Property Assessed Clean Energy (PACE) Renewable Energy Program Plan and Pilot Project

On behalf of Northport Energy Action Taskforce (NEAT) & Levin Energy Partners

by

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April 18, 2017

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Acknowledgements

My Advisor, Gregory Keoleian, Ph.D.
Professor Keoleian lent me his considerable knowledge and experience in sustainable energy systems, as well as something very precious, his time. Thank you for your advice, suggestions, and that extra motivation to meet deadlines.

Andy Thomas, Thomas & Milliken Millworks
Andy deserves special mention because of his willingness to join us in this experiment. Without Andy's interest in the project and procurement of data for the analysis, this pilot project would not have been possible. Thank you for your generosity, support and concern for the wellbeing of our planet.

My Client, Levin Energy Partners
Cory Connolly and Andy Levin provided necessary background information on Michigan PACE as well as kept me informed on potential project resources and contacts. Cory generously gave his time to advise and offer his guidance on the project.

My Client, Northport Energy Action Taskforce (NEAT)
A volunteer organization, NEAT donated much time and effort in assisting me and hosting me during my stay in Northport. This project came together through their energy and continued encouragement. Special thanks to Kathy Freirichs, Doug McInnis, Peter Wolcott, Steve Smiley, Tom Gallery and Joe DeFors.

Northport Survey Respondents
For your ongoing responses to the commercial energy survey and willingness to provide detailed information about the energy consumption of your business. NEAT will need your help going forward and I have no doubt you will prove to be a passionate, motivated partner in reaching ambitious energy goals for the future.

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Abstract

This practicum was conducted for Northport Energy Action Taskforce (NEAT) and Levin Energy Partners as an opus requirement for the Master of Science degree in the School of Natural Resources and Environment (SNRE). The goals of this practicum were to assess the potential of Property Assessed Clean Energy (PACE) in meeting NEAT's future renewable energy goals through a pilot project conducted in Northport. This practicum created and disseminated a commercial energy use survey, analyzed and made recommendations for a pilot project at Thomas & Milliken (T&M) Millworks, and summarized key findings and challenges for future energy projects in Northport.

This practicum assessed several different facility upgrades for a small business in the township of Northport, Leelanau County, MI. Project technologies were: wood biomass combined heat and power (CHP) system, wood chip and pellet boiler, two sizes of solar PV installation, two LED lighting replacement scenarios, and a hybrid project combining solar PV and wood boiler. Project finance focused on PACE and Michigan Saves, while also considering the Rural Energy for America Program (REAP) grant. Recommendations were based on four criteria: cost savings ($), energy savings (kWh), greenhouse gas emissions reductions (kg CO_2 e), and facility wood waste reductions (kg).

Overall, the 89-kW solar array generated the highest cost savings and emissions reductions over a 20-year time horizon. The CHP system performed well for energy self-generation and wood waste reduction, but questions remained about greenhouse gas emissions and fuel availability. Technology analysis led to recommendations and suggestions about the broader implementation of PACE in Northport.

1. Introduction

Communities like Northport are at an energy crossroads. Fossil fuels continue to provide most of the heat and electricity[1] delivered to homes and businesses despite the harmful consequences of greenhouse gas emissions and other pollutants.[2] In 2016, commercial and residential buildings accounted for 19% and 21% of energy consumed in the United States, respectively.[3] At the same time, almost a third of the energy sold to consumers was lost to inefficiencies.[4] Fossil energy consumption is the main source of greenhouse gas emissions from the commercial and residential sectors, accounting for 17% and 20% of CO_2 emissions in 2015.[5]

Businesses and property owners have opportunities to reduce their energy consumption and associated greenhouse gas emissions through distributed energy generation with clean energy technologies and energy efficiency. A 2010 McKinsey & Company report estimated that the US could reduce annual energy consumption by 23% from business-as-usual by "deploying an array of NPV-positive efficiency measures."[6] In Northport, homeowners seem to be making good progress in this area. In a household survey to Northport residents, over half the respondents said they had energy saving appliances installed in their homes. 70% said they choose Energy Star when making the decision to purchase new appliances.[7]

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[1] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." U.S. Energy Information Administration (EIA). Web. 21 Apr. 2016.
[2] "IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change." Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[3] The residential sector accounted for 20,471 million Btu in 2016. Commercial sector accounted for 18,213 million Btu in the same year. In total, 2016 US energy consumption was 97,421 million Btu. "Energy Consumption by Sector." US Energy Information Administration. Monthly Energy Review. From https://www.eia.gov/totalenergy/data/monthly/pdf/sec2_3.pdf on 4/12/2017
[4] "Property Assessed Clean Energy." Lean & Green Michigan™. Levin Energy Partners, 2016.
[5] "US Energy-related Carbon Dioxide Emissions." US Energy Information Administration. From https://www.eia.gov/environment/emissions/carbon/pdf/2015_co2analysis.pdf on 4/12/2017.
[6] Kiely, Tom. "Energy Efficiency: A Compelling Global Resource." McKinsey & Company. 2010.
[7] Cecco, L., Chen, Y., Good, J., Lai, K., Loshakova, E., Weinberg, E. *Northport 100% Renewable Energy Feasibility Study*. University of Michigan School of Natural Resources and Environment. April, 2015.

Energy efficiency is a low-cost resource, estimated to have a levelized cost of 2 to 5 ¢/kWh.[8] Compared to the average cost of electricity in January 2017, 15.23 ¢/kWh for residential and 10.84 ¢/kWh for commercial, energy efficiency savings are cost competitive. Despite the potential for long-term savings, energy efficiency and distributed generation projects face a steep hurdle in upfront costs.[9] Relatively long time horizons mean most companies and individual property owners choose not to retrofit their buildings to save energy. [10] Programs like Property Assessed Clean Energy (PACE) provide a financial mechanism for the property owner to generate cash flow from the first year of the project, effectively overcoming the high upfront cost of energy efficiency and renewable energy upgrades. This report analyzed the efficacy of PACE and similar programs to finance energy efficiency and renewable energy projects through the lens of a small business: Thomas and Milliken (T&M) Millworks. By taking a small business-oriented viewpoint, this practicum attempted to better understand the specific barriers of adoption that could be faced if Northport utilizes PACE or similar financing to achieve its stated goals of meeting 100% of its energy requirements from renewable electricity generation and fuels derived from renewable energy sources.[11]

1.1 Project Background

This practicum drew on research from the 2014-2015 Master's Project conducted by students at the University of Michigan's School of Natural Resources and Environment (SNRE), Luis Cecco, Yiyao Chen, Jeremy Good, Kuan-Ho Lai, Ekaterina Loshakova and Eric Weinberg.

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[8] National Action Plan for Energy Efficiency (2009). Energy Efficiency as a Low-Cost Resource for Achieving Carbon Emissions Reductions. Prepared by William Prindle, ICF International, Inc.

[9] "Energy Efficiency Financing." American Council for an Energy Efficient Economy. From http://aceee.org/topics/energy-efficiency-financing on 3/26/2017.

[10] "Michigan's Energy Finance Marketplace." Lean & Green Michigan™. Levin Energy Partners, 2016. Web. 20 Apr. 2016. <http://leanandgreenmi.com/index>.

[11] Cecco, L., Chen, Y., Good, J., Lai, K., Loshakova, E., Weinberg, E. *Northport 100% Renewable Energy Feasibility Study*. University of Michigan School of Natural Resources and Environment. April, 2015.

The *Northport 100% Renewable Energy Feasibility Study*, laid the groundwork for future renewable energy projects in Northport. With the assistance of the Northport Energy Action Taskforce (NEAT), the group assessed potential energy generation and geographic siting of distributed electricity generation by renewable sources—wind, solar and biomass. Notably, Northport has several renewable generating units already in place: a solar photovoltaic (PV) array at the golf course, a wind turbine and solar PV array powering the waste water treatment plant, and multiple residential installations of rooftop solar PV. The SNRE group conducted a survey on public opinion, which indicated approval of existing renewables by residents, as well as their general favor toward future small-scale, renewable energy projects.

The 2015 SNRE group laid the groundwork for future studies in Northport Township. This practicum applied previous research to create an energy use survey and make recommendations for a pilot project in Northport. The purpose of the pilot project was to assess different facility upgrades and identify financing opportunities for a local business to reduce its energy consumption and greenhouse gas emissions.

1.2 Utility Information for Northport, MI

Leelanau County is in the DTE gas service area,[12] although many property owners use propane, oil or wood to heat their homes and businesses.[13] There are two electric utilities operating in Northport: Cherryland Electric Cooperative and Consumers Energy. Cherryland is a rural energy cooperative that services six counties in Michigan, including Leelanau County. Consumers Energy serves most of the population in Leelanau Township, including Northport.

[12] Licensing and Regulatory Affairs (LARA), Public Service Commission. From http://www.dleg.state.mi.us/mpsc/gas/servarea.htm on 3/14/17
[13] Cecco, L., Chen, Y., Good, J., Lai, K., Loshakova, E., Weinberg, E. *Northport 100% Renewable Energy Feasibility Study*. University of Michigan School of Natural Resources and Environment. April, 2015.

1.3 Energy Use Survey

In 2015, a University of Michigan School of Natural Resources and Environment Master's Project surveyed Northport residents about energy efficiency and renewable energy and conducted an estimate of renewable resources to determine overall feasibility of transitioning to 100% renewable energy. While the group addressed physical and social barriers, it did not design a specific action plan for new renewable development in Northport and Leelanau Township. One of this project's goals was to determine the eligibility of programs like PACE to play a role in that energy transition to 100% renewable energy. Could businesses use PACE to reduce their consumption of nonrenewable energy? This practicum developed its own online survey to gather information about commercial energy use. The primary objective was to determine candidates for PACE finance and more broadly for any type of energy efficiency or renewable energy upgrade in Northport.

1.4 Survey Methodology

The survey was developed using Google Forms. Questions were based on qualifying characteristics of PACE in Michigan and specific questions posed by NEAT. Based on information provided by Levin Energy Partners of Michigan PACE, the survey addressed the following criteria:

- Ownership of business
- Type of business (Agriculture, tourism, manufacturing, etc.)
- Area (ft^2) of facility and property size (acres)
- Annual utility expenses (heat & electricity)
- Type of heating fuel (gas, propane, oil, wood)

- Interest in renewable energy
- Interest in building energy efficiency upgrades

The survey was emailed to over 50 different businesses in Northport. Survey access and ownership was given to NEAT who can now add new businesses and distribute the survey as needed. NEAT can also access the visual statistics generated by the survey and monitor ongoing results to identify new candidates for future project work.

A full copy of the survey has been included in the appendix at the end of this report. NEAT has access to the survey and can track future responders and their responses to inform its efforts in achieving renewable energy and energy efficiency goals in Northport.

1.5 Pilot Project Selection

The goals of the pilot project were to make actionable recommendations to the participating business. PACE and Michigan Saves can overcome the upfront cost barrier to energy efficiency and renewable energy projects, but the long-term savings remain in question. This practicum focused mainly on conducting analysis to provide recommendations for the business but also sought to understand the challenges other Northport businesses would face in adopting energy efficiency and renewable energy technologies.

If implemented, project recommendations represent a very small step toward achieving NEAT's goals of 100% renewable energy for Northport. This pilot attempted to clarify the process of project development and finance to better understand the financing tools that could enable other Northport businesses to make progress towards NEAT's energy goal. For business owners to adopt energy efficiency and renewable energy, the financing process should be transparent and accessible. This report is intended not only to present a learning case for students and faculty at the University of Michigan but to provide a helpful tool for project planners and business owners in Northport.

A candidate for the pilot project was identified before work on the survey had concluded. Andy Thomas of Thomas & Milliken (T&M) Millworks contacted NEAT to obtain facility upgrade recommendations. Due to its compatible timeline and goals, T & M Millworks became the host business for this practicum's pilot project.

Project goals were initially to reduce energy consumption and decrease the carbon footprint of T & M Millworks. Four major criteria were developed for this analysis: cost savings ($), energy savings (kWh), greenhouse gas emissions reductions (kg CO_2 e), and wood waste reductions (kg wood). An energy analysis of T&M Millworks was conducted and different options for facility upgrades were evaluated against the four stated criteria.

1.6 Thomas & Milliken Millworks

Thomas & Milliken (T&M) Millworks is a woodworking business.[14] Figure 1 shows the location of T&M within Northport Township. T&M specializes in custom doors, stairs, windows and moldings. A modern array of woodworking equipment includes molders, a computerized router, a section clamp carrier, a curved shaper, a resaw, and a custom door hanging machine.

The owner of T&M Millworks, Andy Thomas, served as lead contact for this pilot project. Andy provided energy usage data as well as estimates of wood waste generation and facility details.

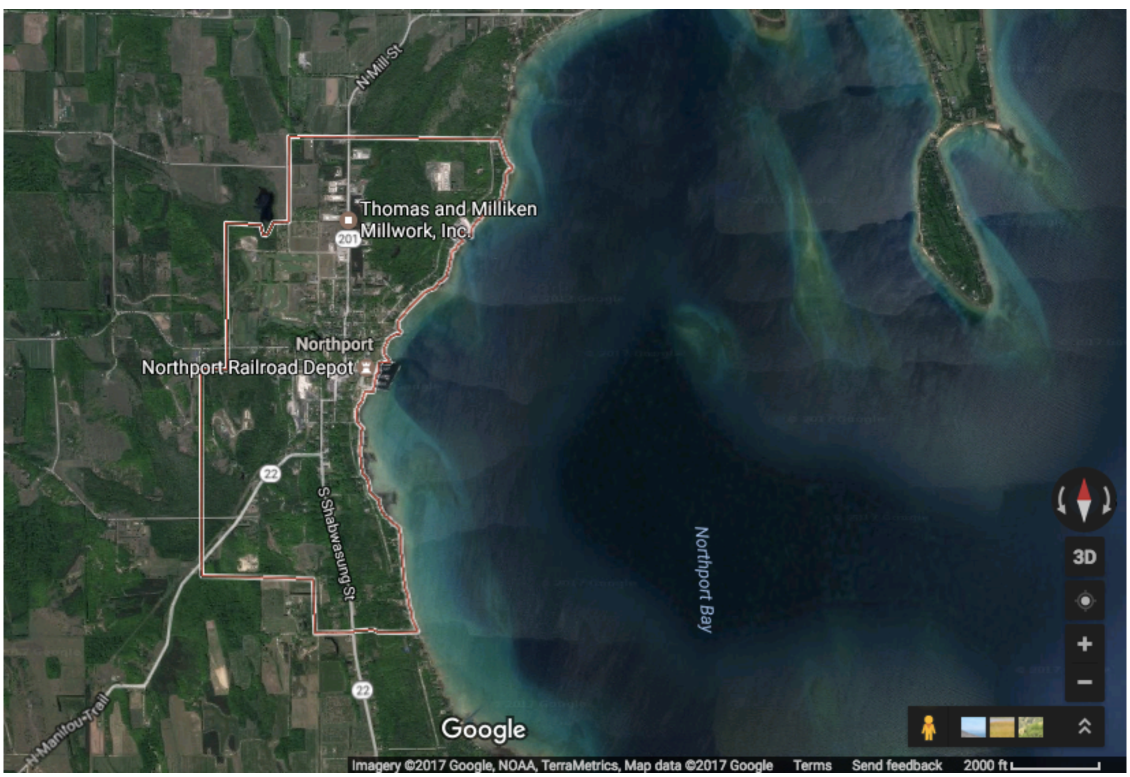

Figure 1. T&M Millworks Location in Northport, MI

[14] "Thomas and Milliken Millworks Inc." https://www.tmmill.com/aboutus/ From 4/42017.

Table 1. Operations Assumptions

Work days	5	days/week
Federal holidays	11	days
Work hours	9	hours/day

Table 2. Annual Energy Consumption and Energy Expenses[15]

Electricity	267,360	kWh/year
Average Power (hourly)	55	kW
Average Electricity Rate (Year 0)	$0.1076	/kWh[16]
Estimated Annual Electricity Costs	$28,767.94	/year[17]
Gas	445.3	Mcf/year
Gas Price (Year 0)	$7.7409	/Mcf[18]
Estimated Annual Gas Costs	$3,447.02	/year[19]

Table 3. Waste Generation[20]

Scrap wood (rippings)	38.2775	m^2/month
Sawdust	7	tons/month
Average wood density	724	kg/m^3 [21]

T&M Millworks spends more on electricity than gas per year. Seasonal variability in workload accounted for much of the observed monthly variation in electricity consumption,[22] while weather accounted for variation in natural gas consumption. In 2015, the millworks' minimum monthly electricity consumption was about 14,000 kWh in March with a maximum of

[15] Thomas, Andy. Personal Communication. 7/01/2016.
[16] Average Michigan retail rate, from EIA: https://www.eia.gov/electricity/state/ on 3/19/2017
[17] Average cost of electricity multiplied by average annual consumption.
[18] Annual price of gas was calculated using 2016 average monthly gas bills from the Detroit area. From https://www.bls.gov/regions/midwest/news-release/averageenergyprices_detroit.htmon 3/14/17
[19] Average cost of gas multiplied by average annual consumption.
[20] Thomas, Andy. Personal Communication. 7/01/2016.
[21] Krajnc, N. "Wood Fuels Handbook." Food and Agriculture Organization of the United Nations. UN Regional Office for Europe. 2015. From http://www.fao.org/documents/card/en/c/42655f7f-3bdb-4695-a7d8-39763219693e/ on 3/22/2017.
[22] Thomas, Andy. Personal Communication. 7/01/2016.

about 23,000 kWh in April. Maximum gas consumption that year was 101.3 Mcf in January and was shut off in June, July, August and September.

T&M Millworks operations produce a substantial quantity of wood waste. Currently, some of the sawdust is donated to nearby chicken farmers who remove it from the facility periodically. Scrap wood is piled in the back lot and burned several times a year to reduce its volume. At the onset of this project, Andy stated the business's concerns about accumulated wood and expressed a desire to "close the loop" on waste.

Conversations with Andy Thomas of T&M Millworks and client contacts helped establish the four criteria by which different technologies were evaluated in this analysis: cost savings ($), energy savings (kWh), emissions reductions (kg CO_2 e), and wood waste reductions (kg wood). The methodology section outlines the process used to quantify values for each of those four criteria over the time horizon of this analysis.

1.7 Project Finance

Three project financing scenarios were considered for the pilot: Property Assessed Clean Energy (PACE), Michigan Saves, and the Rural Energy for America Program (REAP) grant funding for energy efficiency and renewable energy facility upgrades. These financing tools either cover or offset the upfront costs of different energy technologies. Loan financing allows project costs to be distributed over multiple years as opposed to a one-time payment on installation of the technology.

1.71 Michigan PACE

Property Assessed Clean Energy (PACE) is a financing tool that allows a business to voluntarily enter a special property tax assessment, which it then pays off over the next 20 years.[23] That tax assessment can be used to cover the upfront costs of energy efficiency or renewable energy upgrades on the business' property. PACE differs from a conventional loan because it "runs with the land." If the property is sold, the payments and savings flow to the new owner. Under Michigan's PACE statute, the contractor doing the work must guarantee net savings for projects $250,000 and over.

The figure below shows current counties and municipalities that have passed legislature enacting PACE. Leelanau County has an active PACE program but many counties within the state do not. Businesses in these counties and municipalities do not have access to PACE financing, although other financing options, like Michigan Saves, may be available.

[23] "How PACE Works." 3/16/2017. http://leanandgreenmi.com/how_pace_works

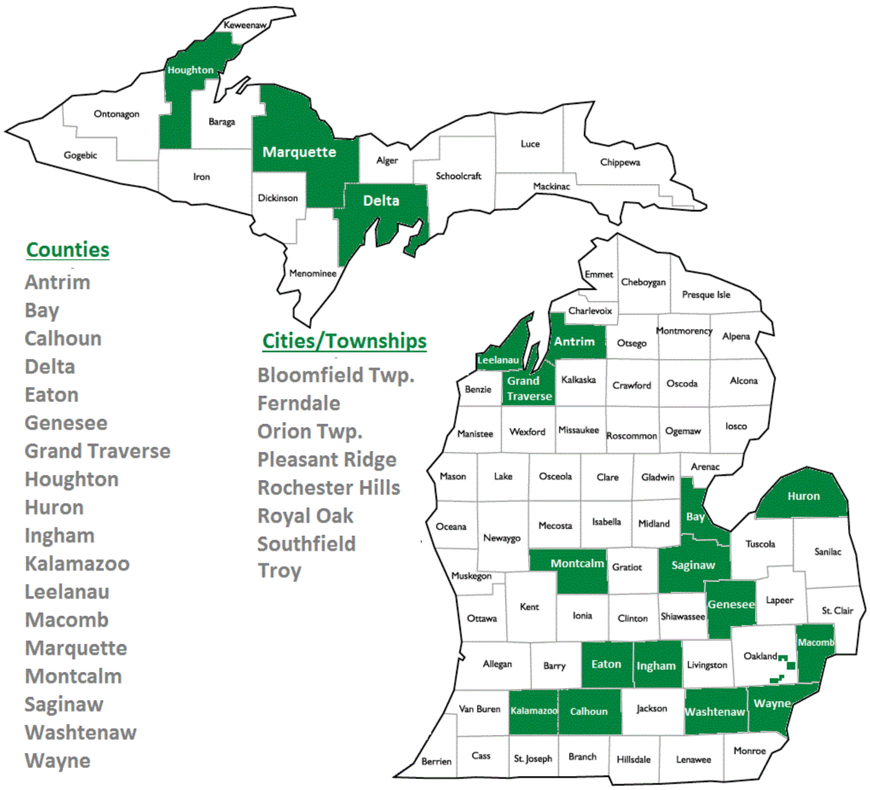

Figure 2. Jurisdictions participating in the Lean & Green Michigan initiative
Source: http://leanandgreenmi.com/index

Because of its longer time horizon relative to traditional small business loans,[24] PACE allows for projects with longer payback time, number of years for the project to cover its upfront expenses. Energy savings allow for an overall positive cash flow to the owner, making PACE an attractive option for businesses with high energy costs.

PACE legislation passed in the state of Michigan in 2010.[25] The city of Ann Arbor enabled its own version of PACE. Other municipalities and counties in Michigan have enacted PACE through the Lean & Green Michigan program, which allows the creation of a PACE tax district if voted through by local ordinance[26]. Currently, there are eighteen counties and eight

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[24] From https://www.sba.gov/offices/headquarters/ofa/resources/4049 on 4/21/2017.
[25] "What Is PACE?" PACENation. PACE*Now*. From http://www.pacenation.us/about-pace/ April 21, 207.

cities or townships that have voluntarily formed a PACE special tax district, including Leelanau County. Leelanau County has approved PACE through the Lean & Green Michigan program.

PACE finance offers an opportunity for business owners to invest in energy efficiency and renewable energy generation. Such projects have the potential not only to save their owners time and money by replacing inefficient or obsolete facility technologies, but also to greatly reduce a business's energy consumption and greenhouse gas emissions.

Despite public acceptance of renewable energy,[27] Northport has not hosted any PACE projects to date. A successful pilot project in Northport could help overcome reticence toward PACE and future renewable energy projects while demonstrating the PACE's value and accessibility to business owners in the community.

Table 4. PACE Loan Parameters

Interest Rate	7%
Estimated Loan Term (years)	20
Number of Payments (per year)	2
Annual Electricity Escalation Rate	2.45%/year
Annual Gas Escalation Rate	1.2073%/year
Government Legal Fee	$10,000
Lender Legal Fee	$10,000
LEP Fee (% Project Costs)	2%

[27] Cecco, L., Chen, Y., Good, J., Lai, K., Loshakova, E., Weinberg, E. *Northport 100% Renewable Energy Feasibility Study*. University of Michigan School of Natural Resources and Environment. April, 2015.

1.72 PACE Limitations for T&M Millworks

Restrictions of PACE finance vary by state. In Michigan, PACE finance is only available for commercial property owners in certain counties and municipalities that have passed legislation to enact PACE.[28] Leelanau County enacted PACE in July 2015.[29] Commercial property owners like Andy Thomas of Thomas & Milliken Millworks can apply for a PACE loan to cover the upfront costs of energy efficiency and renewable energy technology installations.

PACE has certain restrictions that limit project scale. Lenders will not typically lend to projects under $150,000, setting an effective minimum project budget requirement. Furthermore, the maximum loan amount depends on the overall indebtedness of the property owner and the property value. PACE provides 100% financing for projects up to 25% of the property value.[30] For T&M Millworks, that maximum project cost is $187,500. PACE could finance up to $187,500 for a project whose costs are greater, but T&M Millworks would then have to finance the remainder of the project by other means.

A PACE transaction involves the private lender, a local government which acts as an intermediary, and the property owner. Two legal fees will be required to process a PACE loan: government and lender legal fees of $10,000 each. Furthermore, as PACE provider, Levin Energy Partners (LEP) charges a fee of 2% the total project's cost. These fees, while modest relative to a larger project of several hundred thousand dollars and higher, can represent a significant portion of smaller PACE loans.[31]

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[28] Public Act No. 270 of 2010 enables local governments to adopt PACE programs to promote the installation of energy efficiency and renewable energy systems by property owners.
[29] "County of Leelanau, Michigan PACE Program." Levin Energy Partners. From http://www.leelanau.cc/downloads/county_pace_report.pdf on 2/27/17
[30] Connolly, Cory. Personal Communication. 4/21/2017.
[31] Legal fees constitute 15% of project costs for a project of $150,000, which would incur an additional $23,000 in fees.

PACE is limited to certain types of technology upgrades. Electricity, heating and water savings upgrades are all eligible for PACE finance. Within those categories, nearly all energy efficiency and renewable energy system installations are available to commercial property owners, including lighting, insulation, heating systems, and solar photovoltaic (PV).

PACE legislature requires that loans of $250,000 finance projects are cash flow positive over the span of the project's time horizon.[32] This limitation requires PACE projects to consider cost effectiveness as a component of the analysis. This constraint does not apply to T&M Millworks as the maximum project cost with PACE is $187,500.

Energy savings must also be demonstrated, either through efficiency upgrades or energy self-generation. Analysis focuses on energy a savings as a key performance indicator for proposed projects. Over a 20-year time horizon, the project must be shown to reduce energy consumption in the facility.

To apply PACE constraints to T&M Millworks, an energy project that receives 100% financing from PACE must meet the following criteria:

1. Total project costs sum from $150,000 and $187,500
2. Demonstrate potential energy savings over a 20-year time horizon

An unstated but nonetheless important consideration for PACE is project cash flow and payback. Projects that fail to recover their costs over the 20-year time horizon of the loan represent a financial burden on T&M Millworks, which reduces the business's overall willingness to take on debt, hire contractors, file paperwork, and devote time and energy to the proposed facility upgrades.[33] Negative net savings do not rule out a project for T&M Millworks,

[32] Connolly, Cory. Personal Communication. 4/21/2017.
[33] Thomas, Andy. Personal Communication. 7/1/2017.

but they could reduce the attractiveness of the project and decrease the business's likelihood of using PACE financing.

Levin Energy Partners summarizes the ideal project outcome with PACE: "The project will be cash flow positive from beginning to end."[34] That scenario requires all upfront project costs to be covered entirely with PACE and total annual savings to exceed total annual payments, which amounts to net positive cash flow for the entire time horizon of the project.

1.73 Michigan Saves

Michigan Saves is a nonprofit organization that provides loans for residential and commercial energy savings.[35] Like PACE, Michigan Saves finances energy efficiency and distributed generation projects by providing short to medium-term loans with fixed interest rates. Notably, the current interest rate is lower than PACE, at 6% compared to 7% with PACE. However, interest rates are subject to annual variation and must be reassessed at the time of analysis. A simple Michigan Saves commercial loan typically has the following characteristics:

Table 5. Michigan Saves Loan Parameters

Amount (Range)	$2,000-$300,000
Interest Rate	6%
Estimated Loan Term (years)	5
Number of Payments (per year)	12

[34] "How PACE Financing Works." Levin Energy Partners. 3/16/2017. http://leanandgreenmi.com/how_pace_works

[35] "Business Energy Finance." Michigan Saves. From http://michigansaves.org/business-energy-financing/ on 3/24/2017.

Todd O'Grady, Michigan Saves Business Energy Financing Program Coordinator, provided details on a special type of loan available to Consumers Energy customers and projects up to $75,000.[36] T&M Millworks would be able to utilize this loan, which has a 0% interest rate for the first 24-36 months. The parameters for the Consumers Energy Michigan Saves loan are as follows:

Table 6. Consumers Energy Michigan Saves Parameters

Amount (Range)	$2,000-$75,000
Interest Rate (months 1-36)	0%
Interest Rate (months 37-60)	6%
Estimated Loan Term (years)	5

This special loan would be more attractive than both standard Michigan Saves and PACE for smaller projects due to the lower interest rate. Michigan Saves loans are shorter term so payments would be dispersed between the first five years. Unlike PACE, Michigan Saves would not allow the payments to be distributed over twenty years.

1.74 MI Saves Limitations for T&M Millworks

Most projects at T&M Millworks that would qualify for PACE should also qualify for Michigan Saves. That said, project costs would have to be much smaller to qualify for the special Consumers Energy loan. For this reason, the project analysis section details whether projects qualify for PACE, Michigan Saves or Consumers Energy Michigan Saves.[37]

[36] O'Grady, Todd. Personal Communication. 1/20/2017.
[37] Projects that qualify for Consumers Energy Michigan Saves utilize those loan parameters as opposed to the standard Michigan Saves parameters.

1.75 Rural Energy for America Program (REAP) Renewable Energy Systems & Energy Efficiency Grants

The Rural Energy for America Program (REAP)[38] provides small grants and guaranteed loan finance for renewable energy and energy efficiency upgrades to agricultural producers and small businesses in eligible areas. Any small business owner in Leelanau County is eligible to apply for a REAP grant. Funds must be used for a specific list of the following renewable energy technologies:

- Biomass (for example: biodiesel and ethanol, anaerobic digesters, and solid fuels
- Geothermal for electric generation or direct use
- Hydropower below 30 megawatts
- Hydrogen
- Small and large wind generation
- Small and large solar generation
- Ocean (tidal, current, thermal) generation

REAP grants can also be used to fund these energy efficiency technologies:

- High efficiency heating, ventilation and air conditioning systems (HVAC)
- Insulation
- Lighting
- Cooling or refrigeration units
- Doors and windows
- Electric, solar or gravity pumps for sprinkler pivots

[38] "Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans and Grants." From https://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency on 3/26/2017.

- Switching from a diesel to electric irrigation motor
- Replacement of energy-inefficient equipment

Two types of grants are available: restricted and unrestricted. The first type provides up to $20,000 to eligible businesses for any of the previous types of projects. Applications are submitted biannually.[39] The unrestricted grant provides up to $500,000 for renewable energy projects or $250,000 for energy efficiency projects (Minimum of $2,500 for renewable energy and $1,500 for energy efficiency) There is an annual submission deadline to apply for the unrestricted loan.[40]

The REAP grant has additional requirements. Grant-only applicants must provide at least 75% of the project costs. If applying for a loan or combination of loan and grant, applicants must provide at least 25% of the project costs. A technical report must be submitted for projects of $200,000 or greater and energy efficiency projects require an energy audit.

The application for REAP is comprehensive and requires project technologies to be finalized. For that reason, this practicum did not attempt to submit a grant application. Instead, focus was on the first step of identifying possible project types and assessing energy and cost savings of each project to help T&M Millworks make its decision. Analysis did not include the REAP grant due to the uncertainty in being selected as a recipient, but such a possibility should be considered for all the project technologies mentioned in this report.

The REAP grant could provide a means to make a project cash flow positive or offset the costs of a project not entirely financed by PACE. The technologies chosen for this analysis would qualify for the REAP grant. If selecting one of the projects described in the analysis

[39] The most recent dates were October 31, 2016, and March 31, 2017.
[40] The most recent deadline was March 31, 2017.

section of this report, T&M Millworks should submit a REAP grant application to help offset project costs.

2. Analysis Methodology

Projects were suggested for analysis by practicum clients and client contacts. Four criteria were chosen for evaluation: savings ($), energy savings (kWh), greenhouse gas emissions reductions (kg CO_2 equivalent), and wood waste reduction (kg). Those criteria were developed over the course of multiple conversations with Andy Thomas of T&M Millworks, who stated his priorities in conducting the pilot.

2.1 Technology Selection

Projects were researched or suggested by the project clients. Andy Thomas requested analysis of the Borealis Combined Heat and Power system, providing additional data from the manufacturers. After it became clear that that technology had some challenges, other projects were identified for analysis and comparison.

Table 7. Role of Client Contacts in Selecting Project Technologies

Technology	Type	Identified by	Source
Borealis Combined Heat and Power	Heat and Power (Biomass)	Andy Thomas, T&M Millworks	http://www.borealiswoodpower.com/aboutchp.php
Solar Photovoltaic (PV)	Power (Solar)	Northport Energy Action Taskforce	NREL, System Advisor Model
Fröling T4 Wood Chip and Pellet Boiler	Heat (Biomass)	Northport Energy Action Taskforce	https://www.froeling.com/us/products/hackgut/t4.html
LED Lighting Replacement	Energy Efficiency	Todd O'Grady, Michigan Saves	http://www.homedepot.com/
Combined Project: Fröling Boiler and Solar PV	Heat (Biomass) and Power (Solar)	Cory Connolly, Levin Energy Partners	https://www.froeling.com/us/products/hackgut/t4.html, NREL, System Advisor Model

In some cases, projects were sized differently to determine a range of possible options. For example, many different capacities of solar PV were examined in SAM before the analysis settled on 20-kW and 89-kW capacity projects. The 20-kW solar array was chosen as the largest capacity that qualified for net metering under Consumers Energy. The 89-kW solar array was the largest capacity in terms of price that qualified for PACE financing.

Several different wood boilers were also examined before the Fröling T4 wood chip and pellet boiler was selected. In this case, the T4 was sized based on its heat output which was determined to be compatible with the heating requirements of T&M Millworks. For the T4, a cost estimate was provided by a member of the client organization, which was not the case for the other wood boilers examined. Cost estimates for installation of boilers varied wildly, so it was deemed most acceptable to use this technology, with a known cost parameter.

The LED lighting replacement scenario was chosen as an energy efficiency project, because it was believed that the fluorescent tube lighting installed in T&M Millworks was inefficient and obsolete. Lighting replacement promised to be a candidate for Michigan Saves financing on its own, or could have been combined with another project for PACE financing.

The combination project was an experiment, with the joint objectives of heating and electricity savings, as well as qualifying for PACE financing. That project came together readily as it required no additional research, using known parameters from the solar 20-kW PV array and the Fröling T4 boiler.

2.2 Energy Generation and Savings

Analysis methodologies differed by technology. Generally, technical characteristics of each project provided the power or heat output used to estimate energy generation or consumption pre- and post-installation, or Year 0 compared to Year 1 and onward. Standard parameters for energy consumption and hours of operation were used to compare each project to the base case in Year 0. Energy consumption in subsequent years was compared to Year 0 to quantify grid electricity or natural gas savings.

System Advisor Model (SAM) by the National Renewable Energy Laboratory (NREL) was used to model the electricity generation of solar photovoltaic (PV) panels in standing array. All analyses used the same location for weather data: USA MI Traverse City (TMY2), with the following characteristics:

- Station ID: 14850
- Latitude/Longitude: 44.7333 °N, 85.5833 °W
- Time Zone: GMT -5
- Elevation: 192 meters above sea level

2.3 Cost and Net Savings

Estimated annual energy savings were converted to monetary savings by using utility price rates for gas and electricity, with respective escalators for each year. Costs and savings were compared to determine net cash flow each year. Depending on the project and financing parameters, costs came from multiple sources: loan payments, additional energy spending if the project required inputs like electricity, or replacement technologies. Savings were simply the reduction from energy consumption in Year 0, multiplied by the relevant utility rate with cost escalation. In the case of LED replacements, number of new lamp replacements were considered for both Year 0 (fluorescent) and Year 1 onward (LED) and credited to annual savings.

2.4 Greenhouse Gas Emissions Reductions

Avoided emissions of greenhouse gases (kg CO_2 equivalent) were based on energy use for each project. Carbon emissions factors from electricity were calculated using EPA's eGrid 2014 database.[41] Annual non-baseload emissions rates were used to calculate emissions avoided by reducing electricity consumption. Emissions factors for natural gas and combustion of woody biomass were based on EPA's greenhouse gas emissions inventory.[42] It was assumed no pollution controls for greenhouse gases were installed in either the Borealis CHP or the Fröling T4 wood boiler. Using those emissions factors, energy usage was converted to greenhouse gas emissions (kg CO_2 equivalent) and calculated for each year of the project's 20-year time horizon. Total emissions over twenty years were included in the analysis section.

[41] "eGRID2014 GHG Annual Output Emission Rates" EPA. From https://www.epa.gov/sites/production/files/2015-10/documents/egrid2012_ghgoutputrates_0.pdf on 3/24/2017

[42] "Emissions for Greenhouse Gas Inventories." EPA. From https://www.epa.gov/sites/production/files/2015-11/documents/emission-factors_nov_2015.pdf on 3/24/2017

3. Project Analysis

Six project types were examined for analysis: Borealis Combined Heat and Power, Fröling T4 Wood Chip and Pellet Boiler, two sizes of solar photovoltaic (PV), 20-kW and 89-kW DC, two LED lighting replacement scenarios, and a combined project that involved two technologies: the Fröling boiler and the 20-kW PV solar array. Analysis followed the methodology outlined in the previous section to quantify energy savings, cost savings, emissions reductions and wood waste reductions to evaluate each project.

3.1 Borealis Combined Heat and Power System

The first technology examined was a combined heat and power (CHP) system for wood chips by the Canadian company, *Borealis*. CHP would utilize readily available and otherwise unwanted waste wood as fuel. The idea of closing the waste loop by adopting a CHP system fit in with PACE objectives by meeting heat and electricity needs for the entire facility. At 45 kW heat/110 kW electric, the CHP system would meet almost all the electrical and all the facility's heating demands, given sufficient fuel. Closing the waste loop meant eliminating problematic wood waste from the facility, as opposed to moving the waste elsewhere or burning it periodically, the current practice. Excess sawdust was packed into boxes and donated to nearby chicken farmers while wood scrap was piled outside the facility and reduced by burning.

A waste-burning system combined the benefits of low-cost fuel with useful waste elimination. Fuel was not considered free because equipment and additional energy were required to convert scrap wood into wood chips.

Concerns to be addressed in this analysis were: cost effectiveness, availability of fuel, and overall environmental benefit. Questions to be answered were:

1. Does the system recover its costs over the specified time horizon?

2. Can the facility meet its fuel requirements from waste wood, given the known rate of waste production?
3. What are the avoided emissions of the CHP Borealis?

The following analysis sought to answer those three questions by applying project methodology discussed previously, except where otherwise noted.

Table 8. Borealis CHP Costs Summary

Technology	**Model Name**	**Cost**
CHP System	Borealis CHP	$273,000
Wood Chipper	RONGDA BX216	$5,000
Total		$278,000

Borealis would install the gasifier and engine of the CHP system. Support equipment to convert scrap wood into wood chips was selected separately and added to the total costs.

Project cash flow modeled over a 20-year time horizon revealed net savings of $277,704 with annual savings of $24,429 on Year 0. Savings came from avoided costs of electricity and gas as the CHP provided most of the facility's electricity and all its heating requirements. Electricity savings did not include electricity consumed that was not provided by the system and for additional energy needed to power support machinery for conversion of wood waste into wood chip fuel.[43]

[43] With the new CHP system, annual energy generation rose from 267,360 kWh/year to 288,569 kWh/year, assuming conversion of all available wood waste into chips. The CHP system generated 244,603 kWh electricity annually, requiring 43,966.15 kWh consumption from the grid.

3.11 Borealis CHP Financial Indicators

The Borealis CHP generated substantial annual savings from reduced energy consumption. Natural gas expenses dropped to $0, with an effective 100% reduction in natural gas purchased. Eliminating most of electricity consumption from the grid resulted in 91% reduction in purchases from the electricity grid.

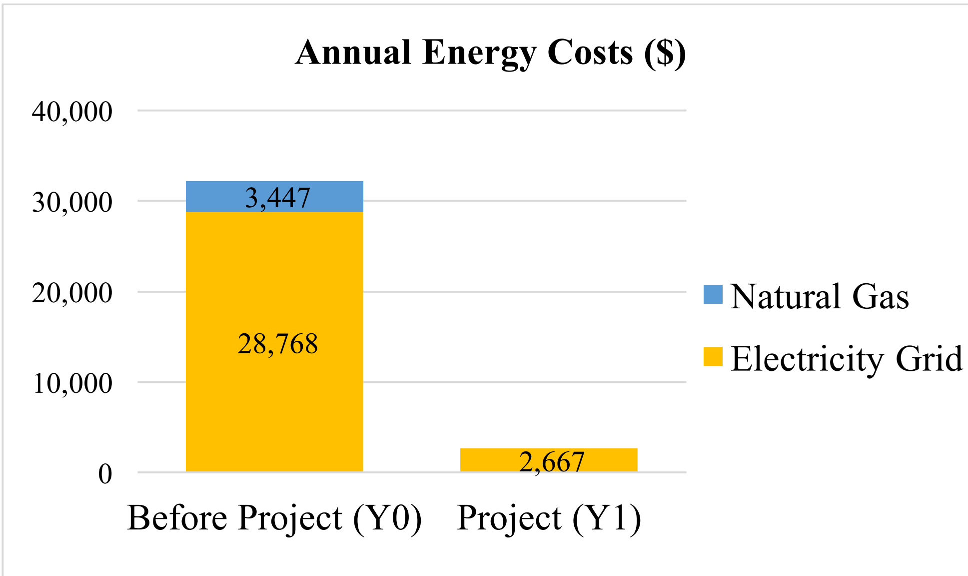

Figure 3. Annual Energy Costs Before and After Borealis CHP Installation

Table 9. Borealis CHP Financial Performance

Net Annual Cash Flow (Year 1)	$24,429
Cumulative Net Savings	$277,704
NPV (2.3% discount rate)	$149,399
IRR	7%
ROI	27%
Payback (years)	10

3.12 Borealis CHP Fuel Requirements

The previous cash-flow calculations were contingent on adequate fuel supply. One of the questions this analysis sought to answer was: *does the facility's wood waste meet its fuel demands?* To address this question, Andy Thomas provided waste generation estimates from one month of work at T&M Millworks.

The following parameters were used in performing the energy potential calculation:

Table 10. Wood Fuel Availability and Consumption

Parameter	**Value**	**Units**	**Source**
Sawdust	44,452.03	kg/month	Andy Thomas, T&M Millworks
Scrap wood (rippings) for chips	18,013.39	kg/month	Andy Thomas, T&M Millworks
EC Pellets (10% Moisture)	17	MJ/kg	UN FAO "Wood Fuels Handbook" [44]
EC Wood Chips (30% Moisture)	12.2	MJ/kg	UN FAO "Wood Fuels Handbook"
Conversion Efficiency (heat)	65	%	Borealis CHP[45]
Conversion Efficiency (electricity)	30	%	Borealis CHP

Based on those estimates and the above heat content parameters, conversion of wood to wood chips would yield 216,161 kg chips or 1,846,012 MJ per year. At the assumed conversion efficiencies for heat and power, that value translated to a potential 1,384,509 MJ heat provided per year and 256,391 kWh electricity per year. Comparing those numbers to expected annual energy consumption 37,411.3 MJ heat and 288,569 kWh electricity, wood chip fuel meets heating needs and most of the total electrical demand.

[44] Krajnc, N. "Wood Fuels Handbook." Food and Agriculture Organization of the United Nations. UN Regional Office for Europe. 2015. From http://www.fao.org/documents/card/en/c/42655f7f-3bdb-4695-a7d8-39763219693e/ on 3/22/2017.

[45] "The Borealis Process." Wood Power Corp. From http://www.borealiswoodpower.com/process.php on 4/12/2017.

Based on the estimated rate of wood waste generation, wood chips can only meet about 80% of the facility's entire electrical needs. Due to capacity constraints, the CHP system would be unable to meet the facility's average load regardless of fuel availability. The Borealis CHP system has a max power rating of 45 kW. Compared to T&M's average daily load of 55 kW,[46] the facility would always require additional power. Supplying the deficit of 10 kW by the electricity grid reduces the facility's overall fuel requirements. Accounting for this grid input, the system would only have to provide 244,603 kWh annually, consuming 216,161 kg of wood chips per year.

The energy and fuel necessary to process the wood waste into wood chips must also be considered in overall energy consumption. Processing 216,161 kg wood, the wood chipper requires an additional 3,234 kWh annually. The 61-kW chipper would have to draw power from the electricity grid, incurring additional electricity costs each year.

[46] Thomas, Andy. Personal Communication. 7/1/2017.

3.13 Borealis CHP Annual Electricity and Fuel Consumption

Unlike energy efficiency technologies, the Borealis CHP generates additional electricity and heat that the facility consumes instead of electricity from the grid or natural gas from the utility. In Y1 of the project, natural gas consumption was reduced to 0% of the baseline in Y0. Biomass consumption rose to meet both heating and electricity demands of the facility. The figure below shows the difference from Y0 to Y1 in terms of facility energy consumption by source.

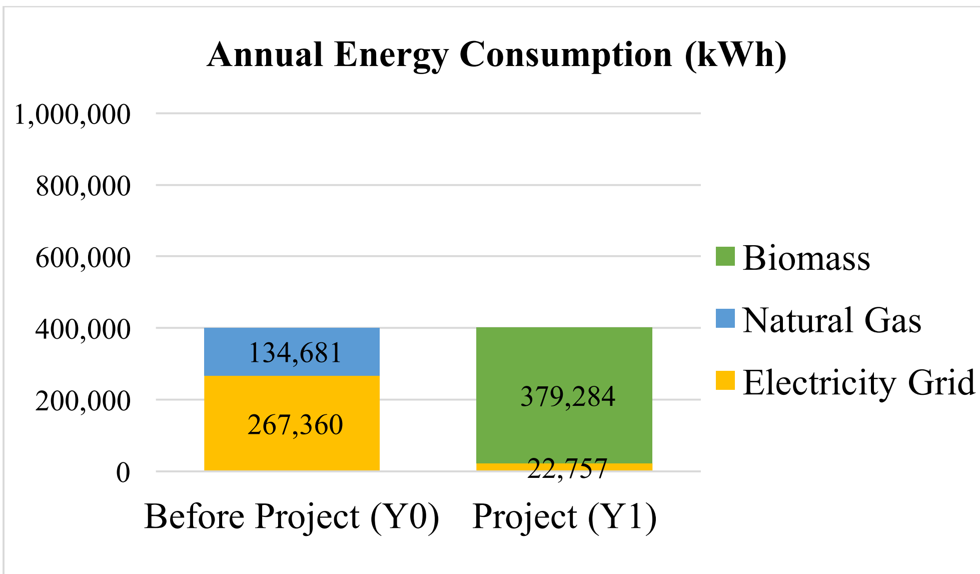

Figure 4. Annual Energy Consumption, Y0 to Y1

Table 11. CHP Borealis Energy Savings

CHP Electricity	244,603	kWh
Wood Chips (CHP)	216,161	kg
Electricity (Chipper)	3,234	kWh
Total Electricity (CHP)	247,837	kWh/year
Total Gas (CHP)	0	Mcf/year

Fuel estimates show that if the estimated rate of wood chip production remained constant, wood chips could provide 100% of the facility's heating and roughly 80% of its electricity needs. The system's 45-kW capacity proved to be as much of a constraint as fuel.

Overall, the CHP technology was very successful at reducing wood waste. 100% of the available wood chips were used in order to meet 80% of the facility's electricity needs. This consumption left the shavings and sawdust untouched, but nevertheless provided a significant service in reducing overall wood waste (kg wood).

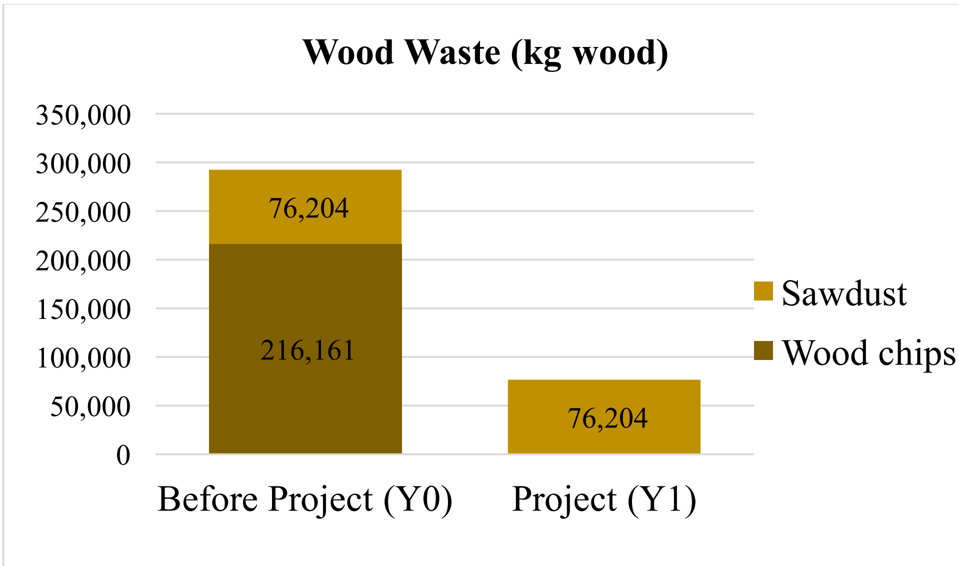

Figure 5. Wood waste reduction by Borealis CHP, Y0-Y1

There is little certainty about the amount of fuel produced monthly. All wood waste generated at the facility was stacked in one pile for periodic burning, but careful month-to-month records of wood waste and burn schedule were not available. It is entirely possible that some of the wood waste in the pile was generated in previous months, creating an overestimate. For that reason, more certainty about wood waste should be established before verifying the size of the Borealis CHP for a facility upgrade.

If waste availability proves to be a larger constraint than previously believed, there are several possible workarounds. Though less ideal than producing and disposing all waste on-site, T&M Millworks could take on waste wood from other woodworking or construction facilities.

Or, if no waste is available, wood chips can be purchased at relatively low cost.[47] Lastly, while Borealis recommends using wood chips of a specific size, the CHP can run up to 30% fines, which could include the shavings produced as a woodworking byproduct. T&M generates an ample supply of shavings to provide fuel as needed, but the makers of Borealis should be consulted to ensure that this practice will not damage the machinery or reduce the effective life of the CHP system.

3.14 Borealis CHP Avoided Emissions

The third part of this analysis addressed the avoided emissions of the Borealis CHP system. Despite the system's efficiency and modernity, combustion of wood chips and shavings would undoubtedly produce emissions of greenhouse gases and criteria pollutants. Only greenhouse gases were examined, but criteria pollutants should be studied further for their local effect and the potential health risk posed to facility workers and neighbors.

EPA emissions factors of CO_2, CH_4, and N_2O were calculated from three different sources: electricity from the grid, natural gas, and combustion of wood and wood residue (shavings). Global Warming Potential (GWP) converted all units to kg CO_2 equivalent.

Electricity emissions reductions were based on the electricity savings provided by the CHP system less electricity consumed from the grid, including additional electricity required to power the wood chipper. Annual emissions (kg CO_2 e) rose from Y0 to Y1 due to the increased on-site combustion of woody biomass for combined heat and power.

[47] $70-100 per US ton. From https://www.alibaba.com/showroom/wood-chip-bulk.html on 3/22/2017

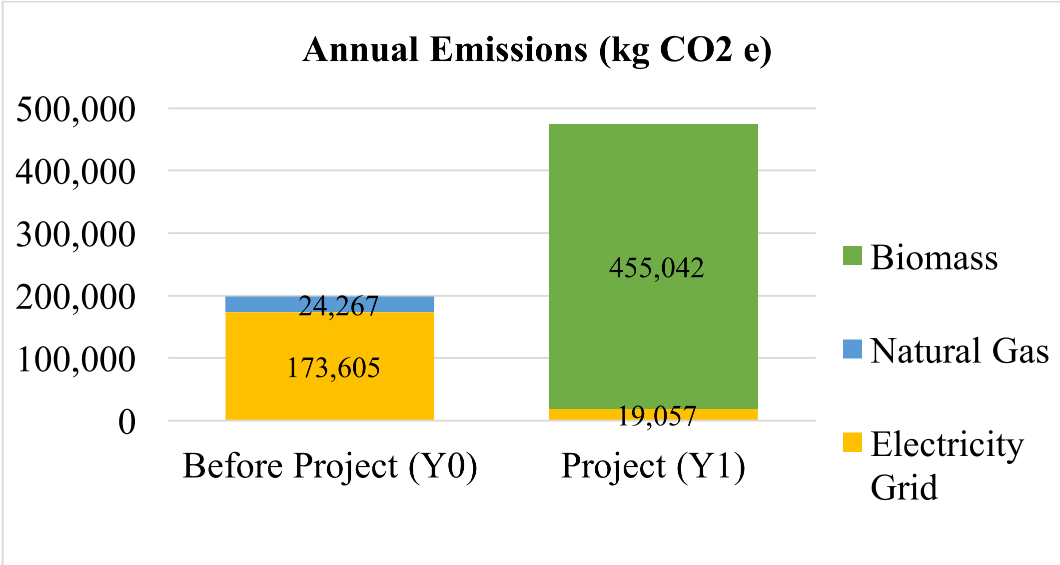

Figure 6. Annual Emissions at T&M Millworks, Y0-Y1

Table 12. Borealis CHP Avoided Emissions, Year 1

Wood Emissions (CHP)	-266,760	kg CO_2 Equivalent
Electricity Grid	174,069	kg CO_2 Equivalent
Natural Gas	24,267	kg CO_2 Equivalent
Total Emissions Reductions	-68,424	kg CO_2 Equivalent

Overall, the project increases greenhouse gas emissions by 68,424 kg CO_2 equivalent per year. Reductions were from offsetting electricity from the grid and from replacing natural gas with the CHP system. However, the emissions incurred by meeting most of the facility's energy needs from burning wood proved much higher than anticipated.

This analysis did not consider the lifecycle of the woody biomass. Presumably, each tree sequesters an equivalent amount of carbon as is emitted from combustion. Furthermore, the business-as-usual case for T&M Millworks is to reduce wood waste by periodic burning. The analysis did not attempt to include these sinks and sources of greenhouse gases, but perhaps a fairer analysis could consider the baseline scenario emissions. Thus, combustion by the CHP system below the amount burned by T&M Millworks at present would not increase greenhouse gas emissions. This scenario was not included in the analysis because the present rate of wood burning was not known.

3.15 Borealis CHP PACE Finance

The combined costs of the CHP unit and supporting technologies put this project well above the PACE project cost constraint of 25% of property value, or $187,500. However, in theory, the PACE loan could cover the maximum $187,500 and seek out other financing options to cover remaining costs. This analysis assumed that PACE covered the maximum amount and the remaining $90,500 was covered upfront (Year 0). The project had the following cash flow and net savings characteristics:

Table 13. Borealis CHP PACE Financial Indicators

Annual PACE Payment	$19,941
Net Annual Cash Flow (Year 1)	$7,657
Cumulative Net Savings	$141,193
NPV (2.3% discount rate)	$178,506

3.16 Borealis CHP Michigan Saves Finance

Michigan Saves could finance 100% of this project costs. Payments were distributed from Year 1 to Year 5. After Year 5, payments ended and net savings rose from -$36,855.88 to $29,540.48. Overall, Michigan Saves yielded higher overall savings than PACE, but it required five years of negative cash flow to cover the loan payments.

Table 14. Borealis CHP Michigan Saves Financial Indicators

Annual Michigan Saves Payment	$65,996

Net Annual Cash Flow (Year 1)	-$38,398
Cumulative Net Savings	$300,522
NPV (2.3% discount rate)	$264,698

3.2 Fröling T4 Wood Boiler

T&M Millworks had two wood boilers installed in 1995.[48] Due to the age of the system and the abundance of wood waste fuel, this practicum considered a wood boiler replacement scenario using the Fröling T4 wood chip and pellet boiler.

3.21 Project Costs Summary

The Fröling T4 model sold in the US by the company TARM Biomass was recommended by a member of the NEAT group and local contractor, Steve Smiley.[49] Smiley provided cost estimates for the wood boiler and installation costs. A wood chipper was purchased separately and included in the total project costs.

Table 15. Fröling Boiler Installation Costs

Technology	Model Name	Cost
Wood Chip and Pellet Boiler	Fröling T4	$100,000
Wood Chipper	RONGDA BX216	$5,000
Total		$105,000

The Fröling T4 model can burn both wood chips or wood pellets. If wood chips were temporarily unavailable, shavings could be pelletized and converted into usable wood fuel. An electric pelletizer retailed at $3,600.[50] This additional equipment would add to project costs and could increase annual energy consumption, but it would provide a supplementary and abundant source of wood fuel. This analysis assumed the wood boiler would burn only wood chips, but it

[48] Thomas, Andy. Personal Communication. 7/01/2016.
[49] Steve Smiley provided cost estimates for wood boiler and installation as $60,000 and $40,000, respectively. Smiley, Steve. Personal Communication. 9/13/16.
[50] "Wood Pellet Energy Machine." Alibaba.com. From https://www.alibaba.com/product-detail/Factory-supply-hot-selling-bioenergy-wood_60389133998.html?spm=a2700.7724838.0.0.n8CRfs on 3/24/2017.

would not be difficult to replace or offset some of that consumption with wood pellets in a future analysis.

Like the Borealis CHP system, installing a wood boiler combined the benefits of free fuel with wood waste reduction. Criteria considered were the same as those of the CHP Borealis, and of all project technologies in this analysis: cost savings ($), energy savings (kWh), emissions reductions (kg CO_2 e) and wood waste reduction (kg wood).

3.22 Fröling Boiler Financial Indicators

Overall, this technology did not save as much on energy costs as the Borealis CHP. The Fröling boiler effectively reduced gas consumption to zero. That said, the boiler generated no savings from electricity because it met facility heating demands only. The figure below shows energy cost reductions from Year 0 to Year 1.

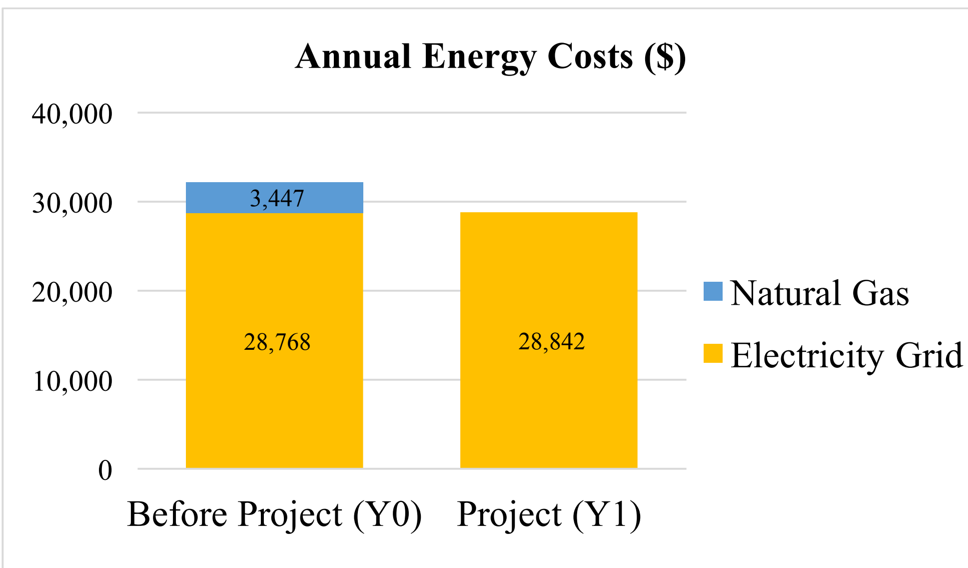

Figure 7. Annual Energy Costs, Before and After Fröling Boiler Installation

Table 16. Fröling Boiler Financial Performance

Net Annual Cash Flow (Year 1)	$3,489

Cumulative Net Savings	-$26,614
NPV (2.3% discount rate)	$60,501
IRR	-3%
ROI	-87%
Payback (years)	44

Project cash flow modeled over a 20-year time horizon yielded net savings -$26,614.13 with annual gas savings of $3,488.64 on Year 0. Additional electricity expenses were considered due to additional energy needed to power support machinery for conversion of wood waste fuel. Electricity consumption rose by 675 kWh, adding an additional $74.39 to electricity costs on Year 1. From previous fuel requirements calculations, wood waste from wood chips would be able to meet the facility's heating requirements.

3.23 Fröling Boiler Annual Energy and Fuel Consumption

It was assumed that the facility used as much energy for facility operations and heating each year of the project. Annual electricity consumption rose by a 675 kWh, the amount required to power the wood chipper. For the most part, energy consumption remained constant, but energy sources varied before and after the project installation. Heat energy changed from natural gas to biomass because the Fröling boiler met 100% of the facility's heating requirements. The figure on the following page shows the change in annual energy consumption for the year immediately following project installation (Y0-Y1).

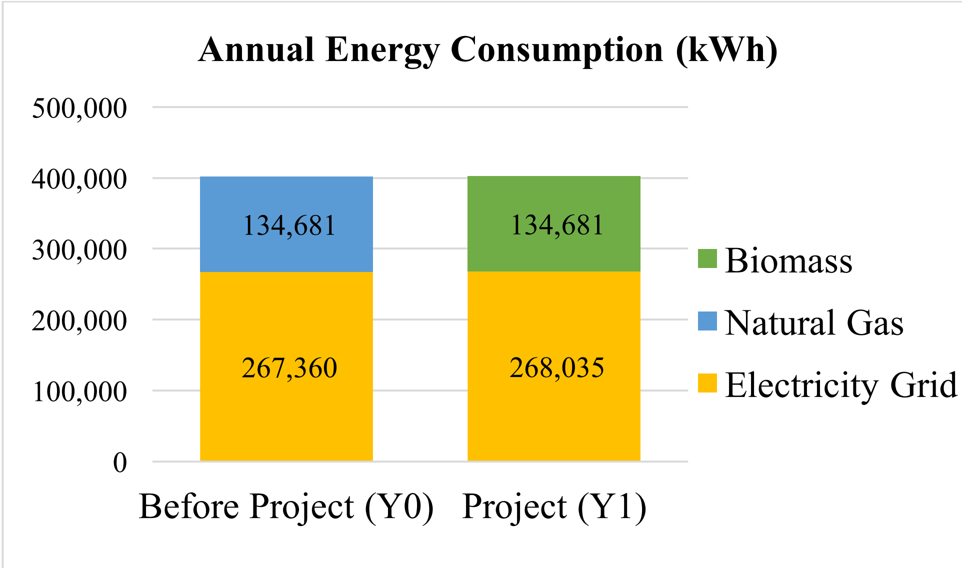

Figure 8. Fröling Boiler Annual Energy Consumption at T&M Millworks, Y0-Y1

Table 17. Fröling Boiler Energy and Fuel Consumption

Energy from wood	41,568	MJ
Wood Chips (T4)	3,407	kg
Electricity (Chipper)	675	kWh
Total Electricity	268,035	kWh
Total Gas (CHP)	0	Mcf/year
Total Wood Chips	3,407	kg

Electricity consumption and costs rose overall due to the processing demands of the wood chipper. Wood chip fuel met all the facility's heating needs, reducing gas consumption to zero from Year 1. The boiler consumed 3,407 kg wood chips per year, around 2% of the total wood waste.

Wood waste reductions were minimal but come with more certainty in meeting demand for fuel. Due to the low fuel use, it seems likely that T&M Millworks would be able to meet all of its fuel needs for the Fröling boiler from on-site wood waste alone.

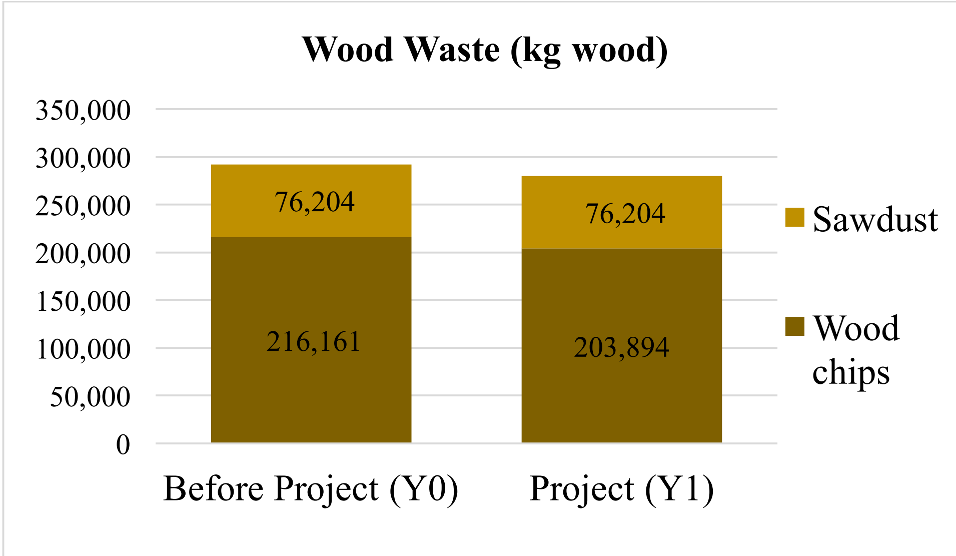

Figure 9. Fröling Boiler Wood Waste Reductions, Y0-Y1

Greenhouse gas emissions were mostly unchanged, but went down slightly, due to the higher efficiency of the Fröling boiler than natural gas. The figure below shows annual emissions before and after the project.

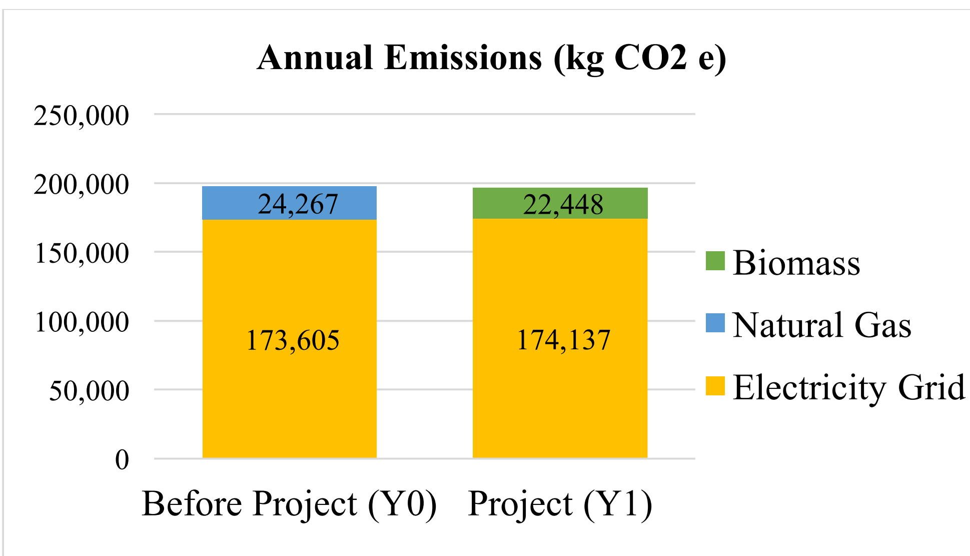

Figure 10. Fröling Boiler Annual Emissions Y0-Y1

Table 18. Fröling Boiler Emissions Reductions, Y1

Wood Emissions (Boiler)	-6,236	kg CO_2 equivalent
Electricity Grid	-532	kg CO_2 equivalent
Natural Gas	24,267	kg CO_2 equivalent
Total Emissions Reductions	17,500	kg CO_2 equivalent

The Fröling T4 showed reductions in emissions to 17,500 kg CO_2 equivalent per year. Emissions reductions came exclusively from replacing natural gas with biomass. Emissions from additional electricity use and wood boiler combustion slightly offset reductions from natural gas. Over the project's 20-year horizon, greenhouse gas emissions were reduced by 349,994 kg CO_2 equivalent.

3.24 PACE Finance

This project does not meet the minimum $150,000 cost required for PACE finance. Adding additional equipment or combining this project with another project could qualify it for PACE. While project costs are too low for PACE, this project would qualify for Michigan Saves financing.

3.25 Michigan Saves Finance

Michigan Saves could finance 100% of this project's costs. This project was too costly to be eligible for the Consumers Energy Michigan Saves loan so standard Michigan Saves parameters applied. Payments were distributed from Year 1 to Year 5. After Year 5, payments ended and net savings rose from -$21,266.43 to $3,704.38. Due to the low annual savings, Michigan Saves yielded net negative cash flow over the 20-year time horizon.

Table 19. Fröling Boiler Michigan Saves

Annual Michigan Saves Payment	$24,927
Net Annual Cash Flow (Year 1)	-$21,438
Cumulative Net Savings	-$46,247
NPV (2.3% discount rate)	-$54,822

3.3 Solar PV: 20-89 kW

Two different solar systems were evaluated using NREL's System Advisor Model, 20-kW and 89-kW DC. The systems qualified for the Investment Tax Credit (30%) and MACRS depreciation schedule for tax savings during the first six years of the projects. The 20-kW system was the maximum capacity that qualified for Consumers Energy true net metering policy. By installation cost, the 89-kW system was the largest project that qualified for 100% PACE financing.

3.31 Solar System Parameters

SunPower SPR-X20-327-COM was selected for the photovoltaic panel due to its outstanding Energy Sage rating.[51] SunPower's monocrystalline Silicon panel had the following characteristics:

- Nominal efficiency: 20.0603%
- Maximum Power: 327.183 Watts DC
- Temperature Coefficients: -0.321%/°C, -1.050 W/°C
- Material: Monocrystalline Silicon
- Module Area: 1.631 m^2
- 25-year Warranty

The string inverter model selected for analysis was the SMA America STP 60-US-10 (400 VAC) 400V (CEC 2015) with the following characteristics:

- Maximum AC Power: 59,859 W AC
- Maximum DC Power: 61,100.1 W DC
- Power Consumption during Operation: 87.9831 W DC

[51] "The Best Solar Panels of 2016 by EnergySage Rating." From http://news.energysage.com/best-solar-panels-complete-ranking/ on 2/27/17

- Power Consumption at Night: 7.1 W AC

The inverters were assumed to have a lifespan of 10 years and require replacement on Year 11.[52] Other cost parameters for the solar system were as follows:

Table 20. Solar System Costs

Module	0.64	$/W DC
Inverter	0.13	$/W DC
System Equipment	0.33	$/W DC
Labor	0.19	$/W DC
Installer Margin and Overhead	0.72	$/W DC
Sales Tax	6.00	%

Solar financial incentives included for all projects, were:

- Investment Tax Credit: 30%[53]
- Depreciation Schedule: 5-year MACRS[54]

The 20-kW solar array had the following characteristics:

- Nameplate Capacity: 17.995 kW DC
- Two-axis Tracking
- Panel Degradation Rate: 0.5%/year
- Number of Modules: 55
- Number of Inverters: 1
- Modules per String: 11

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[52] "How Inverters Work." From http://greenzu.com/solar-pv-inverter on 3/24/2017.
[53] The ITC amounts to a tax credit of 30% project costs in first year after installation.
[54] Basis for calculation is 85% of project costs beginning the first year after installation.

- Strings in Parallel: 5
- Total Module Area: 89.7 m^2
- Total Land Area: 0.1 acres (404.686 m^2)

The 89-kW solar array had the following characteristics:

- Nameplate Capacity: 86.376 kW DC
- Two-axis Tracking
- Panel Degradation Rate: 0.5%/year
- Number of Modules: 264
- Number of Inverters: 4
- Modules per String: 11
- Strings in Parallel: 24
- Total Module Area: 430.6 m^2
- Total Land Area: 0.4 acres (1,618.74m^2)

3.32 Electricity Rates

SAM used electricity rates from Consumers Energy, General Service – Primary, Customer Voltage Level 1,[55] with a monthly charge of $50 and a price escalator of 2.5%/year. Consumers Energy rates in Year 0 were $0.11744/kWh from June-September and $0.108428/kWh from October-May.

Consumers Energy stipulates that an installation of 20-kW and under is eligible for true net metering. Thus, monthly total excess electricity rolled over to the next month in kWh, effectively generating energy credits using retail rates.

[55] CVL 1 is available to customers using 0 to 2,400 V. From https://www.consumersenergy.com/uploadedFiles/CEWEB/SHARED/Rates_and_Rules/electric-rate-book.pdf on 2/27/17.

For the 89-kW installation, surplus electricity generated was credited for sell rates in place of buy rates. This lower rate reflects Consumers Energy modified net metering policy by which distributed generators with systems sized greater than 20 kW are credited with the generation portion of retail rates.[56]

3.33 Solar PV Financial Indicators

Both sizes of solar PV generated reasonably constant electricity savings over the twenty-year time horizon. The smaller, 20-kW solar installation cut electricity expenses by about 12% while the larger, 89-kW system, reduced electricity by 56%. The figure below shows the difference between Y0 and Y1 of the two different solar projects.

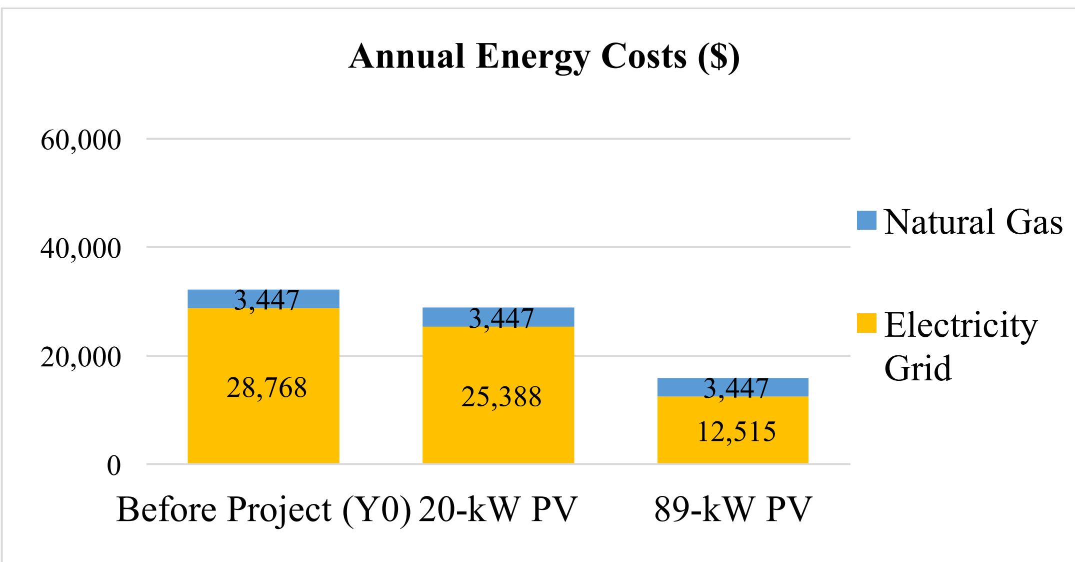

Figure 11. Energy Costs Before and After Solar PV Installation, Y0-Y1

[56] Net Metering Program. From http://www.michigan.gov/mpsc/0,4639,7-159-16393_48212_58124-253269--,00.html on 3/24/2017

Table 21. Solar PV Financial Indicators

Solar PV 20-kW

Net Electricity Savings (Year 1)	$3,380
Cumulative Net Savings	$57,231
NPV (2.3% discount rate)	$39,104
IRR	15%
ROI	61%
Payback (years)	11

Solar PV 89-kW

Net Electricity Savings (Year 1)	$16,253
Cumulative Net Savings	$390,005
NPV (2.3% discount rate)	$289,850
IRR	23%
ROI	129%
Payback (years)	11

The tables above use net electricity savings as a basis for the payback calculation. However, the real cash flow of the project is heavily influenced by the investment tax credit and MACRS depreciation schedule. The figure below shows the influence of these two incentives on tax savings in Y0. The units are the same as Figure 11 (energy costs) for comparison.

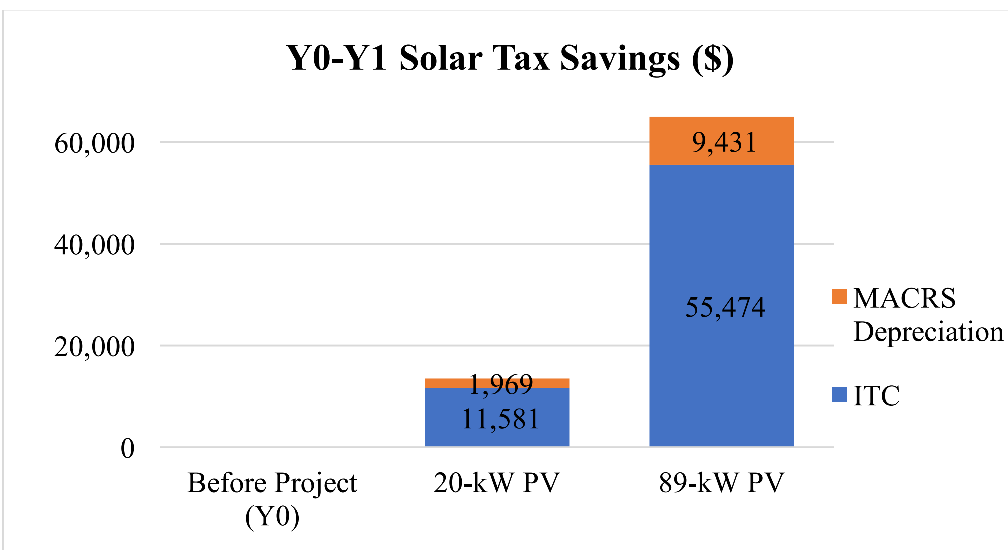

Figure 12. Solar Tax Savings for 20-kW and 89-kW Solar PV, Y0-Y1

Table 22. Energy Consumption, Electricity Grid and Solar PV

PV Size	Electricity Grid, Before Project (kWh/yr)[57]	PV Generation (kWh/year)	Electricity Grid, After Project (kWh/year)[58]
20-kW DC	267,360	30,658	119,926
89-kW DC	267,360	147,434	236,702

Both solar PV projects showed positive cumulative net savings and avoided more emissions than the biomass projects. Incentives provided an important additional source of savings for both projects. For the 20-kW PV project, $21,425.31 of the total $103,033.54 savings over 20 years came from the investment tax credit and MACRS depreciation schedule. Overall, these projects provided substantial energy and emissions reductions for their costs.

The figure below shows energy consumption at the facility. It was assumed facility electricity requirements remained constant between years but grid electricity was offset by generation from solar systems.

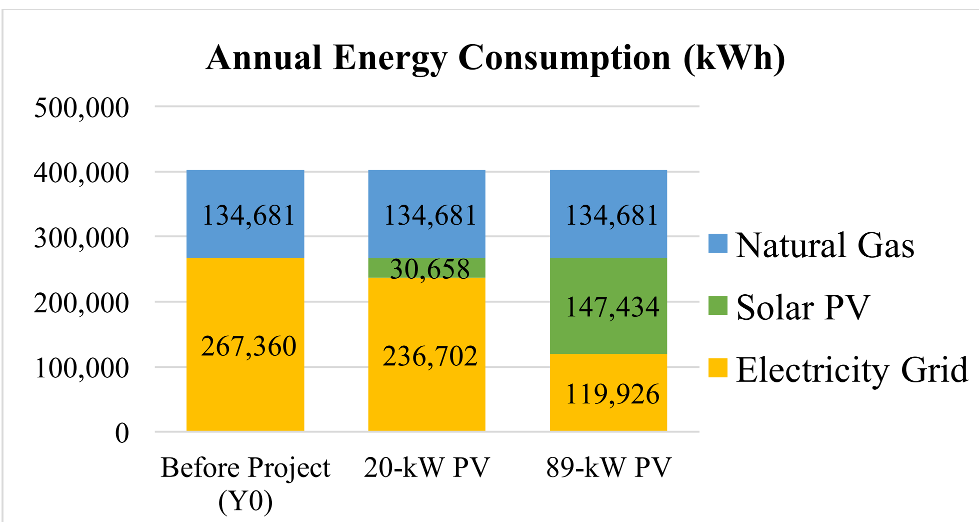

Figure 13. Annual Energy Consumption Before and After PV Installation, Y0-Y1

[57] Based on Year 0.
[58] Based on Year 1.

Emissions reductions were proportional to the amount of grid electricity offset by electricity generated by the PV systems. The figure below shows emissions at T&M Millworks before and after the project.

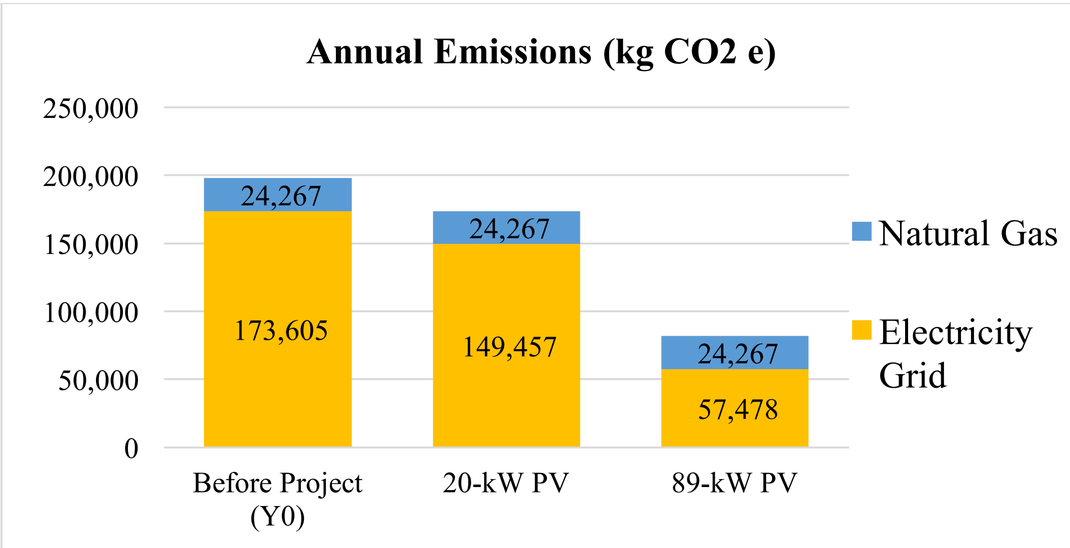

Figure 14. Solar PV Annual Emissions, Y0-Y1

Table 23. Avoided Emissions from Solar PV

Avoided Emissions from Reduced Grid Electricity Consumption, Year 1

20-kW	24,148	kg CO_2 equivalent
89-kW	116,127	kg CO_2 equivalent

Avoided Emissions from Reduced Grid Electricity Consumption, over 20 Years

20-kW	460,687	kg CO_2 equivalent
89-kW	2,215,453	kg CO_2 equivalent

3.34 Solar PV PACE Finance

The 20-kW solar project does not meet the minimum $150,000 cost required for PACE finance. Increasing the size of the project to 71-kW, or 228 panels and 4 inverters, would meet the minimum qualifications for PACE. This analysis did not include a project of those characteristics. The 89-kW solar system, which was analyzed, represents the maximum project size for PV due to the maximum PACE project cost constraint of $187,500.

Table 24. PACE Financial Performance, 89-kW Solar PV

Annual PACE Payment	$19,692
Net Savings (Year 1)	$81,158
Net Savings (Year 10)	-$375
Cumulative Net Savings	$213,988
NPV (2.3% discount rate)	$194,841

3.35 Solar PV Michigan Saves Finance

The 20-kW solar project's costs were low enough to qualify for the Consumers Energy Michigan Saves loan. Payments were distributed from Year 1 to Year 5, with 0% interest in Year 1 to Year 3. While this project represented roughly a quarter of the 89-kW PV project's energy and emissions reductions, its relatively low cost and lower land use requirement could make it an attractive option for a smaller project, or as part of a combined project.

Table 25. Michigan Saves Financial Performance, 20-kW Solar PV

Annual Michigan Saves Payment	$7,221
Net Savings (Year 1)	$9,709
Net Savings (Year 10)	$4,017
Cumulative Net Savings	$64,589
NPV (2.3% discount rate)	$45,706

3.4 Combined Project: 20-kW PV Solar Array and Fröling Wood Boiler

Two different technologies, 20-kW PV and the Fröling wood chip and pellet boiler, were combined for this project. Given the relatively high electricity savings of solar PV and the heat savings of the Fröling T4 wood boiler, it was likely that a combined project would increase energy savings. Solar PV performed well financially but did nothing about the facility's wood waste, while the Fröling T4 brought natural gas consumption to zero and helped dispose of waste but failed to recover its costs in the given time horizon. The combined project used parameters identical to the 20-kW solar PV and Fröling T4 wood chip and pellet boiler described earlier in the analysis section. Question for the analysis were:

1. Do the two projects, when added together and financed with PACE, make up their costs over a 20-year time horizon?
2. Are the combined energy and emissions reductions an improvement over any of the other, "larger" projects analyzed (89-kW Solar PV, LED lighting replacement)?
3. Does combination affect this project's financing qualifications?

The following tables summarize project costs for the combined project as well as financial performance over the 20-year time horizon of this analysis.

Table 26. Combined Project Cost Summary

Project	**Model Name**	**Cost**
Solar PV 20-kW	*Panels*: SunPower SPR-X20-327-COM *Inverter*: SMA America STP 60-US-10 (400 VAC) 400V (CEC 2015)	$38,604
Fröling T4 Wood Chip and Pellet Boiler	Boiler: Fröling T4 Chipper: RONGDA BX216	$105,000
Total		$143,604

Table 27. Combined Project Financial Performance

Annual Cash Flow (Year 1)	$20,077
Annual Cash Flow (Year 10)	$7,083
Cumulative Net Savings	$18,201
NPV (2.3% discount rate)	-$12,235
IRR	1%
ROI	-87%
Payback (years)	44

3.41 Combined Project Energy Savings

Energy consumption, generation and savings from heating and electricity were converted to kWh. Net electricity savings were annual PV generation less added electricity consumption from the wood boiler and wood chipper. The wood boiler met the facility's heating needs, reducing gas consumption to zero.

Table 28. Combined Project Electricity and Gas Savings

Electricity Generation from PV (Year 1)	30,658	kWh/year
Additional Electricity for Boiler (Year 1)	675	kWh/year
Gas Savings from Boiler (Year 1)	37,411	MJ/year
Annual Energy Savings (Year 1)	40,375	kWh
Total Energy Savings (20 Years)	779,230	kWh

3.42 Combined Project Avoided Emissions

Overall, the combined project yielded a net emissions reduction of 41,647. Emissions reductions from the solar PV generation and avoided natural gas consumption were slightly offset by additional emissions from wood combustion and added electricity consumption. Over the project's 20-year horizon, emissions reductions totaled 956,103 kg CO_2 equivalent. The table below summarizes emissions from this project and emissions avoided through reduced consumption of energy from the electricity grid and from natural gas.

Table 29. Combined Project Emissions

Wood Combustion	-6,236	kg CO_2 equivalent
Grid Electricity Consumption (Boiler and Chipper)	-532	kg CO_2 equivalent
Grid Electricity Savings (PV)	24,148	kg CO_2 equivalent
Natural Gas	24,267	kg CO_2 equivalent
Total	41,647	kg CO_2 equivalent

3.43 Combined Project PACE Finance

This project did not meet the $150,000 minimum for PACE financing. However, it would be feasible to increase the number of solar modules to qualify for PACE. If so, the project would likely not be strongly cash flow positive due to the added fees required for the PACE finance. At $150,000, fees would be $22,500, roughly 15% of the project costs.

3.44 Combined Project Michigan Saves Finance

This project qualifies for standard Michigan Saves but not the Consumers Energy Michigan Saves loan. Given the previous project and financial parameters, project cash flow and other indicators were:

Table 30. Combined Project Michigan Saves Financial Performance

Annual Michigan Saves Payment	$9,164
Net Savings (Year 1)	$10,943
Net Savings (Year 10)	$7,129
Cumulative Net Savings	$116,961
NPV (2.3% discount rate)	$109,074

The solar installation generated the most savings in the first five years of the project. This front loading of savings worked well with Michigan Saves scheduled payments which were arranged for the first five years of the project. Overall, this combined project saw net positive savings within the Michigan Saves loan parameters.

3.5 LED Lighting Replacement

A lighting replacement scenario considered the costs and savings of replacing all fluorescent tube lights to LEDs of similar brightness. The analysis looked at 1-1 lighting replacement and at replacement by illumination for the entire facility, which included: work room, office, storage, and break room.

The current number and type of lights in each room were as follows:

Table 31. Lights for Replacement by Number

Room	Estimated Area (m^2)[59]	Type of Lighting	Number of Lights
Work Room	1,264	Fluorescent (8' T12)	130
Storage	78	Fluorescent (4' T12)	8
Break Room	78	Fluorescent (4' T12)	8
Office	19	Fluorescent (4' T12)	2

Without specific technical information about current facility lighting, common models for industrial and commercial lighting were selected to represent the two types of fluorescent tube lighting used in T&M Millworks.[60] LED replacements were selected for their similar brightness and dimensions, in addition to favorable online reviews.[61] The lights, current and replacement, are summarized in the table on the following page.

[59] Figure estimated from total square footage of the facility, 15,483 ft^2. Thomas, Andy. Personal Communication. February 1, 2017.
[60] Sylvania 60-W Fluorescent Tube (8'). From https://www.lowes.com/pd/SYLVANIA-15-Pack-60-Watt-4-100K-Cool-White-Fluorescent-Tube-Light-Bulbs-Common-94-in-Actual-94-in/3744315 on 3/26/2017 and Philips T12 (4'). From http://www.bulbs.com/product/F40T12-CWSUPREME-ALTO on 3/26/2017. Fluorescent lights also required ballast: OSRAM FL Ballast from https://www.lowes.com/pd/OSRAM-2-Bulb-Commercial-Electronic-Fluorescent-Light-Ballast/50260887
[61] GELCO LED (8') from http://www.bulbs.com/product/F40T12-CWSUPREME-ALTO on 3/26/2017 and LumGen LED (4') from http://www.lightup.com/t8-led-4ft-tube-18w-direct-wire-clear-1800-lumens-lumegen.html

Table 32. Lights for Replacement by Type

Name	Type	Power (W)	Brightness (lumen)	Lifespan (hours)
Sylvania 60-W (8')	FL	60	3,850	12,000
Philips (4')	FL	40	2,600	24,000
GELCO (8')	LED	33	4,400	50,000
LumGen (4')	LED	18	2,160	50,000

Given the known brightness properties and estimated area of each room, levels of illuminance (lux or lm/m^2) were calculated for the facility at present. The facility's current illuminance provided a target for the LED replacement scenario. Notably, the illuminance of the workroom averaged 396 lux (lm/m^2), below the recommended illuminance level for "Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, [and] Laboratories."[62]

Table 33. Recommended Light Levels by Activity (National Optical Astronomy Observatory)

Activity	**Illumination** ***(lux, lumen/m^2)***
Public areas with dark surroundings	20 - 50
Simple orientation for short visits	50 - 100
Working areas where visual tasks are only occasionally performed	100 - 150
Warehouses, Homes, Theaters, Archives	150
Easy Office Work, Classes	250
Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories	500
Supermarkets, Mechanical Workshops, Office Landscapes	750
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1,000
Detailed Drawing Work, Very Detailed Mechanical Works	1500 - 2000
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2000 - 5000
Performance of very prolonged and exacting visual tasks	5000 - 10000
Performance of very special visual tasks of extremely low contrast and small size	10000 - 20000

[62] The National Optical Astronomy Observatory (NAOAO). "Recommended Light Levels for Outdoor and Indoor Venues."From https://www.noao.edu/education/QLTkit/ACTIVITY_Documents/Safety/LightLevels_outdoor+indoor.pdf on 3/31/2017.

This analysis did not consider it a goal to achieve 500 lux average illuminance, the recommended level for the average workplace, or 750 lux, the recommended level for mechanical workshops. However, the recommended table of illuminance values should be taken into consideration for future planning.

For this analysis, it was assumed the facility preferred to remain at the same average illuminance (lux). Thus, the number of lights for replacement was determined by calculating the number of lights required to maintain current illuminance in each room.

Table 34. LED Replacements by Illuminance

Room	**Estimated Area (m^2)**	**Illuminance (lm/m^2)**	**LED Replacement**	**Number Required (Lights)**
Work Room	1,264	396	GELCO (8’)	114
Storage	78	268	LumGen (4’)	10
Break Room	78	268	LumGen (4’)	10
Office	19	268	LumGen (4’)	2

3.51 LED Replacement Project Costs

Electricity consumption before replacement and after replacement was used to determine overall electricity savings. While energy savings proved a component of net annual cash flow, labor costs proved almost equal in terms of annual savings. Labor costs were incurred by lighting replacements as lights reached the end of their effective lifespans, and needed to be replaced. Analysis used a standard rate of $65/hour and 15 minutes per replacement per light.[63] The figures below show electricity costs from before and after the project for the 1-1 replacement scenario.

[63] “Cost-effectiveness of Linear T8 Lamps.” Pacific Northwest National Laboratory. Solid-State Lighting Program, Building Technologies

Table 35. LED Replacement Project Costs Summary

Costs, LED Replacement (1-1)

Project	Cost
Workroom Lights	$3,899
Other Lights	$126
Labor Costs (Y 0)	$2,405
Total	$6,430

Costs, LED Replacement (by illuminance)

Project	Cost
Workroom Lights	$3,899
Other Lights	$126
Labor Costs (Y 0)	$2,405
Total	$6,430

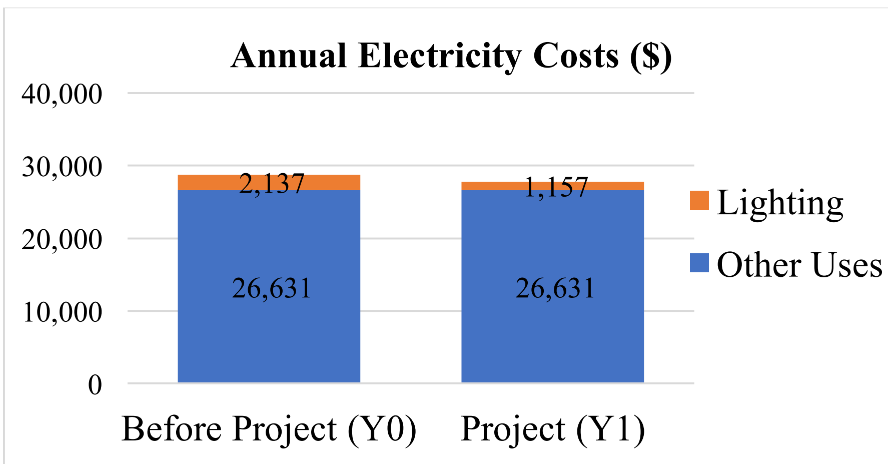

Figure 15. Electricity Costs, Y0-Y1, 1-1 LED Replacement

Compared to Year 0, savings are modest due to lighting's relatively small impact on overall electricity consumption. Lighting represents roughly 3% of the facility's annual electricity requirements. Annual replacement costs are effectively halved, yielding an estimated $433 in savings from avoided replacement per year.

Office, Office of Energy Efficiency and Renewable Energy, US Department of Energy. May 2014 (Revised Jan 2017).

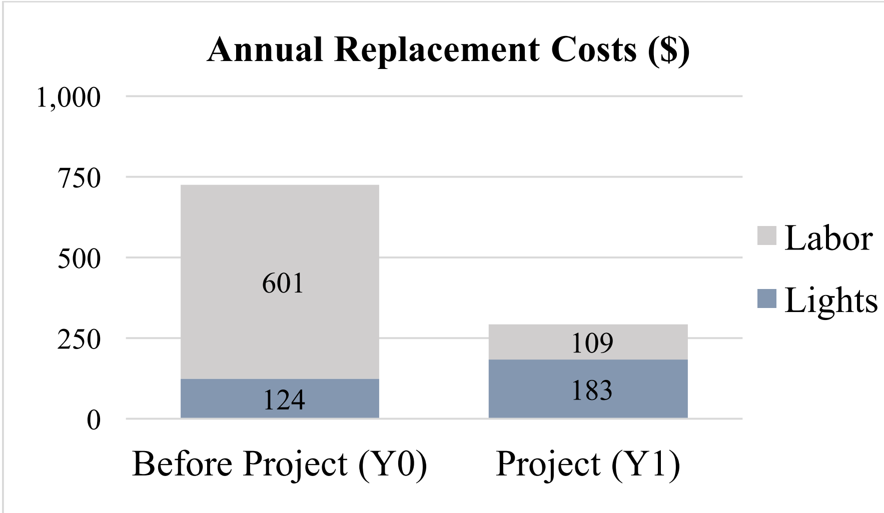

Figure 16. Annual Replacement Costs, Y0-Y1, 1-1 LED Replacement

3.52 LED Lighting Replacement Financial Indicators

Analysis of the two replacement scenarios yielded similar financial results. Both projects generated under $2,000 cash flow in savings per year and were net savings positive, with a very short payback period. That said, savings were very modest compared to the other project technologies analyzed mainly due to the low potential savings of lighting, which represented a small fraction of the facility's electricity consumption.

Table 36. 1-1 LED Replacement Financial Performance

Annual Cash Flow (Year 1)	$1,833
Cumulative Net Savings	$35,528
NPV (2.3% discount rate)	$25,877
IRR	30%
ROI	453%
Payback (years)	3.51

Table 37. LED Replacement by Illuminance Financial Performance

Annual Cash Flow (Year 1)	$1,908
Cumulative Net Savings	$38,361
NPV (2.3% discount rate)	$28,166
IRR	34%
ROI	567%
Payback (years)	3.02

Lighting replacement is a relatively small project compared to the others in this analysis. The short payback of light replacement makes this an attractive option as a cost savings upgrade, either on its own or in addition to another project.

3.53 Electricity Consumption and Savings

Electricity from lighting represents about 7% of the facility's electricity demands. Because of this relatively low usage from lighting, energy savings from lighting efficiency improvements were modest. The figure below shows the reduction in energy consumption at T&M Millworks before and after the 1-1 LED lighting replacement scenario. In total, this scenario led to a 3% reduction in energy consumption.

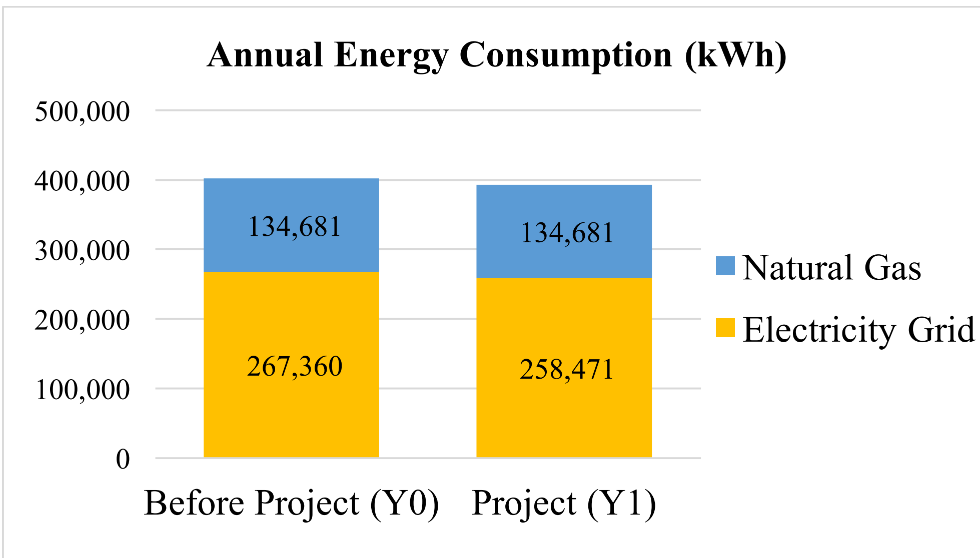

Figure 17. LED 1-1 Replacement Annual Energy Consumption, Y0-Y1

Table 38. Energy Savings by Replacement Scenario

Replacement Scenario	Fluorescent (kWh/yr)[64]	LED (kWh/year)[65]	Electricity Savings (kWh/year)
LED (1-1)	19,389	10,500	8,889
LED (by illuminance)	19,389	9,413	9,976

[64] Based on Year 0.
[65] Based on Year 1.

3.54 LED Replacement Emissions Reductions

Emissions reductions from LED replacement were modest due to the relatively small impact of lighting in energy consumption at T&M Millworks. The figure below shows the emissions reductions from the 1-1 LED replacement scenario. In total, emissions decreased by about 4% between Year 0 and Year 1.

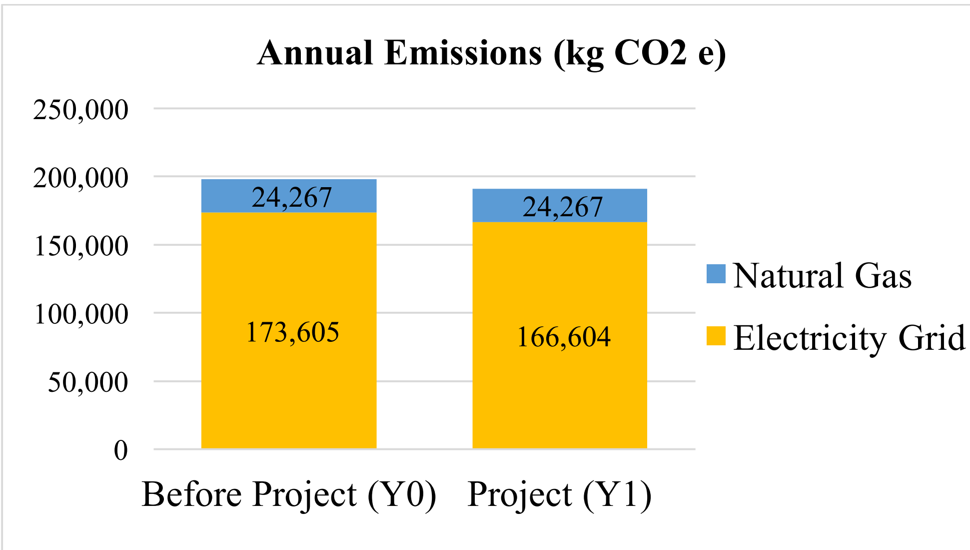

Figure 18. 1-1 LED Replacement Annual Emissions, Y0-Y1

Table 39. LED Avoided Emissions by Replacement Scenario

Avoided Emissions, Year 1

LED (1-1)	7,001	kg CO_2 equivalent
LED (by illuminance)	7,857	kg CO_2 equivalent

Total Avoided Emissions over 20 Years

LED (1-1)	140,028	kg CO_2 equivalent
LED (by illuminance)	157,149	kg CO_2 equivalent

Both replacement scenarios showed positive cumulative net savings and provided regular energy savings and emissions reductions to the facility. The low cost of replacement makes LED light a good candidate for a Michigan Saves loan or REAP grant project.

3.55 LED Replacement PACE Finance

This project does not meet the minimum $150,000 cost required for PACE finance but would qualify for Consumers Energy Michigan Saves financing.

3.56 LED Replacement Michigan Saves Finance

The 20-kW solar project's costs were low enough to qualify for the Consumers Energy Michigan Saves loan. Payments were distributed from Year 1 to Year 5, with 0% interest in Year 1 to Year 3. While this project represented roughly a quarter of the 89-kW PV project's energy and emissions reductions, its relatively low cost and lower land use requirement could make it an attractive option for a smaller project, or as part of a combined project.

Table 40. LED Replacement Michigan Saves Financial Performance

Michigan Saves Financial Indicators, LED Replacement (1-1)

Annual Michigan Saves Payment	$1,203
Net Savings (Year 1)	$630
Net Savings (Year 10)	$2,071
Cumulative Net Savings	$35,944
NPV (2.3% discount rate)	$33,539

Michigan Saves Financial Indicators, LED Replacement (by illuminance)

Annual Michigan Saves Payment	$1,076.29

Net Savings (Year 1)	$831.66
Net Savings (Year 10)	$2,175.60
Cumulative Net Savings	$38,733.90
NPV (2.3% discount rate)	$36,183.84

This project performed well with Michigan Saves loan parameters and generated considerable net savings compared to the upfront project costs. While it may be an excellent choice for a small-scale (3%) reduction in greenhouse gas emissions, a larger project would be necessary for deeper reductions in energy use and emissions.

4. Discussion

Different metrics were used to compare performance between projects. Considerations included percent annual energy savings, percent annual emissions reductions, and avoided greenhouse gas emissions (kg CO_2 equivalent) per dollar.

Percent annual energy savings and emissions reductions compare the contribution of each project in reducing T&M Millworks's annual energy consumption, greenhouse gas emissions, respectively, and wood waste, as compared to the baseline case (Year 0 in all projects). Annual energy and emissions reductions were averaged from the total 20-year time horizon of each project to account for variations in energy savings for projects like solar PV.

Table 41. Project Comparisons Relative to Year 0

Project Type	Annual Energy Savings[66]	Annual Emissions Reductions	Wood Waste Reduction
20-kW PV	7%	10%	0%
89-kW PV	35%	47%	0%
Wood Boiler	2%	7%	2%
1-1 LED Lighting	2%	3%	0%
Wood Chip CHP System	55%	-29%	67%
Solar Array and Boiler	10%	20%	2%

Another metric for project evaluation was to compare each criterion to dollars invested in the project, yielding the approximate utility per dollar. For example, emissions reductions were measured in kg CO_2 equivalent. A plot of dollars spent on the project versus avoided greenhouse gas emissions revealed that some projects were more efficient at reducing greenhouse gases than others. In this case, project costs were considered the total costs of installation at Year 0, which

[66] Considered all energy not purchased from utilities as savings. Energy from self-generation like solar and wood biomass generation was treated like efficiency savings for this calculation.

did not include net savings over the time horizon studied. The rationale here was to determine expected greenhouse gas reductions for each dollar invested in a project. A clear flaw with this metric is that some projects incurred additional costs after Year 0: LED lights needed replacing, solar required an additional inverter on Year 11, and the biomass technologies incurred additional electricity costs. While expanding the figure to cover the entire time horizon would provide a degree more realism, diagram below provides a quick visual assessment of which projects performed more efficiently in terms of greenhouse gas reductions.

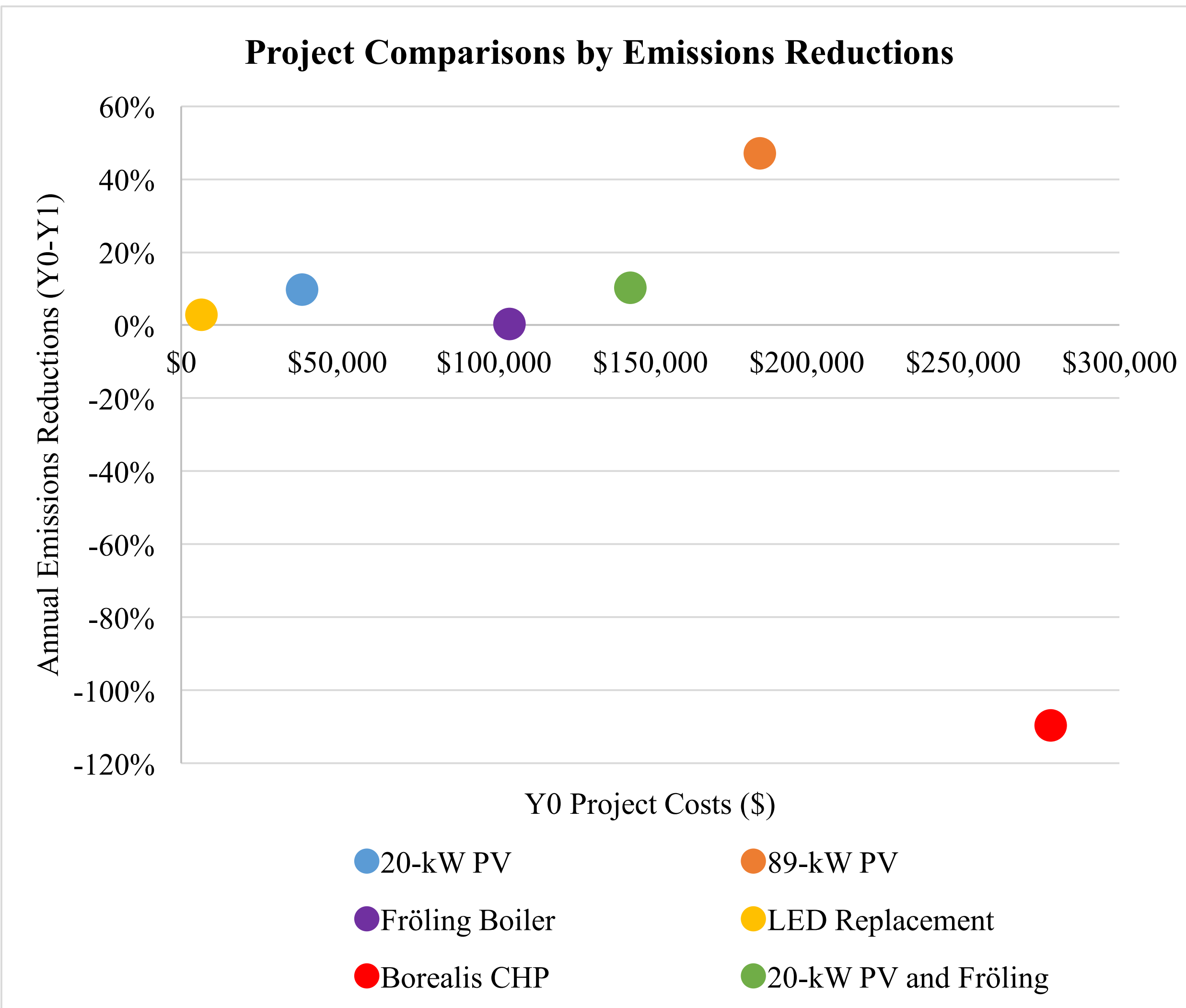

Figure 19. Project Installation Costs (Y0) and Emissions Reductions

The figures above and below compare project installation costs (Y0) to percent emissions reductions and energy savings.

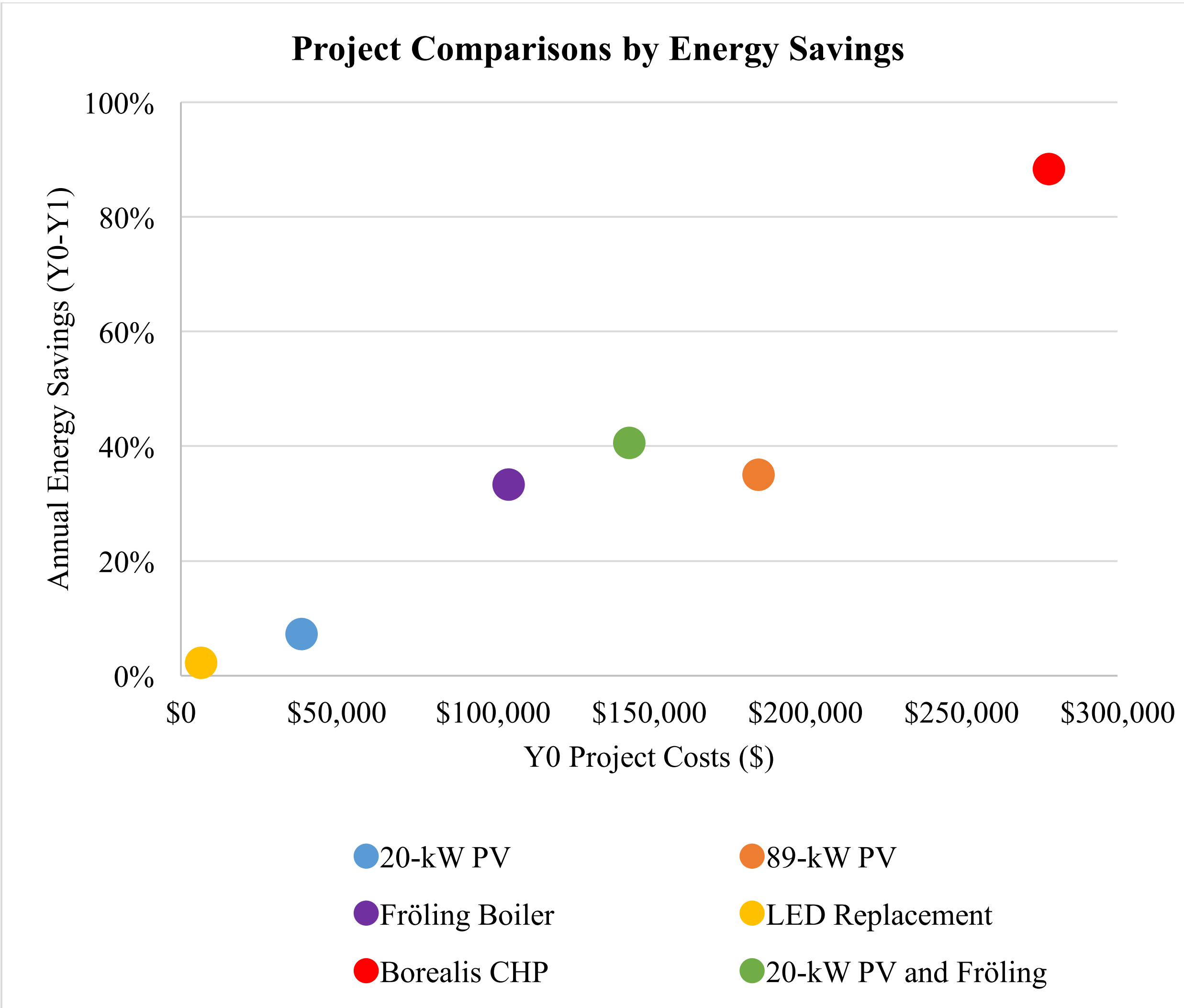

Figure 19. Project Installation Costs (Y0) and Emissions Reductions

4.1 Recommendations

Recommendations varied depending on the objectives of the facility upgrade. If the goal was to reduce the most greenhouse gas emissions sparing no expense, the 89-kW solar PV avoided the most emissions in twenty years, at 2,215,453 kg CO_2 equivalent. If, however, the goal was to find the least-cost facility upgrade, LED lighting replacement would be a clear choice. However, looking at only Year 0 means ignoring all future savings and costs. Expanding the scope showed both cost savings and emissions reductions over the given time horizon.

The ranking matrix below shows project performances for the four criteria over the 20-year time horizon. The 89-kW solar PV generated the highest net savings ($) and emissions reductions (kg CO_2 e) over twenty years, while the Borealis CHP system performed best for energy savings (kWh) and waste reduction (kg wood).

Table 42. Ranking Matrix

Project Type	Net Savings ($)	Energy Savings (kWh)	Emissions Reductions (kg CO2 Eq.)	Waste Reduction (kg)
20-kW PV	$62,090	584,886	460,687	0
89-kW PV	$422,905	2,812,728	2,215,453	0
Fröling Boiler	-$26,614	2,676,148	22,622	245,320
LED Replacement	$35,528	177,779	140,028	0
Wood Chip CHP System	$352,503	7,101,779	-5,143,412	4,972,918
20-kW PV and Fröling	$19,180	3,265,004	486,436	245,320

Color and Number Ranking

1	2	3	4	5	6

Highest rank Lowest rank

The color system ranked projects to compare their relative tradeoffs. The Borealis CHP system generated the second most savings over 20 years but proved to be emissions reductions negative, meaning it produced more greenhouse gases than it avoided. As the only technology that created more emissions than it reduced, the CHP performed the worst out of any project for greenhouse gas emissions reductions (kg CO_2 e). However, it outperformed the other projects in terms of wood waste reduction and energy savings. While the Borealis CHP represents the most self-generation of electricity and heat, and disposes of the most wood waste, the 89-kW PV project saved more over the time horizon of study.

The combination project deserved some mention. Between solar PV and the highly efficient Fröling T4 wood boiler, this project rated second highest in terms of emissions reductions. However, the relatively low cost savings of the combined project make it a less attractive candidate for a PACE or Michigan Saves loan.

4.2 PACE & Michigan Saves

Financing any system with PACE or Michigan Saves adds to the total cost of the project through interest and added fees. Projects with high cash flow were highly desirable candidates because they proved net cash flow positive even with the added cost of annual payments. To fulfil the PACE ideal of "cash flow positive from beginning to end," projects required comparatively high savings.

Table 43. Savings by Project Finance

Project Type	**PACE 20-Year Net Savings ($)**	**Michigan Saves 20-Year Net Savings ($)**	**REAP Grant in Y0 ($)**
20-kW Solar PV	-	$64,589	+ $9,651
89-kW Solar PV	$213,988	$388,330	+ $46,229
Wood Chip and Pellet Boiler	-	-$46,247	+ $26,250
LED Lighting Replacement	-	$35,944	+ $1,607
Wood Chip CHP System	$141,193	$300,522	+ $69,500
Combination 20-kW Solar PV and Wood Boiler	-	$116,961	+ $35,901

Of the six projects, three qualified for PACE and all projects qualified for Michigan Saves. The 89-kW solar PV project provided the greatest net savings and highest emissions reductions. Notably, projects financed with Michigan Saves had lower costs due to PACE's higher interest rate and additional fees. Prior to selecting any project, interest rates and fees should be verified with PACE and Michigan Saves to ensure there are no unanticipated added costs.

The REAP grant was not included directly in the analysis. However, REAP grants could offset project costs by up to $500,000. The REAP grant brings with it certain constraints that have been identified previously in this report. While it was not assumed that T&M Millworks received the REAP grant, any project eligible for PACE or Michigan Saves could benefit from the REAP grant. A decrease in upfront costs would effectively reduce the total cost to be financed, reducing annual payments. Ideally, this loan could provide an opportunity for T&M Millworks to turn a cash flow negative or a weakly cash flow positive project into one that provides both cost and energy savings.

4.3 Challenges

PACE and Michigan Saves can overcome the upfront cost barriers of most energy efficiency and renewable energy technologies for T&M Millworks. This analysis reviewed multiple project scenarios, resulting in different cash flows, energy savings and emissions reductions over a 20-year time horizon. Projects had to be carefully sized to meet PACE cost constraints, which for T&M Millworks ranged from $150,000 to $187,500 to qualify for 100% financing. Those projects that did not qualify for PACE used Michigan Saves financing.

One of the greatest challenges was making reasonable conclusions about the facility's energy savings without first conducting an energy audit. PACE contractors are expected to conduct an audit to determine age and efficiency of facility upgrades, leaks in the building envelope, and quantify energy savings from various small energy efficiency upgrades. Unfortunately, no contractor was willing to conduct an energy audit on the facility without a contract. Such a system means the property owner must commit to a contractor before understanding the costs and savings of a potential facility upgrade. From an analysis perspective, that makes no sense. Property owners should be able to understand their facility's energy consumption, and specifically areas where there are potential energy savings, *before* selecting a project type and contractor.

It should be noted that a walkthrough was conducted with Cory Connolly of Levin Energy Partners. The walkthrough qualified T&M Millworks for PACE finance but it was not a comprehensive energy audit. It is highly recommended that an energy audit be conducted at T&M Millworks to determine the energy savings potential of energy efficiency facility upgrades. Weatherization improvements, insulation, and sealing the building envelope could provide heat savings that were not included in this analysis. Furthermore, project technology performance was based on company and consumer data, but was not field-tested. Before investing in any new technology, it is recommended to review the assumptions made by this analysis by related studies, communications with users of the technologies, and, if possible, to test specific technologies to verify technical performance.

The costs of time and expertise present another challenge for Northport business owners interested in PACE or Michigan Saves. To conduct this analysis, many parties were contacted, including PACE providers, contractors and third-party energy analysts. A great deal of labor went into researching the technologies and comparing them to create the project recommendations. It is difficult to imagine every small business owner would be willing to invest the time and energy required to analyze every energy project. Therefore, if NEAT is serious about PACE and other energy financing in Northport, it should consider improving local knowledge about those programs. Levin Energy Partners conducts training sessions for PACE contractors in Traverse City and other parts of Michigan. Attending those sessions to foster knowledge about PACE and similar programs would help create more expertise on energy finance in the community. Should funding be available, local businesses would benefit from a full-time energy auditor and analyst to conduct the types of analysis utilized in the pilot to recommend facility energy upgrades. If NEAT and Levin Energy Partners are serious about implementing PACE on a broader scale, Northport businesses will require the added support of energy experts to aid in decision-making and project selection.

NEAT's stated objective of 100% renewable energy in Northport was and still is ambitious. Commercial energy financing offers a means to overcome monetary barriers to energy savings, but it is contingent on pre-existing knowledge of and interest in programs like PACE. To further its goals, NEAT should work with Levin Energy Partners to spread awareness of PACE in Northport and employ local experts who can advise business owners on best ways to reduce their energy consumption and evaluate the tradeoffs when considering the installation of new facility upgrades.

5. Conclusions

With sufficient support, businesses in Northport could also utilize PACE or Michigan Saves to finance energy efficiency and renewable energy projects. Given the wide range of technologies eligible for financing, businesses like T&M Millworks stands to gain much by investing in energy savings. While 100% renewable energy seems a distant and challenging goal, a business focused on the next 5-20 years can demonstrably reduce their greenhouse gas emissions by investing in clean energy generation and energy efficiency technologies. Moreover, installing a new facility energy upgrade is a concrete action that can be taken by an individual or property owner. PACE or Michigan Saves can finance the reduction of a business's greenhouse gases, and at present, requires no revolution in policy or technology to do so.

This project began by taking a high-level view of Northport. However, by narrowing its scope to T&M Millworks, the pilot project demonstrated clear, concrete steps that can be taken to help achieve NEAT's energy goals. The analysis determined the feasibility of using PACE and Michigan Saves to finance energy projects, as well as demonstrated and quantified the benefits of financing energy efficiency and renewable energy.

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7. Appendix: Energy Use Survey Questions

Thank you for taking the time to complete this survey. Please ensure the information provided is as accurate as possible.
* Required

1. Email address *

2. Name *

3. Do you own a business in Leelanau County?

* Mark only one oval.

- o Yes
- o No
- o Other:

4. If yes, what is the name of your business? *

5. Do you own the property?

* Mark only one oval.

- o Yes
- o No
- o Don't know
- o Other:

6. Which of the following describes your business?

* Check all that apply.

- ❑ Agriculture
- ❑ Banking
- ❑ Bar
- ❑ Construction

- ❑ Dining
- ❑ Grocery
- ❑ Hospitality
- ❑ Manufacturing
- ❑ Media
- ❑ Recreation
- ❑ Retail
- ❑ Winery or brewing company
- ❑ Other:

Do you represent a non-profit organization?

* Mark only one oval.

- o Yes
- o No
- o Other:

8. Approximately how many square feet is your business?

*Mark only one oval.

- o Less than 1,000 square feet
- o Between 1,000 and 5,000 square feet
- o Between 5,000 and 20,000 square feet
- o Between 20,000 and 50,000 square feet
- o Between 50,000 and 100,000 square feet
- o Over 100,000 square feet
- o Don't know

9. How many acres of undeveloped property do you own?

* Mark only one oval.

- Less than 1
- Between 1 and 5
- Between 6 and 10
- Between 11 and 20
- Over 20
- Don't know

Approximately how much do you spend on your annual electricity bill?

* Mark only one oval.

- Less than $1,000
- Between $1,000 and $5,000
- Between $5,000 and $10,000
- Between $10,000 and $20,000
- Over $20,000
- Don't know

11. Which is your electric utility?

* Mark only one oval.

- Cherryland Electric Co-Operative
- Consumers Energy
- Don't know
- Other:

12. Approximately how much do you spend on your annual heating bill?

*Mark only one oval.

- Less than $500
- Between $500 and $2,000
- Between $2,000 and $5,000
- Between $5,000 and $10,000
- Over $10,000
- Don't know

13. What do you use to heat your business? Check all that apply.

- ❑ Natural Gas
- ❑ Propane
- ❑ Wood - cord
- ❑ Wood - pellets
- ❑ Heating oil
- ❑ Other:

Are you interested in any of the following energy upgrades? Check all that apply.

- ❑ Energy efficiency
- ❑ Solar photovoltaic
- ❑ Passive solar
- ❑ Biomass or wood (chips, pellets, etc.)
- ❑ Heat pumps - geothermal or air-source
- ❑ Wind
- ❑ Other:

15. Are you interested in any of the following facility upgrades?

Check all that apply.

- ❑ Insulation
- ❑ Windows
- ❑ Doors
- ❑ Lighting
- ❑ Heating and cooling
- ❑ Other:

About

I am a graduate student at the University of Michigan, Ann Arbor, conducting research on behalf of the Northport Energy Action Taskforce (NEAT) and Levin Energy Partners, providers of Property Assessed Clean Energy (PACE) in Michigan. We are assessing the potential for energy efficiency and renewable energy for businesses in Northport. If you would like to learn more about my research, please feel free to send me any questions or comments. For more information on PACE in Michigan, please visit: http://leanandgreenmi.com/.

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