Macalester College Institutional Action Plan for Carbon Neutrality

Adapted by Justin Lee from the
Environmental Studies Senior Seminar 2009 Report

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Executive Summary

Introduction:

The Environmental Studies 2009 Senior Seminar in conjunction with the Sustainability Office created a roadmap for carbon neutrality by 2020. An institutional climate action plan is a requirement of the American College and University Presidents Climate Commitment (ACUPCC), which Macalester College President Brian Rosenberg signed in December, 2006. Carbon neutrality occurs when energy and resources are used in a way that does not increase the net amount of carbon dioxide or other greenhouse gases (GHG) in the atmosphere over time. In 2007-2008, Macalester College emitted an estimated 19,351 metric tons of $C0_2$ equivalents.

Target Dates:

We present two timelines for achieving carbon neutrality based upon different completion dates of 2020 or 2030. A survey of colleges and universities in the ACUPCC shows that 2020 is an ambitious goal. If Macalester were to adopt this goal, the college would emerge as a leader in combating climate change because few institutions are attempting to achieve carbon neutrality by 2020. The target date 2030 would position Macalester as a respectable institution but without noteworthy accomplishment in this area. We recommend committing to the 2020 target date.

Strategy and Projects:

We outline a three-part strategy for carbon neutrality that is designed to be as cost-effective as possible. This approach (outlined below) will not work well unless it is enacted as a comprehensive package.

1. *Invest in Energy Efficiency*
    - The potential cost savings from increasing energy efficiency on campus are significant; energy efficiency strategies should be implemented as soon as possible. The cost savings then need to be used to implement the following strategies, which will create a self-funding path to carbon neutrality. We are waiting for the final results of two large efficiency studies, but the preliminary data suggest that these projects can generate approximately $250,000 a year.

2. *Transition to Carbon-Neutral Fuel Sources*
    - Heating and electricity together comprised 66% of Macalester College's emissions in 2007-2008. Our electrical emissions benefit from the Minnesota Renewable Energy Standard that requires Xcel Energy to generate 30% of their power from renewable sources by 2020. We also have some limited opportunities to develop renewable sources on campus.
    - Macalester College can cost-effectively eliminate heating emissions by transitioning to burning biogas produced in Minnesota. The fuel switch saves significantly on capital costs because it does not require any infrastructure changes on campus. This is a final solution that we propose beginning in 2015 for a carbon neutrality date of 2020.

- Before transitioning to biogas, we recommend immediately phasing out fuel oil #6 to allow some efficiency upgrades to the central boilers, such as economizers and an O_2 trim system, to reduce our overall energy demand.

3. *Offset the Remaining Emissions*
    - Full implementation of energy efficiency and transition to biogas are estimated to reduce our total emissions 52% by 2020. The remaining emissions are from sources we cannot control such as commuting and air travel. These remaining sources will need to be negated by purchasing Renewable Energy Credits (RECs) or Certified Offsets.
    - We do not recommend purchasing offsets until 2020. Since offsets do not provide a financial return, it is wiser to invest first in projects that do provide a financial return and only then use offsets when absolutely necessary.
    - If Macalester paid to offset 48% of emissions today, the cost would be approximately $50,000 a year based on the pricing used for the IGC offsets.
- *Education Summary*
    - As part of the ACUPCC, Macalester College must incorporate sustainability into its curriculum.
    - Recommended immediate goals include expanding the definition of sustainability, compiling Departmental Resource Guides, establishing an interdepartmental concentration in sustainability, and conducting a follow-up survey.
    - Short-term goals include integrating sustainability into first year courses, offering grants for sustainable curriculum and course development, and including sustainability training for new and visiting faculty.
    - Recommended long-term goals include tenure reform, greater incentives for incorporating sustainability, and a sustainability requirement.

Immediate Implementation Recommendations:

We recommend implementing the following projects in the next three years:

2010

- Transition to 100% Natural Gas
- Implement the energy efficiency upgrades recommended by Cook & Associates
- Install Oxygen Trim on boilers
- Vending Misers

2011

- Implement residential energy efficiency upgrades

2012

- Replace remaining #6 Fuel Oil with BioHeat
- Install Economizer on boiler

Over the next three years, climate neutrality will require investments in energy efficiency. The following table shows the estimated capital investment and generated savings.

Year	Capital Required	Annual Savings Generated
2010	$345,000	$239,186
2011	$72,000	***$240,384***
2012	$60,000	$45,000

Figure 1: Summary of Capital Investments and Annual Savings Generated from Energy Efficiency Projects

Conclusion:

Carbon neutrality is necessary for an innovative institution such as Macalester College; it will be a valuable addition to the institution's vision and brand. Carbon neutrality is financially possible, even in a tough economic climate, if pursued as a comprehensive package. We recommend investing first in energy efficiency and capturing these savings to finance the rest of the process in a sustainable, self-funding manner. If Macalester College becomes carbon neutral by 2020, it will benefit from energy savings and recognition amongst peer institutions. The project also has opportunities for hands-on experiences that will further enhance the education Macalester College is able to provide to its students.

Abbreviations

ACUPPC – American College and University Presidents Climate Commitment
B3 - Minnesota Buildings, Benchmarks, and Beyond guidelines
CA/CP – Clean Air/Cool Planet
GHG – Greenhouse Gas
HVAC – Heating, Ventilating, and Air Conditioning
LEED – Leadership in Energy and Environmental Design standards, developed by the U.S. Green Building Council
MacCARES – Macalester Conservation and Renewable Energy Society
MPIRG – Minnesota Public Interest Research Group
0_2 Trim System - Oxygen Control Trim system
RFP - Request for Proposal

INTRODUCTION

In 2007 Macalester College President Brian Rosenberg signed the American College and University President Climate Commitment (ACUPCC), which commits Macalester College to becoming climate neutral and incorporate climate and sustainability into its curriculum. The College is required to audit its greenhouse gas emissions annually and provide institutional structures to ensure eventual carbon neutrality. In addition, Macalester must implement three immediate actions to reduce emissions and develop a plan with specific targets and timetables (macalester.edu/sustainability).

The 2009 Environmental Studies Senior Seminar developed this report to recommend a strategic plan for creating a carbon neutral Macalester College. This report uses data obtained thanks to the work of the 2008 Environmental Studies Senior Seminar and Sustainability Associate Justin Lee. The 2008 Senior Seminar calculated Macalester College's first greenhouse gas emissions report for the years 1990-2006. Sustainability Associate Justin Lee updated the emissions report for 2007 with the Clean Air/Cool Planet (CA/CP) calculator[1]. This report, completed by the 2009 Environmental Studies Senior Seminar, explains the baseline campus emissions, which were calculated by the 2008 Environmental Studies Senior Seminar in collaboration with Facilities Services and the Sustainability Office. In addition, we develop specific mitigation strategies and implementation timelines to reduce Macalester's emissions. The strategies are divided into overarching categories, with explanations of current energy systems, an outline of all options researched, and a specified order of prioritization. Additional information about assumptions, calculations, and detailed explanations can be found in the Appendices.

[1] The Clean Air/Cool Planet calculator is available at: http://www.cleanair-coolplanet.org/

Campus Emissions: 2007-2008 Greenhouse Gas Emissions Audit

In the fiscal year 2007-08, Macalester College emitted 19,351 metric tons of carbon dioxide equivalents. These emissions predominantly come from heating, electricity, and air travel. This is an 11% reduction from the 21,675 eCO_2 emissions in 2006-07.[2]

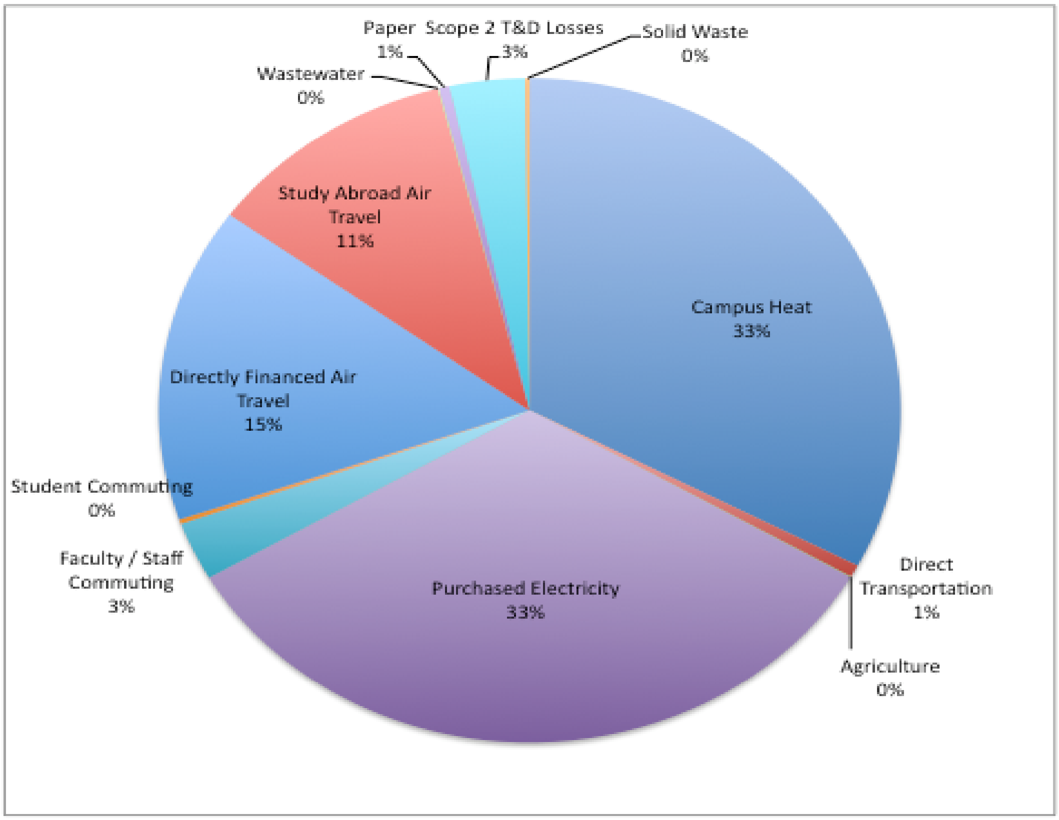

Figure 2 Macalester College GHG Emissions per Sector for 2007/08.

Purchased Electricity: 6,482 MT eCO_2 (33% of overall emissions)
In 2007/08 electricity was the single largest source of emissions. This section includes all electricity purchased by the college, including the electricity that runs the main campus chiller plant and air conditioning in the auxiliary buildings. Macalester College purchases electricity from the local utility Xcel Energy. There is a small wind turbine on campus, but on average it produces less than 0.01% of total campus energy consumption.

Campus Heat: 6,386 MT eCO_2 (33% of overall emissions)
This includes all of the fuel used to heat Macalester Campus throughout the year. Macalester has a central heating plant that, depending on price and availability, burns

[2] **Please Note:** The reduction in energy is in large part due to increased accuracy in data collection and does not represent an actual decline. The 21,675 MT eCO_2 is different than the results reported by the 2008 ES Senior Seminar because the electricity custom fuel mix changes being applied retroactively. For more details, please see the full 2007-2008 Macalester College GHG Emissions Inventory at http://www.macalester.edu/sustainability.

natural gas, fuel oil #2, or fuel oil #6. This also includes all of the natural gas used to heat the auxiliary buildings that are not connected to the central plant.

Directly Financed Air Travel: 2,993 MT eCO_2 (15% of overall emissions)
There are two separate air travel categories in the CA/CP calculator. This section includes all air travel directly paid for by Macalester for all students, faculty, and staff.

Study Abroad Air Travel: 2,144 MT eCO_2 (11% of overall emissions)
This section calculates the impact of Macalester students traveling abroad for study away programs. While the College does not directly pay for these tickets, the travel is considered integral to the educational experience, and the emissions are thus included in campus calculations.

Scope 2 T&D Losses: 641 MT eCO_2 (3% of overall emissions)
Transmission & Distribution Losses is the energy that is wasted by the long distance transport of electricity. This is the first year that this has been calculated separately from the Purchased Electricity category.

Faculty / Staff Commuting: 555 MT eCO_2 (3% of overall emissions)
This is an estimated calculation of the fuel used by faculty and staff commuting to and from work and on work-related local travel throughout the year.

Direct Transportation: 116 MT eCO_2 (3% of overall emissions)
Direct Transportation is a measure of the emissions of all campus-owned vehicles or non-airplane travel directly paid for by the school. This covers emissions from Facilities Services vehicles, the van fleet, buses for field trips or sports teams, etc.

Paper: 87 MT eCO_2 (<1% of overall emissions)
This section tracks the emissions from paper consumption. This is the first year that paper use has been tracked for the GHG emissions audit.

Student Commuting: 44 MT eCO_2 (<1% of overall emissions)
This includes all Macalester student transportation to and from their off-campus residences during the academic year.

Wastewater: 11 MT eCO_2 (<1% of overall emissions)
This section includes only potable water flushed into the sewage system and does not account for irrigation water or stormwater impacts. The majority of these emissions come from the treatment and incineration of Macalester-produced sewage.

Agriculture: 8 MT eCO_2 (<1% of overall emissions)
The only source of agriculture emissions is fertilizer application on campus lawns.

Solid Waste: 38.6 MT eCO_2
The majority of Macalester's waste is placed in a landfill where methane is captured and burned to produce electricity.

FUTURE EMISSIONS TRAJECTORIES

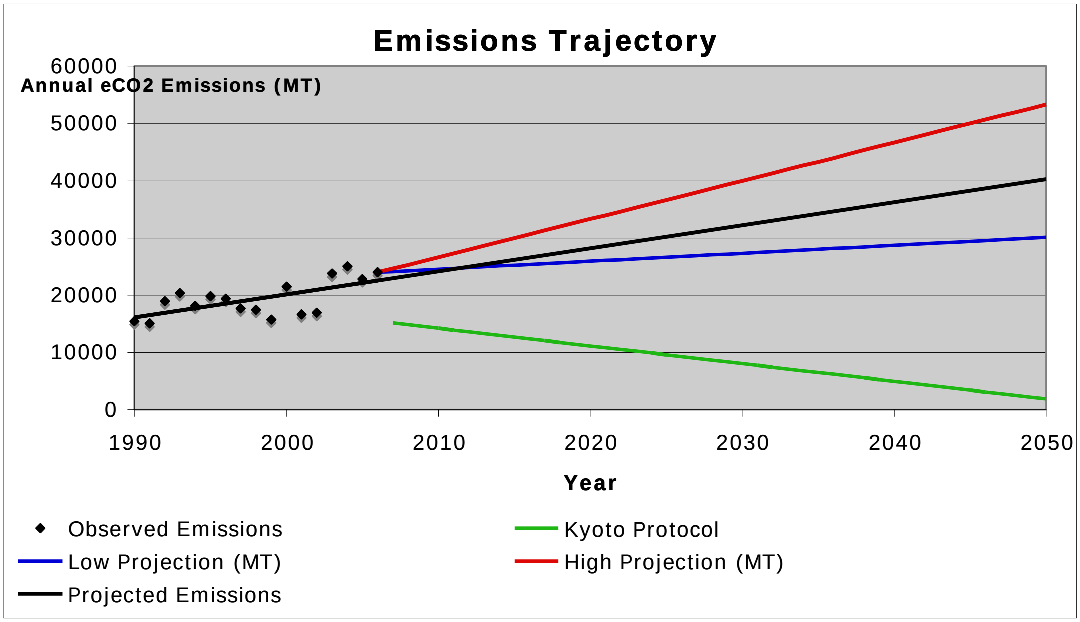

Figure 3 Macalester College Emissions Trajectory

Emissions for the past 19 years have shown an average annual increase of approximately 340 metric tons. This data is projected from observed emissions from 1990 to 2008. To account for uncertainty surrounding this estimate, we show high and low estimates for the trajectory. We can compare these trajectories to the Kyoto Protocol scenario in which we would need to reduce emission to be in line with an annual 2% reduction below 1990 levels. This trajectory would take us below 2,000 metric tons of eCO2 by 2050.

Target Date:

We propose 2020 as the earliest potential target date for carbon neutrality at Macalester College. This target date requires an ambitious action plan and investments in energy efficiency during the next 1-2 years. Projects with high capital costs can be delayed until energy savings from the initial efficiency projects have accrued and can be used for financing. It is possible for Macalester to become carbon neutral by 2020. Achieving this goal would position Macalester as a leader amongst institutions of higher education.

A target date of 2030, on the other hand, would be easier because it allows more time for logistical and planning decisions. The choice between the two target dates represents a tradeoff between strengthening Macalester's leadership reputation and minimizing up-front capital costs in a difficult economic environment.

2020 Action Timeline

The following section outlines possible strategies to reduce carbon emissions for each of the major emission sectors in the 2007-2008 audit. Because most of these strategies are specific actions, we will refer to them as projects. In addition to descriptions of each project, we have calculated the projects' potential costs and carbon emission reductions. No single project or handful of projects will allow Macalester College to become carbon neutral; in order to achieve its goal, the college needs to implement an array of strategies. Nevertheless it is important to acknowledge that some projects, similar to picking low-hanging fruit, are easier to accomplish or represent a more balanced tradeoff between upfront costs and carbon reductions.

We have developed two types of plans for achieving carbon neutrality by 2020 or 2030. The first scenario assumes that all projects can be funded and implemented beginning in the 2009-2010 academic year. If so implemented, the projects would negate 54% of current emissions, and offsets would be used to account for the remaining 46%. The second scenario reflects this time frame and shows that listed projects could account for 53% of the reduction, while offsets would cover the last 47%.

The pages that follow are the final analyses of emissions reductions and costs, as calculated using the Clean-Air Cool Planet Campus Carbon Calculator.

Immediate Projects

Immediate projects are ones that have a favorable balance between estimated costs and carbon reductions. These projects should be implemented immediately because of quick payback or little upfront cost in both the 2020 and 2030 carbon neutrality scenario.[3] Measurements of cost-effectiveness are divided into Internal Rate of Return (over 100%), Net Present Value (>$1,000,000), and Discounted Payback Time (<5 years)[4]. Note that some projects fall into more than one category.

Project	**Category and Estimated Benefit**		
	High Internal Rate of Return	High NPV	Low Discounted Payback Time
Energy Efficiency Coordinator Position	22,972%	$1,923,802	---
Vending Misers	195%	---	.53 years
Sub meter Installation	146%	$1,507,668	.70 years
Fluorescent Bulb Upgrade	133%	---	.77 years
Ed Cook’s Recommendations	---	$3,365,157	1.29 years
O_2 Trim	---	---	1.04 years

Figure 4 Immediate Projects Organized by Measurements of Cost-effectiveness.

Greatest Carbon Reduction Projects

Projects with the greatest amount of carbon reduction could collectively account for 46% of Macalester’s overall reductions. These projects should be prioritized because of their

[3] Numbers listed in dollars and percentages are taken from the 2030 scenario, since this is the recommended scenario for carbon neutrality. Numbers for the 2020 scenario are similar, but can be referenced in the executive summary calculator output sheet.
[4] Only applied to projects with a capital cost.

disproportionate influence on overall emissions. The top five projects for emissions reduction, not including the bulk of offsets[5], are listed below.

Project	Energy Reduction (%)
Shift to Biogas	36.8 (On-Campus Energy Generation)
O_2 Trim	3.3
Energy Efficiency Coordinator Position	2.8
Ed Cook's Recommendations	2.8
Roof Solar	2.7

Table 5 The Top 5 Carbon Reducing Projects (by Percent Energy Reduction)

The best carbon-reducing projects also have some of the lowest NPV, meaning that they may not be cost-effective by themselves. Some of the projects with the largest emissions reductions have longer payback periods and lower NPV (See Figure 1). In order for carbon neutrality to be a cost-effective proposal for Macalester, the entire suite of projects and strategies must be enacted as a package.

Order of implementation is also important. Some projects are designed as short-term solutions that are to be implemented immediately while broader, better solutions are developed. The shift to natural gas, for example, will immediately help reduce carbon emission until a shift to biogas is feasible.

A carbon neutrality plan prioritizes cost and carbon reduction, but there are important criteria that should also be emphasized. Projects with any combination of the following characteristics should be secondary priorities to cost effectiveness and carbon reductions: beneficial social and environmental effects, the possibility for student and faculty educational involvement, potential for community outreach, synergistic properties with other projects, opportunity for future improvements, and the potential to scale up. The comprehensive list that follows includes projects that have one or more of these characteristics.

On-Campus Energy Generation

Current Systems and Strategies

The majority of Macalester's heating demand and a portion of its hot water needs are met by a centralized high-pressure closed-loop steam plant underneath the Janet Wallace Fine Arts Center. The system provides heat and hot water to 26 campus buildings and 11 privately and college-owned residences from September-May while small water heaters across campus supply hot water during the summer when the central plant is off. The main system maintains the buildings at an average 68^{o} F.

The main system burns natural gas and #6 fuel oil. The type of fuel used (natural gas or fuel oil) varies based on heating needs and the relative prices per Btu of different fuels. Macalester also has an interruptible service contract with the local gas utility Xcel Energy that allows Xcel to cut off the natural gas supply during peak winter demand up to a total of 15 days a year. The arrangement of an interruptible source of natural gas requires Macalester to maintain a steady supply of fuel oil. Macalester does, however, benefit from the contract because it grants us a year-round discounted natural gas rate.

There are two sources of renewable energy on-campus. The first is a small wind turbine

[5] Numbers listed in dollars and percentages are taken from the 2030 scenario, since this is the recommended scenario for carbon neutrality. Numbers for the 2020 scenario are similar, but can be referenced in the executive summary calculator output sheet.

near Olin Rice Hall that produces approximately 1300 kWh annually, which amounts to less than 1% of total campus consumption (2008 Inventory). In addition, the EcoHouse has a solar hot water system that reduces the need for gas powered hot water. An educational photovoltaic array is on the roof of the Olin Rice Science Center.

Future Strategies for Carbon Neutral Heating

We recommend a three-part plan to reduce our heating emissions close to zero. Please note that this does not include efficiency gains from infrastructure upgrades; those are examined later in this report. As part of the fuel plan, we recommend first that Macalester College commits to burning 100% natural gas. Secondly, when it becomes necessary to use fuel oil in accordance with Macalester's interruptible gas service, we recommend using bioheat instead of #6 fuel oil. The first two parts of the plan are temporary measures that will reduce emissions until Macalester is able to secure a long-term alternate source of fuel. Finally, as a long-term solution, we recommend that Macalester enter a biogas contract in order to make a permanent switch to biogas. Since biogas does not contain fossil carbon, it is a carbon neutral heating option. Each of these strategies is explained in greater detail below.

Commit to 100% Natural Gas

Since natural gas burns significantly cleaner than #6 fuel oil[6], the switch to biogas would decrease emissions by 1-5% annually. Natural gas is currently assumed to be more expensive than #6 fuel oil, but price projections indicate that it will be cheaper in the near future. Our predictions show that switching to natural gas will attain an average discounted annual cash flow of approximately $12,500. Since natural gas is already used in the boilers on-campus, there is no infrastructure cost to make this switch. In fact, because natural gas also has fewer soot by-products, using it reduces maintenance costs and machine wear. In addition, reducing the use of fuel oil will allow Facilities Services to invest in projects that will increase the overall efficiency of the boilers in the central plant. We are currently unable to implement these efficiency changes because #6 fuel oil is too dirty of a fuel to allow them (please see the energy efficiency section for more details).The switch to biogas is an easy and profitable project for the college; we recommend that Macalester switch to 100% natural gas in the 2009-2010 academic year.

Use Bioheat as Alternative Heating Fuel

This strategy is only intended to replace #6 fuel oil as the alternative fuel that Macalester needs to maintain on campus because of the interruptible natural gas contract with Xcel Energy. The use of bioheat as an alternative fuel should begin at the same time as the switch to natural gas. Bioheat is a blend of #2, # 6 or ultra low sulfur heating oil and biodiesel – usually made from soybean oil. In comparison to #6 fuel oil, bioheat reduces carbon emissions as well as emissions of particulate matter, carbon monoxide, and hydrocarbons. The ratio of biodiesel to heating oil varies, and for Macalester we recommend a B20 blend that is 20% biodiesel and 80% #2 fuel oil. The use of a B20 blend could reduce carbon dioxide emissions by 16%, nitrogen oxides by 6%, and carbon monoxide by 9%[7]. Bioheat B20 is cost comparable to #2 fuel oil, which is currently more expensive than #6 fuel oil. In Minnesota demand for B20 fuel oil is rising, which could result in an increased supply in the future. In the long run, we project that prices for B20 are likely to fall while fossil fuel prices are likely to rise. Even though the Macalester's current heating oil vendors do not supply biodiesel, there are several suppliers in Minnesota with which Macalester could arrange a contract.

[6] EIA
[7] Harvard Green Campus Initiative

Biogas

Biogas is a mixture of gases produced by the anaerobic digestion (decomposition without oxygen) of organic matter. Because biogas is composed primarily of methane, which is also the main component of fossil fuel-derived natural gas, it has a similar energy content per unit volume. Biogas is considered a renewable fuel under international greenhouse gas accounting methods developed by the Intergovernmental Panel on Climate Change. The biogenic carbon contained in biogas is part of the natural carbon balance and does not increase atmospheric concentrations of carbon dioxide. Additionally, biogas production uses organic waste that would otherwise end up in landfills where it would decompose and release methane to the atmosphere. Methane should be considered seriously because it has 21 times the global warming potential (GWP) of carbon dioxide. Transitioning to biogas would reduce GHG emissions by preventing methane produced from waste decomposition in landfills from entering the atmosphere.[8]

The final step in eliminating Macalester's heating emissions is to switch to using 100% biogas. We do not recommend this as an immediate project because of the difficulties of locating and developing a relationship with a biogas producer who has sufficient supply to meet Macalester's year-round heating needs. In order to provide time to arrange the logistics, the permanent switch to biogas should occur by 2015. Total reductions would be 100% of heating emissions or approximately 35% of total emissions. In accordance with the interruptible service contract with Xcel, Macalester would likely have to retain a store of Bioheat because the biogas would be produced by a rural organization and then shipped through Xcel Energy's natural gas pipelines to the college.

Although biogas would be slightly more expensive than natural gas, it would provide the most dramatic decrease in emissions of all of the proposed projects. We recommend that the College submit a formal Request for Proposal (RFP) for a biogas supply contract. It would likely be most feasible for Macalester to initially contract with a rural biogas producer while continuing to investigate the available collaborative possibilities with a local digester facility[9].

Co-generation

Installing a co-generation plant was considered and dismissed as infeasible for Macalester College at this time (see On-Site 4 for details).

Biomass

A biomass facility on campus was also rejected due to high capital costs, storage, and preliminary concerns about future fuel availability and pricing.

Electricity Projects

Markim Hall Photovoltaic Array

Markim Hall, the newly constructed LEED Platinum building, was designed with a 22Kw photovoltaic PV roof system. This system would produce about 29,000 kWh and prevent 0.05% of total emissions. It would save money by reducing Macalester's peak electrical load by 18 kWh. Based on electrical savings ranges from15-25 years, the project would cost $120,000 after income and state tax benefits. Because tax credits do not apply to Macalester (due to its status as

[8] See Appendix On-Site 2 for additional information about assumptions concerning source material and associated emissions.

[9] See Appendix On-Site 2 for more details.

a tax exempt organization), it is important to collaborate with a for-profit entity that could realize the tax benefits. In addition to producing energy on-site, solar photovoltaic is a powerful and visible symbol. For this reason, it should prove easier to raise funds for photovoltaics than for a less charismatic project. A photovoltaic installation on Markim Hall would also serve as a pilot project to help Facilities Services personnel to understand the costs and logistics of maintaining such a system. It would also help us evaluate the costs and benefits of proceeding with solar on other parts of campus.

Rooftop Photovoltaic Arrays across Campus

This large project would involve using the available flat roof space on the large central buildings on campus to put up solar panels similar to those proposed for the IGC. If 50 year panels were installed in 2020, they would reduce 2,655,079 kWh per year or 2.85% of total emissions. This amounts to 454 MT $eCO_{2.}$ A detailed analysis will be necessary to determine all possible effective locations. The expertise of building engineers will be necessary to determine mounting and load-bearing requirements.

Parking Lot Solar

This longer term project, set for 2030, would involve setting up photovoltaic awnings over portions of Macalester's parking lot space. Structural costs would be higher than roof arrays because awnings need to be installed. Overall this project will reduce carbon emissions 1.82% or 290.5 MT $eCO_{2.}$

Fleet Projects

Biodiesel Campus Fleet

Macalester currently has six rental vans that operate on 2-year contracts. We recommend that the college change the 2011-2012 contract from gasoline to diesel vans. The EIA estimates that diesel vans are between 20- 40% more efficient than gasoline vans. Switching to diesel vans would reduce our fleet emissions by approximately 15%. In addition we would have the option of using biodiesel blends such as B20, which would reduce emissions by a further 20%[10]. *The switch to a diesel fleet results in a 1.5% reduction in overall emissions.* The greater efficiency would generate savings, offsetting the higher cost of diesel vans. We predict an average discounted annual cash flow of approximately $22,000. In light of the cost savings and carbon reductions, we recommend that Macalester transition from gasoline rental vans to diesel vans when the next contract expires.

Time	Project
Immediate (1-5 years)	Switching from #6 Fuel Oil to Natural Gas, Switching from #6 Fuel Oil to Biodiesel (100%), Solar Electric on the IGC
Medium (5-10 years)	Biogas for heating (rural source), Hybrid fleet
Long-term (10+ years)	Biogas for heating (local source), Electricity from roof solar across campus

Table 6 Timeline of Fuel Use Transitions On Campus

[10] EIA

Summary of Fuel Transition Recommendations

Heating:

- Replace #6 fuel oil with natural gas - effective immediately.
- Replace #6 fuel oil with a B20 blend of biodiesel (20% biodiesel, 80% #2 fuel oil) - by 2012.
- Replace natural gas with biogas from a rural producer - by 2015.
- Look to collaborate on supply of biogas from a local digester - by 2020.

Electricity:

- Install solar panels on the IGC

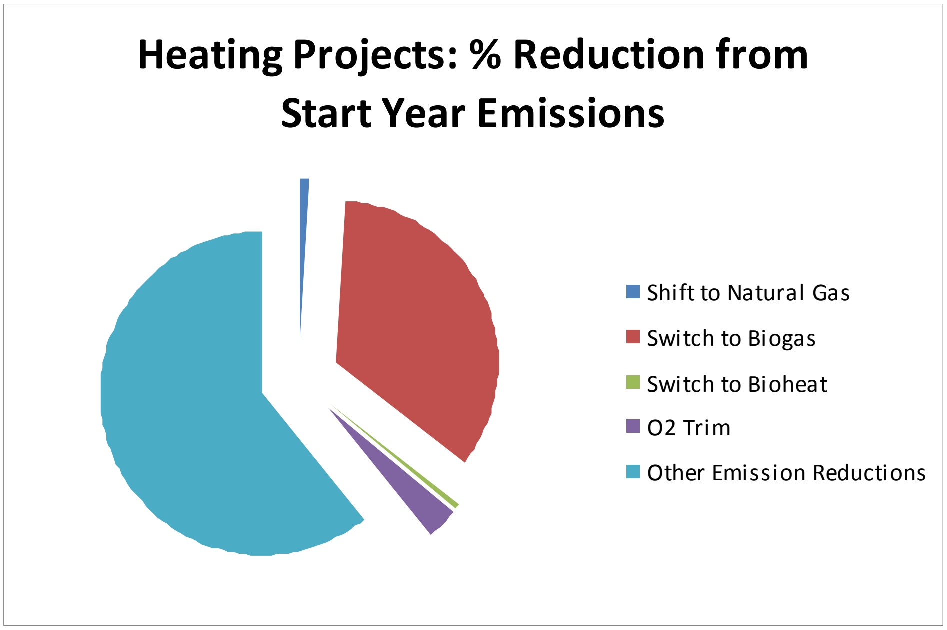

Table 7 Percentage Reduction (from Start year Emissions) of Heating Projects

Energy Efficiency

There are two types of energy efficiency – infrastructure upgrades that are less energy intensive and behavior changes that reduce the overall demand for energy. The most cost effective energy is that which we do not use. Energy efficiency is an excellent investment for Macalester that continues to pay returns for years. In the following section, we recommend several specific investments Macalester College should make in buildings and the central heating plant to save energy as well as several strategies to encourage more efficient behaviors by campus community members. We do not examine specific strategies for building insulation and HVAC systems because there are two professional audits of these systems that will provide more accurate results. We do, however, recommend that any package of suggestions with a payback of less than 5 years be automatically funded.

Central Heating Plant

Economizers

Economizers are boiler heat recovery devices that increase the overall efficiency of the heating system. They are installed in the smokestack and use the hot exhaust gases to preheat boiler water so that less additional energy is required to urn the water to steam. Economizers can increase the boiler efficiency by about 5%. Unfortunately economizers are not an immediately feasible option because the soot from the #6 fuel oil clogs quickly them. On the other hand, economizers are compatible with biogas and natural gas. Even if Macalester College first burns bioheat for the full 15 days a year for the interruptible gas contract with Xcel Energy, it should not damage the economizers. Economizers are a profitable investment once Macalester has switched to natural gas or biogas. We recommend conducting a cost-benefit study on economizers and installing them on the #1 and #2 boilers in conjunction with the switch to natural gas.

O_2 Trim

An oxygen control (O_2 Trim system) measures the oxygen level in the boiler exhaust and adjusts the amount of oxygen entering the boiler to fine tune efficiency. The O_2 Trim system can reduce natural gas use by 2-4%. Xcel Energy offers a rebate of 25% up to $5000 to help defray the start-up costs. We recommend initiating a Request for Proposal (RFP) process and installing one on each boiler in conjunction with the switch to natural gas.

New Construction and Major Renovations

Energy Efficiency Building Standards

All construction and renovation should strive to minimize energy demand by following stringent energy efficiency standards and incorporating renewable energy sources. These standards can be adopted from sustainable building guidelines such as LEED or Minnesota Buildings, Benchmarks, and Beyond (B3) guidelines. This project specifies that every square foot of new buildings and major renovations, such as the proposed new Fine Arts Center, should *achieve the same BTU and KWH/sqft as the IGC.* Based on current practices, the marginal cost of implementation of one square foot of efficient building is about $14[11]. Each square foot would save approximately $2 a year - a seven year payback on the additional investment. Building projects are a visible reflection of the college's commitment to sustainability, and this physical demonstration of the Macalester mission should be taken seriously.

Expand Central Heating Plant to Additional Buildings

The central heating plant produces heat more efficiently than small, individual boilers in buildings across campus. It is for this reason that many colleges and universities use a central boiler system. The Macalester College central plant has excess capacity that could be used to heat additional buildings if the distribution network was expanded; however, it is very expensive to do this retroactively. The high retroactive costs come from converting the individual buildings' heating systems to hot water and excavating and replacing the street.[12] It is important that all new construction and major renovation plans include a feasibility study of the costs associated with connecting additional buildings to the central heating plant and chiller. We recommend that this be made an official building policy to ensure that this option is examined.

Existing Buildings

Edward H Cook & Associates Recommissioning Study

Facilities Services is currently working with energy consultant Edward H. Cook &

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[11] NCRI

[12] See Appendix: Efficiency 3

Associates to examine energy efficiency opportunities in the sixteen largest buildings on campus. The study will inspect the Heating, Ventilation, and Air Conditioning (HVAC) and lighting systems as well as options for upgrading them. The report will also include recommended insulation standards for all campus buildings. The final results will include cost estimates and payback calculations to help Macalester prioritize energy efficiency investments.

Although the study is not complete, Cook & Associates estimated for this report that Macalester could save 1.5 million kWh (10%) by implementing their suggestions. The estimated capital cost is $250,000 with a payback of 1.2 years for the entire package. A 10% reduction in electrical consumption would prevent the release of 600 MT eCO2. These savings need to be captured and used to fund the rest of the climate action plan. The final results of the efficiency study should be available fall of 2009.

Auxiliary Buildings

A number of college-owned buildings fall outside the scope of Ed Cook's study. These can be divided into two categories: buildings owned and used by Macalester that are not connected to the central plant and High Winds Fund rental properties. These buildings account for approximately 1.5% of total emissions. The High Winds Fund has maintained value during the economic crisis and has the financial resources to make these investments. For rental properties where Macalester does not pay the energy bills, rent could be increased to account for the reduced energy demand, which would allow High Winds to recoup the investment.

The single-family style residences should undergo an Xcel Energy efficiency audit to identify problem areas and recommend improvements. Typical recommendations include adding insulation to the walls or attic, installing programmable thermostats, upgrading to Energy Star appliances, and behavior changes such as air-drying clothing. According to Mary Morse from the Neighborhood Energy Connection, these measures can reduce energy consumption by at least 20%. All these actions should have paybacks of five years or less. Larger and more expensive projects, such as a new roof or water heating system, have the potential for greater energy reductions. Heating water alone can account for around 13% of home energy use.[13]

Vending Miser

A vending miser is a device attached to vending machines to reduce energy consumption. A motion sensor shuts off the machine when it is not in use and automatically powers it up when a person comes within range. Vending misers can cut the electricity use of a vending machine in half saving approximately 1500 kWh a year. Vending misers can also prolong machine life and cut maintenance costs by reducing the number of compression cycles and bulb burnouts. The Vending Miser still runs a cooling cycle so the quality of the vending products is not compromised. There are 27 eligible machines on campus.

Behavior Change

Behavioral changes can reduce electricity use by at least 15% - about a 5% overall reduction in campus emissions.[14] Facilitation behavioral change requires a minimal up-front expense and can result in extraordinarily high internal rates of return. Savings range from $140-$195 per metric ton reduced, or $48,000-$62,000 annually. The savings could be used to finance

[13] Carlson 2009

[14] In previous years, Campus/Dorm Wars reduced electricity consumption by about 18%, so we assume this to be our reduction potential. Electricity represents about 33.5% of Macalester's emissions, so a conservative 15% reduction in electricity use is approximately a 5% reduction in overall emissions.

other emission reduction projects. Next we outline two initial investments that harness the vast energy, cost, and emissions savings from simple behavior changes.

Macalester's progressive culture suggests that individual behavior on campus would be relatively efficient already, but we have not taken advantage of the full energy-saving potential. Due to the aggregate nature of our electricity system, individuals not only avoid directly paying for their consumption, but they are also unaware of the magnitude of their impact. The lack of incentives and incomplete information are shortcomings that we must address to encourage behavior change and propel Macalester to campus carbon neutrality.

One large and highly successful project that illustrates the potential of behavior changes is the Dorm Wars that are a part of the Minnesota Camus Energy Challenge. Student efforts, led by MacCARES and MPIRG, initiated a major annual behavior change campaign called Campus Wars (and its intra-campus counterpart, Dorm Wars) in 2006. The campaign is designed as an energy saving contest both between colleges and individual dorms on each campus. The contest is during February and inspires energy saving habits that ideally continue through the spring semester and become habitual. Macalester has saved over 170,000 kWh per month each spring since Campus/Dorm Wars began. The savings are equivalent to 18% of average electricity use during those months.[15]

Campus/Dorm Wars illustrates two powerful tools for energy-saving behavior change. First, during the month of February, dorm residents receive information about their building's energy reduction relative to the other dorms. Students learn about their energy use and are encouraged to meet and consider potential goals and norms. Second, the competition provides an incentive to reduce energy use. While the combination of information and incentives leads to an extraordinary reduction in electricity use in spring months, Campus/Dorm Wars has less of an effect in the fall semester. Nevertheless Macalester should use the two tools that characterize Campus/Dorm Wars, energy consumption feedback and reduction incentives, to capture enormous energy savings year-round. This competition should also be expanded to include faculty and staff.[16]

Energy Use Feedback – Submeters

All campus buildings have meters that allow Facilities Services to track and record energy use. While this information is useful at the building level, it does not give individuals much information about how their behavior affects Macalester's energy use. Individuals and departments also lack an incentive to, and a clear understanding of how, they should change their behavior. Providing energy use feedback on a local level, such as on each floor of a building, creates a sense of personal responsibility and should have a strong negative effect on electricity use. In order to provide a sufficient level of information feedback, we suggest installing additional electric meters on every floor. This information could be disseminated on a website, and perhaps visually portrayed by an eye-catching electricity meter on each floor.

Based on the assumptions in Appendix Efficiency 5, submeter installations would reduce carbon emissions by 289 metric tons per year (or 1.6% of our current emissions), and yield a net cost savings of $175 per metric ton. Over the 30-year lifetime of the project, behavioral change from submeters could reduce carbon emissions by over 8,600 metric tons, save the College over

[15] Monthly data from fiscal year 1992-2008 were used to approximate a linear trajectory.
[16] Appendix: Efficiency 6 and 7 for more details about the assumptions, costs, and energy use impacts of these projects.

$1.5 million, and pay for itself in under a year.[17] *The next step is to work with our vendor Trane to verify the cost of installing these meters and determine financing.*

Energy Efficiency Officer

An effective incentive structure can significantly affect behavior, and disaggregating energy use information enables us to adjust incentive structures to make individuals feel more responsible for their energy use. An Energy Efficiency Officer could work on this type of project. The student would be responsible for developing and implementing a new incentive structure that would accomplish this. Currently individuals overuse energy because they are not charged for their use of resources. An effective incentive structure imposes some cost, whether explicit or implicit, to encourage conservation would decrease the college's overall draw on resources.

Macalester can utilize this information in one of two ways. First, departments could be directly charged for their energy use. This would require a restructuring of the departmental budgeting system, which could be politically infeasible on campus. The alternative, while less effective[18] and easier to implement, would encourage energy reductions by redirecting energy savings into the budget of the department responsible for the savings. By giving departments an opportunity to benefit financially from energy conservation, we impose an implied cost of energy use. This could be used similarly in residential buildings to encourage individuals to reduce energy consumption.

The Energy Efficiency Officer would be a cost-effective investment due to the enormous potential for behavior change through the design and implementation of an improved incentive structure. The dramatic energy reduction resulting from Campus/Dorm Wars illustrates the power of very inexpensive incentives (mostly competition and pride) on energy use. This position would be responsible for harnessing this effect year-round in both residential and academic buildings. Appendix Efficiency 7 contains several potential projects for behavior-based reductions in energy consumption that the new officer could consider. This position could also ensure that efficiency and green building measures are utilized to their full potential.

Given the assumptions shown in Appendix Efficiency 6, the energy efficiency staff position could reduce annual carbon emissions by 515 metric tons (2.85% of base year emissions) and would save the college $125 per metric ton. Over 30 years, the energy efficiency staff position could reduce carbon emissions by 15,500 metric tons, save the College nearly $2 million, and pay for itself.

[17] Further resources on the effects of energy monitoring can be found through Oberlin College's Campus Resource Monitoring System website and reports, located at http://www.oberlin.edu/dormenergy/.

[18] Psychological research has shown the avoidance of a loss to be a more powerful incentive than the capture of a gain.

Immediate (1-5 years)	Purchase and install vending misers on all machines. Conduct pilot project energy audits on 6 auxiliary buildings. In conjunction with the shift to natural gas, install O2 trim and economizers. Install submeters. Create Energy Efficiency Staff position. Establish Efficient Building guidelines. Implement suggestions from Edward H. Cook and Associates on projects with quickest payback.
Medium (5-10 years)	Continue energy audits on auxiliary buildings. Continue to follow Efficient Building Guidelines on all building projects. Implement remaining suggestions from Edward H. Cook and Associates.
Long-term (10+ years)	Continue to follow Efficient Building Guidelines. Continue to reevaluate Energy Efficiency on campus and take effective measures to improve efficiency in accordance with new efficiency technologies.

Figure 7 Summary and Timeline of Energy Efficiency Projects

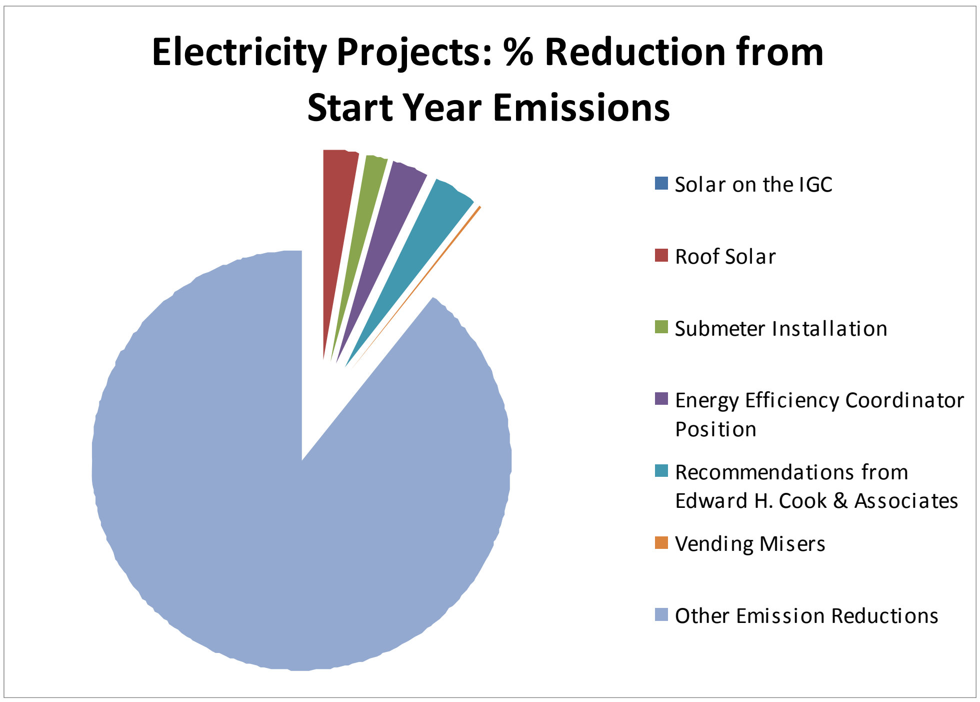

Figure 8 Percentage Reduction from Start Year Emissions from Electricity Projects

Procurement

Background

Macalester College's Procurement Department hired a sustainability student worker in 2007 to assist in the department. To date, students have:

- Assisted with finding vendors for recycled paper products
- Developed a list of environmentally preferred products used by various Macalester College departments
- Drafted a Sustainable Purchasing Policy

The following are additional recommendations for purchasing.

100% Recycled Paper

Macalester uses approximately 24,000 pounds of printing paper every year. Document Services stocks Boise ASPEN 8 1/2 x 11, 20#, #4 Grade White Paper with 30% post-consumer recycled content for all printers and copiers. We recommended switching to 100% post-consumer waste recycled paper. Thanks to the work of Kim David and Paula Leonhart, Macalester recently upgraded its letterhead stationary to 100% recycled content. However using 100% recycled paper across campus would significantly reduce Macalester's negative environmental impact. Macalester is paying $3.45 per ream for 30% recycled paper. We estimate that 100% recycled paper will cost $3.55 per ream. If the college were to purchase 100% recycled paper, the cost increase would only be $480.00 per year[19]. For the price of $480.00, Macalester would be able to reduce its use of trees by 100%, energy use by 43%, gas emissions by 37%, water use by 46%, and solid waste generated by 49%[20].

Document Services is currently supplied by The Loffler Paper Company, which does sell 100% recycled paper. Document Services currently uses approximately 250,000 sheets of paper every year. If the department was to switch to 100% recycled paper, the additional cost would only be $255.00[21]. The switch to 100% recycled paper demonstrates Macalester's commitment to sustainability; the change requires only a minimal investment and provides a large reduction of carbon emissions.

Bottled Water

There is an active Macalester student coalition focusing on reducing or banning bottled water on campus. In place of plastic-intensive bottles, Macalester could provide more water fountains in campus buildings and equip certain fountains with spigots to fill reusable bottles. The Procurement Department has a Bottled Water Joint Purchasing Agreement with Culligan Bottled Water that is currently under-utilized; only the College Relations and Athletics departments purchase bottled water through this centralized contract. Eight other departments across campus purchase bottles of water from other vendors. Using list prices of 5-gallon bottles for the various other vendors and the contract price of Culligan bottled water, we calculated that the college could save $313.60 per year by purchasing exclusively from Culligan through the contract[22].

Sustainable Procurement Policy

The current 12-page policy is too long and complicated for widespread use. We propose shortening it to 3-4 pages and making it easier to understand. Susan Abou-Nasr, of Facilities Management, used the draft of the policy to purchase furniture for the Institute for Global Citizenship. She suggested condensing the policy to increase its use. She also advocated separating the "suggested vendor" from the policy, which was previously attached to it. Once the policy is shorter, we need to track its use in the short term and mandate (or at least encourage) its use to work towards more centralized purchasing.

Reduce Free Printing

Macalester currently provides unlimited free printing across campus for its students. We believe that free printing leads to irresponsible or increased paper use. We therefore propose that

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[19] See Procurement Appendix 1.
[20] According to Environmental Defense's paper calculator using Boise premium recycled papers.
[21] Procurement Appendix 3.
[22] See Procurement Appendix 2.

Macalester provide a specified amount of free printing for each student up to a certain page amount per semester. Once a student reaches that page limit they must pay for every additional page printed. The limit could be based on class load or type.

Sustainable Food Initiatives

Emissions from the process of producing and transporting food are difficult to quantify; although we know that they represent a significant sector of Macalester's carbon footprint. We do not have sufficient information to calculate the emissions impacts of food services changes. We have enrolled Macalester in a food emissions calculator pilot project, headed by Jennifer Andrews through Clean Air/Cool Planet to help evaluate carbon emissions based on food in the coming year.

Café Mac is doing great work in providing sustainable food services. A new program initiated this semester is a food waste measurement and donation program. They are recording how much food waste the college generates and then shipping it to Barthold Farm, a local hog farm, for use as feed. Café Mac should also continue to purchase as much local[23] food as possible, which decreases transportation emissions and costs. The "Eat Local" days have been a huge success but leave considerable room for expansion.

Another recommendation is to eliminate trays from Café Mac. Dozens of institutions have already eliminated trays leading to significant reductions in energy, water, and food waste. Harvard University, for example, decreased food waste 22% after the elimination of trays[24]. Cleaning a single requires a third of a gallon of water. Without trays schools have saved thousands of gallons of water a month[25].

Zero Waste

Reducing solid waste as much as possible will reduce carbon dioxide equivalent emissions because of the decreased transport of waste, landfill methane emissions, and incineration. Reducing solid waste will also decrease production costs. A Zero Waste Committee meets regularity.

Current Systems and Strategies

Macalester College generates approximately 290 tons of solid waste per year. Disposing of this material creates 34 metric tons of carbon emissions[26]. This figure does not include hazardous, biomedical, and construction waste. Under the previous contract with Allied Waste, 95% of Macalester's waste was sent to a Refuse Derived Fuel incinerator in Newport, MN. Now 25% of our waste goes to Resource Recovery Technologies, an RDF incinerator in Newport, MN, and 75% to Seven Mile Creek landfill. At this landfill, methane is captured and used to generate electricity.

During decomposition in a landfill, methane is emitted as a byproduct. Methane is 23 times more potent as a greenhouse gas than carbon dioxide. For every 100 tons of waste in a landfill, 99 metric tons of carbon dioxide equivalents are emitted. In terms of greenhouse emissions, incineration is the least offensive. However incineration inevitably comes with a cost

[23] 'Local' can be defined as the upper Midwest, including Michigan.
[24] Zhang, Stacy (2009). "Test Driving Trayless Dining." http://www.dailyprincetonian.com/2009/03/04/22925/
[25] Nichols 2009
[26] Environmental Studies Senior Seminar 2008, Wells, and Savanick Hansen.

– toxic output. Incinerators release carcinogenic dioxins, carbon monoxide, nitrogen oxides, particulates, chlorinated hydrocarbons, volatile organic compounds, and trace metals.

There are 25 work-study students in the Macalester Recycling Operations (MACRO) department, a sector of Facilities Management run by Jim Davidson. These workers haul the recyclables into 90-gallon carts located at two sites on campus. There are two cardboard compactors for this recycling. Eureka Recycling picks up the recycling once a week[27]. Macalester is also working with Eureka Recycling to develop a zero-waste plan. Waste is collected by janitorial staff and disposed of in one of 11 dumpsters on campus. During the summer, dumpsters are emptied one to three times a week and daily during the academic year.

The Eureka Recycling Baseline Study determined that only 19% of Macalester's waste stream by weight is actually unusable. Organic, compostable substances make up 36% of waste, while 37% is recyclable and 8% is reusable. Macalester currently collects and recycles around 26% of the total waste stream (70% of recyclable materials). The Macalester Recycling Organization continues to work on increasing the recycling rate on campus.

On February 9, 2009, Macalester began a contract with Barthold Farms in St. Francis, MN to take all food waste generated at Café Mac and Catering Services for use as pig feed. The pigs at Barthold Farms are free-range, are not fed growth stimulants or "unnecessary" antibiotics, and are grown to adulthood over a full year. Weekly food waste brought to Barthold Farms ranges between 3000-3200 pounds. Although the associated daily transportation is a source of carbon emissions, it is has less of an impact than the methane that would be generated by putting this food in a landfill.

Zero Waste Strategies

Macalester College can be zero-waste by 2025 if it moves forward with the following projects and timelines. As noted above, the waste stream is composed of 81% divertible resources. Macalester should focus on getting all recyclables, reusables, and compostables delivered to the correct receptacles or on a different track entirely.

Create concrete goals

The Zero-Waste Committee should adopt short and long-term waste reduction and recycling goals and create a comprehensive campus-wide plan. This will allow for long-term planning and create accountability for the Zero Waste program. A public, visible program will also raise awareness and encourage students, faculty, and staff to participate.

Collect 100% of Recyclable Materials

The quickest and easiest way to reduce solid waste to increase our recycling rate to 100%. Recycling infrastructure, such as bins and employees, are already in place; the only piece left to increase the rate is an education campaign to make sure that community members are properly sorting materials in the bins. Macalester also has a revenue sharing contract with Eureka Recycling under which Macalester receives 50% of the profits from selling the collected material. Increasing the recycling rate would increase the amount of money that Macalester receives each month from Eureka Recycling.

Encourage Donations of Reusable Materials

There are many secondhand clothing stores in the area, and Macalester could facilitate student connections with places like Goodwill or Everyday People to encourage donations. This

[27] Eureka Recycling

institutional support could be as simple as a link on the sustainability website. The sustainability website could also include information like drop-off hours for clothing stores and further links to the ReUse Center, Twin Cities Free Market, etc. A listing service, MacFreeSwap, started April 2004 and can be accessed on the school website through the 1600 Grand program.

Year-Round Habitat for Humanity Collections

Macalester could expand the annual Move-Out collections into a year-round program. Move-Out is the biggest time for collections because of the chaos at the end of the year when everyone tries to leave campus in one weekend. A year-round program would give students more time to properly dispose of their clean, reusable materials.

Expand Pig-Feed Program

Barthold Farms captures food waste from the dining hall and catered events. A drop-off site and in-home buckets located in main traffic areas would allow community-members who do not eat in Café Mac to compost food waste.

Compost tumblers at EcoHouse and Veggie Co-op

Instructions for using the 50-gallon composting tumblers should be presented at Move-In to new residents at each location. MULCH is currently in charge of gathering the compost, and may be able to design these materials. These small-scale composters are important for the success of our urban gardens, and can serve as an educational tool.

Minimize Waste

- *Send styrofoam packaging (trays, boxed items, packaging materials) to Coon Rapids Recycling Center.* This would involve creating and publicizing a drop-off site (or a few sites) on campus.
- *Encourage better paper printing policies*. A coordinated paper reduction campaign needs to be undertaken. There are plenty of ways to do this at each of the printing sites on campus. Strategies could include setting duplex printing and copying settings as the printer default, encouraging professors to accept double-sided printing, providing information about setting laptops to duplex, educating the community about on-screen editing, creation of one-sided printing notebooks, instituting a fee for printing, and following through with an energetic awareness campaign about each of these possibilities.
- *Collect plastic bags and stretch wrap.* It's in the Bag, a campaign by Minnesota Waste Wise, provides bins for collection of plastic bags, which are then picked up by Merrick, Inc. Macalester could either participate directly by obtaining a bin, or collecting our own and dropping them off at a participating location nearby.
- *Eliminate bag liners for trash and recycling bins.*

Comprehensive awareness campaign

A comprehensive waste awareness campaign needs to be undertaken. Community-based social marketing may be helpful for this educational outreach. This type of outreach would be effective because it focuses on understanding and removing barriers while simultaneously enhancing benefits. Such marketing methods would encourage strategy for sustainable behaviors that would catch on in the Macalester community[28]. A recycling student worker should be assigned and develop communications. In addition, this model would be ideal for a psychology project. This campaign could also fit well into the annual month-long Recyclemania competition between colleges. Zero Waste goals could also be incorporated into the energy-use-based Dorm Wars.

In addition to pursuing a zero-waste strategy, an institutional preference should be set for incineration rather than landfill contracts with waste removal. There is a greenhouse gas emissions advantage to incineration but a trade-off in its emissions of toxins. Neither of these waste options are good ones.

A zero-waste behavior campaign is the best way to reduce waste and carbon emissions. Increased community awareness could also result in other benefits such as reduced levels of toxic pollution. Eliminating waste helps ensure that what we buy, produce, and use on campus will follows sustainable closed loop practices. The goal is to drive our economy toward the concept of cradle-to-cradle production rather than continuing to support the cradle-to-grave[29] system.

Landscaping

Current System and Strategies

The Grounds department, a section of Facilities Services that is led by Jerry Nelson, is in charge of landscaping as well as snow removal and contracted waste hauling.[30] The campus is divided into quadrants, each of which is overseen by one of four full-time employees: Kurt Olson, James Peterson, Sandra Street, and Gary Zahrbock. Their collective workspace consists of 53 total acres which includes approximately 27.5 acres of turf and ornamental gardens, 545 acres of parking spaces, 6 miles of sidewalk, and 5 acres of irrigated athletic fields. Lawn care on Vernon Street properties is contracted out to the Steigauf Brothers Lawncare Company. Care for the High Winds properties are contracted out through Tom Welna.

The Grounds mission statement explains that the department "serves to maintain the campus grounds as a safe and aesthetically pleasing environment"[31]. This mission statement is very amenable to expanding the work of sustainability in the department. Macalester's own Campus Master Plan advocates for a move toward sustainable grounds-keeping.

> "Integrating sustainable practices into campus operations and development need not constitute added costs in the name of altruistic or ideological sacrifice, but rather can become a methodology through which to realize competitive advantage in attracting

[28] McKenzie-Mohr and Smith
[29] McDonough, William, and Michael Braungart
[30] Custodial Services is in charge of recycling processes.
[31] Macalester Grounds Department

prospective students, realize long-term monetary and resource savings, as well as fulfill an environmentally progressive ideological agenda[32]"

The Campus Master Plan outlines general changes and improvements for the open spaces on campus including Shaw Field, the North lawn, the Woodlawn, and the athletic fields. These changes call for a mind toward functional landscape design (native plantings) and stormwater management. However the Campus Master Plan does little to flesh out possible opportunities for these changes.

Alternative landscaping has much to offer for reducing water use, improving stormwater management practices, minimizing yard waste, maximizing compost, lessening chemical use on campus, and beautifying our grounds. The main operation that contributes GHG is fertilizer use.

Fertilizer

Macalester College uses three types of fertilizer and applies an estimated average of 7444 pounds of fertilizer per year. Since 1990, Macalester has applied 4000 pounds of 10-10-10, 36,000 pounds of 46-0-0 (Urea), and 94,000 pounds of 18-0-18. Due to synthetic fertilizer's high nitrogen content (a greenhouse gas with 296 times the heat trapping capacity of carbon dioxide), annual application emissions are 7 metric tons of carbon dioxide equivalents[33]. Not assessed in the report, but alluded to, are the emissions involved in production of synthetic fertilizers. To make one 50-pound bag of the most common fertilizer, a gallon and a half of fuel oil is used[34].

Macalester fertilizer use records are cumulative so annual fluctuations in use have not been taken into account. Fertilizer use has probably declined in the past few years because of a reduction in green space on campus. For example, the football field is now outfitted with artificial turf, and the new buildings on campus[35] take up more space.

Currently, fertilizer is applied at the rate of one pound per 1000 square feet of turf per year. On athletic fields, the ratio is higher – five pounds per 1000 square feet. Flower beds are allocated six bags of 10-10-10 fertilizer to be used at the discretion of the grounds managers. Once a year, pesticides are used for broadleaf weeds. The herbicide Roundup is used for spot treatment of remaining weeds continually throughout the growing season, usually up to a few gallons per year.

Lawn and Yard Waste

Another sustainability concern is yard waste. All clippings and trimmings from Grounds are stored in a 20-yard compost roll-off dump from Veolia near the Janet Wallace parking lot. When full, about six to seven times a year, Veolia hauls the contents to a Vadnais Heights site where it is fully composted. This costs about $300 per dump[36].

Plant choice affects waste as well as fertilizer use. Most gardens are currently a mix of perennials and annuals – the former as a base and the latter to add color during the summer blooming season. Annuals are expensive, intensive, and they create a lot of waste in terms of energy and disposal of old plants each year.

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[32] Bruner/Cott and Close Landscape Architecture, and Offices N
[33] Environmental Studies Senior Seminar 2008, Wells, and Savanick Hansen
[34] Minnesota Environmental Partnership
[35] Leonard Center – 2008, Institute for Global Citizenship – 2009
[36] Hastings 2009

Irrigation

There are four main irrigation systems on campus, as well as separate systems for the Alumni House and the President's House. Macalester meters irrigation water on the main systems separately from the main campus supply so that it does not pay unnecessary sewer treatment fees. In 2008, the Athletics Fields system used 5,392,000 gallons of water, Kagin Commons used 120,000 gallons, and the Campus Center and Shaw Field systems together used 566,000 gallons. All of these systems are on timers, but only the athletic fields have rain sensors for weather-appropriate programmed watering. There is an unmonitored drip irrigation system on Grand Ave, which is run off of the Kagin system. The President's House and the Alumni House are not metered and are watered from their own systems.

Existing Sustainability Programs

The Grounds Department has already taken some strides toward sustainability. In 2008, Zoe Hastings ('11) became the first sustainability student worker in the department. This position will be a great conduit between student groups interested in making change and the Grounds department. The position can also serve as a facilitator within Grounds to give workers the support they need to implement their own ideas.

Some sustainable strategies already in place include mulching mowers which leave clippings on the lawns to be recycled into the soil. A program of lawn aeration reduces soil compaction, stimulates root development, increases water and oxygen intake, and reduces water run-off and the need for fertilizers. Watering during early morning and non-peak hours of the day reduces evaporation and maximizes efficiency.

The campus has four native plant or experimental planting sites: the rain garden near the library, the Olin-Rice drainage prairie, and two green roofs: one on the link between the Turk and Doty residence halls and the other on top of Kagin Commons. These planting sites are environmentally beneficial because they require little or no fertilizers/chemicals. The sites also support the mission of Macalester because they provide educational opportunities. Tom Ibsen, Macalester alum, is working to develop website material and neighborhood tours to disseminate information about restoration and functional landscaping in the area.

Recommended Strategies

A simple record-keeping system for the type, amount, and cost of synthetic fertilizers used each year would help solidify the data needed to calculate carbon emissions. It would also be helpful to have greater baseline statistics regarding water usage for irrigation. This could be worked into the data collection student worker position Matt Kazinka ('11) is currently developing[37]. Greater communication and institutional memory is necessary in order to move forward efficiently and directly.

Organic Fertilizers

Organic fertilizers from a sustainable source will offer more benefits (including a more functional and live soil) than conventional synthetic fertilizers. St. Olaf College uses Sustane brand, which would not be cost-effective for Macalester unless lower application rates of fertilizer were used. However the use of Sustane brand or similar products could be explored through pilot projects[38].

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[37] A data collection student worker position within the Facilities department has been approved for the '09-'10 academic year.

[38] See Appendix: Landscaping 3

Convert athletic fields to artificial sports turf

Application rates of fertilizers are five times higher on athletic fields than the rest of campus. Because irrigation rates on these fields are also high, converting the baseball fields to an artificial turf like that on the football field may be cost effective[39].

Increase perennial, functional landscaping on campus

Perennial functional landscape requires little or no fertilizer, irrigation, or chemicals because native perennials have evolved complex mutualistic systems. The initial cost of the plantings would be paid off by reduced maintenance costs. There are botany students, alums like Tom Ibsen of Grass Roots Restoration, and community members that are interested in working to establish aesthetically pleasing, functional landscapes. More perennials might also mean fewer annuals, which are a source of waste. Schools currently experimenting with functional landscape design include Ithaca College, Pomona College, St. Olaf College, Carleton College, and Seattle University[40].

Explore the use of turf mixes outside of Kentucky Bluegrass

Fescues with their own nitrogen-fixing qualities are used at Pomona College and Seattle University as alternatives to *Poa pratensis* in areas where short-cut grass is not necessary.

Reduce Excessive Wear

Since the majority of fertilizer is used in order to establish newly seeded or sodded areas on campus, stopping behavior that wears down lawns unnecessarily will also decrease the need for fertilizer.

Reduce Pesticide Use

- *Choose weed suppressing groundcovers where possible.* Instead of spraying pesticides or herbicides, groundcovers can sometimes accomplish the same task. Other similar tactics include sheet mulching as well as vinegar and mulch application.
- *Research and experiment with Integrated Pest Management*. There is growing research about the use of biopesticides and other systems practices that suppress and divert insects and other predators of gardens.
- *Minimize applications to once a year*. Simply scaling back on the amount and frequency of pesticides and herbicides will drastically reduce negative chemical impacts.
- *Explore winter de-icing products that take less energy to produce and have less of an environmental impact.* Other schools have experimented with liquid de-icer rather than sand, salt, or Ice Melt.

Reduce Irrigation

- *Install meters and sensors to monitor all water use in terms of irrigation.* As mentioned above, good baseline data is imperative for understanding what needs to be changed.
- *Use drip irrigation systems where possible.*

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[39] See Appendix: Landscaping 2

[40] See van Andel and Aronson for more information on ecosystem benefits, and Appendix: Landscaping 1 for analysis.

- *Control all water centrally.* This way, watering can be shut off when not weather-appropriate (watering is wasteful during high heat and unnecessary during rain events).
- *Install more rain gardens.* Functional landscape design encompasses the idea of rain gardens. (See stormwater section for more detail.)

Reuse Compost On-Site

Compost, compost tea from Macalester compost tumblers, and vermiculture bins could be used as natural fertilizer and soil amendment.

Decrease energy use

Leave grass at a 3 inch height before cutting to reduce unnecessary amounts of mowing. This tactic is in use at St. Olaf College, Willamette College, and Seattle University. Also, replacing the Grounds machines with biodiesel, solar or electric equipment would reduce energy costs and emissions.

Storm Water Runoff

Current Systems and Strategies

As a small school in an urban setting, Macalester has a phenomenal amount of green space. However, the buildings and paved zones on campus contribute to our stormwater runoff. The Capital Region Watershed District oversees the stormwater system in the Macalester area and monitors run-off water quality. The East Kittsondale monitoring site is nearest campus and has reported the highest relative levels of total suspended solids (TSS) and total phosphorus (TP) out of the 13 stormwater monitoring sites in the area[41]. Also heavy storm water runoff contributes to erosion on campus, increasing the need for fertilizers and irrigation, and the level of maintenance to care for our landscapes.

Recommended Strategies

Alternative Paving Options

Porous Pavers are an option but can be expensive and cause maintenance problems. Porous Pavers also have a variable life span when used in parking lots. SUDS Netpave is an alternative to paving that specifically designed to manage and reduce storm water runoff. Benefits include reduced runoff, increased groundwater recharge, minimized environmental damage, and beautification of campus landscaping. Netpave was recommended as an option in the Macalester College Campus Master Plan. Price estimations are difficult to make as the prices for Netpave and other alternative paving techniques depend on the size and range of a project. We recommend that Macalester assess the feasibility of Netpave or other alternative pavers to reduce the campus storm water runoff.

Filter Strips

For paved areas that are not slated for renovation in the foreseeable future, we recommend using landscaped filter strips around the perimeters of these surfaces. Currently paved areas allow 90% runoff; however filter strips of native vegetation could reduce that significantly[42]. Filter strips act as barriers against runoff by creating natural landscapes for infiltration, sediment trapping, and nutrient trapping. Each of these will not only reduce runoff

[41] City of St. Paul
[42] Ohio State University, 2008

on campus, but decrease the contribution of pollutants and suspended solids to the local environment. The cost of adding filter strips is also low because the campus landscape is continually being renovated and maintained.

Rain Gardens

Macalester currently has two rain gardens located at the front of the library and by the Olin Rice Science Center. Rain gardens are simple and could be installed in several additional locations on campus. Additional rain gardens should be positioned next to a paved area where it could act as a catchment, dug out to create a shallow pit that does not come into contact with the water table, and be planted with vegetation that can survive periodic flooding[43]. The plants should be perennial natives, which are adapted to the Minnesota climate. These gardens also filter run-off and recharge the local water system.

Rain Barrels

Rain barrels are an inexpensive and effective solution to reduce rooftop storm water runoff. They are large plastic barrels placed below drainage pipes coming off of rooftops. The collected rain can then be used for landscaping projects, which would reduce the amount of water used for irrigation as well as runoff. A demonstration barrel is in use at the EcoHouse.

Green Roofs

There are two green roofs on campus; one is a $300ft^2$ project on the link between Turk and Doty, and the other is a $1,350ft^2$ project on top of Kagin Commons. Both of these were initiated and installed by Macalester students and have proven to be effective remediation strategies. The rooftop gardens insulate the buildings, provide space for carbon sequestration by plants, capture and use stormwater, and reduce the urban heat island effect. Adding more green roofs on campus would increase carbon sequestration and reduce storm water runoff. We urge administrators to keep green roofs in mind when designing new projects, such as the Fine Arts building.

Additional Benefits to Alternative Landscaping

Landscaping projects that contribute to campus environmental sustainability offer unique ways to actively involve and educate students. Macalester students are interested in acting hands-on to understand and influence how their campus functions. There is an abundance of students who willingly volunteer their time to help make this campus a more sustainable and healthy environment. Projects like the green roofs are proof of student interest because the rooftop gardens would not have been a success without the dedication of passionate students.

Also stormwater reduction projects on campus would provide an exceptional learning opportunity for students. Departments ranging from Biology, Chemistry, Environmental Studies, and beyond could use the implementation of these projects as opportunities to teach students about the hands-on applications of environmental theory.

Finally, initiatives and innovative projects bolster Macalester Colleges's reputation and attract a great range of potential students. Similar campuses, such as Grinnell College, have several opportunities for hands-on environmental learning for students specifically interested in this type of interaction. If our campus had opportunities of such caliber, we could expand our interest base and perhaps bring new sources of funding to campus.

[43] Rain Garden Network, 2009

Transportation

Current Systems and Strategies

Macalester lacks a comprehensive multi-modal transportation strategy and has not identified priorities for reducing carbon emissions from transportation. While Macalester's Campus Master Plan proposes some strategies - mainly increasing parking availability and accessibility while decreasing parking lot visibility - the administration does not systematically manage institutionally-funded air travel. It is within the long-term financial and environmental interest of Macalester to address institutionally-sanctioned air travel, which currently represents 26% of Macalester's total greenhouse gas emissions. The 2007-2008 fiscal year cost of institutionally-funded air travel, excluding student study abroad, was $902,526. In comparison, only 3% of Macalester's emissions come from student, faculty, and staff commuting.

Recommended Strategies

Monitor, Stabilize and Reduce Institutionally-funded Air Travel

Macalester-funded air travel represents the vast majority of Macalester's travel-related greenhouse gas emissions and transportation costs. Designing strategies and systems that address institutionally funded air travel should be prioritized. Colleges and universities fly for various reasons; many trips cannot be avoided. For purposes such as fundraising for a capital campaign, a phone call or email does not elicit the same response as a personal visit. For other reasons, such as a national collegiate sports event, digital communication is not applicable. The table below shows disparities in air miles travelled for the 2007-2008 school year by office or department. If Macalester implemented travel caps of any kind (mandatory, voluntary, etc), it would probably be best to apply them at the department and office level.

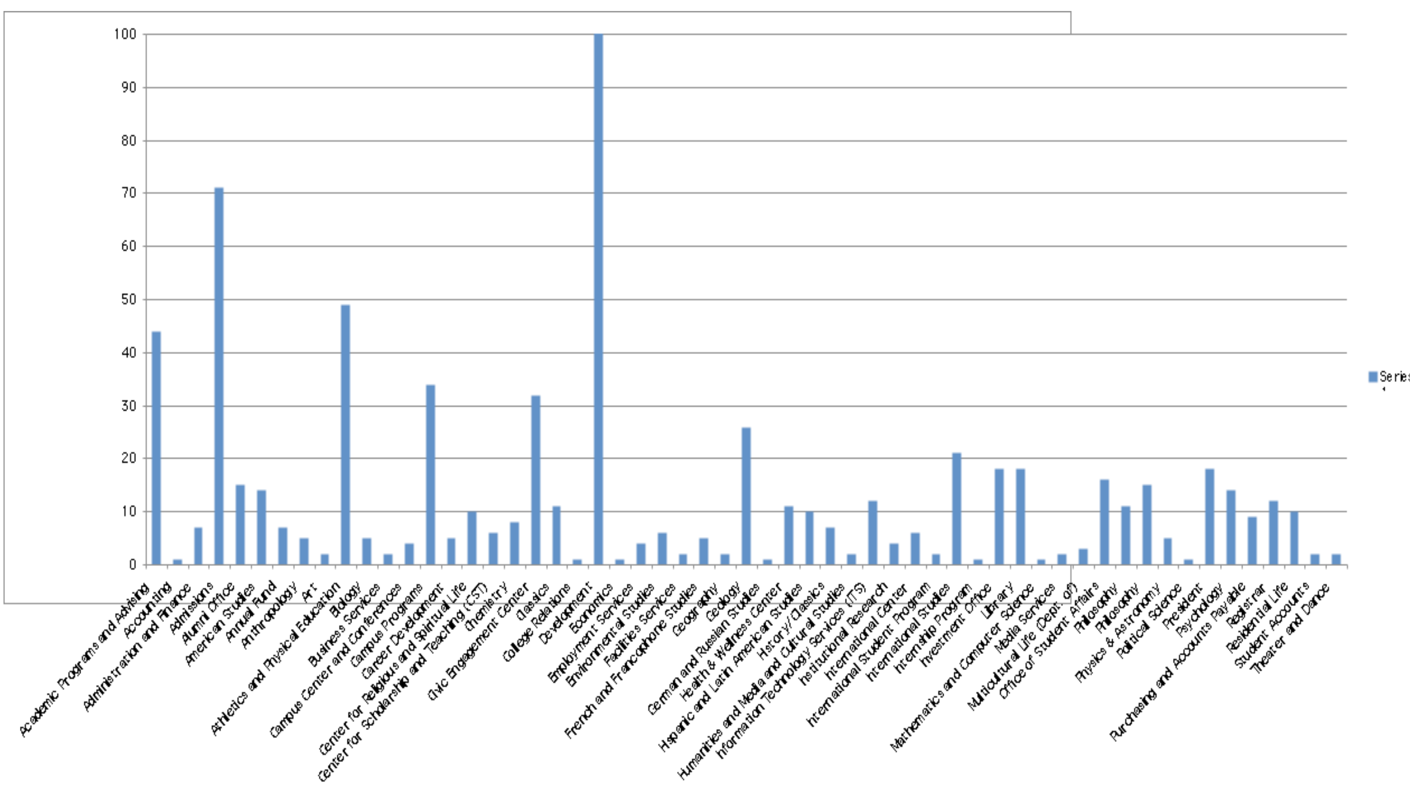

Figure 9 Travel by Department

While certain trips cannot be avoided, travel policy should incentivize national and continental travel for trips that have some flexibility (speakers, guests, field trips, conferences, research, etc.). Another way to reduce emissions is to incentivize direct flights in which the carbon-intensive actions of take-off and landing are minimized.

Below is a long-term scenario for management of college-sponsored air travel. For the immediate future, from now until 2010-2011, Macalester should stabilize total miles flown at current levels. By 2020-2021, Macalester should achieve a 5% decrease in mileage, reducing the total miles flown to 3,662,755. By 2030, the college should achieve a 10 percent decrease from current levels. By 2050, Macalester should strive for a 30% reduction in miles flown.

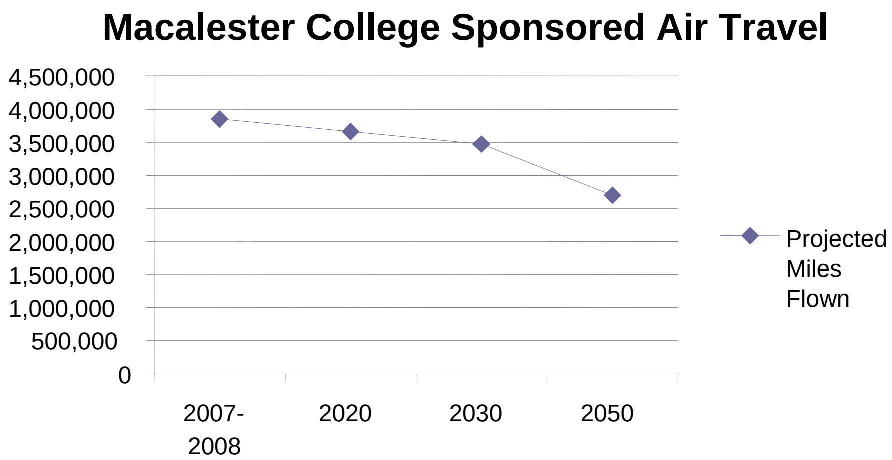

Figure 10 Proposal for reducing the number of Macalester sponsored air travel (in miles)

There are significant political and logistical hurdles involved in reducing travel-related emissions within an institutional culture committed to global travel. Within our existing campus culture, it is uncommon to meaningfully consider the global impact of using fossil fuels to move around the world. However, addressing air travel emissions will require the entire Macalester community to consider the repercussions of travel at individual and institutional levels.

Emphasize Continental Study Abroad Programs

Learning within other cultures is clearly found within the core mission of Macalester College, but study abroad contributes 11% of total emissions. Our recommendations are **not** meant to interfere with the success of Macalester's international education programs. Similar to institutionally-funded air travel, participation in study abroad programs should be maintained or even increased without increasing emissions. Short and direct flights produce far fewer emissions and are often cheaper and more convenient; therefore, short and direct flights should be emphasized over indirect flights to distant destinations.

Macalester should offer students high quality study abroad opportunities within the continent that minimize the externalized costs of flying. The idea of "staying local" when going abroad may seem counter-intuitive, but is logical from an economical and environmental perspective. The map below shows that relatively few students study in the Caribbean, Mexico and Central America. Broadening opportunities for cross-cultural learning in these destinations should be among the priorities of a more cost- and carbon-conscious International Center.

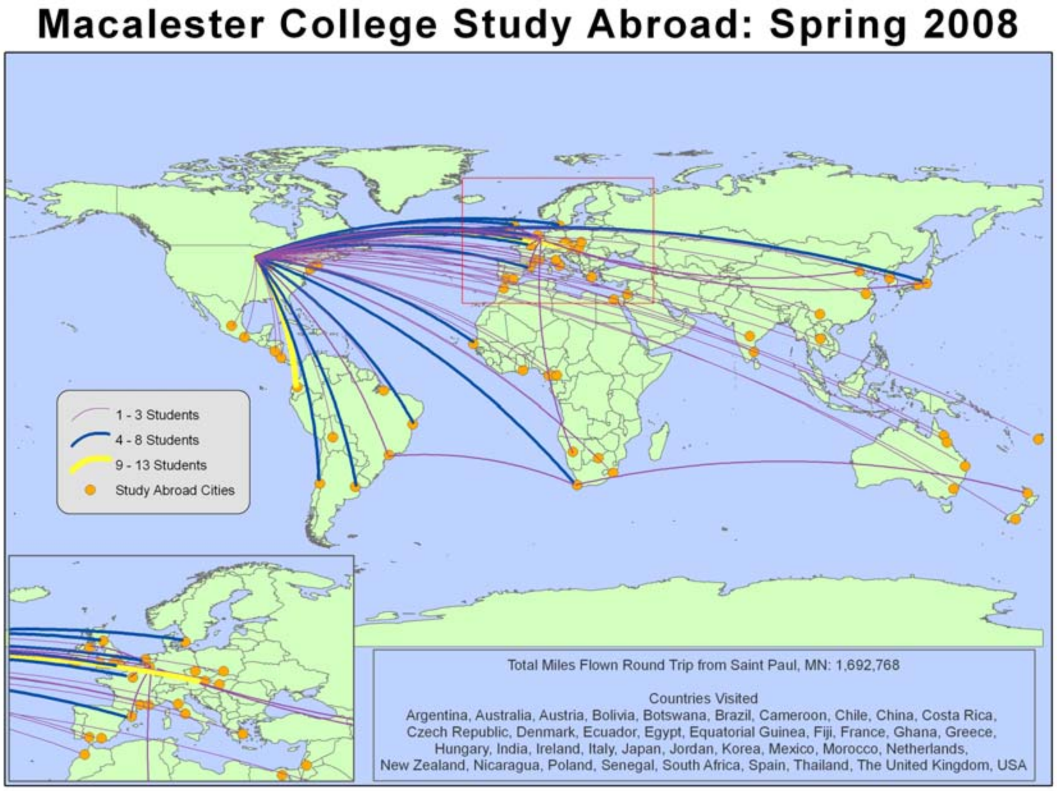

Figure 11 Study Abroad Destinations of Macalester Students in Spring 2008

Discourage Single-Occupant Vehicles; Incentivize Walking, Biking, Transit and Carpools

Several institutional programs and policies that strengthen the sustainability of Macalester's transportation system are already underway. They include:

- ***Zipride***, the online ride sharing board purchased in March 2009
- ***Subsidized Bus Passes***, one of two immediate actions taken by Macalester in 2009 towards fulfilling the Presidents Climate Commitment. This program includes both pay-per-ride SuperSaver cards and unlimited “Go To (College)” cards.
- ***Macalester's Bike Share program***, a joint collaboration between MacBike, the Information Desk, and Student Employment was implemented in 2006.
- The ***HOURCAR*** car-sharing program, founded in 2004, currently serves Macalester College as well as the Mac-Groveland community with two Toyota Priuses.

Pedestrian-Oriented Development Projects

The Grand Avenue planted median enhances our neighborhood and makes walking safer on a busy road. Low-cost traffic calming options, especially Leading Pedestrian Intervals during hours when traffic flow allows it, should be considered. Macalester should also maintain and strengthen its relationship with the Department of Public Works to better-facilitate pedestrian-oriented development.

Walk to Work

The High Winds Fund provides financial assistance for staff who purchase homes within one mile from campus by offering "fix up" matching grants up to $3000 for home improvement projects[44]. This small program deserves greater resources because it is the most direct and efficient strategy for managing parking demand at Macalester.

Fleet Project

Macalester's van fleet is relatively fuel-inefficient but represents an opportunity for highly-efficient transport of students, faculty, and staff.

1. Switch rental fleet from gasoline to diesel/biodiesel

Macalester currently operates six rental vans using two-year contracts. Facilities Services should consider changing its 2009-2010 contract for all six vehicles from gasoline to diesel vans. The EIA estimates that diesel vans are between 20% and 40% more efficient that gasoline vans. Switching to diesel vans would result in reducing our fleet emissions by approximately 15%. Additionally, diesel vans provide the option of using biodiesel blends, such as B20, that would reduce emissions by a further 20%[45]. Although the Macalester fleet only accounts for 1% of total carbon emissions, these are important reductions toward carbon neutrality. The greater efficiency of the vehicles would generate savings that would offset the greater cost of diesel vans. We recommend that Macalester move from gasoline rental vans to diesel vans in the following school year. Merit Chevrolet, one of Macalester's dealership partners, provides this option.

2. Invest in Hybrid Vans

For hybrid electric vans that use conventional engines or B20 in diesel engines, GHG emissions will be up to 71% lower than for diesel vehicles and 65% lower for vehicles using B20. Such an investment would significantly reduce our fleet emissions (EIA). There are a number of different options when investing in hybrid vehicles. Although the cost of a hybrid van is high, the vans would probably pay for themselves in the long run because of reduced fuel costs and rental contracts. We recommend that Macalester begin considering its hybrid van options and invest within the next 2-4 years.

Transportation Master Plan

Macalester should create a publicly available *Transportation Master Plan* to complement the *Campus Master Plan*. This should include an exhaustive list of current projects, policies and strategies that guide the school's transportation systems. To create this document, we recommend that Macalester convene a subcommittee of the Sustainability Advisory Committee to draft goals for reducing transportation related carbon emissions. When looking for model transportation policies, Macalester could examine the St. Paul Department of Planning and Economic Development Comprehensive Transportation Plan, which is accessible at stpaul.gov. The plan is guided by four central strategies: 1) Provide a Safe and Well-Maintained System 2) Enhance Balance and Choice 3) Support Active Lifestyles and Healthy Environment 4) Enhance and Connect Communities. Understanding city and regional transportation plans will aid Macalester's process of creating its own transportation plans and strategies.

Verified Emissions Reductions

Current Systems and Strategies

On the path to carbon neutrality, emissions reductions are the first priority. Following reduction measures, verified emission reductions become the next method for reaching our goal. Since these are a relatively new concept, it is necessary to clarify the definition. The broad

[44] Hansen, Sustainability at Mac
[45] EIA

concept is that a verified emissions reduction (VER) decreases or avoids the emission of greenhouse gases in one location to compensate for emissions in another. VERs are created by investing in projects that reduce GHG emissions, such as renewable energy projects, energy efficiency, methane abatement, plant-based carbon sequestration, etc. The American College and University Presidents Climate Commitment requires that VERs be "real and tangible, additional, transparent, measurable, permanent, verified, synchronous, registered and retired"[46]. By utilizing VERs, we can neutralize our remaining carbon footprint that is unaffected by our other emissions reduction strategies.

There are two main types of VERs:

Renewable Energy Credits

RECs, also referred to as green tags, green certificates, or tradable renewable certificates, are specifically related to electricity. An REC is expressed in megawatt-hours of electricity while an offset is referenced to in metric tons of CO2-equivalents (MT CO2e). The purchase of one REC involves 1 megawatt-hour or 1000 kilowatt-hours. Green-e certification is available for RECs to guarantee high-quality renewable energy.

Carbon Offsets

Carbon offsets, on the other hand, focus on the output of emissions and can be used for any source of GHG emissions, including heating, transportation and electricity. One carbon offset purchase accounts for 1 MT CO2e. Independent auditors can certify an offset as a verified emission reduction.

The Consumer's Guide to Carbon Offsets, available from Clean Air/Cool Planet, provides useful information regarding the concept of offsets. According to the guide, offsets range from $5 to $25 per ton and typically average approximately $10 per ton[47]. Options can differ in quality, which makes it important to recognize the criteria that constitute a good VER. These criteria include additionality, baseline definition, permanence, and clear ownership. Additionality refers to the idea that the funding allows a project to occur that otherwise would not have happened. An appropriate baseline definition provides a way to judge the reduction in emissions and the actual amount that a project is offsetting. The characteristic of permanence is important, showing that the benefits will not reverse themselves in the future. Clear ownership and registering VERs help prevent double counting and double selling. Over time, monitoring and verification ensure quality.

Possible Strategies

There are many different ways to offset carbon emissions. Possibilities include purchasing credits from a third-party, investing in a project, developing a project, or prompt delivery. As a result, we must identify priorities that are the most important to Macalester, choosing the offset strategies that fit our plans. Some of the most common strategies used by other schools to offset carbon emissions include: sequestration, methane projects, renewable energy projects, energy efficiency, or a mix two or more of these strategies. To see a more detailed description of different offset strategies see Appendix: Offsets 1.

[46] ACUPCC, 2008
[47] Trexler Climate & Energy Services, 2006

Local Projects

An additional requirement that we feel should be included in decisions about VERs is a preference for local projects. However, we were unable to locate local vendors at this time.[48] One future option for local VERs is to work with local energy organizations. We found that the most feasible option for this would be to fund the Neighborhood Energy Connection (NEC) Energy Improvement Financing program. By providing loans and guidance, this organization offers St. Paul residents the opportunity to increase energy efficiency within their homes. While this option is highly recommended, we are still unsure as to whether the NEC has the ability to track specific changes on the amount that we will have offset[49].

Macalester Administrated Projects

A sequestration project could also be used as an educational tool. Combining a sequestration project with a land conservation/restoration project would provide an excellent learning opportunity and a way for Macalester to give back to the community. Students would also have the unique opportunity to learn about native plant species and the interactions with the broader ecosystem. While implementing this project, we would have to closely follow the guidelines for sequestration as laid out by the ACUPCC because the project would be sponsored by the college, not by a certified VER vendor.

Sustainability Fees

Some schools participating in the PCC have instituted a sustainability fee that is added to the tuition bill. This fee funds offsets that the school wishes to participate in and can also offset individual student carbon footprints on campus. The fee could be used to fund offset projects or other emissions reduction strategies or added to the Clean Energy Revolving Fund (CERF) to be invested in campus energy efficiency. Other options for student offsets are also available from vendors. Renewable Choice Energy, for example, offers a Student Bundle Offset for $25 to account for three months of dorm living. WindStreet Energy offers a $30 GreenU card, which serves as a fundraiser by allocating $8 back to the institution.

We propose that the college incorporate a $20 sustainability fee into student tuition. We also recommend an optional or mandatory travel offset for faculty and staff. This would be a $10 or $15 charge and would go toward the same fund as the sustainability fee. If Macalester has approximately 1,800 students on campus and charges each of them a $20 sustainability fee, the fund would produce $36,000 each year. The fund would be larger once we account for the faculty and staff travel offsets as well.

Offset and REC companies

The market for RECs and offsets is continually changing and expanding. Since our focus is to offset locally if possible, we only included companies based in North America. The following companies are some of the main players in the market at the time of writing of this paper (April 2009): Bonneville Environmental Foundation (BEF), NextEra Energy Resources, Renewable Choice Energy, TerraPass, and WindStreet.[50] The prices we found ranged from

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[48] NativeEnergy offers some offsets locally in Minnesota, but we were unable to contact them. This company builds Native American community-based renewable energy projects focusing on environmental, social, and economic benefits. Although we were unable to reach them, we think that NativeEnergy may be a good choice as an offsets vendor.

[49] Interview with LeAnne Karras, 2009

[50] This list of companies in the offset and REC market is not extensive and does not examine offset quality at the project level – something that should be done prior to purchasing.

$2.62-$35 for the RECs and from $5.36-$13.12 for the carbon offsets, as shown in the table below. Company details on the headquarters location, the types of projects funded, and the quality of offsets and RECs are located in Appendix: Offsets 2. References for additional information on specific projects and other companies are available in Appendix: Offsets 3.

An alternative to RECs is Xcel Energy's Windsource program, which puts Green-e certified wind power into the electrical grid in place of conventional power. The consumer pays the additional cost of wind power generation and receives a reimbursement for the avoidance of fuel for conventional power. The Windsource price is $3.53 per 100 kilowatt-hour (kWh) in addition to regular energy prices, which are constantly changing.[51] Currently the October through May period costs $9.87 per kWh for on-peak usage and $1.91 per kWh for off-peak usage. The price for June through September is $1.21 per kWh for off-peak usage and $1.55 per kWh for on-peak usage.

The table below summarizes the costs for these companies. A more detailed table that separates the price ranges is in Appendix: Offsets 4.

Company	**REC Price* per 1 mWh**	**Offset Price* for 1 MT CO2e**
BEF	$20-35	
NextEra	$4	
Renewable Choice	$2.62-6.96	$5.36-5.48
TerraPass	$6.15	$13.12
WindStreet	$4	
Xcel Windsource	$35.30**	

prices in 2009 dollars* * renewable energy, but not a credit*

Figure 12 Prices of RECs and Offsets per company

Institute for Global Citizenship Offsets

As a part of the LEED Platinum application for the Institute for Global Citizenship, the college is offsetting 100% of the building's electricity and heat for a 2-year period. With Renewable Choice Energy, Macalester will offset the projected annual electricity usage of 76,793 kWh with a Green-e certified wind energy RECs and 6,382 therms of natural gas with a methane capture project at the Upper Rock Islands County Landfill in Illinois. The total cost for the two years will be $1347.04[52].

Recommendations

We need to purchase to make Macalester's community carbon neutral according the President's Climate Commitment? Because offsets serve as a back-up strategy to fuel shift and energy efficiency projects, we can only estimate how many offsets the campus will need to buy in the future.

According to current estimates based on Clean Air-Cool Planet's calculator, a fast-track path to become carbon neutral by 2020 will involve purchasing 7983 RECs and 5150 carbon offsets over a thirty-year period for a total price of $830,813. In the long term, we hope that Macalester places the priority on implementing energy efficiency and fuel shift projects in order to bring our campus to carbon neutrality.

[51] 1000 kilowatt-hours (kWh) equal 1 megawatt-hour (mWh).
[52] Letter to Erica Downs, 2009

2020 Scenario:

	Amount	Price
RECs	7983	$ 353,429
Offsets	5150	$ 477,384
Total		$ 830,813

2030 Scenario:

	Amount	Price
RECs	7983	$ 353,429
Offsets	5500	$ 509,827
Total		$ 863,256

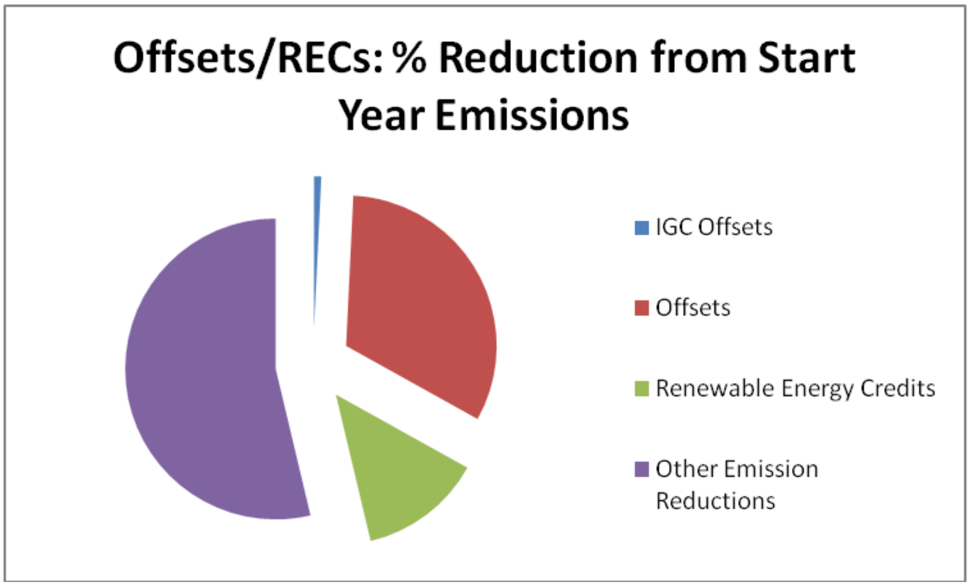

Figure 13 Comparison of REC/ Offset Costs for Carbon Neutrality in 2020 and 2030

EDUCATION, RESEARCH AND COMMUNITY OUTREACH

Current Systems and Strategies

The President's Climate Commitment requires a strong educational plan that affects change academically and behaviorally both within Macalester College and in the greater community. In order to best address these goals, the plan has been divided into three sections: Curriculum, Research, and Community Outreach.[53] Each section is organized into three subcategories: current programs and immediate recommendations, short-term recommendations, and medium/long-term recommendations. These subcategories are based on the projects' cost and infrastructure impacts. Investigation for the Educational Plan was carried out through interviews and a faculty-wide Sustainability Survey.[54]

While sustainability is erroneously thought of as an environmental issue, the concept includes economic and social concerns and should be thought of as an expression of global citizenship. Interdisciplinary approaches embody sustainability, taking into account the value of approaching the world around us in a variety of ways. Interdisciplinary majors include: American Studies, Environmental Studies, Humanities, Media, and Cultural Studies, International Studies, and Women's, Gender, and Sexuality Studies. The Environmental Studies department in particular strives to incorporate sustainability into its curriculum. Its growth in

[53] Categories are separated for clarification, but all overlap to some degree.
[54] All interview notes are attached in Appendix:Education 4-8.

recent years is indicative of the institution's greater emphasis upon sustainability in academia. Some would argue that the pursuit of a liberal arts degree itself fits the idea of sustainability because of its adherence to an interdisciplinary approach to education, valuing knowledge across a variety of disciplines

Recommended Immediate Strategies

Expand the Definition of Sustainability

In order to make sustainability a curriculum priority, the definition must be expanded to be accessible and inclusive of all disciplines. Sustainability is often though of as sustainable development was defined by the Brundtland Commission: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[55] Macalester College uses an expanded definition of sustainability that includes social and economic considerations. The college prefers to define sustainability as:

The continuous effort to meet the needs of the present generation without compromising the ability of future generations to meet their needs by working toward a healthy environment, informed by social justice, and strong economies. At Macalester, sustainability is infused throughout our core values of academic excellence, internationalism, multiculturalism, and service to society.[56]

In the survey sent to all faculty, Naran Bilik, anthropology professor, stated that all of his courses deal with the concept of sustainability because anthropology takes a "holistic approach and studies all aspects of human life; fieldwork and local point of view/local knowledge are important to an anthropologist (Curriculum and Sustainability Survey, 2009)." A more holistic meaning of sustainability must be disseminated throughout campus.

Departmental Resources Guides

We recommend developing Departmental Resource Guides to provide resources, examples, and other tools to assist professors wishing to infuse sustainability into their courses. Each academic department would receive a pamphlet listing the ways in which sustainability can be applied to their respective disciplines. In addition, a list of classes that address sustainability would provide a reference point for professors who want to incorporate sustainability.

Interdepartmental Concentration in Sustainability

The creation of a sustainability concentration would make sustainability an academic priority. Some examples of existing concentrations include African Studies, Global Citizenship, and Community and Global Health[57]. The possibility of an interdepartmental concentration in sustainability is dependent upon faculty interest and collaborative efforts[58]. Since concentrations require the support of multiple departments, a proposal needs to be created by a variety of faculty members and be presented to the Educational Policy and Governance (EPAG) committee. If

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[55] Center for a World in Balance. http://www.worldinbalance.net/agreements/1987-brundtland.php
[56] Macalester College Sustainability Office. http://www.macalester.edu/sustainability/strategicplan/bestthinking.html
[57] Macalester College Course Catalog 2008-2009 p. 48
[58] Kathy Murray Interview

approved, the proposal would be voted upon by the rest of the faculty. In addition, concentrations must be resource-neutral; the formation of a sustainability concentration cannot require additional funds. It is important to note that the criteria needed for the creation of a sustainability concentration already exist because many courses in a variety of departments already incorporate sustainability; although 1-2 courses must be developed specifically for the purpose of this concentration.

Follow-up Survey

The survey was crucial to obtain feedback from a broad range of departments on the topic of sustainability. We advise conducting a follow-up survey every few years to measure improvement and understand the current opinions on campus.

Recommended Short-Term Strategies

First Year Course Sustainability Goals

First Year Courses provide an opportunity for students to familiarize themselves in a supporting environment with an academic setting. Every first year course must meet a set of goals detailed in the course catalog (Appendix: Education 10). According to the 2008-2009 Course Catalog, first year courses are meant to enhance college-level writing and basic library research skills. By infusing sustainability within the first year course, students will receive the knowledge to enhance their sustainable behavior within an academic environment and discover the importance of sustainability. A possible addition to the goals of the First Year Course requirement could be worded as such: "To provide students with the ability to enhance sustainable behavior within an academic setting and connect sustainability within a variety of disciplines." This would have to be approved by the EPAG committee in order to be added to the course description.

Grants for curriculum and course development

Curriculum development grants already exist; although most do not exceed $1,000 and are meant to modify existing courses. There needs to be funding, modeled after existing grant structures, specifically designated for creating sustainability courses. Grant money could be used for travel to appropriate conferences or field sites, educational material such as books, or to hire work-study students to help develop the course.

New and Visiting Faculty Training

The new tenure track faculty take part in an orientation program run by Dr. Adrienne Christiansen, head of the Center for Scholarship and Teaching. The workshop focuses on classroom management skills such as how to lead an effective discussion and how to grade fairly. There is no sustainability component in the training. Faculty have also expressed apprehension about incorporating sustainability programming, and that it might take away from the important basics[59]. Visiting professors have a different orientation that has less investment in pedagogical training and more emphasis on welcoming them to the Macalester community. Instead of mandatory and regular programming throughout the year, like the new tenure track faculty receives, there is optional programming on various topics that they can choose to attend.

Recommended Long-Term Strategies

Tenure Reform

[59] Interview with Professor Christiansen

In interviews with faculty members, some cited their concerns that professors competing for tenure would find working with sustainability to be a deterrent to gaining tenure. This concern is founded upon the ways in which tenure is chosen, which is a complex and nuanced decision process. Tenure is based on the applicant's teaching ability, the quality of research and scholarship, and the ability of the professor to include students in research. In addition, it is crucial that the professor's research be publishable. In fact there is an increase in scholarly work on sustainability, and it is in a professor's interest to contribute to this nascent field. The concern expressed by Macalester professors is that professors competing for tenure are disproportionately burdened. However, if a professor is able to incorporate sustainability as well as excel in the arenas of teaching and scholarship, it will be viewed positively by those who make tenure decisions. Curricular development does, in fact, play a large role in decisions made about which professors receive tenure.

A greater tenure emphasis on involvement with student work and new curriculum development would encourage professors to be more engaged in issues such as sustainability. As one professor explained, since his work with student organizations on sustainability projects was not taken into account, it actually was not in his best interest to be involved in these types of projects. This is because it usually takes time away from the type of work that is valued more such as research and being published. However, if the professor is able to integrate sustainability into his or her coursework, it can contribute to a higher change of obtaining tenure. If on campus projects, activism, and involvement in the Macalester community were valued more in tenure decision making, then it would encourage more professors to become involved with sustainability projects and curriculum development without feeling as though it is compromising their chances of tenure. The Provost and other members of the tenure committee should reevaluate the criteria used to assess tenure positions on campus.

Greater Incentives for Integrating Sustainability

This award would be part of their title and could be modeled after other endowed professorships such as the "Margaret Weyerhaeuser Harmon Professor" or the "DeWitt Wallace Professor." In fact, the college is attempting to create more endowed professorships and the Step Forward Campaign states that it hopes to raise enough money to create ten more of these positions. One of these ten could be a sustainability position, which could be separate from the "Sustainable Professor Award." The campaign states four key criteria for the new endowed professorships, and one of them is emerging disciplines. If the sustainability concentration is created, it could be one of these emerging fields[60].

Sustainability Requirement

A sustainability requirement is a very controversial issue for faculty members. There are some fierce opponents to idea of adding another graduation requirement. In order for a new requirement to be institutionalized, the EPAG committee has to approve it. If the interviews and survey results as representative of the overall sentiment, then the requirement would not pass an immediate EPAG vote[61]. It is important that this change not be forced, which will create more opposition. Instead concerns should be addressed so that more professors will support the recommendation.

The difficult aspect of this recommendation is that there are a number of different reasons for the opposition to the requirement, so there are many issues that need to be addressed to

[60] For more information see the Step Forward campaign website: http://www.macalester.edu/development/

[61] Appendix: Education 1

change the opposing opinions. Many faculty members reported that there were already too many requirements, and that they had just finished the process with other requirements. Another complaint was that when new requirements are created, it can affect which departments get new tenure track positions; because there is a finite number of faculty, that would mean that some departments would have positions taken away and that others, specifically Environmental Studies, would have more added. One faculty member reported that the college is more departmentalized than most other liberal arts colleges, so a key concern is whether a new requirement will benefit their student majors[62].

Research Recommendations

Macalester offers a number of research opportunities that either incorporate sustainability in their purpose or have the potential to do so. The Lilly Grant, Three Rivers Mellon Grant, Student/Faculty Research Collaboration, Arnold and Mabel Backman Foundation, Mellon Mays Undergraduate Fellowship Program, National Park Service, and the Wallace Fund all offer the possibility to fund sustainable research projects. The Macalester Website has compiled a *Student Research* page that describes these projects in greater detail[63].

Currently 36 classes contain a civic engagement component[64]. Furthermore, many majors require an internship for completion, including Political Science and Environmental Studies. Also students have the option of completing internships for academic credit. These community components within the academic realm are related to sustainability, as civic engagement is a valuable educational tool for understanding the importance of sustainable connections and practices for future generations.

Community Outreach

For a college community, outreach is a necessary area to develop. Community outreach allows both students and members of the community to learn through interacting with people from diverse backgrounds. This exchange makes community outreach an important aspect of any sustainability plan. At Macalester there are already a number of community outreach programs with a sustainability focus in existence. Some of these efforts engage the greater community, some engage the Macalester community, and others involve both communities.

One of these is a student worker position in the Civic Engagement Center. This student creates newsletters with articles about sustainable issues at Macalester and in the Twin Cities. The sustainability worker in the Civic Engagement Center also helps connect people working on the same sustainability issues. This student worker also organizes the environmental education program at the Rando Education Center. In this program, 10 to 15 Macalester students go to three different schools around the Twin Cities and teach about environmental issues[65].

Another current community outreach effort at Macalester is the Environmental Leadership Practicum course that is required of all Environmental Studies majors. In this course, students intern at environmental organizations around the Twin Cities. Macalester also offers a Chuck Green Fellowship in which students learn about community involvement and spend time working in the community with a selected organization. Students work with these organizations on social, organizational, or policy problems. In the past, some of these individual projects have had a sustainability focus. Lives of Commitment is a similar program for first year students.

[62] Hornbach
[63] Appendix: Education 9
[64] Interview with Karin Trail-Johnson
[65] Rivenburgh Interview

Residential Life and new student orientation provide many informative teaching tools and sustainability-focused events to students. These efforts include sustainable fliers on the residence hall bulletin boards, residence hall energy reduction competitions, as well as brochures and booklets on sustainability handed out during orientation. In addition a session called Community Connections during orientation focuses on how students can become engaged in global and local communities in a sustainable way. Residential Life also puts Residence Hall Assistants (RAs) through sustainability training sessions. The Environmental Studies department also reaches out to the Macalester community through EnviroThursdays, hour long weekly talks that are open to all students and faculty. The topics addressed in these discussions focus on environmental issues.

There are other programs in the Twin Cities and at Macalester that include elements of sustainability. The Experimental College (ExCo) offers courses to anyone in the community, including students. Educational sustainability tours of the Macalester campus are open to the public. Macalester also holds roundtable discussions and civic forums that have addressed the topic of sustainability and environmental citizenship. Macalester students are also involved in community efforts outside of Macalester such as Hour Car. This program offers the use of a hybrid car to anyone in the community who subscribes.

Recommended Immediate Strategies

Sustainability Focused Floor Meetings

All residence halls should have at least one floor meeting a year that focuses on sustainability. This meeting could include education on how to live more eco-friendly and develop sustainable living habits in a college setting. Sustainability trainers, similar to the school's SEXY (Students Educating X's and Y's) trainers, could lead these floor meetings. A student worker position could be created to compensate these sustainability trainers for their services.

<u>Sustainability Student Worker Positions</u>

More student worker positions that focus on sustainability need to be created in order to integrate sustainability throughout the campus. Some of these jobs could be on campus while others could be off campus allowing students to work with the greater community on sustainability issues. On campus jobs could be similar to the sustainability student workers in the library. This position could be expanded to other departments giving each department their own student worker who works on sustainability issues in their department.

Sustainability Day of Discussion

The Macalester community should hold a sustainability-themed Day of Discussion modeled after previous Day of Discussion events. This event would offer students a chance to discuss sustainability at Macalester and in their own lives while raising awareness of the issues. By opening this forum for discussion, students and other community members will have the chance to participate in decisions about trade-offs, financing, and priorities of the projects in this Plan. This inclusion will help make projects more successful and better received on campus.

Sustainable Study Abroad Programs

An additional recommendation is for Macalester to offer sustainable study abroad programs. Some options include setting up programs where students study and live in eco-villages with sustainable practices and increasing the number of intercontinental study abroad programs.

IMPLEMENTATION

This report contains numerous projects that, when implemented as a package, significantly reduce greenhouse gas emissions and save the college money. These projects range from cheap and relatively simple to costly and difficult to implement. We recommend that the Sustainability Advisory Committee and the Sustainability Office lead on prioritizing projects, emphasizing how projects with low upfront costs and high savings can build funds for more costly projects that have a larger impact on school greenhouse gas emissions.

Tradeoffs and Sustainability

Macalester could greatly benefit from using a broad definition of sustainability that avoids categorizing it as an interest group and emphasizes its integration into the operations of the college. If we define sustainability as making the college and its activities function in a more ecologically, economically, and socially responsible way in the world, sustainability is not a cost but a necessity over the long term. While certain financial tradeoffs do exist, we believe that great opportunities exist for improving the efficiency and effectiveness of campus programs while creating positive social impact and furthering sustainability at no additional cost. This effort will require making structural changes and take time to implement, but the long term benefits will be worth the effort.

Major Policy Recommendations

- Defining and expanding the role of the Sustainability Office on campus

Sustainability Office

The Sustainability Office was created as a central node for sustainability activities on campus. The Sustainability Office has started working with the operational and academic systems of Macalester to support the college's sustainability efforts and manage the implementation of the American College and University Presidents Climate Commitment and the Talloires Declaration. The Sustainability Office interprets sustainability for Macalester and develops a strategic plan, of which this report is a part. The office is currently working on articulating a sustainable vision and working it into substantial, innovative actions that make Macalester more environmentally, socially, and economically sustainable. The office has already engaged many stakeholders around the college in defining sustainability on campus and forming a sustainability plan currently in development. Many departments at Macalester still have little interaction or experience with the Sustainability Office and are unsure how it relates to their work. We encourage the college to strongly support, expand, and publicize efforts to define and implement sustainability work on campus by increasing the influence and resources of the office.

Expanding the Sustainability Office requires a very clear definition of its mission and role. We see the office being most effective by defining and promoting a broad definition of sustainability by setting standards, driving major initiatives, fostering communication across departments and campus stakeholder groups, building the capacity for increased interdepartmental collaborations, and advising the implementation of strategic sustainability related projects.

This expansion does not mean that the Sustainability Office has to spearhead every project or come up with them. Expert consultants, such as Edward H. Cook, play an important role, and the Sustainability Office should be provided with resources to turn to outside experts when necessary. There are also experts on campus, particularly in the Facilities Services department. These people understand the workings of Macalester College more than anyone and know where changes can be made. However, the Facilities Department does not have the time, money, or mandated priority to research and implement these changes. By allowing Facilities Services the opportunity to identify opportunities and emphasizing the institutional will to make these projects happen, we can allow these experts to participate in the move towards carbon neutrality.

Student Work Study

We urge the school to redefine, reallocate and require more from student work-study positions while engaging them more deeply in the college's operations. Work-study positions can help move towards carbon neutrality and more effective school operations by expanding departmental research and development capabilities, gathering contacts and resources, and coordinating with other student workers to foster interdepartmental collaboration. While much has come of independent student activism on campus, the creation of specialized positions infused with sustainability has the benefit of ensuring that students have the time and resources needed to coordinate and carry out projects. Student worker positions also allow student work to be continuously institutionalized in department activities despite student turnover from graduation. Department and students can both benefit from more specialized and engaged student work. Departments will benefit from increased research and development on college operations that staff and faculty often do not have the time to do. Students will get the ability to have a positive impact on college operations while getting paid. In addition, increased independence and responsibility in work-study that treats students as an integral part of helping the school to function better will empower students to act innovatively and effectively. Students who feel their work is critical to improving the college will take on more responsibility and will feel better about their contributions. Student workers who get involved in projects as underclassmen can continue to work on them for the rest of their time at Macalester, creating a legacy from their time here.

Some of these changes have already started to occur; new sustainability positions have recently been created in Facilities Services, Café Mac, the Procurement Office, Alumni Relations, Campus Programs, Mac Bike, Information Technology Services (ITS), the Community Engagement Center, and the library. Students in these departments have already begun developing important pieces of sustainability work. Additional positions in the Sustainability Office working on communications and data will also play a key role. This past year, the Sustainability Office started a forum for sustainability workers to meet together to communicate between departments so that students could understand what was going on in each department and give each other feedback and advice. With increased work-study funding next year, this forum is an important step in getting individuals in every department to work together on sustainability, interpreting and implementing campus wide sustainability initiatives all over campus.

Recommended Implementation Plan

- Expansion of CERF
- Implementation Timeline Based on Payback

We suggest implementing projects that save the college money and reduce its emissions concurrently. It makes sense to begin doing efficiency projects that save money right away. It is vital, however, that any money saved from energy efficiency projects be funneled back into a fund that provides capital to implement more emissions reducing projects.

Macalester already has a fund of this type in place called CERF, the Clean Energy Revolving Fund, which collects savings from efficiency projects in order to fund other, often more expensive, projects.

We recommend that CERF, which has a proven success rate, to be the primary fund by which sustainability projects get funding. As a mechanism, CERF works best when projects are taken on as package deals that help pay for each other, as we suggest for Macalester College.

More administrative oversight would be necessary for CERF to take on an expanded role. If certain internal and external changes were made to CERF, it could function as the primary sustainability fund for the college. This could include raising interest rates, changing to year-by-year compounding, or switching to long-term savings generation (like 75% of savings per year). Macalester should create a mechanism for prioritizing non-returning projects that are key to the larger Sustainability Action Plan in return for getting a larger portion of longer-term savings.

Our recommended projects are ranked using a combination of cost and efficiency effectiveness. In the ranking, projects tend to fall under certain categories based on the nature of the strategy to reduce emissions. Calculating the net present value (NPV) allows us to judge the worth of individual projects side by side to determine which projects should be undertaken. NPV is an indicator of how much value an investment or project gains for the school. Projects with a positive NPV should be done immediately, before any others, because they give the school a financial gain. Projects with a negative NPV should not be taken out of consideration altogether but instead can be implemented at a later date.

Projects that Save Money

The first category of projects, all of which have positive NPVs, involves technological upgrades that increase efficiency and reduce electricity use. These include installing oxygen trim systems, completing a switch to compact fluorescent light bulbs, installing misers on vending machines and sub meters on individual buildings. This also includes implementing Ed Cook's consultations and recommendations to the school to increase overall energy efficiency of Macalester's operations. This package of projects should be implemented immediately, ideally during the 2010 academic year.

Projects with Long-Term Payback

The switch to cleaner sources of energy makes up the second group of projects. This group includes immediately shifting from number two and number six fuel oil to natural gas as soon as possible. Other projects in this category include installing solar panels on the IGC and expanding solar energy on campus. These are concrete projects with high paybacks over longer periods of time due to higher start-up costs. These long term projects do save the college money over time, as indicated by their positive NPVs.

Offsets

The third group of projects is offsets, which are costly ways to compensate for Macalester's current emissions as we strive to achieve carbon neutrality. These projects are best understood as a temporary reaction to the shortcomings of our sustainability projects. Offsets have high negative NPVs, because they incur costs without changing infrastructure that can save the college money.

FINANCING

Many of the recommendations made in this report cost money. While some projects are low cost and easy to implement, others are more expensive and more difficult to execute. Although some of these projects require large upfront costs, ultimately they will end up saving the college significant amounts of money. When taken as an entire package, the recommendations outlined in this report will, overall, result in a POSITIVE net gain for the college. However, projects with high capital costs are necessary even though they are required before the savings gained from their implementation are accrued. There are many ways that the upfront costs of these payback projects can be funded. One great source of funding is through CERF. The revenue generated through efficiency projects funded by CERF is recycled back through the organization to finance additional environmental initiatives. We recommend that this fund is expanded to harness all payback projects with a carbon neutral focus. CERF projects should include the funding of staff time. Senior class gifts and alumni donations are other ways our carbon neutral recommendations can be funded. The senior class gift raises approximately $25,000 per year, which could be put straight into sustainability projects if the donating class is so inclined. Highly visible, large-scale projects (for example, solar panels) could be attractive to individual donors as well. Some of our recommended projects could be completely funded by gifts to the college. Other funding initiatives we recommend include sustainability fees charged directly to students' accounts and air travel fees for study abroad and other academic trips. Energy saving improvements can be partially funded through the use of conservation rebates offered by Xcel Energy. These rebates help pay for the upfront costs of energy efficiency improvements and offset the cost of installation.

We also believe that the goals of the Step Forward Campaign should be adjusted to include sustainability, thereby encouraging further funding for our recommended projects and other environmental plans. Along with this, we recommend that Macalester extends the payback period of projects to longer than ten years. The projected cost of utilities to 2014 is an increase of eight percent, which could change the projection of payback projects. Considering the PCC and its implications for the direction of the college, such a change seems necessary if Macalester is to "step forward into a new era." The nation-wide popularity of the ACUPCC ensures that our peers will be transitioning into new modes of sustainable behavior, and Macalester should not be left behind. Peer colleges may also serve as a financing source by considering joint action on large projects, purchasing contracts, and the like. This could lead to even more powerful projects and alleviate the financing pressure on a single institution.

The above strategies are all important and viable ways to fund our recommended projects. However, a piecemeal approach to reaching carbon neutrality will not work. Different proposed projects have different net present values (NPV's) associated with their implementation; specifically some projects will require an investment over their entire lifespan while others will end up generating revenue. It should not come as a surprise that the projects resulting in the greatest reduction in carbon require the greatest monetary investment while the projects with fewer reductions tend to offer returns on initial investments. Taken as a complete package, our projects have a positive NPV; in the long run, the implementation of all the projects will generate revenue for the college. However if our projects are not applied altogether, the college runs the risk of either losing money by investing in higher-cost initiatives or not reaching carbon neutrality by investing in only money-making projects. It is also essential that Macalester capture the savings created by these projects in order to reinvest that money in the more costly, carbon eliminating proposals.

CONCLUSION

Macalester College needs to reduce its dependency on fossil fuels and build a sustainable foundation to move the institution into the future. This plan provides concrete steps towards carbon neutrality in a world-wide battle against the adverse effects of environmental degradation and global climate change. In addition, it has the potential to set an example for other schools and institutions across the country. We hope that our plan will give rise to additional creative strategies to move our society towards a carbon neutral future. Macalester prides itself on its environmentally conscious and active student body, its faculty and staff, and its principles of social and environmental responsibility. Our institution has the potential to serve as a model for exemplary strategies that mitigate the effects of global climate change within an urban campus-setting and instill the value of sustainable practices in the campus and surrounding communities.

It is important to note that this report focuses mainly upon carbon neutrality. We focus primarily upon quantitative data and specific steps that can be taken to achieve this goal. We recognize, however, the importance in discussing and incorporating the qualitative aspects of sustainability. In addition, we conducted our research according to current price projections, which are subject to volatile markets and may affect the accuracy of the data. Updated prices and market conditions must be considered when evaluating the above recommendations.

Thanks to all who participated, guided, and assisted with the making of this project. Our contact list at the end of this document provides a comprehensive list of those who made this report possible and who may be consulted for future research.

APPENDICES

Appendix: On-Site 1—Natural Gas and Bioheat

Switching from #6 fuel oil to natural gas

Start Year……………………………………2010
Duration……………………………………..5 years
Units…………………………………………1
Marginal Capital Cost per unit……………....None
Impact of Project..170 MT eCO_2 annual reduction
Name of the Researcher(s)…………………...Aparna Bhasin
Contact Info……………………………….....bhasin.aparna@gmail.com

Explanation of Assumptions:

- The project start year is 2010 because there are no infrastructural changes necessary in switching the majority of our fuel consumption from #6 fuel oil to natural gas.
- In order to maintain a mix of #2 and #6 fuel oil for the fifteen days of possible interruptible service from Xcel, we calculate Macalester's total usage annually and then 15 days from that amount. In doing so, we maintain Macalester's projected #2 fuel usage and switch only #6 fuel oil to natural gas.
- Our price estimations for natural gas are based on those found in the Clean Air/Cool Planet Calculator.

Switching from #6 and #2 fuel oil to Bioheat:

Start Year……………………………………2012
Duration……………………………………..50 years
Units…………………………………………1
Marginal Capital Cost per unit……………....None
Impact of Project.. 95 MT eCO_2 annual reduction
Name of the Researcher(s)…………………...Aparna Bhasin
Contact Info……………………………….....bhasin.aparna@gmail.com

Explanation of Assumptions:

Biodiesel Blend Options: Blends containing a high percentage of biodiesel (e.g., over 20%) have an increased susceptibility to crystallization due to cold temperatures and the possibility of filter plugs (at high concentrations, biodiesel acts as a solvent and suspends the sludge from fuel oil in the tank causing filter plugs). Hence, we chose a B20 blend in our recommendations for Macalester.

- *Suppliers:* Biodiesel needs to be blended into fuel oil before it can be stored in tanks. Recently, petroleum terminals and pipeline racks have installed a biodiesel blending capability. Ron Marr of the Minnesota Soybean Processors told us that most pipeline terminals that serve Minnesota have in place heated biodiesel storage that blends biodiesel into #2 fuel oil. Macalester purchases its fuel oil from Koch Refining or Flint Hills Resources' Pine Bend Refinery in Rosemount, Minnesota. Although they would not be able to provide use with a bioheat supply, Macalester should consider other supplier options.
- *Costs:* Based on historic prices from Clean Air/Cool Planet, we find the cost of B20 bioheat (20% biodiesel and 80% #2 fuel oil) to be fairly similar to that of #2 fuel oil. We therefore use these prices in our estimations.

Appendix: On-Site 2—Biogas

Start Year……………………………………2015
Duration……………………………………..50 years
Units…………………………………………1
Marginal Capital Cost per unit……………....None
Impact of Project... 5,864 MT eCO_2 annual reduction
Name of the Researcher(s)…………………...Rebecca Schneider
Contact Info……………………………….....rkschneider5@gmail.com

Detailed Description:

Biogas is produced at an anaerobic digester facility. During anaerobic digestion, bacteria are used to convert feedstock to produce biogas, which is mostly comprised of methane. Feedstock could include sewage sludge, agricultural wastes, energy crops, or municipal solid wastes. Once biogas is cleaned to pipeline standards, it can be introduced into the existing natural gas pipeline grid.

Explanation of Assumptions:

- *Contract with Rural Producer:* In a short-term scenario, Macalester would be able to purchase biogas by entering into a contract with a rural producer and with Xcel Energy, our natural gas provider. To promote price competition, Macalester would submit a Request for Proposals for biogas delivery to the Xcel distribution system. One potential biogas supplier is Bison Energy, an anaerobic digestion facility in Sioux County, Iowa. Currently, Rock-Tenn, a major paper plant in St. Paul, offsets its natural gas consumption with biogas produced at the Bison Energy digesters. In this scenario, Macalester would contract for delivery by displacement - the biogas would be actually fed into the existing natural gas pipeline grid and not directly serviced to Macalester.
- *Costs:* The biogas cost estimates that we use for our projections are based on historic and future contract information from Ross Weber. We found that biogas from a rural source would be $0.99 more expensive per MMBtu than natural gas.
- *Local Digester:* In a longer-term scenario, Macalester could receive biogas from a digester built in the Twin Cities. There are various organic wastes and energy crops that could be supplied to produce the biogas. The biogas could then be directly piped to Macalester's campus and burned in the heating plant.
    - Linden Hills is one Minneapolis neighborhood that is already looking to construct a local anaerobic digester to process the community's own organic wastes to produce various forms of energy. Linden Hills Power & Light completed a digester feasibility study in November 2008 and are looking to move forward and examine potential sites as informed by the study. While Macalester would not benefit directly from the Linden Hills digester, it would provide an important model for future digester construction in the Twin Cities urban setting.
- Organic source material for the production of biogas for Macalester, i.e. any type of agricultural waste or energy crop, would need to be obtained because this would most likely be the case in both of our short and long-term scenarios. This is an important assumption because although biogas from organic source materials such as agricultural wastes and energy crops contains "biogenic" carbon that under international greenhouse gas accounting methods (IPCC) is part of the natural carbon balance and will not contribute to atmospheric concentrations of carbon dioxide; municipal solid waste does contain a percentage of plastic.

Appendix: On-Site 3—Flat Roof Solar

Description:

Large scale photovoltaic arrays located around campus on currently open roof space. Using estimates of the roof size of each building, the available space, loss from shading, panel angles and seasonal variation, this estimate seeks to provide a rough number of the generating capacity of the core campus, assuming current efficiencies and costs. Costs are estimated using conservative estimates of cost increases in electricity rates over time and potential reduction in the peak demand portion of campus electricity bills (~1/2 the electricity bill cost).

Start Year……………………………………2020
Duration……………………………………..50 years
Units…………………………………………725
Marginal Operating Cost per unit…………… $50
Activity change………………………………1,724,152 kwh reduction
Impact of Project.. 454.7 MT eCO_2 annual reduction
Name of the Researcher(s)…………………...Austin Werth
Contact Info………………………………......austin.werth@gmail.com

Concrete Assumptions:

Solar Radiation – monthly estimates have been taken from pvwatts.org, based on Minneapolis estimates
Panel Efficiency – Assumed to be 17.20% based on panels recommended for the IGC project
Shading Loss – 66% based on conversion of roof square footage to panel square footage at a 40º angle

Explanation of Assumptions:

• Assumes all the sunny roof space will be available for and used for solar electric generation.
• Estimates panel square footage based on 40º angled panels and shading loss, but does not account for larger building shading or the particulars of the surface.
• Omits how current roof elements will interact with or prevent solar from being installed and the load bearing capacities and/or mounting requirements that are unknown without engineering studies.
• Additional unknowns include efficiency increases in lower temperatures and the effect that snow will have on generating capacity in the winter.

Appendix On-Site 4: Central Heating Plant Description

System Design and Function

The majority of Macalester's heating needs and a portion of its hot water needs are met by a central high pressure steam plant located under the fine arts complex, along with all the control equipment for the system. Through the combustion of various fuels, large boilers produce high-pressure steam (~90 psi) that is distributed through a system of pipes around campus where it goes through heat exchangers to heat campus buildings and provide hot water. The system is connected to 26 campus buildings and 11 privately and college owned houses. Exceptions are the stadium, which has an electrical heating system and the buildings on the west side of Macalester street, south of Grand Ave, which have their own systems. The heating plant typically runs September through May (the "heating season") when four operators, under the guidance of the chief engineer, must operate and maintain the plant boilers on a 24-hour basis. The boilers are shut off in the summer, from commencement to September or October, at which point heating and hot water needs are met by smaller building boilers and heating systems in all buildings (either electric or natural gas). A central heating plant like this is significantly more efficient than buildings that are individually heated, providing significant efficiency from scale, especially during the coldest months. A system like this also requires time to ramp up, making it unfeasible to turn on and off and restricting its usage to the coldest months of the year.

System Details

The heating plant contains three boilers, two small and one larger one. The boilers are most efficient when they are operating at their maximum level. For this reason on lower demand days a smaller boiler will be used, and on higher demand days either the two small boilers or the one larger boiler is used. All three boilers are not operated at once, giving the system excess capacity.

The boilers heat water based on a set temperature for heating the dorms. Currently this is 68°F (building, not steam temp), though it often varies by building depending on staff and faculty preferences. The steam from the boilers goes out at high pressure to the buildings. Once there, the pressure is decreased and it runs through a heat exchanger for heating and hot water needs. As the steam loses its heat (cools down), it changes state from a gas (steam) to a liquid (condensate). This remaining water returns to the central heating plant as liquid to be heated back up, creating a closed loop system.

Fuels

The heating plant boilers can burn 3 different types of fuels #2 fuel oil (diesel fuel), #6 fuel oil and natural gas. The two smaller boilers can burn #6 fuel oil and gas and the larger (and newer) boiler can burn #2 and gas. In terms of emissions, natural gas is best, then #2, then #6. #6 fuel oil is a heavy fuel the consistency of road tar that is a byproduct of petroleum refining and has the highest carbon emissions per BTU and the highest number of other harmful pollutants. For this reason it is currently not legal to buy a boiler that burns it today. [more info here] Our older boilers have been grandfathered in because they were installed in the 60s. While #6 is recognized as a much dirtier fuel than natural gas or #2, it is typically the cheapest, which is why it is burned. Mac pays more for low sulfur versions of #6 and #2 fuels, which it buys from Koch Industries. The natural gas is purchased from Xcel.

The decision as to what fuel the heating plant burns is decided on a month-to-month basis, based mainly on the season and pricing. Natural gas is more expensive than #6 most of the time. #2 is rarely burned because it is typically 2-3 times more expensive per million btu's . [price?] The central plant burns natural gas during periods of low demand because it is easier to turn on and off. At high demand periods during January, February and March #6 is burned due to its cheaper price. Fuel oil #6, however, is only feasible and cost effective under high demand conditions because its high viscosity requires it to be heated before it can be burned, taking more time to start. Natural gas burns cleaner and results is lower wear and tear on the boilers and for this reason, Facilities Management is willing to pay up to a 5% premium for natural gas when deciding which fuel to burn.

The service for each of the fuels is different and affects the fuel usage as well. #2 and #6 fuel oil are stored in two separate 25,000-gallon tanks and must be filled at night by a tanker truck from a terminal off the Art center parking lot. There is no long-term contract with the supplier, Koch Industries. Mac gets an interruptible natural gas service from Xcel, which requires stored fuel be on hand during curtailment periods. In return for a lower rate, Mac agrees to curtail use of natural gas during periods of peak natural gas demand, usually during periods of extremely cold weatherto prevent dangerously low gas line pressure. Mac interrupted its service 4 times during the the '08-'09 heating season [fact check]correct. Mac commits to a monthly price for natural gas.

Sources: This information is compiled from the 2004 Environmental State of the College reports, a 2006 Environmental Science final project report, heating plant website and various interviews with staff in Macalester's Facilities Department. The two main facilities contacts have been Mike O'Connor the chief engineer and Curt Stainbrook the mechanical systems manager.

Appendix: Efficiency 1—New Buildings

Start Year……………………….……………. **2010**
Duration……………………….……………**20 years**
Units………………………………………..**152,379 (square feet)**
Marginal Capital Cost per unit……………….. **$14**
Grants………………………………………. **N/A**
Annual Marginal Operating Cost per unit....… **-$2**
Activity Change……………………………….. **4.006kWh saved annually per unit,**
Name of the Researcher……………………….. **Tim Campbell**
Contact info …………………………….…….. **507.217.7706**

Assumed 0.05% annual growth in square footage from baseline of 1.38 million square feet (2009)(David Wheaton) to get 152,379 additional square feet over 20 years.

Marginal capital cost, we assumed $250/square foot for a regular building and a 5% higher price for LEED platinum (standard sustainable guideline)/ square foot.

Annual marginal operating cost/unit was reached assuming a lifetime return on investment of a factor of 10 of the original investment ($14/unit) (Kats, et al) = $ 140/unit. Then assumed this over a lifetime of 70 years= $140/70= $2 savings per unit/year.

To determine activity change, numbers for the Institute for Global Citizenship were used to determine kwH/square foot of sustainable building. It will use (estimated) 76,793 kWh annually/ 17,000 square feet = 4.517 kWh. Since this is a 46.9% decrease, business as usual buildings operate at 8.523 kWh. 8.5 - 4.517= 3.983 kWh.

BTU savings were determined based on a traditional building baseline of 13,949 therms/17,000 sq. feet = 0.8205. Under LEED platinum, 6,382 therms/ 17,000 sq. ft= 0.3754. 0.8205 – 0.3754= 0.4451 btu saved/ square foot.

Appendix: Efficiency 2—Vending Machines

Start Year…………………………….…………… **2010**
Duration…………………………….…………… **15 yrs**
Units…………………………….…………… **27**

- There are 31 total vending machines on campus, but the 4 new ones in the Leonard Center operate using card readers which are incompatible with the Vending Miser technology

Marginal capital cost per unit…………………………….…………… **$164**

- 2004 prices
- The Misers are produced and sold by USA Technologies, Inc.

Annual marginal operating cost per unit…………………………….…………… **$65**

- Because the misers shut down the lightbulbs and compressor, they last longer and require less maintenance time and money

Activity Change…………………………….…………… **1458 kwh/year**

- This is based on a 44% decrease in energy use from the current rate

Name of Researcher…………………………….…………… **Louise Sharrow**
Contact…………………………….…………… ELSharrow@gmail.com
School Contact…………………………….…………… **Douglas Rosenberg**, Director of Budget and Institutional Services

Explanations, assumptions, calculations, etc.

Vending misers are devices which drastically reduce the energy consumption of vending machines by turning them off when they are not in use. They have a motion sensor which powers them back on as soon as someone enters the vicinity, so they do not make sense for vending machines in 24 hour high traffic locations. The compressor is still powered on peridiocally, so the temperature and quality of the product is not comprised. Vending machines are usually replaced every 10-15 years (according to Doug Rosenberg/vendor), and most of the machines we have now are about six years old. The misers are easily installed on the current machines, and will increase their life span by reducing the number of compression cycles over the life of the machine. The activity change is the average of kWh reduction based on a Tufts University report, a University of Louisville report, and a Kill-a-Watt measurement of the kwh use of a drink machine in the basement of Olin Rice. It will be important to create some sort of signage that will explain new sensors so that people do not think they are broken, and provides a contact number in case of problems. USA Technologies provides a guarantee, so any problems should not harm the College budget.

According to Douglas Rosenberg, the least utilized machines currently are located in Carnegie, the CRSL, and Humanities. These machines could be eliminated without much student complaint or loss in revenue.

Appendix: Efficiency 3 –Heat Plant Expansion

- Cost to convert the heating system in each building, assuming they are heated with hot water radiators: $5,000 each
- Cost to connect each building, with excavation, piping, and site restoration: $5,000 each
- Cost of the steam and condensate return piping: $1,100 per foot;   If the total length of run to the buildings is 1,000 feet, then the cost would be $1,100,000.
- Cost of street restoration: $15,000

Numbers obtained in a personal email communication between Edward Cook and Louise Sharrow, April 20, 2009.

Appendix: Efficiency 4—Edward H.Cook and Associates Recomissioning Project

Start Year……………………………………….**2010**
Duration…………………………….………. **1 year**
Units…..**1**
Marginal Capital Cost/Unit……………………. **$250,000 (2009 dollars)**
Grants………………………………..………. **N/A**
Annual Marginal Operating cost/unit……………$**0**
Impact of Project…………………...…………**1,500,000 fewer kWh**
Name of researcher……………………………... **Tim Campbell**
Contact info that will still be valid next year…….**507.217.7706**

For the recommissioning project, all of Ed Cooks recommendations were lumped into one unit for the calculator, as the breakdown of projects is not yet available. For the purpose of the calculator, the sum of the projects was entered as a one-year project.

Marginal Cost per unit is an average based on Ed Cook's preliminary estimate of between $200,000 and $300,000 for similarly sized campuses.

Activity change was calculated based on Ed Cook's estimate that Macalester uses around $15,000,000 kWh annually and that we could save 10% of this amount by implementing his recommendations. This number of kWh was reached by extrapolating numbers from 2004.

Appendix: Efficiency 5—Auxiliary Buildings

Project- 'Auxiliary' Building Energy Audits
Start Year…………………………………………. **2010**
Duration…………………………………………. **2 years**
Units…………………………………………. **6** (*recommended # of first-round pilot units*)
Marginal Capital Cost per unit…………………………………………. **$125** (2009)
Annual marginal operating cost per unit…………………………………………. **none**
Activity change…………………………………………. **none**
Name of Researcher…………………………………………. Louise Sharrow
Contact…………………………………………. ELSharrow@gmail.com

Explanations, assumptions, calculations, sources, etc.-

This project involves the College getting energy audits on a number of the auxiliary buildings, defined as any building owned by the College that is rented out, or that is used by the College but is not connected to the heat plant. This includes buildings occupied by students (i.e. the French House) and those managed as rental properties by High Winds. These audits examine the energy use in a house and make recommendations for improvement projects. 6 units is a recommended number for the initial round of audits. It is probably not worthwhile to audit and renovate all the houses, because they probably won't all be owned forever (according to Tom Welna) and that would be a lot of money for not much gain, so it is recommended that the two houses on Princeton (a duplex and 1673) be audited b/c they are ON the district heating, the Scotsdale building (Breadsmith) because it is large and likely inefficienct with high usage, and either 3 houses on Vernon St. (2 student ones and one professor rental) or 2 houses (1 professor and 1 student) and 77 Mac (because the College will directly receive the gains of reduced energy in this building because it pays the bills. The housing stock in this neighborhood is also quite uniform, so a few representative audits can provide insights into necessary changes in other buildings without conducting audits on each property. There is no activity change because the audits only make recommendations. The changes are in the next project.

Project- Residential Energy Efficiency
Start Year…………………………………………. **2011** (because you have to do the audits first)
Units…………………………………………. **6**
Marginal capital cost per unit…………………………………………. **$5,000** (2008)
Grants…………………………………………. **variable**, for example natural gas furnace rebate $75-$100
http://www.xcelenergy.com/Business/Programs_Resources/ConservationRebates_Incentives_Business/Pages/Heating.aspx
Annual marginal operating cost per unit…………………………………………. **??**

- These would probably save annual operating costs because CFLs, etc. often have longer life spans and require less maintenance

Activity change…………………………………………. **1339 kwh/yr** and **– 37760566 BTU/yr**
Researcher…………………………………………. Louise Sharrow
Contact…………………………………………. ELSharrow@gmail.com
Explanations, assumptions, calculations, etc.- This project is essentially to implement any actions identified in the audit with a 5 year or less payback, as well as basic behavior changes (hanging clothes to dry, etc.). The start year is 2011 to allow for a year for the audits to happen. The units are 6 because that is how many audits I recommended. However, the audits can indicate changes

that should happen in non-audited buildings because the housing stock in this neighborhood is architecturally very similar. The marginal cost is based roughly on EcoHouse numbers for basic projects- they spent a little less than $2,000 on insulation but they were already well insulated so this number will likely be higher in the typical house, a solar tube costs $400, energy star appliances cost maybe an average of $75 extra, and a programmable thermostat costs $60. The activity change is based on reducing consumption by 20%, which according to Mary Morse from The Neighborhood Energy Connection is about the average to low amount you can expect doing these basic activities (i.e., doesn't include revamping hot water systems, etc.). The kwh and BTU are a 20% reduction of the average kwh and ccfs of 3 off-campus buildings from June 2005 through August 2008: 180/182 Vernon, 1662 Princeton and 1668 Princeton. This is one duplex and 2 regular houses, fairly typical for the architecture of this area and the other houses owned by Macalester. The activity change is **problematic** because there is no way to separate the money saved from the carbon saved. For these buildings (with the exception of 77 Mac), the cost savings goes to the tenants who pay the energy bills, but the carbon reductions count for the college. So putting this project in the calculator requires the assumption that the College will find some way to recoup that money. One suggestion would be to raise rents by the amount of money that the energy bills decrease, so the cost to the renter does not increase but the College gets some return on the investment. Also, it is imperative to make sure the proper recycling and disposal methods for old appliances, esp. refrigerators, are utilized.

Appendix: Efficiency 6—Submeter Installation Project Details

Start Year……………………………………**2010**
Duration……………………………………..**10 years (estimated life of submeters)**
Units…………………………………………**42 meters**
Marginal Capital Cost per unit……………....$**1500 (2009 dollars)**
Annual Marginal Operating Cost per unit…..**$231.28 (2009 dollars)**
Impact of Project...**647,236 kwh/year**
Name of the Researcher(s)…………………...**Cael Warren**
Contact Info……………………………......**cael.warren@gmail.com**

Explanation of Assumptions
Duration – Assume a submeter life of 10 years
Units –
Campus Center – No submetering necessary
Kagin– No submetering necessary
Olin-Rice – 3 meters (3 floors). Could be split further, given very high energy consumption, if we can effectively attribute use to certain departments.
Humanities/FAC – 7 meters (4 floors in Humanities, plus one for music, art, and theater buildings)
Carnegie – 4 meters (4 floors)
Old Main – 4 meters (4 floors)
Dupre – 5 meters (5 floors, basement and first floor could go together)
Doty – 5 meters (5 floors, basement and first floor could go together)
Turck – 4 meters (4 floors, basement and first floor could go together)
Bigelow/30 Mac – 5 meters (3 bigelow floors plus a residential basement, 30 Mac)
Wallace – 5 meters (4 floors and a residential basement)
GDD – 3 meters (3 floors)
Kirk – 8 meters (8 sections)
Cultural House– No submetering necessary
Leonard Center– No submetering necessary
77 Mac– No submetering necessary
Weyerhaeuser– No submetering necessary
Stadium– No submetering necessary
Assume each building already contains one meter. 53 meters necessary, of which 11 already exist, so we need 42 additional meters.
Marginal Capital Cost per unit – The price ranges from about $500-$1500. We assume the upper bound because a prominent display of the submeters' information will be essential to its effectiveness.
Annual Marginal Operating Cost per unit – Assume the unit would use about the same energy as a high-energy desktop computer, which uses about 2891 kwh annually. We found this information at http://michaelbluejay.com/electricity/computers.html. We multiply that by the approximate cost of $0.08 per kwh to estimate annual operating costs.

Impact of Project

Controlling for the trend in electricity consumption over time, energy consumption in the spring months (March, April, May) was reduced by about 171,000 kwh per month by having campus/dorm wars in February of that year. In other words, we've consumed 171,000 kwh less per month in the spring months after dorm wars than would be expected from our prior trend. If we captured that effect for the whole academic year (assumed nine months), we would save over 1.5 million kwh annually. (A 95% confidence interval range is 678,168-2,402,939.)

We assume that the energy use feedback associated with dorm wars led to 25% of the observed reduction in energy use from dorm wars, and we attribute the remaining 75% of the reduction to factors captured by the energy efficiency staff position. By this assumption, the limited (weekly) feedback on dorm-level energy use led to an annual reduction of 385,138 kWh, or 3.6% f electricity use in 2008. More frequent and disaggregated feedback should have a greater impact, and research has shown that feedback alone can reduce energy use by 10-15% (Parker et al. 2006). We use a lower figure of 6% to account for the nonresidential nature of some buildings on campus (the study was based on residential buildings) and to account for the overlap in effects between this project and the energy efficiency staff position, despite our optimism about how the socially conscious Macalester community would respond to more complete information about their energy use. Annual reduction is based on fiscal year 2008 electricity consumption.

Parker, Danny, David Hoak, Alan Meier, Richard Brown, "How Much Energy are We Using? Potential of Residential Energy Demand Feedback Devices", Proceedings of the 2006 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Asilomar, CA, August 2006.

Other Notes:

- The more disaggregated the info, the more effective the submeters will be. People are most responsive to feedback on their own behavior, so providing feedback for a building as a whole will be less effective than feedback about one floor of a building, and detail at the room level would be most effective of all (but presumably cost-prohibitive).
- We assume that the information on the submeters is made readily available to the residents/users of campus buildings, as this is crucial to their impact. Given the potentially extremely high return on investment, we must limit expense by reducing the display's prominence; to do so would only reduce the long-term savings.

Appendix: Efficiency 7—Energy Efficiency Staff Position Project Details

Start Year……………………………………2010
Duration……………………………………..10 years (can be renewed)
Units…………………………………………1 full-time position
Marginal Capital Cost per unit……………....$500 (2009 dollars)
Annual Marginal Operating Cost per unit…..$70,000 (2009 dollars)
Impact of Project..1,155,415 kwh/year
Name of the Researcher(s)…………………...Cael Warren
Contact Info……………………………......cael.warren@gmail.com

Explanation of Assumptions

This project is the creation of a full-time staff position in the sustainability office, in charge of creating the energy-saving effect of campus/dorm wars year-round. Getting students, faculty, and staff excited about saving energy will be this person's job.

Duration – Assume a retention period of 10 years

Marginal Capital Cost per unit – Assume cost of hiring a new employee is $500

Annual Marginal Operating Cost per unit – Assume a total cost of the position to be around $70,000 per year. This should be a high estimate, given that the qualifications for the position need not (and, for sake of having a person who can relate easily to students, perhaps should not) be more than a bachelor's degree.

Impact of Project

Controlling for the trend in electricity consumption over time, energy consumption in the spring months (March, April, May) was reduced by about 171,000 kwh per month by having campus/dorm wars in February of that year. In other words, we've consumed 171,000 kwh less per month in the spring months after dorm wars than would be expected from our prior trend. If we captured that effect for the whole academic year (assumed nine months), we would save over 1.5 million kwh annually. (A 95% confidence interval range is 678,168-2,402,939.)

This total effect of campus/dorm wars represents in energy use is due to factors that would be the responsibility of the energy efficiency staff person, which leads to the activity change figure shown above.

Appendix: Efficiency 8—Energy Efficiency Project Ideas

Minifridge Policy

Dorm room refrigerators use more energy than any other student-owned appliances in the dorm rooms, but their use is currently only minimally regulated. Size requirements and (starting in the 2009-2010 academic year) a limit of one refrigerator per double dorm room are a great step toward reducing this large source of emissions, but more can be done. First and foremost, we need a more accurate picture of how many refrigerators are currently used in the dorms in order to form effective policies. If 90% of dorm rooms currently have student-owned refrigerators, the most efficient policy could be to provide an energy-efficient refrigerator in each dorm room and disallow the use of student-owned refrigerators.[66] If, on the other hand, only half of dorm rooms have refrigerators, policies and incentives that encourage against bringing a refrigerator to campus might be the better option. For example, an energy efficiency requirement for student-owned refrigerators (potentially enforced by allowing only approved models) would reduce energy use per refrigerator. In addition, a student energy fee for refrigerator owners could both discourage owning refrigerators and also generate revenue for other emissions reduction projects. Finally, we recommend that Residential Life negotiate with our current refrigerator rental vendor to ensure that the refrigerators available for rental are the most efficient models available.

Computer Energy Efficiency Settings

Computers are also major users of energy on campus, and while computer use is essential to the academic experience that Macalester offers, we recommend the following to ensure that computer use is as energy efficient as possible. ITS has taken large steps toward greater energy efficiency in computer use by using energy-saving sleep settings on all campus-owned computers. These settings, however, are not the default on all computer models, so student-owned computers have not necessarily been set up to conserve as much energy as possible. An awareness campaign, beginning with a prompt (and clear instructions) to change these settings when a computer is initially registered, could be extremely effective and inexpensive. Harvard University has implemented such a campaign, finding that the returns on their relatively small investment were enormous. Energy efficiency settings on student-owned computers are therefore a source of a large reduction in energy use, and encouraging their use should be a very high priority for the Energy Efficiency Staff Person.

Windows

Another large source of inefficiency on campus is inappropriate use of windows in both the dorms and academic buildings. Reducing the number of open windows during the cold months could involve several courses of action depending on the reasons the windows are opened. If campus community members open windows because of uncomfortable temperatures in rooms, more localized temperature monitoring and regulation could be very effective at reducing this behavior. If the motivation for opening the window is ventilation, as is often the case in dorms, simply making students aware that the hallways are ventilated could cause many students to choose the desirable behavior of opening their door rather than their window for ventilation. Understanding the source of the behavior is therefore an essential first step to determining the most effective course of action. Nonetheless, reducing overall temperatures in the buildings could be partially effective as a first step, given that most buildings are warmer

[66] Hamline University has installed one refrigerator-microwave combination appliance in each dorm room, and staff there could be consulted about the impact of this investment.

than necessary in the cold months. We therefore recommend a preliminary one or two degree reduction in temperatures in campus buildings, along with the collection of more information about the motivations for opening windows in campus buildings. With this information, the Energy Efficiency Staff Person can determine evaluate the cost-effectiveness of installing systems of more localized temperature monitoring and control.

Sustainability Resources

Macalester's sustainability website, while improved drastically in the last few years, could still be expanded and publicized much more. Other campuses have extensive sustainability information available on their websites, with a variety of tips and resources for campus community members, and the availability of these resources is made known through posters and other forms of media on campus. Macalester should expand its sustainability website in a similar fashion and make its contents more widely known in the campus community, so that campus community members know more about how they can reduce their carbon footprint on campus.

Appendix: Procurement 1

1) **100% Recycled Paper**

We assumed Macalester uses 6 million sheets of Boise ASPEN 8 1/2 x 11, 20#, #4 Grade White Paper, 30% post consumer recycled content, or 24,000 pounds of paper every year. The college is currently paying $3.45 per ream for this paper, or $0.69 per pound of paper. The list price for the equivalent 100% post consumer recycled paper is $3.55, or $0.71 per pound of paper. When multiplied out, Macalester could be purchasing 100% recycled paper for only an additional $480.00 per year.

2) **Bottled Water**

Culligan bottled water costs $4.10 per 5-gallon jug, and the list price for the same bottled water from Chippewa is $9.00. Assuming similar prices for the rest of the vendors, we calculated the savings per bottle of water purchased to be $4.90. Assuming the 8 departments that do not currently purchase water from Culligan switched, and assuming each department orders 8 jugs per year, we calculated a net savings of $313.60 per year.

Department	Bottle Vendor
English	Kandiyohi
Psychology	Glenwood
ITS	Kandiyohi
Art	Chippewa
Admissions	Chippewa
Development	Kandiyohi
Presidents Office	Chippewa
College Relations	Culligan
Advancement	Chippewa
Athletics	Culligan

3) **Document Services – 100% Recycled Paper**

For this calculation, we assumed Document Services uses 250,000 sheets of paper every year; there are 500 sheets of paper per ream, and 30 reams of paper per case, equaling 17 cases of paper every year (rounded up to the nearest case.) Document services currently purchases 30% recycled paper for $37.50 per case, and Loffler offers 100% recycled paper for $52.50 per case. Multiplied out, Document Services is currently spending $637.50 on 30% recycled, and would need to spend $892.50 to switch to 100% recycled paper, an increase of $255.00 per year.

Appendix: Solid Waste 1

Project Name: Café Mac and Catering Food Waste to Barthold Farms
Start Year: 2009
Duration: Forever
Units: 63 tons per year
Marginal Capital Cost per Unit: -$193.50 (Savings!)
Grants: None, yet.
Annual Marginal Operating Cost per unit: -$193.50 (Savings)
Activity Change: 413 tons to 350 tons of solid waste
Name of Researchers: Ellie Rogers

Contact info valid next year: Jim Davidson and the Zero Waste Committee (http://www.macalester.edu/maccares/zero_waste_committee.htm)
Explanation of assumptions, calculations, sources:

Calculation and assumptions for Units

- 3000-3200 pounds = 1.5 tons = Weekly waste picked up by Barthold Farms
- 48 = Total tons per 32 week occupied school year
- About half as much trash comes out of Macalester during months that school is not in session (Eureka Recycling Baseline), so an assumed .75 tons might be picked up during the other 20 weeks of the year. This totals 15 tons for the rest of the year.
- 63 tons = Total food waste diverted from waste stream

Calculations and assumptions for annual marginal capital cost per unit:

- Since signing on to Barthold Farms, we have lessened regular Veolia waste pickups to 3 times per week from the campus center, as opposed to the previous 6 pickups. This has cut our monthly bill of $1800 bill to $900 per month.
- A usual annual bill from Veolia would be about $1800*8 school months + $900*4 non-school months = $18,000 to Veolia
- The pickup for the hogfarm cost us $581 in March. If we assume the same half-waste during non-school months, we estimate $581*8 school months + 290.5*4 non-school months= $5810 to hogfarm for the same service
- $18,000-$5810 = $12,190 savings with hogfarm
- $12,190/63 tons = $193.50 savings per unit

Project is already done!

Appendix: Solid Waste 2

Project Name: Zero-Waste Campus Phase I – Diverting non-waste waste stream
Start Year: 2010
Duration: 10 years
Units: 271.53 tons (this is a new number because of the reduction from hogfarm project)
Marginal Capital Cost per Unit: *$3257.80* SAVINGS
Grants: None, yet.
Annual Marginal Operating Cost per unit: $*3257.80* SAVINGS
Activity Change: 350 tons to 78.47 tons of solid waste in steady reductions of 27.153 tons per year for 10 years. A total of 271.53 change.
Name of Researchers: Ellie Rogers
Contact info valid next year: Jim Davidson and the Zero Waste Committee (http://www.macalester.edu/maccares/zero_waste_committee.htm)
Explanation of assumptions, calculations, sources: It is assumed that this project can start next year, in fact is already in progress. It is also assumed that Macalester can divert the entire recyclable (37%), compostable (36%), and reusable (8%) waste stream in 10 years. This is a total of 81% of the waste stream, or approximately 334.53 tons per year. The waste stream percentages were taken from the baseline study by Eureka Recycling in 2007, but of course fluctuate. The baseline of 413 tons is taken from the Macalester College Greenhouse Gas Emissions Inventory.

The decrease of 27.15 tons ((350 tons – 78.47 tons)/10 years) per year is necessary to meet the goal, and assumed possible with behavior change strategies implemented by the Zero Waste Committee.

Calculation and assumption of cost of waste contract:

- $18,000 annually (see hogfarm project) for campus center dumpster alone
- There are 11 dumpsters on campus, ranging in size. If we assume 3 at campus center size, 3 at half the size, and 5 at one-quarter of the size, we can assume ($18,000*3 + $9,000*3 + $4,500*5) an estimated annual contract of $103,500. Multiply this by ten years and we have *$1,035,000.*
- The costs of a behavior change campaign, better labels, and some new programming could be anything. We will assume that each year, at student worker would work on this change for 10 hours per week for 32 weeks = 320 hours at $8 pay = $2560. New equipment or spending budget for the process to zero waste could be as little as $2500. This gives us an annual spending of $5060. This cost over 10 years is *$50,600.*
- For each of the 10 years, if we expect constant reduction in waste, we would see our Veolia bill to decrease according to frequency of pickup, weight of load, and locations of pickup. These will all fluctuate in a non-predictable manner in the real world. But for estimation's sake, we will assume a constant decrease. This means that in total, our $18,000 bill will decrease 81% (to match the residual solid waste not taken care of in Phase I) to $3420 in year 10, decreasing by 1/10 annually for an even scale, or $1458. For example, in year one after the first 1/10 reduction in waste, the Veolia bill would be $16,542. The entire 10 years of waste contract at this decreasing scale would cost *$99,810.*
- *The cost of current waste strategies: $1,035,000.*
- *The cost of zero-waste phase I strategy: ($99,810+50,600)= $150,410*
- *$1,035,000-$150,410 = $884,590 SAVINGS over 10 years*
- *$884,590 / 271.53 tons= $3257.798 SAVINGS per unit over 10 years*
- *Annual savings: $884,590/10 years / 27.153 tons = $3257.80 per unit per year*

Appendix: Solid Waste 3

Project Name: Zero-Waste Campus Phase II – Eliminating non-divertable waste
Start Year: 2020 **Duration**: 5 years
Units: 78.47 tons
Marginal Capital Cost per Unit: $192.94
Grants: None, yet.
Annual Marginal Operating Cost per unit: $192.94
Activity Change: 78.47 tons to 0 tons of solid waste in steady reductions of 15.694 tons per year for 5 years.
Name of Researchers: Ellie Rogers
Contact info valid next year: Jim Davidson and the Zero Waste Committee (http://www.macalester.edu/maccares/zero_waste_committee.htm)
Explanation of assumptions, calculations, sources: It is assumed that this project can start next year, in fact is already in progress. It is also assumed that Macalester can reduce the entire non-divertable waste stream in 5 years. This is currently a total of 19% of the waste stream, or approximately 78.47 tons per year. The waste stream percentages were taken from the baseline

study by Eureka Recycling in 2007, but of course fluctuate. The baseline of 413 tons is taken from the Macalester College Greenhouse Gas Emissions Inventory. Hopefully with purchasing shifts and other sustainable changes, the number will actually be less, so this is a high estimate.

The decrease of 15.694 tons per year is necessary to meet the goal, and assumed possible with behavior change strategies implemented by the Zero Waste Committee.

- $3420 is the estimated annual waste contract after Phase I of the Zero Waste project (see Phase I). The cost over 5 years with no change would be *$17,100.*
- The costs of a behavior change campaign, better labels, and some new programming could be anything. We will assume that each year, at student worker would work on this change for 10 hours per week for 32 weeks = 320 hours at $8 pay = $2560. New equipment or spending budget for the process to zero waste could be as little as $2500. This gives us an annual spending of $5060. This cost over 5 years is *$25,300.*
- For each of the 5 years, if we expect constant reduction in waste, we would see our Veolia bill decrease according to frequency of pickup, weight of load, and locations of pickup. These will all fluctuate in a non-predictable manner in the real world. But for estimation's sake, we will assume a constant decrease. This means that in total, our $3420 bill will decrease 100% (to match the zero-waste) decreasing by 1/5 annually for an even scale, or $684. For example, in year one after the first 1/5 reduction in waste, the Veolia bill would be $2736. The entire 10 years of waste contract at this decreasing scale would cost *$6840.*
- *The cost of current waste strategies: $17,100.*
- *The cost of zero-waste phase II strategy: ($25,300+6840)= $32,140*
- *$17,100-$32,140 = $15,140 over 5 years*
- *$15,140/78.47 tons= $192.94 cost per unit over 10 years*
- *Annual savings: $15,140/5 years / 15.694 tons = $192.94 per unit per year*

Appendix: Landscaping 1

Project Name: Conversion of 13.25 acres to functional landscaping
Start Year: 2010
Duration: N/A
Units: 1697.65 pounds synthetic fertilizer
Marginal Capital Cost per Unit: -$4.99 COST
Grants: None (yet).
Annual Marginal Operating Cost per unit: Year one: -$4.99, year two SAVINGS $7.71
Activity Change: From 6790.6 pounds synthetic fertilizer to 5092.95 pounds. (25% reduction)
Name of Researchers: Ellie Rogers
Contact info valid next year: Zoe Hastings, grounds sustainability worker (zhastings@macalester.edu), Jon Sammons and JR Johnson Supplies as Sustane representative and supplier (651)-636-1330.
Explanation of assumptions, calculations, sources:
Functional landscape refers to landscaping, generally native plants, but with some non-natives, planted to mimic a prairie ecosystem with grasses and forbs alike. It is termed functional landscaping because it needs no fertilizer or irrigation once established, just tending. So replacing a fourth of Macalester's land to functional landscaping would then reduce fertilizer use by one fourth as well.

Calculation of current annual cost:

- Fertilizer: 1697.65 pounds of synthetic fertilizer per year costs $.373/pound = $*633.22*
- Assume even labor and maintenance for lawns and gardens to functional landscaping
- Irrigation: 4981.54 square feet at $2.50 per square foot = *$12,453.85*
- *Total current annual cost = $13,087.07*

Calculation of cost with project:

- Seeds: 10 pounds Pure Live Seed needed per acre. 50% forbs, 50% grasses (information from Minnesota. Scientific and Natural Area Program. Going Native : A Prairie Restoration Handbook for Minnesota Landowners. St. Paul, Minn.: Minnesota Dept. of Natural Resources, Section of Ecological Services, Scientific and Natural Areas Program, 2000.)
- 5 pounds of forbs = $1425 for 13.25 acres =$18,881.25
- 5 pounds of grasses = $202 for 13.25 acres = $2676.50 (prices for Northern Upland Mixes from Prairie Restoration Inc.)
- Total =*$21,557.75 one-time cost*

Calculation of marginal cost per unit:

- $13,087.07-$21,557.75 = -$8470.68 / 1697.65 pounds synthetic fertilizer = -$4.99
- Annual marginal cost per unit: year one see above
- Annual marginal cost per unit: year two and on, $13,087.07-$ 0 = $13,087.07/1697.65 pounds = $7.7089

Appendix: Landscaping 2

Project Name: Conversion of all athletic fields to artificial turf
Start Year: 2010
Duration: 10 years

Units: 653.4 pounds synthetic fertilizer
Marginal Capital Cost per unit: $3845.50 SAVINGS
Grants: None (yet).
Annual Marginal Operating Cost per unit: Year one: costs $717.38 per unit, but after that, switches to savings of $506.99 savings per unit
Activity Change: Previously 7444 pounds of fertilizer used, with conversion to turf on 3 acres of athletic fields, we reduce fertilizer use by 653.4 pounds per year, to 6790.6 pounds per year.
Name of Researchers: Ellie Rogers
Contact info valid next year: Zoe Hastings, grounds sustainability worker (zhastings@macalester.edu), Jerry Nelson of Grounds.
Explanation of assumptions, calculations, sources: It is assumed that this project can start next year. Installing turf has already been done on the football field, which is generally a 1.3 acre area. The baseball diamonds make up the other fields in the 5 acre athletic field complex. To make safe estimates, we rounded down to 3 acres of athletic field possible to convert to turf. Each 1000 acres of athletic field requires 5-6 pounds of fertilizer per year.

Calculation of activity change

- 3 acres x 43,560 square feet = 130,680 square feet of athletic fields to convert to artificial turf
- 130,680/1000 = 130.68 areas for application of 5-6 pounds of fertilizer
- 130.68 * 5 pounds of fertilizer = 653.4 pounds of fertilizer used on three acres of athletic field per year

Calculation of original cost:

- From information from Jerry Nelson, 13-13-13 fertilizer is bought in 50 pound bags costing $22 each.
- 653.4 pounds / 50 pounds = 13.068 bags per year
- 13.068 * $22 = $287.496 or *$287.50 per year for buying fertilizer*
- Staff maintenance time: 10 hours/week for 20 weeks/year = 200 hours at $8/hour = *$1600 for staff time*
- Irrigation: at $2.50 per square foot * 130,680 square feet = *$326,700 for irrigation*
- 45 gallons gasoline per year for mowing 3 acres * $2 cost of gasoline = *$90 for gasoline* (estimate from University of Vermont Extension: http://www.uvm.edu/pss/ppp/articles/fuels.html, gasoline cost is current price)
- Total of $328,677.50 per year

Calculation of estimated cost of artificial turf:

- 130,680 square feet of athletic fields
- Artificial turf can cost between $6-8/square foot, according to www.sporturf.com
- 130,680 * $6 = $784,080
- Plus installation, round to $800,000 in year 1

Marginal Cost per unit:

- $800,000 *1 = $800,000 for 10 years of artificial turf
- $331,264.96 *10 = $3,312,649.60 for 10 years for maintenance of grass
- $3,312,649.60-$800,000 = $2,512,649.60 savings over 10 years

- $2,512,649.60 savings/653.4 pounds = 3845.49985 = $3845.50 SAVINGS

Annual marginal operating cost per unit:

- Year one: $800,000-$331,264.96 = $468,735.04 / 653.4 units = $717.38 per unit
- Year two 0-$331,264.96 = -$331,264.96 / 653.4 units = $506.99 savings per unit

Appendix: Landscaping 3

Project Name: Conversion from Synthetic Fertilizer to Organic or "Application of Fertilizer – Organic"
Start Year: 2010
Duration: Forever
Units: 6790.6 pounds fertilizer
Marginal Capital Cost per Unit: -$12.34 (Cost)
Grants: None (yet).
Annual Marginal Operating Cost per unit: -$12.34 (Cost)
Activity Change: Previously 6790.6 pounds per year of synthetic fertilizer. Replace with 186,111.1 pounds of Sustane 4-6-4 Landscaper's Choice organic fertilizer.
Name of Researchers: Ellie Rogers
Contact info valid next year: Zoe Hastings, grounds sustainability worker (zhastings@macalester.edu), Jon Sammons and JR Johnson Supplies as Sustane representative and supplier (651)-636-1330.
Explanation of assumptions, calculations, sources: It is assumed that this project can start next year. The baseline of 6790.6 pounds of fertilizer is taken from the Macalester College Greenhouse Gas Emissions Inventory, with subtraction of pounds eliminated byi installation of artificial turf.

Calculations for marginal capital cost per unit:

- Organic fertilizer cost (Brand = Sustane): $.465/pound at $23.25/50 pounds in 2009 dollars. Price taken from http://www.jrjohnson.com, the Sustane supplier in the Twin Cities.
- Current cost of synthetic fertilizer: Using historical amounts of all three synthetic fertilizers currently in use over 18 years, costs estimated by Jerry Nelson of Grounds.
  - 4000 pounds of 10-10-10 at $22/40 pounds = $2200
  - 36,000 pounds of 46-0-0 at $22/50 pounds = $15,840
  - 94,000 pounds of 18-0-18 at $17/50 pounds = $31,960
  - Grand total of $50,000/18 years, or $*2777.78/year*
  - Grand total of 134,000 pounds/18 years, or 7444 per year
  - $.373/pound
- Cost of organic fertilizer at similar application rates:
  - 7444 pounds per year at 1 pound/1000 square feet = 7,444,444.44 square feet of campus fertilized each year.
  - Sustane fertilizer requires 25 pounds/1000 square feet = 186,111.1 pounds of Sustane to get equivalent coverage annually.
  - 186,111.1 pounds per year at $.465/pound = $86,541.66 annual cost
- Marginal cost = $*2777.78* -$86,541.66 = -$83,763.88

Marginal cost per unit = -$83,763.88/6790.6 pounds = -$12.34

Appendix: Transportation 1

Appendix: Transportation 2

Switching rental fleet from gasoline to biodiesel(B20)

Start Year……………………………………**2012**

Duration……………………………………..**Until hybrid vans are readily available**

Units…………………………………………**6 vans**

Marginal Operating Cost per unit…………… Approximately $700

Impact of Project.. **260 MT eCO_2** annual reduction

Name of the Researcher(s)…………………...**Aparna Bhasin**

Contact Info………………………………......**bhasin.aparna@gmail.com**

Explanation of Assumptions:

- We use B20 (20% biodiesel and 80% diesel) in our estimations as it provides more emissions reductions than B2 or B5, yet is more readily available than B100.
- For cost estimates, we find that historically B20 is approximately $0.20 cheaper than diesel. Using this estimate we project future prices from diesel projections in the Clean Air Cool Planet Calculator.
- Additionally, the EIA finds that on average diesel vehicles are approximately 10% more expensive than their gasoline equivalents. We then apply this increased cost to our rental van contracts.

Appendix: Offsets 1—Offset strategies

Sequestration can take two different forms – geological and terrestrial. Geological sequestration is the process of capturing carbon emissions from a point source and then storing that carbon in underground geological formations (Big Sky Carbon, 2008). This type of sequestration is permanent but requires more technology to perform. It also requires access to geological formations that have the ability to store carbon. These formations include deep saline formations, basalt formations, oil and gas reservoirs, and unmineable coal beds. Estimates show deep saline formations as the best opportunity for carbon sequestration (Big Sky Carbon, 2008). One issue with this type of sequestration is the possibility of leakage (ACUPCC, 2008). The lack of implementation of geological sequestration means that it is not well-researched, and its use of technology makes it much more expensive than terrestrial sequestration. Additionally, a disturbance such as an earthquake could completely reverse projects with geological sequestration.

Terrestrial sequestration is the long-term storage of carbon in soil and vegetation that prevents carbon accumulation in the atmosphere. It can include forest projects, changes in farming techniques, or the planting of native grass species (ACUPCC, 2008). Some of the more common types of terrestrial sequestration are afforestation and reforestation. Afforestation is the planting of forests on lands that have not historically had forests on them (Big Sky Carbon, 2008). Reforestation is the planting of forests on lands that have had forests on them before but no longer do (Big Sky Carbon, 2008).

Although not as common as the aforementioned types of sequestration, avoidance of deforestation can count as a carbon offset (ACUPCC, 2008). Such a plan is easy to use as an offset and can provide a form of conservation, which ties in nicely to the education requirement laid out in the PCC. This type of offset must be additional in order to count as an offset. This form of sequestration is not entirely permanent due to the release of the carbon when the plants die. However, proper forest management can account for dieing trees so that there are no net carbon emissions. Additionally, only complete avoidance of deforestation counts as an offset, meaning that the sequestration will not count if it results in the deforestation of another wooded area instead. Another downfall of this type of project is the measurement of the amount of carbon that the plants are actually taking up (ACUPCC, 2008).

Another way of addressing offsets is through methane projects, which focus mainly on using animal waste in a way that prevents the waste from emitting methane into the atmosphere. These projects capture and destroy the methane by burning it and converting it to carbon dioxide, which is much less potent than methane and therefore an offset. Methane is estimated to be twenty-one times stronger than carbon dioxide as a greenhouse gas (Terrapass, 2009). Some forms of methane capture on farms are anaerobic digesters, lagoon covers, and electricity generators. Another type of methane capture is performed by using the methane captured in a landfill for energy. These projects are fairly straightforward in terms of additionality because the waste would otherwise not be used for anything else (ACUPCC, 2008). A problem with this type of project is the chance for disincentives to regulate landfills (ACUPCC, 2008). As methane capture becomes more profitable, it is possible that the people involved would oppose landfill regulation. Since this regulation likely causes a greater decrease in emissions than methane capture, opposing it could be detrimental and potentially result in greater emissions of greenhouse gases.

Some of the most common renewable energy projects are the development of wind farms. This type of offset is considered a fossil fuel reduction (ACUPCC, 2008). Wind farms provide a source of clean renewable energy, avoiding carbon emissions of dirty energy sources like coal and natural gas. These types of offsets are beneficial due to their payback. They also tend to have clear methodology and accounting as well (ACUPCC, 2008). One fallback of this type of project is the initial cost. Energy production in a wind farm is more expensive due to the nature of the production of power. Wind farms depend on the amount of wind present in an area and only produce energy when wind is actually blowing (ACUPCC, 2008). Another issue is determining who actually owns the project and whether or not it is additional. When using this type of project the user must be sure not to double count the offsets for more than one emitter. In addition to wind, other types of renewable energy projects include photovoltaic solar power, solar thermal, geothermal, hydro, and biomass energy production.

Fuel switching projects fall under the same category of offsets as renewable energy projects due to their avoidance of dirtier types of fuel. This type of offset can be achieved through switching from oil to natural gas for electricity or heat production as well as switching a fleet from gas or diesel to biodiesel or ethanol. These types of projects avoid ambiguity due to the sole ownership of the project.

Appendix: Offsets 2—Offsets providers

- NextEra Energy Resources, a subsidiary of the FPL Group, is based out of British Columbia. Its projects focus on cogeneration and biomass gasification. NextEra works with the EarthEra Renewable Energy Trust so that 100% of the customer's purchase goes to funding the renewable energy projects and the Trust covers the administration and other costs.
- Renewable Choice Energy is an employee-owned company based out of Boulder, Colorado. Their offsets are real, transparent, and quantifiable. Their RECs are Green-e certified, and the American Carbon Registry, part of the Environmental Resource Trust (ERT), certifies their GHG offsets.
- Bonneville Environmental Foundation (BEF) is a Portland, Oregon-based nonprofit organization. They implement solar and wind projects that are Green-e certified.
- TerraPass is a San Francisco-based company with projects focused on wind energy and on methane capture at landfills and on farms. Their offsets are real, additional, permanent, quantifiable, independently-verified, and not double-counted or double-sold. They register their offsets through the Voluntary Carbon Standard (VCS) registry and the Climate Action Reserve.
- WindStreet is based in New Jersey. Their RECs are Green-e certified; their website does not provide any information on their projects.

Appendix: Offsets 3—Offsets & REC Resources

http://apps3.eere.energy.gov/greenpower/ - U.S. Department of Energy's website; includes links to projects and providers of renewable energy certificates and greenhouse gas offsets

CarbonOffsetList.org - provides a list of offset projects approved by the Environmental Defense Fund and reviewed by the Environmental Resources Trust.

http://www.cleanair-coolplanet.org/ConsumersGuidetoCarbonOffsets.pdf - link to Clean Air-Cool Planet's Consumers' Guide to Offsets

http://www.carboncatalog.org/providers/ - list of carbon offset providers around the world

http://www.green-e.org/getcert_ghg_products.shtml - list of Green-E certified companies

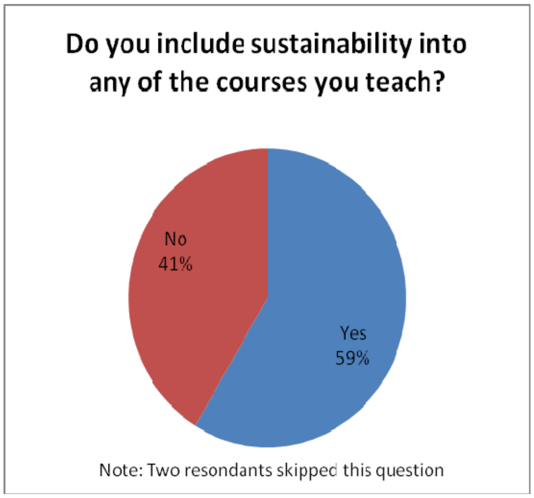
http://www.presidentsclimatecommitment.org/offsetprotocol.php - offset protocol from the American College & University Presidents' Climate Commitment

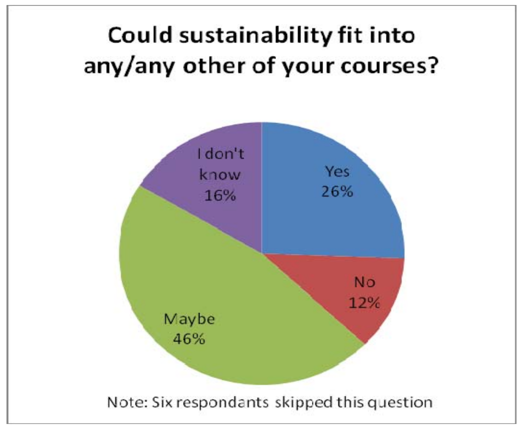
Appendix: Offsets 4—Detailed Price Chart for Offsets and RECs

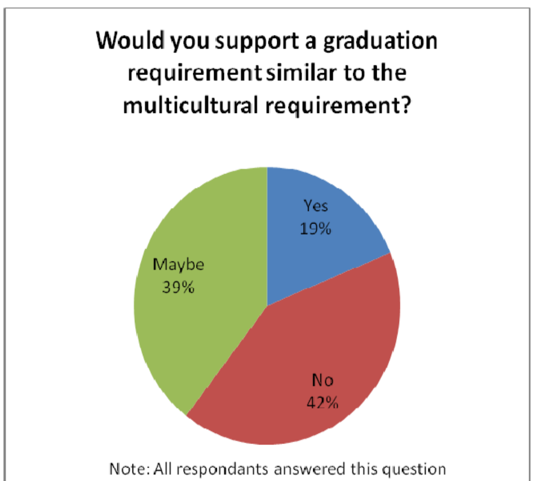
Company	REC price* ($/MWh)	Offset price* ($/MT-CO2e)	Date & Source
BEF - 100% Wind	20.00		3/1/09 website
BEF- 50% Wind & 50% Solar	27.00		3/1/09 website
BEF - 100% Solar	35.00		3/1/09 website
Renewable Choice - Clean Source 2009	5.36		3/30/09 IGC Proposal
Renewable Choice - Clean Carbon 2009		6.28551	3/30/09 IGC Proposal
Renewable Choice - Clean Source 2010	6.37		3/30/09 IGC Proposal
Renewable Choice - Clean Carbon 2010		6.88272	3/30/09 IGC Proposal
Renewable Choice - America Wind 2009	2.62		3/11/09 mtg with Sully Lineberger
Renewable Choice - Choice Carbon		5.48	3/11/09 mtg with Sully Lineberger
Renewable Choice - Clean Source	6.96		7/7/08 IGC Proposal
Renewable Choice - Clean Source	6.64		6/11/08 Macalester Proposal
NextEra - 2009 vintage	4.00	**	3/6/09 email with Joseph Garcia
TerraPass	6.15		3/6/09 email with Mira Karp
TerraPass		13.12	3/6/09 email with Mira Karp
WindStreet - 100% Green-e	4.00		3/10/09 by phone with David Hall
WindStreet - 20% Green-e, 80% tier-2	2.00		3/10/09 by phone with David Hall
Xcel Windsource***	35.30		3/31/09 by phone; on website
prices in 2009 dollars			
***carbon offsets also available through NextEra; no current price quote obtained*			
****renewable energy, but not an REC*			

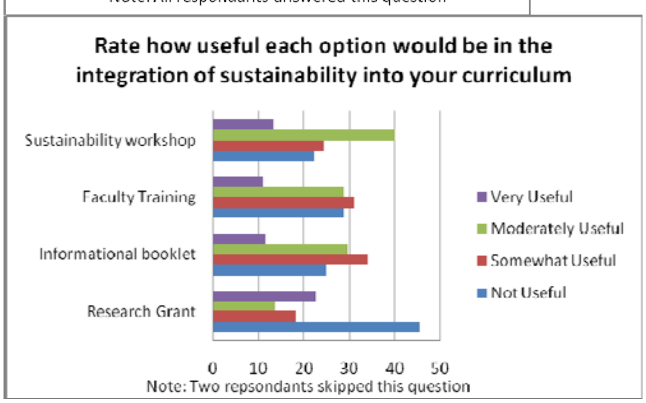
Appendix: Education 1—Survey Graphs

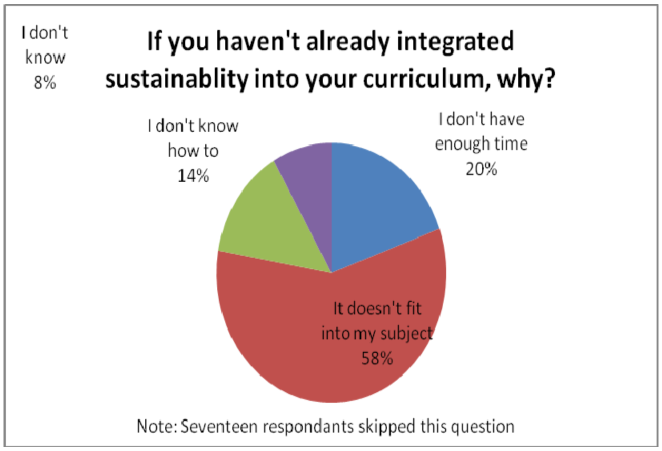
These graphs depict the the answers that we received with our Faculty Survey on sustainability and curriculum. The survey consisted on ten questions, but the six below are the only multiple choice ones that could be graphed. The other questions not represented below asked for feedback on our sustainability definition, the names and the academic departments of the respondents, the courses the teach, and additional feedback. In total we had 48 respondants. We sent out the survey to the faculty list serve with support from Provost Kathy Murray.

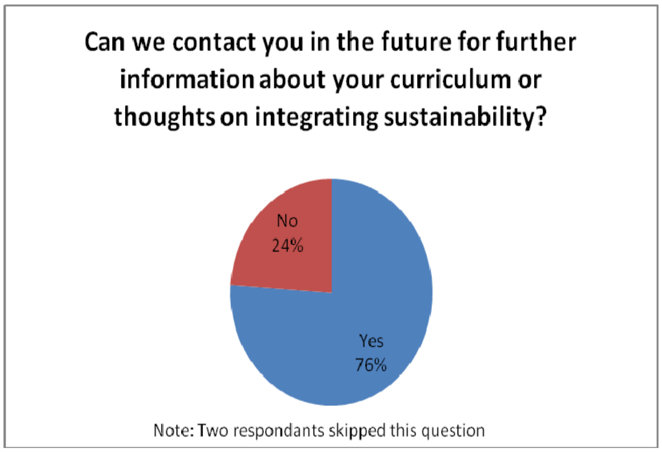












Appendix: Education 2—Current Classes With Sustainability Content

This list reflects only the classes that professors listed in the survey, and is dependent upon their individual interpretations of the classes, the themes they chose to emphasize. We predict that this list could be expanded to include many other classes, if a more holistic definition of sustainability was disseminated to the faculty. Also, whether or not the course absorbs sustainable themes depends upon the professor who teaches these courses as each professor can choose to highlight different aspects within a certain subject.

This list is by no means exhaustive. There are a number of different ways to incorporate sustainability in the classroom, whether through classroom behavioral practices (i.e. saving paper by single spacing documents, encouraging less paper waste, etc.) or by encouraging projects about sustainability, no matter what the subject. For example, students in Jerald Dosch's environmental science class examined a number of sustainability issues on campus including:

storm water runoff, heating fuels and alternatives, energy monitoring, and solar energy. In order to understand the reasons why these classes have been singled out, a more holistic concept of sustainability is necessary.

Anthropology: ANTH 257: Peoples and Cultures of Mongolia, ANTH 294: Peoples and Cultures of China Ethnicity, ANTH 280: Race Topics in Linguistic Anthropology, ANTH 111: Cultural Anthropology. All taught by Naran Bilik.
Biology: BIOL285/ENVI285: Ecology and lab, ENVI133: Environmental Science and lab, BIOL 194: Restoration Ecology and lab (beginning fall 2009) by Jerald Dosh
Classics: Roman World taught by Beth Severy-Hoven.
English: ENGL 135: Intro to Poetry; ENGL 394: Poetry of Environment; ENGL 304: Medieval Monsters, Marvels, and Magic. All taught by Theresa Krier.
Humanities, Media, and Cultural Studies: HMCS 110: Texts and Power, and HMCS 376: Critical Social Theory and the Media taught by Clay Steinman.Media Institutions, Environmental Issues and the Media Critical Social Theory and the Media taught by Michael Griffith.
All **Environmental Studies** courses, including cross listed courses. Courses are cross listed with a variety of departments which include, but are not limited to: American Studies, Biology, Economics, English, Geology, Geography, History, International Studies, Philosophy, Political Science. Some courses are already listed in the above list.

Appendix: Education 3—Department Resource Guides

In many of the interviews conducted and responses for our survey, faculty expressed a frustration that they did not know how to integrate sustainability into their courses or that it was not related. This partially reflects a need for education on the new definition of sustainability, which transcends beyond environmental issues, and includes issues of social and economic sustainability. The recommendation of creating departmental resources guides would help faculty members understand how their discipline related to sustainability. A guide would be made for each department with information on: how sustainability relates to the discipline, courses that already have sustainability components, courses that are particularly relevant to sustainability, classes within the discipline that are offered at other institutions and address sustainability and possible related materials for professors to educate themselves with. This will require a great deal of outside research, interviews with faculty in all departments and a inventory of the sustainability courses. It is preferable that each discipline appoint someone from within their department to aid in the creation of their guide.

These survey responses show different ways that professors have included sustainability into their courses from different disciplines.

"Since I teach a great deal of literature that was composed before the advent of print, students like to hear about scribes, quill pens, the difficulty of making a written page, trying to write in unheated scriptoriums in winter, writing with bad light, therefore the preciousness of books and the written word. My students seem to enjoy entertaining the notion that our new environmental problems, our new economic problems, and our old habits of waste might lead us to some affinity with those pre-print writing technologies. I've even taken classes for demonstrations on the making of the medieval book, at the Minneapolis Center for Book Arts. " – Theresa Krier, English professor,

"Just certain topics as they relate to our practices. Also mentioning the artists whose work centers around sustainability issues."- Anonymous Art Professor

Appendix: Education 8—Step Forward Webpage
http://www.macalester.edu/development/endowedprofessorships/

THE CORNERSTONE OF ACADEMIC RIGOR

The *Step Forward* campaign aims to expand the number of endowed chairs and professorships, creating 10 new named chairs for a total of 31--a nearly 50 percent increase. By supporting a professor's salary with endowed funds, the college's operating budget can meet other pressing needs.

Step Forward Campaign Goals
For Endowed professorships and program support

Endowed funds to support new and existing faculty positions	$22 million
Endowed funds to support new curricular initiatives:	$4.5 million
Total goal for endowed professorships and curricular support:	$26.5 million

New Professorships and faculty fellowships established through the *Step Forward* campaign

Through the leadership and generosity of donors, the *Step Forwar*d campaign has already established five new endowed professorships and faculty fellowships.

OPENING NEW AVENUES FOR SCHOLARSHIP
Priority academic disciplines for new endowed chairs

The new endowed chairs established by the *Step Forward* campaign will enhance scholarship and teaching in disciplines where unique visions and global issues are needed.

Key areas of emphasis identified by Macalester faculty and staff include:

<u>Languages and culture</u>
Key priorities include the creation of an endowed chair or chairs who can teach courses in areas such as Arabic languages and culture, Jewish studies, Chinese language and culture, Latino/a studies, and indigenous peoples of the Americas. Investment in this area will give Macalester the flexibility to expand and strengthen its offering of language courses in order to match

burgeoning student interest.

The Sciences

By creating a new chair or chairs specializing in aspects of the sciences, Macalester can expand the depth and breadth of its curriculum in areas of critical importance such as neuroscience, the history of science, and aspects of the natural sciences such as climatology, epidemiology, materials science, or agriculture/food science.

Arts and Literature

The creation of a new chair or chairs with the expertise to expand courses in areas such as art history, comparative literature, and multimedia arts will provide new avenues for curricular development and bring heightened visibility to Macalester's efforts in these fields.

Emerging Disciplines

Macalester seeks to create a number of endowed chairs with the intent of giving the college the utmost flexibility to meet the needs of emerging disciplines. These chairs will provide the college with a means of ensuring that faculty expertise remains strong in a wide swath of disciplines.

Appendix: Education 9—Student Research
http://www.macalester.edu/studentresearch/fundingsources/index.html#threerivers

Student/Faculty Summer Research Collaboration

The Student/Faculty Summer Research Collaboration program is funded by the W.M. Keck Foundation along with gifts from alumni, friends, corporations and other foundations.

The Student-Faculty Summer Research Collaboration Program enables teams of Macalester faculty and students to engage in significant projects over a four to ten week period during the summer. Projects must be related to the faculty member's curricular, pedagogical, scholarly, or creative interests and should be planned and executed by the student and faculty member working together. The projects should be designed to permit completion of a substantial portion of the work during the summer and result in a creative product by the student (a musical score or work of art exhibited for public, critical review; an honors project or co-authored poster or paper for publication or presentation at a professional meeting; a curriculum module or technology application to be implemented by the faculty; etc.) to be completed by the end of the subsequent academic year.

Arnold and Mabel Beckman Foundation

The Arnold and Mabel Beckman Foundation makes grants to program-related, non-profit research institutions to promote research in chemistry and the life sciences, and particularly to foster the invention of methods, instruments and materials that will open up new avenues of research in science. Arnold O. Beckman was the leader in establishing the modern instrumentation industry by creating innovative measuring and monitoring tools.

Lilly Grant

The purpose of the Lilly Project is to explore and reflect upon the relationship between the work that we do and the values we hold. From the personal to the global, the Project sponsors programs designed to investigate how moral and ethical concerns shape our personal, national, and international understandings of work itself and our own working lives. Some programs guide students in discerning the ideological content of work and the ethical questions embedded in particular types of work. Others offer students opportunities to explore their own values commitments and put them to work in specific settings. Still others aid students in developing their own vocational trajectories, designed around religious or philosophical commitments.

Mellon Mays Undergraduate Fellowship Program

The fundamental objective of MMUF is to increase the number of minority students, and others with a demonstrated commitment to eradicating racial disparities, who will pursue PhDs in core fields in the arts and sciences. The program aims to reduce over time the serious underrepresentation on the faculties of individuals from certain minority groups, as well as to address the attendant educational consequences of these disparities.

National Park Service (NPS)

The National Park Service funded several St. Croix National Scenic Riverway research grants. The research grants focus on improving the understanding of rare mussels living in the St. Croix National Scenic Riverway through demographic analysis, distribution studies, and modeling of endangered species. More information about the St. Croix National Scenic Riverway is on the National Park Service web site (http://www.nps.gov/sacn/). More information about the National Park Service is available at http://www.nps.gov/.

Wallace Fund

The Wallace endowment provides funds for faculty scholarship and associated research expenses. DeWitt Wallace '11 and his wife, Lila, were co-founders of the Reader's Digest and were major benefactors of Macalester, donating more than $50 million to the college in their lifetime. DeWitt Wallace, who died in 1981, was the son of James Wallace, a dedicated and highly regarded early faculty member and president of Macalester. Money from an endowment fund established by Dewitt and Lila Wallace for Macalester continues to provide major support for several of the college's programs, including Wallace Research Grants for faculty. The Wallace Research Grants are intended to support all types of research and creative activity. Funds, up to a maximum of $7,000 may be requested for any research needs, and proposals may include a personal summer stipend.

Three Rivers Mellon Grant

The Andrew W. Mellon Foundation awarded a grant to Macalester College in July 2007 to support the development of the Three Rivers Center. The aim of Three Rivers Center is four-fold: 1) to innovate, assess and refine curriculum that takes advantage of the diverse learning opportunities the Three Rivers offer; 2) to extend conventional instruction into the field through field-based modules integrated into courses and through student-faculty research collaborations undertaken primarily in the summer; 3) to upgrade existing instructional and research facilities and capacities to support the initiative; and 4) to establish and upgrade the human infrastructure for learning, including the creation of long-term partnerships with community groups, academic entities and government organizations.

Appendix: Education 10—First Year Courses

(From 2008-2009 Macalester College Course Catalog)

The goals of the First Year Course requirement are:

*To introduce students to critical inquiry within at least one discipline or interdisciplinary area.

*To instruct students in college level writing (including multiple drafts and appropriate citation of source materials) and library research skills.

*To help students adjust to Macalester’s academic expectations.

*To connect incoming students to advisers who get to know the students well from the start.

*To provide a supportive community of other first-year students with shared interests and experiences to aid in the transition to college. (p. 32 Course Catalog,).

Appendix: Calculator 1

Additional assumptions made for the calculator

Growth

We assumed that there will be no growth in the student, faculty or staff populations. This is in keeping with an institutional plan of stability. We also assume, in the calculator, that there will be no growth in building area. We know that this is not the case. There are several building projects planned, and Markim Hall has already been added since the inventory.

We feel, however that this assumption was necessary and justified. It was necessary because of a problem with the calculator. Many of our projects have activity changes which are a percentage of use (this is particularly true of efficiency projects). The calculator does not have a way to handle this, however, so that the impact of these projects does not change as usage does. Without addressing this problem, the calculator would never show us decreasing emissions as a result of efficiency projects.

We felt it was justified because of a project which does not appear anywhere in the calculator, green building. Essentially, new construction at Macalester must not increase emissions. If that is done, our assumption of no growth is effectively accurate. Much of the construction being planned replaces old and highly inefficient buidings, so emissions could be held flat, even as we add more square footage. A commitment to efficient buildings is very important to both the accuracy of our numbers and the possibility of meeting the goal of carbon neutrality.

Xcel Fuel Mix

We learned Xcel's current fuel mix from their press office. The future retail fuel mixes were extrapolated assuming that Xcel meets it's legislatively mandated Renewable Portfolio Standards. That is, 30% renewable energy (25% wind) by 2020. These projections were entered into the Custom Fuel Mix tab in the calculator ("CustFuelMix"). As a result of these projections *a good amount of our emissions reductions come from changes made at our utility, not on campus.* We also assume that there will not be any changes in the fuel mix after 2020.

Interaction of projects

There are some (mostly efficiency) projects that depend on other (mostly fuel shift) projects. The reductions from the O2 Trim are dependant on a shift to natural gas. The "O2 Trim 2" project appears in the project input and project summary pages and the graphs, but should not properly be regarded as its own project. It is not a new O2 Trim installation (and so has no capital cost). It is the same equipment as in the "O2 Trim" project. It had to be put in as a separate project because it no longer saves natural gas after the switch from natural gas to biogas, but instead reduces our use of biogas and hence costs. The full impact of the energy efficiency coordinator position relies on the installation of submeters.

Discount rate

We assumed a discount rate of 5.00% for all our calculations and projects. This is based off the discount rate used by the college, as quoted by David Wheaton (VP for Admin & Finance).

Prices

All prices, both input and output, are in 2005 dollars.

Energy Unit Conversions

For purposes of this project, a number of our calculations included converting the energy content of each fuel to comparable units. We used the following conversion factors from the U.S. Department of Energy:

1 MMBtu = 6.667 gallons of #6 fuel oil
1 MMBtu = 7.143 gallons of #2 fuel oil
1 gallon of #6 fuel oil = 0.15 MMBtu
1 gallon of #2 fuel oil = 0.14 MMBtu

Carbon Neutrality Target Date Scenarios:

2020

Our first scenario, attaining carbon neutrality by 2020, is based on the assumption that all projects will be implemented as soon as thought feasible. This scenario therefore does not necessarily account for difficulties concerning large capital costs and initial outlays.

2030

The second scenario, attaining carbon neutrality by 2030, changes the timings of the implementation of different projects. In this scenario we recommend implementation of projects with positive NPVs first, while delaying those projects with high capital costs. In this way high initial outlays are decreased by the payback from more profitable projects.

The calculator was prepared by Aparna Bhasin (bhasin.aparna@gmail.com) and Asa Diebolt (adiebolt@gmail.com).

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