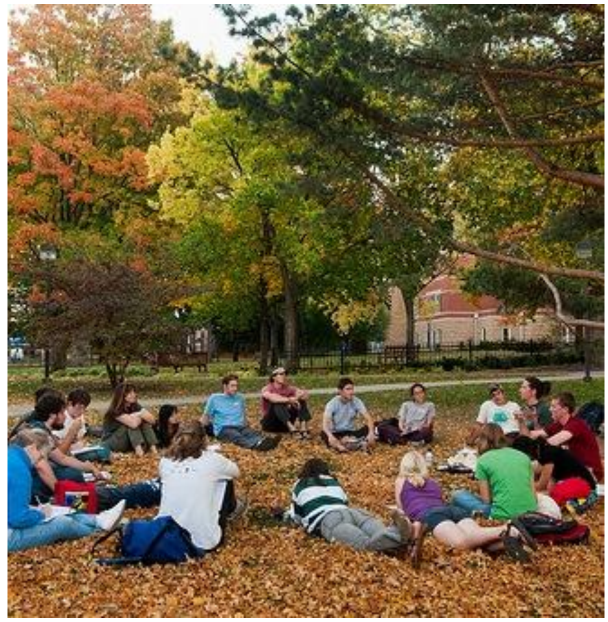
Beyond Efficiency and Offsets:
Re-envisioning Macalester's Climate Action Plan

Macalester college
Environmental Studies Senior Seminar
Spring 2012

Written by the Environmental Studies Senior Seminar of spring 2012

Elspeth Cavert

Elizabeth Foster

Anne Harold

Bryna Helle

Samuel Levang

Clare Pillsbury

Reid Usedom

with invaluable guidance and leadership from our professor:

Professor Louisa Bradtmiller

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Executive summary

This updated climate neutrality plan is designed to account for 100% of Macalester College's climate emissions by 2025 primarily through a large off-site investment in wind in addition to small scale on-site solar and geothermal projects. We recommend a multifaceted approach towards climate neutrality that favors renewable energy technology over offsets. A focus on renewable energy meets our goal of fulfilling Macalester's Presidents' Climate Commitment with strategies that are local, generate new capacity, are financially responsible, and reflect Macalester's core values.[1] The neutrality plan is intended to improve upon the original proposal written by the Environmental Studies Senior Seminar of 2009.[2]

The 2009 plan outlined three steps towards carbon neutrality: invest in energy efficiency, transition to biogas as a heating source, and offset the remaining emissions. The energy efficiency projects have been completed. Biogas is unfeasible due to lack of storage space for the fuel and the absence of a local producer capable of meeting our demand. We are opposed to carbon offsets because they are unreliable, unregulated, and likely to grow more expensive.

We recommend wind energy as the primary strategy because it will bolster local economies, provide educational opportunities, and has the potential to generate a profit. In our plan, 78% of Macalester's emissions will be accounted for by investments in off-site wind farm development. We outline three investment strategies and provide a guide for determining the most fiscally responsible course of action depending on the prices of renewable energy credits (RECs), electricity, and turbine prices in the year 2020, when development should begin. We favor a strategy in which Macalester invests directly into a wind farm in southeastern Minnesota capable of accounting for 78% of emissions, as this option creates the clearest association with new renewable capacity and offers the potential for payback. We also propose two strategies which would require a smaller upfront investment by annually purchasing RECs from other wind farms not under Macalester's ownership.

Smaller percentages of our emissions will be accounted for with on-site solar and geothermal installations. The immediate installation of solar projects on the Vernon St. residences and Markim Hall will account for less than 1% of Macalester's carbon emissions, but have significant value for public relations and academics. Geothermal heating and cooling systems installed in the Spanish House and EcoHouse could provide the same benefits and pay themselves off within five years.[3] In total, our recommended projects will account for the emissions that the 2009 plan intended to cover with biogas and carbon offsets, and allow Macalester to achieve the admirable goal of climate neutrality with solutions that are reasonable, effective, and aligned with Macalester College's mission.

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[1] Mission & History. *Macalester College.* 2001. Web. 30 April 2012

[2] Environmental Studies Senior Seminar. Macalester *College Institutional Action Plan for Climate Neutrality*. Macalester College Environmental Studies Department & Macalester College Sustainability Office. 2009. PDF.

[3] Smith, Brian. Message to author. 23 April 2012. Email.

Carbon neutrality & changing conditions

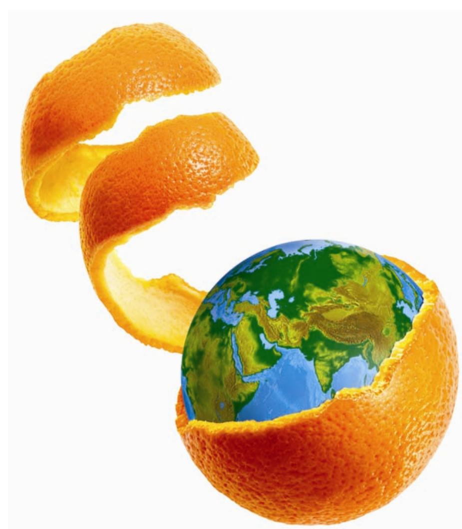
Why Carbon Neutrality?

Macalester is a leader among American colleges in addressing climate change. In 2007, President Brian Rosenberg signed the American College and University Presidents' Climate Commitment (ACUPCC), an action that demonstrated Macalester College's dedication to addressing the global issue of climate change. As a result, Macalester set the goal of becoming carbon neutral by 2025. This commitment establishes Macalester as an ambitious signatory and reflects the focus of our mission statement on academic excellence, civic engagement, multiculturalism, and internationalism.

By participating in the ACUPCC, Macalester College is modeling the necessary collaborative action for reducing carbon emissions. The global scale of the impending effects of climate change requires the cooperation of all nations; joining a group of 676 other educational institutions is one way that Macalester can demonstrate that climate solutions are feasible for urban communities.[4] The responsible and progressive action of our college towards the goal of carbon neutrality will serve as an example of the possibilities available to other institutions and will add to the global reduction of greenhouse gas emissions.

In addition, ethics based on principles of environmental justice dictate that Macalester College should take full responsibility for the consequences of its carbon footprint. While less developed countries are likely to bear the most drastic consequences of anthropogenic climate change, Macalester is part of a nation that is the one of the largest per capita emitters of carbon in the world.[5] Participation in climate change mitigation is therefore in strong alignment with Macalester's mission of internationalism and social justice.

Education, Macalester's highest priority, is another goal of the ACUPCC commitment. Achieving climate neutrality should be a process that provides students with opportunities to learn about the impacts of climate change and create viable solutions. By involving its students in the process of making decisions and implementing projects to achieve carbon neutrality, Macalester is demonstrating its commitment to academic excellence because hands-on experience is a vital component of a leading educational program. Potential for educational value also stretches beyond our campus because this endeavor will serve as an exemplary model of sustainability for the surrounding community. By encouraging innovative solutions, Macalester takes the lead in the movement towards carbon neutrality in the classrooms and in the community.



[4] American College and University President's Climate Commitment Website. 2007. Web. 30 April 2012.

[5] United Nations Development Project. *Unequal Carbon Footprints: Shares of Emissions and Population*. Human Development Report: Indices & Data. 2001. Web. 29 April 2012.

Macalester's Current Situation

The Clean Air/Cool Planet emissions calculator estimates that Macalester emitted 26,824 metric tons of carbon dioxide equivalents in the 2007-2008 academic year, which serves as the baseline for Macalester's carbon neutrality plans.[6]

The most recent campus emissions audit for the 2009/2010 academic year calculates 19,351 metric tons of carbon dioxide equivalents.[7] The reduction is largely due to efficiency projects that were recommended in and implemented after the 2009 plan. There are three low capacity renewable energy sources on campus (a wind turbine and two small solar arrays), but the majority of Macalester's demand is met by non-renewable sources.[8]

Electricity use and heat continue to be the largest sources of emissions (33% of total) followed by transportation (33%). The College's heating and hot water system burns primarily natural gas on an interruptible contract from Xcel Energy, with #2 and #6 fuel oils are used as backup fuel, and cannot be run on renewable fuels at this time. Though transportation emissions could potentially be reduced, they cannot be eliminated. Therefore, we recommend generating enough renewable energy to compensate for emissions from both heating and college-related travel.

Why is a new carbon plan needed?

Macalester's original carbon neutrality plan does not adequately fit the College's needs and mission. Our research has demonstrated that there are now other resources that Macalester can and should utilize in order to meet the ACUPCC goals, generate new renewable capacity, and potentially produce revenue.

Macalester's current Institutional Action Plan for Carbon Neutrality, written in 2009, lays out three primary strategies for achieving carbon neutrality by 2025. The plan recommends implementing a wide variety of small energy efficiency improvements and transitioning Macalester's heat production fuel source to biogas to eliminate 52% of total carbon emissions. The 2009 plan recommends purchasing offsets to eliminate the final 48% of emissions (largely attributed to electricity, air travel and commuting) beginning in 2025. While this plan would succeed in achieving carbon neutrality, it does not advance the College as an environmental leader, reflect the ethics of Macalester's mission statement, create educational opportunities, or encourage financial responsibility.

Following the 2009 efficiency recommendations, Macalester has upgraded its infrastructure, reduced emissions, and saved a considerable sum in electricity costs. Thus, to fulfill the ACUPCC agreement, Macalester will have to move beyond efficiency. We also recommend against following the other two facets of the original plan, transitioning to biogas and purchasing offsets.

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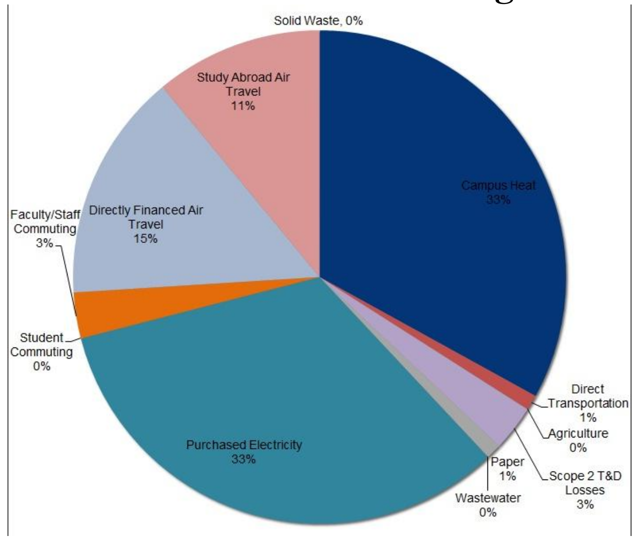
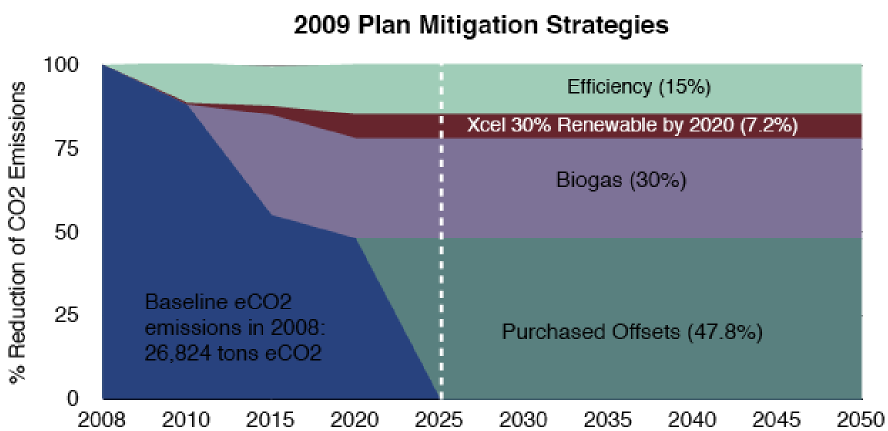
[6] Environmental Studies Senior Seminar. *Macalester College Institutional Action Plan for Climate Neutrality*. Macalester College Environmental Studies Department & Macalester College Sustainability Office. 2009. PDF.

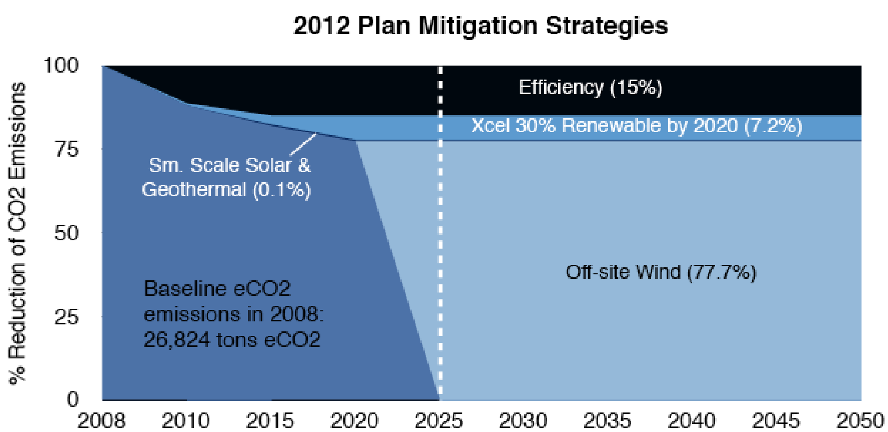
[7] Sustainability Office. *2009-2010 Summary of Greenhouse Gas Emissions*. Macalester College. 2010. PDF.

[8] Sustainability Office. *Sustainability Plan:1st Revision*. Macalester College. 2011. PDF.

Macalester's Carbon Budget







The problem with biogas

Biogas is produced by the breakdown of organic matter through anaerobic digestion. This process produces a gas that is composed mostly of methane and, after processing, can be used in place of a variety of different fuels, including natural gas.[9] A variety of different types of material can be used to produce biogas, including food waste, animal waste, or energy crops like wood pellets or grass. Unfortunately, our research on local sources for biogas and the measures necessary for its implementation shows that using this fuel to operate our heating systems is not a feasible solution for Macalester.

The basic problem with implementation of biogas for Macalester is finding and storing the material to be digested. If we were to use outside fuel sources, wood pellets would be the best option because they are relatively compact and do not emit odor. However, this fuel source would require the construction of storage silos and daily fuel deliveries in order to maintain operation of the system. Four 20-foot wide, 40-foot high silos would be required to hold the pellets, and keeping them stocked would require the delivery of an entire semi-truck load of pellets every day. In addition to the infrastructure costs of building the silos and the digester, the cost of wood pellets is estimated at $220 per ton, which would increase the cost of operating Macalester's boilers by approximately $600,000 a year.[10]

Another potential option for Macalester is to use cafeteria waste. In theory, this would be a more economical and accessible source of organic material, as we would not have to buy material to digest and it would be produced directly on campus. However, Macalester's cafeterias do not produce anywhere near the volume of waste we could need to be able to power the entire campus' heating needs through biogas. In order for this method of biogas production to work, we would need to purchase and store food waste from other locations, which would be more expensive, require more storage space and produce unpleasant odors. Midwest Biogas, which has constructed similar cafeteria-waste digesters in other areas, estimates that almost 20,000 square feet of space would be necessary to store the food waste needed to power this type of digester.[11]

Due to the space constraints on campus and our desire to find economically advantageous carbon neutrality strategies, using biogas on campus at Macalester is not a viable option. In other locations, biogas producers refine their product so it can be directly injected into existing natural gas pipelines. However, no local producers are currently available to develop this type of contract with Macalester.

[9] US Department of Energy. *What Is Biogas?* Alternative and Advanced Fuels. 26 August 2011. Web. 5 March. 2012.

[10] *Macalester College Boiler Plant Study*. 7 February 2012.

[11] Nelson, Nick. *Biogas At Macalester*. Telephone Interview. 3 April 2012.

The case against carbon offsets

In the 2009 action plan, the purchase of carbon offsets - credits which represent remote carbon sequestration projects - accounted for 48% of emission reductions.[12] We recommend against purchasing carbon offsets until all other options have been explored. Though buying offsets appears to be a simple and fast method of achieving our goal of carbon neutrality by 2025, we feel they do not serve the financial or educational goals of our plan.

As a school committed to local community engagement and global citizenship, Macalester must take a wide-angle view in approaching neutrality. Carbon offsets are not an innovative solution and do not enhance our image as a forward-thinking and self-sustaining institution. Carbon offsets will not inspire enthusiasm from current students or funding from our prospective donors. Some believe that purchasing offsets allows people or institutions to assuage their guilt and thereby encourages fuel-intensive activities that may have been less wasteful or never initiated had offsetting not been an option.[13] Worse, offset projects are often dismantled long before capturing the greenhouse gases they were meant to address. For example, forests planted to sequester carbon are sometimes cut down a few years after the carbon credit has been claimed.[14] Another concern is that carbon offset providers are currently unregulated. A number of organizations have attempted to create sets of standards that weed out unsuitable offset providers. However, most consumer guides[15] still advise against choosing the lower-priced products, as these are often instances of double counting, or selling credits for carbon sink projects that would have occurred anyway.

Unlike many of the renewable energy projects detailed in this proposal, purchased offsets provide no return and will never pay themselves off. Currently, carbon offsets cost between $5 and $25 per ton of carbon dioxide. There is no guarantee that carbon offsets will remain in that price range in 2025 or beyond. It is probable that carbon offsets will increase in cost over the long run as more people and institutions attempt to offset their emissions either voluntarily or in accordance with potential future emissions reduction laws. Shifting availability and price of conventional energy sources, changing policy and technological developments could all affect the cost of offsets. One recent analysis of potential scenarios estimates that the price of offsets could rise up to a maximum of $257 per ton, which would bring the cost of offsetting all our emissions to over $3,000,000 a year.[16] In the interest of presenting Macalester with the most progressive, sensible, and financially viable options, unregulated and unpredictable carbon offsets should undoubtedly take a backseat to renewable energy options that provide a return and are already decreasing in price.

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12 Environmental Studies Senior Seminar. Macalester *College Institutional Action Plan for Climate Neutrality*. Macalester College Environmental Studies Department & Macalester College Sustainability Office. 2009. PDF.

13 Anderson, Kevin. "The Inconvenient Truth of Carbon Offsets." *Nature* 484 (2012): 7. Print.

14 Gies, Erica. "A Guide to Offsetting Your Carbon Emissions." *Grist*. Web. 01 May 2012. <http://grist.org/cities/gies2/>.

15 "Verified Carbon Standard." *Verified Carbon Standard*. Web. 01 May 2012.

16 Securities, Eco. "A Report for NWPCC: Forecasting the Future Value of Carbon - A Literature Reveiw of Mid- to Long-term Carbon Price Forecasts." (2009). Web.

Currently unfeasible options

Due to Macalester's size, location and resources we have determined installing a campus-wide geothermal heating and cooling system or large solar arrays are not possible methods of reducing carbon emissions. In addition, cogeneration is also unfeasible at this time as a result of the existing cooling infrastructure.

Large-scale geothermal

Installing a campus-wide geothermal heating and cooling system is not an option for Macalester. Over 31 of the College's 53 acres are covered by buildings, and much of the rest is taken up by trees and additional structures. A vertical loop system for the entire campus would require about 2,400 boreholes spaced approximately 15-20 feet apart. [17] According to Mark Dickinson, facilities director at Macalester College, the project would require 12 acres of open land that Macalester does not have.[18]

Another problem is that a large geothermal heating system at Macalester would require special enhancements that would make it more expensive. The extensive piping needed to connect all the wells in the system would decrease the efficiency of heat transfer, as water in normal geothermal systems tends to lose its intended temperature when traveling over long distances.

One option to avoid this efficiency loss would be to create several geothermal installations connected to individual buildings. This would involve disconnecting the building from the central heating system and installing expensive new equipment, which would not be cost effective. Markim Hall, which has the capacity for geothermal, is already so efficient that it would not be cost effective to install a new heating and cooling system.

Large-scale solar

Minnesota's relatively lukewarm solar radiation rate of 3.68 kWh/day and the current average cost of $7/W installed make large scale solar arrays an illogical option for Macalester at this time. Replacing the entirety of Macalester's emissions would require the equivalent of approximately 18 football fields of open space for the panels, an up-front cost of $83 million dollars, and a payback time of around 52 years - 27 years longer than the average lifetime of a modern solar panel.[19]

Macalester's urban campus lacks the acreage necessary for large arrays of PV panels, and due to Minnesota's relatively weak insolation rate there is little chance of finding opportunities to develop or invest in an off-site farm.

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[17] Dickinson, Mark. Message to author. 13 Feb. 2012. Email.

[18] Dickinson, Mark. Message to author. 13 Feb. 2012. Email.

[19] The Cost of Solar Panels. Cooler Planet. 2012. http://www.solarpanelinfo.com/solar-panels/solar-panel-cost.php

Cogeneration

Cogeneration, or combined heat and power, uses a single fuel source to produce both electricity and heat and is considered to be a highly efficient means of energy utilization. Compared to an efficiency rate of about 30% from traditional power plants, cogeneration plants extract energy from the single fuel source at a rate of 60-80%.[20] These efficiency gains result in benefits such as reduced air pollution, reduced greenhouse gas emissions, increased power efficiency and reliability, reduced grid congestion, and avoided distribution loss.[21]

In order for a cogeneration system to be cost effective, there would need to be a constant demand for steam production. Macalester does not have a high enough heat demand in the summer to maintain production of a constant amount of steam for the system, and therefore electricity would have to be produced by running a generator. This would include utilizing natural gas or fuel oil in an inefficient process (efficiency of electricity production using a generator is around 30%), and therefore would not provide enough energy savings to cover a payback time of five years.

While other colleges and universities have been able to find an additional use for the steam in the summer, it has been mainly through the employment of steam absorption chillers which use heat instead of mechanical energy to provide cooling.[22] Macalester recently installed an electric chiller, which eliminates this potential use for steam at the moment.

Future recommendations for co-generation include installing a heat absorption chiller and a cogeneration system concurrently. As facilities hopes to install new boilers in the next few years, it may be possible to coordinate the installation of a cogeneration system and steam absorption chillers when the boilers are replaced again in a few decades.

Macalester's Absorption Chiller

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[20] Combined Heat and Power- Effective Energy Solutions for a Sustainable Future. Oak Ridge National Library. 1 December 2008.

[21] *Combined Heat and Power Partnership*.United States Environmental Protection Agency. 25 April 2012. Web. 28 April 2012.

[22] Energy Information Library. *Absorption Chillers*. Sacramento Municipal Utility District. n.d. Web. 20 April 2012.

Feasible Strategies and proposal

Macalester should prioritize mitigation strategies that create new renewable energy capacity and attract positive publicity. While any steps we make towards carbon neutrality will demonstrate our commitment to sustainability, more benefits would come from designing thorough, respected, and innovative solutions.

Improving our image as a green college would help attract the interest of prospective students. A 2012 Princeton Review survey of 8,200 college applicants revealed that 69% of rising college students consider an institution's environmental efforts an important factor in their decisions.[23] A visible or creative system of carbon reduction may increase Macalester's applicant pool, which likely to improve the quality of the student body as well as increase Macalester's standing in college ranking systems. Achieving climate neutrality could also attract interest and funding from our alumni.

Finding renewable energy solutions despite our limitations as an urban campus will make us a model for schools and institutions facing similar restrictions. Our size, location, and proximity to a major airport limits our ability to produce renewable energy on site. Despite this inconvenience, the situation poses an exciting challenge to develop a unique combination of on- and off-site projects that still create pathways for education and engagement. Our research on available renewable energy technologies has ruled out several options. At the moment, biogas and cogeneration projects are prohibited by their price and our small area. However, we have multiple options for large-scale wind generation and significant opportunities for smaller solar power projects on campus.

We recommend a multifaceted approach that uses off-site wind energy development to account for a majority of our emissions, and smaller on-site solar power to create educational opportunities, familiarize ourselves with the technology, and illustrate our commitment to sustainability.

Small-Scale Projects

Though small scale projects aren't able to make a significant reduction in campus emissions, having such a visible and traceable means of energy would bring sustainability into the consciousness of students and encourage them to think about sustainability in their daily lives. Their visibility and quantified impact on campus could help normalize renewable energy, helping to make sustainability and climate neutrality less of a special interest on campus.

Finally, this measure could be a visible and inspiring example for the surrounding residential community. Their presence in the neighborhood could very well pique the interest of our neighbors and lead to a more collaborative, community-based project. Seeing Macalester's simple but effective commitment to green energy will solidify its reputation as a sustainability minded entity and perhaps encourage more people who live in the area to take similar measures in their own houses.

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[23] Iovino, Jason. "Green Guide Press Release." *The Princeton Review*. 2012. Web. 17 Apr. 2011.

Solar

Rather than attempting a large solar power project, we propose employing solar on a smaller scale atop the many houses and small buildings owned by the College. This approach would allow us to experiment with multiple forms of solar technology and determine which among them – if any – are suited to the school's needs. Small solar panel installations could become a valuable educational tool, creating opportunities for students to become familiar with the technology and monitor its performance in our specific conditions.

The most auspicious solar opportunity is the residential properties that the school owns, such as the Spanish House and the French House. Innovative Power Systems, a local solar energy firm, has analyzed the potential production of the Spanish House, and returned a realistic plan Macalester could pursue. This plan involves implementing a 4.33 kW photovoltaic array on top of the Spanish House, producing approximately 5,400 kWh, which is more than the Spanish House requires annually. In doing so, it would offset 8,000 pounds of carbon. This proposal would cost around $24,000, which, given the the available rebates and bonuses currently available from Xcel Energy, could be reduced to $9,600. According to the current price of electricity, would pay itself off in just over 22 years.[24]

Aside from producing all of the house's energy and minimizing its carbon footprint, this project would provide many secondary advantages for Macalester. For example, classes like physics and environmental science would have the opportunity to study the dynamics of the panels first hand. Different test methods could be used such as "unplug all electrical devices" month or "turn the heat down" month, where the challenges could track how the measures affect energy consumption, and give students an idea of what does and does not make a significant impact.

Digital mock-ups of solar panels on the Spanish House (Vernon St.) completed by Innovative Power Systems. The images were used to estimate tree cover and array capacity.

[24] Borell, Jamie. Innovative Power Systems. Message to author. 2 Apr. 2012. Email.

Geothermal

Though geothermal is not a feasible large-scale solution for Macalester, small scale projects for residential buildings are recommended. The Vernon Street residential houses that are owned by Macalester appear to be the best candidates for installing geothermal systems, as they are not connected to the central heating plant. However, new geothermal systems would only be cost effective when used to their maximum potential in buildings with air conditioning.

There are two existing houses that already have air conditioning systems installed, 196 and 200 Vernon Street (Spanish House and Eco House). As these two houses are next door to each other, they could share one geothermal system. If Macalester decides to install small scale geothermal system in the future, it would be advisable to connect it to these two houses. The estimated payback time would be 2-5 years. [25]

[25] Smith, Brian. Message to author. 23 April 2012. Email

Large-Scale strategy: wind

Why wind?

There are many economic benefits of wind energy, especially for a farm situated in southern Minnesota. As an investor, Macalester College would benefit from these advantages as well as from the state's strong renewable energy infrastructure. After hydropower, onshore wind power is the least costly renewable energy source. The cost of building and operating a wind farm over its lifetime is cheaper than offshore wind, solar photovoltaics, solar thermal, geothermal, or biomass development.[26] The cost of producing wind electricity continues to decrease; the price has fallen dramatically from 40 cents/kWh in 1980 to 2.5-5 cents/kWh today.[27] Turbine construction has been credited with revitalizing economies by adding to the tax base and creating new sources of income. [28]

The environmental benefits of wind power equal its economic advantages. First of all, wind is a free and inexhaustible resource. Wind turbines do not produce particulate emissions that contribute to air and water pollution. Although wind farms require large swaths of land, the actual footprint of turbines is small and the land can be used for secondary purposes in addition to electricity generation. Wind turbines overall have less of a negative environmental impact per kilowatt-hour than photovoltaics and nuclear plants, not to mention fossil fuel-based sources of energy. The life cycle analysis of wind farm construction is also a favorable environmental aspect of wind generation. Carbon accounting of wind energy should include additional emissions and energy input from the turbine manufacturing, installation, and maintenance. Modern turbines yield over 20 times more electrical output relative to their lifetime input energy, even based on a conservative 20 year life estimate.[29] Therefore, turbines typically recoup their entire lifetime input energy and emissions in less than a year of operation. The energy used to develop and install turbines is 'paid back' within five months and the carbon emitted from the setup is paid back within three months.[30]

Wind power is an especially feasible option for Macalester because of our significant wind resources as well as the infrastructure and expertise needed for further wind development. Over 60% of the 87 counties in the state have average wind speeds above the minimum standard that makes wind projects economically viable.[31] Minnesota is also the headquarters for the country's largest wind farm builder, for several law firms specializing in wind development, and for over 100 companies involved in the manufacturing supply chain of wind turbine components.[32] Minnesota has consistently been ranked as one of the top five states in the nation for current wind power generation.[33] Because of its location, Macalester will be able to buy or create as much wind capacity as the College needs to meet its carbon commitment now and in the future.

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[26] Energy Information Administration. *Annual Energy Outlook 2011*. December 2010. PDF.

[27] Why Wind Energy? *Windustry*. 2012.

[28] "Community Wind." *Windustry*. 2012. http://www.windustry.org/communitywind

[29] Flanagan, Bill. "An Environmental Life Cycle Perspective of Wind Power." GE Global Research. *Workshop on Next-Generation Wind Power: RPI Center for Future Energy Systems*. 12 May 2010. PDF.

[30] Ibid.

[31] Clayton, Billy Steve. "An Interactive Guide to Minnesota's Wind Power. *The Star Tribune*. 11 June 2009. Web.

[32] Positively Minnesota. "Wind Power Overview." *Department of Employment & Economic Development*. 2012. Web.

[33] Minnesota Wind Facts. National Wind. 1 January 2011. Web. 30 April 2012.

Why off-site generation?

The current on-site 10 kW wind turbine, erected in 2003, produces approximately 1300 kWh annually which is less than 1% of campus energy consumption. If Macalester were to meet all of the campus electricity needs through on-site wind generation it would require two to three utility size (1.5MW, 80m tall) wind turbines. In order to account for the carbon produced from electricity, heating and air travel Macalester would need three times that, or 10 MW of wind capacity.

Macalester does not have the space on campus to build a turbine, much less multiple turbines, of that size. In addition, it would be difficult to obtain a permit and public approval for a structure as tall as a utility grade turbine, both of which have stopped recent proceedings for Metro State University's on-site turbine proposal.[34]

Off-site generation of wind power means that Macalester will be unable to directly connect to the energy produced by the off-site wind farm, as it can with the current on-site turbine. This is due to the current infrastructure of transmission lines, the prohibitive cost of building new transmission lines and the inefficiency of long-distance transmission of electricity.[35] Thus, in order for Macalester to be able to account for the campus' carbon emissions from an off-site wind farm, the college must have ownership of Renewable Energy Credits, the accepted way of tracking the environmental benefits of renewable energy.

[34] Melo, F. "St. Paul City Council Rejects Wind Turbine at Metro State." *The Star Tribune*. 4 April 2012. Web.
[35] Wald, Matthew. "Wind Energy Bumps Into Power Grid's Limits." *The New York Times*. 26 August 2008.

Understanding Renewable Energy Credits

A renewable energy credit (REC) is a commodity that represents the environmental and carbon benefits of renewable energy over conventional methods of energy production. When electricity is generated from a renewable energy source (usually wind or solar facilities), RECs are generated according to the amount of carbon-free electricity produced. In this way, RECs are more concrete than conventional carbon offsets in that they are directly associated with the displacement of fossil fuel energy from the electrical grid. They are also bought and sold in a highly regulated market, such that RECs cannot be double-counted.

Purchasing RECs is therefore an accepted means of achieving carbon neutrality without making drastic changes to personal usage, and is a primary strategy employed by a number of "green" corporations including Google.[36] However, RECs do not necessarily generate new renewable energy capacity. Because RECs are tied to a unit of energy produced and not an introduction of new generating capacity, RECs can be sold from existing projects and therefore may not lead to any new generation. RECs are therefore a less direct means of achieving carbon neutrality relative to direct investment in renewable energy infrastructure.

The price of RECs varies depending on the type of market you enter, your region of the country, and the type of energy you buy.[37] [38] There are two broad divisions of the REC market: compliance and voluntary. Macalester would be purchasing RECs on the voluntary market specifically for wind produced in the midwest. RECs that are specifically sourced from wind (rather than from solar or from a mix of renewable energy sources) have considerably cheaper and more stable pricing than RECs sourced from other technologies or from other parts of the United States. Historically wind REC prices in the midwest have been stable at $1/MWh. [39] [40]

Predicting the future cost of RECs depends on several unknowns, the most notable being national climate legislation and statewide renewable mandates. Under these circumstances the demand for RECs would increase substantially, and prices will increase accordingly. Though models are uncertain, REC prices have the potential to surpass $40.00/MWh.[41]

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[36] Google Green. "A Better Web: Better for the Environment." *Google*. n.d. Web. 30 April 2012.

[37] Bird, L. "Overview of Renewable Energy Certificate (REC) Markets." *National Renewable Energy Laboratory*. *FTC Workshop*. 2008. PDF.

[38] Heater, Jenny. Voluntary Market & Renewable Energy Certificate (REC) Overview. *National Renewable Energy Laboratory*. 2011. PDF.

[39] Heater, Jenny. National Renewable Energy Laboratory. Phone Interview. 10 April 2012.

[40] Orest, Yusef. Juhl Wind Development. Personal Interview. 5 April 2012.

[41] Bird, L. "Overview of Renewable Energy Certificate (REC) Markets." National Renewable Energy Laboratory. *FTC Workshop*. 2008. PDF.

Understanding Power Purchasing Agreements

A Power Purchasing Agreement (PPA) is a legal contract signed between the owner of a wind farm and the regional utility provider that specifies a fixed price at which the utility will purchase electricity from the farm owner. This allows wind-based electricity to be incorporated into the greater electrical grid and sold to the public without requiring farm owners to develop their own transmission infrastructure. PPAs are typically long-term contracts of 10-20 years, providing the farm owner with good price stability.

Since the passage of Minnesota's Renewables Portfolio Standard (RPS) in 2007, Xcel has signed numerous PPAs with local wind farm owners at favorable prices of $0.03/kWh or greater.[42] [43] There are several complexities which may alter this number for Macalester's purposes. Firstly, Xcel has already exceeded its short-term goals for meeting the RPS and is currently reluctant to negotiate new PPAs.[44] In addition, standard PPAs are negotiated such that the utility provider claims ownership of the RECs so they can be sold in voluntary markets to earn additional revenue.[45] Negotiating an agreement in which Macalester, the farm owner, maintains possession of the RECs would potentially reduce our contracted price as well as eliminate the College's need to purchase RECs.

Understanding Production Tax Credits

In addition to the price of electricity agreed upon in the PPA, there are state and federal tax incentives available to wind farm owners. Because we are a tax-exempt institution, the college would not be able utilize many of these credits. Therefore, it would be advantageous for Macalester to partner with a for-profit entity (a "tax investor") in any model where Macalester owns a wind farm.

A tax investor assumes a significant portion of the upfront cost and earns the investment back by reaping the tax incentives. Ideally this tax investor would be affiliated with a Macalester graduate who would be willing to accept low rates of return on the initial investment.[46] The outside investors with tax appetite would cover the majority of the upfront costs for Macalester; Macalester would buy out the tax investor's shares in the project after a certain agreed-upon number of years.

This financial model depends on the existence of a tax credit for generating new renewable energy; the federal production tax credit (PTC) for wind expires at the end of this year. It is not clear yet if the PTC will be renewed. However, "since 1999, the PTC has expired on three occasions, and has been extended on five occasions." [47]

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42 North Carolina State University & National Renewable Energy Laboratory.. "Minnesota." *Database of State Incentives for Renewable Energy*. 2012. Web.

43 Facilities Management. "The History of CArleton's Wind Turbine." *Carleton College*. 4 October 2006. Web.

44 Will Cooksey, National Wind. Phone Interview. 27 March 2012.

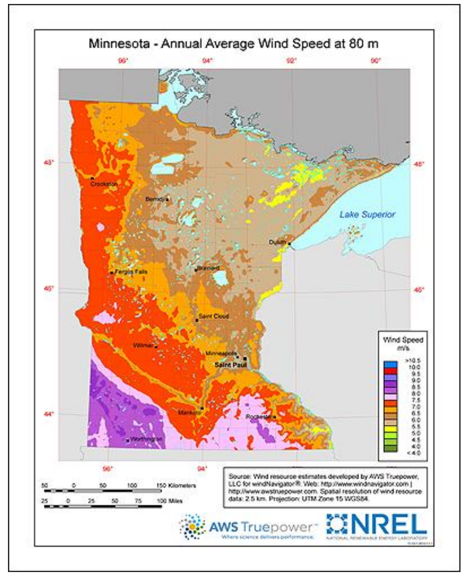
45 In the Matter of Xcel Energy's Petition for a Determination of Entitlement to Renewable Attributes of Energy Purchases Pursuant to Renewable Energy Requirements, Minn. P.U.C., June 2, 2011 (2011 WL 2433555).

46 Orest, Yusef. Juhl Wind Development. Personal Interview. 5 April 2012.

47 Wiser, Ryan. Testimony Prepared for a Senate Finance Committee Hearing on "Clean Energy: From the Margins to the Mainstream." *Wind Power and the Production Tax Credit: An Overview of Research Results.* Hearing, 29 March 2007. PDF.

Estimating Wind Capacity

An off-site wind farm development has the advantage of being scalable such that Macalester has the ability to negate any fraction of its total carbon emissions with a single investment in wind energy. The amount of energy produced by a wind turbine is consistent on yearly time scales, so with some basic assumptions about turbine location and reliability, it is straightforward to calculate the amount of capacity that Macalester would need to invest in to account for different components of its carbon emissions.



Wind sites are characterized by a class system according to the average annual wind speed in the area. Generally class 4 sites and above are considered viable for commercial development of wind infrastructure, corresponding to an annual average speed of 7.5m/s or higher at a tower height of 80m.[48] Because wind is an intermittent resource, an important consideration for determining the actual output of a wind turbine is the capacity factor. The capacity factor describes the ratio of output power to nameplate power for an installed turbine, averaged over long timescales. For a class 4 or greater site (which are abundant in Southern Minnesota), it is typical to assume a capacity factor of 35%.[49] In addition to capacity factor, the effect of downtime caused by regular maintenance operations must be considered. Modern wind turbines are highly reliable, and a typical downtime is less than 2%.[50]

Macalester's ten year average electricity consumption is 13,240,000kWh/year. [51] At a site with 35% capacity factor and 2% downtime, an installed capacity of 4.3MW is required to produce an amount of clean wind power equivalent to Macalester's electricity use.[52] Electricity consumption is roughly one third of Macalester's total emissions; offsetting all of the college's emissions through wind energy production requires 12.7MW of installed capacity, equivalent to 39,000,00kWh/yr of wind energy. This number can be decreased substantially by taking into account Minnesota's Renewables Portfolio Standard (30% by 2020 for Xcel Energy[53]) as well as the planned efficiency measures laid out in Macalester's 2009 carbon action plan. By factoring these reductions into the above calculation, Macalester requires only 30,000,000 kWh per year of clean energy production to compensate for the entirety of its carbon emissions, which can be produced by 10.1MW of installed wind capacity in southern Minnesota.

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[48] National Renewable Energy Laboratory.Classes of Wind Power Density. *Renewable Resource Data Center.* n.d. Web. 30 April 2010.

[49] Wind Logics. Turbine Capacity Factor. *Minnesota Department of Commerce*. January 2006. PDF. mn.gov/commerce/energy/images/80MeterCFWindMap.pdf

[50] Jacobson, M. Z. and Delucchi, M. A. "A Path to Sustainable Energy by 2030." *Scientific American*. November 2009. http://www.scientificamerican.com/article.cfm?id=powering-a-green-planet

[51] Campus Carbon Calculator Spreadsheet. *Macalester College*. 2010. http://www.macalester.edu/sustainability/data/datamain.html

[52] Hahn, B., Durstewitz, M. & Rohrig, K. "Reliability of Wind Turbines." *Wind Energy*, 329-332 (2007).

[53] Minnesota. *DSIRE*. 2011. http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MN14R&re=1&ee=1

Wind Investment Project Strategies

Within the existing market structure, there are several potential ways in which Macalester could claim carbon reductions from an off-site wind project in order to meet our commitment to the ACUPCC:

1. **Macalester purchases RECs starting in 2025 for 30 million kWh of wind energy in order to offset the carbon produced from electricity use, heating, and air travel for the campus.**

2. **Macalester builds or invests in an off-site wind farm much smaller than what would be required to account for all of the college's carbon emissions. Outside investors with tax appetites cover the majority of the upfront costs for Macalester; Macalester buys out those shares in the project after a certain agreed-upon number of years. Macalester does not maintain ownership of the RECs, instead Macalester uses the revenue from the electricity sales to purchase RECs. Therefore, the farm's capacity is sized such that revenue from electricity sales is able to pay for the required RECs (somewhere between 0.2-7MW depending on REC prices and negotiated PPA).**

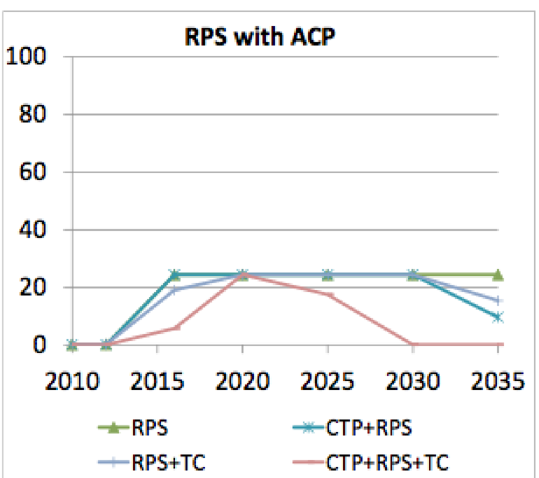
3. **Macalester builds or invests in an off-site wind farm and comes to own 10MW of wind capacity. Outside investors with tax appetites cover much of the upfront cost for Macalester and claim PTC incentives; Macalester buys out those shares in the project after a certain agreed-upon number of years, and Macalester gradually earns back its investment through electricity sales. The negotiated PPA gives ownership of the RECs to Macalester in order to account for all of its carbon emissions.**

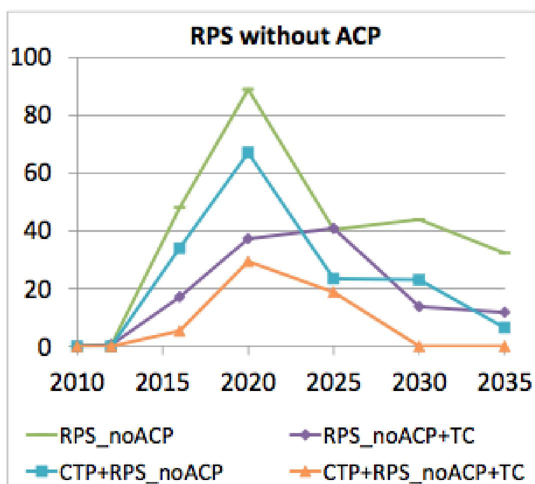
Model Analysis

To analyze and provide a decision-making framework for choosing between our proposed wind scenarios, we developed a basic model to determine under what market conditions each wind strategy is feasible. While strategy 1 is the most favorable financially in current market conditions, strategies 2 and 3 become increasingly favorable with small changes in REC, electricity, and turbine manufacturing markets. Our model outlines the upfront cost, annual cost, and annual revenue for current, best, and worst case scenarios. Turbine cost is the most relevant for upfront cost; REC prices are most relevant for annual cost; and electricity prices are most relevant for annual revenue.

RECs are the best-constrained variable. We are focused solely on the analysis of the voluntary midwest wind REC market and do not include the relationship between the voluntary and compliance markets in our modeling. In the "current" and "best" scenarios, REC prices are assumed to be $1/MWh. This estimation is based on historical data available from the National Renewable Energy Laboratory, phone interviews with staff on the NREL's Market and Policy Impact Analysis Group, and a personal interview with a wind farm developer from Juhl Wind.

From 2005 to now, there has been a $4/MWh range in REC prices (Figure X, below this section, REC graph). [54] [55] Since 2008 REC prices have declined and have held steady since 2009 at $1/MWh. It is unlikely that demand (and therefore, the price of RECs) will increase significantly without new energy legislation.[56] The "current" scenario in the model uses a $1/MWh REC price and (Figure X, the decision making table) uses $1-6/MWh, a range based on the historic range of REC prices plus a dollar. The "current" and "best" scenarios use $1/MWh. In this graph,





[54] Heater (née Sumner), Jenny. Voluntary Market & Renewable Energy Credit (REC) Overview. *National Renewable Energy Laboratory*. 16 June 2011. PDF.

[55] Bird, L. "Overview of Renewable Energy Certificate (REC) Markets." National Renewable Energy Laboratory. *FTC Workshop*. 2008. PDF.

[56] Heater, Jenny. National Renewable Energy Laboratory. Phone Interview. 10 April 2012.

The worst scenarios for each wind investment strategy use a mid-level estimate of REC prices. Professional economic models predicting the price of RECs given various policy scenarios implemented in 2020 demonstrate a large range of potential prices. The models show an initial peak in REC cost (between $30-$90) with the market stabilizing between $1-40/REC depending on the legislation.[57] Our models use $20/MWh and our decision-making figure uses a range of $10-$20/MWh to define favorable conditions for strategy 2.

The second variable in our model, the price of electricity, is less well constrained. We chose to use $0.03/kWh for the "current" scenario after conversations with several wind developers and the VP for Facilities at St. Olaf College (MN) that is currently negotiating a wind contract with Geronimo Wind.[58] [59]Advised by Minnesota-based lawyers with wind development and energy contracting experience, we set the price of electricity in the "worst" scenario at $0.015/kWh to reflect the potential price cut we could receive from Xcel Energy if our PPA were to include ownership of the produced RECs.[60]

Projecting the price of energy into the future is difficult; the price changes every 5 minutes on the wholesale Midwest electricity market, and the future price depends heavily on politics and fossil fuel extraction.[61] We incorporate a generally rising price of electricity, which is consistent with historical trends, but we recognize in our recommendations that the price of electricity is highly variable and could change dramatically.

The third variable in our model, the cost of wind turbines, is generally well constrained in that the worst case scenario is the current actual price. We use $2 million/MW of installed capacity as the cost of construction, situating, and operating industrial sized wind turbines. We have been advised by a staff member of Juhl Wind that $2 million/MW may actually be a high estimate, but we have tried to be both as accurate and conservative as possible. Without any research to support a lower figure, we use $2 million/MW in our "current" and "worst" case scenarios. In general the cost of technology decreases, and although we were unable to find research on the predicted cost of turbines, we have taken the decreasing cost of turbines into account with our model. Our best case scenario wind turbine cost is $1.4 million/MW.

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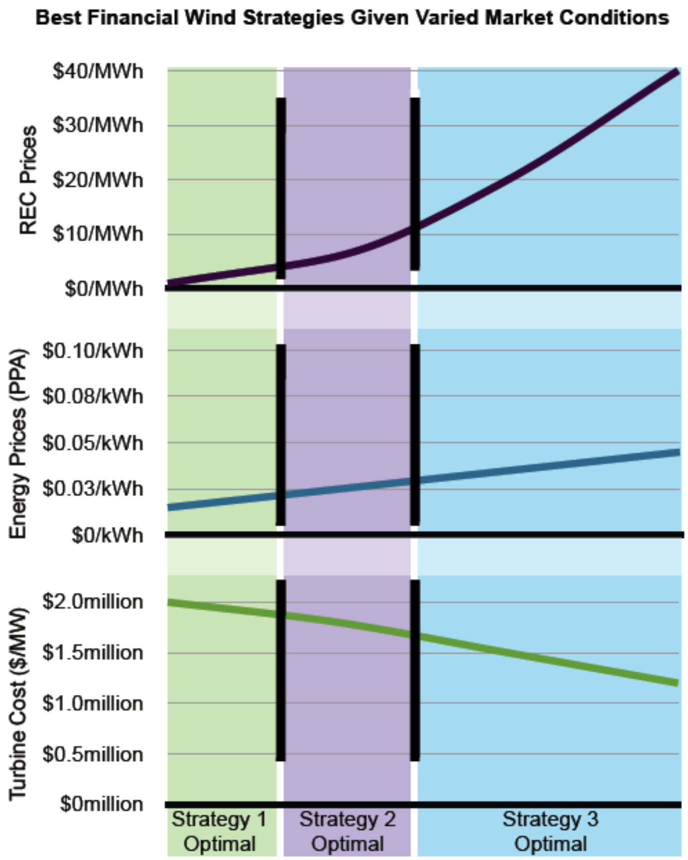
57 Palmer, K., Paul, A., & Woerman, M. Federal Policies for Renewable Electricity: Impacts and Interactions. *Resources for the Future*. January 2011. PDF.

58 Sandberg, Peter. Vice President, Facilities Management, St. Olaf College. Phone Interview. 21 March 2012.

59 Real time data for the MISO (Minnesota Independent Transmission System Operator) market is available here: https://www.midwestiso.org/marketsoperations/realtimemarketdata/pages/lmpcontourmap.aspx.

60 Swanson, Dave and Hensley, Robert. Dorsey and Whitney Law. Phone Interview. 28 March 2012.

61 Sandberg, Peter. Vice President, Facilities Management, St. Olaf College. Phone Interview. 21 March 2012.



This chart is designed to be a tool in deciding between investment options. Given different market conditions, each column shows optimal wind investment strategies. The market conditions we consider here include: REC markets, electricity markets, and turbine manufacturing costs. In the green column, strategy 1 is the best option for the College when REC and energy prices are low and turbine costs are high. In the purple column, strategy 2 is optimal as REC and energy prices rise and turbine costs rest between $2 - 1.5 million/MW. In the blue column, strategy 3 is optimal as REC prices rise above $10/MWh, electricity prices are at or above $0.03/kWh and turbine cost falls below $1.5million/MW.

		Current Market	Best Market	Worst Market
Scenario Description	RECs ($/MWh)	$1.00	$1.00	$20.00
	Turbines ($/MW np)	$2,000,000.00	$1,400,000.00	$2,000,000.00
	PPA Electricity Price ($/kWh)	$0.030	$0.040	$0.015
Strategy 1 Purchase RECs	Upfront Cost	$0.00	$0.00	$0.00
	Annual Cost	-$30,000.00	-$30,000.00	-$600,000.00
	Annual Revenue	$0.00	$0.00	$0.00
	20 Year Cost (Turbine Lifetime)	-600,000.00	-$600,000.00	-$12,000,000.00
Strategy 2 Own Limited Capacity Wind, Purchase RECs	Capacity to buy RECs (MW)	0.3	0.2	13.0
	Upfront Cost	-$391,389.43	-$342.465.75	-$26,092,628.83
	Annual Cost	-$30,000.00	-$30,000.00	-$600,000.00
	Annual Revenue	-$30,000.00	-$30,000.00	-$600,000.00
	20 Year Cost (Turbine Lifetime)	-$652,315.72	-$342,465.75	-$26,092,628.83
	20 Yr 50% Tax Investor	-$326,157.86	-$171,232.88	-$13,046,314.42
Strategy 3: Own 10 MW Wind Capacity and RECs	Upfront Cost	-20,200,000.00	-$14,140,000.00	-$20,200,000.00
	Annual Cost	$0.00	$0.00	$0.00
	Annual Revenue	$900,000.00	$1,200,000.00	$450,000.00
	20 Year Cost (Turbine Lifetime)	-$2,200,000.00	$9,860,000.00	-$11,200,000.00
	20 Yr 50% Tax Investor	$7,900,000.00	$16,930,000.00	-$1,100,000.00
	20 Yr Break Even PPA Price	$0.034/kWh	$0.024/kWh	$0.034/kWh

Strategy 1 Analysis

In strategy 1, Macalester purchases RECs starting in 2025 for 30 million kWh of wind energy in order to offset the carbon produced from electricity use, heating, and air travel for the campus. This option has no potential payback but involves less upfront capital investment. Under the current conditions with low REC prices, this is the cheapest option for Macalester adding an additional $30,000 to Macalester's annual electricity and heating bill. Over 20 years, this option will cost Macalester $600,000 at the current REC price level ($1.00/MWh).[62]

However, should the price of RECs increase, this option becomes increasingly more expensive for the college. Literature reviews of financial modeling studies predicting REC prices given different policy decisions have found that REC prices could reach $20/MWh or higher in 2020.[63] In this worst case situation, the annual cost of purchasing RECs (assuming Macalester's energy use does not increase) is $600,000. Over 20 years, Macalester could spend $12,000,000 to achieve carbon neutral certification.

Committing to Scenario 1 in 2025 and into the future indefinitely is financially risky for the College given the likelihood of climate legislation. In addition to increasing costs, there is little to no potential for alumni donations into a continual purchase of RECs. Scenario 1, although it is convenient with a relatively low upfront cost in the current market, does not contribute significantly to Macalester's reputation, does not directly create new renewable energy generation, and could potentially be prohibitively expensive in the long term for the College.

Strategy 2 Analysis

In Scenario 2, Macalester will build or invest in an off-site wind farm so that the College owns the wind capacity necessary to pay for the 30 million kWh of RECs that account for the campus' emissions. Macalester would work with a third party wind developer and ideally outside tax investors to build and finance the wind farm. A third party wind developer would be in charge of designing, constructing, and operating the wind farm. There are several wind development companies in Minnesota that have contracted or are looking to work with colleges and universities in this manner. Geronimo Wind Energy and Juhl Wind Inc. are two such developers whose staff provided information for this project.

The electricity produced by the wind farm would be sold to the local utility (Xcel Energy) through a PPA. In this scenario, Macalester does not maintain ownership of the RECs generated by the wind development project; instead Macalester would use the revenue from the electricity sales to purchase RECs. This investment strategy does not necessarily generate new capacity equivalent to Macalester's emissions, but it allows a stepping stone into the ownership of renewable energy generation while continuing to incentivise more generation through the purchasing of RECs. It also provides the college with a clear physical symbol to showcase its action towards carbon neutrality.

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[62] Phillips, S.J. "Minnesota PUC Clarifies That 'Other Credits' Includes RECs." *Stoel Rives LLP*. 2 June 2011. Web.

[63] Swanson, Dave and Hensley, Robert. Dorsey and Whitney Law. Phone Interview. 28 March 2012.

Strategy 3 Analysis

In Scenario 3, Macalester will build or invest in an off-site wind farm such that Macalester owns 10.1MW of wind capacity and the RECs linked to the renewable energy produced. The electricity generated will be sold to a utility, likely Xcel. The PPA will allocate to the generator (Macalester College) the benefit of "any tax credits, allowances or other credits" related to the generation facility, giving the College the ownership of all RECs for the 10 MW of wind capacity.[64] It is likely that in the negotiation with the utility for the PPA, the utility will pay a lower price per kWh for the electricity in exchange for Macalester maintaining ownership of the RECs.[65]

Macalester would no longer need to purchase RECs to account for the campus' carbon emissions in this scenario. Instead, all revenue from the wind farm will go to the College. However, the upfront cost for the college is significantly higher than in either of the two previous scenarios. A 10MW wind farm is currently estimated to be a $20 million investment, although there is potential for a lower price in the future. [66]

While still being an off-site solution, this direct method of investment in wind energy provides the clearest association with new capacity and an unambiguous method of accounting for Macalester's carbon footprint. Direct ownership of a large off-site wind farm has never been used by a college as a way of achieving carbon neutrality, and would demonstrate a highly innovative solution to other urban institutions. It is also the only purchasing option for wind energy which offers the potential for a positive return on the initial investment. However, this large upfront cost comes bundled with long-term risk, and unfavorable market conditions could mean that such a project would not pay itself back before the useful lifetime of the turbines expires.

Bottom Line for Wind

Investment in wind energy is an innovative, responsible, and financially viable way of meeting Macalester's commitment to the ACUPCC. If Macalester is to utilize off-site wind energy as its primary strategy for achieving carbon neutrality by 2025, the college should spend the next 5-8 years watching the relevant political and market trends.

A conclusive decision should be reached several years in advance of the 2025 date, such that the chosen project can be online in time to meet the ACUPCC commitment. As our models indicate, there is uncertainty in financial projections associated with this field which could exceed even the wide cost range we have given. Therefore, the scenarios presented here should be used only as a guideline and should be reassessed regularly according to current market conditions.

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[64] Phillips, S.J. "Minnesota PUC Clarifies That 'Other Credits' Includes RECs." *Stoel Rives LLP*. 2 June 2011. Web.

[65] Swanson, Dave and Hensley, Robert. Dorsey and Whitney Law. Phone Interview. 28 March 2012.

[66] American Wind Industry Association. "10 Steps to Developing a Wind Farm." March 2009. PDF.

CONCLUSION

In this revised carbon neutrality plan, we rule out the renewable energy options proposed in the 2009 *Institutional Action Plan for Carbon Neutrality* and propose a new set of recommendations focused on off-site wind investment. Biogas, once thought to be a viable option, is not currently feasible for implementation at Macalester. No local producers exist to supply Macalester with this fuel, and onsite generation would require more storage space than the campus could accommodate. Converting the college's heating plan to a cogeneration system was also determined to be infeasible due to existing infrastructure constraints.

Geothermal heating and solar electricity generation are two other renewable technologies that are not suitable for large-scale implementation at Macalester, primarily due to space constraints and prohibitively high costs. It may be possible to install small-scale geothermal and solar systems on the college owned residential houses for educational purposes.

Small scale geothermal and solar projects, although making only a minimal contribution to achieving carbon neutrality, will provide educational opportunities for students. While biogas, cogeneration, solar, and geothermal are do not currently offer realistic possibilities for large-scale development, these technologies should be regularly re-evaluated as limitations based on high cost and space requirements may improve in the future.

In addition to further investigating small scale geothermal and solar installations, our new recommendations include investing in one of three possible options for off-site wind farms to account for 78% of Macalester's CO_2 emissions. Selecting the most fiscally responsible method for investing in wind energy will require knowledge of current market conditions, including the price of RECs, electricity, and wind turbine infrastructure in the year 2020, when development should begin.

We recommend direct ownership of a wind farm (Strategy 3) most highly because it represents the most concrete way for Macalester to achieve carbon neutrality, and also offers the potential to pay for itself in the long-run. Wind investment Strategies 1 and 2 are also acceptable options given different market conditions.

Implementing these updated recommendations will allow Macalester to fulfill its commitment to carbon neutrality by 2025 through the ACUPCC with strategies that are financially responsible and reflect the core values of Macalester.

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Brian Smith, Geotechnologies

Frank Hartranft, Michaud Cooley Erickson

Louisa Bradtmiller, Professor

Mark Dickinson, Director of Facilities Services

Suzanne Savanick Hansen, Sustainability Manager

David Wheaton, VP for Administration & Finance

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