields carbon neutrality from its start. The plan requires significant upfront costs however pays extreme dividends in the long run. Our plan has three major components, renewable energy in the form of wind turbines, conservation of energy in the form of an indoor temperature drop, and carbon offsetting through www.terrapass.com

The first step to our plan of carbon neutrality is to install 4 wind turbines on Calvin's behalf. The research of previous ENGR 333 classes was adapted to our research in order to find what types of costs and production we could expect to see from the wind turbines. A plan was developed to implement 4 wind turbines onto Calvin's campus over a 20 year period. The 4 wind turbines would only cut about 10% off of Calvin's carbon footprint however they would lead to significant profits that are later used for the purchase of Carbon credits.

The next step in our plan is to adopt another suggestion from a previous ENGR 333 class in the adaption of a temperature drop on campus. This temperature drop not only lowers the campus' gas usage, and thus shrinking our carbon footprint, but it also saves large amounts of money which again can be applied toward carbon credits at the construction of the wind turbines.

The final step in our plan is offsetting the remaining portion of Calvin's carbon footprint due to energy purchasing and use with carbon credits from www.terrapass.com. The credits would be purchased in early years of the plan at the schools expense however at later years the plan will pay for itself and even surpass the funds required for complete carbon neutrality through offset credits.

Figure 1 shows the projected annual costs for our college to achieve carbon neutrality through our three step plan.

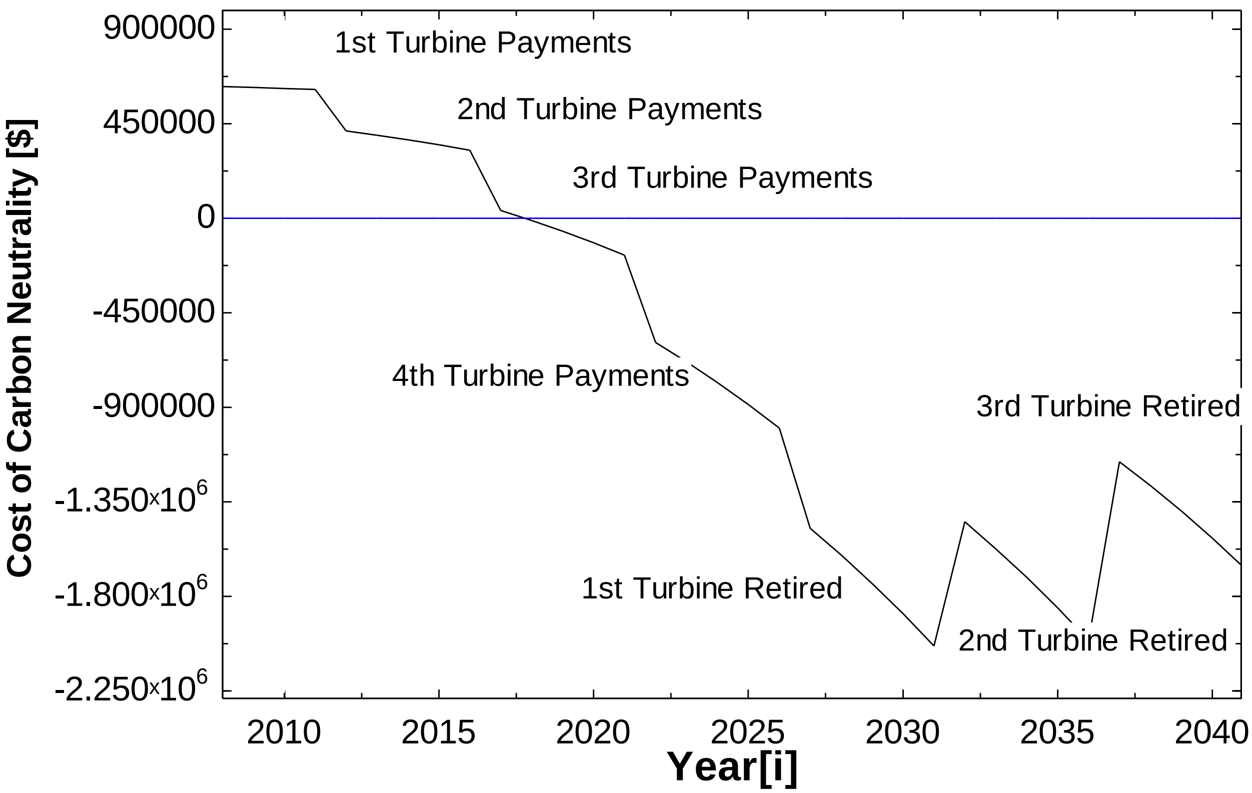

Figure 1: Annual Payments for Carbon Neutrality

Conclusion

As a conclusion to the energy purchasing and use groups plan for carbon neutrality we would like to point out that while carbon neutrality is not impossible, it is by no means easy. Complete carbon neutrality will not only have a cost but will also require lifestyle changes by members of the community at large. While acknowledging the difficulty in achieving carbon neutrality one must also acknowledge the incredible opportunity for Calvin College to be a leader in our community here in west Michigan and in the academic community at large. Complete carbon neutrality on Calvin's campus would make a statement about Calvin's values and its desire to maintain good stewardship of all of God's resources. Carbon Neutrality may be difficult, but it's certainly not impossible.

Appendix A.1: Boiler System Model Explanation

Through conversation will Paul Pennock a model was developed to estimate the energy use of the existing boiler infrastructure, and new boiler infrastructure with the increased heating load of the new field house complex. To develop very accurate model of the boiler system would take a few heating seasons of carful study on boiler operation on campus. This is due to the fact there is now record of how boilers exactly operate throughout the year on campus. For example, the boiler in the library runs 100% of the year, yet it automatically adjusts its flame intensity to match the load, but there is no record of how and when it does this.

As a result, this model is based on how Paul Pennock described the existing boiler operate on campus. This information was used to calculate the actual heating load of campus. The actual heat load was used in a model with new boiler efficiencies to see how much the new boilers reduced the MTCE on campus. Last, the existing load number was increased by 50% for the increase load presented by the new field house complex (this percentage was provided by GMB engineers). The results are presented in the main appendix text.

This model may not give an exact number or MTCE increase by the new field house and boilers swaps, but it does confidently show that these things do not cancel each other out. There will increase in Calvin's carbon footprint. Find the discussed model in the rest of this appendix.

Appendix A.2: Carbon Offset Credits Discussion

Carbon offset credits, often referred to as carbon offsets or carbon credits, are essentially a tradable commodity which are used as part of a carbon trading system, whether it be mandatory or voluntary. They are typically sold in units of dollars (or Euros, pounds, or other currencies) per metric ton of carbon dioxide emitted. Carbon credits can come either from projects which remove carbon dioxide (CO2) from the atmosphere or from projects which reduce the amount of CO2 which would otherwise have been released to the atmosphere. An example of the former is reforestation projects, wherein people plant young trees in areas which were previously cleared. This obviously can have significant environmental benefits, including increase in wildlife habitat, watershed health, erosion control, and many more. An example of the latter type of carbon credit-generating project is the construction of a wind turbine "farm" to replace the construction of a coal-fired power plant. In contrast to the reforestation, this is detrimental to the environment, although much less so than the coal-powered generating facility it replaced. While this is a major difference, it is not always apparent to people who buy carbon offsets, nor is the information always made available by vendors of the credits. Nevertheless, the two methods share a common principle, which involves reducing the greenhouse gas emissions from current values.

Carbon offsets allow the people who can most easily reduce carbon emissions to be compensated for their efforts, and thereby make sure that carbon emission reductions are made in the most cost-efficient way possible. This is particularly useful in a system where carbon emissions are limited, and industries must find ways to reduce their carbon emissions or to offset them with purchased credits. At that point, it becomes very important to weigh the cost of equipment or operations upgrades versus the cost of carbon offset purchasing. Whichever option is determined to be most cost-effective will most likely be adopted.

At an educational institution, the use of purchased carbon offsets becomes more ambiguous, particularly if there is no mandated cap on carbon emissions in the region. In that case, purchasing carbon offsets becomes something very similar to paying taxes: a necessary evil which contributes very little real value to the institution beyond possible advertising claims. In such a case, it may be regarded as more worthwhile to pay slightly more for carbon offset costs in order to support a program which is more visible to students, staff, and the community. In the unique environment of an educational institution, the focus is indeed on education, and it might well be said that carbon credits would not be the most advantageous way to pursue carbon emissions reductions.

Appendix A.3: Energy Use Raw Data

2003

	Jan	Feb	Mar	Apr	May	Jun
Gas (mmBTU)	21550	17653	15297	21908	13866	10457
Gas (kWh)	6.32E+06	5.17E+06	4.48E+06	6.42E+06	4.06E+06	3.07E+06
Cost*	$139,644.00	$114,391.44	$99,124.56	$141,963.84	$89,851.68	$67,761.36

	Jul	Aug	Sep	Oct	Nov	Dec
	11083	10546	13913	15297	15874	20115
	3.25E+06	3.09E+06	4.08E+06	4.48E+06	4.65E+06	5.90E+06
	$71,817.84	$68,338.08	$90,156.24	$99,124.56	$102,863.52	$130,345.20

Electicity (kWh)
Cost

Emission Break down (lbm/kWh)	
coal	2.117
gas	1.314

energy Compostion	**Percent of Energy**	**lbm CO2**
Coal	0.57	0
Gas	0.18	0
Nuclear	0.2	0
Renewable	0.05	0

Yearly Analysis	**Total**
Gas (mmBTU)	100731
Gas (kWh)	29523000
Cost*	$652,736.88
Electicity (kWh)	0
Cost	$86,828.00
$/kWh	#DIV/0!
Total Cost*	$739,564.88

Yearly Carbon Analysis	
Gas (lbm)	38793222.00
Gas (metric tonnes)	17596.49
Electricty (lbm)	0.00
Electricity (metric tonnes)	0.00
Total (metric tonnes)	17596.49

2004

	Jan	Feb	Mar	Apr	May	Jun
Gas (mmBTU)	24504	23352	21554	16322	13053	13332
Gas (kWh)	7.18E+06	6.84E+06	6.32E+06	4.78E+06	3.83E+06	3.91E+06
Cost*	$158,785.92	$151,320.96	$139,669.92	$105,766.56	$84,583.44	$86,391.36

	Jul	Aug	Sep	Oct	Nov	Dec
	11596	12194	13097	14626	18208	20236
	3.40E+06	3.57E+06	3.84E+06	4.29E+06	5.34E+06	5.93E+06
	$75,142.08	$79,017.12	$84,868.56	$94,776.48	$117,987.84	$131,129.28

Electicity (kWh)
Cost

Emission Break down (lbm/kWh)	
coal	2.117
gas	1.314

energy Compostion	**Percent of Energy**	**lbm CO2**
Coal	0.57	0
Gas	0.18	0
Nuclear	0.2	0
Renewable	0.05	0

Yearly Analysis	**Total**
Gas (mmBTU)	112117
Gas (kWh)	32858000
Cost*	$726,518.16
Electicity (kWh)	0
Cost	$89,957.00
$/kWh	#DIV/0!
Total Cost*	$816,475.16

Yearly Carbon Analysis	
Gas (lbm)	43175412.00
Gas (metric tonnes)	19584.24
Electricty (lbm)	0.00
Electricity (metric tonnes)	0.00
Total (metric tonnes)	19584.24

2005

	Jan	Feb	Mar	Apr	May	Jun
Gas (mmBTU)	23593	19945	21624	16781	15283	10883
Gas (kWh)	6.91E+06	5.85E+06	6.34E+06	4.92E+06	4.48E+06	3.19E+06
Cost*	$152,882.64	$129,243.60	$140,123.52	$108,740.88	$99,033.84	$70,521.84

	Jul	Aug	Sep	Oct	Nov	Dec
	11139	12327	7707	10391	15863	19766
	3.27E+06	3.61E+06	2.26E+06	3.05E+06	4.65E+06	5.79E+06
	$72,180.72	$79,878.96	$49,941.36	$67,333.68	$102,792.24	$128,083.68

Electicity (kWh)
Cost

Emission Break down (lbm/kWh)	
coal	2.117
gas	1.314

energy Compostion	**Percent of Energy**	**lbm CO2**
Coal	0.57	0
Gas	0.18	0
Nuclear	0.2	0
Renewable	0.05	0

Yearly Analysis	**Total**
Gas (mmBTU)	108109
Gas (kWh)	31682000
Cost*	$700,546.32
Electicity (kWh)	0
Cost	$77,193.00
$/kWh	#DIV/0!
Total Cost	$777,739.32

Yearly Carbon Analysis	
Gas (lbm)	41630148.00
Gas (metric tonnes)	18883.31
Electricty (lbm)	0.00
Electricity (metric tonnes)	0.00
Total (metric tonnes)	18883.31

2006

	Jan	Feb	Mar	Apr	May	Jun
Gas (mmBTU)	19933	20106	17563	11203	10229	7537
Gas (kWh)	5.84E+06	5.89E+06	5.15E+06	3.28E+06	3.00E+06	2.21E+06
Cost*	$129,165.84	$130,286.88	$113,808.24	$72,595.44	$66,283.92	$48,839.76
Electicity (kWh)	1733210	1693594	1737504	1891044	1977043	1712523
Cost	$101,219.86	$105,069.15	$119,057.59	$131,215.35	$135,549.32	$119,042.68

	Jul	Aug	Sep	Oct	Nov	Dec
Gas (mmBTU)	7054	11920	10444	13847	14559	17663
Gas (kWh)	2.07E+06	3.49E+06	3.06E+06	4.06E+06	4.27E+06	5.18E+06
Cost*	$45,709.92	$77,241.60	$67,677.12	$89,728.56	$94,342.32	$114,456.24
Electicity (kWh)	1992280	1691539	1952033	1994287	1742391	1336487
Cost	$134,662.96	$122,475.97	$137,418.40	$131,268.28	$124,643.49	$108,356.15

Emission Break down (lbm/kWh)	
coal	2.117
gas	1.314

energy Compostion	**Percent of Energy**	**kWh**
Coal	0.57	6124603
Gas	0.18	1934085
Nuclear	0.2	2148984
Renewable	0.05	537246

Yearly Analysis	**Total**
Gas (mmBTU)	86571
Gas (kWh)	25371000
Cost*	$560,980.08
Electicity (kWh)	10744918
Cost	$711,153.95
$/kWh	$0.07
Total Cost	$1,272,134.03

Yearly Carbon Analysis	
Gas (lbm)	33337494.00
Gas (metric tonnes)	15121.79
Electricity (lbm)	15507173.11
Electricity (metric tonnes)	
Total (metric tonnes)	15121.79

2007

	Jan	Feb	Mar	Apr	May	Jun
Gas (mmBTU)	23303	24383	16502	14257	10987	6058
Gas (kWh)	6.83E+06	7.15E+06	4.84E+06	4.18E+06	3.22E+06	1.78E+06
Cost*	$151,003.44	$158,001.84	$106,932.96	$92,385.36	$71,195.76	$39,255.84
Electicity (kWh)	1368371	1383898	1763767	1814449	2018586	1943657
Cost	$106,137.92	$111,682.49	$138,158.43	$141,201.87	$143,902.00	$139,254.71

	Jul	Aug	Sep	Oct	Nov
Gas (mmBTU)	7280				
Gas (kWh)	2.13E+06				
Cost*	$47,174.40				
Electicity (kWh)					
Cost					

Emission Break down (lbm/kWh)	
coal	2.117
gas	1.314

energy Compostion	**Percent of Energy**	**lbm CO2**
Coal	0.57	444792.329
Gas	0.18	140460.736
Nuclear	0.2	156067.484
Renewable	0.05	39016.871

Yearly Analysis	**Total**
Gas (mmBTU)	95490
Gas (kWh)	27984000
Cost	$618,775.20
Electicity (kWh)	780337.42
Cost	$0.00
$/kWh	$0.00
Total Cost	$618,775.20

Yearly Carbon Analysis	
Gas* (lbm)	36770976.00
Gas* (metric tonnes)	16679.21
Electricty (lbm)	1126190.77
Electricity (metric tonnes)	510.84
Total (metric tonnes)	17190.04

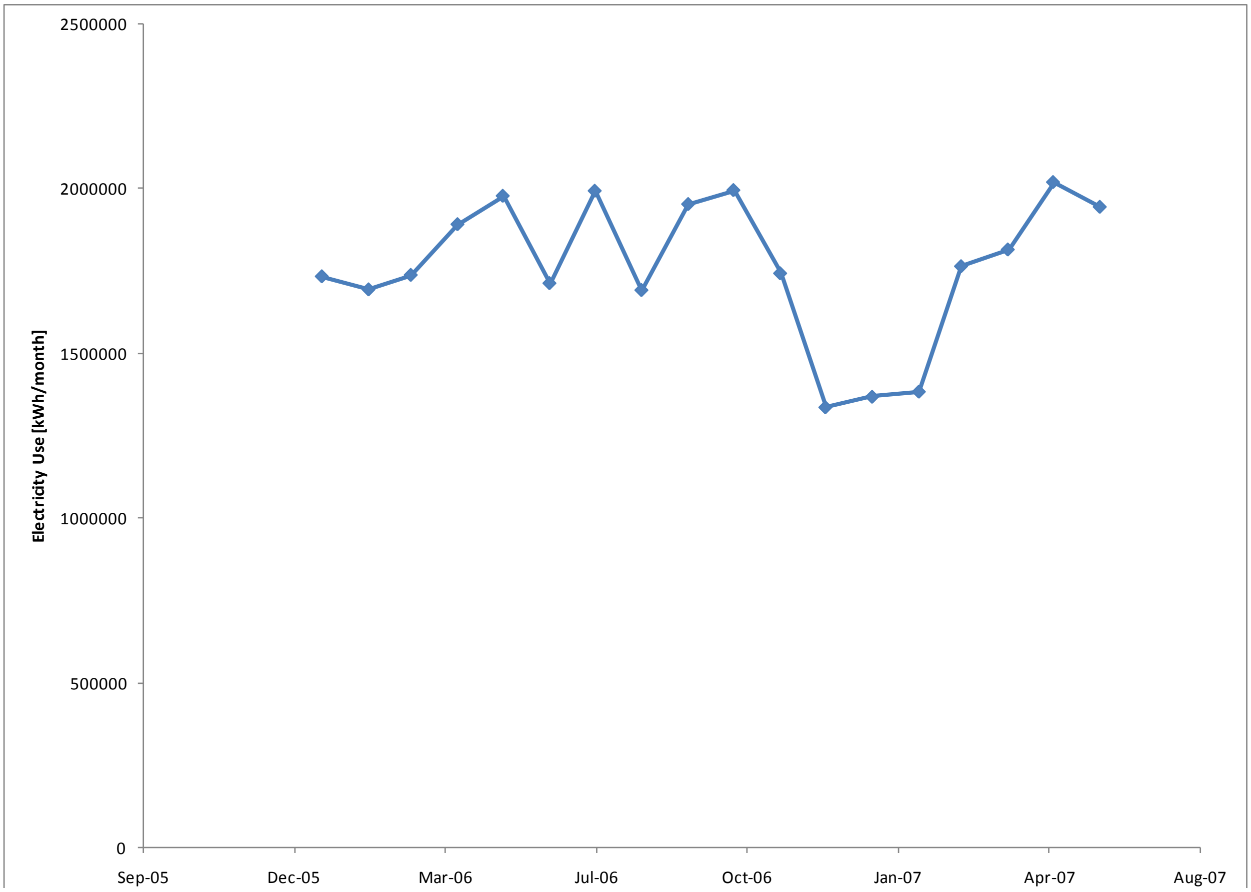

Figure 3.1 Monthly Electricity Use

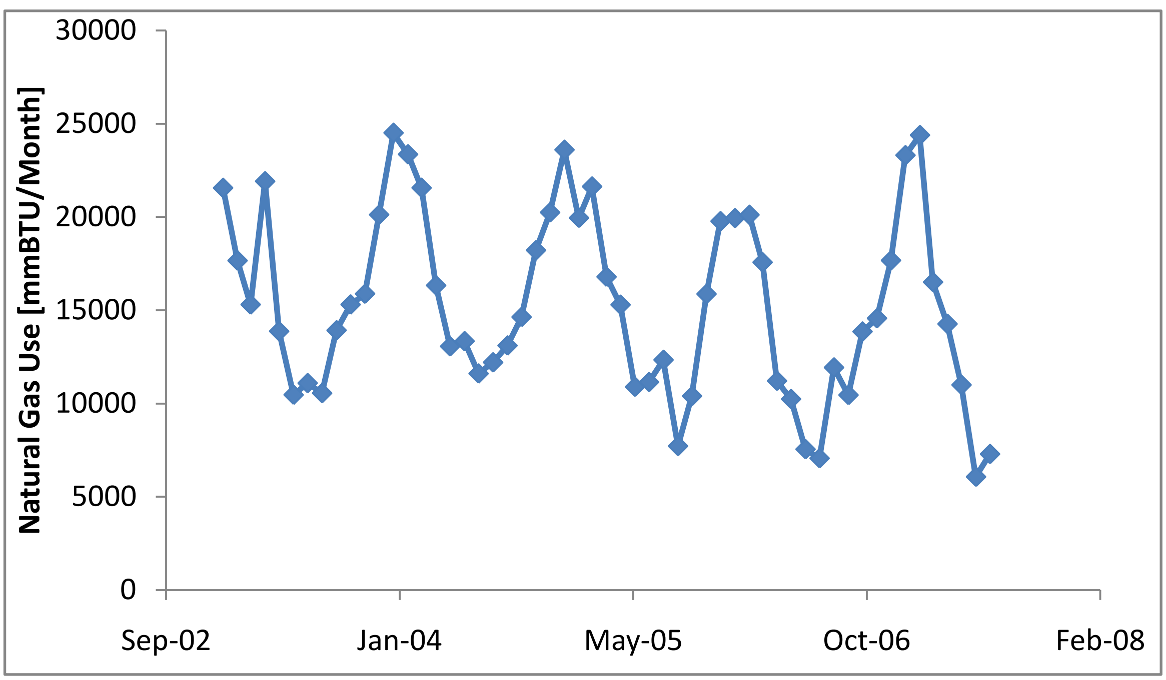

Figure 3.2: Monthly Gas Use

Appendix A.4: Boiler System Model EES Worksheet

```
"!Knowns"
"Fuel Information"
LHV_CH4=50010[kJ/kg]
Heating_season=.58[year]*convert(year,s)

"Boiler Efficiency"
    "Existing Setup"
Eta[0]=.65                              "Apartments"
Eta[1]=0.67                             "Commons"
Eta[2]=0.67                             "Commons"
Eta[3]=0.67                             "Commons"
Eta[4]=0.92                             "Library"
Eta[5]=0.67                             "KDH"
Eta[6]=0.67                             "KDH"
Eta[7]=0.65                             "SDPP"
Eta[8]=0.65                             "SDPP"
Eta[9]=.62                              "PE"
Eta[10]=.62                             "PE"

    "New Setup"
Eta[11]=.65                             "Apartments"
Eta[12]=0.67                            "Commons"
Eta[13]=0.67                            "Commons"
Eta[14]=0.67                            "Commons"
Eta[15]=0.92                            "Library"
Eta[16]=0.67                            "KDH"
Eta[17]=0.67                            "KDH"
Eta[18]=0.97                            "SDPP"
Eta[19]=0.97                            "SDPP"
Eta[20]=.62                             "PE"
Eta[21]=.62                             "PE"


"Boiler Power Rating"
P[0]=300[hp]*convert(hp,kW)             "Combined Apartments"
P[1]=338[hp]*convert(hp,kW)             "Commons"
P[2]=338[hp]*convert(hp,kW)             "Commons"
P[3]=338[hp]*convert(hp,kW)             "Commons"
P[4]=300[hp]*convert(hp,kW)             "Library"
P[5]=150[hp]*convert(hp,kW)             "KDH"
P[6]=150[hp]*convert(hp,kW)             "KDH"
P[7]=300[hp]*convert(hp,kW)             "SDPP"
P[8]=300[hp]*convert(hp,kW)             "SDPP"
P[9]=125[hp]*convert(hp,kW)             "PE"
P[10]=125[hp]*convert(hp,kW)            "PE"

    "New"
P[11]=300[hp]*convert(hp,kW)            "Combined Apartments"
P[12]=338[hp]*convert(hp,kW)            "Commons"
P[13]=338[hp]*convert(hp,kW)            "Commons"
```

```
P[14]=338[hp]*convert(hp,kW)                        "Commons"
P[15]=300[hp]*convert(hp,kW)                        "Library"
P[16]=150[hp]*convert(hp,kW)                        "KDH"
P[17]=150[hp]*convert(hp,kW)                        "KDH"
P[18]=400[hp]*convert(hp,kW)                        "SDPP"
P[19]=400[hp]*convert(hp,kW)                        "SDPP"
P[20]=125[hp]*convert(hp,kW)                        "PE"
P[21]=125[hp]*convert(hp,kW)                        "PE"


"Operation Variable - This method assumes that the most effcient boiler is being used flat out, and then next most efficient boiler is brought online and the process repeats"
f[0]=.7                                             "Apartments"
f[1]=.4                                             "Commons"
f[2]=.2                                             "Commons"
f[3]=0                                              "Commons"
f[4]=.75                                            "Library"
f[5]=.75                                            "KDH - Dorm loop"
f[6]=.75                                            "KDH - Dorm loop"
f[7]=.5                                             "SDPP"
f[8]=.5                                             "SDPP"
f[9]=.5                                             "PE"
f[10]=0                                             "PE"
   "New"
f[11]=1                                             "apartments"
f[12]=1                                             "Commons"
f[13]=0                                             "Commons"
f[14]=0                                             "Commons"
f[15]=1                                             "Library"
f[16]=1                                             "KDH - Dorm loop"
f[17]=1                                             "KDH - Dorm loop"
f[18]=1                                             "New SDPP"
//f[19]=0.2812                                      "New SDPP"
f[20]=0                                             "PE"
f[21]=0                                             "PE"

"kg Nat Gas Used By Existing Campus"
duplicate i=0,10
m_used[i]=(P[i]/(LHV_CH4*eta[i])*f[i])*heating_season
end

m_GasUse[1]=SUM(m_used[i],i=0,10)

"Useful Kg of Nat Gas"
Duplicate i=0, 10
m[i]=(P[i]/(LHV_CH4)*f[i])*heating_season
end

"Load Calculations"                                  "Switch Out Load and New_load"
Load=SUM(m[i],i=0,10)*LHV_CH4*convert(kJ,mmBTU)
//Load=SUM(m[i],i=11,21)*LHV_CH4*convert(kJ,mmBTU)

New_load=Load*1.5
New_Load=SUM(m[i],i=11,21)*LHV_CH4*convert(kJ,mmBTU)
```

```
"Useful Kg of Nat Gas - Finds f for new boiler in SDPP"
Duplicate i=11, 21
m[i]=(P[i]/(LHV_CH4)*f[i])*heating_season
end

"kg Nat Gas Used By New Boiler Setup"
duplicate i=11,21
m_used[i]=(P[i]/(LHV_CH4*eta[i])*f[i])*heating_season
end

m_GasUse[2]=SUM(m_used[i],i=11,21)

"Carbon Calculation"
MTCE=((m_GasUse[2]*LHV_CH4)*1.314[lbm/kW-hr]*convert(kJ,kW-hr)-
(m_GasUse[1]*LHV_CH4)*1.314[lbm/kW-hr]*convert(kJ,kW-hr))*convert(lbm,mton)

Increase = New_Load-Load
```

Unit Settings: [kJ]/[C]/[kPa]/[kg]/[degrees]

$heating_{season}$ = 1.829E+07 [s]	Increase = 7920 [mmBTU]	LHV_{CH4} = 50010 [kJ/kg]	Load = 15840 [mmBTU]
MTCE = 1332 [mton]	New_{load} = 23761 [mmBTU]		

No unit problems were detected.

Calculation time = .0 sec

Appendix A.5: Carbon Neutrality EES Model

```
"Calvin's Energy Use Projection"
r_r_use=.02
r_r_gas=0.00
    "Electricity"
Elect_use_2006=21453935[kW-hr/yr]
Gas_use_2006=162058[mmBTU/yr]

duplicate n=0,2
    Use_elect[n]=Elect_use_2006*(1+r_r_use/m)^(n*m)
end duplicate n

duplicate n=3,50
    Use_elect[n]=2*Elect_use_2006*(1+r_r_use/m)^(n*m)
end duplicate n

    "Gas"
duplicate n=0,2
    Use_Gas[n]=Gas_use_2006*(1+r_r_gas/m)^(n*m)
end duplicate n

duplicate n=3,50
    Use_Gas[n]=(7920 [mmBTU/yr] + Gas_use_2006)*(1+r_r_gas/m)^(n*m)
end duplicate n

// 7920 mmBTU is the increased load due to the new spoelhof center less the savings from the installation
of higher effeciency boilers


"Fuel Cost"
FC_2005=7.96[$/mmBTU]                       "Nat Gas Cost"
EC_2006=0.07[$/kWh]                         "Electricity Cost"

"Finacial Cost"
r_r=0.02                                    "fuel escalation rate Nat Gas"
r_r_elect=0.02                              "Electricity escalation rate"
r_i=.04                                     "inflation rate"
r_n=(1+r_r)*(1+r_i)-1                       "Nat Gas"
r_n_elect=(1+r_r_elect)*(1+r_i)-1           "Electricity"
i=.03                                       "interest rate"

n=0
x=50
m=12
"Natural Gas"
duplicate n=0,x
    FC[n]=FC_2005*(1+r_n/m)^(n*m)
end duplicate n

duplicate n=0,x
    FC_pv[n]=FC[n]/((1+i/m)^(m*n))
end duplicate n
```

```
"Electricity"
duplicate n=0,x
    EC_elect[n]=EC_2006*(1+r_n_elect/m)^(n*m)
end duplicate n

duplicate n=0,x
    EC_pv[n]=EC_elect[n]/((1+i/m)^(m*n))
end duplicate n

"Energy Savings"
Heat_savings=162000 [$/yr]
Energy_saved=Heat_savings/FC_2005

duplicate n=0,x
    Cost_savings[n]=Energy_saved*FC_PV[n]
end duplicate n


"Carbon Savings"
Carbon_emission=1.314[lbm/kWh]
Carbon_emission_elect=1.44[lbm/kWh]
Carbon_saved=energy_saved*convert(mmBTU,kWh)*Carbon_emission*convert(lbm,mton)

duplicate n=0,x
    Carbon_cost[n]=Cost_savings[n]/Carbon_saved
end duplicate n

"2007 price"
PV_WindTurbine[1] = 820000[$/yr]

duplicate i=2,17
PV_WindTurbine[i] = PV_WindTurbine[1]*(1+r_i)^i
end

EnergyProductionPerTurbine = 2053 [MW-hr/yr]

//  We will implement a plan to phase in 4 Wind turbines each being paid off in 5 year periods

duplicate i=2,6
WindTurbinePayment[i] = PV_WindTurbine[2]* (r_i*(1+r_i)^(5))/((1+r_i)^5 - 1)
end

duplicate i=7,11
WindTurbinePayment[i] = PV_WindTurbine[7]* (r_i*(1+r_i)^(5))/((1+r_i)^5 - 1)
end

duplicate i=12,16
WindTurbinePayment[i] = PV_WindTurbine[12]* (r_i*(1+r_i)^(5))/((1+r_i)^5 - 1)
end

duplicate i=17,21
WindTurbinePayment[i] = PV_WindTurbine[17]* (r_i*(1+r_i)^(5))/((1+r_i)^5 - 1)
end

duplicate i=22,36
WindTurbinePayment[i] = 0
```

```
end

duplicate i=2,6
ElectricitySavings[i] = EnergyProductionPerTurbine*EC_elect[i]*convert(mW,kW)
end

duplicate i=7,11
ElectricitySavings[i] = EnergyProductionPerTurbine*2*EC_elect[i]*convert(mW,kW)
end

duplicate i=12,16
ElectricitySavings[i] = EnergyProductionPerTurbine*3*EC_elect[i]*convert(mW,kW)
end

duplicate i=17,21
ElectricitySavings[i] = EnergyProductionPerTurbine*4*EC_elect[i]*convert(mW,kW)
end

duplicate i=22,26
ElectricitySavings[i] = EnergyProductionPerTurbine*4*EC_elect[i]*convert(mW,kW)
end

duplicate i=27,31
ElectricitySavings[i] = EnergyProductionPerTurbine*3*EC_elect[i]*convert(mW,kW)
end

duplicate i=32,36
ElectricitySavings[i] = EnergyProductionPerTurbine*2*EC_elect[i]*convert(mW,kW)
end

duplicate i=37,40
ElectricitySavings[i] = EnergyProductionPerTurbine*1*EC_elect[i]*convert(mW,kW)
end

"Wind Turbine Analysis"

duplicate i=2,36
Net_Turbine_Value[i] = - WindTurbinePayment[i] + ElectricitySavings[i]
end

"Carbon Footprint"
    "Nothing"
duplicate n=2,36
    Carbon_Footprint[n]=(Use_elect[n]*Carbon_emission_elect+Use_gas[n]*convert(mmBTU,kWh)*Carbo
n_emission)*convert(lbm,mton)
end duplicate n

    "Less Heat Laod"
duplicate n=2,36
    Carbon_Footprint_heat[n]=Carbon_Footprint[n]-Carbon_saved
end duplicate n

    "Less Turbines"
duplicate n=2,36
    Carbon_Footprint_turbine[n]=Carbon_Footprint[n]-Carbon_saved-
(electricitysavings[n]/(EC_elect[n]))*carbon_emission_elect*convert(lbm,mton)
```

```
end duplicate n

duplicate n=2,36
    CarbonOffsetCost[n]=Carbon_Footprint_turbine[n]*11 [$/mton]
end

duplicate n=2,36
CostOfCarbonNeutrality[n] = -(Net_Turbine_Value[n] - CarbonOffsetCost[n])
end

duplicate n=2,36
Year[n] = 2005+n
end

CarboneNeutralityNetValue = SUM(CostofCarbonNeutrality[n],n=2,36)

duplicate n=2,36
zero[n] = 0
end
```

Unit Settings: [kJ]/[C]/[kPa]/[kg]/[degrees]

CarboneNeutralityNetValue = -2.380E+07 [$/yr]

$carbon_{emission,elect}$ = 1.44 [lbm/kWh]

EC_{2006} = 0.07 [$/kWh]

EnergyProductionPerTurbine = 2053 [MW-hr/yr]

FC_{2005} = 7.96 [$/mmBTU]

$Heat_{savings}$ = 162000 [$/yr]

m = 12

r_i = 0.04

$r_{n,elect}$ = 0.0608

$r_{r,elect}$ = 0.02

$r_{r,use}$ = 0.02

$Carbon_{emission}$ = 1.314 [lbm/kWh]

$Carbon_{saved}$ = 3555 [mton/yr]

$Elect_{use,2006}$ = 2.145E+07 [kW-hr/yr]

$Energy_{saved}$ = 20352 [mmBTU/yr]

$Gas_{use,2006}$ = 162058 [mmBTU/yr]

i = 0.03

n = 0

r_n = 0.0608

r_r = 0.02

$r_{r,gas}$ = 0

x = 50

No unit problems were detected.

Calculation time = .0 sec

Array variables are in the Arrays window

Appendix B: Land Use and Water and Wastewater Management Group

Purpose

The purpose of the Land Use and Water and Wastewater Management group was to analyze the impact of land and water use on the net carbon footprint of Calvin College. Our group quantified the emissions attributed to consumption of potable water and emission of wastewater in addition to sequestrations on campus. After the carbon footprint was quantified, our tasks changed to minimizing this impact by proposing methods to reduce emissions and increase sequestrations.

Procedure

Land Use

The impact of land use was measured primarily on the basis of the sequestration potential of the various plant communities on campus. Much of this data was acquired from a previous study conducted by Professor Dornbos. Professor Dornbos broke the campus up into general plant communities and provided area, sequestration potential, and total carbon sequestered per year of each community. The data from this study can be found in Appendix A.1. In order to determine the best method of improving the sequestration on campus, the plant community with the highest sequestration potential was determined. Buckthorn was considered, but due to the plants' intrusive nature and tendency to spread uncontrollably buckthorn was found to be an unattractive option. White oak was selected as the plant community for optimal sequestration. In order to apply our theory, our group determined what portions of the campus are able to be converted to white oak. The replanting of forested areas would require too much work and provide minimal results. Our group also decided that most of the areas planted with manicured grass are necessary for campus appearance. It was determined that the best area for this improvement was the prairie. Another method for improvement that was suggested utilized a newly developed fertilizer than sequesters one-quarter of its weight in carbon. The fertilizer, however, is still in the design phases and not available for commercial purchase. The data for Calvin's fertilizer use can be seen in Appendix B.2. The article about the carbon sequestering fertilizer can be seen in Appendix B.3.

Water Use

In regard to water use, our group based the analysis on data taken from the college's utility bills, which were ascertained from Dan Slager in the Physical Plant. Our group found values for the amount of water consumed on campus and the water and sewer costs (see Appendix B.4). In order to determine the carbon footprint of water and sewer use, our group made the assumption that half the costs for water and sewer charged by the utility company were a result of the energy costs to the utility company for treatment and pumping. This value was converted to metric tons of carbon emitted using a conversion factor from the energy company's website (see Appendix B.5). Methods of water use reduction were then considered, as reducing the amount of water used would reduce the energy requirements on the utility company induced by the college. The options included installing low-flow showerheads, low-flow toilets, improved irrigation systems, frontloading washers, and waterless urinals. Low-flow showerheads, low-flow toilets, and frontloading washers have already been implemented on campus and the irrigation system is already fairly efficient. The one option that our group considered for water reduction was the waterless urinal. There is currently only one waterless urinal on campus (in the Bunker Interpretive Center). This option was explored by assuming that 50 of the existing urinals on campus were replaced with waterless urinals; at a cost of $350 per urinal. A previously conducted study provided the data on how much water would be saved per urinal. Our group conducted an analysis on data from the water reduction study to determine how much carbon would be reduced by the resulting reduction in water use.

Our group also discovered some research for a carbon sequestering “tree” that uses a chemical reaction of carbon dioxide and calcium hydroxide to sequester carbon. The artificial tree is a purely theoretical option for Calvin at this time because the design seeing only conceptual. However, the sequestering potential is great enough (estimates say 90,000 metric tons per year) that our group considered it. The best option would be to construct the “tree” on land purchased away from campus due to the unsightly appearance of the “trees”. The article regarding the tree can be found in Appendix B.6.

Conclusion

Land Use

Based on research by Professor Dornbos, the group determined that current land use sequesters 51 metric tons of carbon per year. The breakdown between plant community sequestrations can be seen in Appendix A.1. The land use research returned three viable options for increased sequestration. The first, planting white oak trees, a technology that is currently available. The other two options, the green fertilizer and the carbon sequestering “tree” are theoretically feasible but not yet in production. Implementation of white oak trees on Calvin’s prairie areas came to a cost of about $9709 per metric ton sequestered and would sequester a maximum of about 1.02 additional metric tons per year. The experimental green fertilizer would cost about$6578 per metric ton sequestered and would sequester a maximum of about 1.03 additional metric tons per year. The artificial tree is still very much a conceptual idea even in terms of cost, but a rough estimate said that when fully operational it would cost approximately $80-$100 per metric ton of carbon sequestered and would sequester a maximum of about 90,000 metric tons per year. This idea seems a bit miraculous but if functional could secure Calvin’s carbon neutrality.

Water Use

The group determined that based on current water use and sewer production, Calvin creates about 1756.5 metric tons of carbon per year in emissions from energy companies. The calculations for this value can be found in Appendix B.5. The only viable option researched by the group was the installation of waterless urinals on campus. The waterless urinals would reduce emissions by about 53 metric tons of carbon per year, at a cost of about $330 per metric ton reduced (not including the variable cost of filters and maintenance).

Appendix B.1: Campus Sequestration Data

Sum of CO_2 Sequestered

Species:	CO_2 ($\mu g/m^2/sec$)	CO_2 *3600Sec: CO_2 fixed $\mu g/m^2$	SPECIES
1	12265.61188	44156202.75	GRASS
2	33857.75691	121887924.9	GR = goldenrod
3	-9505.690852	-34220487.07	SB = wild strawberries
4	19351.09289	69663934.42	DOG = red-osier dogwood
5	29260.78629	105338830.7	HAW = downy hawthorn
6	32227.487	116018953.2	BT = common buckthorn
7	20218.28762	72785835.44	DW = gray dogwood
8	-7651.305078	-27544698.28	MAP = sugar maple
9	-1618.388002	-5826196.806	ASH = white ash
10	10774.4493	38788017.47	BEE = american beech
11	60859.75422	219095115.2	OAK = white oak

Areas of Communities

Community	Areas in Square Feet	Area in Square Meters
Maintained Lawn	5299944.498	492364.8439
Prairie	1415833.458	131530.9282
Shrub	1242236.178	115403.7409
Edge	939852.4385	87312.29154
Early Successional	2546533.92	236573.0012
Mature Forest	788744.5164	73274.36557

Community	**Mton/m^2/yr**	**Total CO2 (Mton/yr)**
Maintained Lawn	4.416E-5	2.17E+13
Prairie Grassland	4.383E-5	5.77E+12
Shrub	8.75E-5	1.01E+13
Edge	9.44E-5	8.24E+12
Early Succesional	1.669E-5	-3.95E+12
Mature Forest	12.894E-5	9.45E+12

Appendix B.2: Fertilizer Data

CALVIN COLLEGE GROUNDS CHEMICAL USE-

2006 Fertilizer Totals

Nitrogen- 9084 #
Phosphorus- 1964.5#
Potassium- 4818#

25% by weight?

Breakdown of products used

15-0-15/team- 20050#
29-3-6- 14350#
17-37-7- 3600#
22-0-22- 2000#
24-4-12- 2150#
Milorganite 6-2-0- 5800#

2006 Weed Control Totals

Team (crabgrass pre-m) - 256#
Millennium Ultra (broadleaf) - 42 gallons
Cool Power (broadleaf) - 10 gallons
Drive (crabgrass post emergent) - 8#
Sledgehammer (nut sedge post emergent) - 2.9 gallons
Gallery (pre emergent) - 2#
Pendulum (pre emergent) - 3 gallons
Round up (post emergent non selective) 10 gallons

2006 Insecticide Totals

Merit (insecticide) - 3.75#

2006 Fungicide Totals

Eagle fungicide (dollar spot, pythium control) - .31 gallons

Pond Care

Cutrine (algaecide) – 8.25 gallons
Radiance (algaecide) - 5 gallons
Copper sulfate (algaecide) - 25 #
Bio Kleen bacteria- 113#

Have an efficient fertilizing syst.

Turf

Irrigated acres: 120 acres **Non irrigated acres:** 255 acres

Mowing schedule: 2 – 3 times per week as needed

Fertilizers: Par-ex 29-3-6: 24-4-12: Shaws: 15-0-15 with Team / Milorganite

Annual amounts: Total 44,189 lbs. in 2003

Herbicides: Millennium / Round-up

Annual amounts: 28.2 Millennium / Approx. 20 gallons Round - up

Pesticides: Team / Shaws / Diazanon / Fungicides

Annual amounts: Team on fertilizer application in spring and as necessary

Sports Fields: Baseball: 1 **Softball:** 2 **Soccer:** 2 **Football:** 0

Lacrosse: 1 **Cross Country Course:** 1 **Tennis Courts:** 6 **Track:** 1

Discus/Hammer Throw: 1 **Shot-put:** 1 **Javelin:** 1 **Practice fields:** 2

Type of drainage: 4 bypass; 2 sand caps; 2 no drainage **Aeration schedule:** 3 – 4 times a year spring/summer/fall

Sand topdressing: Athletics TDS 2150 195 tons **Over seeding:** 600 lbs on athletic fields

Infields: 4 ton turface/15 tons stone dust **Lining:** done by PE Department

Notes Total 390 acres total.

120 irrigated turf

14.67 athletic fields

15.75 roads

11 sidewalks

27 parking lots

18.91 Buildings

182 natural area.

* does not include [illegible]

Irrigation

Type of systems: Toro: Yes **Rain Bird:** ____ **Hunter:** ____ **Rain Bird:** ____ **Other:** ____

Automatic: yes **Central control:** 50% **Manual:** none **Wells:** 7 **Municipal:** none

Operating pressure: 60 – 80 psi **Main sizes:** 3 – 4" **# Zones:** 384 **# Heads:** approx 3500

Installation: In house: Small jobs **Sub contract:** Large jobs

Maintenance: In house: 100% **Sub contract:** None

Notes: In process of switching campus to 100% central control

Outdoor Signage

Design: In house: 100% **Sub contract:** none

Installation: In house: 100% **Sub contract:** none

Maintenance: In house: 100% **Sub contract:** none

Notes: Some fabrication is sub-contracted out.

Other Programs

Notes:

Calvin College
2006 Irrigation Water Use Report

Sentinel Zones

101	75 zones	6771205 gallons
102	95 zones	4911842 gallons
103	57 zones	6354590 gallons
104	37 zones	2940055 gallons
105	38 zones	3019480 gallons

Total for Sentinel zones- 23997172

Non Sentinel Zones

141 zones 11203860 gallons

TOTAL WATER USAGE- 35201032 gallons
Total zone count-443 zones

Procedure for obtaining data:

I was able to be more accurate this year having three wells with flow meters allowing me to average the total gallons per zone over the year more accurately. I took the total gallons from 101, 102 and 103 and divided by the number of zones in those three controllers to find an average zone output of 79460 gallons per zone. This number was multiplied by the total number of zones on campus (443) to obtain the total gallons of 35201032. This number does not reflect the water drawn from the Tongue property or the Bunker Interpretive Center. These numbers do reflect the changes at S.E. in the summer of 2006, but not the changes made at the MPS Building as these changes were made after the system was shut down for the year.

Water usage breakdown per month:

April- 3%
May- 13%
June- 23%
July- 28%
August- 26%
September- 7%

- water table is down abt 75 ft + well is down abt 15 ft more
- sprinklers may shut down if it senses rain
- computers tell when sprinkler head is broken

Appendix B.3: Carbon Sequestering Fertilizer Article

Renewable Hydrogen, High Volume Carbon Sequestration and a Nitrogen Fertilizer Offer a Sustainable Future

BLAKELY, Ga., Aug. 27 /PRNewswire/ -- The hydrogen research team from Clark Atlanta University, Georgia Institute of Technology, DOE National Renewable Energy Laboratory (NREL), Scientific Carbons, Inc. and Envirotech, Inc., at 11:46 PM on August 25, began producing hydrogen from biomass while permanently sequestering 25% by weight of the material. The resulting carbon, in its activated state as produced with USDA AARC funding, is highly adsorbent and can be combined with co-products of the process to form a slow-release nitrogen fertilizer. The fertilizer and farm industry can use this process to offer a verifiable carbon sequestration service while increasing farm income and crop yields. The use of the sequestered carbon as a carrier for nitrogen and as a soil amendment, preventing harmful runoff of farm chemicals is a win-win for farmers. Fertilizer manufacturers and farmers can become a major force in the battle against global warming while facilitating the production of hydrogen from renewable resources.

This work in hydrogen production is the culmination of a two-year field research project. The first hour of the 100-hour demonstration showed the clear difference system's two flares. The yellow hydrocarbon rich flame contrasted against the almost clear flame, slightly blue from a small amount of methane. The project has focused on expanding the demonstration of hydrogen production while producing valuable co-products from farm and forestry sources of biomass. Co-products are essential to the economics of sustainable hydrogen production.

Scientific Carbons, Inc. (SCI) is a technology development company focused on bio-refining. On August 22, 2002, SCI and NREL filed for patent protection on a slow-release fertilizer made while producing biomass based hydrogen and a sequestered carbon co-product. Danny Day, President of Scientific Carbons said, "The preliminary numbers look promising. A small percentage of the global unused agriculture and forestry waste could sequester the amount of carbon building up in our atmosphere and deliver nitrogen to plants that can sequester even more. Using this technique, farming could be the most successful and economically profitable method of sequestering the excess atmospheric carbon generated by fossil fuels. Economic development can lead to innovative sequestration techniques and we want to help demonstrate sustainable ways to serve mankind."

The announcement by U.S. government of commitments of over $20 billion to global warming research has demonstrated the seriousness of the issue of carbon build up in our atmosphere. Carbon sequestration without economic benefits would strain the global economy and hurt the poorest nations first by reducing investment dollars available for economic development. SCI is currently seeking international partners and facilities to continue this important research. Mr. Day said, "This work benefits the farm economy and ultimately, all life on earth."

http://www.prnewswire.com/cgi-bin/stories.pl?ACCT=104&STORY=/www/story/08-27-2002/0001790040&EDATE=

Appendix B.4: Calvin Utility Bills

Calvin College
2006 Irrigation Water Use Report

Sentinel Zones

101	75 zones	6771205 gallons
102	95 zones	4911842 gallons
103	57 zones	6354590 gallons
104	37 zones	2940055 gallons
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Total for Sentinel zones- 23997172

Non Sentinel Zones

141 zones 11203860 gallons

TOTAL WATER USAGE- 35201032 gallons
Total zone count-443 zones

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Water usage breakdown per month:

April- 3%
May- 13%
June- 23%
July- 28%
August- 26%
September- 7%

- water table is down abt 75 ft + well is down abt 15 ft more
- sprinklers may shut down if it senses rain
- computers tell when sprinkler head is broken

Billing Date	Reading Dates	Number of Days	1801 Beltline (HCF)	3301 Burton (HCF)	Conversion HCF-Gallons	GALLONS	Previous Year	Difference (gallons)	Fiscal Year Total
07/18/96	06/11-07/16	35	470	4726	x 748 =	3886608			
08/15/96	07/16-08/13	28	280	4667	x 748 =	3700356			
09/12/96	08/13-09/10	28	190	1567	x 748 =	1314236			
10/17/96	09/10-10/15	35	2230	6290	x 748 =	6372960			
11/14/96	10/15-11/12	28	1870	4320	x 748 =	4630120			
12/12/96	11/12-12/10	28	1510	3700	x 748 =	3897080			
01/16/97	12/10-01/14	35	1530	3240	x 748 =	3567960			
02/13/97	01/14-02/11	28	2260	3770	x 748 =	4510440			
03/20/97	02/11-03/18	35	2050	4460	x 748 =	4869480			
04/17/97	03/18-04/15	28	1590	2910	x 748 =	3366000			
05/15/97	04/15-05/13	28	1660	4260	x 748 =	4428160			
06/19/97	05/15-06/17	35	410	2400	x 748 =	2101880			46,645,280
			1801	3301					
07/17/97	06/17-07/15	28	250	3400	x 748 =	2730200	*3886608*	***-1156408***	
08/14/97	07/15-08/12	28	210	3790	x 748 =	2992000	*3700356*	***-708356***	
09/18/97	08/12-09/16	35	1010	4190	x 748 =	3889600	*1314236*	***2575364***	
10/16/97	09/16-10/14	28	2290	5050	x 748 =	5490320	*6372960*	***-882640***	
11/13/97	10/14-11/11	28	2210	3890	x 748 =	4562800	*4630120*	***-67320***	
12/18/97	11/11-12/13	32	2800	3550	x 748 =	4749800	*3897080*	***852720***	
01/22/98	12/13-01/16	34	2440	830	x 748 =	2445960	*3567960*	***-1122000***	
02/19/98	01/16-02/17	32	4320	1820	x 748 =	4592720	*4510440*	***82280***	
03/19/98	02/17-03/17	28	4290	1610	x 748 =	4413200	*4869480*	***-456280***	
04/23/98	03/17-04/21	35	4330	1740	x 748 =	4540360	*3366000*	***1174360***	
05/21/98	04/21-05/19	28	5320	3010	x 748 =	6230840	*4428160*	***1802680***	
06/18/98	05/19-06/16	28	2090	3060	x 748 =	3852200	*2101880*	***1750320***	50,490,000
			1801	3301					
07/23/98	06/16-07/21	35	4130	3220	x 748 =	5497800	*2730200*	***2767600***	
08/20/98	07/21-08/18	28	3160	2410	x 748 =	4166360	*2992000*	***1174360***	
09/17/98	08/18-09/14	27	780	4700	x 748 =	4099040	*3889600*	***209440***	
10/15/98	09/14-10/13	29	1500	6030	x 748 =	5632440	*5490320*	***142120***	
11/12/98	10/13-11/10	28	4660	1890	x 748 =	4899400	*4562800*	***336600***	
12/17/98	11/10-12/15	35	5420	1860	x 748 =	5445440	*4749800*	***695640***	
01/21/99	12/15-01/15	31	2400	630	x 748 =	2266440	2445960	***-179520***	
02/18/99	01/15-02/12	28	3950	1450	x 748 =	4039200	4592720	***-553520***	
03/18/99	02/12-03/16	32	4870	1750	x 748 =	4951760	4413200	***538560***	
04/22/99	03/160-4/20	35	4110	1300	x 748 =	4046680	4540360	***-493680***	
05/20/99	04/20-05/18	28	5230	1560	x 748 =	5078920	6230840	***-1151920***	
06/17/99	05/18-06/15	28	2490	630	x 748 =	2333760	3852200	***-1518440***	52,457,240
			1801	3301					
07/22/99	06/15-07/20	35	2750	1960	x 748 =	3523080	*5497800*	***-1974720***	
08/19/99	07/20-08/17	28	1410	3429	x 748 =	3619572	*4166360*	***-546788***	*** Note: *3301* is
09/16/99	08/17-09/14	28	2140	2670	x 748 =	3597880	*4099040*	***-501160***	estimate of <u>3429</u>
10/21/99	09/14-10/19	35	4570	3990	x 748 =	6402880	*5632440*	***770440***	based on avg. of
11/18/99	10/19-11/16	28	4360	1970	x 748 =	4734840	*4899400*	***-164560***	past periods.
12/21/99	11/16-12/16	30	4430	2840	x 748 =	5437960	*5445440*	***-7480***	
01/20/00	12/16-01/18	33	2110	1130	x 748 =	2423520	2266440	***157080***	
02/17/00	01/18-02/15	28	3820	1740	x 748 =	4158880	4039200	***119680***	
03/16/00	02/15-03/14	28	4100	2080	x 748 =	4622640	4951760	***-329120***	
04/20/00	03/14-04/18	35	4040	1970	x 748 =	4495480	4046680	***448800***	
05/18/00	04/18-05/16	28	3850	2860	x 748 =	5019080	5078920	***-59840***	
06/15/00	05/16-06/13	28	1830	1880	x 748 =	2775080	2333760	***441320***	50,810,892

			1801	3301					
07/20/00	06/13-07/14	31	2020	2220	x 748 =	3171520	*3523080*	***-351560***	
08/17/00	07/14-08/15	32	2260	3580	x 748 =	4368320	*3619572*	***748748***	
09/14/00	08/15-09/12	28	3040	3540	x 748 =	4921840	*3597880*	***1323960***	
10/19/00	09/12-10/17	35	4710	4050	x 748 =	6552480	*6402880*	***149600***	
11/16/00	10/17-11/14	28	4270	2690	x 748 =	5206080	*4734840*	***471240***	
12/19/00	11/14-12/15	31	4230	1980	x 748 =	4645080	*5437960*	***-792880***	
01/18/01	12/15-01/16	32	2300	820	x 748 =	2333760	*2423520*	***-89760***	
02/15/01	01/16-02/13	28	3820	1530	x 748 =	4001800	*4158880*	***-157080***	
03/15/01	02/13-03/13	28	4180	1760	x 748 =	4443120	*4622640*	***-179520***	
04/19/01	03/13-04/17	35	4020	1730	x 748 =	4301000	*4495480*	***-194480***	
05/17/01	04/17-05/15	28	3050	4020	x 748 =	5288360	*5019080*	***269280***	
06/14/01	05/15-06/12	28	1420	1660	x 748 =	2303840	*2775080*	***-471240***	51,537,200
			1801	3301					
07/19/01	06/12-07/17	35	2250	3120	x 748 =	4016760	*3171520*	***845240***	
08/16/01	07/17-08/14	28	1650	1830	x 748 =	2603040	*4368320*	***-1765280***	
09/13/01	08/14-09/11	28	2950	2460	x 748 =	4046680	*4921840*	***-875160***	
10/18/00	09/11-10/16	35	5650	3470	x 748 =	6821760	*6552480*	***269280***	
11/15/00	10/16-11/09	24	3820	2140	x 748 =	4458080	*5206080*	***-748000***	
12/20/00	11/09-12/18	39	5310	2690	x 748 =	5984000	*4645080*	***1338920***	
01/17/02	12/18-01/15	28	2460	740	x 748 =	2393600	*2333760*	***59840***	
02/14/02	01/15-02/12	28	3890	1820	x 748 =	4271080	*4001800*	***269280***	
03/14/02	02/12-03/12	28	3980	1690	x 748 =	4241160	*4443120*	***-201960***	
04/18/02	03/12-04/16	35	4580	1950	x 748 =	4884440	*4301000*	***583440***	
05/16/02	04/16-05/14	28	4820	2610	x 748 =	5557640	*5288360*	***269280***	
06/13/02	05/14-06/11	28	2780	2010	x 748 =	3582920	*2303840*	***1279080***	52,861,160
			1801	3301					
07/18/02	06/11-07/16	35	2570	4120	x 748 =	5004120	*4016760*	***987360***	
08/15/02	07/16-08/13	28	1790	2670	x 748 =	3336080	*2603040*	***733040***	
09/12/02	08/13-09/10	28	2080	2820	x 748 =	3665200	*4046680*	***-381480***	
10/17/02	09/10-10/15	35	5290	4550	x 748 =	7360320	*6821760*	***538560***	
11/14/02	10/15-11/12	28	4600	1880	x 748 =	4847040	*4458080*	***388960***	
12/19/02	11/12-12/17	35	5560	2270	x 748 =	5856840	*5984000*	***-127160***	
01/16/03	12/17-01/14	28	2030	530	x 748 =	1914880	*2393600*	***-478720***	
02/13/03	01/14-02/11	28	3920	1450	x 748 =	4016760	*4271080*	***-254320***	
03/13/03	02/11-03/11	28	4310	1620	x 748 =	4435640	*4241160*	***194480***	
04/17/03	03/11-04/15	35	4420	1700	x 748 =	4577760	*4884440*	***-306680***	
05/15/03	04/15-05/13	28	4260	1930	x 748 =	4630120	*5557640*	***-927520***	
06/12/03	05/13-06/10	28	3290	1750	x 748 =	3769920	*3582920*	***187000***	53,414,680
			1801	3301					
07/17/03	06/10-07/15	35	2140	2920	x 748 =	3784880	*5004120*	***-1219240***	
08/14/03	07/15-08/12	28	1900	2020	x 748 =	2932160	*3336080*	***-403920***	
09/11/03	08/12-09/09	28	2350	2540	x 748 =	3657720	*3665200*	***-7480***	
10/16/03	09/09-10/14	35	4040	5900	x 748 =	7435120	*7360320*	***74800***	
11/13/03	10/14-11/07	24	2660	3540	x 748 =	4637600	*4847040*	***-209440***	
12/18/03	11/07-12/16	39	5730	2820	x 748 =	6395400	*5856840*	***538560***	
01/15/04	12/16-01/13	28	1860	710	x 748 =	1922360	*1914880*	***7480***	
02/12/04	01/13-02/10	28	3480	1620	x 748 =	3814800	*4016760*	***-201960***	
03/11/04	02/10-03/09	28	3310	1800	x 748 =	3822280	*4435640*	***-613360***	
04/15/04	03/09-04/13	35	3100	1880	x 748 =	3725040	*4577760*	***-852720***	
05/13/04	04/13-05/11	28	3530	2840	x 748 =	4764760	*4630120*	***134640***	
06/10/04	05/11-06/08	28	2380	1830	x 748 =	3149080	*3769920*	***-620840***	50,041,200

			1801	3301					
07/15/04	06/08-07\13	35	2420	2330	x 748 =	3553000	*3784880*	***-231880***	
08/12/04	07/13-08/10	28	1360	2840	x 748 =	3141600	*2932160*	***209440***	
09/09/04	08/10-09/07	28	1060	3350	x 748 =	3298680	*3657720*	***-359040***	
10/14/04	09/07-10/12	35	2950	6820	x 748 =	7307960	*7435120*	***-127160***	
11/10/04	10/12-11/09	28	3130	3420	x 748 =	4899400	*4637600*	***261800***	
12/16/04	11/09-12/14	35	3020	4180	x 748 =	5385600	*6395400*	***-1009800***	
01/20/05	12/14-01/18	35	3170	1200	x 748 =	3268760	*1922360*	***1346400***	
02/17/05	01/18-02/15	28	3750	1620	x 748 =	4016760	*3814800*	***201960***	
03/17/05	02/15-03/15	28	3810	1800	x 748 =	4196280	*3822280*	***374000***	
04/21/05	03/15-04/19	35	4470	1880	x 748 =	4749800	*3725040*	***1024760***	
05/19/05	04/19-05/17	28	2830	3004	x 748 =	4363832	*4764760*	***-400928***	
06/16/05	05/17-06/13	27	1120	2600	x 748 =	2782560	*3149080*	***-366520***	**50,964,232**
07/21/05	06/13-07/19	36	1390	4780	x 748 =	4615160	*3553000*	***1062160***	
08/18/05	07/19-08/16	28	970	3120	x 748 =	3059320	*3141600*	***-82280***	
09/15/05	08/16-09/13	28	1370	4040	x 748 =	4046680	*3298680*	***748000***	
10/20/05	09/13-10/18	35	4130	4700	x 748 =	6604840	*7307960*	***-703120***	
11/17/05	10/18-11/15	28	3430	2430	x 748 =	4383280	*4899400*	***-516120***	
12/21/05	11/15-12/20	35	3770	2500	x 748 =	4689960	*5385600*	***-695640***	
01/19/06	12/20-01/17	28	1680	1080	x 748 =	2064480	*3268760*	***-1204280***	
02/16/06	01/17-02/14	28	2870	1860	x 748 =	3538040	*4016760*	***-478720***	
03/16/06	02/14-03/14	28	3290	2320	x 748 =	4196280	*4196280*	***0***	
04/20/06	03/14-04/18	35	3020	2200	x 748 =	3904560	*4749800*	***-845240***	
05/18/06	04/18-05/16	28	3100	3200	x 748 =	4712400	*4363832*	***348568***	
06/15/06	05/16-06/13	28	1260	2620	x 748 =	2902240	*2782560*	***119680***	**48,717,240**
07/20/06	06/13-07/18	35	840	4210	x 748 =	3777400	*4615160*	***-837760***	
08/17/06	07/18-08/15	28	1060	3280	x 748 =	3246320	*3059320*	***187000***	
09/14/06	08/15-09/12	28	1550	3900	x 748 =	4076600	*4045680*	***30920***	
10/19/06	09/12-10/17	35	5160	3890	x 748 =	6769400	*6604840*	***164560***	
11/16/06	10/17-11/14	28	4010	2370	x 748 =	4772240	*4383280*	***388960***	
12/20/06	11/14-12/19	35	4180	2340	x 748 =	4876960	*4689960*	***187000***	
01/18/07	12/19-01/16	28	1830	990	x 748 =	2109360	*2064480*	***44880***	
02/15/07	01/16-02/13	28	3510	1960	x 748 =	4091560	*3538040*	***553520***	
03/15/07	02/13-03/13	28	3370	2360	x 748 =	4286040	*4196280*	***89760***	
04/19/07	03/13-04/17	35	3730	2530	x 748 =	4682480	*3904560*	***777920***	
05/17/07	04/17-05/15	28	3830	3470	x 748 =	5460400	*4712400*	***748000***	
06/14/07	05/15-06/12	28	1070	2480	x 748 =	2655400	*2902240*	***-246840***	**50,804,160**
07/19/07	06/12-07/17	35	820	5420	x 748 =	4667520	*3777400*	***890120***	
08/16/07	07/17-08/14	28	410	3580	x 748 =	2984520	*3246320*	***-261800***	
09/xx/07	08/14-09xx				x 748 =	0	*4076600*	***-4076600***	
					x 748 =	0	*6769400*	***-6769400***	
					x 748 =	0	*4772240*	***-4772240***	
					x 748 =	0	*4876960*	***-4876960***	
					x 748 =	0	*2109360*	***-2109360***	
					x 748 =	0	*4091560*	***-4091560***	
					x 748 =	0	*4286040*	***-4286040***	
					x 748 =	0	*4682480*	***-4682480***	
					x 748 =	0	*5460400*	***-5460400***	
					x 748 =	0	*2655400*	***-2655400***	**7,652,040**

City Of Grand Rapids
Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
B281350290A	MAY 17, 2007	JUN 7, 2007

Service Type
RESIDENTIAL WATER & SEWER

Service Address
3485 BURTON ST SE

Government Unit
GRAND RAPIDS 2007

Meter Readings

Date	Type	Reading
Previous: FEB 10, 2007	Actual	3573
Current: MAY 02, 2007	Actual	3914

Days Billed:	81
Pro-Rated Units:	0
Meter Change Units:	0
Metered Units Used:	341
Total Units Used:	341

Summary of Charges

Quarterly Billing

Previous Balance	$1,687.59	
Late Payment Fee	$.00	
Other Charges/Credits	$.00	
Payments Received - Thank You	$1,687.59CR	
Balance Before Current Charges		$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$77.63	
Water Volume 341 HCF x 1.46000	$497.86	
Sewer Base Rate (Readiness to Serve Charge)	$66.63	
Sewer Volume 341 HCF x 2.37000	$808.17	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$1,450.29

Total Amount Due: $1,450.29

Monthly Payment Option (A $1.00 Fee will be added to your next bill): $483.43

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
MAY 17, 2007	JUN 7, 2007
Service Address	**Account Number**
3485 BURTON ST SE	B281350290A
Monthly Payment Option	**Total Amount Due**
$483.43	$1,450.29

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

Amount Enclosed:

0701 02281350290011 00145029 00048343

Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
B281350201A	MAY 17, 2007	JUN 7, 2007

Service Type
COMMERCIAL WATER & SEWER

Service Address
3455 BURTON ST SE

Government Unit
GRAND RAPIDS 2004

Meter Readings

Date	Type	Reading
Previous: FEB 12, 2007	Actual	1583
Current: MAY 02, 2007	Actual	1758

Days Billed:	79
Pro-Rated Units:	0
Meter Change Units:	0
Metered Units Used:	175
Total Units Used:	175

Summary of Charges Quarterly Billing

Previous Balance	$948.02	
Late Payment Fee	$.00	
Other Charges/Credits	$.00	
Payments Received - Thank You	$948.02CR	
Balance Before Current Charges		$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$75.71	
Water Volume 175 HCF x 1.46000	$255.50	
Sewer Base Rate (Readiness to Serve Charge)	$64.98	
Sewer Volume 175 HCF x 2.37000	$414.75	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$810.94

Total Amount Due: $810.94

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
MAY 17, 2007	JUN 7, 2007
Service Address	**Account Number**
3455 BURTON ST SE	B281350201A
Monthly Payment Option	**Total Amount Due**
Not Available	$810.94

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

Amount Enclosed: ______

0701 02281350201015 00081094 00000000

City of Grand Rapids
Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
B281350230A	MAY 17, 2007	JUN 7, 2007

Service Type
COMMERCIAL WATER & SEWER

Service Address
3465 BURTON ST SE

Government Unit
GRAND RAPIDS 2005

Meter Readings

Date	Type	Reading
Previous: FEB 12, 2007	Actual	3165
Current: MAY 02, 2007	Actual	3360

Days Billed:	79
Pro-Rated Units:	0
Meter Change Units:	0
Metered Units Used:	195
Total Units Used:	195

Summary of Charges

Quarterly Billing

Previous Balance	$1,170.08	
Late Payment Fee	$.00	
Other Charges/Credits	$.00	
Payments Received - Thank You	$1,170.08CR	
Balance Before Current Charges		$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$127.03	
Water Volume 195 HCF x 1.46000	$284.70	
Sewer Base Rate (Readiness to Serve Charge)	$108.70	
Sewer Volume 195 HCF x 2.37000	$462.15	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$982.58

Total Amount Due: $982.58

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
MAY 17, 2007	JUN 7, 2007

Service Address	Account Number
3465 BURTON ST SE	B281350230A

Monthly Payment Option	Total Amount Due
Not Available	$982.58

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

Amount Enclosed:

0701 02281350230015 00098258 00000000

City Of Grand Rapids
Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
B281350260A	MAY 17, 2007	JUN 7, 2007

Service Type
RESIDENTIAL WATER & SEWER

Service Address
3475 BURTON ST SE

Government Unit
GRAND RAPIDS 2006

Meter Readings

Date	Type	Reading
Previous: FEB 12, 2007	Actual	4240
Current: MAY 02, 2007	Actual	4846

Days Billed:	79
Pro-Rated Units:	0
Meter Change Units:	0
Metered Units Used:	606
Total Units Used:	606

Quarterly Billing

Summary of Charges

Previous Balance	$2,649.17	
Late Payment Fee	$.00	
Other Charges/Credits	$.00	
Payments Received - Thank You	$2,649.17CR	
Balance Before Current Charges		$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$127.03	
Water Volume 606 HCF x 1.46000	$884.76	
Sewer Base Rate (Readiness to Serve Charge)	$108.70	
Sewer Volume 588 HCF x 2.37000	$1,393.56	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$2,514.05

Total Amount Due: $2,514.05

Monthly Payment Option (A $1.00 Fee will be added to your next bill): $838.03

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
MAY 17, 2007	JUN 7, 2007

Service Address	Account Number
3475 BURTON ST SE	B281350260A

Monthly Payment Option	Total Amount Due
$838.03	$2,514.05

Amount Enclosed:

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

0701 02281350260018 00251405 00083803

City Of Grand Rapids
Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
B281350190A	MAY 17, 2007	JUN 7, 2007

Service Type
COMMERCIAL WATER & SEWER

Service Address
3445 BURTON ST SE

Government Unit
GRAND RAPIDS 2003

Meter Readings

Date	Type	Reading
Previous: FEB 12, 2007	Actual	952
Current: MAY 02, 2007	Actual	1049

Days Billed:	79
Pro-Rated Units:	0
Meter Change Units:	0
Metered Units Used:	97
Total Units Used:	97

Summary of Charges Quarterly Billing

Previous Balance	$592.98	
Late Payment Fee	$.00	
Other Charges/Credits	$.00	
Payments Received - Thank You	$592.98CR	
Balance Before Current Charges		$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$75.71	
Water Volume 97 HCF x 1.46000	$141.62	
Sewer Base Rate (Readiness to Serve Charge)	$64.98	
Sewer Volume 97 HCF x 2.37000	$229.89	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$512.20

Total Amount Due: $512.20

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
MAY 17, 2007	JUN 7, 2007

Service Address	Account Number
3445 BURTON ST SE	B281350190A

Monthly Payment Option	Total Amount Due
Not Available	$512.20

Amount Enclosed:

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

0701 02281350190014 00051220 00000000

City Of Grand Rapids
Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
B281350160A	MAY 17, 2007	JUN 7, 2007

Service Type
COMMERCIAL WATER & SEWER

Service Address
3435 BURTON ST SE

Government Unit
GRAND RAPIDS 2002

Meter Readings

Date	Type	Reading
Previous: FEB 12, 2007	Actual	1685
Current: MAY 02, 2007	Actual	1878

Days Billed:	79
Pro-Rated Units:	0
Meter Change Units:	0
Metered Units Used:	193
Total Units Used:	193

Summary of Charges

Quarterly Billing

Previous Balance	$1,053.78	
Late Payment Fee	$.00	
Other Charges/Credits	$.00	
Payments Received - Thank You	$1,053.78CR	
Balance Before Current Charges		$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$75.71	
Water Volume 193 HCF x 1.46000	$281.78	
Sewer Base Rate (Readiness to Serve Charge)	$64.98	
Sewer Volume 193 HCF x 2.37000	$457.41	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$879.88

Total Amount Due: $879.88

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
MAY 17, 2007	JUN 7, 2007

Service Address	Account Number
3435 BURTON ST SE	B281350160A

Monthly Payment Option	Total Amount Due
Not Available	$879.88

Amount Enclosed:

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

0701 0228135016011 00087988 00000000

City of Grand Rapids
Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
B281350131A	MAY 17, 2007	JUN 7, 2007

Service Type
COMMERCIAL WATER & SEWER

Service Address
3425 BURTON ST SE

Government Unit
GRAND RAPIDS 2001

Meter Readings

Date	Type	Reading
Previous: FEB 12, 2007	Actual	1634
Current: MAY 02, 2007	Actual	1826

Days Billed: 79
Pro-Rated Units: 0
Meter Change Units: 0
Metered Units Used: 192
Total Units Used: 192

Quarterly Billing

Summary of Charges

Previous Balance		
Late Payment Fee	$1,170.86	
Other Charges/Credits	$.00	
Payments Received - Thank You	$.00	
Balance Before Current Charges	$1,170.86CR	$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$75.71	
Water Volume 192 HCF x 1.46000	$280.32	
Sewer Base Rate (Readiness to Serve Charge)	$64.98	
Sewer Volume 192 HCF x 2.37000	$455.04	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$876.05

Total Amount Due: $876.05

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
MAY 17, 2007	JUN 7, 2007

Service Address	Account Number
3425 BURTON ST SE	B281350131A

Monthly Payment Option	Total Amount Due
Not Available	$876.05

Amount Enclosed:

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

0701 02281350131011 00087605 00000000

Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
M122841600A	APR 19, 2007	MAY 10, 2007

Service Type
COMMERCIAL WATER & SEWER

Service Address
1802 E BELTLINE AV SE

Government Unit
GRAND RAPIDS 2918

Meter Readings

Date	Type	Reading
Previous: MAR 13, 2007	Actual	9515
Current: APR 17, 2007	Actual	9736

Days Billed:	35
Pro-Rated Units:	0
Meter Change Units:	0
Metered Units Used:	221
Total Units Used:	221

Summary of Charges Monthly Billing

Previous Balance	$715.49	
Late Payment Fee	$.00	
Other Charges/Credits	$.00	
Payments Received - Thank You	$715.49CR	
Balance Before Current Charges		$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$56.28	
Water Volume 221 HCF x 1.46000	$322.66	
Sewer Base Rate (Readiness to Serve Charge)	$48.16	
Sewer Volume 221 HCF x 2.37000	$523.77	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$950.87

Total Amount Due: $950.87

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
APR 19, 2007	MAY 10, 2007

Service Address	Account Number
1802 E BELTLINE AV SE	M122841600A

Monthly Payment Option	Total Amount Due
	$950.87

Amount Enclosed:

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

0704 131228416000011 00095087 00000000

City of Grand Rapids
Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
M122841580A	APR 19, 2007	MAY 10, 2007

Service Type
COMMERCIAL WATER & SEWER

Service Address
1800 E BELTLINE AV SE

Government Unit
GRAND RAPIDS 2917

Meter Readings

Date	Type	Reading
Previous: MAR 13, 2007	Actual	1485
Current: APR 17, 2007	Actual	1516

Days Billed: 35
Pro-Rated Units: 0
Meter Change Units: 0
Metered Units Used: 31
Total Units Used: 31

Summary of Charges — Monthly Billing

Previous Balance	$183.12	
Late Payment Fee	$.00	
Other Charges/Credits	$.00	
Payments Received - Thank You	$183.12CR	
Balance Before Current Charges		$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$56.28	
Water Volume 31 HCF x 1.46000	$45.26	
Sewer Base Rate (Readiness to Serve Charge)	$48.16	
Sewer Volume 31 HCF x 2.37000	$73.47	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$223.17

Total Amount Due: $223.17

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
APR 19, 2007	MAY 10, 2007

Service Address	Account Number
1800 E BELTLINE AV SE	M122841580A

Monthly Payment Option	Total Amount Due
	$223.17

Amount Enclosed:

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

0704 13122841580012 00022317 00000000

City Of Grand Rapids
Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
B281350320A	MAY 17, 2007	JUN 7, 2007

Service Address
3495 BURTON ST SE

Service Type
RESIDENTIAL WATER & SEWER

Government Unit
GRAND RAPIDS 2009

Meter Readings

Date	Type	Reading
Previous: FEB 10, 2007	Actual	172
Current: MAY 02, 2007	Actual	581

Days Billed:	81
Pro-Rated Units:	0
Meter Change Units:	0
Metered Units Used:	409
Total Units Used:	409

Summary of Charges

Quarterly Billing

Previous Balance	$2,612.22	
Late Payment Fee	$.00	
Other Charges/Credits	$.00	
Payments Received - Thank You	$2,612.22CR	
Balance Before Current Charges		$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$77.63	
Water Volume 409 HCF x 1.46000	$597.14	
Sewer Base Rate (Readiness to Serve Charge)	$66.63	
Sewer Volume 409 HCF x 2.37000	$969.33	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$1,710.73

Total Amount Due: $1,710.73

Monthly Payment Option (A $1.00 Fee will be added to your next bill): $570.25

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
MAY 17, 2007	JUN 7, 2007

Service Address	Account Number
3495 BURTON ST SE	B281350320A

Monthly Payment Option	Total Amount Due
$570.25	$1,710.73

Amount Enclosed:

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

0701 02281350320011 00171073 00057025

Water and Sewer Services
(616) 456-3200

Customer Service Office
1101 Monroe Avenue NW
Grand Rapids, MI 49503

Account Number	Bill Date	Due Date
M122841572A	AUG 16, 2007	SEP 6, 2007

Service Type
COMMERCIAL WATER & SEWER

Service Address
1801 E BELTLINE AV SE

Government Unit
GRAND RAPIDS 395

Meter Readings		
Date	Type	Reading
Previous: JUL 17, 2007	Actual	29480
Current: AUG 14, 2007	Actual	29890

Days Billed: 28	
Pro-Rated Units:	0
Meter Change Units:	0
Metered Units Used:	410
Total Units Used:	410

Summary of Charges Monthly Billing

Previous Balance	$4,014.85	
Late Payment Fee	$.00	
Other Charges/Credits	$.00	
Payments Received - Thank You	$4,014.85CR	
Balance Before Current Charges		$.00
Current Charges		
Water Base Rate (Readiness to Serve Charge)	$377.56	
Water Volume 410 HCF x 1.46000	$598.60	
Sewer Base Rate (Readiness to Serve Charge)	$321.84	
Sewer Volume 410 HCF x 2.37000	$971.70	
Miscellaneous Charges/Credits	$.00	
Total Current Charges		$2,269.70

Total Amount Due: **$2,269.70**

Special Information

Return this portion with payment. Make checks payable to Grand Rapids City Treasurer

City of Grand Rapids Treasurer
RM 220 City Hall - Water/Sewer
300 Monroe Avenue NW
Grand Rapids, MI 49503-2296

Bill Date	Payment Due Date
AUG 16, 2007	SEP 6, 2007
Service Address	**Account Number**
1801 E BELTLINE AV SE	M122841572A
Monthly Payment Option	**Total Amount Due**
	$2,269.70

Amount Enclosed:

CALVIN COLLEGE
3201 BURTON ST SE
GRAND RAPIDS MI 49546

0708 13122841572017 00226970 00000000

Appendix B.5: Water to Carbon Calculations

Address	Per Quarter Water Volume [HCF]	Per Quarter Sewer Volume [HCF]	Annual Water [HCF]
1800	93	93	372
1802	663	663	2652
3425	192	192	768
3435	193	193	772
3445	97	97	388
3455	175	175	700
3465	195	195	780
3475	606	588	2424
3485	341	341	1364
3495	409	409	1636
1801 and 3201			

	Tap Water	Sewer	Readiness to Service Charge	
Annual Sewer [HCF]	Total Gallons/Year [Gallons / Year]	Total Gallons/Year [Gallons / Year]	Water [$]	Sewer [$]
372	278256	278256	675.36	577.92
2652	1983696	1983696	675.36	577.92
768	574464	574464	302.84	259.92
772	577456	577456	302.84	259.92
388	290224	290224	302.84	259.92
700	523600	523600	302.84	259.92
780	583440	583440	508.12	434.8
2352	1813152	1759296	508.12	434.8
1364	1020272	1020272	310.52	266.52
1636	1223728	1223728	310.52	266.52
	50804160	50804160		

Total Campus Use:	**59672448**	**59618592**	[gallons]

Cost without Service Charge		Cost of Service Charge	
$116,473	**$188,898**	4199.36	3598.16

Total Costs	$305,371	
Energy Cost (est.)	$152,685.72	
Energy	1696.508	MW-hr
CO_2 Emissions	1756.520528	met. Tons

Appendix B.6: Carbon Sequestering Tree Article

Synthetic trees could purify air

By Molly Bentley

A scientist has invented an artificial tree designed to do the job of plants.

But the synthetic tree proposed by Dr Klaus Lackner does not much resemble the leafy variety.

"It looks like a goal post with Venetian blinds," said the Columbia University physicist, referring to his sketch at the annual meeting of the American Association for the Advancement of Science in Denver, Colorado.

But the synthetic tree would do the job of a real tree, he said. It would draw carbon dioxide out of the air, as plants do during photosynthesis, but retain the carbon and not release oxygen.

If built to scale, according to Dr Lackner, synthetic trees could help clean up an atmosphere grown heavy with carbon dioxide, the most abundant gas produced by humans and implicated in climate warming.

He predicts that one synthetic tree could remove 90,000 tonnes of CO2 in a year - the emissions equivalent of 15,000 cars.

"You can be a thousand times better than a living tree," he said.

Carbon sinks

For now, the synthetic tree is still a paper idea. But Dr Lackner is serious about developing a working model. His efforts suggest the wide net of ideas cast by scientists as they face the challenge of mitigating climate change.

Dr Lackner believes that carbon sequestration technology must be part of the long-term solution. Global reliance on fossil fuels would not decrease any time soon, he said, and developing countries cannot be expected to wait until alternatives are available.

The technology calls for two things: seizing carbon and then storing it. Direct capture of CO2, from power plants for example, is the simplest, according to Dr Lackner. But this doesn't work for all polluters. A car can't capture and store its carbon dioxide on-board; the storage tank would be too large.

"It's simply a question of weight," he said. "For every 14 grams of gasoline you use, you are going to have 44 grams of CO2."

The alternative is to capture emissions from the wind. In this case, a synthetic tree would act like a filter. An absorbent coating, such as limewater, on its slats or "leaves" would seize carbon dioxide and retain the carbon.

Dr Lackner predicts that the biggest expense would be in recycling the absorber material.

"We have to keep the absorbent surfaces refreshed because they will very rapidly fill up with carbon dioxide," he said. If an alkaline solution such as limewater were used, the resulting coat of limestone would need to be removed.

Dr Lackner is considering other less-alkaline solutions to prevent carbonate precipitation.

"There are a number of engineering issues which need to be worked out," he said.

Home use

A synthetic tree could be planted anywhere. A small one could sit like a TV on the lawn to balance out the CO2 emitted by one person or family.

But more practically, said Dr Lackner, a device the size of a barn would sit in the open air, near repositories for easy transportation and storage of carbon.

He estimated that 250,000 synthetic trees worldwide would be needed to soak up the 22 billion tonnes of CO2 produced annually.

But not everyone is rooted to the idea. Massachusetts Institute of Technology engineer Howard Herzog thinks Dr Lackner's design will not hold together on the scale he proposes.

He said you would expend more energy in capturing the CO2 - in keeping the slats coated in absorbent and disposing of it - than you would save.

"Once the solvent captures the CO2, it holds it on tight," said Dr Herzog, "and it's going to take a lot of energy to break those bonds."

He said that much more research was needed on the technology.

"The idea of air capture is seductive and would really be great to have," said Dr Herzog, "but it's important to separate out the concept from the technical details."

'Early days'

Meanwhile, Dr Lackner is pursuing his idea for carbon storage. While he was at the US Department of Energy's Los Alamos National Laboratory, his team worked on a storage method based on a natural chemical process known as rock weathering.

When CO2 binds with magnesium, it creates carbonate rocks which, according to Dr Lackner, retain carbon permanently and safely.

Currently, he said, the process is still too expensive to develop on a large scale.

But Dr Lackner is optimistic that the costs for carbon capture and storage will come down.

"This is still the early days of climate solutions," he said.

http://newsvote.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/2/hi/science/nature/2784227.stm

Appendix C: Solid Waste and Recycling

Objective

To minimize Calvin's carbon footprint through better waste management and increased student awareness.

Method

The group first researched Calvin's current solid waste and recycling practices and set boundaries for what would be included in the team's analysis. The team received help and information from various resources at Calvin on statistics for food waste and recycled materials. These statistics, along with data from the Environmental Protection Agency (See Appendix C.2), were used to calculate the carbon output generated from solid waste disposal and recycling. Once the team had determined the carbon footprint from Calvin's current waste management situation, the team was able to decide on solutions that could be implemented to alleviate carbon output. The carbon footprint from implementing better waste management was then subtracted from the current waste management carbon footprint in order to find the potential carbon reduction. Finally, the group determined the cost of this carbon reduction. A schedule of the group's work throughout the semester can be seen in Appendix C.1.

Results

Table 1: Carbon Footprint for Solid Waste and Recycling

	Carbon Output [MTCE]
Current	258
Potential	147
Reduction	111

Table 2: Costs of Waste Management on an Annual Basis

Current recycling cost	$80,000
Current labor cost	$16,000
Projected recycling cost	$140,000
Projected initial cost	$10,000
Projected increased labor cost	$40,000
Cost of carbon reduction	$757/MTCE

A more detailed look at the carbon footprint showed that 90 tons of food scraps (in one school year) only accounted for about 3% of total emissions (See Appendix C.3). Because food waste would realistically not be reduced more than half, the team chose to omit food waste from their following analyses and instead focus on recycling in order to reduce carbon emissions.

Currently, Calvin has 20 recycling sites on campus and pays students to collect and sort the materials. The team's plan proposed adding 50 sites at the costs shown above, and instead of students, collection would become a custodial job. However, after contacting some people at Calvin, the team learned that Calvin was going to add 100 more sites. Therefore, the team's work was finished.

Conclusions

To achieve maximum possible reductions for this group would mean every student recycles all materials and does not waste any food. Primarily, this would be done through campaigns and flyers to increase student awareness about the effects their waste has on the environment. However, this is an ideal situation and inevitably would not occur. For example, Calvin will always serve food, which leads to waste, and ultimately carbon emissions from the food thrown into a landfill. The same goes for recyclables; inevitably not everything will be recycled so there can never be a complete reduction of carbon. The team came to the conclusion that carbon neutrality was impossible to achieve solely through better waste management. However, it is possible to drastically reduce emissions from the waste and recycling sector (45%) if effective campaigns were led to improve student's recycling habits.

Appendix C.1: GANNT Chart for Semester

	18-Sep	25-Sep	2-Oct	9-Oct	16-Oct	23-Oct	30-Oct	6-Nov	13-Nov	20-Nov	27-Nov	3-Dec
Research Calvin's Waste Situation	■	■	■									
Research Calvin's Recycling Situation	■	■	■									
Visit Physical Plant and Co-Gen Plant		■	■									
Calculate Carbon Footprint				■	■	■	■					
Calculate Maximum Potential Reduction				■	■	■	■					
Find more detailed costs of recycling					■	■	■					
Assess Feasibility of Reduction Ideas							■	■	■			
Write Final Carbon Reduction Proposal							■	■	■			
Present Findings and Proposals										■		
Write Tech Memo										■	■	■

Appendix C.2: Environmental Protection Agency Data

Per Ton Estimates of GHG Emissions for Alternative Management Scenarios

Material	GHG Emissions per Ton of Material Source Reduced (MTCE)	GHG Emissions per Ton of Material Recycled (MTCE)	GHG Emissions per Ton of Material Landfilled (MTCE)	GHG Emissions per Ton of Material Combusted (MTCE)	GHG Emissions per Ton of Material Composted (MTCE)
Aluminum Cans	(2.24)	(3.70)	0.01	0.02	NA
Steel Cans	(0.87)	(0.49)	0.01	(0.42)	NA
Copper Wire	(2.00)	(1.34)	0.01	0.01	NA
Glass	(0.16)	(0.08)	0.01	0.01	NA
HDPE	(0.49)	(0.38)	0.01	0.25	NA
LDPE	(0.62)	(0.46)	0.01	0.25	NA
PET	(0.57)	(0.42)	0.01	0.30	NA
Corrugated Cardboard	(1.52)	(0.85)	0.11	(0.18)	NA
Magazines/third-class mail	(2.36)	(0.84)	(0.08)	(0.13)	NA
Newspaper	(1.33)	(0.76)	(0.24)	(0.20)	NA
Office Paper	(2.18)	(0.78)	0.53	(0.17)	NA
Phonebooks	(1.72)	(0.72)	(0.24)	(0.20)	NA
Textbooks	(2.50)	(0.85)	0.53	(0.17)	NA
Dimensional Lumber	(0.55)	(0.67)	(0.13)	(0.21)	NA
Medium Density Fiberboard	(0.60)	(0.67)	(0.13)	(0.21)	NA
Food Scraps	NA	NA	0.20	(0.05)	(0.05)
Yard Trimmings	NA	NA	(0.06)	(0.06)	(0.05)
Grass	NA	NA	(0.00)	(0.06)	(0.05)
Leaves	NA	NA	(0.05)	(0.06)	(0.05)
Branches	NA	NA	(0.13)	(0.06)	(0.05)
Mixed Paper, Broad	NA	(0.96)	0.09	(0.18)	NA
Mixed Paper, Resid.	NA	(0.96)	0.07	(0.18)	NA
Mixed Paper, Office	NA	(0.93)	0.13	(0.16)	NA
Mixed Metals	NA	(1.43)	0.01	(0.29)	NA
Mixed Plastics	NA	(0.41)	0.01	0.27	NA
Mixed Recyclables	NA	(0.79)	0.04	(0.17)	NA
Mixed Organics	NA	NA	0.06	(0.05)	(0.05)
Mixed MSW	NA	NA	0.12	(0.03)	NA
Carpet	(1.09)	(1.96)	0.01	0.11	NA
Personal Computers	(15.13)	(0.62)	0.01	(0.05)	NA
Clay Bricks	(0.08)	NA	0.01	NA	NA
Concrete	NA	(0.00)	0.01	NA	NA
Fly Ash	NA	(0.24)	0.01	NA	NA
Tires	(1.09)	(0.50)	0.01	0.05	NA

Appendix C.3: Waste Management Scenarios

GHG Emissions from Baseline Waste Management (MTCE): (105)

Commodity	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Total MTCE
Corrugated Cardboard	46	-	46	NA	(47)
Magazines/third-class mail	2	-	2	NA	(2)
Newspaper	5	-	5	NA	(5)
Office Paper	15	-	15	NA	(14)
Food Scraps	NA	-	90	-	(4)
Mixed Plastics	50	-	50	NA	(7)
Mixed MSW	NA	-	764	NA	(25)

GHG Emissions from Alternative Waste Management Scenario (MTCE): (183)

Commodity	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Total MTCE
Corrugated Cardboard	-	92	-	-	NA	(78)
Magazines/third-class mail	-	4	-	-	NA	(3)
Newspaper	-	10	-	-	NA	(8)
Office Paper	-	30	-	-	NA	(23)
Food Scraps	NA	NA	-	90	-	(4)
Mixed Plastics	NA	100	-	-	NA	(41)
Mixed MSW	NA	NA	-	764	NA	(25)

Appendix C.4: Carbon Footprint Calculations

Base

	MTCE	Multiplier	Total MTCE	
Cardboard	78	1.5	117	
Magazines	3	1.5	4.5	
Newspaper	8	1.5	12	
Office Paper	23	1.5	34.5	
Food Scraps	4	1	4	
Plastics	41	1.33	54.53	
MSW	25	1.25	31.25	
			257.78	**MTCE**

Alternative

	MTCE	Multiplier	Total MTCE	
Cardboard	47	1.5	70.5	
Magazines	2	1.5	3	
Newspaper	5	1.5	7.5	
Office Paper	14	1.5	21	
Food Scraps	4	1	4	
Plastics	7	1.33	9.31	
MSW	25	1.25	31.25	
			146.56	**MTCE**
Reduction			**111.22**	**MTCE**

Appendix C.5: Recycling Bin and Labor Costs

	Current	Our plan	Calvin plan
Total bins	20	70	120
Bin cost (per site) [$]	0	200	200
Total bin cost [$]	0	10000	20000
Student wage [$/day]	64	168	208
Bin collection cost [$/week]	384	1008	1248
Total initial cost [$]	0	10000	20000
Annual site cost [$/year]	16128	42336	52416

Appendix D: Construction and Renovation

Objective:

The original objectives for the entire class consisted of creating an inventory of Calvin College's present rate of Green House Gas (GHG) emissions and sequestration potential; creating a detailed list of steps to be taken to achieve Carbon Neutrality; document a plan towards Carbon Neutrality; and perform an economic analysis of that plan. The Construction and Renovation group was tasked with applying those goals within the spheres of constructing new buildings and improving existing buildings.

Procedure:

Before we could start our analysis, we had to define what we would analyze. We decided that we would examine how much carbon dioxide is emitted during a construction project, and how much we could reduce our carbon emissions by renovating the dorms. Carbon emissions resulting from day-to-day operation of buildings fell under the purview of the Energy group. In terms of Carbon emissions, we would only consider buildings that were currently under construction or were planned for the near future. Existing buildings are regarded as beyond our scope, as the construction has been completed and any carbon dioxide already emitted into the atmosphere. This left us with three buildings that fell within our construction scope: The Spoelhof Fieldhouse Complex, a new wing to be added the Kalsbeek-Huizinga dorm, and the new addition to the Commons. For reductions of carbon dioxide due to building renovation, we would look primarily at the seven dorm buildings and how we might save energy there.

Construction:

Actually determining the amount of carbon dioxide emitted during a construction process is extremely difficult due to the large variety of construction conditions and locations. And unfortunately, there is currently no standard metric to measure the amount of carbon dioxide emitted during a construction project. So to determine how much carbon dioxide is emitted during construction, we would have to account for everything from whether building materials were local or shipped a long distance, what type of materials are used, how much waste was produced during construction, and even what types of vehicles the construction workers used. Quite frankly, this was beyond our skills and resources, certainly impossible for projects which are still in the planning stages.

Fortunately, we found a website (www.buildcarbonneutral.org) which claimed to predict how much carbon dioxide would be produced during construction with an accuracy of ±25%. We entered as much data on each of the three projects as we could find (see Appendices D.1, D.2 and D.2) into the website and obtained the data on Table 1. Because construction projects emit a large amount of carbon dioxide in a short period, we annualized the emitted carbon over a 20 year period in an effort to smooth out year-to-year variations in total carbon dioxide emitted each year. Carbon emissions are measured in Metric Tons Carbon dioxide Emitted, abbreviated MTCE.

Renovations

To determine how much carbon dioxide emissions could be reduced by renovating the dorms, we needed to find how we could reduce energy usage, and convert those energy savings into reductions of carbon dioxide emissions. Thanks to Professor Piers' Sustainability study (Appendix K) it was easy to convert energy savings into carbon dioxide reductions, but actually determining how we might save energy was highly frustrating.

Unfortunately, when the campus heating system was installed, very little instrumentation was included to determine how much energy each part of campus required. All we knew was how much energy the entire campus used. Since we had no direct instrumentation, we decided to model a dorm mathematically and determine the heating load on the building based on inside and outside temperatures, and a calculated insulation value for the walls, windows and roof. However, while this process would work well for a single temperature difference, it was very poor for weather changes and accounting for whether it was sunny, overcast, rainy or snowing, in addition to the fluctuating temperatures that are part of the normal seasons in Michigan. To account for these differences, we attempted to use HVAC design software borrowed from the Geothermal Senior design team. But this effort was stymied by a lack of training with a complicated program, and again we were back at square one. Finally we found a comparable dorm at the University of Maine that had undergone a renovation quite similar to the one we wished to perform on Calvin's dorms. Using the University of Maine's published data (Appendix D.2) and a cost estimate provided by Bernie Tolsma of Rainier Group, Inc. (Appendix D.3) we arrived at the data provided in Table 2.

The Future

There are several improvements that can be made on our work in the future. When a standard metric for measuring the amount of carbon dioxide emitted during a construction process is produced, that metric should be applied to any new construction projects that Calvin undertakes. And there are many renovations that will improve campus energy efficiency that we cannot quantify until instrumentation to measure energy use on a building by building basis is installed. Among these renovations is motion sensitive lighting. Most classrooms already have this, but bathrooms and dorm hallways do not. The dorm hallways and basements are lit twenty-four hours a day. Obviously energy savings are possible here.

Final Results

As seen in Table 1, the carbon dioxide emissions that fell within our group's sphere of responsibility totaled 1134 MTCE per year when annualized over a 20 year period. As seen in Table 2, through renovations we can reduce emissions by 36.4 MTCE per year. Other reductions are possible, though not measureable at this point. Within the realms of Construction and Renovation, we did not find any methods of sequestration.

Table 1: Carbon dioxide emitted during construction		
	Total MTCE during construction	Annualized over 20 years
New KH dorm Wing	1926	96.3
Commons Addition	2694	134.7
Spoelhof Fieldhouse Complex	18060	903
Total	22680	1134

Table 2: Data from University of Maine's renovation		
	Stodder Hall	Applied to Calvin
Carbon Saved each year	5.2 MTCE	36.4 MTCE
Money Saved each year	$4,800	$33,600
Capital investment	$85,750	$600,000
Break even point (4% inflation)	32 years	32 years

Appendix D.1: Data on Commons Addition

From: http://www.calvin.edu/publications/spark/2007/summer/commons.htm

The Changing Commons
Plans for new gathering space recognize shift in student expectations
By Lynn Bolt Rosendale '85

To provide a communal gathering spot has always been the purpose of the Calvin College Commons, a building that was completed on the Knollcrest campus in 1967.

The "Commons" name was retained from the Franklin campus very intentionally, according to Phil Lucasse, dean of students at Calvin from 1956-1969.

"A more common name for buildings like this one was 'student union,'" he said, "but we wanted this to be thought of as a common space where people-students, but also professors and administrators-would come to meet."

In fact, in one of the first meetings of the student union committee, which was appointed to "mold the functions of the student union building constructed on the Knollcrest campus according to the purpose of the college," it was decided that the building would keep the name "Commons" to emphasize the community aspect of the college.

Forty years ago the building housed a large dining hall, the bookstore (now the Campus Store), the snack shop (now Johnny's), as well as some additional meeting space, just as it does today.

Forty Years Ago

Four decades ago though, student interests, student tastes and student experiences were very different, said Henry DeVries, Calvin vice president for administration and finance. "The Commons was built for its time," he said. "Food was served family style around six-foot-round tables. When I was a student, we compared the dining experience to home; students now compare it to a restaurant. Their expectations are completely different."

With changing expectations, options and facilities have to change. "Our students come to us with a wide range of culinary experiences," he said. "That's why our offerings-things like sushi night, Indian food, vegan chocolate cake-have expanded. We're serving very sophisticated consumers, and we need to be able to meet the needs of contemporary students."

Commons: A tract of land belonging to or used by a community as a whole.

In researching other institutions, Calvin administrators discovered that the dining experience is third on students' lists of college comparisons. Only their academic department and the residence halls outrank dining in terms of what prospective students consider important on a college campus.

With that in mind, an extensive remodeling and expansion of the Commons are in the planning stages.

A New Living Place

In addition to expanded dining options, the new Commons would provide space for student organizations, group study and commuter students.

"One of the things we have really come to understand is how much place matters," said Shirley Hoogstra, Calvin vice president for student life. "That was demonstrated so clearly in the renovation of Johnny's. Previously, it wasn't a very inviting place. Now it's intimate, warm, friendly and wireless, and it's busy. It gets used for meals and as a conversation and study place. The problem is there are very few places like that on campus."

An expanded Commons would incorporate a lot of "sticky spaces," Hoogstra said. Conversation, meeting and resting alcoves along the "main street" of campus, where students and visitors would feel comfortable, is one of the key components of the new space.

"We would like to provide places for continued conversation about concepts from the classroom," Hoogstra said. "By providing space, we extend the life of that conversation."

Another key element is space for student organizations. In the 1960s, there were seven student organizations. Today, there are 61 student groups, among them the Environmental Stewardship Coalition, Students for Compassionate Living, the American Institute of Architecture Students, the Calvin Climbing Club, the Rowing Club and, of course, media organizations such as *Chimes, Prism* and Calvin Video Network (CVN).

"Students like to affiliate around common goals and projects, and we encourage students to do that," Hoogstra said. "It's like a laboratory for the ideas and concepts they're learning in the classroom. But our space is outdated to accommodate these groups."

The new Commons would include flexible space that the various student organizations could share.

The Plans

Going from the current 91,000 square feet (58,000 in the Commons and 23,000 in the Commons Annex), to the planned 134,000 square feet should provide plenty of options, according to architect Larry Payne of WTW Architects, the Pittsburgh, Pa., firm contracted to design the new structure.

"We are planning for many lounges and other spaces that are conducive to interaction between students, faculty and the administration," he said. "One of the new 'social anchors' of the proposed Commons will be a large, multistory fireplace that we foresee becoming very popular as a gathering spot for many activities, including acoustic performances and listening to spoken word."

The building's design will strive to enhance the existing Prairie-style architecture.

"Student unions built during the '60s and '70s have generally been considered to be 'inflexible' and 'dark' by the individuals who now use them," Payne said. "Today's structures not only need to align with the culture of the institution, but also the values of the current and future generations of students who will be attending higher-education institutions."

"I think it's important that the building reflect Calvin values," Hoogstra added. "Creation, friendships, integration of student life and the academic division-these are all values that should have a place in this building."

Construction for the new facility is expected to begin in 2009.

"What I hope for this space," said Hoogstra, "is that students can find it to be a place where they can attach, where they find friends, where they feel like they belong."

— Lynn Rosendale is the managing editor of Spark *.*

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The Commons Annex

The preservation of green space has become an important element in urban design, particularly in the last decade or so. But some Calvin students in the late 1970s were ahead of their time in considering this very issue during the development of Calvin's campus.

A group of students, many of them affiliated with the Calvin Ecology Club, spoke out against the proposed addition, now called the Commons Annex. In fact, more than 500 students signed a petition urging the administration to seek an alternative solution.

"We came along at the tail end of students who took a kind of adversarial stance about things," said Steve Timmermans '79. "It was at a time when adopting a protest mentality was more accepted."

The students were opposed to the building plan that was originally supposed to span from the Commons to the Hekman Library. Their opposition drew attention from several media sources.

"I think we thought of it like the Berlin Wall," Timmermans said of the annex. "To have all that building blocking off the middle of campus didn't seem like a great plan."

There was also the space usage issue, which Timmermans studied independently during interim of 1979. He presented his findings in a report: "Is the Proposed 'Commons Expansion' Really Needed?" His conclusion was that "the proposed building would indeed be extravagant and unnecessary, and that present facilities are satisfactory for students and for conferences."

The administration was willing to listen to the opinion of Timmermans and other student protesters. "The administration was very responsive," recalled Timmermans, now president of Trinity Christian College in Palos Heights , Ill. "At the time I know that we were impressed with the fact that the administration listened to us as students who had valid opinions and needed to be heard. Our conversations helped recast the building."

In fact, the building was scaled down from its original 30,000 square feet to 22,000 square feet by eliminating the lounge for commuters. This allowed for the open space between the Commons Annex and the Hekman Library, which still exists today and will be maintained in the new plan.

Appendix D.2: Published Data on University of Maine's Stodder Hall

From: http://www.ifma.org/daily_articles/2006/mar/03_06.cfm

Dressing Up The Dorms: University of Maine Caters To Students' Individual Needs While Saving Money

It's a pretty common site around college campuses in cold-weather states: The snow and temperature are falling. The icicles are forming. Students shiver and shuffle to class in layers of clothing.

And the dormitory windows are wide open.

That's right. Despite the chilly temperatures and biting winds, many students open their dorm windows to let in cool air. Why? Because it's the only option once a room overheats. For a university, it's also a pretty expensive option.

"That's wasting a lot of energy and money," said Joe Caron, the associate director of property management for Student Auxiliary Services (SAS) at the University of Maine.

Like many campus administrators who manage older dormitories, Caron struggled to find cost-efficient ways to maintain a comfortable living environment for students while conserving energy. It's a challenge that has perplexed many a facility manager.

At the University of Maine, located in Orono, overheating occurs because campus dormitories are divided into zones. Each zone consists of as many as 25 rooms—and a single sensor in a designated room dictates the temperature for the entire zone. But not every room is the same temperature and many end up too stifling. This is especially true on the upper floors, which gain heat from below and never adjust. The result: open windows, wasted energy and high utility bills for the university.

An uncomfortable living environment also is a contributing factor to the trend of students bypassing dorms for other options. Off-campus housing has fewer restrictions and offers more personal control.

"We live in an individualistic society and that's reflected in students' housing choices," said Gordon Nelson, the university's director of Property Management.

And administrators at the University of Maine took careful note of that as they studied ways to make their dorms more appealing.

"We wanted to have it more like a hotel, where people are in control of their environment instead of having it dictated," Nelson said. "The main goal was to allow students to maintain their own comfort."

In 2004, the university contracted with Honeywell to upgrade the existing heating system in Stodder Hall, a nearly 40-year-old building with about 140 rooms located on the southwest side of campus. The primary objective was to give each student individual control over their room temperature. And the results have been very favorable—school officials are planning to upgrade the rest of the dormitories.

As part of the contract, the university changed out all of the steam traps in Stodder Hall and replaced the radiator valves in each room. Honeywell technicians then installed individual heating controls in all of the rooms, which allow the students to control their own temperatures instead of relying on the zone system.

The most impressive part of the project was that Honeywell tied the controls together through its Enterprise Buildings Integrator (EBI) building management system. With EBI, Caron, Nelson and other facility managers can monitor the temperatures and controls of each room from their computer screens. EBI also allows staff to control the temperatures themselves, which is essential during holiday breaks when students are gone for weeks at a time.

In addition, Caron has used EBI to track temperature trends over long periods of time for rooms that have a history of service calls.

“It’s very user friendly,” he said. “We have a floor plan of the building with each room numbered. You can click on a room to get more detail and see the temperatures in the room.”

By tracking trends, administrators can better identify problems which makes for more effective troubleshooting.

Besides the HVAC system, Honeywell also tied the building’s electric, steam and water meters into EBI. This allows university personnel to monitor spikes in energy consumption. Consequently, they can detect and pinpoint problems quicker, cutting down on wasted energy even more.

In the past, when students would call to complain about their room temperatures, SAS would contact—and pay—an outside technician to go to the room and investigate. With EBI, Caron can diagnose most problems from his office. The solution sometimes is as simple as telling a student over the phone how to operate his or her controls. As a result, the university spends less on maintenance and students are pleased with the quick response.

During the spring of 2005—shortly after the upgrade—Stodder Hall residents made only two service calls total. In comparison, other dorms make about 10 to 20 calls per semester, Nelson said.

Another benefit: the results of the project have led university officials to work on getting Stodder Hall recognized as a green building to show its commitment to energy conservation. Along with the HVAC improvements, Stodder Hall has adopted an aggressive recycling program and added an organic food court. The university also is looking to address water conservation issues at the dormitory.

But the biggest impact has been having temperature controls in each room. Because students no longer leave windows ajar to cool their rooms, less energy is wasted and utility bills have gone down. In fact, the school is forecast to save at least 1,600 gallons of oil per year. And it will reduce nitrogen oxide emissions by 87 pounds annually and sulfur oxide emissions by almost 420 pounds.

“The students are conscious about the green effort. Recycling numbers are way up. We try to preach environmental impact to our people in the classroom, the campus and the community,” Nelson said.

Of course, the fact that students are more comfortable makes it easier for them to think about the environment.

“People’s first concerns are their individual work stations or residence,” Nelson said. “That was our ultimate goal here, to make sure on-campus students have a comfortable living environment. Once we’re able to improve their immediate surroundings, it’s easier to get them to pay attention to conservation issues.”

Nelson hopes similar HVAC upgrades to the other dorms will yield the same results. The University of Maine is moving ahead with plans to upgrade six dormitories in the next two years. And the long-term goal is to have all 19 campus dorms retrofitted with individual thermostats.

Soon, the only time students will open a window during the winter will be to bring in some frigid air to stop the sweating during finals week.

Appendix D.3: Cost Estimate on Stodder Hall Renovation

Courtesy of Bernie Tolsma Jr. of Reiner Group Inc.

Hey Brian,
I just got off the phone with my dad and here is what he estimated. It probably isn't a perfect number but it is pretty close.

Material : $200/room (includes valve and steam trap)
Labor: 2.5 hrs/room @ $85/hr so $212.50/room

Would double material costs- typical amount to cover overhead/profit

Total: $612.5/room or $85,750.

This estimate only includes what is done in the rooms themselves. In addition to this they probably changed the main boiler. But this will give you a good idea. If you want more information about these modifications, my dad said they probably used a valve similiar to the 'danfoss' valve. (http://na.heating.danfoss.com/Content/268e8ab9-69b6-4e83-9fa5-dc8d56afcfa2_MNU17392440.html)

If you need to cite any of this information it can be cited as an interview with Bernie Tolsma Jr. with Reiner Group Inc..

Hope this helped,
Bill Tolsma

Appendix F: Transportation Group

Objectives

The goal of the transportation group was to determine the carbon footprint of Calvin College related to transportation. This group also sought to find transportation related methods of reducing this footprint.

Procedure

To determine the carbon footprint, daily automobile commutes, service vehicle activity, and airplane flights were examined. The group decided that flights and commutes to and from campus at the beginning of each semester were beyond Calvin's control and should therefore not be counted toward their Carbon footprint. However, Calvin does have influence over emissions from daily commutes (by means of parking costs and availability) as well as business flights of faculty-staff, interim flights of students and faculty, and any other flight resulting from Calvin associated business. Details of calculations used to find the carbon footprint from transportation are located in Appendix F.1 - F.4.

Air traffic was not targeted in developing solutions for reducing the carbon footprint due to a lack of viable reduction options. For service vehicles, replacing campus safety vehicles with Electric Vehicles was considered. To reduce commuter emissions, this group considered a combination of solutions which would promote the use of bikes (bike lanes and rental bikes) and public transportation (full subsidy of the Rapid for Calvin faculty and staff) and would discourage driving (higher parking costs). The goal was also to make students more mindful of the costs of daily commutes (daily instead of yearly parking fees). More in depth analysis of these solutions is located in Appendix F.5 - F.10.

Results/Conclusions

The total carbon footprint for Calvin College due to transportation is shown in Figure F-1 below. Commuter traffic was by far the biggest source of emissions.

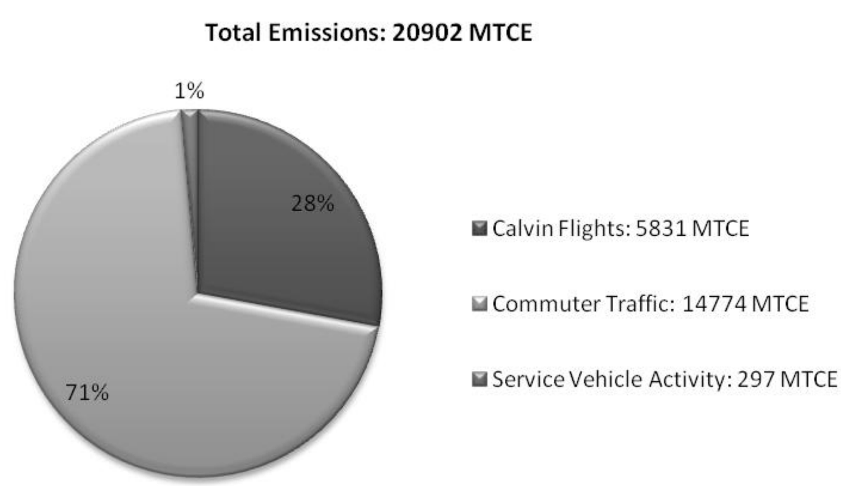


Figure F-1: Carbon Footprint

A summary of the various reduction options is listed below in Table F-1. Note that increasing parking costs both reduce carbon emission and provide money which can be used for other reduction options.

Table F-1: Carbon Reduction Options

	Carbon Reduction	Annual Cost	Annualized Ratio
	MTCE	$	$/MTCE
EV gift to a student each month	1.25	240,000.00	192,000.00
Campus Safety in Evs	0.96	80,000.00	83,333.33
Full Rapid Subsidation	207	77,500.00	374.65
Adding Lake Dr. Bike lane and path	14.93	2,138.90	143.31
Calvin owned bikes	3.14	305.56	97.18
Daily Parking Tolls	677.84	(83,089.44)	(122.58)
Increase permit fees	1355.67	(885,365.00)	(653.08)

The Student Senate Survey also showed positive student response to several of these carbon emissions reduction options. When asked which option would reduce incentive to drive, 37% of students surveyed chose free use of the Rapid and 25% chose bike lanes on Grand Rapids roads. Full details of the survey are located in Appendix F.11. However, to maximize reduction of carbon emissions, a combination of these options would be even better. Promotion of busing and biking joined with discouragement of driving offers two reasons instead of one for choosing the more environmentally friendly option. Lastly, educating students and faculty about how to use the Rapid and about environmental issues will further increase the success of these measures (25% of students surveyed said they did not use the Rapid because they were unsure of how to use it).

There are also non monetary benefits to these reduction options. Decreased commuter traffic means less maintenance on parking lots and provides more visitors' parking on campus which will be useful once the new Fieldhouse is completed. These measures will also make students more knowledgeable of public transportation, making them more likely to use it after they graduate, and environmental issues. The benefits far outweigh the costs.

Appendix F.1: Commuter Footprint

Introduction

These calculations were performed by the CCCN: Transportation group. The purpose of these calculations is to determine the amount of carbon emitted annually as a result of commutes to and from Calvin's campus annually.

Procedure – Data Collection

Number of Commutes

Data was collected near the end of September 2007. Five traffic hoses were used with permission from the Kent County Road Commission. These five hoses were first placed on the entrances and exits on the east side of campus during a week day and a weekend day. Data was collected for a 24 hour cycle during the week day and weekend day. This was repeated on the five entrances and exits on the west side of campus.

The traffic hoses are rubber hoses that are triggered by increases in air pressure sent to a data collection box. Whenever the traffic hose (which is stretched across the road) is ridden over, the air pressure increases and is processed as one vehicle by the data collection box. One hose is designated incoming traffic and a second is designated outgoing traffic. The pressure increase can also result from jumping on or biking over the hoses.

Distance of Commutes

Matt Jeltema compiled a list of distances from campus to the off campus addresses of every faculty-staff and off-campus student parking permit. Addresses were used to calculate lat-long coordinates for Calvin and home addresses on file. Straight-line distance was calculated between the coordinates. Batch coordinate and distance calculations were done using online tools at www.batchgeocode.com. Matt commented on the lack of reliability in the addresses provided for the parking permits as many of them are home addresses rather than local addresses.

Automobile emissions

Since every vehicle emits different amounts of carbon, a method for calculating the average carbon emitted is needed. For these calculations, the percentages of each type of vehicle driven for daily commutes are needed. To obtain this information, the vehicles parked on campus on October 9 were tallied. The numbers of hybrids, small cars, midsize cars, minivans, SUVs, trucks, and diesel vehicles were tabulated.

Procedure – Data Analysis

Number of Commutes

The data was downloaded by the Kent County Road Commission and simplified in an Excel document. The number of pressure increases is tabulated by time of day. There is a weekday and weekend table for every entrance/exit. A master table was created for both weekend and weekday data by adding the data from each entrance/exit together. Graphs of this data can be found in Figures 1 and 2 below. From the summed data, total weekday and weekend commutes were calculated assuming 196 weekdays and 78 weekend days during one academic year.

These calculations assume a 5% increase in traffic due to winter months. During the summer months, 10% of the typical traffic load is assumed.

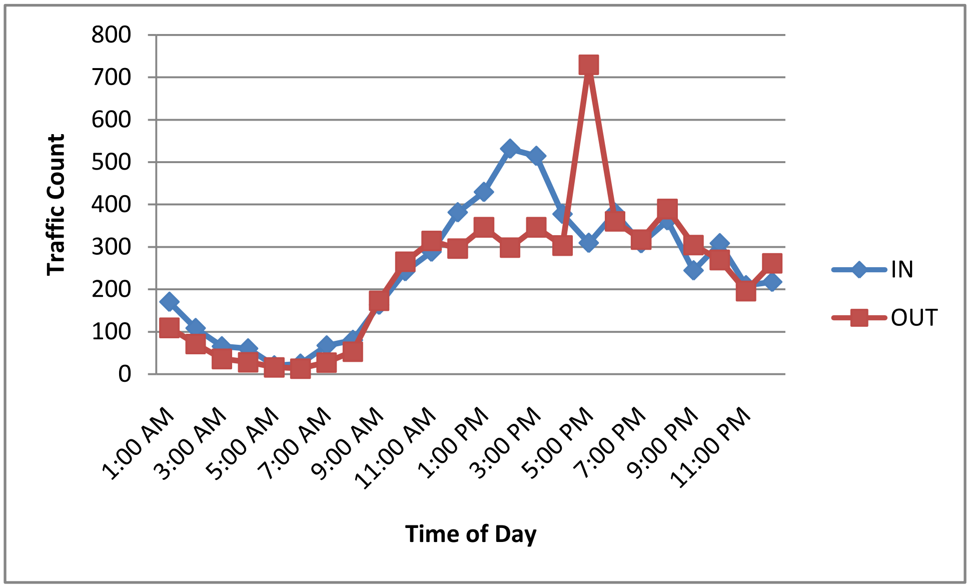


Figure F.1-1: Weekend traffic distribution.

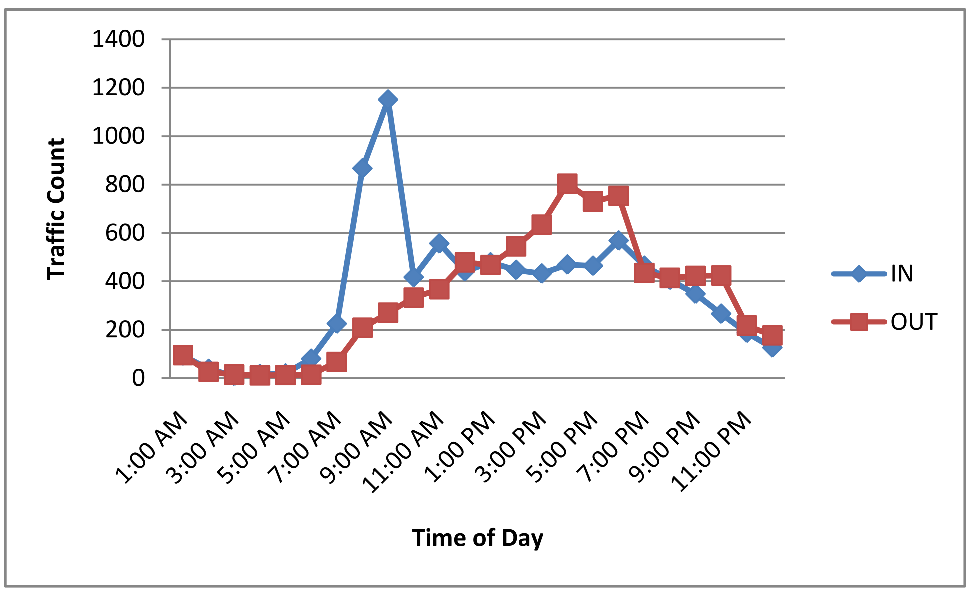


Figure F.1-2: Weekday traffic distribution.

Distance of Commutes

In an attempt to remove any non local addresses, all student commute distances greater than 26 miles and faculty-staff distances greater than 50 miles were thrown out of the sample population. The remaining distances were averaged and termed the average commute distance. Since routes to and from campus vary, a straight line distance was used as a conservative estimation.

Automobile emissions

The percents and average MPG of each vehicle were used to calculate the average gas consumption or diesel consumption per commute. This was used with the CO_2 emitted per gallon of gas or diesel to determine the CO_2 emissions per commute.

Annual CO_2 emitted

The CO_2 emitted per commute was multiplied by the annual number of commutes to determine the annual CO_2 emitted by commuting traffic.

Conclusions

During the course of one academic year, Calvin is responsible for 4.4 million commutes. These commutes result in 14,774 metric tons of CO_2 per year. These numbers have significant error resulting primarily from inaccurate commute distances and a conservative number of annual commutes.

It was also found that the average Calvin automobile operates at 22.39 miles per gallon.

Appendix F.2: Carbon Footprint due to Air Travel

Introduction

These calculations were performed by the CCCN: Transportation group. The purpose of these calculations is to determine the amount of carbon emitted annually as a result of airline traffic of Calvin related travels. These travels include business flights of faculty-staff, interim flights of students and faculty, and any other flight resulting from Calvin associated business.

Procedure – Data Collection

Carlson Wagonlit Travel provided us with the market flight miles purchased by Calvin from and to each combination of destinations during the 2006-2007 academic year. Terrapass.com provided us with the distance between airports and the pounds of CO_2 emitted for a single person on a one way flight between any combination of departure and arrival locations. The exact website was: http://www.terrapass.com/flight/flightcalc.html?submit.x=32&submit.y=2

Procedure – Data Analysis

The number of miles between locations purchased by the Calvin Market was tabulated and divided by the distance between airports. The resulting number was the number of flights purchased in the Calvin Market. This number was then multiplied by the CO_2 emissions of a single person flying to and from each destination. This provided the total pounds of CO_2 emitted on all flights to and from specific destinations. The sum of these numbers gives Calvin's total pounds of CO_2 emissions during the year. This number was then converted to metric tons of CO_2 emitted.

Not all divisions in the first step came out to whole numbers of flights, so there is a difference in the total miles flown between destinations in the Calvin Market and the flight distance according to terrapass.com. This will result in a small amount of error.

Conclusions

During the course of one academic year, Calvin is responsible for 5,800 metric tons of CO_2 emissions per year from airline travel.

Appendix F.3: Carbon Footprint from Service Vehicle Traffic

Introduction

These calculations were performed by the CCCN: Transportation group. The purpose of these calculations is to determine the amount of carbon emitted annually as a result of service vehicle traffic on Calvin's campus annually.

Procedure – Data Collection

According to Doug Kok of the Physical plant, all service vehicles are fueled by two on campus fuel tanks. It is estimated that 800 gallons of gas are used weekly and 250 gallons of diesel are used monthly.

Procedure – Data Analysis

The amount of fuels consumed was converted to a yearly basis. This was then multiplied by the CO_2 emitted per gallon of fuel to find the total annual carbon emissions by service vehicles. The fuel CO_2 emission rates are 19.4 lb/gal of gas and 22.2 lb/gal of diesel according to http://www.epa.gov/otaq/climate/420f05001.htm. The total emissions were then converted to metric tons.

Conclusions

During the course of one academic year, Calvin is responsible for 300 metric tons of CO_2 emissions per year from service vehicles.

Since the original numbers are weekly and monthly estimates, errors are multiplied when converted to annual figures. Since this is the only information the Physical Plant and Campus Safety record, this is the best estimate available.

Appendix F.4: Commuter Footprint Calculations

Commutes

academic weekdays per year:			195.75	days
academic weekend days per year:			78	days
weekday incoming:	8566	\	16486	commute sper day
weekday outgoing:	7920	/		
weekend incoming:	5856	\	11375	commute sper day
weekend outgoing:	5519	/		
total annual weekday commutes:			3227134.5	commutes
total annual weekend commutes:			887250	commutes
Total annual commutes:			4,428,106.32	commutes

assumes:
5% greater to account for the increase in traffic from October through April
10% of the total traffic continues through the summer months

Emissions

Total annual commutes:	4,428,106	commutes
average commute distance:	7.79	miles
CO2 emissions from Gas:	19.4	lb/gal
CO2 emissions from Diesel:	22.2	lb/gal
avg gas consumption per commute:	0.38	gal/commute
avg diesel consumption per commute:	0.24	gal/commute
CO2 emissions from Gas per commute:	7.36	lb/commute
CO2 emissions from Diesel per commute:	5.40	lb/commute
CO2 emissions per commute:	7.36	lb/commute
Total annual CO2 emissions:	14,774	metric tons

	MPG	# of vehicles	% of vehicles	gal per avg commute
Hybrids	55	8	0%	0.141631977
Small Cars	32.5	335	17%	0.239684885
Midsize Cars	23	1069	55%	0.338685164
Minivans	16	146	8%	0.486859923
SUVs	14	284	15%	0.55641134
Trucks	12	96	5%	0.649146563
Diesel Cars	32	1	0%	0.243429961
		1939	100%	

Appendix F.5: Emission Reductions through Parking Adjustments

Introduction

This memo summarizes the calculations performed to estimate the carbon emission reduction and associated costs of increasing parking permit fees and installing daily parking tolls to replace off-campus commuter student parking fees.

Calculations

From previous calculations, it is known that the 'average Calvin car' operates at 22.39 MPG and emits 19.4 lb of CO_2 per gallon. It is also known that Calvin is responsible for 5,812,065 commutes averaging 7.8 miles to or from campus annually. This information was used to calculate the carbon emission reductions for deterrents to commuting. These deterrents were increasing parking permit fees and using daily tolls for off-campus students. Increasing parking permit fees was estimated to reduce commutes by 10% while daily tolls reduced commutes by 15%. Addition information used was the quantities of parking permits (916 dorm, 1362 off-campus, 780 staff, 283 apartments) and the current cost of a parking permit ($35).

Results

Increasing parking permits to $300 per year will reduce emissions by 1356 metric tons per year and earn Calvin an additional $885,365. Arguments ought to be made for this additional revenue to be used for further emission reductions.

Using daily tolls for off-campus students on weekdays (with free parking on weekends) results in 2,050 metric tons of emission reductions at a cost of $4,400. A toll of 20 cents per day for each academic weekday would result in $39 worth of parking fees, roughly equivalent to the current parking permit fee.

Appendix F.6: Emission Reductions through Electric Vehicles

Objective

The goal of this analysis is to determine the how much CO_2 will not be emitted if campus safety switch from using petrol operated vehicles to Electric Vehicles (EV) and how long it will take for the electric vehicles to pay themselves. Also to be determined is the amount of CO_2 that will be reduced if Calvin College gives a student an EV every month.

Calculations

For this analysis, the purchase price of $20,000 for an EV is used and the number of campus safety vehicles is 4. The money saved by using an EV instead of a petrol operated vehicle is about $2190. The amount of CO_2 emitted per kWh is 0.966 kg/kWh, the cost of electricity per kWh is $0.07/kWh, and the amount of electricity an EV uses every year in dollars is $52.50 approximately. The monthly distance covered by all the campus safety vehicles combined is 1250 miles. One gallon of fuel is used to travel 35 miles and 19.4 pounds of CO_2 released to the atmosphere from every gallon of fuel.

For the calculations of the amount of CO_2 that will be reduced if Calvin gives a student an EV every month, the distance driven by a student every year is assumed to be 3000 miles and the yearly cost of electricity is $42.

Conclusions

If campus safety stop driving the petrol operated vehicles they have now and start using the electric vehicles, the amount of CO_2 emitted would be 0.96 metric tons less per year. It will take about 2 years and 3 months for the electric vehicles to pay themselves. In addition, 1.25 metric tons of CO_2 per year will not be emitted if Calvin gives an electric vehicle to a student every month.

Appendix F.7: Emission Reductions through Bike Path on Lake Drive

Background

It is currently very difficult for Calvin Students to exit the college via the lake drive entrance/exit by bike or by foot. There is no path leading to this drive on which one could bike, and the drive itself is a very busy one at many times during the day. Since Lake Drive is a commonly used route from Calvin to many other places in Grand Rapids including Gaslight Village and Eastown, it would be beneficial if it were friendlier to bikes. If a path were put in place joining the paths already existing around Calvin to Lake Drive, and the City were encouraged to add a bike lane to Lake Drive carbon emissions could be reduced by decreasing car traffic and increasing bike traffic.

Assumptions

The estimated cost of building a bike path for building a standard path similar to those already in place around Calvin is $75/meter. The path would span approximately 200 meters. Calvin would not be responsible for the cost of installing a path along Lake Drive itself, they need only petition the city of Grand Rapids to do so. Finally Calvin would pay for the installation of 3 streetlights along the path, and 3 on its property along lake drive to make the area safer for biking at night or in the evening. The street lights cost $1000 each for a total cost of $6000. In addition to these costs some money could be allocated for landscaping the area with native plants that would be both aesthetically pleasing and carbon sequestering. With these measures in place it is assumed that 25 people per week would bike instead of drive to Gaslight village or Eastown. This would correspond to 100 miles not driven by Calvin Students each week. The average car at Calvin gets 22.39 miles per gallon of gasoline. 19.4 lbs of carbon are emitted from each gallon of gasoline burned. These assumptions led to the information produced in tables 1 and 2.

Results

Table F.7-1: Project Costs

Cost of Path	$15,000.00
Cost of Street Lights	$6,000.00
Cost of Bike Lane	$-
Total	$21,000.00

Table F.7-2: Carbon Reductions

25	less trips
22.39	MPG
19.4	lb/gal
7.79	miles per avg commute
195	weekdays/year
14.93	**MTCE**

Adding a bike lane to Lake Drive would save 14.93 MTCE per year at a cost of a one time cost of $21000.

Appendix F.8: Emission Reductions through Rental Bicycles

Background

Calvin Owned bikes would enable students to check out a bike for free to make short trips to local off campus destinations such as D & W and Reeds Lake. This would help to reduce the carbon emissions by students traveling by bike and not by car. It would also help to instill a more environmental mindset into Calvin students. Fixed gear bikes were chosen because of the ease of maintenance and repair. In addition, these bikes would be used for relatively short commutes in which the use of a mountain bike or multiple gear bikes would not be necessary. Figure F.7-1 shows a picture of a fixed gear bike.

Figure F.7-1: Fixed Gear Bike

Assumptions

The cost of a fixed gear bike was found to be around three hundred dollars on www.rscycle.com. It was estimated that a good start-up number of bikes would be ten bikes. The reason is that students should be able to rely on always being able to rent a bike but groups of 4 or 5 students might choose to take a trip to D & W or Reeds Lake together. If the bikes are used more frequently more bikes could easily to purchase. In addition, ten bikes would easily be able to be stored in a dorm basement or on a bike rack. It was conservatively estimated that each of the bikes will make 2 trips of 5 miles that would have otherwise been traveled with a car over the course of the week. This leads to a total of 100 miles a week. With these assumptions the information in Table F.7-1 was computed.

Conclusions

The bikes would initially be either rented from Campus Safety or Student Development (located in the library). If the bikes get a lot of use the future plan would be to expand to have bike rentals in more locations around campus. The bikes would be checked out using student ID cards. Total emissions reduced are shown in Table F.7-1 below.

Table F.7-1: Total Emissions Reduced

cost of bike	300	dollars/bike
number of bikes	10	bikes
number of miles	100	miles/week
CO2 emissions	19.4	lbs/gallon
"average Calvin car"	22.39	miles/gallon
total emissions reduced	**1.25766**	metric tons/year

Appendix F.9: Emission Reductions through Subsidizing the Rapid

Objective

The objective is to determine costs and emission savings for fully subsidizing the Rapid.

Procedure

The first thing was to determine current ridership by Calvin students of the Rapid. The Rapid provided data showing monthly Calvin ridership during the past year. The current ridership of the Rapid is approximately 31000 rides per year (as provided by Nicholas Monoyios at the Rapid). For each of those rides Calvin currently pays $0.50 (information provided by William Corner, the Director of Campus Safety) and if multiplied by total rides the current amount Calvin pays was found to be $15,500. If Calvin was to fully subsidize the Rapid, $1.00 per ride would be paid by Calvin. Using an estimated percentage increase, total costs for subsidy are calculated. The difference between what Calvin pays now and what they would pay for full subsidy is the additional money that would be needed to cover full subsidy of the Rapid. To calculate the carbon offsets by subsidizing the Rapid, the average commute distance and emissions per commute were used. For details of the calculation of these numbers refer to (to be decided later). It is assumed that each new ride on the Rapid after subsidy is one less commute and thus less carbon emitted. Full calculations can be found in Appendix F.10

Results and Conclusions

Results from the Student Survey suggest a conservative estimate of a 355% increase. This increase would cost Calvin an additional $94,492 and reduce emissions by 264 MTCE. The cost per carbon reduction is $360/MTCE. This cost would decrease to a minimum of $300 as ridership further increased as shown in Figure F.9-1 below.

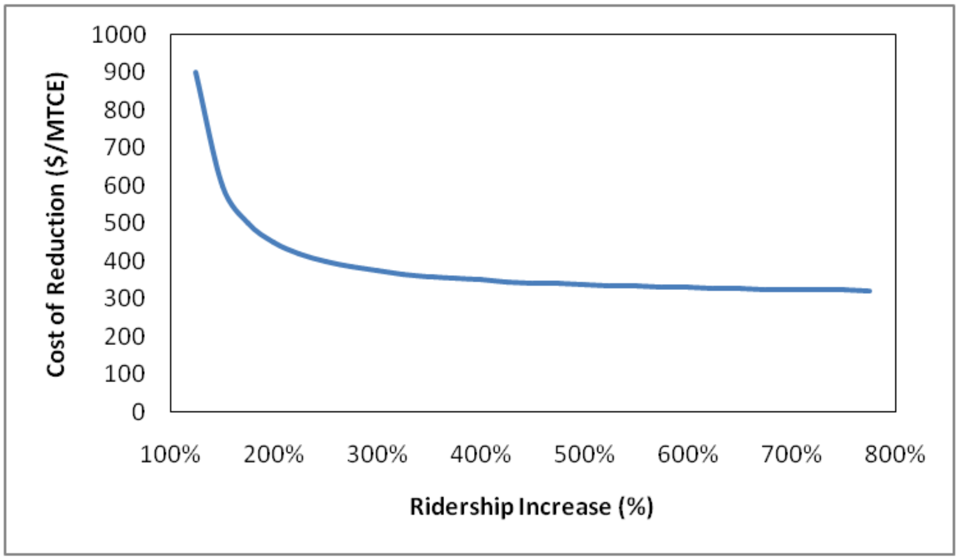


Figure F.9-1: Cost of Carbon Reduction as Ridership Increases

The costs and emission savings are shown in Table F.9-1 below.

Table F.9-1: Cost and Carbon Emissions Savings for Full Subsidy as Ridership Increases

Ridership Increase	Total Rides	Cost Increase	Carbon Saved	Cost/MTCE
%	-	$	MTCE	$/MTCE
100	31000	0	0	-
200	62000	46500	103	450
300	93000	77500	207	375
400	124000	108500	310	350
500	155000	139500	414	337
600	186000	170500	517	330
700	217000	201500	621	325
800	248000	232500	724	321

Fully subsidizing the Rapid is a low cost way to reduce carbon emissions at Calvin. Besides reducing emissions, it will make students more knowledgeable of public transportation and making them more likely to use it after they graduate. Also, with more people utilizing the Rapid, there will be fewer constraints on parking around Calvin. Finally, if ridership increases enough Calvin will be a major user of the Rapid and will be to influence routes and schedules. The benefits are well worth the cost.

Appendix F.10: Emissions Reductions by Subsidizing the Rapid - Calculations

Rapid Use						
Ridership Increase	355%					
Rapid Costs						
	Cost/Ride	**Rides/yr**	**Cost/yr**			
Present	$ 0.50	31000	$ 15,500			
Future	$ 1.00	109992	$ 109,992			
Difference	$ 0.50	78992	**$ 94,492**			

Total annual commutes saved:	78,992	commutes
average commute distance:	7.79	miles
CO2 emissions per commute:	7.36	lb/commute
Total annual CO2 emissions:	**264**	**metric tons**
Cost of CO2 emisssion reduction	**358.53**	$/metric ton

Student Senate Survey Results

Frequency of Use	Never	Seldom	Sometimes	Usually	Always	Totals
Rating (rides/month)	0	1	4	10	15	
Present	740	263	140	52	22	1673
Future	203	314	358	194	150	5936
Car Ridership	438	79	149	219	334	

Ridership Data - Provided by the Rapid

Month	Rides
Oct-06	3502
Nov-06	2871
Dec-06	1898
Jan-07	2957
Feb-07	2932
Mar-07	2958
Apr-07	2958
May-07	2601
Jun-07	2117
Jul-07	1730
Aug-07	1530
Sep-07	2820
Total	**30874**

Appendix F.11: Student Senate Survey Results

Sample size: 1219 Students (28% of student body)

How often do you use your car?		
(Not Answered)	2	0.16 %
Never	100	8.20 %
Seldom	79	6.48 %
Sometimes	149	12.22 %
Usually	219	17.97 %
Always	334	27.40 %
N/A	336	27.56 %
How often do you ride the Rapid?		
(Not Answered)	2	0.16 %
Never	712	58.41 %
Seldom	263	21.58 %
Sometimes	140	11.48 %
Usually	54	4.43 %
Always	22	1.80 %
N/A	26	2.13 %
How often would you ride the Rapid if it were free?		
(Not Answered)	1	0.08 %
Never	186	15.26 %
Seldom	314	25.76 %
Sometimes	358	29.37 %
Usually	194	15.91 %
Always	150	12.31 %
N/A	16	1.31 %
What inhibits your use of the Rapid? Select all that apply.		
(Not Answered)	133	5.94 %
It is too expensive ($.50)	165	7.37 %
The bus does not go where I need to go	414	18.50 %
The bus doesn't run at a convenient time for me	505	22.56 %
The bus takes too long	484	21.63 %
I don't understand how the bus system works	537	23.99 %
Which of the following would reduce your incentive to drive? Select all that apply.		
(Not Answered)	236	12.03 %
Free bus passes	721	36.77 %
More bike racks on campus	310	15.81 %
Bike lanes on Grand Rapids roads	487	24.83 %
Higher parking fees	207	10.56 %

Appendix G: Financing

Objective:

The Carbon Neutrality Project resulted in various plans to make Calvin College carbon neutral. The Finance group was responsible for selecting the most cost effective way of becoming carbon neutral, and determining how the funding to implement this plan would be obtained.

Method:

First, all of the data calculated by the various teams involved with the project was collected, and the most cost effective plans were examined. From the beginning the Finance team noticed that the Waste Management, Land Use, and Construction groups encompassed only a small portion of the total carbon emissions at Calvin College. Even though all of these areas were important, it was decided to focus on the two biggest carbon producers; Transportation and Energy Use. The best plans from each of these groups were examined and a cost effective method for becoming carbon neutral was chosen. Next, the amount of money needed for the college to be carbon neutral for a certain period of time was calculated. Finally, a plan was created for how the college would obtain the required funding.

Results:

The Energy Use group had formulated a plan to make their carbon emissions net zero through the installation of wind turbines and carbon offset purchasing for thirty five years. Because of this, the lifespan of this project was set at thirty five years. This plan required a large amount of upfront funding, but also generated a large amount of funding later on because Calvin would not have to purchase as much electricity. The next big concern was getting the Transportation group's carbon emissions to be net zero, however this was much more difficult. The one plan that the Transportation group suggested that was selected to be implemented was to raise the parking fees at Calvin. The Transportation group determined that this would discourage people from driving, thus emitting less carbon, while at the same time generating money that could be used to fund carbon neutrality projects. The Transportation group also proposed other plans to work towards carbon neutrality, however none were as cost effective as carbon offset purchasing. Even so, it was decided that these other projects would help to show the community that Calvin was taking action to move towards neutrality, and they should be implemented. Next the total costs of this project over its lifespan were calculated. The results of all of these calculations can be seen in Table 1.

Table 1. Project Costs

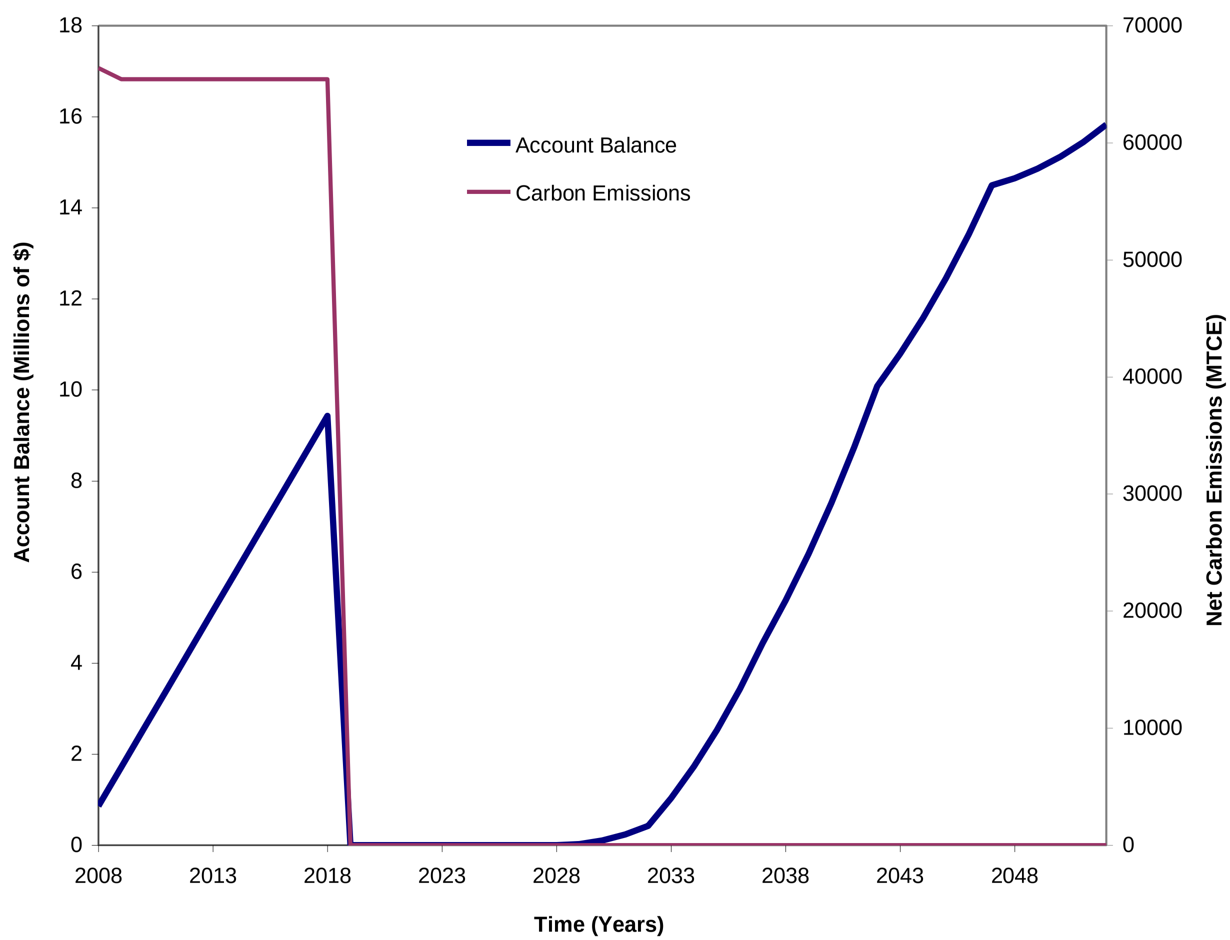
Total Cost of Energy Use Neutrality	$4,223,857
Total Cost of Transportation Offsets	$3,582,497
Total Present Value of Funding Required	$7,806,353
Minimum Annual Funding Required	$857,000
Annual Funding Requested	$1,050,000
Available Funding for "Community Image" Projects	$193,000
Total Saved Over Project Lifespan	$15,800,000

The annual funding required is the total amount of money that Calvin would need to save every year, if the parking tolls were increased to be carbon neutral in eleven years solely through wind turbines and large quantities of offsets. The annual funding requested is the amount of money the Finance group believes should be saved every year to fund projects that are not as cost effective, but show the community that Calvin cares. Examples of these would be fully subsidizing the Rapid, or buying Calvin owned bikes that the students could borrow. The funds required to implement this plan could be generated through a 1.16% ($250) tuition increase, government grants, or donations.

Appendix G.1 - Calculations

Year	Energy Group Funding Required
2008	$611,703.36
2009	$607,532.29
2010	$602,820.69
2011	$597,529.12
2012	$400,314.38
2013	$379,996.90
2014	$358,106.08
2015	$334,537.45
2016	$309,179.87
2017	$22,136.40
Total	$4,223,856.53

	Total Carbon		Cost	
	66400	MTCE/yr	$0.00	
-Energy	42352	MTCE/yr	$4,225,000.00	
Remainder	24048	MTCE/yr	$0.00	
-Transport	271	MTCE/yr	($83,000.00)	/yr
Remainder	23777	MTCE/yr	$0.00	
Need to buy	24000	MTCE/yr in Credits		
Cost Offset	$264,000.00	730400		
Total	$181,000.00	$466,400.00		
	$3,582,497	PV of carbon offsets 35yrs 4%		
Total PV	$7,806,353.33	Energy PV + Offset PV		
Future Value	$11,554,964.21	Future Values, 11yrs, 4%		
Annualized	$856,222.85	Annualized 11yrs 4%		
Total	$857,000.00	need to save this much per year for 11 years for		
Calvin Students	4200	Calvin to be carbon neutral for the following 35 years		
Tuition Increase	$250.00	So if Tuition goes up $250 per year, we are definitely good		
Current Tuition	$21,460.00			
Percent increase	1.16%	Percent Tuition went up		
Annual Funds Requested	$1,050,000.00			
Excess money	$193,000.00	This is how much extra is generated		
Total annual excess	$193,000.00	<--- Start math		
Annual Savings Required	$857,000.00			
Rapid subsidation	$94,492.00			
Remainder	$98,508.00			


Account Balance
Carbon Emissions
Account Balance (Millions of $)
Net Carbon Emissions (MTCE)
Time (Years)
0
2
4
6
8
10
12
14
16
18
0
10000
20000
30000
40000
50000
60000
70000
2008
2013
2018
2023
2028
2033
2038
2043
2048

Appendix H: Calvin College Carbon Neutrality Design Project

Fall 2007
BIOL354b and ENGR333a
Professors Warners and Heun

The May 2007 report by the UN's Intergovernmental Panel on Climate Change (IPCC, http://www.ipcc.ch/) noted that there was a 70% increase in Greenhouse Gas (GHG) emissions between 1970 and 2004. With projected increases in global economic activity, especially in China and India, curbing GHG emissions will become increasingly difficult over the coming decades.

The most common greenhouse gas is carbon dioxide (CO_2). Net CO_2 emissions (or CO_2 equivalent emissions) are becoming a proxy for the overall environmental impact of an individual or an organization. Net GHG emissions are calculated as GHGs generated less GHGs sequestered. (It is possible to sequester CO_2 by, for example, planting additional trees.) Sequestration may be accomplished by an organization itself or by purchasing emission credits associated with GHG emission reduction or sequestration projects external to the organization.

Resources exist to calculate the "carbon footprint" of an organization, i.e., the net CO_2 equivalent emissions (emissions less sequestration) during a year by that organization. (For example, see http://www.carbonfootprint.com/USA/calculator.html for a personal CO_2 emissions calculator.) An organization is said to be "carbon neutral" when its net CO_2 equivalent emissions are zero. Recently, over 70 presidents of US colleges and universities made a commitment to reduce greenhouse gas emissions (http://www.presidentsclimatecommitment.org/) by their institutions and approach "climate neutrality." Several colleges, including Middlebury College in Vermont, have studied options for achieving carbon neutrality on their campus. And, the National Wildlife Federation (NWF) has initiated a program to support campuses that commit to carbon neutrality goals. NWF "Campus Climate Champions" commit to reducing carbon emissions by 2% annually.

The question for you this semester is "*What would it take to make Calvin College carbon neutral?*" Your answer to this question should take the form of a comprehensive plan for Calvin College to achieve carbon neutrality. The plan must be appropriate for the mission of Calvin College (http://www.calvin.edu/about/mission.htm), its history, and its present context. Elements of your proposed plan should include:

- An inventory of Calvin's present rate of GHG emissions and sequestration potential
- A detailed list of steps to be taken by Calvin to achieve carbon neutrality
- A schedule showing a timeline for implementing the plan
- Detailed documentation showing that the proposed plan will provide carbon neutrality
- A realistic plan to finance any capital projects that appear in the plan
- A financial evaluation of the economic costs of implementing the plan

Your deliverables are:

(a) a final report that proposes a feasible plan for making Calvin College carbon neutral

(b) two posters to be presented at the Calvin Environmental Assessment Program (CEAP) conference on Thursday 29 November 2007, and
(c) a joint Biology/Engineering seminar on Wednesday 5 December 2007 in SB010 at 3:30 PM.

The customer for your report is Calvin's Vice-President for Finance, Henry DeVries.

The final written report should follow the technical memo format, including a two-page summary with conclusions. The Executive Council is responsible for the introductory two pages and planning for the final report. Each team must provide a detailed appendix (in technical memo format, of course) to the overall technical memo that describes the analyses performed and the contributions of the team.

Your final report will consist of:
(a) a paper copy of your final technical memo with extensive appendices,
(b) an electronic copy of your final report (.pdf format, one single file), and
(c) electronic copies of any programs or analysis tools that you developed during the project.

You must distribute copies of your final report to the VP for Finance, your supporting resources (see below), and the professors. You must also send a note of appreciation to your resources for their assistance during the semester.

To develop the required plan, you must first identify which areas you want to study this semester. These areas will be studied by 5 groups of 4–5 students each. Submit the list of study areas to Professor Heun by Wednesday 5 September 2007. The professors highly recommend that you organize the study areas following the outline of the Sustainability Statement recently adopted by Calvin College. So, for example, one group may be dedicated to researching CO_2 effects of Energy Purchasing and Use (item 4 in the Statement); another group may consider Transportation (item 7 in the Statement); etc. Note that item 9 (Campus Grounds and Land Use) is an area of opportunity for evaluating sequestration options.

After the study areas are defined, professors will select students to fill the groups for each study area. To apply for one of the available groups, prepare a cover letter and resume and deliver it to your professor by Friday 7 September 2007. Your cover letter should indicate the group in which you are interested and why you are qualified for that position. Groups will be announced in class on Tuesday 11 September 2007.

You may find it necessary to adjust the management structure as the semester progresses. Each group should select one individual to represent it on an Executive Council that provides coordination among the groups. All groups must arrange a tour of Calvin's existing physical plant facilities (including our co-gen plant) with Paul Pennock (see *Supporting Resources* below).

The first tasks for each group will be to (a) develop a schedule of your activities for the semester and (b) assess the contribution of your area to Calvin's current carbon footprint.

There will be three short, in-class progress reports in the form of oral presentations. There will be a longer in-class final presentation that summarizes the results of the Calvin College Carbon Neutrality project. Each student must give either (a) one of the progress report presentations or (b) part of the final presentation. The presentations must be professional quality, must concisely report your progress, and must provide sufficient technical detail for customer, professor, and peer review of your progress.

The in-class progress reports must include the following elements:

- Status relative to your schedule (and any re-planning that has occurred since your last report)
- Work accomplished since your last report (including technical details)
- Issues or concerns (and plan for addressing them)
- Work planned for upcoming reporting period

The final in-class oral report should provide the final technical details of your work, how your work was used in the final plan for your group, and the final conclusions for your group.

Bring printed copies of your in-class presentations for guests and the professors.

Although the customer for this report is the VP for Finance, your final grade will be assigned by the professors. Students will be graded on (a) the quality of their team's contribution to the overall effort of the classes and (b) peer evaluation. The professors, in conjunction with our external resource persons, will select an exemplary student for a teamwork award at the end of the semester.

Supporting Resources:

- Paul Pennock, Calvin Physical Plant: contact for physical plant tours and general physical plant information
  (616) 262-9230 (mobile)
  ppennock@calvin.edu (email)
- Henry DeVries, VP for Finance, hdevries@calvin.edu, 6-6148
- Chuck Holwerda, Electronics Shop, 6-6438
- Classroom learning on biology, exergy, economics, and thermal analysis
- Prior laboratory and lecture classes

Appendix I: Students Involved

Energy Use and Purchasing

Fred Thielke

Aaron Maat

Jordan Wanner

Robert Strodtman

Ben LoCascio

Land Use and Water and Wastewater Management

Eric Bratt

Dan Engel

Emilie Deschamps

Alysha Kett

Bill Tolsma

Solid Waste and Recycling

Joe Englin

Chris Lowell

Amanda Messer

Dan Michalowski

Construction and Renovation

Eu Sung Chung

Philip Baah-Sackey

Jessica Driesenga

Brian Medema

Matt Snyder

Transportation

Adebo Alao

Joshua Harbert

Peter Hiskes

Christina Overbeck

Dan VandenAkker

Appendix J: Statement on Sustainability

Environmental Stewardship Committee
Calvin College
DRAFT - WORKING DOCUMENT ONLY

Vision

As a confessional community in the Reformed tradition, Calvin College seeks to be caretakers of creation and agents of renewal for creation in our daily lives and as a collective community. The guiding principles in this document are evidence of our desire to live out our pledge of love and fidelity to Jesus Christ, who gave his life so the whole of creation could be reconciled to God. This document is offered in the spirit of encouragement and shalom, rather than legalism, in our desire to do God's work in God's world. In hope and expectation during this present time we avail our lives to God's faithful working out of the coming shalom.

Purpose

Our purpose is to infuse Calvin's vigorous liberal arts education with thoughtful, Biblically based practical guidelines that lay a foundation for living in a way that honors the Creator and his beloved creation. The Reformed tradition recognizes the important role of creation as God's general revelation of goodness and grace. We also recognize our responsibility to interpret, wisely use, and compassionately care for God's creation. In doing so, we take seriously the Biblical mandate to be stewards of God's good earth. Sustainable living is the daily working out of the stewardship mandate. We seek to live as part of the natural world in ways that mirror the care and love God has for the creation. To live in a sustainable fashion means our daily activities will be conducted in such a manner that they do not seriously jeopardize, but instead promote, the well being of other people, other species, and the ability of future generations of all creatures to flourish. This policy is intended to challenge ourselves to lead lives of increased meaning and purpose, lives that promote healing and reconciliation within creation. We consider this response to be a divine calling, the working out of which will bear fruits of love and hope in our groaning world.

Commitment

To advance sustainability principles in all aspects of our daily operations, an honest assessment of our current practices is necessary. Calvin College already exhibits a genuine commitment of stewardship in many areas of our community life. Yet, we also admit that progress can be made in many other areas. It is the objective of the Environmental Stewardship Committee that this statement will enhance our efforts, in all we say and do, wherever we may be, to further the Kingdom of God on earth.

Intent

This statement is intended to challenge all of us to lead lives of meaning and purpose, lives that promote healing and reconciliation among all elements of the creation. This statement challenges us to move forward and presents many examples and starting points for education and action. We recognize not everything can be done at once, and some of these guidelines will be altered and additional suggestions will be added. We also recognize that tensions may exist between some listed goals, yet we offer this document to assist us all to move closer to the coming shalom.

1. Teaching and Research

Calvin College rightly prides itself on the integration of its Reformed faith with the teaching and research that is conducted here. This integration as it pertains to stewardship is a hallmark of many classes. Yet we encourage principles of stewardship and sustainability to find expression across all disciplines at Calvin. We also encourage more research and scholarship to engage the theological and ethical framing of sustainability principles, as well as the practical working out of this commitment. Our vision is that all of our students, upon graduation, will be steeped in stewardship ethics and thereby motivated to lead lives that honor these principles.

• Develop a Biblical understanding of stewardship as it relates to sustainability activities both in our personal and institutional lives.
• Strengthen and prioritize environmental studies and research.
• Teach energy and environmental literacy to all students.
• Develop a connection to the environment, when people feel connected to and have knowledge about their environment, they will take better care of it.
• Expand opportunities for using the campus physical plant and business operations as a "learning lab" for students.
• Develop community and neighborhood energy and environmental education programs and participate in public dialogue on energy and environmental issues in the wider community.
• Increase opportunities for informal learning about environmental/sustainability issues for students, faculty, staff and public.

2. Purchasing and Administrative Services

Calvin College purchases building material products (such as lumbers, carpet, paint, plumbing, lighting and electrical products, etc), furniture, fixtures and equipment, cleaning and maintenance supplies (such as cleaning solutions, toilet paper, etc), and lawn and landscape products for approximate 400 acres of property and about 2 million square feet of interior space. We recognize that one of our primary methods for exercising our commitment to the environment and sustainability is through our purchasing choices. Through research and policy implementation it is our goal to make environmentally and fiscally responsible purchasing decisions that consider life cycle costs, long term implications and the potential harm to the environment.

• Promote environmentally – friendly product purchasing, i.e., make every effort to buy only products which are durable, reusable, recyclable, made of recycled materials, non-hazardous, energy efficient, sustainably harvested, produced in an environmentally sound manner, etc.
• Develop a practice of repairing/refurbishing durable products.
• Find effective ways to educate the College community about purchasing issues.

• Use the LEED - EB (Leadership in Energy and Environmental Design – Existing Buildings) rating tool to evaluate the sustainability of the operations and maintenance of existing facilities.

3. Solid Waste Reduction and Recycling

Calvin College has a wide ranging recycling program. Currently we recycle office paper, paperboard, corrugated cardboard, books, glass, metal and plastic food and beverage containers, electronic devices, lamps and ballasts, batteries, polystyrene, scrap metal, concrete, used oil and antifreeze. 2005 saw the beginning of efforts to compost organic waste generated from Grounds department activity. Additionally, the college handles and ships hazardous waste in a manner that meets State and Federal guidelines. A recent visit to several comparable institutions by our Grounds Department supervisor shows that we recycle a higher volume and wider variety of items than the other peer institutions. Calvin believes the effort to reduce waste and recycle is biblically based, yet many at Calvin choose not to recycle. With that in mind, we offer the following points to promote discussion and continue to improve the effectiveness of our recycling program.

• Establish a waste reduction ethic in all areas.
• Perform waste stream analysis to determine additional recycling potential.
• Examine ways to make recycling more convenient across campus.
• Enhance our recycling program for paper, cardboard, metal, glass, and plastic.
• Compost organic waste whenever possible.
• Enhance and increase the educational programs on recycling and re-using. Actively promote participation in recycling programs.
• Recycle hazardous waste-containing products, such as fluorescent lamps and ballasts, anti-freeze, solvents, batteries, computer monitors, and TV’s.
• Examine ways to minimize the waste that results from the distribution of College publications and mailings.
• Seek to recycle at least 50% of campus waste stream.
• Create energy databases that document energy use and promote energy conservation projects.

4. Energy Purchasing

Calvin College’s electrical and natural gas cost exceeds 3 million dollars annually. We recognize the importance of exploring and implementing well thought out and fiscally responsible measures to conserve energy in existing buildings, renovations, and new construction. We continually investigate new technologies for improved energy systems and more efficient use of energy resources. We have used renewable energy resources in the past and will continue to consider their use.

• Use energy efficiency measures to flatten campus load profile to lower electrical rates.
• Utilize Calvin's co-generation system to reduce energy use when fiscally possible.
• Buy green power – renewable energy as feasible.
• Monitor developments relative to alternative energy sources for the future.
• Create residential energy conservation programs with student leader.
• Promote linkage between energy conservation effort with programs to reduce carbon dioxide emissions and contributions to global warming.

5. Water and Wastewater

The college uses over 60 million gallons of potable water annually. We are committed to minimizing the consumption of water through new technology in water use fixtures, such as auto shut off faucets and waterless toilet systems. As with natural gas and electricity, we will continue to explore ways to conserve water in existing building, renovations, and new construction. We will maintain efforts to minimize and control water pollution, striving to protect the bodies of water that receive the wastewater and storm water generated by our facilities.

• Implement water conservation program to repair leaks and retrofit inefficient plumbing fixtures – investigate/install waterless urinals and auto shut off faucets.
• Create residential water conservation plans with Student Leaders.
• Distribute the cost of water usage annually and pursue the latest water conservation technologies.
• Protect ground water and storm run-off by minimizing use of salt for ice-melting.
• Use drought-resistant plantings and minimize irrigation.

6. Hazardous Materials

The college acknowledges the important of the safe management of ignitable, corrosive, reactive and toxic materials. We are committed to the protection of human health and the environment from the potential hazards of waste. We will explore ways to reduce the amount of hazardous materials generated and ensure that waste management is environmentally sound.

• Meet or exceed legal “haz mat” handling, collection, disposal, and tracking requirements
• Educate campus hazardous waste generators about minimization and proper disposal techniques.
• Investigate new concepts for reducing and reusing hazardous materials.
• Undertake toxic use reduction and pollution prevention planning.
• Develop a chemical tracking or inventory database.
• Implement a “chemical swapping” program.
• Switch to non/least toxic paint, solvents and cleaning agents.
• Switch print shop to environmentally friendly inks.
• Develop integrated pest management techniques to minimize or eliminate use of pesticides.
• Recycle and recover ozone-depleted CFCs.

7. Transportation

Calvin College is challenged to find ways to demonstrate our commitment to creation care in transportation choices while existing within a culture that so highly values personal automobile usage. With strong leadership from the student Environmental Stewardship Coalition, Calvin has generously subsidized public transportation for our students, faculty and staff. Modifications to our campus environment have been made to promote bicycle usage, and recent consideration of adjusting parking fees has also emerged from a commitment to exhibit more sustainable transportation practices. While these expressions provide a solid foundation, we look forward to additional creative solutions that will provide alternatives to the one-car, one-rider model.

• Encourage travel by carpooling, public transportation, bicycling, and walking.
i. Provide incentives for walking, biking, busing, and ride sharing
ii. Raise parking permit fees.
iii. Increase carpooling parking spots.
iv. Build bike shelters to encourage bike-riding
• Convert the on-campus services vehicle fleet to hybrid or alternative fuels, e.g., natural gas, electric, and biodiesel. Develop a green fleet goal. Maximize housing options on campus to encourage students living on campus and not driving to classes.

8. Food and Food Services

Calvin Food Service (CFS) strives to help its customers (students, faculty and staff) to understand, practice and promote sound environmental policies concerning the reduction of food waste and the promotion of recycling. As a result, CFS works to stay abreast of environmental issues and to implement environmentally responsible policies whenever fiscally and practically possible. To date, CFS has implemented intensive recycling programs for packaging materials to reduce waste. In partnership with the student Environmental Stewardship Coalition, CFS has supported the "CUPPS" mug program to reduce consumption of disposable beverage cups.

• Buy regional produce in season.
• Support local organic farms.
• Promote less meat consumption and eating "low on the food chain" for health and environmental reasons.
• Minimize the use of disposable dinnerware.
• Work more closely with food suppliers to reduce packaging waste.
• Implement a reusable mug program with discounted drinks at dining halls.
• Participate more actively in programs to contribute excess food to the homeless and needy.
• Investigate composting projects

9. Campus Grounds and Land Use

Calvin College has a beautiful campus. Our 400 acre campus boasts a wide variety of mature and healthy trees. Open spaces and athletic fields are well maintained and are an inviting place for recreation or leisure. The 90+ acre nature preserve provides the community with a striking display of natural beauty as well as a valuable tool for student learning. Other natural areas provide additional wildlife habitat. Landscaped areas provide variety and color, and soften the edges of buildings and parking lots. These elements combined give the campus a stable and welcoming atmosphere. The following points are intended to examine common trends in land use and promote discussion within the community about stewardly management of our outdoor environment.

• Promote discussion of campus beauty.

• Reduce lawn areas and grass cutting.
• Promote “natural succession” for unneeded lawn areas.
• Protect woodlands, wetlands, watershed, and wildlife.
• Implement a tree protection policy.
• Plant native species where possible.

10. Building Construction: New and Renovation

"The built environment has a profound impact on our natural environment, economy, health and productivity. In the United States, (construction of) buildings account for 36% of total energy use, 30% of greenhouse gas emissions, 30% of raw materials use, 30% of waste output (136 million tons annually), and 12% of potable water consumption" (U.S. Green Building Council, 2006). Both initial design/construction and life-cycle planning are important factors to develop sustainable solutions. At Calvin, the amount of construction suggests significant opportunities for improvement, as well as teaching opportunities for students and staff.

• Utilize sustainable or “green” design principles for all new construction and rehabs. Obtain at least a LEED (Leadership in Energy and Environmental Design) “Certified” status relative to Sustainable Site, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation and Design.
• Maximize longevity, remodel or retrofit wherever possible. Restoration, renovation, and adaptive re-use of buildings offer the greatest opportunity for conservation of energy – save the energy to produce, transport, construct, install, and dispose of materials. • Design state-of-the-art energy efficiency and exceed energy codes.
• Incorporate renewable energy technologies, including day-light and passive solar.
• Include suitable recycling collection space in building design programs.
• Specify environmentally-friendly building materials, products and practices (such as loosening compacted soil around construction sites for drainage).
• Evaluate options based on life cycle analysis.

11. Campus Site Planning

Calvin’s campus is a beautiful blend of park-like landscaping, wetlands, woodlands, and meadowlands. The placement of buildings, parking and pathways, and management of green areas contribute to individual enjoyment, as well as responsible environmental stewardship. The initial Knollcrest Campus design concepts spoke of an “Organic Architecture” approach to fit the “built environment” into the landscape; these sustainable principles add a new chapter to those guidelines.

• Develop campus master plans that minimize negative impacts and disruption of natural ecosystems and surroundings.
• Preserve and enhance green space.
• Protect natural areas from development.
• Concentrate buildings and arrange campus walkways and roads to minimize on campus driving and create a convenient pedestrian and bicycle campus, i.e., provide bicycle shelters.

• Use water-efficient indigenous plantings, where possible.
• Landscape for energy efficiency as well as aesthetics.
• Make underground systems easily accessible to avoid tearing up landscape

12. Investment Policies

The goal of socially conscious investing by individual shareholders is investment in companies that operate ethically, provide social benefits, and are sensitive to the environment. Because Calvin College currently invests in “funds of funds” rather than picking individual stocks, we have limited opportunities to exert shareholder influence on corporations. That notwithstanding, the college should not neglect opportunities to serve as an “agent of shalom” in evaluating investment options.

• Establish environmental criteria for financial investments.
• Use stockholder influence to encourage environmentally responsible business practices.

13. Outreach.

In many ways Calvin College is uniquely situated to bear evidence of Biblically-based stewardship values to the broader community. Our Ecosystem Preserve stands as a constant visible testimony of our commitment to care for the non-human members of the creation. Many environmentally focused service-learning activities occur outside the campus grounds, bearing further evidence of Calvin’s dedication to creation care. Several scholarly and research efforts provide additional means of expression to a broader population that stewardship is a core value of our faith. We encourage additional outreach activities that expand upon these efforts so that Calvin College becomes increasingly recognized for its love of God and of his beloved creation.

• Expand community service learning efforts to increasingly engage in creation careactivities.
• Forge new partnerships with local environmental groups.
• Work to connect environmental justice principles with social justice emphases.
• Promote off-campus programs to our students that focus on creation care.

Appendix

For something to be sustainable it must be able to continue on indefinitely.

“Sustainability could be defined as a process that reduces the long term impact on natural resources and the environment in a cost effective and socially acceptable manner” “Facility Asset Management , Sustainability and Higher Education”, by Jim Sebesta, APPA’s *Facilities Manager*, Vol. 21, No. 1 Jan/Feb 2005.

“Try to imagine a campus that consumes few natural resources, recycles all waste and abandons climatechanging fossil fuels and instead runs entirely on clean, renewable energy sources.” ‘What is Sustainability?” A reflection on Seven Generations and Beyond,” By Walter Sampson, CEM, LEED, AP, APPA’s *Facilities Manager*, Vol. 21, No.1, Jan/Feb 2005

“What if higher education were to take a leadership role, …would operate as a fully integrated community that models social and biological sustainability itself and in interdependence with local, regional, and global community. In many cases, we think of teaching, research, operations, and relations with local communities as separate activities: they are not. The process of education will emphasize active, experimental, inquiry-based learning and real-world problem solving on the campus and in the larger community, including government and industry. … A campus would "Practice what it preaches" and make sustainability an integral part of operations, planning, facility design, purchasing and investments, and tie these efforts to a formal curriculum."

"Because the University is a microcosm of the larger community, the manner in which it carries out its daily activities is an important demonstration of ways to achieve environmentally responsible living and to reinforce desired values and behaviors in the whole community. This would include an analysis of the full impact of the throughput of resources and energy at the university, the life cycle impact of all the operations and would embrace a strategy for developing indicators to measure the impact and process in making changes to move to the positive. This will necessarily lead to discussions of issues like energy and water consumptions, recycling, green buildings, transportation of people and goods to and from the campus sustainably preferable purchasing, etc. Transparency is important here. We need new indicators of movement towards sustainability and institutional success because we measure what we value and manage what we measure. As always, the role of faculty and students and connecting these efforts back to student learning, research, and action are critical" 'Integrating Sustainability in the Learning Community", by Anthony D.Cortese, Sc.D., APPA's *Facility Manager*, Vol. 21, No. 1, Jan/Feb 2005.

Resources used:

'Integrating Sustainability in the Learning Community", by Anthony D.Cortese, Sc.D., APPA's*Facility Manager*, Vol. 21, No. 1, Jan/Feb 2005
'What is Sustainability?" A reflection on Seven Generations and Beyond," By Walter Sampson,CEM, LEED, AP, APPA's *Facilities Manager*, Vol. 21, No.1, Jan/Feb 2005 Sustainability and
Higher Education," by James Sebesta, APPA's *Facilities Manager*, Vol. 21, No. 1, Jan/Feb 2005

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Appendix K: Professor Piers's Research