Improving Energy Sustainability for the Little Traverse Bay Bands of Odawa Indians (LTBB) Reservation:

Energy Sustainability Analyses and Recommendations for the Little Traverse Bay Bands of Odawa Indians' Environmental Services Program

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By:

Brittany C. Anstead, Ashley M. Green, Katherine L. Gregory, Henrik B. Mader, Brian J. Rassel, Oluwafemi S. Sawyerr, and Puneeth M. Venkatarama Reddy

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Faculty advisors:

Professor Shelie Miller and Professor Gregory Keoleian

Abstract

Recognizing that the pervasive use of nonrenewable energy sources negatively impacts the development of symbiotic relationships with surrounding ecosystems, the goal of our project was to assist the Little Traverse Bay Bands of Odawa Indians (LTBB) Tribal Government in the development of an energy sustainability plan for the LTBB reservation. Four main objectives and project components were defined. The first objective focused on an energy efficiency assessment and optimization analysis of potential energy savings from alternative pathways for reducing energy consumption of the three main tribal government buildings relative to a 2012 baseline; second a spatial analysis of renewable wind and solar energy potentials on the LTBB reservation was developed; third, a financial feasibility assessment of energy efficiency upgrades and renewable energy projects was carried out; and finally, current tribal energy sustainability policies and possible energy policy instruments were examined. These analyses led to the following key recommendations: to upgrade light bulbs and various fixtures for the main three government buildings; to conduct a professional energy audit; to develop a detailed plan for the implementation of solar energy projects; to update present energy policy to embody robust renewable energy and energy efficiency standards; and to investigate the potential creation and implementation of a clean energy law.

Acknowledgements

We wish to thank the following people who were essential to the success of this project: Christina Coger, Jonathan Mauchmar, and Vicki Kelly of the LTBB Environmental Services Program, without your faith and commitment in our project vision we could not have achieved this accomplishment. Chi-miigwech for all of your support as our tribal liaisons! The LTBB Energy Advisory Team, we hope that these recommendations can supplement or further your sustainability goals. Jim Keiser and Alan Proctor of the LTBB GIS Department, we appreciate your cooperation and contribution to the success of the renewable energy analysis. The staff that provided us access to conduct our energy efficiency assessment in the health center, administrative building, and judicial building, thank you for allowing us to enter your space. Our faculty advisors Dr. Shelie Miller and Dr. Gregory Keoleian, thank you for being the guiding compass for our team. We appreciate you sharing critical advice and providing nurturing support throughout our entire project process, especially during the writing of our final capstone report. Joseph Nagle, founder of Strawberry Solar, we thank you for consultation in regards to solar PV projects. Andrew Wheatley, we thank you for your incredible contributions to the lighting optimization analysis. Andrew Eilbert, thank you for your guidance with the energy assessment, and for putting us in touch with contacts at various utilities. Michael Elchinger, Project Lead at NREL, we thank you for your advice and guidance regarding renewable energy projects. Finally, we deeply appreciate the School of Natural Resources and Environment for providing our team the access and opportunity to pursue our capstone masters project.

Chi-miigwech!!

Disclaimer

Opinions expressed in this report represent a consensus of the authors and do not necessarily represent the official position or policies of the Little Traverse Bay Bands of Odawa Indians Tribe.

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Executive Summary

Recognizing that the pervasive use of nonrenewable energy sources negatively impacts the development of symbiotic relationships with surrounding ecosystems, the goal of our project was to assist the Little Traverse Bay Bands of Odawa Indians, henceforth LTBB or Tribe, in the development of an energy sustainability plan for the LTBB reservation. The Little Traverse Bay Bands of Odawa Indians is a federally recognized Tribe with 4,559 Tribal Citizens residing on approximately 336 square miles of land in the northwestern part of Michigan's Lower Peninsula. In 2005, with the goal to institute a new energy economy supporting tribal self-sufficiency via efficient and economically beneficial use of clean energy, the LTBB Tribal Council passed Resolution #051505-01: *Adoption of Kyoto Protocol and Renewable Energy Standards*, henceforth Kyoto resolution.[1] Our project was founded upon the Kyoto resolution's renewable energy standard to meet 25% of energy needs from renewable sources by year 2020. The team broadened this standard to include an assessment of four main objectives which not only incorporated renewable energy technology on the reservation, but assessed potential energy savings from reducing existing energy consumption, examined tribal policy, and analyzed the economics of both energy efficiency upgrades and potential renewable energy projects.

During the course of the project, the team defined the following tasks to address the four main objectives: establishment of an energy baseline for the Tribe; a bottom-up energy efficiency assessment and optimization analysis of energy usage in the three main government buildings including the judicial, administrative, and health center; creation of a financial analysis tool to assess renewable energy and energy efficiency project feasibility; geographic information systems (GIS) spatial suitability analysis to assess wind and solar energy potential; and a research analysis of current LTBB energy sustainability policy and best-practices.

Based on our research, we identified the following key recommendations: upgrade light bulbs and various fixtures for the main three government buildings; conduct a professional energy audit, develop detailed plan and implement solar energy projects, update present energy policy to embody robust renewable energy and energy efficiency standards; and investigate potential creation and implementation of a clean energy law. The energy efficiency assessment and optimization analysis found that implementation of lighting

upgrades in the short term is relatively feasible for the Tribe from a financial perspective. In the long term, a professional energy audit would be beneficial in aiding the Tribe to secure federal grants to finance large clean energy projects. As for the renewable energy analysis, it was found that solar is spatially suitable for the majority of LTBB owned property within the scope of this project. Through an analysis of wind resources and the costs of wind projects, it was determined that wind is relatively unsuitable in comparison to other more efficient alternatives. The tribal policy analysis found that instituting smaller incremental goals into the renewable energy standard and creating energy efficiency standards building on the Kyoto resolution would enhance current LTBB energy policy. Furthermore, instituting a Clean Energy Law could yield robust and binding energy policy instruments, empowering the LTBB to effectively and efficiently achieve sustainability goals.

Chapter 1: Introduction to LTBB Sustainability Project

"We will respect, honor, and care for Mother Earth and her families, keeping the next seven generations in mind. We will provide quality environmental services through a professional atmosphere, well-trained staff, and empirical data collection. We will actively participate in local, regional, and national environmental decision-making processes affecting Indian Country. We will develop and implement ordinances and policies that will ensure the protection of our natural resources. We will continue to be diligent, honest, and accountable while making a positive difference regarding environmental issues."

-Little Traverse Bay Bands of Odawa Indians Environmental Services Program Mission

In the United States, indigenous tribal lands currently comprise five percent of the nation's total land base, the majority of them being rural[2]. Among these indigenous lands is the Little Traverse Bay Bands of Odawa Indians reservation. The LTBB Tribe acknowledges that "tribal lands represent a vast amount of renewable energy potential, including wind and solar power that can meet the energy needs of both local Tribes and surrounding communities.[3]" As a domestic sovereign tribal nation in the United States, LTBB holds sacred its responsibility to protect Mother Earth for the next seven generations[4]. As a key initiative in protecting mother earth and reducing environmental impacts, the Tribe has shown commitment to reducing the current dependence on fossil fuels and investing the development of a renewable energy infrastructure to develop a new and efficient clean energy economy.

The early 1900's industrial revolution transformed the nation's energy landscape, increasing access to electricity and dramatically altering the everyday lives of people; especially the indigenous peoples of the United States. As a result, the present day United States is heavily dependent upon fossil fuels and a centralized energy infrastructure. Within a short century, energy infrastructure has been responsible for an unprecedented influx of greenhouse gas emissions and other highly detrimental pollutants released into the Earth's air, water, and land. At the present rate of fossil fuel consumption, the world is projected to exceed the Intergovernmental Panel on Climate Change's (IPCC) two degree Celsius global temperature limit in as little as the next 30 years.[5] As emissions continue unabated, people around the world are experiencing an increase in extreme weather events, sea level rise, droughts/floods, and other erratic climatic conditions.[6] Many of these climatic fluctuations and contaminant releases directly affect the indigenous peoples of LTBB. This project supports LTBB's commitment to reducing its dependence on non-renewable energy sources that are catalyzing climate change and aims to equip LTBB with a plan to achieve clean energy independence and energy security.

In addition to strengthening the energy and economic security of the LTBB, this project has the potential to serve as a model for other tribal governments. According to the U.S. Census Bureau, it is predicted that most U.S. Tribes will double in size over the next 50 years[7]. Thus, meeting energy needs will be a fundamental concern for Tribal governments seeking to expand land ownership and provide services for citizens. Improving the efficiency of buildings and potentially incorporating renewable energy technologies are economically and environmentally conscious ways to approach future development.

"...Actions taken to reduce greenhouse gas emissions and increase energy efficiency provide multiple local benefits by decreasing air pollution, creating jobs, reducing energy expenditures, and saving money for the community"

-Resolution #051505-01: Adoption of Kyoto Protocol and Renewable Energy Standards

This project seeks to assist the tribal government of the Little Traverse Bay Bands of Odawa Indians in the development of an energy sustainability plan for the LTBB reservation. The LTBB reservation is located on 366 square miles in Charlevoix and Emmet counties in Northwestern Michigan. It should be noted that LTBB does not own all of the property within the boundary. This project is unique because the Tribe is seeking to simultaneously expand its landholdings and services provided to tribal citizens while reducing its environmental impact. Within our energy sustainability framework, our project team established the following four primary objectives:

1. The creation of a 2012 energy baseline for LTBB and an assessment of alternative energy efficiency improvements to reduce energy consumption in the LTBB Administrative, Health, and Judicial Buildings relative to the 2012 baseline.

2. A renewable energy analysis of wind and solar energy potentials and spatial suitability using a Geographic Information Systems (GIS) analysis.

3. An assessment of the financial feasibility of energy efficiency upgrades, renewable energy technologies, and alternative scenarios with varying rates and methods of implementation.

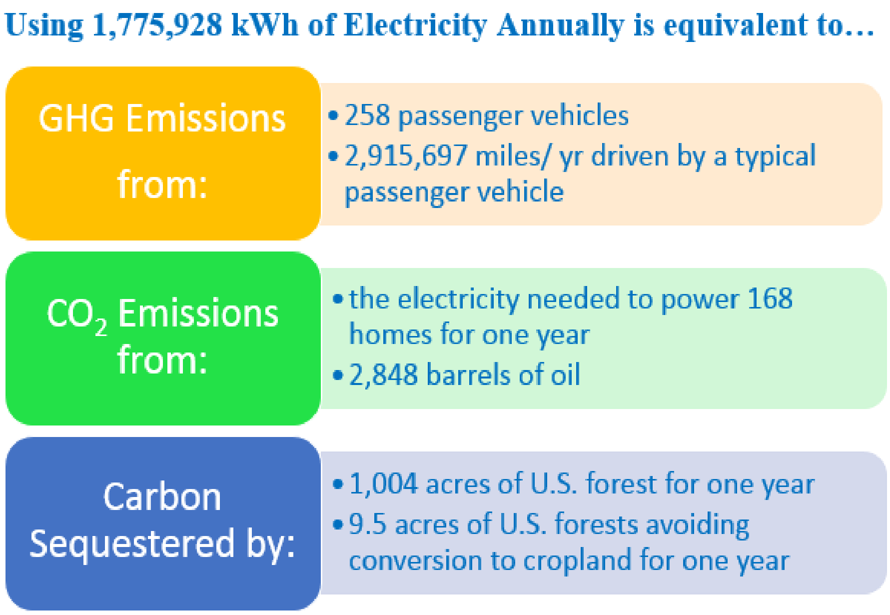
4. An examination of current tribal energy and sustainability policies and assessment of possible future LTBB energy policy instruments.

Chapter 2: Energy Usage by LTBB Reservation

2.1 Methodology for LTBB Energy Analysis

In order to establish a baseline of the Tribe's energy consumption, we evaluated energy use by tribal properties. Although we collected natural gas and electricity consumption data for all government owned buildings, the scope of our analysis focused on the three main government buildings on the reservation: the administrative building, the health building, and the judicial building (also referred to as the Spring Street building). This analysis revealed that LTBB's total consumption of electricity for all government owned buildings (including elders' housing) in 2012 was 1,775,928 kWh.[i] This is equivalent to carbon sequestered by 1,004 acres of U.S. forest for one year or CO_2 emissions from the electricity needed to power 168 homes for one year; refer to figure 1. The total consumption of natural gas for all government owned properties was 73,697 Ccfs. Unfortunately, including recommendations for Ccf reduction was beyond the scope of this project, and analyses therefore focused on electricity reduction.

Figure 1 - Electricity Consumption Equivalencies



*This diagram was made using results from the EPA's Greenhouse Gas Equivalencies Calculator

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[i] Calculated using compiled energy bills from LTBB's properties from the 2012 fiscal year

Based on the data provided in the Tribe's energy bills, we determined that the three main government buildings account for 85% of annual electricity usage for all properties owned by the Tribe, and therefore offer the greatest potential for energy reductions. Consequently, despite establishing an electricity consumption baseline for all LTBB's tribal properties, we exclusively examined the three main government buildings to investigate areas to determine the most resource-efficient improvements. We also calculated the cost of energy based on LTBB's bills to be 0.12$/kWh. Additionally, with limited equipment availability and time constraints, a comprehensive assessment of all government buildings was deemed infeasible. However, the general conclusions from our analysis of these three buildings can be effectively applied to tribal properties outside the scope of analysis.

In addition to examining energy bills for the properties, we also conducted a walkthrough energy assessment of the lighting, appliances, and windows in the administrative, health, and judicial buildings. This entailed recording bulb types and wattage for lighting and appliances, and examining model numbers and the general condition of the windows and appliances in each building. The purpose of this assessment was to gain an understanding of how efficiently the buildings presently operate, and to establish a basis of comparison for potential future upgrades. Following this, we calculated the allocation of energy consumption by building (administrative, health, and judicial) in an effort to determine which end-use areas were the most energy intensive.

We used a combined top-down and bottom-up approach to determine the values presented below in Figure 2. First, we located values from the EIA[8] on electricity usage by building type (administrative, health, judicial); we then calculated the provided kWh in terms of percentages for each sector (heating, lighting etc.)[ii]. Second, we calculated the kWh of electricity used per year by the LTBB by multiplying these percentages by the total kWh use of the buildings (this value was obtained from the energy bills). We combined the EIA computers and office usage into one end-use section for simplicity. We then conducted a bottom-up energy assessment of the building in which we calculated the total kWh used by lighting and computers. Because there were differences in the kWh between the

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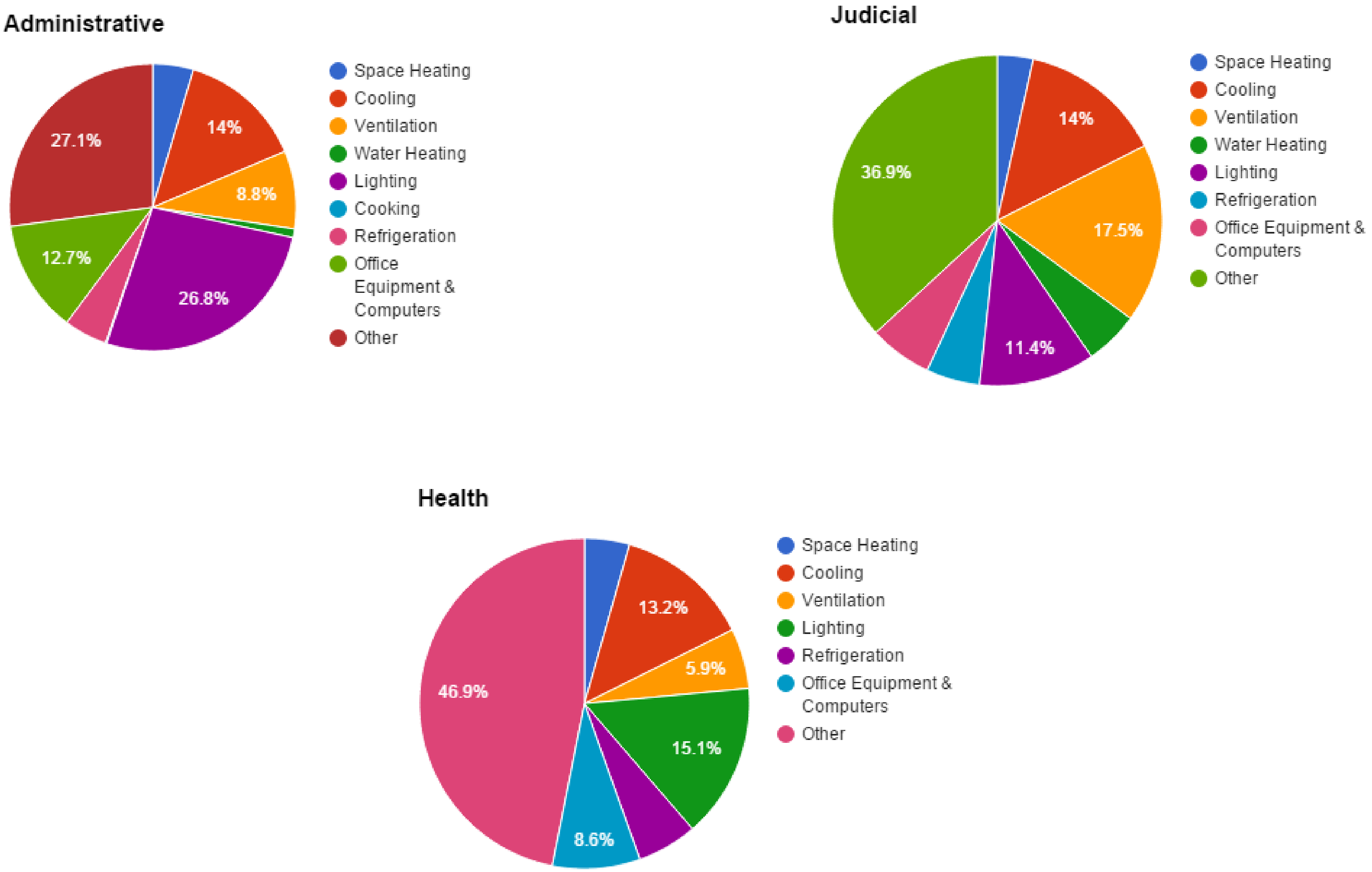
[ii] This data is not adjusted for HDD and CDD

top-down (EIA national averages) and bottom-up approach, we added data that was unaccounted for into the ‘other[iii]’ section. This kWh difference occurred because we did not have the equipment or expertise to conduct a professional energy audit, and also lacked comprehensive access to all parts of the building. Thus, some of our observed data may contain incongruities. The graphs below show that on average, lighting uses the most electricity in comparison to other internal building systems. As a result, the lighting system represented a key focus point for developing the energy efficiency strategies that will be discussed in section 2.7.

[iii] “Examples of "other" include medical, electronic, and testing equipment; conveyors, wrappers, hoists, and compactors; washers, disposals, dryers and cleaning equipment; escalators, elevators, and window washers; shop tools and electronic testing equipment; sign motors, time clocks, vending machines, phone equipment, and sprinkler controls; scoreboards, fire alarms, intercoms, television sets, radios, projectors, and door operators.”

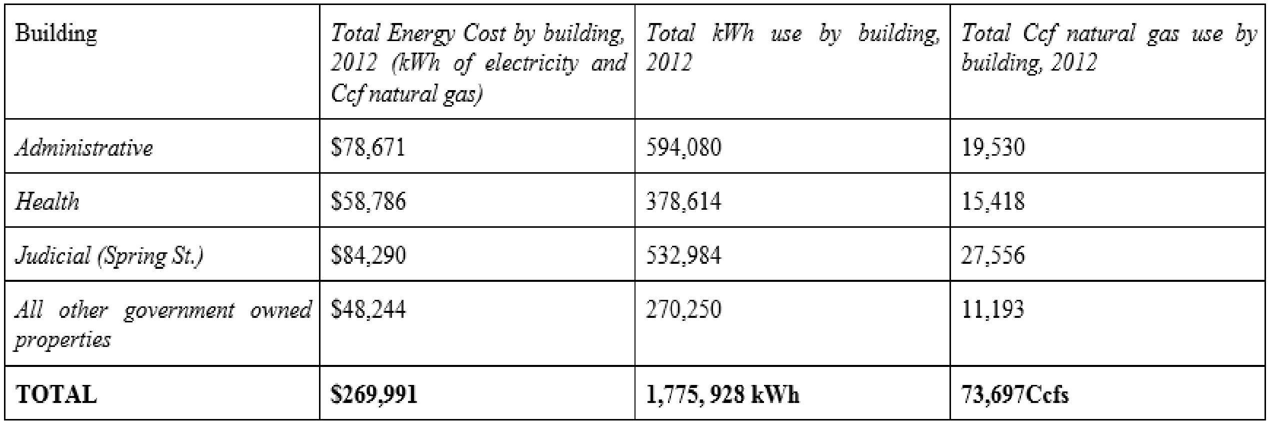
Figure 2 - Energy End-Use by Building, 2012



Energy Overview.

LTBB has already taken steps to reduce energy usage and lessen environmental impact. The 2005 Department of Energy (DOE) grant project and signing of the Kyoto Protocol both illustrate the Tribe's commitment to addressing environmental concerns and furthering sustainability efforts. Many of the existing appliances within the three government owned buildings were Energy Star certified, and there were very few incandescent bulbs in use. Many employees actively sought to reduce their energy consumption. Numerous individuals said they did not use their lights except on very cloudy days, and others brought in their own personal lamps with more efficient bulbs to use in lieu of the overhead lights within their offices. Additionally, various portions of the buildings had motion and/or occupancy sensors, and many people made concentrated efforts to turn off lights in unoccupied rooms[iv]. In contrast, the windows were not Energy Star certified, and many were in poor condition. While it is encouraging to see an awareness of energy usage throughout the three buildings, several improvements are possible.

Table 1 - Energy and Cost Totals for the Administrative Building, the Health Park, and the Spring Street Building

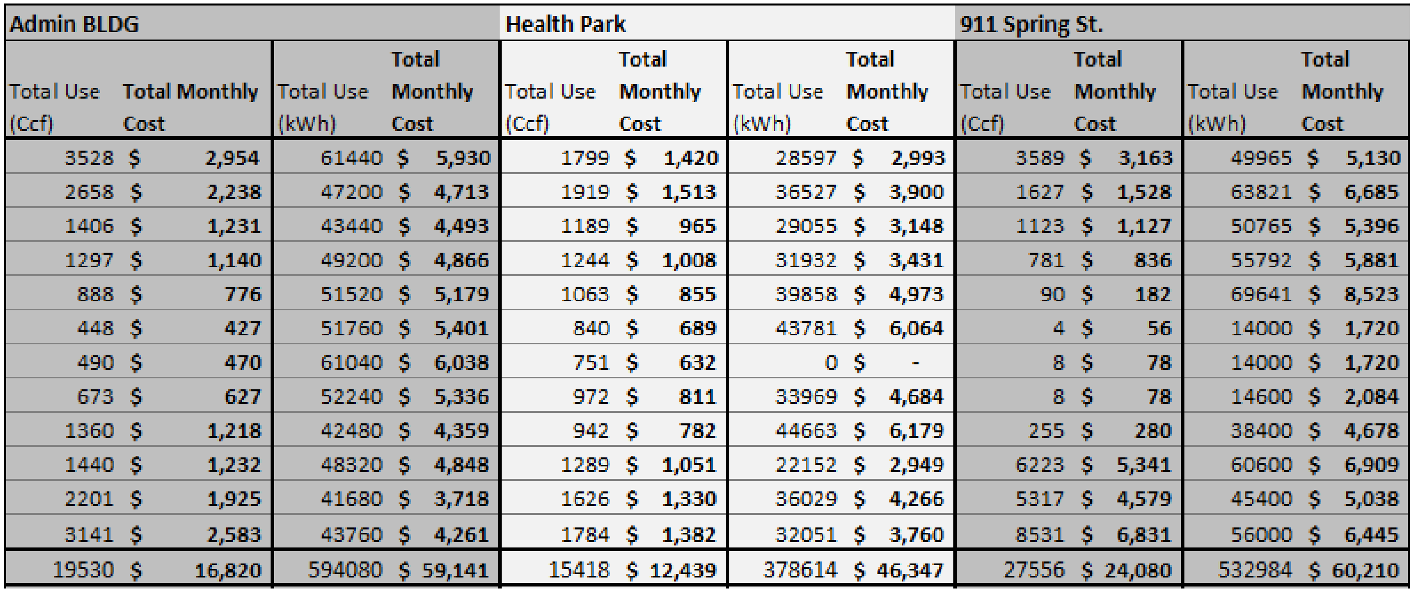


Building	*Total Energy Cost by building, 2012 (kWh of electricity and Ccf natural gas)*	*Total kWh use by building, 2012*	*Total Ccf natural gas use by building, 2012*
Administrative	$78,671	594,080	19,530
Health	$58,786	378,614	15,418
Judicial (Spring St.)	$84,290	532,984	27,556
All other government owned properties	$48,244	270,250	11,193
TOTAL	**$269,991**	**1,775, 928 kWh**	**73,697Ccfs**

[iv] Although this was not true for all spaces, as discussed below in further detail

As seen in Table 1, the administrative building was the largest consumer of electricity in 2012. This is to be expected considering the number of offices, employees, and cultural events that occur within the building, as well as its relatively large square footage. Also in Table 1, we can see the breakdown of natural gas by building. Contrary to expectations, the judicial (Spring St.) building used the most Ccfs of natural gas. The reason for this will be discussed in more detail in the coming pages.

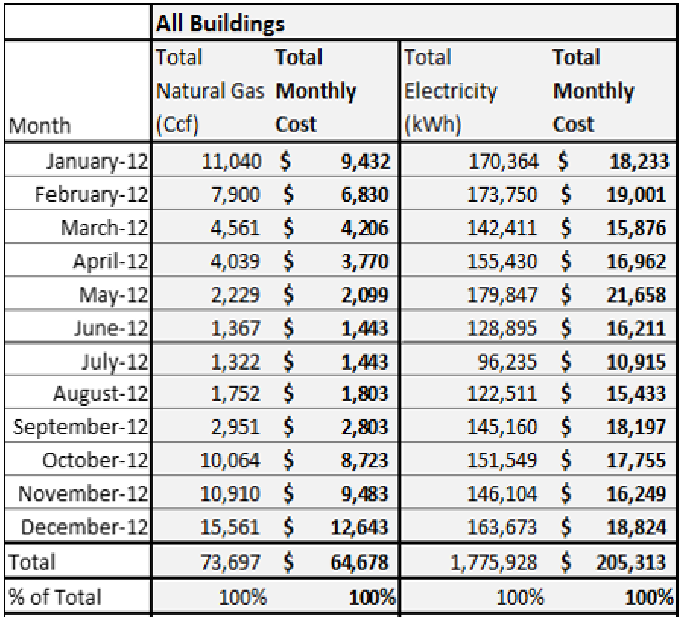
Table 2 - Energy Usage in Main Government Buildings by Month, 2012



Admin BLDG				**Health Park**				**911 Spring St.**			
Total Use (Ccf)	**Total Monthly Cost**	Total Use (kWh)	**Total Monthly Cost**	Total Use (Ccf)	**Total Monthly Cost**	Total Use (kWh)	**Total Monthly Cost**	Total Use (Ccf)	**Total Monthly Cost**	Total Use (kWh)	**Total Monthly Cost**
3528	$ **2,954**	61440	$ **5,930**	1799	$ **1,420**	28597	$ **2,993**	3589	$ **3,163**	49965	$ **5,130**
2658	$ **2,238**	47200	$ **4,713**	1919	$ **1,513**	36527	$ **3,900**	1627	$ **1,528**	63821	$ **6,685**
1406	$ **1,231**	43440	$ **4,493**	1189	$ **965**	29055	$ **3,148**	1123	$ **1,127**	50765	$ **5,396**
1297	$ **1,140**	49200	$ **4,866**	1244	$ **1,008**	31932	$ **3,431**	781	$ **836**	55792	$ **5,881**
888	$ **776**	51520	$ **5,179**	1063	$ **855**	39858	$ **4,973**	90	$ **182**	69641	$ **8,523**
448	$ **427**	51760	$ **5,401**	840	$ **689**	43781	$ **6,064**	4	$ **56**	14000	$ **1,720**
490	$ **470**	61040	$ **6,038**	751	$ **632**	0	$ **-**	8	$ **78**	14000	$ **1,720**
673	$ **627**	52240	$ **5,336**	972	$ **811**	33969	$ **4,684**	8	$ **78**	14600	$ **2,084**
1360	$ **1,218**	42480	$ **4,359**	942	$ **782**	44663	$ **6,179**	255	$ **280**	38400	$ **4,678**
1440	$ **1,232**	48320	$ **4,848**	1289	$ **1,051**	22152	$ **2,949**	6223	$ **5,341**	60600	$ **6,909**
2201	$ **1,925**	41680	$ **3,718**	1626	$ **1,330**	36029	$ **4,266**	5317	$ **4,579**	45400	$ **5,038**
3141	$ **2,583**	43760	$ **4,261**	1784	$ **1,382**	32051	$ **3,760**	8531	$ **6,831**	56000	$ **6,445**
19530	$ **16,820**	594080	$ **59,141**	15418	$ **12,439**	378614	$ **46,347**	27556	$ **24,080**	532984	$ **60,210**

Table 2 shows a month-by-month examination of kWh and Ccf consumption in the three main government buildings, as well as all government owned properties (including government owned residences). This information was compiled using the Tribe’s 2012 energy bills. Once again, natural gas usage (in Ccfs) has been normalized using a conversion to kWh to allow us to examine energy

Table 3 - Consumption for all Government owned Properties



	All Buildings			
Month	Total Natural Gas (Ccf)	**Total Monthly Cost**	Total Electricity (kWh)	**Total Monthly Cost**
January-12	11,040	$ **9,432**	170,364	$ **18,233**
February-12	7,900	$ **6,830**	173,750	$ **19,001**
March-12	4,561	$ **4,206**	142,411	$ **15,876**
April-12	4,039	$ **3,770**	155,430	$ **16,962**
May-12	2,229	$ **2,099**	179,847	$ **21,658**
June-12	1,367	$ **1,443**	128,895	$ **16,211**
July-12	1,322	$ **1,443**	96,235	$ **10,915**
August-12	1,752	$ **1,803**	122,511	$ **15,433**
September-12	2,951	$ **2,803**	145,160	$ **18,197**
October-12	10,064	$ **8,723**	151,549	$ **17,755**
November-12	10,910	$ **9,483**	146,104	$ **16,249**
December-12	15,561	$ **12,643**	163,673	$ **18,824**
Total	73,697	$ **64,678**	1,775,928	$ **205,313**
% of Total	100%	**100%**	100%	**100%**

usage in the same terms. As previously stated and illustrated in Table 3, the total amount of energy consumed by government-owned buildings in 2012 was 1,775,928 kWh of electricity, and 73,697 Ccfs of natural gas.

Administrative Building.

A primary issue at the administrative building was the operation of several lighting systems that did not seem to significantly contribute to the lumens per square foot. On both of our visits to the reservation, we saw outdoor lights left on during the day. Some of the bulbs are moderately energy intensive, such as the 70-watt metal halide bulbs found in the light posts along the exterior entrances and walkways leading to the building. There were also empty areas inside the building where lights were unnecessarily left on, as well as lamp-lit areas with ample natural light. The energy challenges in the administrative building are primarily related to human behavior (i.e. leaving lights on). There are straightforward and cost-effective solutions for these inefficiencies, which will be discussed in further detail subsequently.

Table 4 - Estimated Pollutants from Operating Government-Owned Buildings, 2012

Pollutant	**Total kWh (Electricity)**	**Total Ccf (NG)**	**Approximate Annual Emissions from Electricity (in Kilograms)**[v],[vi]	**Approximate Annual Emissions from Natural Gas (in Kilograms)**[vi],[vii]	**Total Emissions (in Kilograms)**	**Global Warming Potential (100 yr. basis)**[viii]
CO_2	1,775,928	73,697	*1,395,000*	*403,000*	*1,798,000*	*1*
SO_2	1,775,928	73,697	*8,880*	*1,350*	*10,150*	*NA (criteria pollutant)*
N_20	1,775,928	73,697	*18*	*3*	*21*	*310*

Health Park

The health park is a unique building serving many functions. As such, it contains a diverse mix of lighting and appliances. Due to patient confidentiality and basic daily operations, we were unable to look at all of the areas in the health park, and therefore had to extrapolate some of the data for specific areas. Also noteworthy is that we did not look at efficiency upgrades for medical equipment, as we are not qualified to evaluate the cost effectiveness and performance of highly specialized medical equipment, nor were there financially feasible alternative opportunities for energy reduction for such equipment that we knew of.

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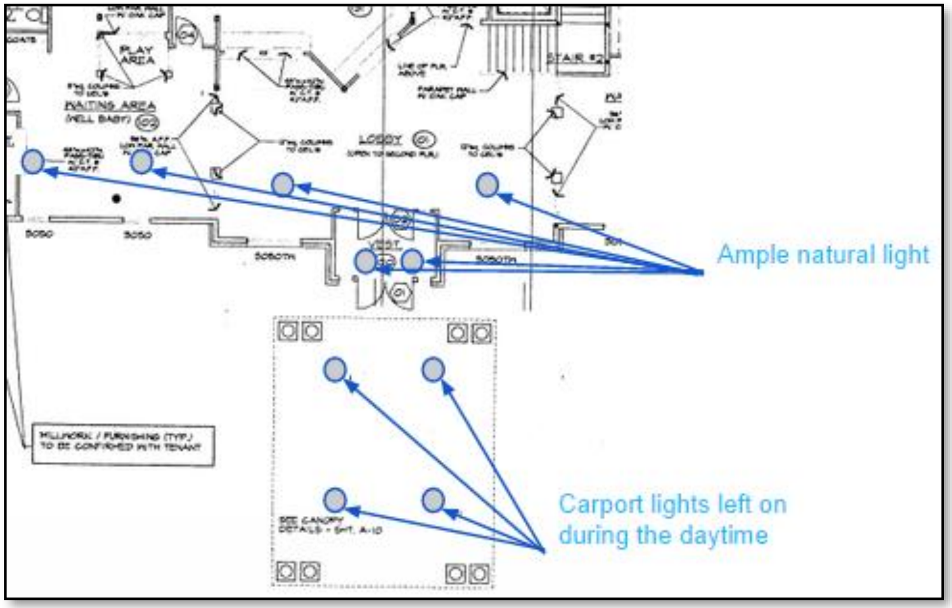
[v] Based on EPA 's emissions factor, a national average of 6.89551x10^-4 metric tons CO2/ kWh

[vi] Based on estimates from the International Carbon Bank and Exchange

[vii] Based on estimates from the International Carbon Bank and Exchange

[viii] Based on Intergovernmental Panel on Climate Change Data

Figure 3 - Potential Area for Lighting Reduction in Health Park



On our first visit to the health park, employees pointed out significant temperature differences between the first and second floors. While we did not have the expertise or equipment to identify the exact cause of the problem, it is likely due to insufficient insulation between floors, or is related to functional issues of the HVAC systems on the two separate levels. Having a professional audit could pinpoint the problem exactly, and identify the best allocation of financial resources to remedy that situation. As in the administrative building, the health park had lights that were left on unnecessarily. The carport in front of the building had all four recessed lights on during our daytime visit. However, the vaulted foyer entrance to the building contrarily was illuminated by several first and second floor windows, which allowed sufficient natural illumination of the space during much of the day. Despite this influx of daylight, several energy-intensive ceiling fixtures were still powered on, and did not seem to contribute to overall visibility in the area.

The second floor waiting area was fully lit with multiple T8 ceiling fixtures, but there were no patients or employees in the area. While the individual bulbs may not represent large energy inputs, in combination there is a significant amount of energy being consumed. Refer to figure 3 for a layout of potential areas for lighting reductions in the Health Park.

Judicial Building (911 Spring Street).

As demonstrated in table 1 entitled "Energy and Cost Totals for the Administrative Building, Health Park, and Spring Street Building" the judicial building located on Spring Street uses much higher quantities of natural gas than any of the other buildings. While natural gas use is generally equal to or less than electricity use in each building, this does not hold true for 911 Spring St. Based on our building envelope observations, these results are not surprising. An inefficient building envelope—particularly old windows—is likely to blame for the elevated natural gas usage at the judicial building.

During our visit, a few individuals demonstrated the difficulty associated with closing certain outdated windows. In one instance, to do so involved one person rolling the window crank inside, while another pushed from the outside to close the window. This is not an ideal scenario from a convenience standpoint; it also points to significant energy and economic losses. Additionally, the back windows on the third floor in the human resources office area were very drafty, and workers cited temperature fluctuations on very windy days. We also noticed a large temperature difference between the courtroom and the other parts of the building. This can likely be attributed to higher R-values in that room (especially due to the bulletproof windows), decreasing heat transfer between the indoor and outdoor environments.

Many individuals in the Spring Street Building had removed T8 bulbs from the ceiling fixtures in order to reduce strain on the eyes and save electricity. While this may result in a more personally comfortable work environment through reduction in harsh light, there are relatively few gains from an energy saving perspective. In T8 fixtures, the ballast still draws power regardless of how many bulbs are installed in the fixture[9]. Bulb-less ballasts can burn up, which means that they may not function if workers try to replace the bulbs in the future. Additionally, many workers added individual lamps to their offices. While most utilized energy saving bulbs, anyone simultaneously operating one bulb in a ceiling fixture and a desk lamp may be using more energy than if the ceiling fixtures were used as intended.

A common sentiment within all three buildings was that the overhead fluorescent lights were overpowering. Many felt that fixtures with three or four fluorescent bulbs were excessive and unnecessary. In several cases, we noticed that employees had either purposefully removed T8 bulbs, or opted not to replace bulbs that burnt out. Thus, there is strong potential to simultaneously increase workplace energy efficiency and employee comfort.

2.2 Common Household Appliances

Our team's assessment identified an array of different appliances used within the government buildings of LTBB such as refrigerators, microwave ovens, washers/dryers, vacuums, personal space heaters, fans, projectors etc. Disregarding refrigerators and microwave ovens, additional appliances cumulatively use 1% of total electricity consumption[ix] (Table 5) of the three government buildings. As such, the potential to generate energy savings through appliance replacements are not significant enough to warrant major changes. However, as will be detailed later in the chapter, improved appliance usage practices can decrease the total energy consumption.

Table 5- Percentage appliances energy consumption to LTBB total energy consumption.

LTBB Total Energy Consumption = 1,775,928 kWh/yr		
Appliance Category	**Energy Consumption (kWh/yr)**	**Percentage of Total LTBB Energy**
Refrigerator	6361	0.36%
Microwave	4341	0.24%
Washer/Dryer	885	0.05%
Vacuums	2879	0.16%
Space Heaters	1980	0.11%
Table fans	231	0.01%
Telephones	1366	0.08%
Total consumption	**18042.7**	**1.02%**

Refrigerators.

Refrigerators are typically energy intensive appliances, but given the size and usage of LTBB buildings, they account for only 0.3% - 0.36% of annual energy consumption,[x] based on rated annual energy use [10]. Almost all refrigerators considered within the energy assessment were Energy Star certified and were less than ten years old.

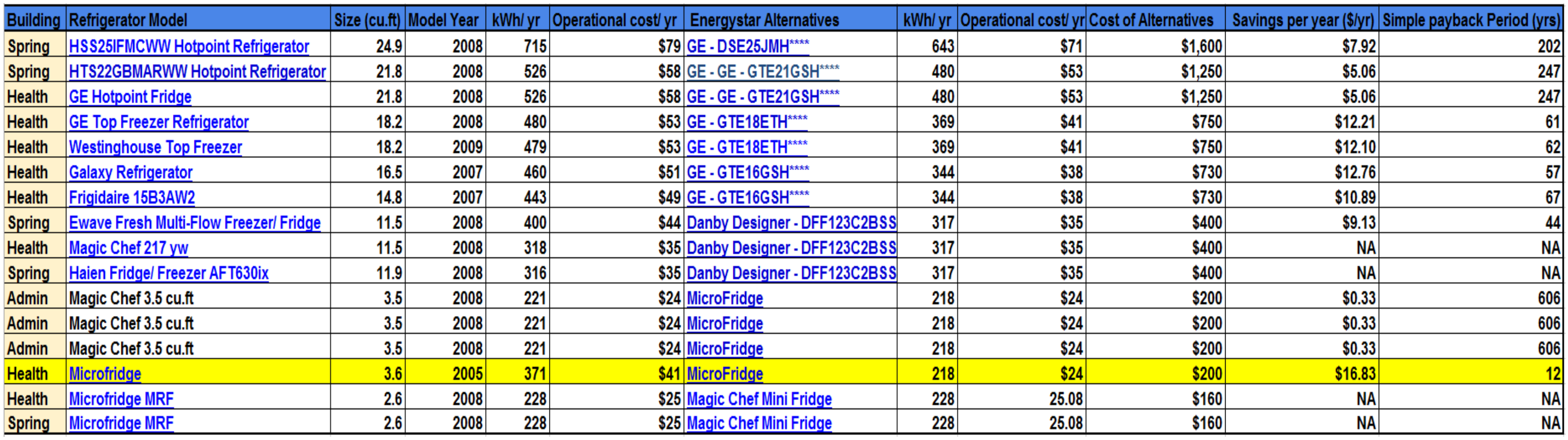
[ix] These percentages are based on the findings from our energy assessment, and have been compared to the Tribe's total energy consumption

[x] Annual refrigerator energy consumption calculated using estimates by Energy Star.gov

Refrigerator Replacement.

As all refrigerators identified during the energy assessment are models produced in the past 6-8 years, the energy efficiency improvements of 2015 model refrigerators do not warrant a replacement as seen from the large payback periods in Table 6. Since most of the refrigerators in the buildings are between 6 and 8 years old, the financial gains from energy savings from replacing currently used refrigerators with the most energy efficient refrigerators in the market through energy bills is around $5/yr. - $13/yr. (Table 6). This table was based on the cost of Energy Star certified 2015[xi] refrigerators and electricity price of 0.11$/kWh, typical in the State of Michigan. Based on the analysis, shown in the Table 6, the refrigerators need to be replaced only after they become too old or until significantly more efficient refrigerators enter the market through the next energy efficiency standards, which are set by Department of Energy. Only one refrigerator, a 3.6 cu ft. microfridge in the health building (highlighted in Table 6), which was more than ten years old, warranted a replacement with a simple payback period of twelve years.

Table 6 - Refrigerator Replacement Analysis

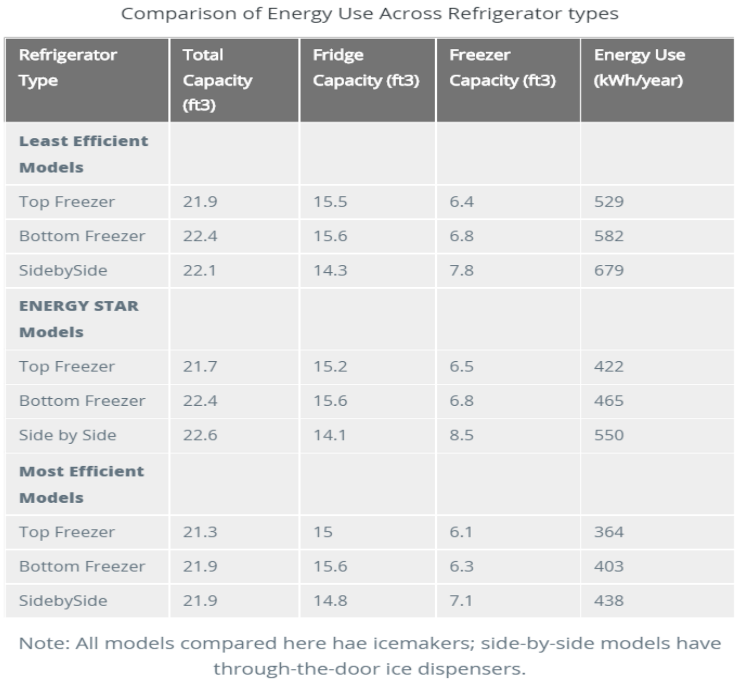


Building	Refrigerator Model	Size (cu.ft)	Model Year	kWh/ yr	Operational cost/ yr	Energystar Alternatives	kWh/ yr	Operational cost/ yr	Cost of Alternatives	Savings per year ($/yr)	Simple payback Period (yrs)
Spring	HSS25IFMCWW Hotpoint Refrigerator	24.9	2008	715	$79	GE - DSE25JMH****	643	$71	$1,600	$7.92	202
Spring	HTS22GBMARWW Hotpoint Refrigerator	21.8	2008	526	$58	GE - GE - GTE21GSH****	480	$53	$1,250	$5.06	247
Health	GE Hotpoint Fridge	21.8	2008	526	$58	GE - GE - GTE21GSH****	480	$53	$1,250	$5.06	247
Health	GE Top Freezer Refrigerator	18.2	2008	480	$53	GE - GTE18ETH****	369	$41	$750	$12.21	61
Health	Westinghouse Top Freezer	18.2	2009	479	$53	GE - GTE18ETH****	369	$41	$750	$12.10	62
Health	Galaxy Refrigerator	16.5	2007	460	$51	GE - GTE16GSH****	344	$38	$730	$12.76	57
Health	Frigidaire 15B3AW2	14.8	2007	443	$49	GE - GTE16GSH****	344	$38	$730	$10.89	67
Spring	Ewave Fresh Multi-Flow Freezer/ Fridge	11.5	2008	400	$44	Danby Designer - DFF123C2BSS	317	$35	$400	$9.13	44
Health	Magic Chef 217 yw	11.5	2008	318	$35	Danby Designer - DFF123C2BSS	317	$35	$400	NA	NA
Spring	Haien Fridge/ Freezer AFT630ix	11.9	2008	316	$35	Danby Designer - DFF123C2BSS	317	$35	$400	NA	NA
Admin	Magic Chef 3.5 cu.ft	3.5	2008	221	$24	MicroFridge	218	$24	$200	$0.33	606
Admin	Magic Chef 3.5 cu.ft	3.5	2008	221	$24	MicroFridge	218	$24	$200	$0.33	606
Admin	Magic Chef 3.5 cu.ft	3.5	2008	221	$24	MicroFridge	218	$24	$200	$0.33	606
Health	Microfridge	3.6	2005	371	$41	MicroFridge	218	$24	$200	$16.83	12
Health	Microfridge MRF	2.6	2008	228	$25	Magic Chef Mini Fridge	228	25.08	$160	NA	NA
Spring	Microfridge MRF	2.6	2008	228	$25	Magic Chef Mini Fridge	228	25.08	$160	NA	NA

[xi] Energy Star certified 2015 refrigerator list gathered from Consortium for Energy Efficiency (www.cee1.org).

All future purchases of refrigerators should target Energy Star certified models. A typical time period for new purchases of refrigerators is 15 - 20 years to warrant the financial investment, since the efficiency standards typically improve over this period to allow monetary gains within a payback period of 10 - 15 years[11]. It is important to note that refrigerators with freezers on top are more efficient than refrigerators of the same capacity with freezers on the side[12]. In the LTBB buildings, there were mini fridges located next to large fridges. Despite these being Energy Star labeled, the use of two different sized fridges instead of one large refrigerator is not energy efficient. This must be considered before the next purchase depending on the requirements of the LTBB building. Energy efficiencies of different refrigerator types is shown in figure 4.

Figure 4 -Energy Efficiency of Different Refrigerator Types



Comparison of Energy Use Across Refrigerator types

Refrigerator Type	Total Capacity (ft3)	Fridge Capacity (ft3)	Freezer Capacity (ft3)	Energy Use (kWh/year)
Least Efficient Models				
Top Freezer	21.9	15.5	6.4	529
Bottom Freezer	22.4	15.6	6.8	582
SidebySide	22.1	14.3	7.8	679
ENERGY STAR Models				
Top Freezer	21.7	15.2	6.5	422
Bottom Freezer	22.4	15.6	6.8	465
Side by Side	22.6	14.1	8.5	550
Most Efficient Models				
Top Freezer	21.3	15	6.1	364
Bottom Freezer	21.9	15.6	6.3	403
SidebySide	21.9	14.8	7.1	438

Note: All models compared here hae icemakers; side-by-side models have through-the-door ice dispensers.

Refrigerator Efficiency Recommendations.

Since replacement of current refrigerators is financially unfeasible, based on the results shown in Table 6, it is important to ensure all the refrigerators are properly maintained (cleaning of fridge and its surroundings) and periodically cleaned (coils, pipes, seals etc.) to avoid inefficient operation. This could increase efficiency of the refrigerator up to 30% depending on the operational age of the refrigerator[13]. Placing refrigerators away from heat sources can reduce its energy consumption, as this avoids excess cooling required to moderate surrounding temperatures[14]. Occasionally checking the door seals for deterioration and drafts is important in decreasing unnecessary energy losses, and can result in potential savings up to 15%[15]. It is also important to turn off the fridge when not in use for extended periods or when empty.

Microwave ovens.

Most of the microwave ovens were large sized with wattage above 650 and used frequently. The energy usage of microwave ovens was close to 0.25% of the total electricity consumption (Table 5). At present, there are no Energy Star labeling or federal efficiency standards for microwave ovens, which limits the range of choices for energy efficient brands. The Department of Energy is scheduled to start Energy Star labels for Microwave ovens, from 2016[16]. These labels should serve as a guide for LTBB to purchase microwaves either for current or future buildings. Since the cost of new microwave ovens might not be recovered within a feasible time period due to minimal financial gains from energy savings, the replacement must be deferred to when the microwaves reach the end of their operational lifespan. The appliance replacement tools mentioned at the end of the section can be used to make financially feasible purchases.

The microwave oven purchases have to be made with respect to the required usage. Microwave ovens typically save 30% - 80%[17] of energy compared to conventional ovens depending on usage patterns and wattage size; hence, from an energy perspective it is important to utilize microwaves over conventional ovens whenever possible. The microwaves also do not heat up rooms and can save energy from cooling during hotter seasons.

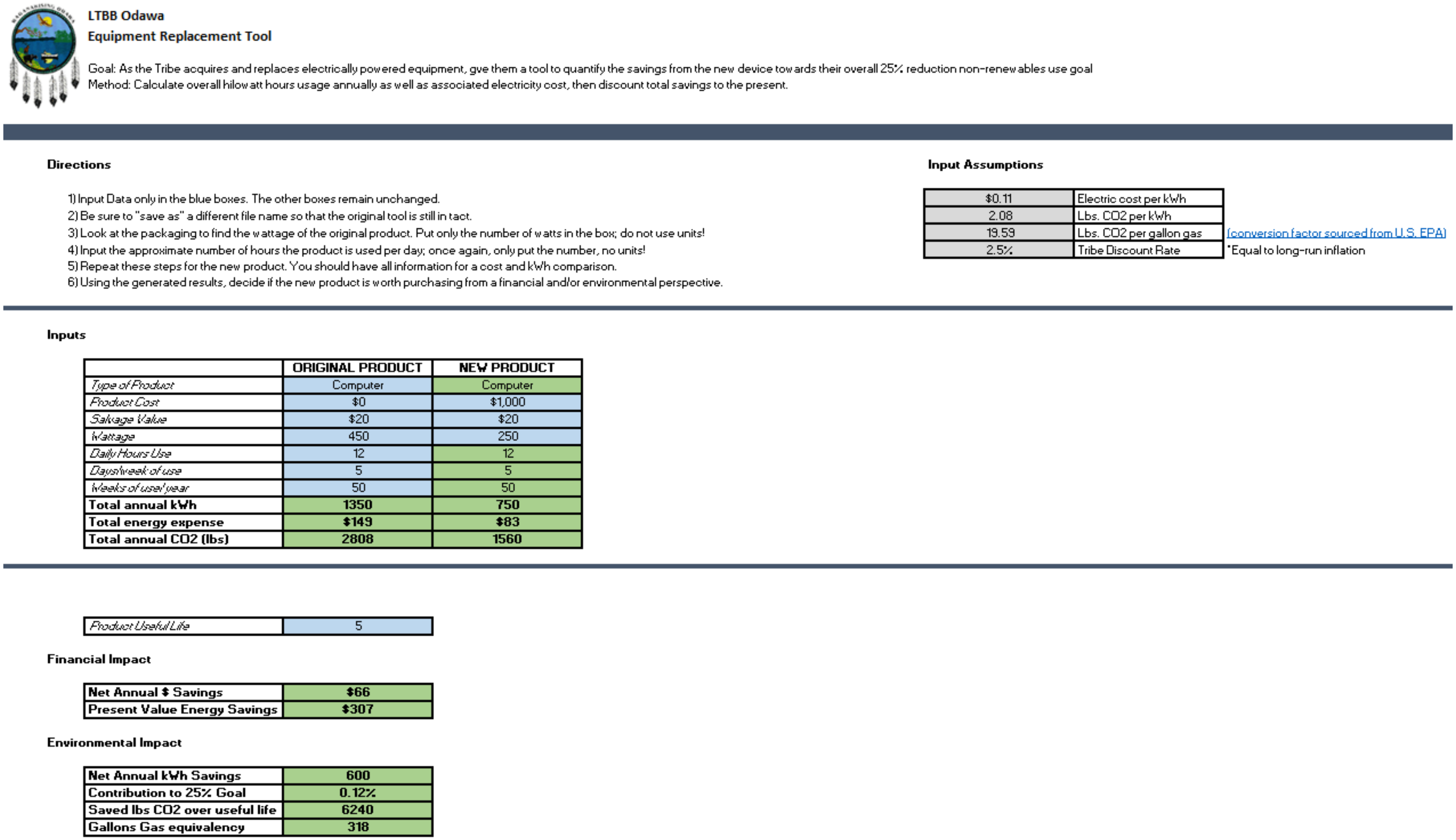
Other appliances.

As mentioned previously, for the remainder of the appliances identified such as washers/dryers, vacuums, personal space heaters, fans, projectors etc., energy consumption was not significant enough to warrant any replacements. Nevertheless, it is important that LTBB utilizes the Energy Star ratings in purchasing all its future appliances to decrease energy consumption. Utilizing the appliance tool provided below could help in making financially beneficial and environmentally conscious choices. Additionally, behavioral changes could decrease energy consumed by these appliances. Unplugging of appliances, when not in use over long periods like overnight and/or over weekends can reduce phantom loads, which can decrease energy consumption. For example, a 120V powered microwave uses energy to convert alternating current (AC) to direct current (DC), and uses an additional 0.5 W of energy when on standby, to power the microwave display. This is known as a “phantom load”, and could lead to an increase in consumption by 35 kWh-40 kWh per year per appliance[18]. Moreover, regular appliance-specific maintenance can increase efficiency.

Decision-Making for Appliance Purchases.

In order to make the best financial and environmental choices possible, we created an excel tool (figure 5) which allows for the comparison of a new appliance to an existing appliance. For instance, in the demonstration below, we are comparing an old and new computer. The individual using the tool fills out the information in the blue boxes, and the green cells change to reflect that information. By inputting specific pieces of information—product costs, salvage value, wattage, hours of use/day, days of use/ week, and weeks/ use per year—the tool generates estimates of annual kWh consumption, approximate annual energy expense, approximate annual CO_2 emissions, and estimated time until payback using a discount rate of 2.5%. In this specific example, making the purchase of a newer, more efficient computer would annually save 0.12% of total kWh consumption. The Tribe can then determine whether the energy savings over time are worth the financial input. We hope that having this information available relatively quickly and easily will enable the Tribe to make rapid and informed decisions that will best meet its needs in both the short and long-term.

Figure 5 - LTBB Odawa Equipment Replacement Tool



LTBB Odawa
Equipment Replacement Tool

Goal: As the Tribe acquires and replaces electrically powered equipment, gve them a tool to quantify the savings from the new device towards their overall 25% reduction non-renewables use goal
Method: Calculate overall hilowatt hours usage annually as well as associated electricity cost, then discount total savings to the present.

Directions

1) Input Data only in the blue boxes. The other boxes remain unchanged.
2) Be sure to "save as" a different file name so that the original tool is still in tact.
3) Look at the packaging to find the wattage of the original product. Put only the number of watts in the box; do not use units!
4) Input the approximate number of hours the product is used per day; once again, only put the number, no units!
5) Repeat these steps for the new product. You should have all information for a cost and kWh comparison.
6) Using the generated results, decide if the new product is worth purchasing from a financial and/or environmental perspective.

Input Assumptions

$0.11	Electric cost per kWh	
2.08	Lbs. CO2 per kWh	
19.59	Lbs. CO2 per gallon gas	(conversion factor sourced from U.S. EPA)
2.5%	Tribe Discount Rate	*Equal to long-run inflation

Inputs

	ORIGINAL PRODUCT	NEW PRODUCT
Type of Product	Computer	Computer
Product Cost	$0	$1,000
Salvage Value	$20	$20
Wattage	450	250
Daily Hours Use	12	12
Days/week of use	5	5
Weeks of use/year	50	50
Total annual kWh	**1350**	**750**
Total energy expense	**$149**	**$83**
Total annual CO2 (lbs)	**2808**	**1560**

Product Useful Life	5

Financial Impact

Net Annual $ Savings	**$66**
Present Value Energy Savings	**$307**

Environmental Impact

Net Annual kWh Savings	**600**
Contribution to 25% Goal	**0.12%**
Saved lbs CO2 over useful life	**6240**
Gallons Gas equivalency	**318**

2.3 Heating, Ventilation, and Air-Conditioning Systems

Heating, ventilation, and air-conditioning (HVAC) systems represent a primary area of energy use by large commercial and office buildings, and as such are a key focus area when seeking to improve the overall energy efficiency of large buildings. Estimates of the proportional contribution to building energy consumption ranges widely depending on location, system type, and building design; however a review of available approximations shows that HVAC systems generally account for between 30-50% of the energy demand of large buildings.[19] In turn, efficiency strategies that focus on HVAC systems have the potential to generate significant efficiency gains. The National Institute of Building Design estimates that replacing outdated HVAC systems with high efficiency models can result in overall cost and energy reductions ranging between 10-40%. [20]

Improvement Strategies.

Improvement strategies for HVAC systems should be approached as a short term and long-term goal set. Full replacement of the heating and cooling units with efficiency-certified alternatives will generate significant savings; however the upfront cost can be economically prohibitive. While this may be the case in some instances, one available estimate shows that replacing an HVAC unit in combination with other efficiency strategies can result in 30% annual energy reductions with a projected payback of 3-5 years.[21] This is clearly subject to particular models and is contingent on the implementation of other improvements; however replacing HVAC systems represents a worthwhile strategy when developing long-term building efficiency goals and plans. This section will highlight specific strategies that generate short-term efficiency gains while supporting long-term reduction goals.

HVAC system energy consumption is dictated by the heating and cooling load of the building, which is in turn is dependent on building design and other energy intensive building systems. As noted by the U.S. Small Business Administration, decreasing the heating and cooling load of the building in question is a primary strategy to generating efficiency gains through the in-place HVAC system.[22] Through encouraging updates for existing inefficiencies within the building, additional benefits can be gained through reduced HVAC energy consumption. This is particularly relevant in terms of inefficient lighting systems, which can act as a negative load for heating. Through the use of energy efficient lighting systems, windows, and building envelope modifications, the load requirement for both heating and cooling is reduced. This effectively reduces the size of the required HVAC system, leading to short-term energy savings as well as long-term cost and energy gains as the size and cost of eventual replacement units is correspondingly reduced.

HVAC Recommendations for LTBB.

In terms of specific recommendations for the LTBB governmental buildings, an HVAC energy efficiency plan should be structured with immediate cost and energy benefits as well as long-term viability in mind. As the buildings are relatively new, immediate replacement of the HVAC systems may not represent the optimal plan in the near future. With the goal of reducing overall building energy consumption, more immediate cost effective improvement strategies such as lighting upgrades, system optimization, and behavioral shifts can be implemented in the near term.

Focusing on specific HVAC system efficiency measures, routine and comprehensive maintenance combined with the installation and monitoring of programmable thermostats represent the most effective near term strategy. Additionally, an inspection of the present units revealed several small tears and loose connections in the HVAC ductwork that result in visibly leaking air and thus wasted energy. Inspecting the current air distribution system for further leakage sites and patching these with metal tape will result in easily achieved, immediately beneficial energy efficiency gains. Looking towards the future, as the current HVAC units begin to near their replacement dates, suitable units with highest operational efficiency should be installed to further reduce energy consumption.

2.4 Information Technology Systems

In large office buildings, overall energy consumption is strongly impacted by the Information Technology (IT) systems and associated appliances. IT systems require significant energy inputs in order to remain consistently reliable and ensure that desired tasks are met without causing delays in user productivity and lost data. As such, it is vital to the development of office energy strategies that care is taken to improve the resource performance of the IT system, while ensuring the functional continuation of existing systems. This section outlines several improvement strategies targeted at reducing both the energy consumption and costs of operating IT systems.

IT Improvement Strategies.

In terms of improving the energy efficiency of IT systems for large office settings, there are a number of effective technologies, resource allocation, and behavioral strategies that can greatly reduce the amount of energy required for consistently reliable operations. This section provides an overview of potentially useful strategies that can be implemented and have proven successful in diverse office settings.

Considerable energy waste occurs in both homes and large office settings during the de-activated phase of various devices. Failing to power off or unplug electronics of all sizes results in the phenomenon referred to as parasitic load, where energy continues to be used by the device during standby or other relatively low power operational states. While the power requirements of such states are comparatively miniscule in relation to the active or use state, over time these small figures compound and represent large inefficiencies. At the national level, the amount of energy lost through parasitic loading is estimated to be in excess of 100 billion kWh per year, at a cost of around $11 billion dollars.[23] Reducing the energy lost in such states is therefore a potentially strong method of increasing the energy efficiency of buildings and especially office settings with numerous electronic devices.

One effective strategy for combating such losses is the integration of smart power strips into the office appliance system. Power strips can ensure that once devices no longer need to be active, they are not drawing power from the wall outlet. In an office setting, this facilitates energy savings without requiring each individual to physically unplug every device within the office, a strategy that would most likely result in negligible gains over time. While standard power strips allow for this function, they still require the user to activate the switch to disconnect the devices from the power supply. Smart power strips eliminate this obstacle to energy savings by using time, room occupancy, or current sensing to determine when the devices should be powered off and cease energy consumption.[24] As such, integrating smart power strips into the workplace can generate energy and cost savings without depending on additional device operations and requiring further labor inputs.

Perhaps the most intuitively useful plan to increase energy sustainability of IT systems lies in replacing outdated devices that draw more power than newer models. While this does represent an effective strategy for reducing energy consumption, it may be economically prohibitive due to the typically high cost of purchasing high efficiency office technology. While this may be the case, once devices are scheduled to be replaced or upgraded, the Energy Star program offers comprehensive, easily accessible information on energy efficient computers, printers, and other office devices. In these instances, targeting new purchases at energy star certified devices will ensure that efficiency gains are generated without compromising operations.

IT Improvements: Behavioral.

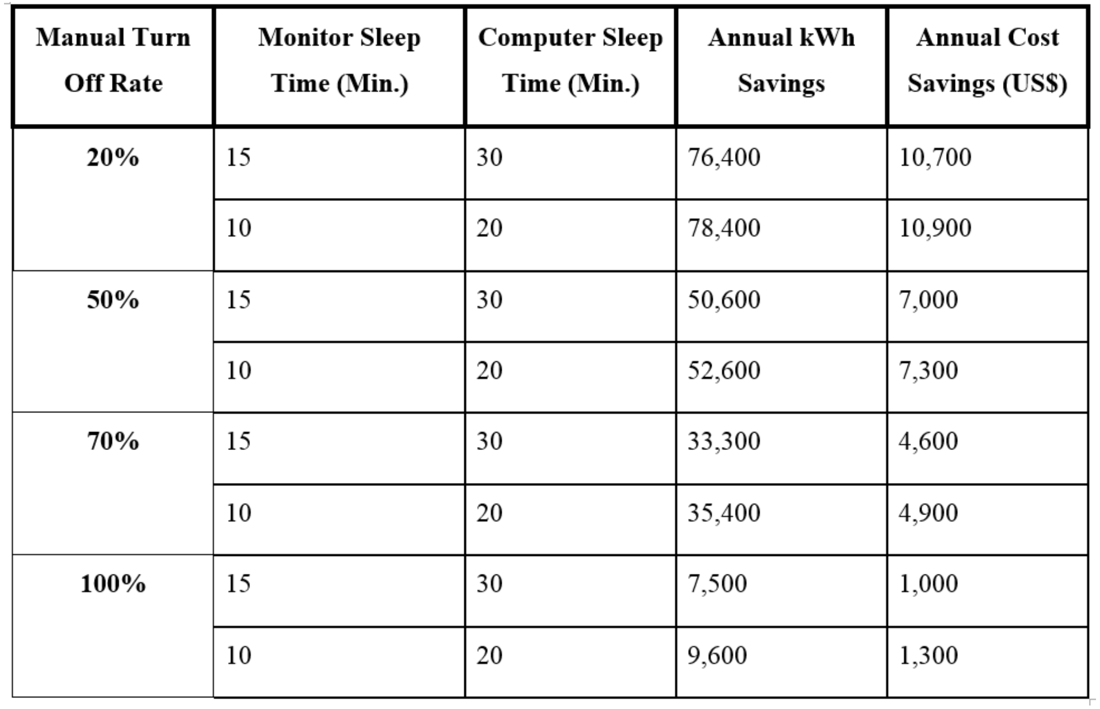
Behavioral efficiency improvement strategies are potentially the most immediately beneficial method of increasing energy efficiency of the IT system. By calling attention to existing inefficiencies within the current system, there is typically little cost involved and concrete benefits can be realized without time or labor intensive inputs.

In a typical office setting, significant energy is wasted by leaving unused equipment on a more intensive power mode than is required for maintaining operational usefulness. This type of behavior impacts all aspects of the IT system, including printers, copiers, fax machines, desktop computers, and shredders. Enabling the power save mode that is already available on office equipment, putting computers to sleep, and ensuring that computers and other devices are turned off when not in use for long periods can result in significant efficiency gains over time. The Energy Star organization has estimated that simply by ensuring that computers enter a sleep or otherwise low-energy mode when not in full use, the user can save between $10-50 in energy costs per computer annually.[25] Energy star also offers a predictive model for estimating energy and cost savings by enabling these power saving features, which will be used in conjunction with figures taken from the completed energy assessment to derive potential savings through this strategy in the following section.

IT Systems: Methodology.

Considering the extent of the LTBB IT system and its importance, maintaining functionality while reducing the overall energy consumption of the buildings under analysis is crucial. As the Energy Star IT initiative has found, a primary strategy for increasing the energy sustainability of commercial buildings is promoting the consistent use of existing energy saving features within the office equipment. In order to evaluate the potential energy savings that would be possible in the LTBB governmental buildings, the Energy Star IT energy use calculator tool was used to generate the following table. The following table illustrates the potential for generating energy and economic benefits through increased use of existing energy saving settings in combination with varying rates of manual nightly computer turnoff.

Table 7 - kWh Savings with Behavioral Adjustments



Manual Turn Off Rate	Monitor Sleep Time (Min.)	Computer Sleep Time (Min.)	Annual kWh Savings	Annual Cost Savings (US$)
20%	15	30	76,400	10,700
	10	20	78,400	10,900
50%	15	30	50,600	7,000
	10	20	52,600	7,300
70%	15	30	33,300	4,600
	10	20	35,400	4,900
100%	15	30	7,500	1,000
	10	20	9,600	1,300

Table 7 was generated using the Energy Star Computer Power Management Savings Calculator. This tool was created and made available by the Energy Star IT Initiative, and uses the existing quantities of appliances combined with estimated behavioral factors to determine cost, emissions and energy savings based on regional electricity mixes and average prices. Data for numbers of computers, monitors, and laptops were generated during an energy assessment that surveyed appliances and the IT system in place in the LTBB governmental buildings. The average emissions characteristics of commercial electricity in Michigan as well as an electricity cost of $0.14/kWh were assumed (this was the cost built-in to the tool and should not be confused with the $0.12/kWh cost that was the Tribe's baseline in 2012). There are a wide variety of specific computer models used within the governmental buildings, which results in a correspondingly diverse energy consumption pattern. To account for this variability within the above evaluation, industry energy consumption averages cited by Energy Star within the calculation tool were used. In addition, an 8-hour workday, 5-day workweek, and 22 non-working days per year were assumed as representative of the operating hours for the LTBB governmental facilities.

Assuming a manual turnoff rate of 50%, with a monitor sleep time of ten minutes, and a computer sleep time of 20 minutes, LTBB could expect to save around 50,600 kWh annually through activating power save features on current devices. This would be about 2.9% of the total 1,775,928 kWh used annually by LTBB. Simple programming of the monitors and computers to go to sleep--as well as a manual turn off rate of 50%--can yield great savings. The best part about this energy-saving strategy is: it's free!

IT System Recommendations.

As indicated above, the potential savings that can be generated by enabling existing power saving features are significant and represent an effective method of increasing the energy sustainability of the LTBB IT system. While it is difficult to accurately model practical energy savings, the Energy Star tool effectively illustrates the strong potential that low input behavioral modifications using existing features could generate.

Notably, enabling power saving features will result in worthwhile gains regardless of nightly manual turn off rates. While lower turn off rates will inevitably result in higher gains from power saving features due to the higher power demand of having more devices powered on, power-saving features are still worth promoting independently of increased manual turnoff. In combination with other useful strategies such as incorporating smart power strips, increased use of power saving features can effectively build on other methods for increasing energy efficiency.

An additional strategy for creating efficiency gains focuses on *right-sizing* access to office equipment. Many large workplaces are characterized by an abundance of devices for printing, copying, scanning, and faxing, which enable efficient communications and benefit productivity. However, the number of devices has not necessarily been optimized for the existing workforce, resulting in unnecessary energy consumption and more expensive operations and maintenance fees. While there is no firm number dictating the most effective device per employee population figure, Energy Star has shown through existing initiatives that many organizations and office spaces can decrease this figure to one multifunctional, networked device per 10 individuals.[26] By right-sizing the number of devices to the workflow that a particular department or office engages in, energy consumption is decreased and generates lower costs for electricity as well as operations and maintenance for excessive devices.

2.5 Building Envelope

"Optimizing building envelope design should be a key part of any long-term energy reduction strategy."-IEA, 2013

What is the building envelope, and why does it matter?

Buildings are inextricably linked to the production of CO_2, as they account for over one-third of energy consumption globally[27]. Energy consumption within buildings accounts for nearly all the GHG emissions in both the residential and commercial sector[28]. The U.S. building sector accounted for roughly 41% of U.S. primary energy consumption in 2010, with about 52% of total building energy consumption attributable to heating, ventilation, and air-conditioning (HVAC) and lighting[29]. HVAC systems, Ccf usage, and lighting costs are directly related to the building envelope of a structure.

The components of the building envelope include the walls (both interior and exterior), the roof, the foundation, and any windows, doors, or skylights[xii] the design might incorporate. The building envelope acts as a thermal barrier, with the goal of minimizing heat transfer between the indoor and outdoor environment[30]. Thus, an outdated or ineffective building envelope can result in greatly elevated energy consumption. Insulation is a key factor in securing the building envelope, as most of the heat in a building is lost through the walls, roofs, and floors[31].

Energy loss through the building envelope is not consistent, and is context specific. Climate is an important consideration, and there are different techniques for reducing the movement of air between the outdoor and indoor environments in hot climates versus cold climates. The age of the building is also important, as older buildings are more likely to have inefficient insulating materials. The type of building, its manner of construction, its geographical position, its orientation, and the choices or actions of its occupants are all factors which contribute to the highly variable nature of energy loss through building envelopes[32].

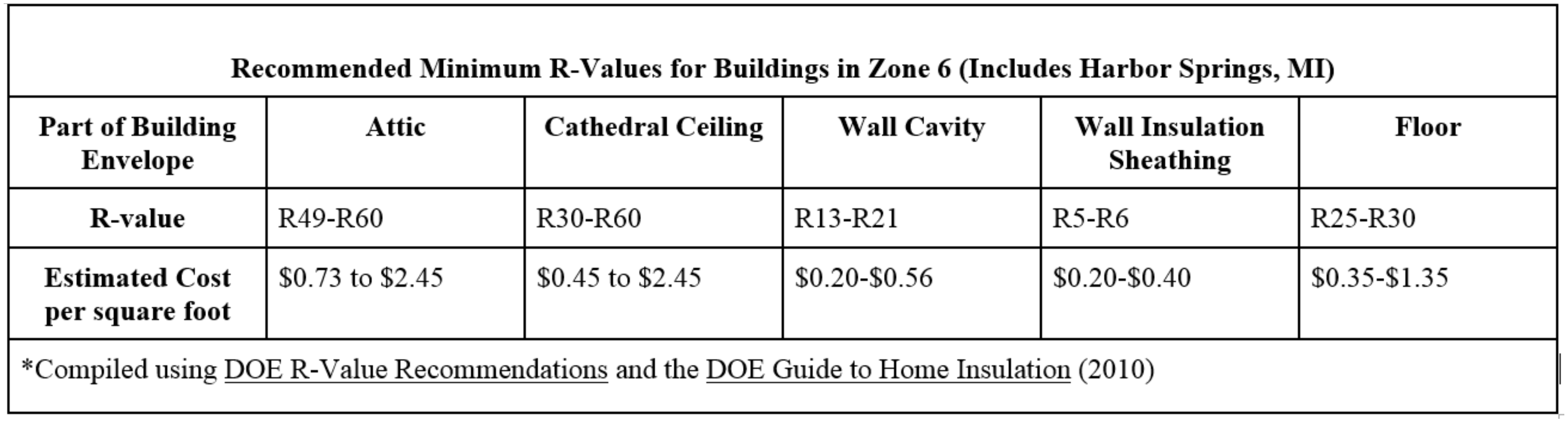
What constitutes a "good" building envelope?

Many factors can contribute to the strength and effectiveness of the building envelope. Especially in a cold climate such as Harbor Springs (part of climate zone 6), it is important to have an appropriate amount of insulation with an adequate R-value. An "R-value" can be defined as "a measure of resistance to heat flow through a given thickness of material"[33]. It is desirable to have the highest R-value possible, so as to have the highest resistance to heat. Information regarding the R-values used in the admin, health, and Spring St. buildings was not available. However, we were informed that the insulation was 6-inch fiberglass batting, and based on this information and the use of an R-value chart,[34] we estimated an R-value of 21 for the three government buildings. As seen in Table 8, recommended R-values for buildings in Zone 6 range from R-13 to R-21. If our estimation for the insulation is correct, then the three LTBB buildings are in the upper range of recommended thermal resistance.

[xii] The word "fenestration" is often used to refer to windows, doors, and skylights in discussions about the building envelope.

Having a high R-value does not in itself make for a secure building envelope. The R-value measures only thermal conduction[xiii]; as such, convection, radiation and air infiltration are not accounted for when using this metric alone[35]. The application and installation of the material is crucial in addressing the other issues associated with reduced energy efficiency. To avoid losses through convection[xiv], it is important that all cavities within the building structure be filled with insulation. It is also important that the insulation be densely packed, which will reduce the effects of air infiltration and radiation[36].

Table 8- R-value Compilation



Recommended Minimum R-Values for Buildings in Zone 6 (Includes Harbor Springs, MI)

Part of Building Envelope	**Attic**	**Cathedral Ceiling**	**Wall Cavity**	**Wall Insulation Sheathing**	**Floor**
R-value	R49-R60	R30-R60	R13-R21	R5-R6	R25-R30
Estimated Cost per square foot	$0.73 to $2.45	$0.45 to $2.45	$0.20-$0.56	$0.20-$0.40	$0.35-$1.35

*Compiled using DOE R-Value Recommendations and the DOE Guide to Home Insulation (2010)

How can an existing building envelope be improved?

During any construction or renovation process with an end goal of a tight building envelope, it is important to adopt a "whole building" approach. A general rule of thumb is to incorporate high levels of insulation, high-performance windows, climate specific

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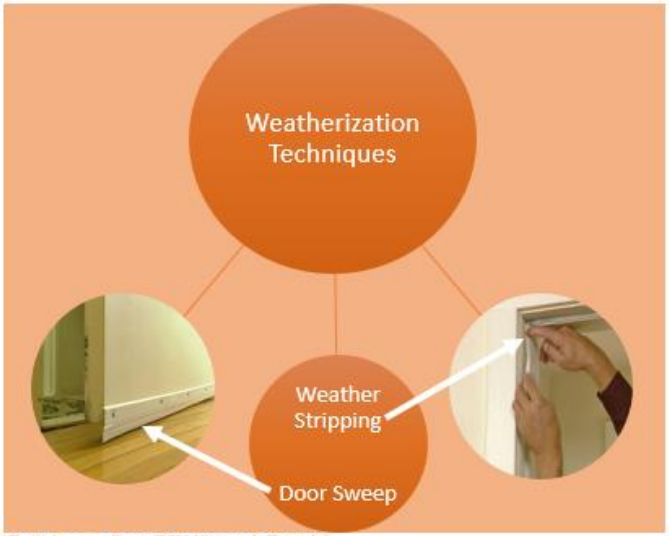
[xiii] Conduction can be thought of as the movement of heat through direct contact. Or, more specifically, heat energy that is transmitted through collisions between molecules as the result of a temperature gradient.

[xiv] Convection refers to heat transfer through liquids or gases.

elements (i.e. highly reflective roofs in warm climates), proper sealing and weatherization techniques, and a design that minimizes thermal bridges (areas which easily conduct heat and allow unwanted infiltration)[37]. Wall studs--which support the building structure--have a low R-value, and do not resist thermal transfer adequately. Putting fiberglass batting over studs can therefore result in a "cold joint"[38]. One strategy used is the installation of "Structural Insulated Panel (SIP) Systems". The SIP System essentially creates a "continuous panel" that uses foam insulation between the joints to further limit heat transfer. Potential savings compared to traditional systems have been estimated to be upwards of 50%[39].

Figure 6.1 - Weatherization Techniques



*Both images from DIY Network Tutorial

It is also important to make sure that the building is properly sealed and weatherized throughout the year. Proper weatherization can reduce energy costs by approximately 20-25% annually[40]. Insulation can only reach its full potential benefits if cracks in the walls or any points of air leakage (i.e. under exterior doors) have been sealed[41]. Tight building envelopes also prevent moisture transfer across gradients, so there is an even greater incentive to maintain a solid building envelope. Caulk and/or spray foam can be used for any cracks or crevices in the walls or ceilings. Weather stripping should be used around doors and windows to reduce infiltration and exfiltration of air (Figure 6.1).

2.6 Windows

When considering cost effective energy efficiency improvements, window replacement is generally a secondary strategy. Replacement can be very costly, and may have long payback periods; consequently, window replacement can make sense in terms of saving energy, but be less attractive financially. The payback period is dependent on the amount of money saved annually in energy costs. When replacing a window, one should first look for an ENERGY STAR rated window, then examine the National Fenestration Rating Council (NFRC) label to determine which window best fits the required metrics for the climate. Refer to Figure 6.2 for an example of a NFRC label. An alternative to window replacement is a window upgrade.

Window Overview.

Figure 6.2 - Example of NFRC Label.

NFRC
National Fenestration Rating Council®
CERTIFIED

World's Best Window Co.
Series "2000"
Casement
Vinyl Clad Wood Frame
Double Glazing•Argon Fill•Low E
XYZ-X-1-00001-00001

ENERGY PERFORMANCE RATINGS

U-Factor (U.S. / I-P)	Solar Heat Gain Coefficient
0.35	**0.32**

ADDITIONAL PERFORMANCE RATINGS

Visible Transmittance	Air Leakage (U.S. / I-P)
0.51	**≤0.3**

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information.
www.nfrc.org

Reasons for Window Replacement.

There are three primary conditions that indicate a need for window replacement. Firstly, windows should be replaced if they are too old; generally speaking the lifetime of a window is 20 years. Second, replacement is needed if the 'draftiness' is causing discomfort, or if windows are unable to close. Finally, replacement should occur if there is excessive water infiltration; however, water infiltration may not always be visible without professional evaluation.

Important Window Metrics.

1. U Factor: This is a heat transfer coefficient that measures how well the window prevents heat from leaving the building. A U-factor is generally between 0.15 and 1.20 Btu/h·ft^2·°F or W/m^2°K[42]. Thermodynamics states that as a consequence of conduction, convection and long wave radiation, heat flows from warmer to cooler bodies. Therefore, heat loss can be a serious issue in the winter months. The lower the U-factor is, the better the window is at insulation. It should be noted that some companies give a center of the glass U-factor instead of a standard U-factor which includes the whole window (glazing, spacers, and framing); the center of the glass U-factor will generally be lower and thus it will appear that the window is better at reducing heat loss[43]. Refer to table 8 for a list of window properties and U-factors.

2. Solar Heat Gain Coefficient (SHGC): This is a measure of the heat that can enter through a window due to solar radiation. It is a number that ranges from 0 to 1, and is dimensionless. A higher value indicates more heat will enter the building; this can be beneficial in winter months, but a hindrance in summer months[44].[xv]

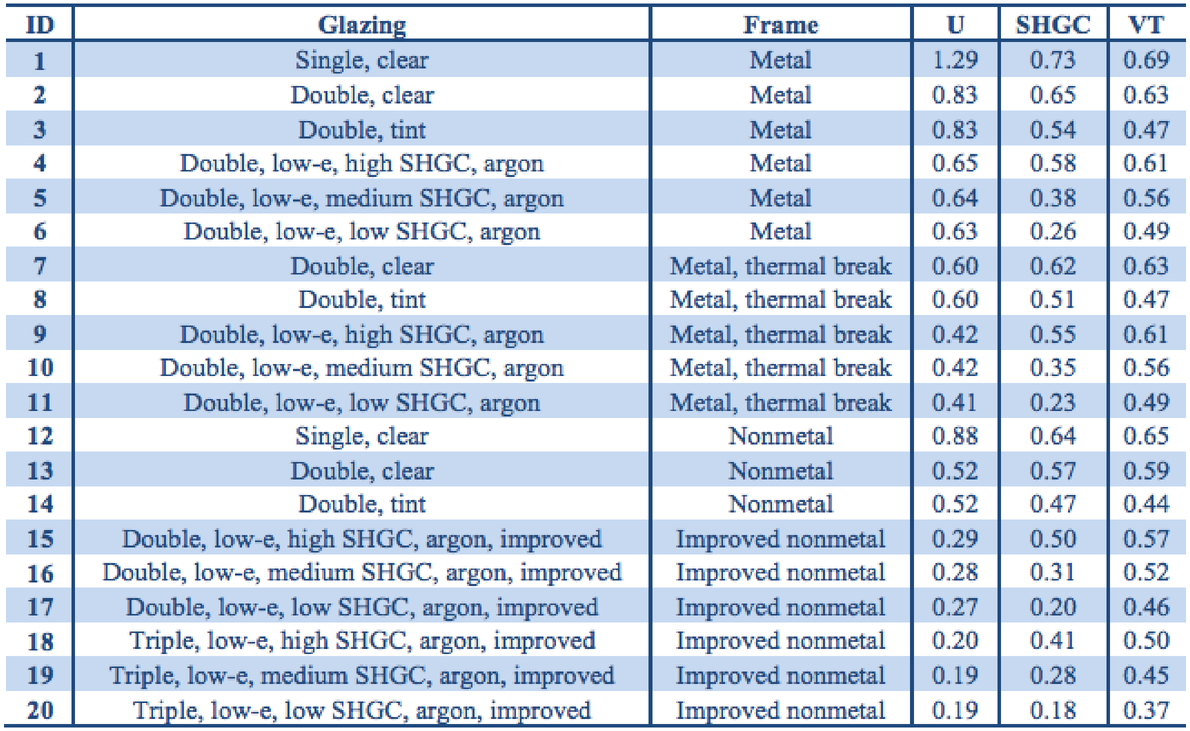
3. Air Leakage (AL): cracks in the window can cause air--which is measured in cubic feet--to seep out. This amount of air is determined by pressure circumstances[45].

4. Visible Transmittance (VT): This is a dimensionless number ranging from 0 to 1 that measures the amount of visible light transmitted through a window[46].

5. Condensation Resistance: This is a dimensionless number ranging from 0 to 100; the higher the number, the better the window is at resisting condensation formation[47].

[xv] *When selecting a window the two most important factors are metrics 1 & 2; many tax credit requirements only focus on these two metrics. Metrics 3 – 5 are not as commonly used; as for NFRC labeling, they are optional.*

Table 9 - Window Properties and U-factors (DOE Data)



ID	Glazing	Frame	U	SHGC	VT
1	Single, clear	Metal	1.29	0.73	0.69
2	Double, clear	Metal	0.83	0.65	0.63
3	Double, tint	Metal	0.83	0.54	0.47
4	Double, low-e, high SHGC, argon	Metal	0.65	0.58	0.61
5	Double, low-e, medium SHGC, argon	Metal	0.64	0.38	0.56
6	Double, low-e, low SHGC, argon	Metal	0.63	0.26	0.49
7	Double, clear	Metal, thermal break	0.60	0.62	0.63
8	Double, tint	Metal, thermal break	0.60	0.51	0.47
9	Double, low-e, high SHGC, argon	Metal, thermal break	0.42	0.55	0.61
10	Double, low-e, medium SHGC, argon	Metal, thermal break	0.42	0.35	0.56
11	Double, low-e, low SHGC, argon	Metal, thermal break	0.41	0.23	0.49
12	Single, clear	Nonmetal	0.88	0.64	0.65
13	Double, clear	Nonmetal	0.52	0.57	0.59
14	Double, tint	Nonmetal	0.52	0.47	0.44
15	Double, low-e, high SHGC, argon, improved	Improved nonmetal	0.29	0.50	0.57
16	Double, low-e, medium SHGC, argon, improved	Improved nonmetal	0.28	0.31	0.52
17	Double, low-e, low SHGC, argon, improved	Improved nonmetal	0.27	0.20	0.46
18	Triple, low-e, high SHGC, argon, improved	Improved nonmetal	0.20	0.41	0.50
19	Triple, low-e, medium SHGC, argon, improved	Improved nonmetal	0.19	0.28	0.45
20	Triple, low-e, low SHGC, argon, improved	Improved nonmetal	0.19	0.18	0.37

Windows can take on many properties that will impact the aforementioned metrics. Table 9 provides some examples.[48] Additionally, Table 10 provides the required window metrics for the LTBB as given by Energy Star; this will be helpful if the LTBB wishes to purchase new windows.

Table 10 - Energy Star Qualifications: Emmett County, MI The table below provides the requirements necessary for any new windows the LTBB purchases if they wish to be Energy Star rated.*

U-Factor	**SHGC**	
Less / = 0.3	Any	Prescriptive
=0.31	0.35 or higher	Equivalent Energy Performance
=0.32	0.40 or higher	Equivalent Energy Performance

Air leakage: </=0.3 cfm/ft^2 (This is for Northern Climate Zones)

*Adapted from ENERGY STAR

Financing Mechanisms.

There are few financing mechanisms for windows. Most tax credits are for residential use only; additionally, utility incentive options are not yet available in Michigan.

Possible Window Upgrades.

Upgrades are a good alternative to window replacement, because the latter can be a very costly endeavor. Upgrades are a remediation of malfunctioning portions of the window; this is in contrast to window replacement, in which the entire window is removed and replaced. One such upgrade involves using triple insulation, a third glass layer on the window which reduces noise and saves energy; it is best suited for areas with cold climatic conditions. It costs 100$ for a 3x5ft^2 double hung window[49]. A second option is to utilize interior storm windows. These are low-e inserts (made of glass or plastic) that can attach to an existing window to make it more energy efficient. However, the first step in this process is to ensure that, “there is no missing glass, rotting wood, broken parts, or egregious air and water leakage. If there are obvious leaks around the frame of the window, some weatherization and rehab may be necessary before installing the storm windows.[50]" These low-e sheets can improve energy efficiency by 12 to 23 percent[51] and they cost $164 and upwards per window[52]. Thirdly, sealants can be used to cover any air leakage pathways detected. To find air leakage points, "shine a flashlight around the edges of the window at night; use a lit incense stick to detect drafts; or, shut the window on a piece of paper—if you can pull it away without tearing, it suggests the window is not closing tightly." To seal the window, caulking or weather stripping—as described in the building envelope section—can be used. [53]Fourthly, one should replace cracked glazing (also known as window glass). If the window is broken it should be repaired immediately. Finally, heavy curtains can be used to trap heat in the winter[54]. This can be helpful, because in the government buildings we noticed that many of the windows did not have blinds or curtains.

One final issue to consider is the cost of installation. The total costs will depend on if new windows and/or window upgrades are installed by a member of the Tribe or by a professional. Different options should be examined to determine the most cost-effective solution for any window replacement.

Windows Analysis.

We measured the potential energy, CO_2, and cost savings accrued over time if a decision is made to replace windows. The CO_2 savings may seem low, but this is because the majority of the energy that windows will save will come from the winter season, which impacts natural gas consumption. The assumptions that went into this analysis are shown below. We found that over time window replacement does generate CO_2 savings; however, due to the high initial cost of window replacement, LTBB would not likely recover its investment in a reasonable time period. Moreover, our analysis was not fully comprehensive because it was limited to the metrics we could measure; consequently, we recommend not replacing the windows until an energy audit can be completed. More in depth recommendations will be given in the proceeding sections.

Windows Methodology.

This section will provide background on the metrics and assumptions that were used to calculate the energy, CO_2 and cost savings:

1. The window areas, by building, were calculated by measuring each window in the buildings.

2. The cooling degree days (CDD), for 2012, were calculated from using a base of 65ºF and the weather station closest to the LTBB. We used 2012 because that is our baseline year.[55]

3. The cost electricity usage was calculated from energy bills provided by LTBB, as shown in section 1 of this chapter.

4. The lifetime of the new window is estimated to be around 20 years, based on data from Energy Star[56].

5. The cooling efficiency measured by SEER (Seasonal Energy Efficiency Ratio) was found from HVAC data. There was limited data on this so we found the SEER value to be 21 BTH/h/W based on a system in the judicial building. We assumed the values would be similar over all three buildings.

6. We made a rough estimate of the old window U-Factor. The windows were lacking sufficient model numbers to cross-reference to locate precise U-Factors. Estimates came from the EPA listing of potential U-Factors based on window features, and example of such a table can be seen in Figure X in Chapter 25. The U-Factor of the replacement window is entered next. For LTBB, this value should be equal to or less than 0.3 with an associated SHGC value of anything, OR a U-Factor of 0.31 with a SHGC factor of 0.35 or higher, OR a U-Factor of 0.32 and SHGC of 0.4 or higher.

7. Additionally, the cost of the window replacement needs to be considered; and finally the discount rate of LTBB is estimated to be 2.5%, this value came from the LTBB financial department.

Calculations & Results.

We determined the amount of kWh saved by estimating the difference between the heat loss of the window with the original U-Factor and the new U-Factor. Next, we calculated the kWh savings. Additionally, we found the annual and lifetime CO_2 and cost savings from replacing the window. Finally, we calculated the contribution window replacement would have towards the 25% reduction goal.

Because we only calculated the electricity savings, the percent contribution to the 25% goal was minimal. This is because the LTBB area does not require extensive cooling; it is in a more heating intensive region[xvi]. Accordingly, the majority of the energy savings will be from a reduction in natural gas usage. The percent contribution to the reduction goal, from window replacement, was 0.09%. We also found that assuming a $100,000 installation cost, the Tribe would not recuperate its investment over the next 100 years.

Windows Recommendations.

As mentioned, the payback period is largely dependent on the window replacement cost. Window replacement can become economically feasible if LTBB receives a grant to cover a portion of the replacement costs.

The administrative building has windows with a U-Factor of 0.39. Although this is far from the 0.30 goal, it is close enough that investing in window replacement for this building would not be wise. However, the judicial and health locations have an estimated U-Factor around 0.83, and although this may be lower in reality, we believe that the windows in the judicial building should be replaced regardless. This is because the windows there had multiple cracks in them, and some occupants reported that they were unable to close their office windows. In regards to the health building, the decision of whether or not to replace the windows depends on costs, and the contribution to the Tribe’s energy reduction goal.

[xvi] The CDD for the tribal area amounted to 421, and the HDD amounted to 6,983

2.7 Lighting

Lighting systems comprise a significant portion of total electricity consumption in buildings, and due to recent technological advances can improve environmental sustainability in a cost-effective manner. Lighting systems typically account for around 30% of total building energy use and represent a primary area of focus when attempting to increase resource efficiencies[57]. In terms of general consumption patterns, the EIA estimates that in 2012 lighting represented 12% of total national electricity use, and in the commercial sector accounted for 21% of consumption[58]. Since 2008, advances in lighting technology and manufacturing techniques have improved energy efficiency while decreasing bulb costs by 85%[59]. In comparison to standard incandescent bulbs, highly efficient LED bulbs "...cut energy use by more than 80 percent and can last 25 times longer"[60]. While it is clear that improving the energy performance of the lighting system alone will not generate sufficient reductions to meet the overall energy savings goal, it will contribute to significant efficiency gains and serve as a vital strategy for LTBB to increase environmental sustainability.

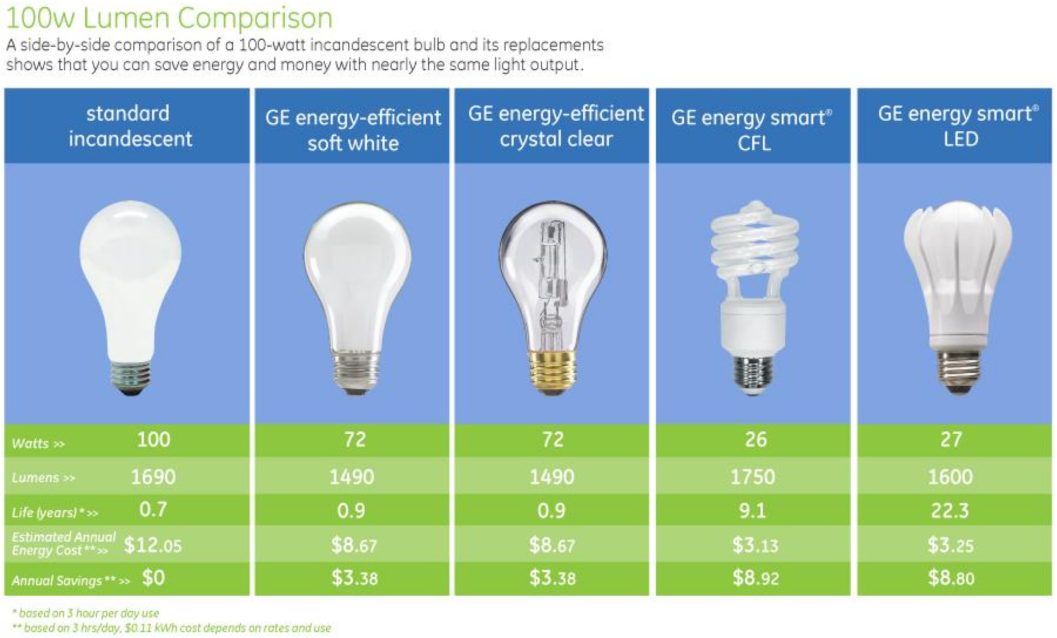
Figure 7-CREE LED Ceiling Troffer

Given that the electricity generation mix of Michigan is fueled primarily by coal, energy consumption and environmental degradation are inextricably linked[61]. The U.S. Energy Information Administration (EIA) estimates that 2.08 lbs. of CO_2 are released per kWh generated by bituminous coal[62]. Minimizing end-user energy consumption decreases primary resources required for electricity generation, reducing emissions of greenhouse gases and other harmful pollutants. This means that a reduction in kWh consumed from lighting would provide financial benefits for the Tribe while reducing emissions of pollutants and greenhouse gases.

In addition to behavioral changes, there are several viable options to reduce unnecessary energy consumption from lighting systems. Opting for more efficient light bulbs, as previously mentioned, is a common option. LED bulbs perform much better than standard incandescent bulbs (see 5 bulb side-by-side comparison[63]. In addition to using far less energy than traditional bulbs, LEDs have much longer lifespans than even compact fluorescent bulbs (CFLs). Replacing standard bulbs with LED equivalents is a worthwhile strategy from both short and long-term planning perspectives. Refer to figure 7 for a GE light bulb comparison.

A more intensive option is to install LED-ceiling fixtures. Although this technology is still quite expensive, the benefits are significant. For instance, this CREE LED Ceiling Troffer (Figure 7) uses 44 watts per fixture. Standard T8 ceiling fixtures generally contain 3-4 T8 bulbs, which are 32 watts each. This means that for each currently in place T8 unit, 96-128 watts are required for operation. By replacing the current fixtures with LED equivalents, power consumption could be reduced by 52-96 watts per fixture.

Figure 8 - GE Light bulb Comparison



100w Lumen Comparison

A side-by-side comparison of a 100-watt incandescent bulb and its replacements shows that you can save energy and money with nearly the same light output.

	standard incandescent	GE energy-efficient soft white	GE energy-efficient crystal clear	GE energy smart® CFL	GE energy smart® LED
Watts >>	100	72	72	26	27
Lumens >>	1690	1490	1490	1750	1600
Life (years) * >>	0.7	0.9	0.9	9.1	22.3
Estimated Annual Energy Cost ** >>	$12.05	$8.67	$8.67	$3.13	$3.25
Annual Savings ** >>	$0	$3.38	$3.38	$8.92	$8.80

* based on 3 hour per day use
** based on 3 hrs/day, $0.11 kWh cost depends on rates and use

Other options include incorporating occupancy sensors or photosensors. Occupancy sensors use passive infrared, ultrasonic, or multi-sensing technologies to determine when individuals are in a given space[64]. When the sensor does not detect an occupant, it turns off the lighting system attached to it, which can reduce energy consumption by 25-75% depending on location, traffic flow, and behavior.[65]

Photosensors work similarly to occupancy sensors, except they detect light rather than motion/ human presence. Photosensors can be defined as “electronic control units that automatically adjust the output level of electric lights based on the amount of light detected”[66]. This means that outdoor or indoor lights can be automatically turned on or off depending on the time of day or flux of light. This type of device is especially useful for outdoor lighting systems that are often left on for extended period of times. Photosensors, like occupancy sensors, can correct for human error.

As evidenced, several options are available for reducing the energy impact of lighting systems, and accounting for human error. These systems can produce especially powerful results when they are employed concurrently. The relative ease and low cost of upgrades makes lighting a very popular sector for energy reduction.

Lighting Methodology.

Targeting the administrative, health, and judicial buildings, we developed an optimization system to explore the potential increases in energy efficiency achievable through alternative mixes of bulb replacement and lighting system modifications over one year of analysis.[xvii] With a comprehensive evaluation of the current lighting system and a review of commercially available efficient replacement options, the system integrates lifecycle[xviii] analyses of cost and energy. We defined the lifecycle of the bulb as the purchase period until the end of our 2,808 hours timeframe. This means we accounted for energy costs (using an average of $0.11/kWh, estimated from LTBB's energy bills), initial bulb purchase costs, and bulb replacement costs (specifically for incandescent bulbs, which have an estimated life of only 1,000 hrs.). We did not examine lifecycle impacts prior to the purchase of the light bulb, nor did we consider disposal costs.

Framed with the objective of minimizing both cost and energy consumption, we found that net energy usage over the period of analysis can be reduced by 8.1% from total consumption while minimizing costs. Through a sensitivity analysis, we determined that the replacement structure is mildly impacted by funding availability with optimal replacement mixes generally targeting the most energy efficient options, despite the high costs of said options. Considering the results of the optimization model, we concluded that

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[xvii] With an assumed 2,808 of operation time for all bulbs

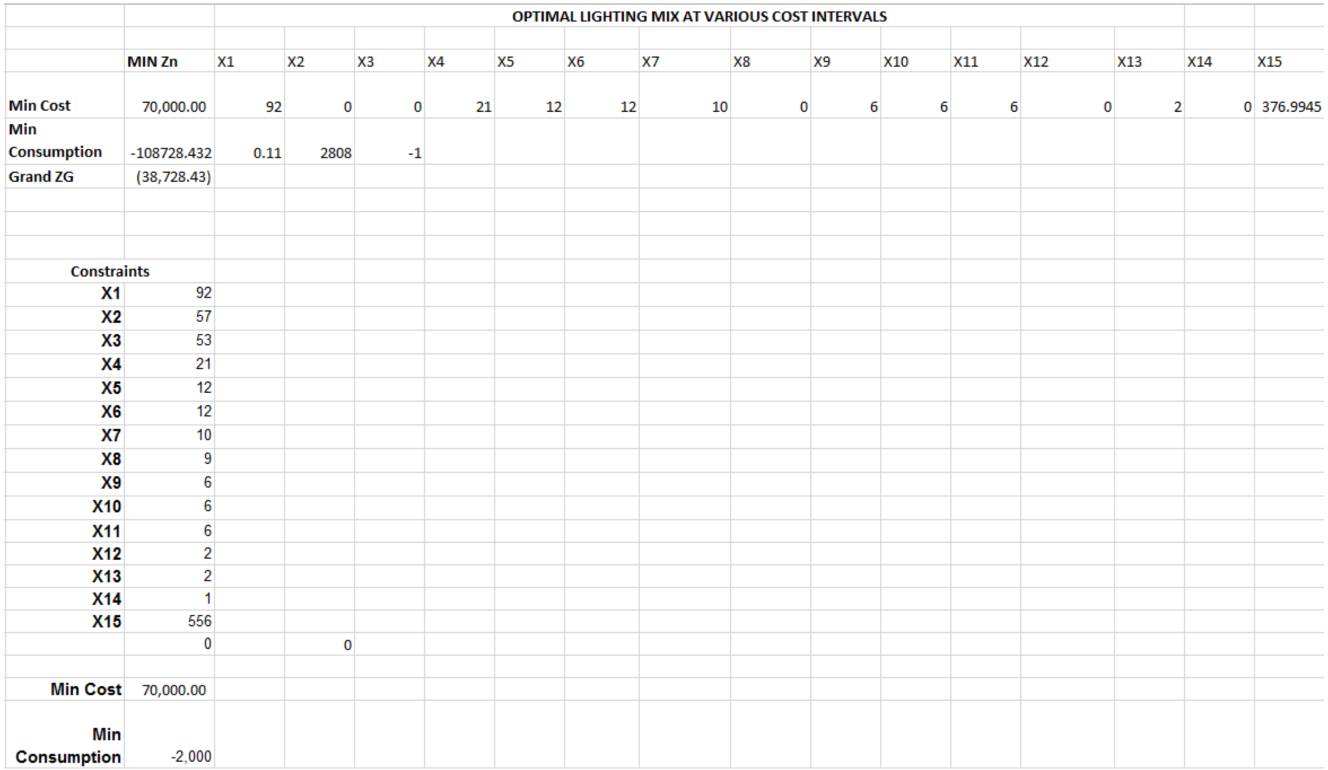
[xviii] For the purposes of this analysis, "lifecycle" refers to the "use phase" (the time of the bulb's purchase until its disposal). A true lifecycle analysis would also consider "upstream impacts" (such as materials needed to create the bulb, and transportation from the bulb manufacturer to the end-user), and "downstream impacts" (costs of disposal).

modifications to the lighting system are warranted, and represent an effective, economically viable method for the LTBB to reduce energy consumption.

Process of Analysis.

Our lighting analysis began with a walkthrough lighting assessment of the Administrative, Health, and Spring St. buildings in July 2014. We went through each building and recorded all fixtures and light bulbs to determine their bulb type and wattage. For rooms we could not enter, or bulbs that were on the ceiling, we either made educated guesses or asked custodial staff for their best estimations of wattage and bulb type. We created an inventory for each of the three buildings individually, and then aggregated the information by bulb type.

Figure 9- Optimization Function for Lighting



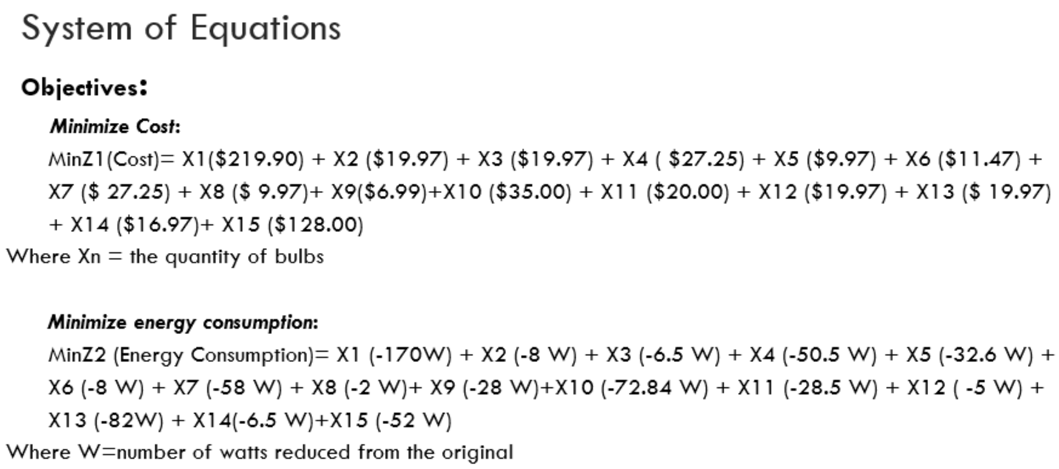
OPTIMAL LIGHTING MIX AT VARIOUS COST INTERVALS

	MIN Zn	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
Min Cost	70,000.00	92	0	0	21	12	12	10	0	6	6	6	0	2	0	376.9945
Min Consumption	-108728.432	0.11	2808	-1												
Grand ZG	(38,728.43)															
Constraints																
X1	92															
X2	57															
X3	53															
X4	21															
X5	12															
X6	12															
X7	10															
X8	9															
X9	6															
X10	6															
X11	6															
X12	2															
X13	2															
X14	1															
X15	556															
	0		0													
Min Cost	70,000.00															
Min Consumption	-2,000															

For each type of bulb in the three buildings, we first established current energy consumption. We then identified efficient equivalents of each bulb type, trying to keep color temperature (degrees kelvin), lumens, and fixture requirements as constant as possible. The energy efficient replacements were priced, and their wattage recorded to compare to the baseline lighting scenario.

We created an optimization function[xix] (seen in figure 9) in order to determine which bulb changes should be prioritized at different price points. Initially our system had two objective functions, to minimize cost and minimize energy consumption (Figure 10). However, we decided it would be more useful to make the goal to minimize consumption for assorted spending intervals, and then ran our model to see which changes would make the most sense from an energy consumption perspective at various price points. As such, price became a constraint, along with the number of bulbs in each category. The different bulb types are represented by variables X1-X15.

Figure 10 - Optimization System of Equations



System of Equations

Objectives:

Minimize Cost:

MinZ1(Cost)= X1($219.90) + X2 ($19.97) + X3 ($19.97) + X4 ($27.25) + X5 ($9.97) + X6 ($11.47) + X7 ($ 27.25) + X8 ($ 9.97)+ X9($6.99)+X10 ($35.00) + X11 ($20.00) + X12 ($19.97) + X13 ($ 19.97) + X14 ($16.97)+ X15 ($128.00)

Where Xn = the quantity of bulbs

Minimize energy consumption:

MinZ2 (Energy Consumption)= X1 (-170W) + X2 (-8 W) + X3 (-6.5 W) + X4 (-50.5 W) + X5 (-32.6 W) + X6 (-8 W) + X7 (-58 W) + X8 (-2 W)+ X9 (-28 W)+X10 (-72.84 W) + X11 (-28.5 W) + X12 (-5 W) + X13 (-82W) + X14(-6.5 W)+X15 (-52 W)

Where W=number of watts reduced from the original

The primary bulb replacement recommendations at the investment intervals of $5,000, $10,000, and $20,000 are listed in Table 10. Also provided is the cost to replace all bulbs in the buildings with efficient equivalents, which would be nearly $24,100. As expected, the model demonstrated that it is not economically sound to replace the compact fluorescent bulbs (CFLs) with LEDs. A few years in the future, as the cost of LED technology declines, replacement of CFLs will make more sense. A surprising find from the model was that regardless of price level, all incandescent bulbs, T5s, and metal halide bulbs should be a priority for replacement. The efficient

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[xix] An optimization function is a mathematical equation which seeks to find the absolute maximum or minimum value allowable under a series of constraints. In our case, the optimization function gives us a combination of bulb purchases which will yield the least possible energy consumption under constraints of bulb numbers and price.

equivalents for T5 bulbs and metal halides are quite expensive (about $12 and $28, respectively). These costs, of course, pale in comparison to the cost of the efficient version of the 250-watt high-pressure sodium (HPS) bulbs. Despite the fact that these efficient equivalents run about $220 at home improvement stores, the energy savings outweigh the costs of the technology, and the model recommends replacing as many of these HPS bulbs as the budget will allow. Generally, the model emphasizes the replacement of the most energy intensive bulbs first, regardless of the price of the efficient alternatives.

Table 11 - Selected Lighting Results and Recommendations

Investment Level	kWh Reduction	% of Annual Total	Replace Metal Halide Bulbs?	Replace Incandescent Bulbs?	Replace T5 Bulbs?	Replace High Pressure Sodium Bulbs?	Replace CFLs?
$5,000	17,361	1	✓	✓	✓	Replace 16	✗
$10,000	28,215	1.6	✓	✓	✓	Replace 39	✗
$20,000	49,923	2.8	✓	✓	✓	Replace 85	✗
$24,088 (total replacement)	56,026	3.2	✓	✓	✓	✓	✓

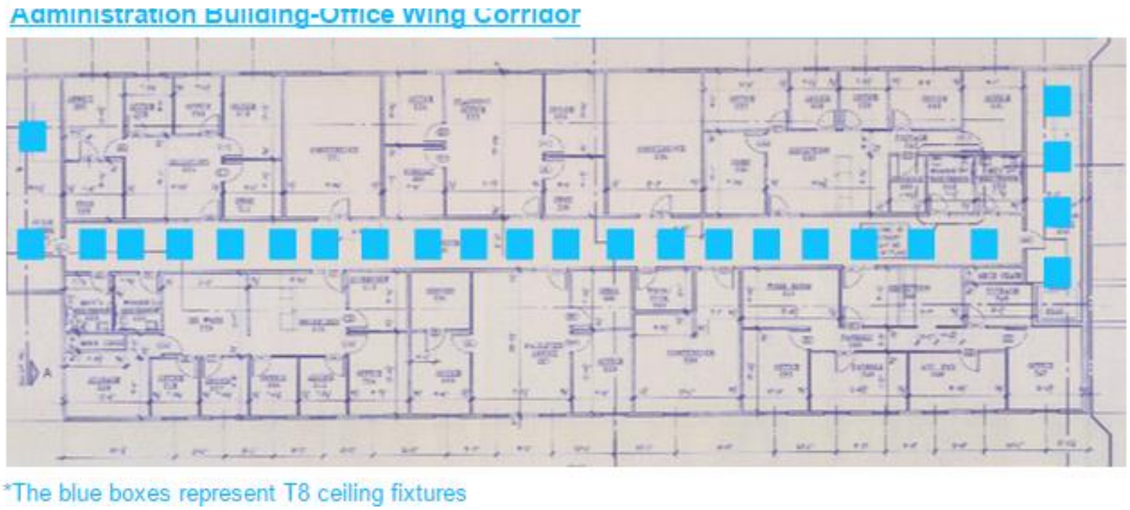
Ceiling fixtures.

Excluded from the lighting analysis were the 2,171 32-watt T8 bulbs found in the ceiling fixtures. Several iterations of running the model indicated that replacing individual bulbs would not be financially efficient. As such, we looked into the replacement of the entire T8 fixture. This analysis was conducted separately, and we determined that replacing the entire fixture would be a much more effective choice than simply replacing light bulbs. This would involve replacing these fixtures with LED systems. These systems use 44 watts per unit, as opposed to the typical 3-bulb T8 fixture, which uses 96 watts per unit.[xx] Switching the systems would result in a savings of 52 watts per unit. We estimated there to be 556 fixtures that could be replaced, which would yield a reduction of 28,912 watts in total. At 2,808 hours of consumption annually per fixture, this would mean a reduction of about 81,365 kWh per year.

Occupancy Sensors.

Occupancy sensors can be incorporated into multiple offices, corridors, and utility rooms to account for human error (i.e. forgetting to turn off the light switch). While there are many potential areas to incorporate these devices, we look specifically at the two largest corridors in the office wing of the administrative building. We counted 19 ceiling fixtures in the hallway, and 6 near the stairs, for a total of 25 fixtures (see Figure 11). There are three bulbs per fixture, and 32 watts per bulb. This means that for two floors, there

Figure 11 - Administration Building Office Wing Corridor



[xx] Based on a consumption of 32 watts per T8 bulb.

are 50 fixtures and 150 bulbs. At a consumption of 4,800 watts total and 2,808 hours of assumed usage per week, these hallways use about 13,478 kWh annually.

According to the U.S. Department of Interior, average savings from occupancy sensors in hallways are around 25%[67]. This means about 3,370 kWh could be saved from installing occupancy sensors in these two hallways. Near Petoskey, MI, installations of occupancy sensors are estimated to take 30 minutes, with a cost of $95 in labor. [xxi] At an estimated cost of $97 per occupancy sensor[xxii], the cost for installing sensors on these two floors should be about $385. Assuming a cost of $0.11/kWh, this should yield about $370 in savings annually. The installation of such devices could be replicated in various other properties and settings for further energy savings.

Photosensors.

Photosensors are devices, which, like occupancy sensors, can correct for human error. As previously stated, we noted on prior trips that the outdoor lights at the administrative building were on during daylight hours. For the purposes of this photosensors analysis, we assume that these 10 metal halide bulbs are left on about 21 hours each day, or 7,280 hours annually. At 70 watts per bulb, this is about 5,100 kWh per year. Assuming that these photosensors would reduce operating time to an average of 12 hours per day[xxiii], consumption would be reduced to 3,070 kWh per year. If these 70-watt metal halide bulbs were replaced with LED equivalents (as was recommended in the optimization function), and additional 58 watts would be reduced per bulb.

Labor costs for the area are assumed to be the same as those for occupancy sensors ($95), with an estimated cost of $16 per photosensors system[xxiv]. Since there are three groupings of outdoor lights at this property, we assume the total cost for this project to be $333. At 2,030 kWh reduction annually and $0.11 per kWh, this would be about $224 of savings annually.

[xxi] According to this contractor cost estimator

[xxii] For a ceiling mounted, self-contained occupancy sensor with 530 sq. ft. of coverage

[xxiii] Based on estimates provided by the Biological Systems Engineering Department at University of Wisconsin-Madison

[xxiv] At a store such as Home Depot

Lighting Conclusions.

All of our analyses made it clear that no matter the financial scenario, resources should be directed toward replacing the 250 watt high-pressure sodium (HPS) bulbs, the metal halide bulbs, and switching the traditional ceiling fixtures with an LED version. Although these products are costly (i.e. a more efficient HPS bulb costs about $220), the energy reduction benefits outweigh the costs. Given funding constraints, bulbs with lesser wattage are generally not worth replacing. For example, it is not financially expedient to replace a 26-watt compact-fluorescent bulb (CFL) with an 18-watt LED bulb. We ran the optimization model at various investment levels, and it only recommended CFL bulb replacement when the Tribe spends all the required money to replace the bulbs. Because CFL bulbs are relatively efficient, the energy savings are simply not enough to justify the purchase. As the price of LED bulbs decreases, replacing existing CFL bulbs will be a more financially expedient choice. Refer to Table 12 for a summary of energy saving measures from lighting upgrades.

Table 12 - Summary of Energy Savings Measures from

#	**Building**	**Area (i.e. lighting)**	**Recommendation**	**Estimated Cost**	**Estimated kWh Red.**	**% Red. from Total**	**Years until payback**
1	Admin, Health	Lighting	Replace 556 existing ceiling fixtures with LED equivalents	$71,170	81,365	4.6%	6.5
2	Admin, Health, Spring St.	Lighting	Replace all bulbs (excluding ceiling fixtures)	$24,088	56,026	3.2%	3.9
3	Admin	Lighting	Install occupancy sensors in two main corridors by offices	$385	3,370	0.19%	2
4	Admin	Outdoor Lighting	Install photo sensors on outdoor bulbs	$335	2,030	0.11%	2
			TOTALS	**$95,980**	**142,791**	**8.1%**	

2.8 Energy Efficiency Conclusion

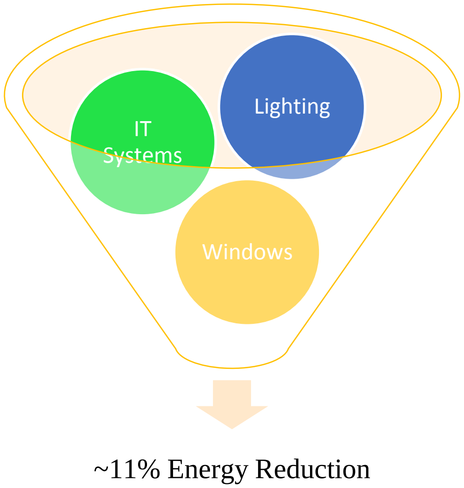
Table 13 - Summary of Energy Saving Measures

Sector	**Estimated Expense**	**Estimated kWh Reduction**	**Estimated % Total reduction**
IT	$0	50,600	2.9%
Lighting	$95,980	142,791	8.1%
Windows	$100,000	1,860	0.09%
TOTAL	***$105,980***	***198,274***	***11.09%***

Summarized above in Table 13 are the energy savings estimated in various sectors of LTBB. Based on our calculations, the Tribe could reduce energy consumption by about 10% if it spends around $100,000. This implies a cost of $10,000 for every 1% reduction in energy usage (although it is clear that for IT, a lot of energy can be saved without a lot of spending). However, there are several other energy-saving mechanisms that could likely be employed, and an analysis by a professional energy auditor would reveal even greater opportunities for savings, with more accurate cost estimates.

In the short-term, it is recommended that the LTBB focus their efforts on lighting and IT improvements. Going forward, it is also recommended that the Tribe pursue a professional energy audit to better understand window and HVAC improvements.

Figure 12 – Energy Savings Visualization



Chapter 3: Renewable Energy

3.1 Introduction to Renewable Energy Chapter

This chapter presents:

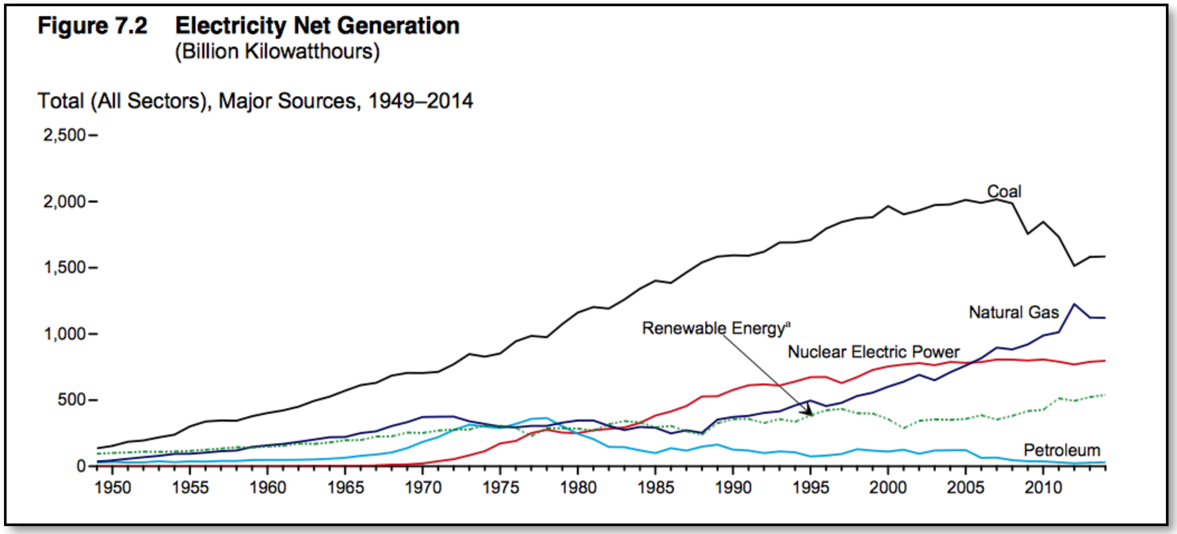
1) An overview of the United States energy mix with a focus on renewable energy and a brief description of wind and solar energy resources, technology, and markets;
2) A reflection on previous LTBB pilot renewable energy projects and the Mno-Gwaashkweziwin (Good Energy) Plan;
3) A spatial suitability analysis of solar and wind energy resources and best practice recommendations made with regards to generation potential based on these analyses.

The renewable energy scope of this project was limited to solar and wind energy resources for a variety of reasons. Firstly, because this project focuses on energy consumption from electricity, narrowing the renewable energy technology to sources that are most suitable for electricity generation on the LTBB reservation was deemed appropriate. Additionally, when looking at the renewable energy landscape in the United States and globally, data shows that wind and solar represent the greatest increase in new renewable energy generation projects being deployed, as well as the greatest share of total renewable energy generation - excluding hydropower.[68]

3.2 United States Energy Mix and Renewable Energy Overview

There is ample room for expansion of renewables, and not merely at the national level. The LTBB Tribe and the US government have both made strides to reduce dependency on conventional power by integrating clean renewable fuel sources into the current energy

Figure 13 -U.S. Energy Mix (EIA Data)



mix. Renewable energy is defined as fuel sources capable of regenerating energy over a short period of time. Examples include the wind, sun, organic matter or biomass, moving water, and the earth's heat better known as geothermal.[69]

Although it is evident that renewables are increasing in popularity, they still account for a relatively small share of energy production in the United States (Figure 13). Non-hydro renewable energy production in the U.S. increased from 4.8% to 7.6% of total U.S. energy production between 2000 and 2010, while fossil fuels still accounted for 77% of energy production in 2010.[70] In the state of Michigan, the energy mix is similar to that of the United States where conventional energy including natural gas, coal, and nuclear make up the majority of the electricity generation, as shown in Figure 14. Renewables, excluding hydroelectric still account for a fairly small share of net electricity generation in Michigan.[71] According to the Energy Information Administration (EIA), in 2013, the majority of the

Figure 14- Michigan Net Electricity Generation by Source, Jan. 2015. (EIA)

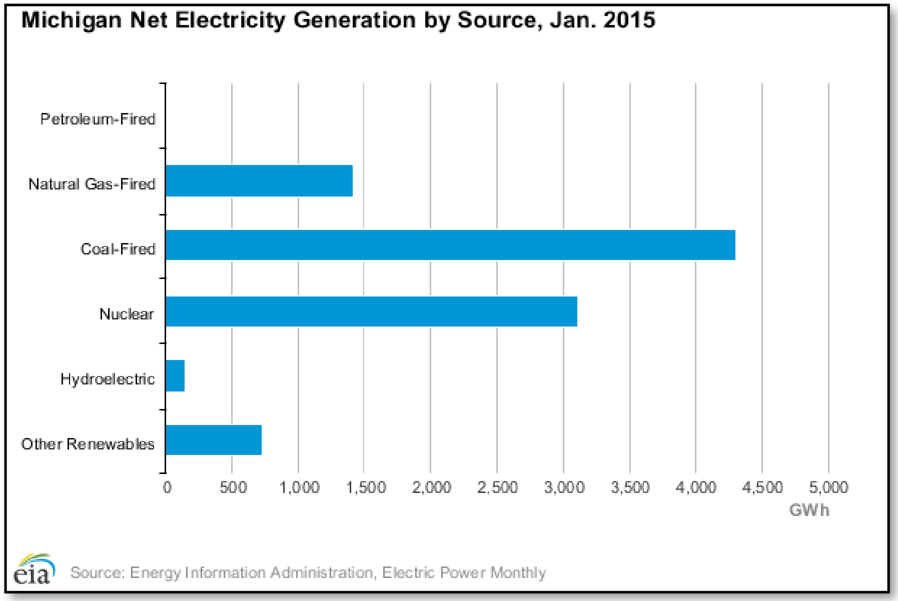
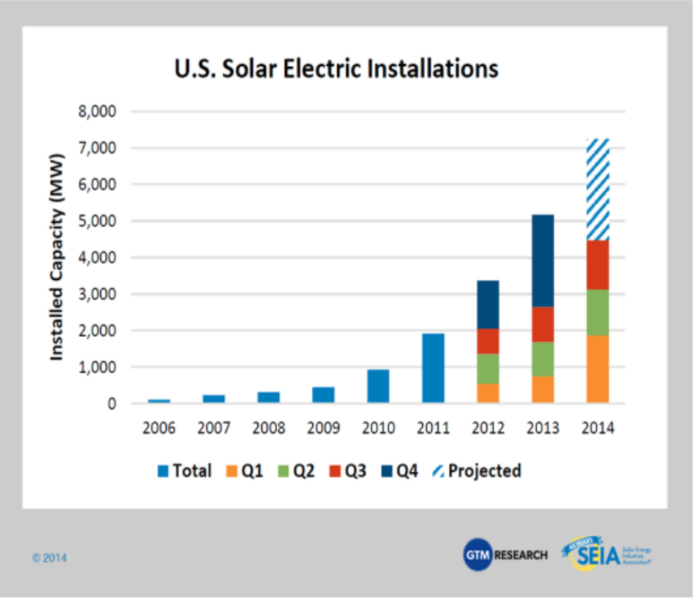


Figure 15-U.S. Solar Electric Installations. (SEIA data)



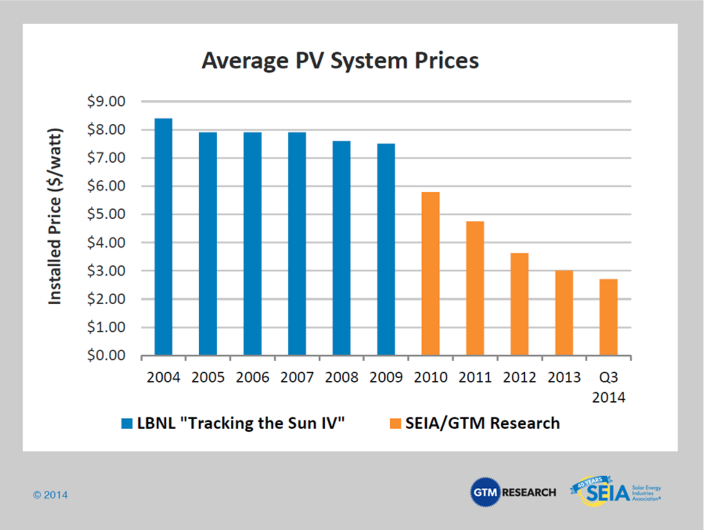
energy mix in the United States was composed of conventional energy sources: 66% fossil fuels and 17% nuclear.[72] Conventional energy is defined as nuclear power and fossil fuel combustion such as coal, oil, and natural gas. In 2013, 77% of US carbon dioxide emissions associated with electricity generation was sourced from coal, 22% from natural gas, 1% from petroleum, and the remaining 1% from other sources[73]. Fossil fuels negatively impact ecosystems, emitting large quantities of greenhouse gases and toxins into the air through combustion, while degrading the environment through mining, drilling, and extraction[74]. As for nuclear, though the operation of nuclear power does not emit greenhouse gases, the construction, intense usage of water, and long-term storage of nuclear waste threatens environmental health and quality.

Developing renewable energy projects is quickly becoming a major goal on the local, state, tribal, and national levels in the United States. At the end of 2008, the cumulative generation power of solar photovoltaic cells in the U.S. was 12,950 MW, while the U.S. alone installed 9,922 MW of wind generating capacity in 2009[75]. As of 2014, according to the Solar Energy Industry Association (SEIA), “There are now over 17,500 MW of cumulative solar electric capacity operating in the U.S., enough to power more than 3.5 million average American homes[76].” Thus, we are seeing the beginning of a growing focus on renewable technologies. Figure 15 shows the increase in U.S. solar electric installations from 2006 – 2014.

The United States government is also working to make the transmission of energy a more efficient process, through initiatives such as the “Smart Grid” program, a concept that gained credence from the 2007 Energy Independence and Security Act[77]. Inefficient transmission of electrical currents is a chief concern related to energy provision. Distance between sites of energy generation and the end user correlates directly with efficiency losses. Generally speaking, the greater the distance, the less efficient the transmission[78]. This implies that well-designed local projects seeking to power local sources can be more efficient than projects, which have a longer distance of transmission.

3.3 Background on Wind and Solar Energy Resources

Figure 16-PV System Pricing (SEIA)



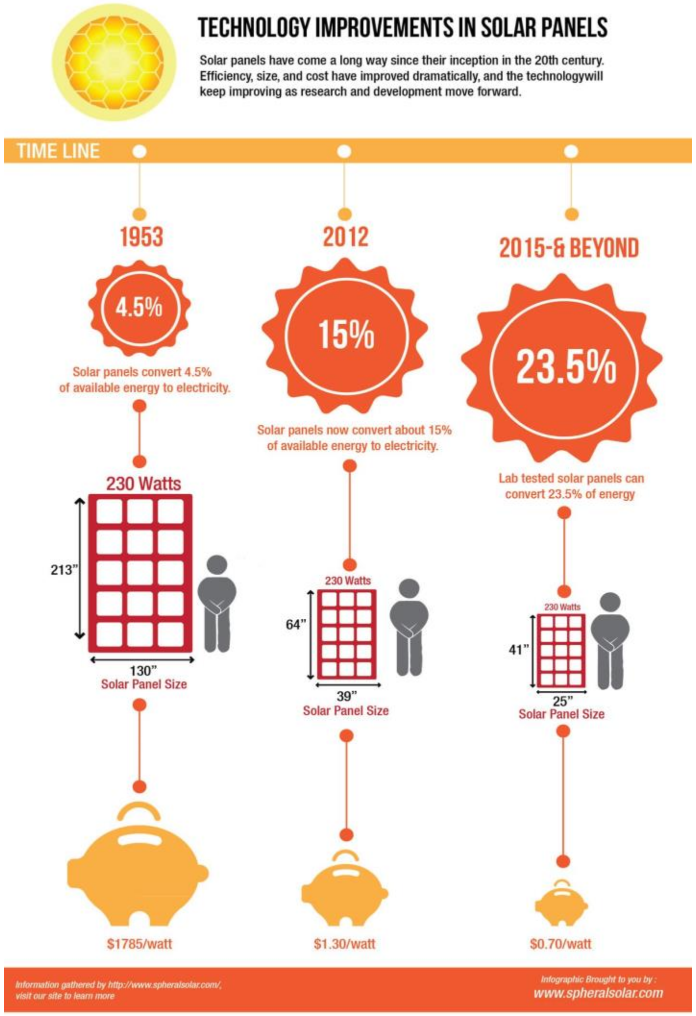
Solar Energy Market and Technology.

Solar energy technology works by harnessing and utilizing the sun’s energy to generate electricity and heat. Worldwide the solar energy market has burgeoned at an incredibly fast rate[79]. Over the course of four years, from 2010 to 2014, the average installed price of a solar PV panel has decreased by 63% in the United States, shown in Figure 16.[80] Contrarily, panel efficiency has increased from 4.5% in 1953, during solar panel infancy, to 15% in year 2010[81]. Since 2010 technological improvements of panels have developed at an incredibly fast rate. Within five years efficiency has been projected to accelerate to 23.5% by year 2015 (Figure 17).[82] As the technology continues to penetrate the market, prices are expected to fall dramatically while efficiency will steadily climb at an unprecedented rate.

There are several different types of solar technologies and methods on the market today, including but not limited to: photovoltaics (PV), which use ionized semiconductor material to convert sunlight directly into electricity -

This is known as the PV effect[83]; concentrated solar power (CSP) that use mirrors or lenses to concentrate a large area of sunlight onto a small area to produce heat[84]; passive solar design that uses a living space, climate, and construction materials to minimize energy usage[85]. This project assessed the potential for LTBB to harvest sunlight using solar PV technology. Traditional PV technology consists of flat-plate silicon solar cells including polycrystalline and monocrystalline panels[86]. These panels generally are the most efficient, especially monocrystalline panels that have the highest efficiency rates between 15% - 20%[87]. Second-generation solar cells are called thin-film solar cells. Thin-film panels are highly flexible, made up of micrometer-sized layers of semiconductor materials and typically reach efficiencies between 7% - 10%[88].

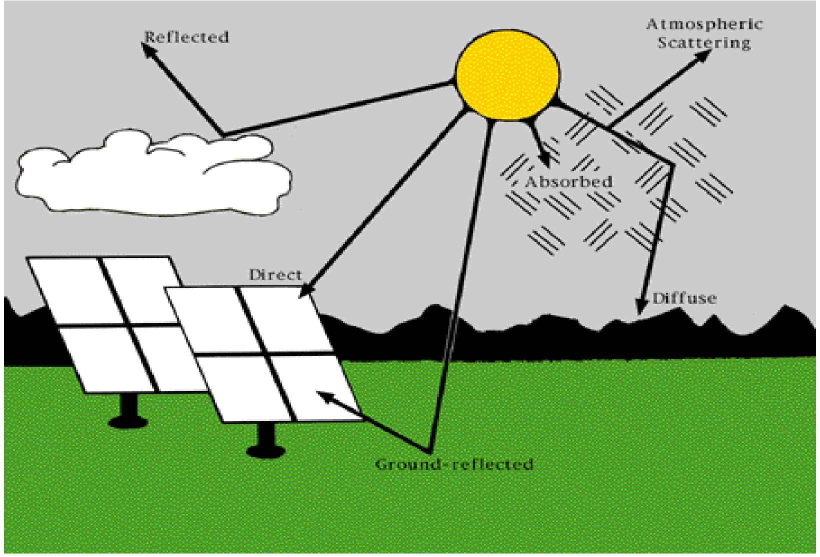
Figure 17 – Timeline of Technology improvements in solar panels (1953 – 2015 and beyond)



Solar Energy Resource Key Terms.

Solar radiation is, "the amount of solar energy that arrives at a specific area of a surface during a specific time interval typically measured as a unit of watts per meters squared (W/m^2)."[89] Total or global solar radiation is composed of direct solar radiation, diffuse horizontal radiation, and ground-reflected radiation, shown in figure 18. On sunny clear days, solar panels make use of direct solar radiation and ground-reflected radiation, where sunlight is traveling in a straight line to Earth or is reflected off of the Earth's surface. Conversely, on a cloudy day, solar panels do not work very efficiently because sunlight is scattered by molecules and particles in the atmosphere. This is better known as diffuse radiation, in which sunlight does not touch the earth's surface and is not captured by the panel.[90]

Figure 18-Solar Radiation (DOE)



Wind Energy Resource.

Wind energy is the kinetic energy created due to the sun's uneven heating of the earth's atmosphere and surface. In the past, this kinetic energy was predominantly harnessed using windmills or sails for tasks such as pumping water, grinding grain, and propelling ships.[91] More modern applications utilize this kinetic energy to drive wind turbines that employ generators to convert the mechanical energy into electricity.

There are two classifications of wind turbines based on the axis, which the turbine blades rotate: vertical axis wind turbines (VAWTs) and horizontal axis wind turbines (HAWT). Although more complex, the more commonly used kind is the HAWT.[92] Wind turbines can be deployed in different ways, depending on need. They can be used as stand-alone applications, where they supply electricity for onsite use. Alternatively, they can also be connected to a utility power grid or used in conjunction with a solar PV system.

For utility-scale sources of wind energy, multiple wind turbines are deployed together in a configuration usually referred to as a "wind farm" or "wind plant". Several electricity providers today use wind farms to supply power to their customers[93].

Although typically used for water pumping or communications, homeowners, farmers, and ranchers in windy areas can also use standalone wind turbines as a way to reduce their electricity bills. Small wind systems also have the potential to be deployed as distributed energy resources; that is, used as "a variety of small, modular power-generating technologies that can be combined to improve the operation of the electricity delivery system.[94]"

Wind Energy Resource Key Terms.

While *wind speed* is important, it is not the sole determinant of how much energy can be generated by a wind turbine. A vital element is *wind power density*, which is the power in the wind expressed per unit of cross-sectional area.[95] The power density is dependent on *mass flow rate*, which is the mass of wind passing through a unit of cross-sectional area per unit time. Both power density and mass flow rate are both dependent on the *air density* as well as the wind speed.[96]

3.4 LTBB Mno-Gwaashkweziwin (Good Energy) Plan and Pilot Renewable Energy Projects

The LTBB has pursued and implemented renewable energy projects in the past. The Tribe developed the "Mno-Gwaashkweziwin (Good Energy) Plan: First Steps Toward Developing Renewable Energy and Energy Efficiency on Tribal Lands" in 2005 as an initiative to learn more about renewable energy options and assess renewable energy potential for specific LTBB owned sites on the reservation. Furthermore the Good Energy Plan laid out a Renewable Strategic Energy Plan. The Tribe's commitment to renewable energy materialized for the first time in 2009 through a Department of Energy grant to develop two pilot renewable energy projects. Below is the LTBB Environmental Services description of these two energy projects:

1. “The first project was to install a cold-weather biodiesel shed and produce biodiesel for LTBB vehicles. Biodiesel is made from used cooking oil and can be made for a fraction of the price of regular diesel fuel. The first batch of biodiesel was produced in June 2012.”[97]
2. “The second pilot project was to install a small-scale wind turbine. LTBB purchased and installed an anemometer to collect wind data beginning in late 2010. Although several sites were evaluated, the Mtigwaakiis Housing site was selected for this project. Construction of the wind turbine was completed on June 8, 2012. To date, the turbine has produced over 1,000 kilowatt hours (or about 15% of total monthly energy use) and reduced CO_2 emissions by 0.70 metric tons. That’s the equivalent of saving 80 gallons of gas or planting 18 trees.” (LTBB, 2014)

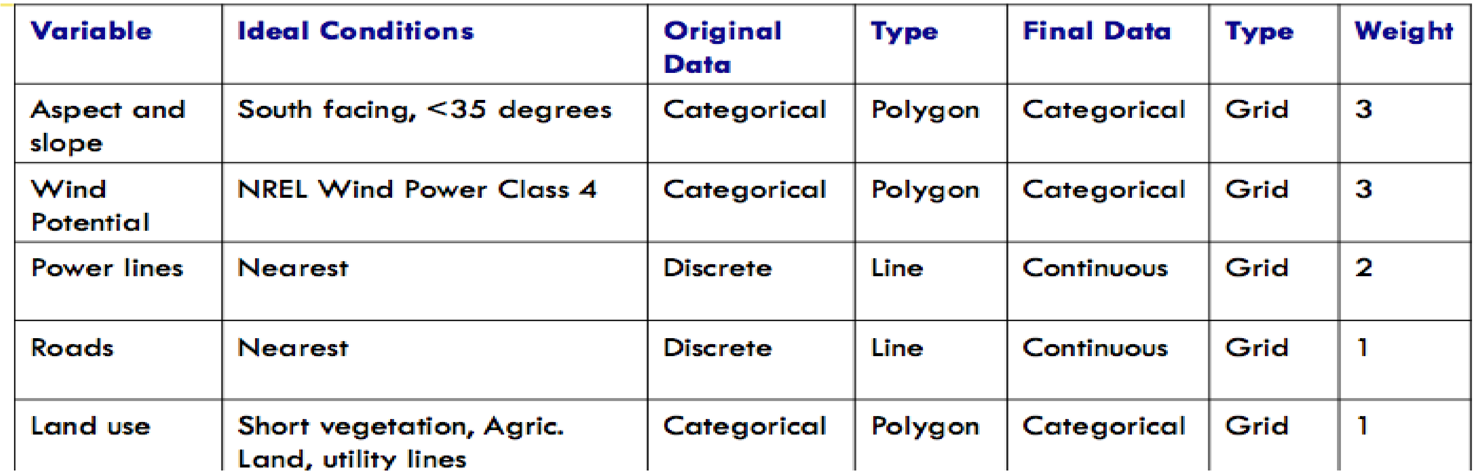
3.5 Wind and Solar Energy Analysis

This section presents the spatial suitability analysis that assessed five variables using Arc GIS 10.2 to identify the best-fit suitable areas (given spatial limitations) within the LTBB reservation. This suitability analysis was limited to spatial parameters and does not include financial constraints or social constraints like NIMBY considerations.

Methodology for GIS Suitability Analysis.

The following variables were obtained from digital databases: NREL 50m high resolution wind data, aspect and slope, land cover, roads data, and digitized transmission power lines (Table 14).

Table 14 - GIS Criteria used to create suitability maps for solar and wind energy potential



Variable	**Ideal Conditions**	**Original Data**	**Type**	**Final Data**	**Type**	**Weight**
Aspect and slope	South facing, <35 degrees	Categorical	Polygon	Categorical	Grid	3
Wind Potential	NREL Wind Power Class 4	Categorical	Polygon	Categorical	Grid	3
Power lines	Nearest	Discrete	Line	Continuous	Grid	2
Roads	Nearest	Discrete	Line	Continuous	Grid	1
Land use	Short vegetation, Agric. Land, utility lines	Categorical	Polygon	Categorical	Grid	1

Creating the suitability maps using multiple factors involved making sure results would be included even if only one single variable met the criterion. As a result, rather than using vector data or *shapefiles* - which often involve the use of Boolean operators (particularly ‘AND’ and ‘OR’ which create results with rigid or too liberal solutions respectively) - we used a raster overlay method that allowed for better trade-offs[98].

Land cover and building footprint data were obtained from the LTBB GIS department; as such, they were *clipped* to the reservation treaty boundary area’s extent. For the other files that contained spatial data for the state of Michigan, these were clipped to the reservation treaty boundary area.

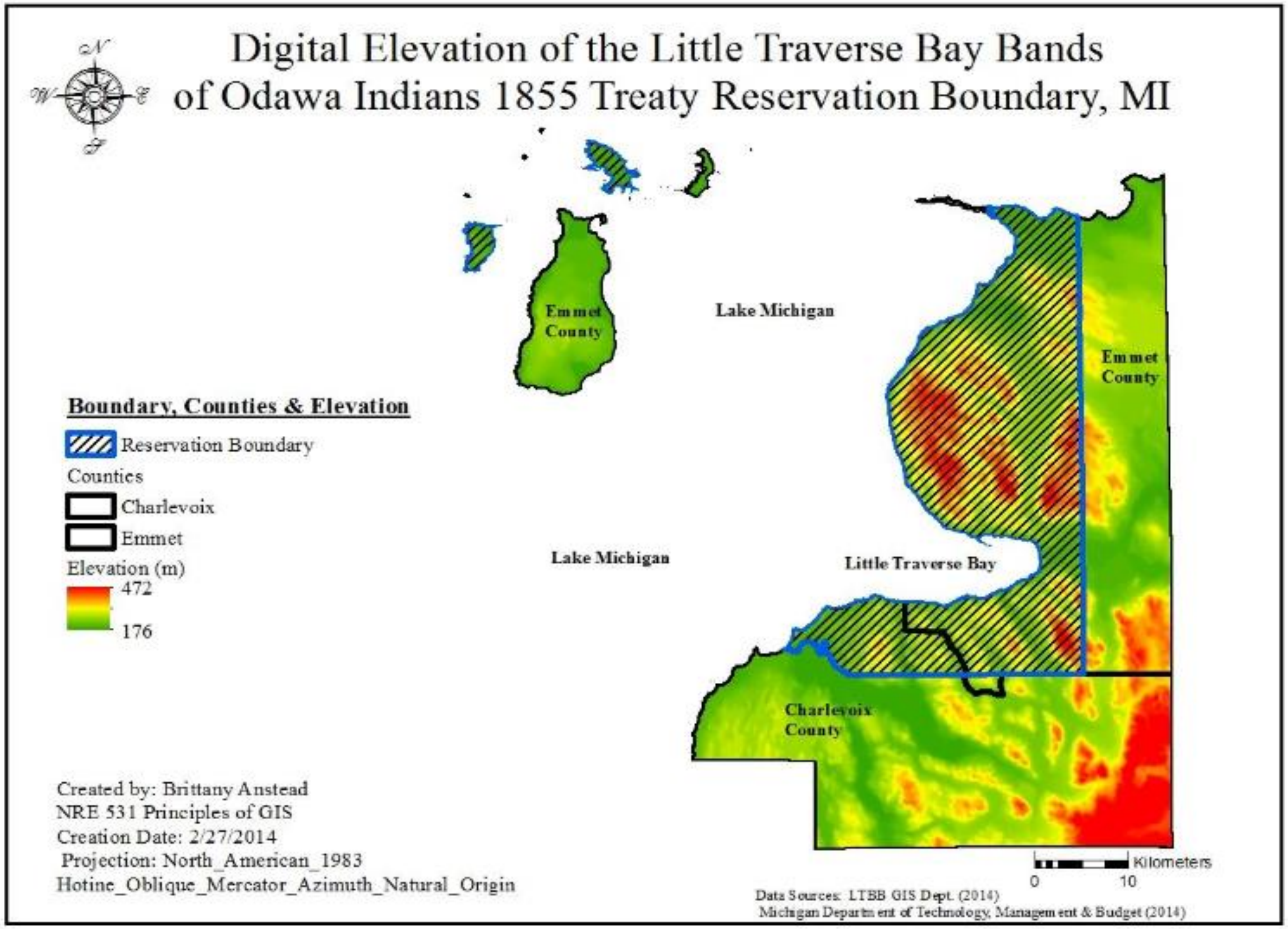
Use of the raster overlay method required that we transform all the variables into *raster grid* files and then *reclassifying* them to form indices for each of the grids: aspect and slope, wind power class, nearness to power lines, nearness to roads and land cover. The reclassified grids were then *stretched* to ensure they all had values ranging between 0 - 100. These grids were then combined with differing weights for each variable’s weight depending on its relative value to siting considerations.

Data Manipulation.

Digital Elevation Model.

To assess solar energy spatial variables, this analysis first imported a digital elevation model (DEM) to see the elevation difference within the Little Traverse Bay Bands of Odawa Indians 1855 Treaty Reservation Boundary. The DEM revealed that the terrain is relatively diverse in elevation and can limit aspect and slope; reducing potential siting for solar photovoltaic panels. Figure 19 below shows the DEM for the reservation area.

Figure 19 - Digital Elevation of the Little Traverse Bay Bands of Odawa Indians 1855 Treaty Reservation, MI.

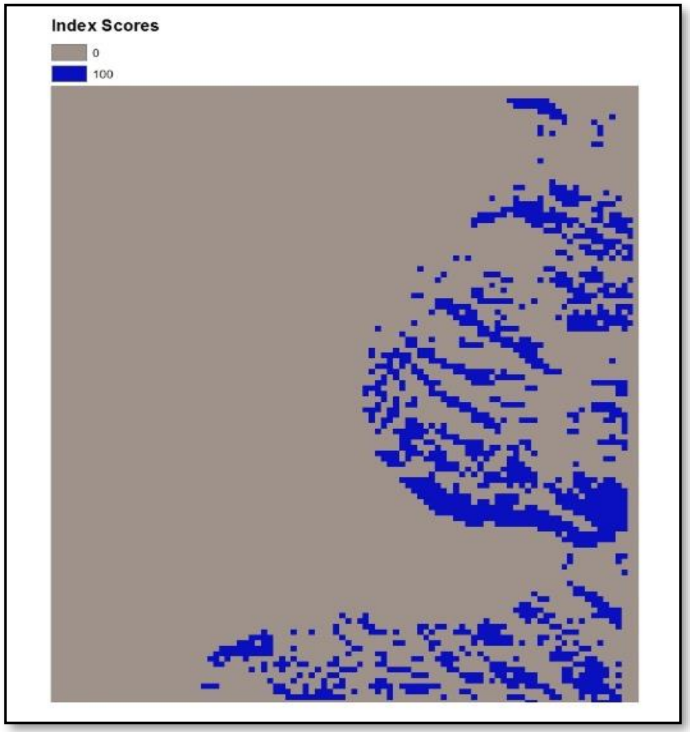


Created by: Brittany Anstead
NRE 531 Principles of GIS
Creation Date: 2/27/2014
Projection: North_American_1983
Hotine_Oblique_Mercator_Azimuth_Natural_Origin

Data Sources: LTBB GIS Dept. (2014)
Michigan Department of Technology, Management & Budget (2014)

The aspect and slope selection criteria included identifying suitable sites for solar installation as south facing aspect and less than 35 degrees slope. The goal of these processing steps was to identify the areas most suitable for small-scale solar which are within LTBB's1855 treaty reservation boundary, and which meet the selection criteria. Figure 20 shows the final grid file for the aspect and slope.

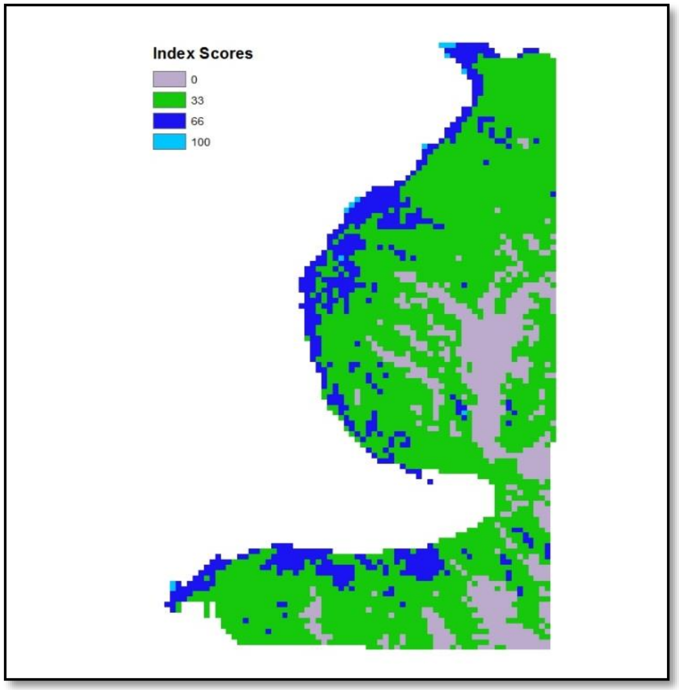
Figure 20 – Aspect and Slope Index



Wind Data.

After clipping the wind data to the reservation boundary area, the data was then converted into a grid file based on Wind Power Class designations. This wind power class grid was then stretched so values ranged from 0 to 100. Table X below shows the interpretation of wind power class relative to wind power density as well as average wind speed. Figure 21 shows the final grid file for the wind potential.

Figure 21 – Wind Suitability Index



Power lines.

A power line *shapefile* was created by *georeferencing* a map image provided by the LTBB GIS department. This *shapefile* was then converted into a grid file and then a *Euclidean distance* calculation was done to create a grid index based on distance, in feet, from the power lines. To create a proximity index, an inverse operation was carried out on the distance grid. This provided nearness to power lines, with higher value indicating a closer location. Finally, this proximity grid was stretched. Figure 22 shows the final grid file for the proximity to power lines.

Roads.

The roads *shapefile* was obtained from the Michigan Department of Technology, Management, and Budget. This data was then clipped to the LTBB reservation boundary area and then converted into a grid file. Like with the power line grid, a Euclidean distance calculation was carried out followed by an inverse operation to generate a proximity index grid, such that the higher the value the closer the location. This proximity index grid was then stretched. Figure 23 shows the final grid file for the proximity to roads.

Figure 22 – Proximity to power lines Index

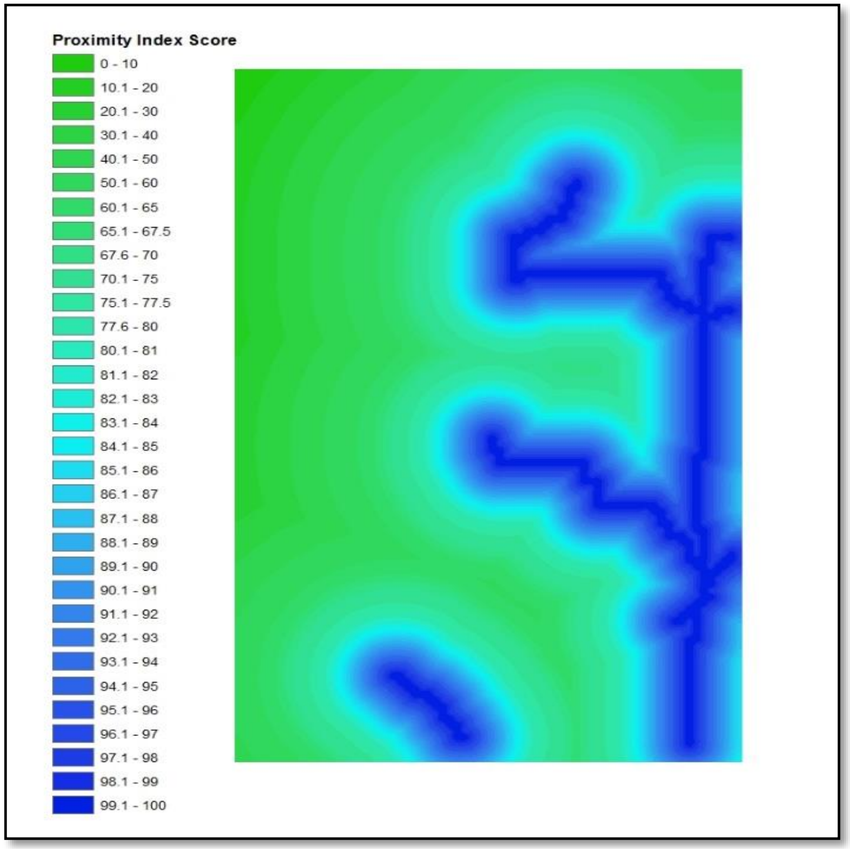
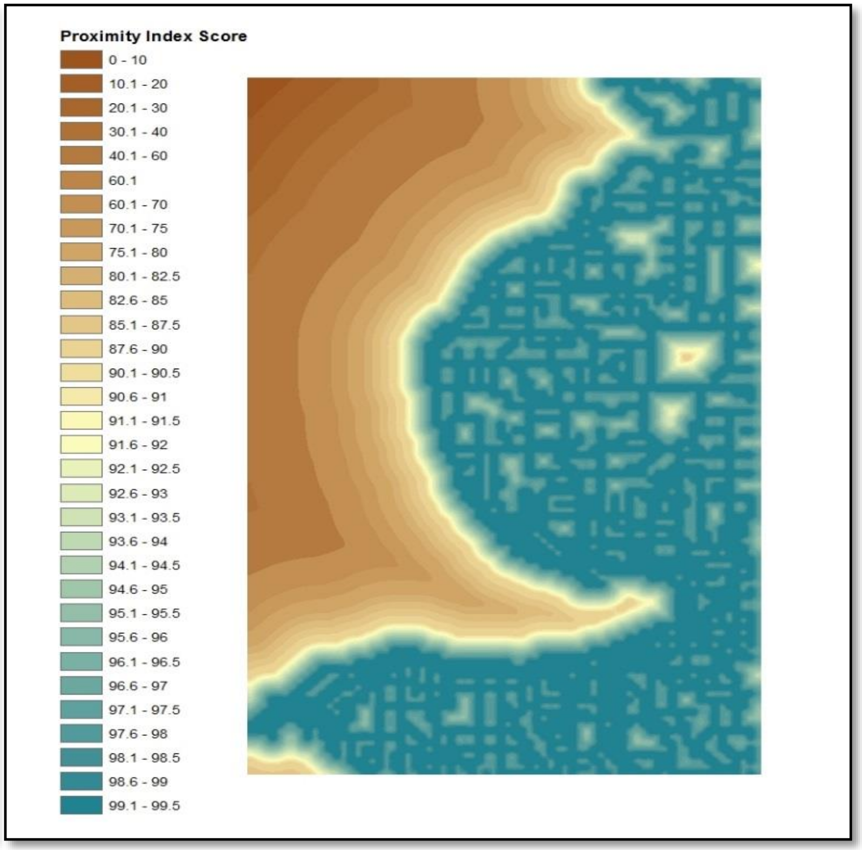
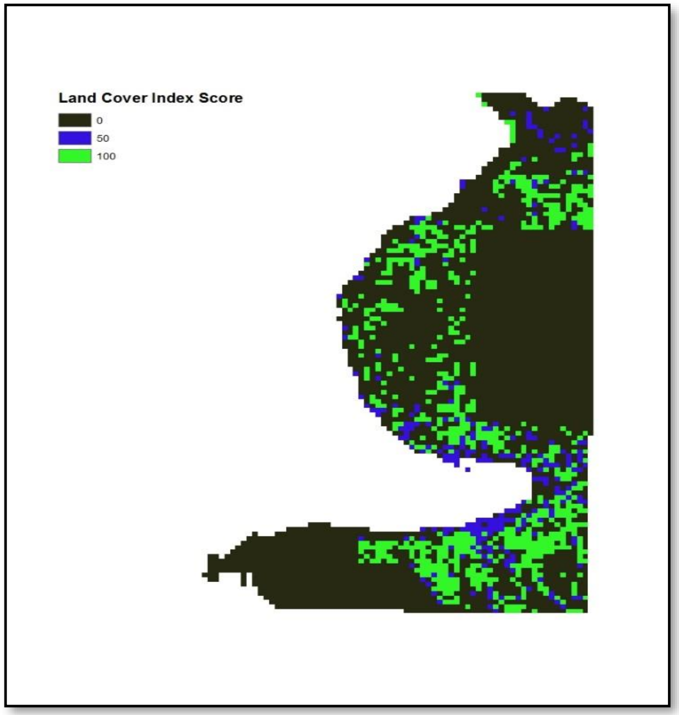


Figure 23 – Proximity to roads index



Land Cover.

Figure 24– Land Cover Index



The land cover data of 2004 provided by the LTBB GIS department was an incomplete analysis. Within the reservation boundary, two large chunks were missing land cover classifications. Though the GIS department was working on the next updated land cover dataset, it was not completed during the project period. Consequently, the 2004 land cover data was used to complete the spatial analysis with the assumption that areas without land cover classifications were unsuitable.

With regards to data handling, first the land use vector data was dissolved to aggregate the various land cover classes and simplify the structure and its *attributes*. This new file was then converted to a grid file and then reclassified. Three classifications were assigned based on land cover type:

1) **Unsuitable** - all forest types, water bodies and marine areas, air and road transportation
2) **Suitable** - Developed areas (commercial, residential, industrial), cemetery
3) **Ideal** - Agricultural lands, pasture and cropland, shrubland, utility lines, waste disposal

These classifications were then assigned index values of 1 for Unsuitable, 2 for Suitable and 3 for Ideal. Finally, this index file was stretched so values ranged from 0 to 100(where Unsuitable had a value of 0, Suitable had a value of 50, and Ideal had a value of 100). Figure 24 shows the final grid file for the land cover.

Solar Generation Potential.

To estimate generation, this analysis used the National Renewable Energy Lab (NREL) PV Watts tool, which quantitatively estimates the average annual generation potential of solar energy in W/m^2. PVWatts estimates solar generation using hourly solar resource data including solar radiation and meteorological conditions mapped at the system location[99]. There are three solar resource data options, including TMY2 and TMY3 data from NREL's National Solar Radiation Database, and SolarAnywhere's satellite imaging resources. The LTBB project analysis used the SolarAnywhere data to estimate potential solar generation. SolarAnywhere data consists of approximately 10km by 10km square grids cells of satellite images of the earth's surface, temperature, wind speed and other meteorological data between 1998 and 2011[100]. This analysis used SolarAnywhere because it offers better resolution than TMY2 and TMY3. The drawback, however, is that satellite solar data is not based off historical weather station data, and thus can create error in the generation potential estimate.

To estimate system losses, PVWatts offers a fairly extensive loss calculator which allows users to manipulate variables to mimic specific conditions. Using the preset values baseline, this analysis only adjusted the snow variable to 14.93% to better estimate the actual system losses for the LTBB reservation. The default PV system size of 4kW was used for the system generation calculation. 4kW assumes that the system is using 16% efficient PV modules in approximately 25m^2. This is not the total area required for the system; additional space needs to be considered for inverts, distance between modules, and other space restricting considerations of the system[101].

Wind Energy Potential.

To estimate generation potential, this analysis utilized the NREL Eastern Wind Dataset. This incorporated three years (2004 - 2006) of 10-minute wind speed and plant output values for 1,326 simulated wind plants[102]. Of the 57 onshore sites for the state of Michigan, the site closest to, and with real time wind patterns most similar to the LTBB reservation area, is Site 5579 located at 44.96N, 85.78W (Petoskey is located at 45.37N, 84.96W).

It is necessary to point out that even though the National Oceanographic and Atmospheric Administrative National Data Buoy Center has a station located in the Little Traverse Bay, the wind data from this station cannot be used because wind patterns at surface level offshore are significantly different from wind patterns at varying hub heights onshore. This is due to several factors including wind shear, terrain effects, and anthropogenic factors like buildings. Using offshore wind data, even from a station relatively near the shore, would present a false representation of the wind profile of the LTBB area, because offshore wind resources are generally of higher quality than onshore resources[103].

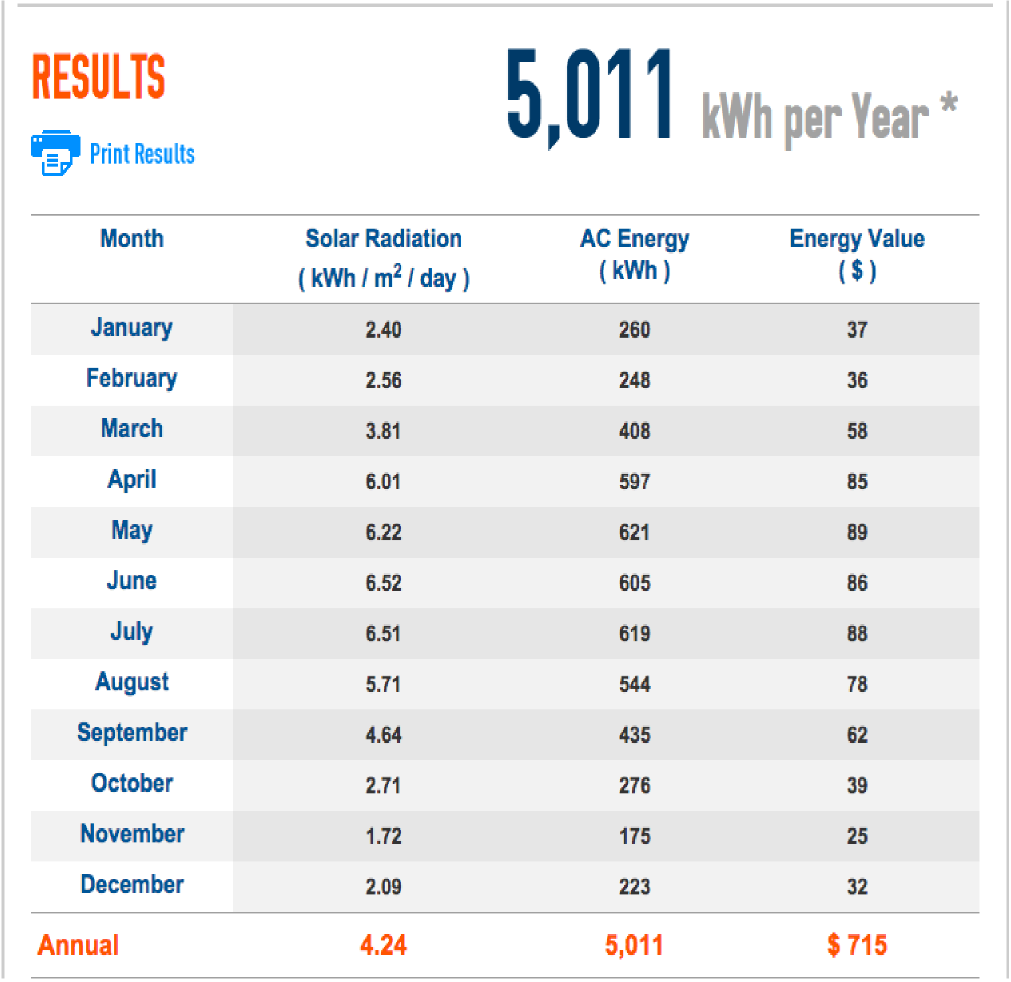
3.6 Results

Solar Generation.

The estimated solar generating potential for the LTBB reservation, as generated by PVWatts, was 5,011 kWh per year with total annual solar radiation (kWh/m2/day) at 4.24 and energy value at $715 (Figure 25)[104].

The slope and aspect spatial analysis found that about 25% of the reservation boundary is suitable for small-scale solar with south facing aspect and less than 35 degree slope. These results suggest that small-scale solar is a fairly viable option for the Little Traverse Bay Bands of Odawa Indians.

Figure 25 - PV Watts Solar Generating Potential for the LTBB Reservation (PVWatts, 2015)



RESULTS

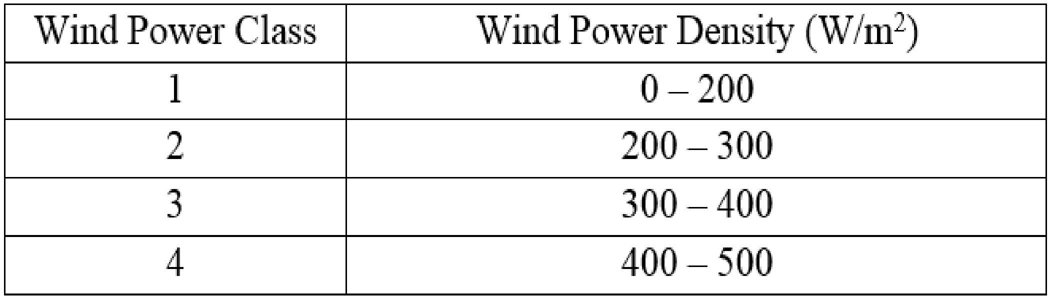
5,011 kWh per Year *

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.40	260	37
February	2.56	248	36
March	3.81	408	58
April	6.01	597	85
May	6.22	621	89
June	6.52	605	86
July	6.51	619	88
August	5.71	544	78
September	4.64	435	62
October	2.71	276	39
November	1.72	175	25
December	2.09	223	32
Annual	4.24	5,011	$ 715

Wind Generation Potential.

Annual average net energy generated over the three years was 2.73 TWh. The site possessing the following characteristics: elevation of 310 meters; wind speed measurements at 100 meter hub height; rated capacity of 138.7MW; net capacity factor of 37.49; and losses of 20.2%.

Table 15: Wind power classification and associated wind power density for 50m Hub Height



Wind Power Class	Wind Power Density (W/m^2)
1	0 – 200
2	200 – 300
3	300 – 400
4	400 – 500

From the GIS spatial analysis using the NREL 50m high resolution data, we see the following wind power class distribution for the reservation land area: 0.3% WPC 4; 13.9% WPC 3; 67.8% WPC 2; and 18.0% WPC 1. Table 15 provides the wind power density attributable to each classification.

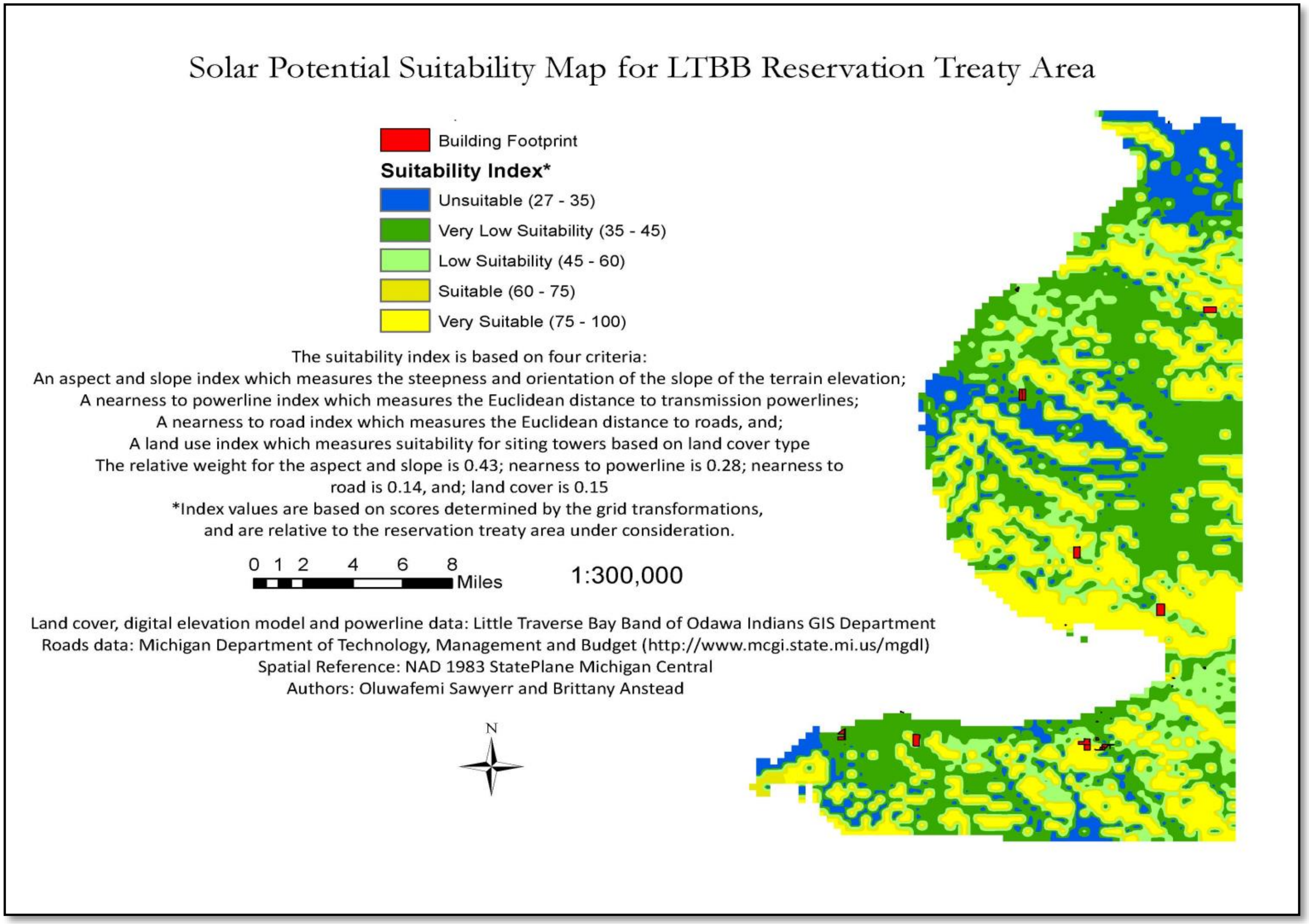
3.7 Renewable Energy Recommendations

Solar Energy Potential Recommendations.

Figure 26 shows the solar potential suitability map with all the weights for all the variables factored in. One of the first things evident from the solar potential suitability map is that all three government buildings, analyzed in this paper, are situated in areas that have high index scores for solar suitability; indicating that they meet most or all of the criteria – aspect and slope, proximity to power lines, proximity to roads and land cover. As such, to meet short-term goals, small scale solar PV systems can be deployed on these properties.

With regards to long-term goals, from the proportion of the map that falls within index scores of 75 – 100, contingent upon the LTBB accessing property within any of these areas, siting of large-scale solar projects will be a possibility. The financial analysis chapter below goes into more detail on such a project.

Figure 26 – Solar Potential Suitability Map



The suitability index is based on four criteria:
An aspect and slope index which measures the steepness and orientation of the slope of the terrain elevation;
A nearness to powerline index which measures the Euclidean distance to transmission powerlines;
A nearness to road index which measures the Euclidean distance to roads, and;
A land use index which measures suitability for siting towers based on land cover type
The relative weight for the aspect and slope is 0.43; nearness to powerline is 0.28; nearness to road is 0.14, and; land cover is 0.15
*Index values are based on scores determined by the grid transformations, and are relative to the reservation treaty area under consideration.

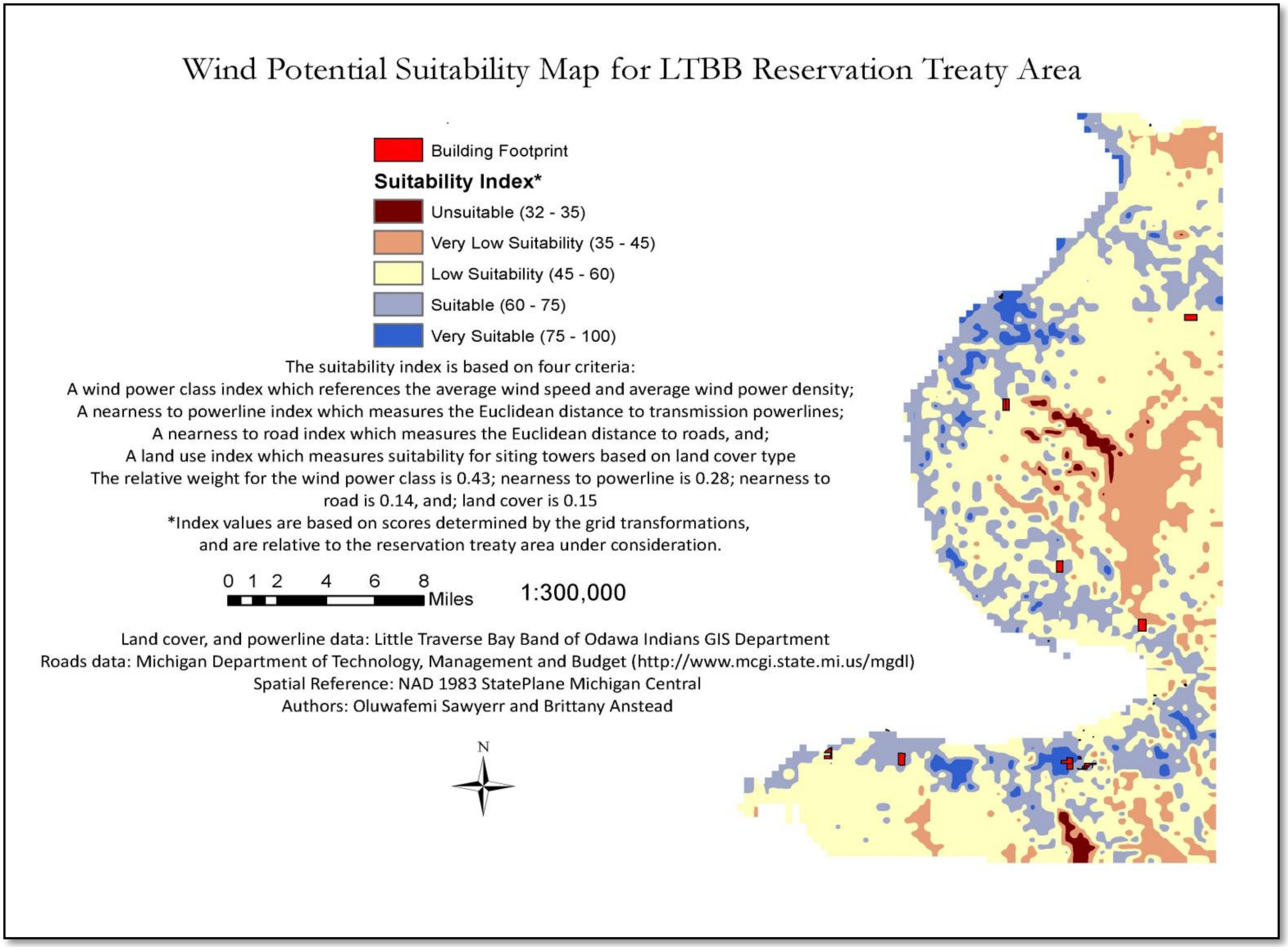
Land cover, digital elevation model and powerline data: Little Traverse Bay Band of Odawa Indians GIS Department
Roads data: Michigan Department of Technology, Management and Budget (http://www.mcgi.state.mi.us/mgdl)
Spatial Reference: NAD 1983 StatePlane Michigan Central
Authors: Oluwafemi Sawyerr and Brittany Anstead

Wind Energy Potential Recommendations.

Figure 27 shows the wind potential suitability map with the weights for all variables factored in. As is seen on the map, the proportion of the reservation area that is suitable for wind is very low. Additionally, only the judicial building is located in a region that has a relatively high suitability. Taking these into consideration with social constraints like view shed and "Not in my back yard (NIMBY)" issues, the siting of wind projects becomes mostly infeasible. This is particularly true when trying to meet short-term renewable energy standard goals.

On a long-term basis, we recommend that more data be acquired on the wind resource within the reservation. With wind speed and wind power density information at multiple hub heights, LTBB will be able to make better projections as to generation potential as well as project cost to inform the decision of whether or not to site a wind project. This will ultimately be affected by whether the social constraints still exist or not. Chapter 4 below also outlines possible ways through which the LTBB can achieve implementing a wind project.

Figure 27 – Wind Potential Suitability Map



The suitability index is based on four criteria:
A wind power class index which references the average wind speed and average wind power density;
A nearness to powerline index which measures the Euclidean distance to transmission powerlines;
A nearness to road index which measures the Euclidean distance to roads, and;
A land use index which measures suitability for siting towers based on land cover type
The relative weight for the wind power class is 0.43; nearness to powerline is 0.28; nearness to road is 0.14, and; land cover is 0.15
*Index values are based on scores determined by the grid transformations, and are relative to the reservation treaty area under consideration.

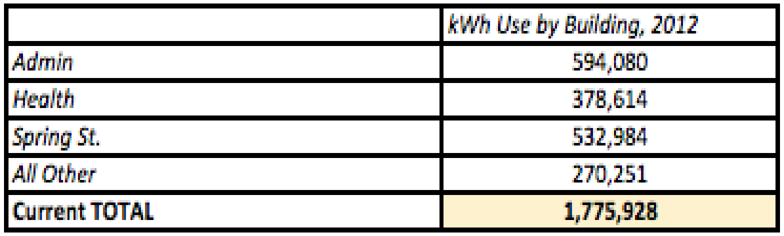
Land cover, and powerline data: Little Traverse Bay Band of Odawa Indians GIS Department
Roads data: Michigan Department of Technology, Management and Budget (http://www.mcgi.state.mi.us/mgdl)
Spatial Reference: NAD 1983 StatePlane Michigan Central
Authors: Oluwafemi Sawyerr and Brittany Anstead

Chapter 4: Financial Analysis

4.1 Financial Analysis Introduction

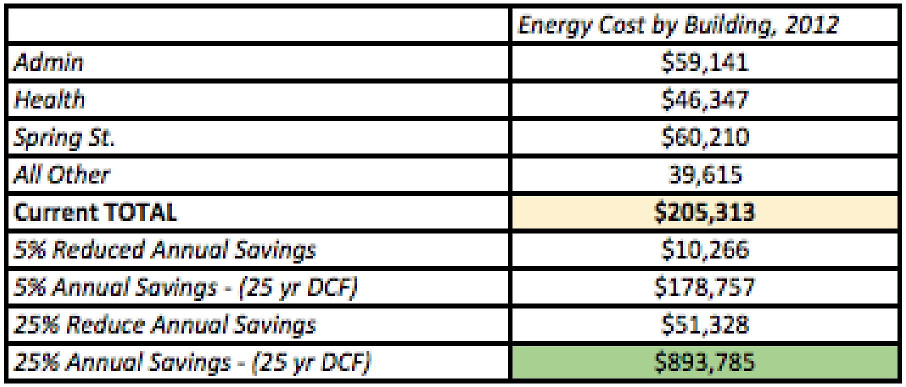
This section evaluates the financial feasibility of the alternative scenarios LTBB could employ to achieve its goal of reducing electricity consumption by 25%. These scenarios include the deployment of renewable energy strategies, the incorporation of energy efficiency measures, or a combination of both. First, we created a theoretically feasible budget to be spent on renewable energy and efficiency projects. This budget assumes that any potential energy project would require the LTBB to cover initial costs. However, this cost could be offset or completely recovered by the savings from reducing electricity consumption and/or generating renewable energy. Next, we explored the financial feasibility of large-scale solar and wind installations. In order to evaluate potential projects and generation possibilities, we reviewed past solar and wind projects implemented by other tribes. Finally, the financial team examined in detail what a large-scale solar installation might cost the LTBB, as our assessments determined that this was the renewable energy project with the highest potential benefits for the Tribe.

Table 16 - Energy Use by Building



	kWh Use by Building, 2012
Admin	594,080
Health	378,614
Spring St.	532,984
All Other	270,251
Current TOTAL	**1,775,928**

Table 17 - Energy Cost by Building



	Energy Cost by Building, 2012
Admin	$59,141
Health	$46,347
Spring St.	$60,210
All Other	39,615
Current TOTAL	**$205,313**
5% Reduced Annual Savings	$10,266
5% Annual Savings - (25 yr DCF)	$178,757
25% Reduce Annual Savings	$51,328
25% Annual Savings - (25 yr DCF)	$893,785

Budget.

To develop a hypothetical budget for funding potential renewable energy projects or efficiency strategies, we referred to current LTBB energy costs. The results of this endeavor are shown in Table 16. As mentioned previously, the Tribe used approximately 1.7 million kWh of energy in 2012, at a cost of just over $200,000. Assuming that the Tribe's goal is to reduce electricity use by 25%--either by generating renewable energy or reducing energy use below 2012 levels—the team was able to generate a 'savings' budget. For every 5% of energy no longer purchased from the utility, the Tribe would save $10,266 that year and every year going forward. To bind the budget in time, the team selected a savings time horizon of 25 years. Net present value was used to calculate the impacts of saving $10,266 every year for the next 25 years. The calculation relies on discounting future cash flows (in this case the saved $10,266) to current value using a discount rate. Based on conversations with the LTBB Chief Financial Officer (CFO), a discount rate of 3% was used. The discounted cash flow analysis indicated that with $10,266 of savings generated every year for the next 5 years, a total savings of $256,650 would be gained at a present value of $178,763. If LTBB was to reduce its total energy expense by 25% annually, it would save $51,328 per year for the next 25 years. Discounted back into present day dollars, the total savings is worth $893,785.

It should be noted that this is a hypothetical budget because the funds are not necessarily available at present. The Tribe will still need to find a source for the $800,000+ dollars to spend on projects. LTBB can, however, be confident that the money will be recaptured over the next 25 years at an interest rate of 3%. This analysis is summarized in Table 17. Following the budget evaluation, we next looked to financing structures that the Tribe could use for large-scale renewable energy projects

4.2 Financing Structures

This section analyzes past financial structures that other tribes used to finance large-scale wind and solar projects. Innovative financial structures are necessary due to the high costs of project implementation. Perhaps the largest barrier to the development of a large-scale wind farm by LTBB is the upfront capital investment. While solar is more affordable, it still presents challenges. This section examines past successes of tribal wind and solar projects, and discusses methods for the LTBB to use if it wishes to go forward with a large-scale project.

Solar Feasibility.

Solar photovoltaic costs have decreased significantly in the past decade and are projected to decrease further in the future. As such, solar generation has become a primary competitive renewable resource within the United States. Generating solar energy with photovoltaics can provide the flexibility for LTBB to implement small or large-scale projects. This developmental flexibility stands in contrast to the limitations posed by large upfront costs and land requirements of wind energy projects. Correspondingly, the capital costs ($/kW) are lower for implementing small scale solar projects as compared to wind energy projects[105]. Solar installations therefore represent a viable alternative to meet LTBB's reduced emissions and energy targets. Despite the variability in solar radiation of the LTBB reservation due to geographical location and weather conditions, innovative siting options and utilization of federal benefits (Investment Tax Credits, etc.) could support a successful solar energy generation project.

Steps for LTBB before developing a renewable energy project:

A. Refer to DOE Tribal Energy Program's "Guide to Tribal Clean Energy Development". The program intends to achieve energy goals by:

  i. "Outlining a process of strategic energy planning for Tribes interested in improving their energy security, sovereignty, and local economy;

  ii. Providing a gateway to renewable energy and energy efficiency information for tribal decision makers and staff."[106]

B. Conduct a thorough analysis of the financial implications of a large-scale renewables project; determine if such a project would be financially justified for the Tribe in the long-term. This includes an assessment of the feasibility of such a project. It is important to set goals based on LTBB's resource availability, and conduct intensive financial analyses before undertaking a renewable energy project.

C. Take advantage of the wind anemometer loan program. This will allow LTBB to measure its own wind speeds; this data can then be used to apply for grants. It should be noted that NREL does not have significantly detailed wind data for the reservation boundary.

  i. The Program: "To qualify for the loan the Tribe must be able to correctly install, maintain and take down the anemometer -have a realistic project planned -agree to swap the data cards in the anemometer on a monthly basis. The Tribe must also identify a combination of the factors necessary to make the project successful. These factors include road access, existing transmission in the area, a reliable wind resource and tribal ownership of lands."[107]

D. Look for utilities and companies with which to establish contracts or to work with as partners.

E. Decide which financial structure (from below) will be best for LTBB.

F. Look into the potential of Tribal Bonds.

Financial Structures.

1. ***Leasing*****:** Tribes can contract land out to a company that will bear most of the financial risk / technical expertise of developing the project. This is advantageous because Tribes are not taxable, but by contracting out land, the recipient business is taxable, and thus the project becomes eligible for tax credits.[108]

Solar energy projects are dependent on Investment tax credits (ITC) for developers to earn tax rebates on the capital expenditure of the solar project. Based on The Indian Tribe Private Letter Ruling 201310001,[109] reservations have a unique advantage as locations for solar developers: they are not subject to federal income tax, but may pass through the investment tax credits to tax equity investors. The tax equity investors can share the tax benefits with the Tribe through the rent it pays them in the "pass through lease" agreement.

Drawbacks:

i. The Tribe does not have control over the project; however to mitigate this, it can stipulate that all disputes be solved in tribal court.[110]

ii. The Tribe might have to acquire its own private letter ruling to attract risk averse tax equity investors in solar projects (solar tax ruling).

Project Examples:

Wind – Kumeyaay Wind Farm**:** 50MW farm of 25 Turbines, which powers 32,500 homes. It has a PPA (Power Purchase Agreement) with the city of San Diego.[111] The Tribe partnered with Babcock & Brown, an investment firm, and GE Financial Services; the project developer was Superior Renewable Energy. GE invested $51 million in the project, and Babcock & Brown will be a long-term manager while retaining a large amount of equity interest.

Solar – The 250 MW Moapa Southern Paiute Solar project between Moapa Band of Paiutes Indians and First Solar is a project which is utilizing Investment Tax credits (ITC).[112] This is also part of the renewable energy plans of the Moapa Band of Paiutes Indians.[113,114]

2. *Sole Ownership*: In this structure the Tribe can own the turbine, but as mentioned earlier this is a financially intensive option. Moreover, LTBB would have to gather its own data, and then apply for grants.

Examples:

The Rosebud Sioux Tribe of South Dakota was able to get a 50% grant from the DOE, which was matched in part by the USDA Rural Electrical Service, and in part by the green tag sales. The PPA was with Basin Electric Power Cooperative.

Green Tags: This is a method of financing renewable energy projects similar to carbon offset bonds. "Green tags represent the amount of carbon dioxide that a renewable energy project would produce if it had been a fossil fuel plant." Green tags are viable for solar energy projects, as the solar resource measurement is more straightforward.[115]

Drawbacks:

i. The Tribe cannot market itself as using green energy.

ii. LTBB may not be very grant competitive if the wind speeds are not high enough.

iii. The Rosebud Sioux Tribe has only built one turbine, and is now looking to expand to building a 30MW wind farm; therefore we do not know if this structure is amenable to a utility scale project.

3. *Flip Structure:* This allows both tribal ownership and tax credit advantages; consequently, it represents a potentially attractive funding structure. In essence, a tribe raises money from other investors to loan to a company towards building the project. The Tribe then leases the land and for the next 10 years, with the company owning 90% and the Tribe 10%. Therefore, the group (the Tribe and company) can take advantage of the 10-year tax production credits. During this time the Tribe will receive interest payments on the loan and land lease agreement. Following the ten-year period the company will make a "balloon payment" for the value of the original lease while the Tribe pays the company for the wind and/or solar farm. The Tribe now owns 90%, and the company 10%, of the project. This is beneficial for the group because the Tribe has debt-free ownership of the wind farm.

Drawbacks:

i. In the event of potential equipment failure, the Tribe may be responsible for the costs. The extent of this culpability largely depends on the specific arrangement and may be negotiated.

4. *Rural Electrification:* There is a rural electrification option where one can connect small turbines and solar panels to a battery storage system. This is a less expensive option overall, but it is one of lower quality energy than a utility scale system and may not be as financially efficient for the Tribe. [116]

5. *Bonds Financing*: An example of this project has yet to be implemented: It will be a 1-2 GW wind farm that six Sioux Tribes will co-develop with the Clinton Initiative. This undertaking will cost between 1.75 and 3 billion dollars. This type of project avoids the use of private equity, federal tax credits, and it also avoids project ownership from outside investors; "issuing bonds taps the most cost-effective finance available (rates are at all-time lows) and keeps it in tribal hands." This project will be the first one to use bonds for such a large project, it will also be the "first new joint municipal power authority formed in the U.S. in decades." The project will be "market-driven" and upfront costs will be financed by private investments and grants, while development costs will be completely funded by the Power Authority bonds.[117]

Potential Complications for All Projects:

1. Right of Way issues: historically tribes have not been fairly compensated for use of their land for transmission. The energy act of 2005 was supposed to have helped this and may alleviate complications.
2. If tribal leadership changes frequently, it could become an issue when developing long-term projects.
3. The organizational structure of the Tribe needs to be tight and efficient for the project to succeed.

Future Projects.

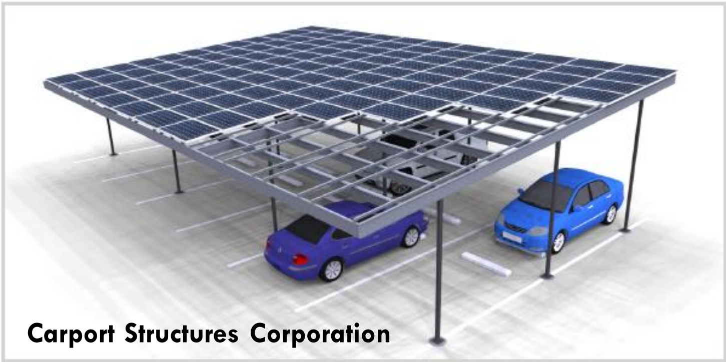
The Cherokee nation, along with four other tribes, will build a 153 MW wind farm using 90 turbines on 6,000 acres of land. The electricity created will first meet tribal demand, with the excess generation sold to the grid. This project will also help create a Native American Green Tag market. The project will be co-built with PNE Wind USA, who will own half the equity. Over the next 20 years, the project is expected to generate $16 million.

> *Side note: The Cherokee are developing skills and expertise from this project to help other tribes develop wind energy resources[118].

Large Scale Solar for the LTBB Odawa.

The team developed a location-specific plan for LTBB, which specifies the requirements, costs, and types of solar systems the Tribe could employ successfully. In cooperation with Michigan solar installer Strawberry Solar, the team determined that the Tribe could develop a 360 kW system that is capable of delivering 440,723 kWh per year, based on geographically adjusted data from NREL. To build the proposed system, the Tribe would need to clear approximately 2.25 acres of southern facing, grid-connected land.[xxv]

Figure 28 - Solar carport (Depiction, only)



If implemented, the array would use 1,440 BenQ 250W panels. The most cost-effective layout would involve the panels sitting on rows of ground-mounted racks in a single group location. An alternative layout would be to use a combination of roof-mounted racks, solar car-ports and ground-mounted racks (Figure 28). Though not the most cost-effective,

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[xxv] Land costs have been excluded at this time because the system may be developed on property currently owned by the Tribe

integrating solar carports could be a viable option for the Tribe as they have fewer land requirements than ground-mounted solar panels. In addition to generating power, solar carports also help keep snow off of vehicles (such as the Tribe's service vehicles and police cars). Further financial analysis and a reputable quote is required before pursuing this option. This is, however, only one option, and this report does not promote a singular technology or company.

If the 360 kW solar array were developed, the projected solar energy generation and correlated reduction in use of fossil fuel derived electricity would be as follows: peak solar energy generation occurs in summer months and would require net metering or an off-take program with the local utility. The basic cost of this system with only one primary array orientation would be $1,080,000 and would generate 25% of the Tribe's electricity needs, or 440,000 kWh per year. Though the correlation between cost and energy output is not precisely linear, this figure demonstrates the potential cost of smaller arrays. For example, generating 5% of the Tribe's energy usage would cost approximately $250,000. Further quoting, site analysis, and suitability evaluations from a solar installer are needed for a comprehensive and detailed assessment of the actual costs to the Tribe. The large-scale solar analysis presented here is intended to illustrate the potential energy generation and approximate costs of such an initiative.

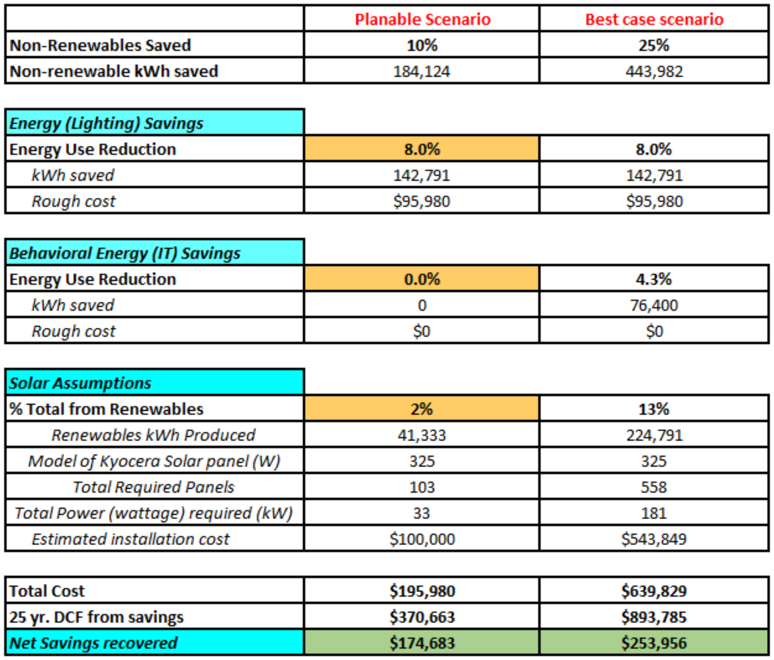
Financial Recommendation.

In order to develop recommendations for the Tribe, the team created a financial scenario planning tool which allows the team and the Tribe to evaluate the financial and energy sustainability impacts of projects focusing on reducing energy use and renewable energy generation. The tool includes information on specific recommendations and their costs, projected kWh savings, and contribution to the overall 25% reduction target. With this information, the tool calculates the comparative metric of *kWh saved per dollar spent* for alternative scenarios. This tool and the comparison metric it develops can be used to inform the allocation of financial resources to projects with the highest potential benefit for the Tribe.

When exploring alternative scenarios, the team first considered a "Best Case Scenario" that would achieve the goal of a 25% reduction in electricity use. Achieving this goal would require a $96,000 investment in all proposed updates available to the three main buildings. This entails modifications to the lighting systems, adoption of efficiency strategies, and behavioral modifications focused on turning off electronic equipment at night and when not in use. This scenario also includes the development of a 225,000 kWh/year solar array composed of approximately 560 solar panels at a cost of $550,000. The total cost of these projects would be approximately $640,000, including no-cost behavior modifications which account for 4.3% of the savings. This best case scenario yields a net present-value savings of $250,000 to the Tribe, which would be recovered from savings on energy expenditures over the next 25 years.

As an example of an alternate scenario, of which there are dozens of possible permutations, the team set out to efficiently spend $195,000 without relying on any behavior change. This scenario entails the adoption of all proposed lighting upgrades, as well as the installation of a much smaller 100-panel solar array. This would yield a 10% net reduction in electricity use. Notably, this scenario has a much higher return when considering the initial investment of $195,000 and the projected, present-valued 25 year savings of $370,000. This is due to the prioritization of the most financially efficient projects. Table 18 summarizes the best case scenario and hypothetical $195,000 budget scenario.

*Table 18 – Financial Energy Scenarios. **Other scenarios can be built using the dynamic tool contained as an addendum to this report.*



	Planable Scenario	Best case scenario
Non-Renewables Saved	**10%**	**25%**
Non-renewable kWh saved	184,124	443,982
Energy (Lighting) Savings		
Energy Use Reduction	**8.0%**	**8.0%**
kWh saved	142,791	142,791
Rough cost	$95,980	$95,980
Behavioral Energy (IT) Savings		
Energy Use Reduction	**0.0%**	**4.3%**
kWh saved	0	76,400
Rough cost	$0	$0
Solar Assumptions		
% Total from Renewables	**2%**	**13%**
Renewables kWh Produced	41,333	224,791
Model of Kyocera Solar panel (W)	325	325
Total Required Panels	103	558
Total Power (wattage) required (kW)	33	181
Estimated installation cost	$100,000	$543,849
Total Cost	**$195,980**	**$639,829**
25 yr. DCF from savings	**$370,663**	**$893,785**
Net Savings recovered	**$174,683**	**$253,956**

Overall, it is recommended that the Tribe first focus on cost-effective measures such as energy efficiency improvements, and then consider large-scale renewable projects.

Chapter 5: LTBB Tribal Policy

5.1 LTBB Energy Policy

"Federally recognized Tribes are considered domestic dependent nations. Tribal sovereignty refers to Tribes' right to govern themselves, define their own membership, manage tribal property, and regulate tribal business and domestic relations; it further recognizes the existence of a government-to-government relationship between such Tribes and the federal government." [119]
-The Leadership Conference on Civil and Human Rights

The Little Traverse Bay Bands of Odawa Indians is one of 566 federally recognized Tribes in the United States.[120] As a domestic sovereign nation, the LTBB tribal government has the power to, "govern themselves, define their own membership, manage tribal property, and regulate tribal business and domestic relations"[88] With this unique autonomy, the Tribe has the opportunity to develop, create, and implement energy efficiency and renewable energy policies that suit its individual needs. As a fairly young tribal government, federally affirmed on September 21st, 1994, LTBB has already made significant gains in bolstering sovereignty, sustainability, and financial security.

LTBB has grown tremendously since 1994 with a key focus on reclaiming land within the reservation itself. In 2005, the Tribe created an independent version of the Kyoto protocol, which included a goal to meet a 25% renewable energy standard by the year 2020. LTBB subsequently created the *Mno-Gwaashkweziwin* - Good Energy Plan in 2006, establishing the framework for renewable energy project development and energy sustainability initiatives on properties owned by the LTBB government. Presently the Kyoto resolution is the sole energy policy for LTBB. Furthermore, it is not binding, meaning that it can be altered when council terms turnover.

5.2 Tribal Policy Recommendation

LTBB has a variety of potential policy avenues to support and further develop sustainability goals. The most straightforward policy recommendation is to update the existing Kyoto resolution to include incremental goals with staggered implementation times in working towards the overall renewable energy standard. Integrating incremental goals would potentially allow for a more financially efficient pathway towards decreasing consumption of nonrenewable energy while maintaining a rigorous implementation structure. In contrast to attempting to develop renewable generation capacity to source 25% in a relatively limited time frame, staggered goals would set a clear path forward that is able to take advantage of diverse funding and energy sustainability strategies.

As an example of what a staggered implementation policy would entail, during year one of the updated standard, the Tribe would set a goal to achieve a 1% increase in renewable energy capacity. By year three LTBB would set a goal to incorporate a total of 3%, increasing renewable energy capacity by 1% per year. It should be noted that the extent of the specific percentage change goals for the staggered standards will be heavily dependent upon projected future budgets for renewable energy projects as well as potential grant availability. Additionally, when creating staggered goals a financial assessment comparing the benefits of purchasing renewable energy technologies at various scales and quantities should be carried out. While outside the scope of this assessment due to price fluctuations and varying installer costs, a financial analysis focused on purchase scale would further inform potential renewable energy goals by identifying the most cost effective implementation strategies. Incremental renewable energy standards are more easily attainable goals which the Tribe can build upon toward a larger final milestone goal.

A second primary policy strategy that the Tribe could pursue is the development of an energy efficiency standard. The current renewable energy standard of 2005 contains a goal to integrate 25% renewable energy sources for Tribal government buildings by year 2020. Considering the present financial and technical constraints discussed in the renewable energy and financial analysis sections, as well as the fact that the Tribe has not yet obtained a professional energy audit, the 25% renewable energy standard by year 2020 is relatively infeasible. Due to the cost-intensive nature of renewable energy projects, it is recommended that the Tribe first consider energy efficiency improvements to lower its overall energy consumption. For this reason, it is recommended that the Tribe create energy efficiency standards to formally structure a path towards increasing energy efficiency. Efficiency standards could also be implemented on an incremental, staggered timeframe in concert with the renewable energy goals. Informing these standards with the bottom-up energy assessment and optimization analysis completed by the project team would ensure that they directly address the desired goals and generate financial and environmental benefits.

Optimally, it is recommended that LTBB create and implement a Clean Energy Law. Instituting a Clean Energy Law could ultimately equip the Tribe with a robust and binding energy policy instrument. This law would integrate both the renewable energy and energy efficiency standards towards a unified outcome. It should be noted that such a law can require fairly intensive regulation, and eventually may require an increase in employee capacity. Considering that the Tribe has previously considered the creation of an Energy Department, it is recommended that the Tribe further investigate the possibility and feasibility of creating an energy department to implement and enforce a Clean Energy Law.

Chapter 6: Strategic Energy Plan Recommendations for LTBB

Below is a list of our final strategic energy plan recommendations for the LTBB Tribe. These recommendations are organized under the four following objectives: energy efficiency, renewable energy, financial analysis, and tribal policy.

6.1 Energy Efficiency

Within the short-term, the energy efficiency assessment and optimization analysis recommends that the Tribe focus on immediate cost-effective improvement strategies such as lighting upgrades, system optimization, and behavioral shifts. Light renovations can be costly, but the energy reduction benefits outweigh the costs. Additionally, the Tribe could consider smaller, easily attainable changes that could be implemented to reduce energy consumption such as promoting the consistent use of existing energy saving features within the office equipment as to reduce energy use of IT equipment. Furthermore, behavioral changes like turning lights off when not in the room or utilizing natural light during the day can aid in reducing overall electricity consumption.

As for the long-term, a professional energy audit would be most beneficial in aiding the tribe to finance large clean energy projects and optimizing building energy systems. Obtaining an energy audit would give an in-depth and prioritized list of areas for the Tribe to focus on energy improvement strategies and would provide a more comprehensive overview of problems with the building envelope, windows, etc. Many federal grants require that tribes have had energy audits before they are eligible to receive funding; thus, investing in an energy audit could enhance LTBB’s eligibility for large grants investing in renewable energy or larger energy efficiency measures. Ultimately, upgrading light bulbs and various fixtures for the main three government buildings and conducting a professional energy audit will produce the best energy and cost savings. Below, we have outlined in detail the recommendations for lighting:

Lighting Recommendations:

a. Replace all incandescent bulbs as soon as possible

b. Replace metal halide (outdoor) and high pressure sodium (HPS) (in ceiling fixtures outside as well as in the admin's building vaulted area) bulbs as funds allow

c. Incorporate occupancy sensors wherever possible

d. Purchase LEDs and LED fixtures whenever possible in the future

e. Maximize natural light in spaces

f. As CFLs die, replace with LEDs, but don't replace them prior to burning out

6.2 Renewable Energy

For the renewable energy analysis, it was found that solar energy is spatially suitable for majority of the LTBB owned property within the scope of this project. To meet the short-term energy sustainability goals, it is recommended that the Tribe begin looking into siting small scale solar projects on the reservation. Considering that the administrative, judicial, and health park are all located in good spatially suitable areas for solar energy, it is recommended that the Tribe first start with a small project on one of these sites. In the long-term, developing and implementing a large-scale solar project, as well as acquiring detailed wind data at multiple hub heights for the Tribe's reservation boundary, would be beneficial in furthering the Tribe's sustainability goals, economic prosperity, and for meeting the current renewable energy standard for the Tribe to be 25% renewable by year 2020.

6.3 Financial Analysis

The financial recommendation is to first complete the projects with the ‘highest kWh reduction per dollar spent’, such as the lighting and behavioral IT suggestions. The Tribe can then look towards large-scale renewable energy projects to meet the rest of the 25% reduction requirement, provided that funds are available. At this stage the Tribe can consult with section 4.2 on how to finance large-scale renewable projects. Essentially, LTBB can lease its own land, own the entire project, partner with a business, or use bonds financing (the last option is relatively new). Finally, the tribe can ensure that all scenarios/projects have a positive NPV by using the scenario-planning tool.

6.4 Tribal Policy

The tribal policy analysis recommends instituting smaller incremental timeframe goals into the renewable energy standard and creating energy efficiency standards for the Kyoto resolution, which would enhance current LTBB energy policy. Furthermore, instituting a Clean Energy Law could ultimately equip the Tribe with robust and binding energy policy instruments empowering the LTBB to better achieve sustainability goals. Conclusively, it is recommended that the Tribe further investigate the feasibility of creating an energy department to implement and enforce a Clean Energy Law.

Chapter 7: Looking Towards the Next Seven Generations

Looking towards the future of LTBB's energy sustainability framework with a focus on creating benefits for the next seven generations, energy efficiency improvements and renewable energy projects are attainable with properly structured and implemented clean energy policies and project financing. There are numerous strategies at varying scales that the Tribe could pursue in order to improve energy sustainability on the LTBB reservation. Considering short-term projects, this report suggests that targeted investments in lighting renovations and encouraging behavior shifts are cost-effective starting points for reducing the Tribe's current electricity consumption in comparison to the 2012 baseline.

Additionally, using this research to develop comprehensive updates to the current renewable energy standards and the creation of energy efficiency standards could enhance the current LTBB Kyoto resolution. In terms of long-term projects and goals, investing in a professional energy audit would provide access to federal grant funding opportunities which the tribe is presently not eligible to receive. Long-term solar PV projects have the potential to generate revenue for LTBB, establish tribal energy independence, and strengthen tribal sovereignty. Instituting a Clean Energy Law could ultimately equip the tribe with robust and binding energy policy instruments, empowering the LTBB to effectively and efficiently achieve sustainability goals. It is additionally recommended that the Tribe investigate the feasibility of creating an energy department to implement and further refine a Clean Energy Law.

In closing, it has been an honor and privilege to work alongside the Tribe's Environmental Services Program, and we hope that this report can serve as a guide and reference in the development of an energy sustainability plan for Little Traverse Bay Bands of Odawa Indians Tribe and reservation. Chii-migwech.

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