EVER-GREEN ENERGY™

Carbon Neutrality Briefing

UNIVERSITY OF MINNESOTA MORRIS

AUGUST 2020

ACKNOWLEDGMENTS

Ever-Green Energy would like to express our gratitude to the University of Minnesota Morris, Troy Goodnough, Bryan Herrmann, Marc Brosius, and Quinton Dornisch. Their hard work, support, direction, and vision has been essential in the development of this report.

ABOUT REPORT AUTHOR EVER-GREEN ENERGY

Ever-Green Energy (Ever-Green) selected the University of Minnesota Morris as part of its 2019 cohort for the Roadmap to Carbon Neutrality program. As part of this program, Ever-Green worked with campus leadership to analyze the existing carbon profile and provide recommendations for near-term actions to achieve carbon neutrality goals. This program complemented the district energy system planning that Ever-Green previously has provided the University of Minnesota Morris, where we identified opportunities for the university to serve several other buildings within the Morris, Minnesota, community.

Ever-Green takes pride in being one of the country's premier district energy system experts, with decades of experience in developing, operating, and managing district energy systems. The team brings a unique combination of technical expertise, business acumen, and operations experience to help municipalities, colleges and universities, health care campuses, and government organizations advance community and campus energy systems. The Ever-Green team applies its depth of knowledge through every step of a system's development and implementation, finding sustainable solutions that are reliable and financially viable to secure a community's energy future. Learn more at ever-greenenergy.com.

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EXECUTIVE SUMMARY

Background

The University of Minnesota Morris (UMN Morris) was one of three college and universities selected for energy planning services as part of Ever-Green Energy's pilot Roadmap to Carbon Neutrality program. Ever-Green launched the Roadmap to Carbon Neutrality program to help campus leaders create actionable plans to make their sustainability and carbon neutrality goals a reality.

UMN Morris was selected for this program for several reasons, including the progress already made toward carbon neutrality, the unique technical and geographic dynamics of their campus, the opportunities for demonstration projects, the potential of integration of solutions with the surrounding community, and a demonstrated record of collaboration and implementation. UMN Morris also had the most ambitious goal to achieve carbon neutrality of any of the 2019 Cohort, with a 2025 deadline. The process for the study is outlined in Appendix V.

Defining Carbon Neutrality

With historic efforts focused on renewable electricity and efficiency, the Roadmap program offered the UMN Morris campus an opportunity to address another key aspect of Scope 1 and 2 carbon emissions: thermal operations. The thermal operations for UMN Morris account for 93 percent of their current carbon profile, therefore addressing the thermal profile is an essential part of achieving their overall carbon and climate goals.

For context, greenhouse gas (GHG) emissions, and carbon specifically, are measured via different levels of scope. The Greenhouse Gas Protocol[1] is the most widely recognized accounting tool for measuring and managing GHG emissions. The GHG Protocol first defines direct and indirect emissions. Direct emissions include sources owned or controlled by the reporting entity. Indirect emissions are attributed from activities related to the reporting entity, but occur elsewhere. GHG Protocol categorizes these into three primary areas of scope:

- Scope 1: All direct GHG emissions.
- Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat, or steam.
- Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g. T&D losses) not covered in Scope 2, outsourced activities, waste disposal, etc.

For the purposes of this report, and in keeping with other formal tracking systems, the term "carbon-neutral" refers to striking a balance between carbon generated by on-campus activities and offset either by off-site carbon-free or carbon-reducing activities. Since UMN Morris already produces enough renewable electricity to power the campus, the focus of this study was on alternatives for carbon-free thermal operations.

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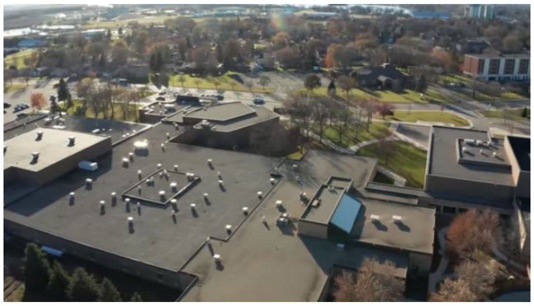
[1] Calculation Tools: FAQ. Greenhouse Gas Protocol. 2012. Accessed August 2016. http://www.ghgprotocol.org/calculation-tools/faq

Advancing UMN Morris Toward Carbon Neutrality

This is an ambitious goal; however, this campus has one of the most advanced renewable electricity portfolios in the US. In 2019, UMN Morris was named the top school for renewable electricity generated on campus per full-time equivalent student, according to a report by Environment America Research and Policy Center[2]. It leads a list of only 40 schools that have achieved 100 percent carbon-free electricity. Comparatively, there are only seven schools that have achieved carbon neutrality, according to Second Nature[3], a national organization that enables tracking and facilitating carbon neutrality commitments in higher education. All of the schools that have achieved this milestone have done so with offsets. Offsets can be a necessary part of decarbonization strategies, however, the schools striving toward carbon neutrality also recognize they must reduce their carbon impact at the source as much as possible.



UMN Morris has clearly established a nationally-recognized sustainability program and clean energy platform, with a demonstrated preference for on-site solutions. The majority of campus power, about 60 percent, is generated by two University of Minnesota-owned 1.65 megawatt wind turbines. Additional green electricity is generated by several solar photovoltaic systems and a back-pressure steam-turbine at the biomass gasification plant.

UMN MORRIS CARBON NEUTRALITY STUDY GOALS

- Deliver long-term, cost-competitive energy
- Develop carbon neutral energy solutions
- Improve energy resilience and sustainability by utilization of local resources
- Eliminate continual fossil fuel usage and related emissions
- Provide a means for UMN Morris's goal of being carbon neutral in the near future

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[2] https://environmentamerica.org/sites/environment/files/Environment-America-Renewable-Campus-Scorecard-4_4_19.pdf

[3] https://secondnature.org/media/colleges-commit-to-carbon-neutrality-getting-there-is-hard/

Findings

At the completion of the study activities, the following findings were identified and validated with the UMN Morris team.

RENEWABLE ENERGY OPPORTUNITIES

Several alternatives were compared in this analysis to determine the most cost-effective and implementable alternatives to business as usual (BAU), which involves the combustion of natural gas to heat campus buildings. For the purposes of this study, BAU assumed upgrades to certain buildings' HVAC systems, along with necessary end of life replacement of system components. The BAU also assumed conversion of the steam distribution system to hot water upon the end of the steam system's useful life, as compared to the alternative scenarios that assume this happens sooner.

Six additional scenarios were evaluated and found to be viable for decarbonization of the campus heating system. The report includes a more detailed assessment of each of these alternatives, including:

- Biofuel, such as biodiesel
- Biomass, such as wood chips
- Geothermal coupled with ground-source heat pumps
- Ethanol plant waste heat recovery
- Solar PV with thermal storage
- Wind with thermal storage

DECARBONIZED ELECTRICITY

UMN Morris will continue to pursue opportunities to decarbonize its electric profile. UMN Morris has a well-established relationship with Otter Tail Power Company, and they are collaborating to leverage the benefits of the wind generation installed in Morris, Minnesota.

DISTRIBUTION

Converting the steam distribution system to hot water is a key element of most proposed decarbonization solutions. A closed-loop hot water system will greatly reduce the temperature of the water used to heat buildings and reduce the fuel and energy demands to supply the system. Utilizing hot water also enables access to more carbon-free thermal energy sources, and improves overall campus efficiency.

EFFICIENCY OPPORTUNITIES

The campus has an admirable program and list of accomplishments for energy efficiency improvements. Efficiency is often an area of perpetual improvement and several key projects were identified for near-term investment, including the following activities:

- Refine operation protocols to optimize equipment performance
- Install exhaust gas energy recovery economizers and outside air economizers
- Install variable frequency drives (VFDs) for all equipment with larger motors
- Improve controls systems in the central plant to enable refined operation protocols
- Implement building instrumentation controls to conform to ASHRAE standards ensuring broad supply and return water differential temperatures, optimizing pumping and providing meter feedback for improved monitoring, troubleshooting and operations staff interaction

Findings Continued

COMMUNITY INTEGRATION & SYSTEM EXPANSION

The scope of this study was focused on the UMN Morris campus, however, in 2017 Ever-Green conducted a district energy study, that in addition to UMN Morris, included Stevens Community Medical Center, and ISD2769 high school, elementary school, and middle school buildings in proximity to the campus. Community integration was not a detailed part of this study, but these connections should be considered if the other recommendations are pursued.

ANTICIPATED GHG REDUCTIONS

Implementation of the proposed district energy system is estimated to reduce the amount of GHG emissions at UMN Morris by an estimated 10,000 tons of carbon dioxide per year, a reduction for the campus heating and cooling systems of 98 percent from the 2018 baseline. This is the equivalent of 2,000 cars per year.

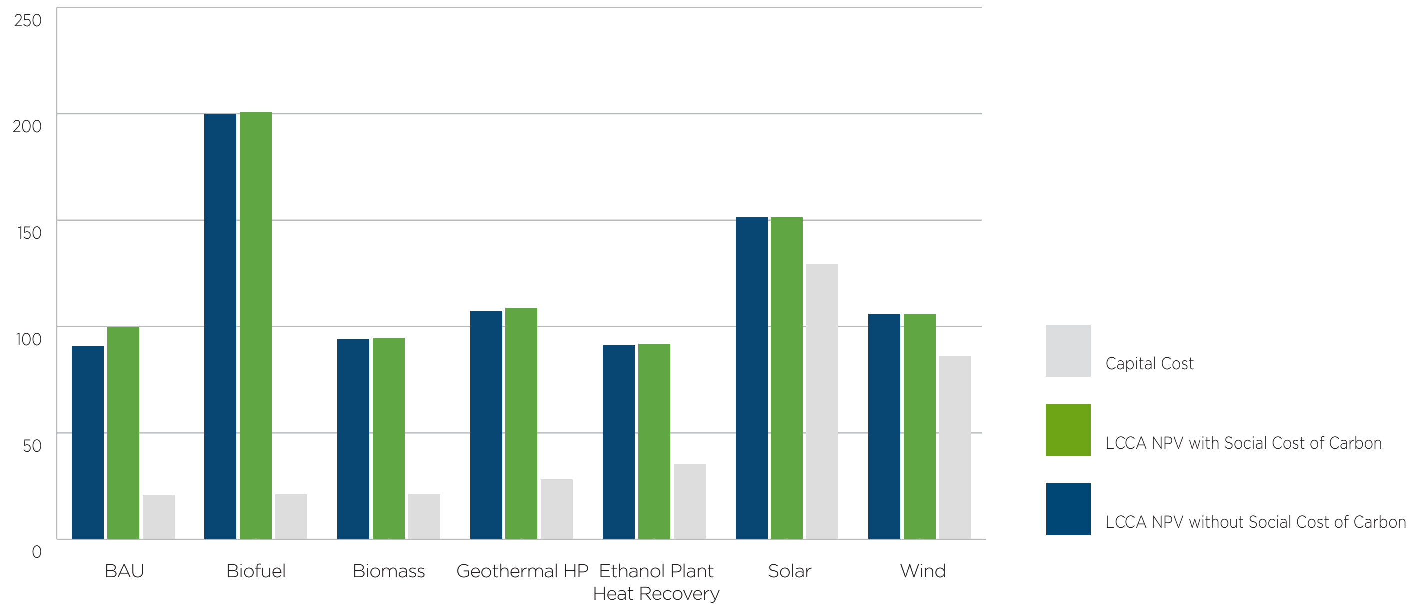
ALTERNATIVE FINANCING & MATERIALS

Several strategies were also identified to improve the financial outlook for the alternatives, including the pursuit of renewable energy credits, utilization of rebates and grants for implementation, directional drilling of distribution piping, and use of newer piping materials that, under the right circumstances, offer lower total cost. These lower-cost piping systems are usually polymer-based and have the added advantage of being corrosion resistant and requiring less chemical use for water treatment. These potential materials should be investigated if system design progresses.

FINANCING FUTURE PROGRESS

The six renewable energy decarbonization scenarios were evaluated for financial viability, looking at both up-front capital costs and life-cycle costs. One iteration of life-cycle cost analysis also included a variable for social cost of carbon at $35/ton avoided. Of the alternatives, biomass, geoexchange, and industrial heat recovery (from the ethanol plant) had compelling life-cycle costs when considered in net present value.

Net Present Value in Millions (30 years)



Next Steps

UMN Morris has several options available to significantly reduce carbon emissions in a cost-effective manner. Coupled with transitioning the campus from steam to hot water, enhanced utilization of biomass, waste heat capture from Denco II, and geothermal with heat pumps can each enable the elimination of nearly 10,000 tons of carbon emissions per year. While some of these technologies are more cost-effective than others, each can be implemented in a cost-competitive manner while investing in the local Morris community. Because carbon accounting is highly technical and evolving, we recommend that UMN Morris reviews guidance by the Greenhouse Gas Protocol (or other recognized carbon accounting standards) for any final determination regarding how these approaches would impact the campus carbon footprint.

Should UMN Morris choose to proceed with decarbonization, a prudent strategy may be to first focus on the conversion of the campus from steam to hot water. This conversion would improve campus efficiency, reduce carbon emissions, and set the foundation for incorporation of the preferred carbon-free solution, once it is selected. Preliminary design of the system conversion is required to validate the assumptions utilized in this Study, or modify as appropriate. Design should be sufficiently developed to verify the viability of each preferred carbon-free energy source, obtain construction estimates for the work, and commence any regulatory and land use discussions that may be needed for implementation. Financial modeling should be enhanced to reflect UMN Morris' preferred financing and implementation approach, and to the extent desired, enable integration with the Morris community. UMN Morris should also perform an assessment of available grant and rebate opportunities that could be applied to improve financial viability.

1. INTRODUCTION

Morris, Minnesota, (Morris) is home to the University of Minnesota Morris (UMN Morris). UMN Morris has existing district heating and cooling systems that distribute steam and chilled water from a central plant to campus buildings. UMN Morris was selected to participate in an Ever-Green Energy (Ever-Green) pilot program called the Roadmap to Carbon Neutrality. This carbon neutrality study (Study) presents multiple alternatives for UMN Morris to achieve carbon neutrality at its campus.

1.1. Carbon Neutrality Study Goals

Ever-Green and UMN Morris collaborated to define a set of goals for carbon neutrality at UMN Morris, providing Ever-Green with direction during the development of this Study. The goals are as follows:

- Deliver long-term, cost-competitive energy
- Develop carbon neutral energy solutions
- Improve energy resilience and sustainability by utilization of local resources
- Eliminate continual fossil fuel usage and related emissions
- Provide a means for UMN Morris's goal of being carbon neutral in the near future

1.2. Process

At the onset of this Study, Ever-Green and UMN Morris team members participated in a project kickoff where UMN Morris shared their vision for an energy system that would serve UMN Morris. Ever-Green gathered information on the existing buildings' generation assets, building mechanical systems, square footage, and occupancy. UMN Morris staff assisted with this data gathering process.

Using the gathered information, Ever-Green developed an energy consumption profile for UMN Morris. Once loads were established, energy supply and distribution options were evaluated, and capital investments and system life cycle costs were estimated in a 30-year life cycle cost analysis (LCCA) model. The model compares the costs and carbon profile for UMN Morris to heat, cool, and power the UMN Morris campus under the business as usual scenario against several low-carbon energy solutions over that time period. The process is explored in greater detail in Appendix V.

2. ENERGY LOAD PROFILE - BUILDING CONSUMPTION

The scope of this Study and estimated heating and cooling loads considered only UMN Morris buildings. In 2017 Ever-Green conducted a district energy study[4], that in addition to UMN Morris, included Stevens Community Medical Center, and ISD2769, which includes the high school, elementary school, and middle school buildings in proximity to the UMN Morris campus. The purpose of the 2017 study was to identify opportunities for leveraging the UMN Morris heating infrastructure to implement a community energy system with the city of Morris. Non-UMN Morris facilities were not part of this current Study, but they should be considered if UMN Morris determines to proceed with the recommended strategies.

2.1. Existing Buildings

2.1.1. Heating

There are 36 existing campus buildings, with 24 currently served by UMN Morris's central plant. The 24 buildings currently receive steam, with 16 converting to hot water heating at the building. Four of the steam buildings are currently planned to be converted from steam to hot water internals by 2025 (Multi-Ethnic Resource Center, Camden, Baumler, Education). Table 1 shows UMN Morris campus buildings' heating service status.

Table 1. Building heating service status

HEATING SERVICE STATUS

Current Internal Mechanical Systems	Conversion Status	Buildings	Square Feet	Load MMBtu/hr
Hot water	Converted	16	740,429	17.6
Steam	Intended	4	59,127	1.4
Steam	Future	4	118,782	2.8
Gas	Not Planned	5	20,076	0.5
Electric	Never	2	4,185	0.1
None	Never	4	26,477	0.0

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[4] Morris, MN - Energy System District Energy Feasibility Briefing, July 2017

2.1.2. Cooling

Thirteen buildings are currently served by UMN Morris's central cooling plant, and two additional buildings receive a combination of district and on-site electric cooling. Ten other buildings have on-site cooling and ten others have none. The cooling status of campus buildings is shown in Table 2.

Table 2. Building cooling service status

COOLING SERVICE STATUS

Current service	Buildings	Square Feet	Load Tons
District cooling	13	627,997	786
Combination of district cooling and on-site cooling	2	70,396	88
On-site cooling	10	222,839	279
None	10	47,844	0

2.1.3. Peak Loads

Existing peak loads for buildings connected to the UMN Morris district energy system:

DISTRICT HEATING

21.8

MMBtu per hour

DISTRICT COOLING

830

tons

2.2. Future Load

There are not currently any planned additional buildings within the bounds of the Study. Five existing buildings not currently served by district heating would add 0.5 percent to the current peak upon projected connection. Efficiency improvements are expected to displace this additional load. Buildings served by on-site cooling systems are electrically powered. They can achieve carbon neutrality by receiving carbon-neutral electricity. Further expansion of the UMN Morris district cooling system is not part of this Study scope.

3. ELECTRICAL ENERGY SUPPLY

3.1. Grid Source Power

Otter Tail Power Company provides all electrical power not generated by UMN Morris assets. Approximately 30 percent of Otter Tail Power Company's electricity will be carbon neutral in 2021/2022 as a result of two large projects, including a 150 MW wind farm in North Dakota and a 245 MW simple-cycle natural gas combustion turbine in South Dakota. In 2021, Otter Tail Power Company will retire the 140 MW coal-fired Hoot Lake Plant in Fergus Falls, Minnesota. The net cost of this electricity is approximately $100 per megawatt-hour (MWhr).

3.2. Self-Generated Power

The campus has two 1.5 kW solar arrays, one of which is fixed and the other with dual-axis tracking, and one 240 kW array that was constructed in fall 2019. Additionally, the campus has one 315kW biomass-fueled back-pressure steam-turbine generator and two 1,650 kW wind turbines. The first UMN Morris wind turbine was erected by West Central Research and Outreach Center in 2005. The second was erected by UMN Morris in 2011. In 2019, Environment America reported that UMN Morris produced the most on-site electricity per student in the US.

3.3. Carbon Credit Strategy

UMN Morris's current electricity profile is approximately 70 percent carbon free. The wind turbines generate approximately 10,000 MWhr per year. Electrical output from the two turbines often exceeds campus load and approximately half of the annual production is sold back to Otter Tail Power Company. Otter Tail Power Company currently holds the Renewable Energy Credits (RECs) for UMN Morris overproduced wind power. UMN Morris owns the RECs for the electricity it uses from the wind turbines. Table 3 shows wind generated electricity at UMN Morris.

UMN Morris Electrical Wind Generation

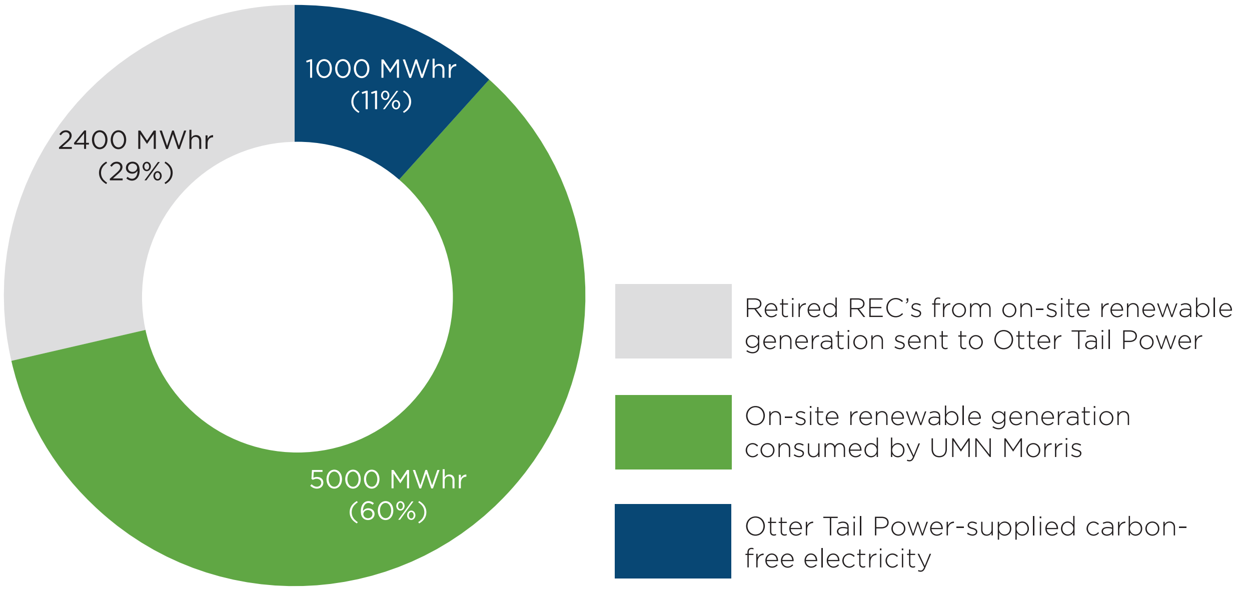


Table 3 shows the carbon profile of Otter Tail Power Company-purchased electricity at UMN Morris. If UMN Morris purchases RECs in an amount equivalent to the total energy produced by the UMN Morris turbines, it would completely offset the carbon-based electricity purchased from Otter Tail Power Company. This would still leave approximately 2,300 MWhr (7,800 MMBtu) worth of RECs generated by the campus that could be applied to offset thermally-based carbon emissions. Table 4 shows UMN Morris's REC equivalent buyback opportunity and their potential application to heating.

Table 3. Otter Tail Power Company Electricity carbon neutrality

ELECTRICITY PROFILE

Otter Tail Power electricity purchased	100%	3,400	MWhr
Carbon neutral electricity	30%	1,000	MWhr
Carbon-based electricity	70%	2,400	MWhr

Table 4. REC equivalent buyback and where applied

REC EQUIVALENT BUYBACK

UMN Morris REC equivalent buyback opportunity	4,700	MWhr	16,000	MMBtu
Carbon-based electricity	2,400	MWhr	8,300	MMBtu
REC equivalent applied toward heating	2,300	MWhr	7,700	MMBtu

There are several opportunities beyond wind-generated RECs to further reduce UMN Morris's thermal footprint. For example, the 240 kW solar system is projected to generate 330 MWh per year. If the RECs for UMN solar power are also purchased, they could add to the wind-generated RECs, providing an additional 1,100 MMBtu of offset. The campus also has a robust on-site composting program that diverts roughly 160 tons of organics from the landfill each year. Expanded waste management practices may also provide emission reduction opportunities.

To better understand campus energy needs, it is useful to compare electrical and thermal demands. The campus uses about 8,500 MWh of electricity each year, with roughly half provided by Otter Tail Power Company and half generated by the wind turbines. The campus uses about 3.7 times more thermal-related energy than electricity. This is unsurprising given the temperature extremes in Morris, Minnesota.

Table 5 shows that after REC purchases, the campus would still need to offset approximately 105,000 MMBtu, which is the energy equivalent of 31,000 MWh (conversion is 3.412 MMBtu/1 MWh).

Table 5. REC Equivalent applied to heating

REC EQUIVALENT HEATING

Annual Heating	113,500	MMBtu
Remaining REC Equivalent towards heating	-7,700	MMBtu
Heating Equivalent requiring action	105,800	MMBtu

The cost of buying RECs in this scenario would range between $17,000 and $31,000 annually. Depending on which carbon-free thermal solution is chosen, an additional carbon-free electricity purchase may be advantageous.

4. CURRENT THERMAL ENERGY PROFILE

4.1. Existing Thermal Energy Systems

4.1.1. Heating

UMN Morris has four central boilers producing steam for a traditional steam district heating system serving the campus, with boiler capacities listed in Table 1. Three boilers are natural gas and oil-fired boilers. A fourth boiler is biomass-fired, capable of burning wood, corn cobs, and natural gas. The fourth boiler drives a back-pressure steam-turbine generator, with the discharge steam serving the UMN Morris heating loop or an absorption chiller. This Study assumes the heating plant equipment needed for continued service will be replaced with appropriately sized equipment in 2040.

To make comparisons between MBH (Thousand BTU/hour) and pounds-of-steam-flow per hour (lbs of steam/hour), one can estimate that 30,000 MBH is roughly equivalent to 31,720 lbs of steam/hour (with an enthalpy value of 946 Btu/lb steam). The campus thermal peak is 22 MMBtu/hour. Therefore, the campus would need to run Boiler 1 at nearly full operation to meet this demand on the coldest days of the year, hence the redundancy in boilers.

Table 6. UMN Morris existing boiler capacities

CURRENT BOILER ASSETS AT UMN MORRIS

Boiler #	Type	Year	Fuel	Pressure (PSI)	Output (MBH)
1	Steam	1968	Gas/Oil	18	24,000
2	Steam	1968	Gas/Oil	18	24,000
3	Steam	1999	Gas/Oil	18	30,000
4	Steam	2007	Biomass/Gas	280	15,000
				Total	93,000

4.1.2. Cooling

UMN Morris has three chillers producing chilled water for a district cooling system serving the campus, with chiller capacities listed in Table 7. Two are centrifugal chillers the other is an absorption chiller.

Table 7. UMN Morris existing chiller capacities

CURRENT CHILLER ASSETS AT UMN MORRIS

Chiller #	Type	Year	Output (MBH)
1	Centrifugal	1999	400
2	Centrifugal	1999	600
3	Absorption	2007	617
		Total	1,617

5. FUTURE THERMAL ENERGY SYSTEM

Ever-Green evaluated viable options for decarbonizing the UMN Morris campus. Each was assessed technically, financially, and environmentally. The proposed alternatives are summarized in this section.

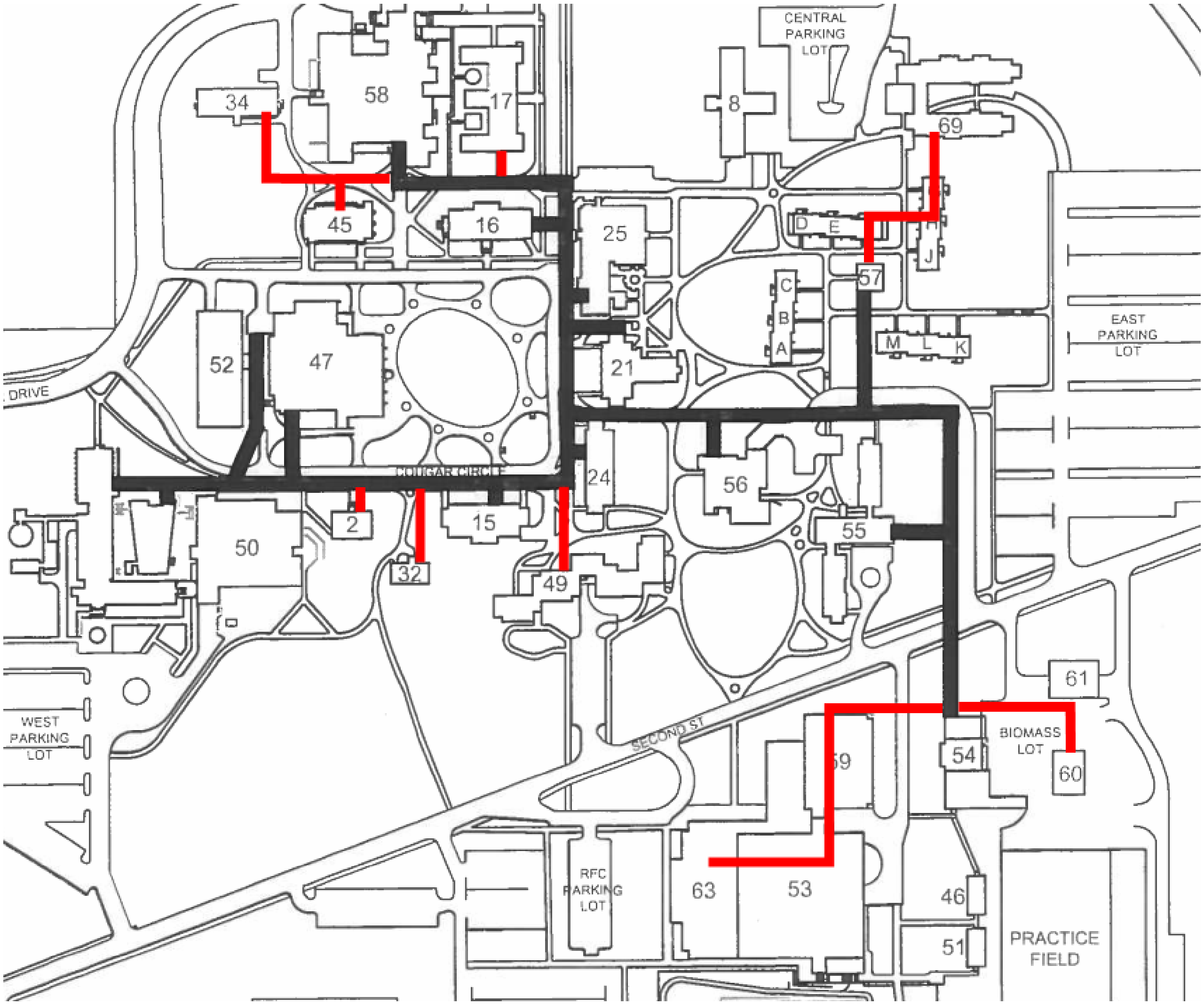
5.1.1. Existing Central Plant

The UMN Morris heating plant is the production facility for all district energy systems and is modeled to remain so for all alternatives. Except as stated below, it would continue to house three existing natural gas-fired boilers to manage excessive peak loads and provide system redundancy.

5.1.2. Distribution

In most of the following alternatives, the proposed changes include eventual conversion of the distribution piping from steam to hot water. The new system's distribution main would be eight inches in diameter, and the service laterals would be three inches or less. Exceptions to this are specifically noted in the appropriate section below. The new hot-water system would utilize the existing steam tunnels and follow the existing steam lateral's pipe route, as shown in Figure 1. The steam tunnels are shown in black and the laterals are red. The new hot-water system could easily be designed to accept external energy sources including, and in addition to, the alternative presented below.

Figure 1. Distribution system tunnels and laterals routing



5.1.3. Hot Water Distribution / Building Energy Transfer Stations

When the distribution system is converted to hot water, an energy transfer station (ETS) may be installed in some or all buildings to transfer heat from the district energy system to the buildings' secondary systems. This ETS includes heat exchangers, valves, piping, controls, instruments, and a flow meter. A picture of a typical ETS is provided in Figure 2.

While the ETS may not be necessary, it is a prudent practice to separate the district energy system from the buildings' secondary hydronic systems. This would be most advantageous if the energy system begins serving other buildings in the Morris community.

A hot water system without an ETS is possible if the buildings are directly connected, sharing the district water, and foregoing the cost of an ETS at each building. The greatest advantage of an ETS is that it hydronically separates each building from the distribution system, which is better for both safety and serviceability. The building's secondary side can operate at safer temperatures and pressures and different buildings' operating strategies are more easily tailored.

Figure 2. Typical district heating interconnection

5.2. Energy System Alternatives

5.2.1. Business as Usual

The basis for comparison of energy system alternatives assumes continued operation of the existing heating and cooling systems in the current state, without the elimination of carbon emissions. Contained within this alternative is the implementation of plans to upgrade certain buildings' HVAC systems, along with necessary end-of-life replacement of system components. The assumed replacements cover assets within the central plant, the distribution system, and campus buildings. Conversion of the steam distribution system to hot water upon the end of the steam system's useful life is also part of the business as usual (BAU) alternative.

5.2.2. Biofuel

The biofuel alternative (biofuel) assumes converting the existing boiler's oil burning systems to B100 biodiesel or an equivalent carbon-neutral liquid fuel oil. This includes a new biofuel storage tank and heated fuel delivery supply and recirculation system. It otherwise assumes the same planned building upgrades and steam system replacements as the BAU alternative.

BIOFUEL **ADVANTAGES**

- Straightforward conversion of existing equipment
- Proven technology
- Ease of operation
- Steam can be used for carbon-free electricity generation
- Steam can be utilized for absorption cooling

BIOFUEL **DISADVANTAGES**

- Heated fuel delivery system adds complexity
- Extreme cold weather operation requires intense monitoring

5.2.3. Biomass

The Biomass (biomass) alternative would primarily utilize the existing biomass boiler to serve UMN Morris's base heating load. It has aspects unique to the existing corn and wood fuel options but it otherwise assumes the same planned building upgrades and system replacements as the BAU alternative. This alternative eliminates carbon credit purchases to achieve carbon neutrality, as steam generated by the boiler is also used to generate electricity in the existing 315 KW generator and its steam is used to generate carbon neutral cooling in the absorption chiller.

BIOMASS **ADVANTAGES**

- Uses existing infrastructure
- Uses local fuel sources
- Steam can be used for carbon-free electricity generation
- Steam can be utilized for absorption cooling

BIOMASS **DISADVANTAGES**

- Labor intensive to operate
- High maintenance and repair cost
- Higher downtime
- Requires active fuel procurement management
- Shorter life of wear items inherent in the abrasive nature of the fuel

5.2.4. Geothermal

The geothermal well field alternative (geothermal) assumes replacing the existing boilers with water-source heat pumps that exchange heat with a geothermal well field. The heat pumps would provide both heating and cooling with redundancy provided from the existing heating and cooling equipment. Due to well field costs, a system capacity that is 50 percent of load could be installed, with the well field capital savings leveraged to offset the cost of a thermal storage tank (TST). This concept works because most of the time the load is 50 percent of peak, or less. The TST would be used to shave peaks by shifting the load to lower demand times of the day. This alternative assumes the distribution system and building upgrades to hot water occur immediately and forgoes most of the existing equipment's end of life replacement costs, except replacement of the smallest existing chiller to maintain system redundancy. Having the TST creates cooling options as well, improving on-site generated power utilization. The heat pumps operate most efficiently and economically at lower supply temperatures. Utilizing this requires some distribution pipe and equipment upsizing, and domestic hot water (DHW) temperature boosting in buildings.

+ GEOTHERMAL **ADVANTAGES**

- Energy efficient
- Proven technology
- Limited operations requirement

- GEOTHERMAL **DISADVANTAGES**

- Increased use of electricity
- Extreme cold weather creates limitations with system operations
- Lower supply water temperature may be problematic in some buildings

5.2.5. Ethanol Plant Heat Recovery

The ethanol plant exhaust gas energy recovery alternative (Denco II Heat Recovery) assumes replacing the existing boilers with an exhaust gas energy recovery system in the exhaust stream of the local ethanol plant (Denco II). Heat exchangers would capture waste heat that would be circulated to UMN Morris for distribution. The absorption chiller would be replaced by a centrifugal chiller, as steam will no longer be generated. This alternative, like the geothermal alternative, assumes distribution system and building upgrades to hot water occur immediately, and forgoes most end of life replacement costs, except for redundancy. Operational limitations from the ethanol plant and final design may require lower supply temperatures, pipe and equipment upsizing, DHW boosting, and a TST. These additional costs are not currently part of the analysis.

+ ETHANOL RECOVERY **ADVANTAGES**

- Energy efficient
- Expandable to serve additional buildings in Morris
- Limited operations requirement

- ETHANOL RECOVERY **DISADVANTAGES**

- Reliance on a third-party entity to provide carbon-free energy. Predicated on the ethanol plant staying in operations
- Lower supply water temperature may be problematic in some buildings

5.2.6. Solar PV

The photovoltaic solar alternative (solar PV) assumes building out solar PV collection to meet UMN Morris's electrical needs, coupled with electric boilers generating hot water. A dual heating and cooling thermal storage tank will allow load shifting year-round and would maximize utilization of on-site generated electricity. A centrifugal chiller would replace the absorption chiller as steam will no longer be generated. This alternative, like geothermal and Denco II Heat Recovery, assumes distribution system and building upgrades to hot water occur immediately, and forgoes most end of life replacement costs. Frequent solar unavailability requires redundant heat generation, and consequently the existing boilers would be replaced at the end of their useful life with appropriately sized units. Solar farms require substantial land use. Current estimates are 4-10 acres per megawatt of panels. The estimated 27 MW solar farm requires 100 to 200 acres. The study does not include any cost for acquiring this land.

SOLAR PV **ADVANTAGES**

- Energy efficient
- Proven technology
- Limited operations requirement

SOLAR PV **DISADVANTAGES**

- Weather dependent solution
- Requires significant land access

5.2.7. Wind

The wind turbine alternative (wind) assumes building out wind turbines to meet UMN Morris's electrical needs, coupled with electric boilers generating hot water. It is otherwise the same as the solar PV alternative. It includes electric boilers, a dual-use TST, and an electric-driven centrifugal chiller. Like the solar PV alternative, it assumes distribution and building upgrades at the beginning, and foregoes end of life costs. Wind unavailability also requires redundant hot water boilers. Like solar, wind farms require substantial land use. Current estimates are 1.5 - 2 acres per megawatt of wind turbines. The estimated 13 MW wind farm requires 20 to 30 acres for the turbines and an up to 800-acre perimeter with minimal wind obstructions. The study does not include any cost for acquiring this land.

WIND **ADVANTAGES**

- Energy efficient
- Proven technology
- Limited operations requirement

WIND **DISADVANTAGES**

- Weather dependent solution
- Requires significant land access

5.3. Estimated Capital Costs

Ever-Green developed an opinion of probable costs for each alternative based on the concepts described in this document. There are hot water conversion capital costs at the plant, to the distribution system, and at the buildings in each alternative. Timing would be immediately upon implementation, or upon end of key equipment's serviceable life. Upgrades would be immediate when required to accommodate a specific carbon-free solution and later when not. Costs below are stated at present value and adjusted for inflation in the model according to their implementation.

The timing of the of steam to hot water conversion also affects the production cooling equipment and individual buildings' HVAC system upgrade timelines to their implementation year. Like above, these are either immediate or at the end of useful life.

5.3.1. Production Capital Cost

Based on the cost of new steam to hot water heat exchangers, pumps, and controls, the plant upgrades for conversion to hot water are estimated at $740,000 for each alternative. A detailed breakdown of these costs is provided in Appendix II.

5.3.2. Distribution Capital Cost

The estimated cost for distribution conversion to hot water is $4,200,000 for each alternative. The estimated costs for hot water main distribution and service laterals are summarized in Table 8. A detailed cost breakdown is provided in Appendix II.

Table 8. Estimated cost for the proposed distribution piping network

ESTIMATED DISTRIBUTION CAPITAL COST

	Pipe Length	Estimated Cost
Ø8"	2,500 Trench Feet	$1,800,000
Ø2" - 3"	3,100 Trench Feet	$700,000
Ø1" - 1.5"	800 Trench Feet	$200,000
Total	6,400 Trench Feet	$4,200,000

5.3.3. Building Interconnection Capital Cost

This Study includes an ETS at each building, but the model can remove these costs. The estimated total cost of upgrading the customer buildings for hot water, including ETSs, is $910,000 for each alternative, with a detailed breakdown provided in Appendix III.

6. FINANCIAL MODEL

Ever-Green utilized the estimated capital costs presented in this report and the financial assumptions shown in the appendices to develop a Net Present Value (NPV) for the alternatives. The NPV compares energy related costs under the current business as usual energy strategy with the alternatives' energy-related costs, over a 30-year analysis. This comparison includes costs related with the energy systems, including construction, operation, fuel, maintenance, etc.

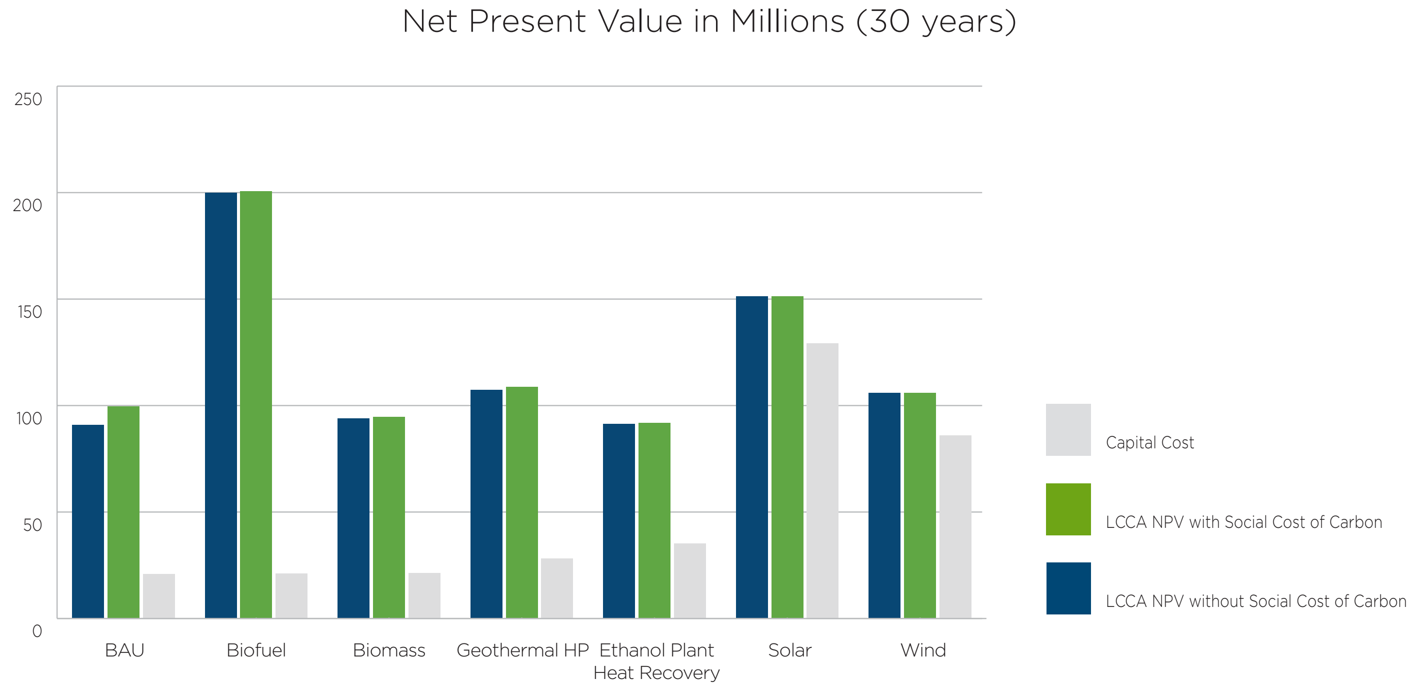
The assumptions within the LCCA are summarized in Appendix I, and the results of the LCCA analyses are summarized in Table 9 and Figure 3.

Table 9. District energy system life cycle cost analysis

LIFE-CYCLE COST ANALYSIS - 30 YEARS NET PRESENT VALUE

	Without Social Cost of Carbon		With Social Cost of Carbon			
	Net Present Value ($ Mil.)	Rank	Net Present Value ($ Mil.)	Rank	Lifecycle GHG Emissions	Capital Cost ($ Mil.)
Business as Usual	$90.9	1	$99.5	3	331,300	$20.9
Denco II Heat Recovery	$91.3	2	$91.9	1	24,000	$35.2
Biomass	$94.0	3	$94.6	2	24,100	$21.2
Wind	$105.9	4	$105.9	4	100	$86.0
Geothermal	$107.2	5	$108.7	5	55,800	$28.1
Solar PV	$151.3	6	$151.3	6	100	$129.1
Biofuel	$200.0	7	$200.7	7	24,000	$21.1

Figure 3 Net Present Value (Millions)



The two lowest net present value (NPV) carbon neutral alternatives are Denco II Heat Recovery at $91.9 million and Biomass at $94.6 million NPV. Overall financial results are highly dependent upon the following factors:

The two lowest net present value carbon neutral alternatives are ethanol plant heat recovery at $71.3 million and biomass at $74.0 million.

- An increase in the interest rate would increase the cost of the proposed systems. A reduction in the interest rate would decrease costs.
- If construction bids for the proposed district energy system are higher than expected, the benefits would be reduced. Lower construction prices would increase benefits.
- If biomass fuel costs increase, district energy system benefits will decrease. Benefits increase if biomass costs were reduced.
- The cost of the waste heat from Denco II is estimated as a factor of the cost of biomass. Discussions with Denco II will need to occur to validate or modify this assumption.
- This is a very high-level model with numerous assumptions that require further validation prior to proceeding with the next stage of development.

There are also several opportunities to reduce cost and provide better overall savings. These options should be pursued further if development progresses:

- Increased renewable energy credits from the use of biomass fuel could improve the financial benefits of the system.
- Use of utility or other rebates to offset the cost of the system's construction will improve results.
- If a compatible piping system is appropriate, directional drilling of distribution piping installation could reduce costs related to excavation and surface restoration.
- There are proven piping materials available on the market that, under the right circumstances, offer lower total cost. Among these systems are polymer-based piping, including types of polyethylene such as raised temperature high density polyethylene and pre-insulated cross-linked polyethylene. Polymer systems have the added advantage of being corrosion resistant and requiring less chemical use for water treatment. These potential materials should be investigated if system design progresses.

7. GREENHOUSE GAS EMISSIONS PROFILE

A diverse and distributed carbon-free energy platform is a key part of the plans to achieve carbon neutrality. On or within a mile of the campus is a biomass gasification facility, solar thermal and PV installations, wind generation, green buildings, and conservation technologies, all of which contribute to the community goals to reduce the carbon portfolio from UMN Morris.

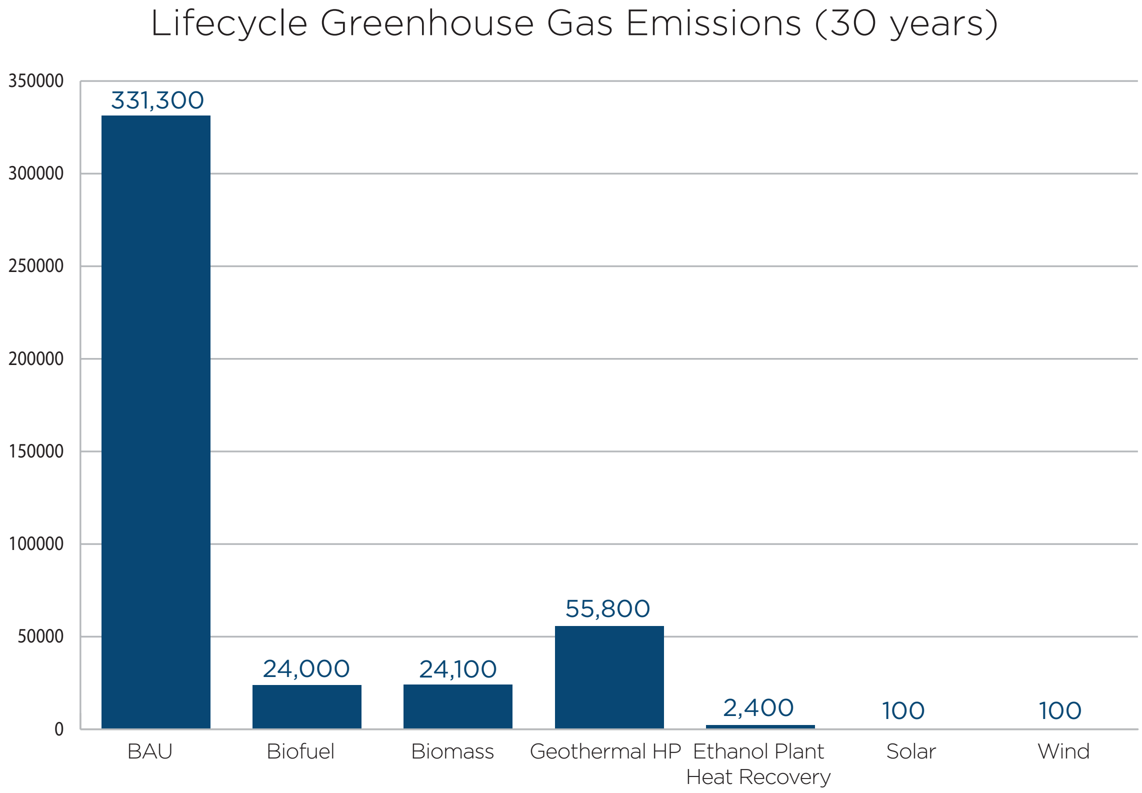
Implementation would reduce heating & cooling GHG emissions by an estimated **10,000 tons of CO_2 per year.**

↓93%

This year UMN Morris achieved a new milestone in its journey toward complete campus carbon neutrality. The campus is now fully carbon neutral in electricity because of on-site clean energy systems.

Building from these successes, implementation of the proposed district energy system is estimated to reduce the amount of GHG emissions at UMN Morris by an estimated 10,000 tons of carbon dioxide per year, a reduction for the campus heating and cooling systems of 93 percent from the 2018 baseline. This is the equivalent of 2,000 passenger vehicles driven per year.[5] GHG emissions are summarized in Figure 4 with a detailed breakdown provided in Appendix IV.

Figure 4 Greenhouse gas emissions per technology over 30 years



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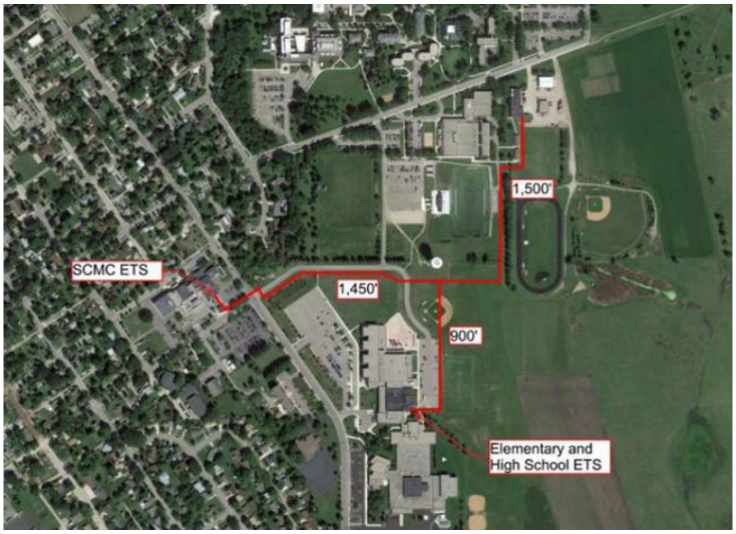
[5] "Greenhouse Gas Equivalencies Calculator," United States Environmental Protection Agency, last modified May 2016, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

7.1. Renewable Power Profile

Over the past decade UMN Morris has built an on-site, community-scale clean energy platform. In 2019, Environment America recognized that UMN Morris produced the most on-site electricity per student in the US. The majority of campus power, about 60 percent, is generated by two University of Minnesota-owned 1.65 megawatt wind turbines. Additional green electricity is generated by several solar photovoltaic systems and a back-pressure steam-turbine at the biomass gasification plant.



AERIAL VIEW OF UMN MORRIS, ADJACENT SCHOOLS & STEVENS COMMUNITY MEDICAL CENTER

UMN Morris worked with Otter Tail Power Company to achieve campus carbon neutrality goals. About 70 percent of campus electricity comes from renewables, including what the campus produces and purchases from Otter Tail Power Company. Otter Tail Power Company is also expanding its renewable portfolio and expects to achieve both 30 percent renewable energy generation and carbon emissions 30 percent below 2005 levels by 2022.

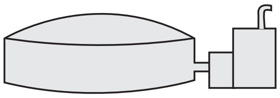
The two wind turbines produce over 10 million kilowatts of power each year. The campus uses about half of the wind-generated electricity, and the other half supplies the local power grid. In partnership with Otter Tail Power Company and support of private giving from donors and friends, the campus now owns additional renewable energy credits (RECs) in an amount equal to the fossil-fuel produced electricity the campus purchases. The RECs are generated from the UMN Morris wind turbines.

7.2. Renewable Thermal

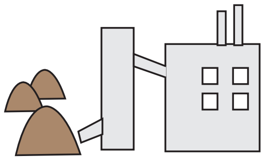
In the conversation about renewable energy, the electric power grid tends to receive most of the focus. However, 39 percent of global CO2 emissions related to energy coming from heating and cooling, so it is important to find solutions that can decarbonize the thermal profile of campuses. Currently, only 10 percent of thermal energy globally comes from renewable sources.

As reviewed in the alternatives for UMN Morris, the renewable thermal options have great potential to reduce the remaining carbon in Scope 1 and 2 emissions. For this campus, the heating operations account for 93 percent of the campus's Scope 1 and 2 carbon profile.

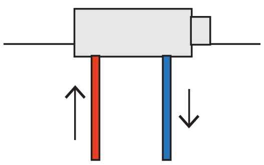
BIOGAS



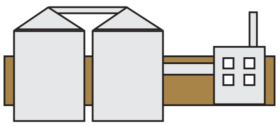
BIOMASS



GEOTHERMAL



ETHANOL PLANT
HEAT RECOVERY



8. ADDITIONAL OPPORTUNITIES

There are a number of opportunities UMN Morris may want to consider that are not within the scope of this Study but could become part of a future phase of implementation if desired. These opportunities include:

8.1. System Expansion

The scope of this Study and estimated heating and cooling loads considered only UMN Morris buildings. In 2017 Ever-Green conducted a district energy study[6], that in addition to UMN Morris, included Stevens Community Medical Center, and ISD2769 high school, elementary school, and middle school buildings in proximity to the UMN Morris campus. Non-UMN Morris facilities were not part of this current Study, but they should be considered if UMN Morris determines to proceed with the recommended strategies.

8.2. Efficiency Opportunities

ASHRAE standards for optimizing system efficiency include optimizing a generally broad temperature differential between supply and return water temperatures, known as delta T (ΔT). Installing temperature sensors on return water will allow operators to determine and monitor ΔT. From this data point, they can develop a program to control relevant parameters and optimize operating efficiency. Such programs are often subject to utility rebates.

Efficiency opportunities also include the following:

- Strategic operation that optimizes performance through prudent equipment dispatch and optimal operating control set points.
- Exhaust gas energy recovery economizers could be installed on the boilers.
- Building cooling outside air economizers could be installed on buildings with shoulder season and overnight cooling loads
- Equipment with possible varying motor load are all candidates for VFDs
- Improved controls:
  - Plant controls can be upgraded to take advantage of the above opportunities and optimize operating strategy and utilize controls best practices
  - Building instrumentation controls can be implemented to conform to ASHRAE standards ensuring broad supply and return water differential temperatures (ΔT), optimizing pumping and providing meter feedback for improved monitoring, troubleshooting, and operations staff interaction.

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[6] Morris, MN - Energy System District Energy Feasibility Briefing, July 2017

9. CONCLUSION AND NEXT STEPS

UMN Morris has several options available to significantly reduce carbon emissions in a cost-effective manner. Coupled with transitioning the campus from steam to hot water, enhanced utilization of biomass, waste heat capture from Denco II, and geothermal with heat pumps can each enable the elimination of nearly 10,000 tons of carbon emissions per year.

While some of these technologies are more cost-effective than others, each can be implemented in a cost-competitive manner while investing in the local Morris community. Because carbon accounting is highly technical and evolving, we recommend that UMN Morris reviews guidance by the Greenhouse Gas Protocol (or other recognized carbon accounting standards) for any final determination regarding how these approaches would impact the campus carbon footprint.

Should UMN Morris choose to proceed with decarbonization, a prudent strategy may be to first focus on the conversion of the campus from steam to hot water. This conversion would improve campus efficiency, reduce carbon emissions, and set the foundation for incorporation of the preferred carbon-free solution, once it is selected. Preliminary design of the system conversion is required to validate the assumptions utilized in this Study, or modify as appropriate.

Design should be sufficiently developed to verify the viability of each preferred carbon-free energy source, obtain construction estimates for the work, and commence any regulatory and land use discussions that may be needed for implementation. Financial modeling should be enhanced to reflect UMN Morris' preferred financing and implementation approach, and to the extent desired, enable integration with the Morris community. UMN Morris should also perform an assessment of available grant and rebate opportunities that could be applied to improve financial viability.

Appendix I: Costs, Financial, Loads, Consumption & Rates

ESTIMATED ALTERNATIVES' CAPITAL COSTS

Capital Costs ($Million)	BAU	Biofuel	Biomass	Heat Pump	Ethanol	Solar	Wind
Plant 2022		$0.23					
Plant 2025			$0.24	$11.14	$17.06	$110.97	$66.70
Distribution 2025				$5.80	$5.80	$5.80	$5.80
Campus Building 2025	$5.24	$5.24	$5.24	$9.92	$9.13	$9.13	$9.13
Plant 2030	$3.72	$3.72	$3.72		$2.00	$2.00	
Campus Building 2030	$2.91	$2.91	$2.91				
Distribution 2040	$7.80	$7.80	$7.80				
Campus Building 2040	$1.24	$1.24	$1.24	$1.24	$1.24	$1.24	$1.24

FINANCIAL ASSUMPTIONS

Financial Item		Units
Life Cycle	30	(Years)
Interest Rate	4%	(%)
Period	30	(Years)
Inflation (Used for Escalation)	2%	(%)

UMN MORRIS ENERGY LOAD PROFILE

UMN Morris Energy Load Profile		Units
Demand Heating	21.80	(MMBtu/hr)
Demand DHW	0.87	(MMBtu/hr)
Demand Cooling	830	(Tons)
Annual Consumption Heating	113,000,000	(MMBtu)
Annual Consumption DHW	4,500,000	(MWH)
Annual Consumption Cooling	1,700,000	(Ton hr)

ALTERNATIVES' INPUT ASSUMPTIONS

Consumption	BAU	Biofuel	Biomass	Heat Pump	Ethanol	Solar	Wind
Annual Electric (MWh)	8,465	8,465	8,492	19,779	8,492	42,955	42,955
Annual Fuel (MMBtu)	169,462	141,795	141,795	0	127,961	0	0
Annual Water (kgals)	9,749	3,763	3,763	203	3,072	3,072	3,072
Annual Staff Maint. (hrs)	14,144	14,768	19,968	11,440	9,984	6,864	6,864
Annual 3rd Party Maint. (hrs)	1,414	1,477	1,997	1,144	998	686	686

ELECTRICAL CONSUMPTION

Electrical Consumption (MWh/yr)	BAU	Biofuel	Biomass	Heat Pump	Ethanol	Solar	Wind
Non-Heating & Cooling Electric /yr	6,551	6,551	6,551	6,551	6,551	6,551	6,551
Annual Heating & Cooling Electric /yr	1,914	1,923	1,941	13,228	1,941	36,404	36,404
Total Electric /yr	8,465	8,474	8,492	19,779	8,492	42,955	42,955

ALTERNATIVES' INPUT ASSUMPTIONS

Rates	BAU	Biofuel	Biomass	Heat Pump	Ethanol	Solar	Wind
Electric Rate ($/MWh)	$100	$100	$100	$100	$100	$100	$10
Fuel Rate ($/MMBtu)	$4.60	$31.20	$4.47	$0.0	$3.450	$3.450	$0.0
Water Rate ($/kGal)	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41
Sewer Rate ($/kGal)	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41	$3.41
Labor Cost Staff ($/hr)	$41.84	$41.84	$41.84	$41.84	$41.84	$41.84	$41.84
Labor Cost Third Party ($/hr)	$100	$100	$100	$100	$100	$100	$100
GHG Electric (#/MWH)	181	181	181	181	181	181	0
GHG Fuel (#/MMBtu)	117	0	0	0	0	0	0
GHG Water & Sewer (#/kgal)	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Social Cost of Carbon ($/Ton)	$35	$35	$35	$35	$35	$35	$35
Cost of Carbon Offsets ($/Ton)	$7	$7	$7	$7	$7	$7	$7

Appendix II: Size and Unit Cost

ESTIMATED EQUIPMENT COSTS

Line Item	Size	Units	Unit Cost		Total
15k gallon biofuel fuel tank, piping, burner mods	15,000	Gallons	$12.00	$/Gal.	$180,000
Convert Existing Plant to HW	21.8	Mmbtu/hr	$33,945	$/MMBtu/hr	$740,000
Biomass plant upgrades	15	Mmbtu/hr	$11,333	$/MMBtu/hr	$170,000
Electric Boilers	21.8	Mmbtu/hr	$74,771	$/MMBtu/hr	$1,630,000
Central Heat Pumps	21.8	Mmbtu/hr	$336,239	$/MMBtu/hr	$7,330,000
Ethanol Plant Heat Recovery	21.8	Mmbtu/hr	$483,486	$/MMBtu/hr	$10,540,000
Solar	26.6	MW	$2.83	M$/MW	$75,380,000
Wind Capital Expansion	12.7	MW	$2.85	M$/MW	$36,230,000
Thermal Storage Tank	2,000,000	Gallons	$1.05	$/Gal.	$2,100,000
New Electric Chiller 430 ton	430	Tons	$1,302	$/Ton	$560,000
Chiller Replacement 600 ton	600	Tons	$1,300	$/Ton	$780,000
Chiller Replacement 400 ton	400	Tons	$1,300	$/Ton	$520,000
Chiller Replacement 617 ton absorber	617	Tons	$1,831	$/Ton	$1,130,000
Boiler Existing Plant Equipment end of life Replacement	33	MMBtu/hr	$56,970	$/MMBtu/hr	$1,880,000
Biomass blr & handling Equipment end of life Replacement	15	MMBtu/hr	$86,000	$/MMBtu/hr	$1,290,000
Install HW Distribution	6,534	Trench Ft.	$642.79	$/TF	$4,200,000
Replace Steam Distribution System with HW[††]	6,534	Trench Ft.	$642.79	$/TF	$4,200,000
Initial round Convert four slated buildings steam to HW	59,300	sq.ft.	$12.82	$/Sq.ft.	$760,000
ETS in Customer HW/CHW Buildings	21.8	Mmbtu/hr	$41,743	$/MMBtu/hr	$910,000
Final Round Remaining HW Customer Connection	106,000	sq.ft.	$14.34	$/Sq.ft.	$1,520,000
Customer HVAC End of Life Replacement	830	Tons	$807	$/Ton	$670,000

Appendix III: Building Conversions, Energy Transfer Stations, Building Cooling Replacement

ESTIMATED BUILDING CONVERSION COSTS

	Building Name	GSF	Heating	Building Conversion	ETS	Building Cooling Replace	Cooling
702	Multi - Ethnic Resource Center	7,800	Steam	$550,000	$30,754	$6,178	DX wall
708	Saddle Club Barn	14,496	None				None
715	Spooner Hall	21,700	Hot water		$36,448	$17,186	DX wall
716	Camden Hall	18,500	Steam	$1,150,000	$35,495	$14,652	DX wall
717	Welcome Center	18,000	Hot water		$35,334	$14,256	District
719	Seed House	2,581	None				None
721	Behmler hall	27,000	Steam	$1,650,000	$37,794	$21,384	DX wall
724	Blakely Hall	17,000	Hot water		$35,000	$13,464	District/ DX
725	Imholte Hall	35,000	Hot water		$39,458	$27,720	District
732	Education	6,000	Steam	$450,000	$29,443	$4,752	DX wall
734	Pine Hall	16,000	Steam	$1,050,000	$34,650	$12,672	DX wall
741	Transportation	5,000	GAS				None
745	Humanities	17,000	Hot water		$35,000	$13,464	District
746	Annex North	1,600	GAS			$1,267	DX wall
747	Student Center	53,000	Hot water		$42,271	$41,976	District
749	Clayton Gay Hall	52,000	Hot water		$42,138	$41,184	DX wall
750.1	Old Science	62,000	Hot water		$43,386	$49,104	District
750.2	New Science	83,000	Hot water		$45,539	$65,736	District
751	Annex South	1,600	GAS				None
752	Briggs Library	57,000	Hot water		$42,785	$45,144	District

	Building Name	GSF	Heating	Building Conversion	ETS	Building Cooling Replace	Cooling
753	Cougar Sports Center (PE)	66,000	Steam	$550,000	$43,839	$52,272	District
754	Heating Plant	1,800	Gas/Steam				None
755	Independence Hall	50,000	Hot water		$41,864	$39,600	District/ DX
756	Food Service	23,000	Hot water		$36,801	$18,216	District
757	Apartments Buildings A,B,C,D	13,000	Hot water		$33,476	$10,296	DX wall
758	Humanities Fine Arts	108,000	Hot water		$47,573	$85,536	District
759	Swimming Pool Building	20,000	Steam		$35,957	$15,840	District
760	Shop Building	4,000	Steam		$27,527		None
761	Maintenance Storage Building	9,000	None				None
763	RFC	43,000	Hot water		$40,829	$34,056	District
764	Facilities Storage	4,000	GAS				None
765	LaFave House	4,500	GAS			$3,564	DX heat pump
766	Big Cat Stadium	2,900	Electric				None
767	Recycle Center	1,200	Electric				None
768	Soccer Press Box	400	None				None
769	Green Prairie	25,000	Hot water		$37,314	$19,800	District

Appendix IV: Greenhouse Gas Calculation Assumptions

PREVIOUS THREE-YEAR UMN MORRIS CONSUMPTION

Sources	Years	Quantity		Energy	Units	Tons
Boiler Gas (avg)	2016-2018	111,632,333	CF	113,307	MMBtu/yr	6,628
Boiler Oil (avg)	2016-2018	1,147	gal	160	MMBtu/yr	13
Boiler Solid Biofuel (avg)	2016-2018	0	lb	0	MMBtu/yr	0
Electricity (avg)	2016-2018	8,464,997	kWhr	8,465	MWhr/yr	3,931
					Total	10,572

CARBON EMISSION RATES

Source	Rate	
Natural Gas	117	CO2 lb/MMBtu
EPA MROW Emission Factor †	1536	CO2 lb/MWh
Electric Utility †	1548	CO2 lb/MWh
Gasoline	157.2	CO2 lb/MMBtu
Diesel	161.3	CO2 lb/MMBtu
Wood	262	CO2 lb/MMBtu

† http://www.epa.gov/climateleadership/documents/emission-factors.pdf

††ttps://www.xcelenergy.com/company/corporate_responsibility_report/library_of_report_briefs/climate_change_and_greenhouse_gas_emissions

Appendix V

Overview of Process

The study process emphasized implementable solutions to address the campus carbon profile while maintaining energy system reliability and efficiency, and simultaneously developing a long-term strategy to achieve carbon neutrality. These solutions must maintain flexibility to adapt to energy system as market conditions, energy sources, building needs, and technologies change.

The Roadmap program was developed, in part, to design a carbon neutrality planning methodology that could be replicated and refined to help campuses across the US. For the purpose of building from and improving this methodology, the process is outlined below:

Charting the Course – Data Collection and Vision Setting

A successful and actionable planning process requires setting a collective vision that can be supported across the stakeholder and leadership groups in the institution. This usually includes facilities, sustainability, environmental, health and safety, and finance. These stakeholders and leadership structures will vary from school to school.

The advancement of campus energy systems requires developing a broad coalition of system champions. These initial working sessions and goal-setting discussions help set clear expectations and priorities for the work. These kickoff meetings also included on-site campus visits to perform high level assessments of the existing energy systems and building consumption and identifying potential renewable energy sources on campus and within the adjacent community for future integration.

Data Assessment and Future Consumption Profiling

Once goals and priorities are defined, the Ever-Green team assessed current energy loads and compared those loads to similar-use buildings on other similar campuses to identify any deviations and opportunities for energy efficiency improvements. In coordination with UMN Morris staff, Ever-Green worked to understand how energy needs are being met, any concerns with the system, and how energy needs may be changing in the future. Ever-Green also analyzed primary options for growth into the adjacent community that could help the economics of implementing carbon neutrality.

Source Identification

Ever-Green developed a comprehensive list of all energy carbon neutrality options on the campus and within the community, including integration of new technologies, integration of other existing energy sources, and integration of renewable energy solutions already available within the region. During this work, all options will be identified and considered. Ever-Green identified short-term and long-term system solutions that can improve the campus carbon profile, along with budget estimates for implementation.

Identification of Preferred Strategies and Implementation Planning

Ever-Green performed a qualitative assessment of opportunities that are most viable for short and long-term implementation. As outlined in this report, challenges and benefits of each solution were developed, along with high-level cost estimates for the most attractive options.