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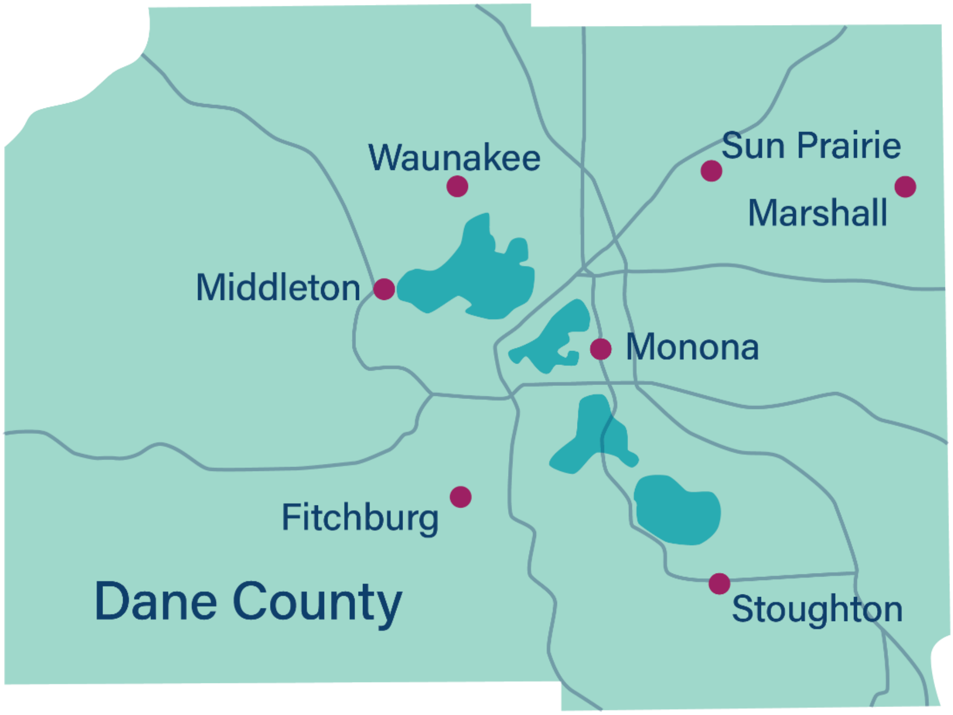
Municipal Energy Plan - Seven Community Collaboration

Community Specific Chapters



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A NOTE ON THE THREE PARTS TO THE ENERGY PLAN

We divided the energy plan into three parts: a main report, community-specific reports (this document), and appendices. All three documents comprise the final energy plans developed for the Seven Community Energy Planning Collaboration of the Wisconsin Office of Energy Innovation Planning Grant.

The main report provides background on the project and process, and overarching recommendations that can be applied to all communities in this collaboration. The community specific reports (in this document) can be read as seven standalone chapters (one for each of the collaborating communities) that detail the community-specific municipal energy profile and corresponding recommendations. The appendices provide further detail should the reader want to dive deeper into the calculations and assumptions in the analysis.

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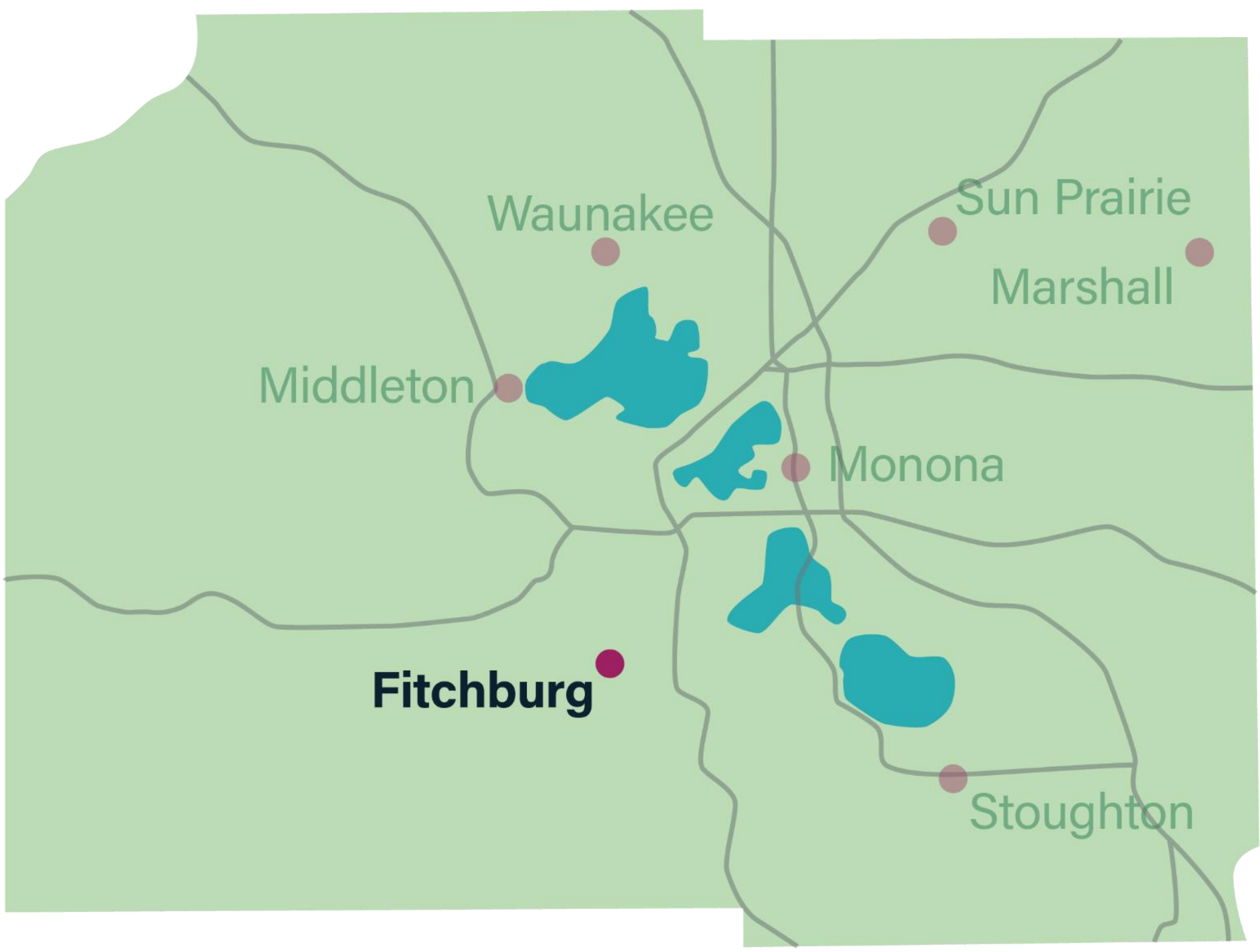
COMMUNITY-SPECIFIC MUNICIPAL ENERGY PLAN



Wisconsin Office of Energy Innovation Grant

FITCHBURG BACKGROUND

As one of the largest communities in this collaboration, by population and by geographic area, Fitchburg has seen considerable growth over the past two decades. The municipal operations include relatively new buildings with a good level of innovation. The recently constructed public library incorporated geothermal energy for its heating and cooling system. Fitchburg has invested in a significant amount of behind-the-meter solar for multiple city buildings. The City is part of the Energy Independent Communities, which is a voluntary agreement between the State of Wisconsin and communities that adopt the goal of generating 25 percent of their energy from renewable energy sources locally by 2025. The city council recently passed a resolution to reduce municipal-wide energy use by 30 percent and to reach 100 percent renewable electricity by 2030.

This chapter provides a detailed summary of the Fitchburg energy plan. We begin by summarizing Fitchburg's energy profile to provide a baseline understanding of current energy consumption, costs and carbon emissions for 2018. We then delve into our recommendations for near terms investments or action, split out into four categories: building energy efficiency, street lighting opportunities, fleet opportunities, and solar energy opportunities.

COMMUNITY ENERGY PROFILE

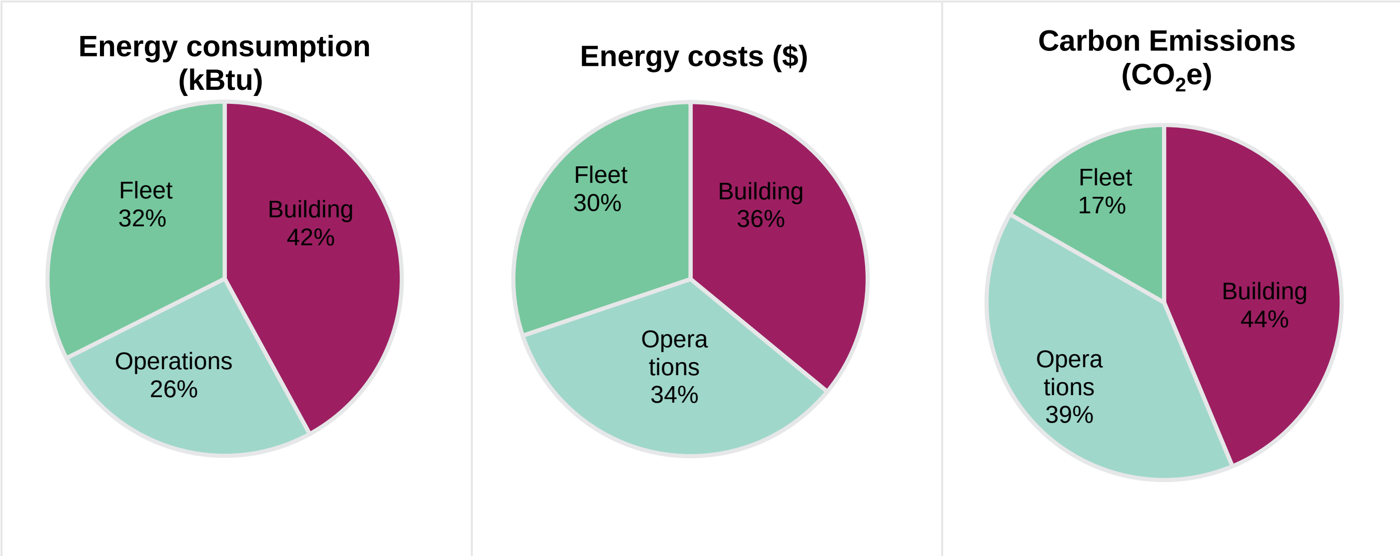
The three main energy inventory elements for Fitchburg's energy profile include buildings, operations, and municipal fleet. Table 1 provides details by category on what was included in development of the Fitchburg energy profile, based on the data provided by Fitchburg staff.

Table 1: Fitchburg inventory elements (2018 baseline)

Buildings	Operations	Fleet
City Hall	Non-street lighting	21 Police vehicles
Library	Other operation	6 Administration vehicles
Maintenance	Parks and Rec	16 Parks & Recreation vehicles
Safety Building/Firehouse	Public Works Garage	20 Public Works vehicles
Community Center	Street lights	11 Utility vehicles
New Fire Station	Well/pumps/lifts	16 Emergency vehicles
Police Processing		

Figure 1 illustrates the percent contribution of each source to total energy use, cost, and carbon emissions. The cost and carbon intensity of the different fuels (electricity, natural gas, gasoline, and diesel) can significantly impact the contribution of each source to the total.

Figure 1: Fitchburg energy consumption, cost and carbon emissions (2018)



Breaking these elements down further, Table 2 details the annual energy use, carbon emissions, and energy costs associated with each building and operation use type. The buildings are listed individually; if there were multiple meters per building, we aggregated the values up to the building level. If there were multiple meters for operation data, it was aggregated by use type such as non-street lighting and wells, pumps, and lifts. Fitchburg's City Hall, Fire Station, Library, and Public Works Garage host net-metered PV systems. The amount of electricity used by these buildings, as shown in Table 2, reflects the net electricity that Fitchburg purchased from the utility, with any reductions from solar panel production included as part of that amount. This energy profile excludes a very small amount of energy that the City purchases from Alliant Energy, estimated to be less than 3% of all energy consumed.

Table 2: Fitchburg baseline energy, CO_2e and cost data by building and operation use type (2018)

	Use/building	Net Electricity (kWh)	Natural gas (therms)	Carbon emissions (CO_2e metric tons)	Percent of total CO_2e	Energy cost
Buildings	City Hall	753,097	26,878	716	16%	$98,965
	Community Center	167,400	6,839	164	4%	$22,515
	Fire Station	167,829	6,122	160	3%	$22,135
	Library	809,193	274	618	13%	$89,175
	Maintenance	93,173	18,559	170	4%	$21,385
	Police Processing	32,080	484	27	1%	$3,820
	Safety Building	139,600	9,763	158	3%	$21,215
Operations	Non-street lighting	139,049	-	106	2%	$15,295
	Other operation	37,365	-	29	1%	$4,110
	Parks and Rec	58,840	1,772	54	1%	$7,535
	Public Works Garage	13,122	-	10	0.2%	$1,445
	Street lights	559,012	-	426	9%	$61,490
	Well/pumps/lifts	1,572,247	-	1,197	26%	$172,940
	Fleet			770	17%	$234,250
	Total	4,542,007	70,691	4,605		$776,275

Figure 2 illustrates how the baseline energy use intensity (EUI) of each Fitchburg building compares to the ASHRAE 100-2018 target and benchmark value for similar use buildings. This comparison serves as a helpful benchmarking exercise, but it's important to note that the ASHRAE values represent a typical building type and do not account for buildings that may house multiple city departments or functions.

Figure 2: Fitchburg EUI benchmarking and comparison to ASHRAE target and benchmark

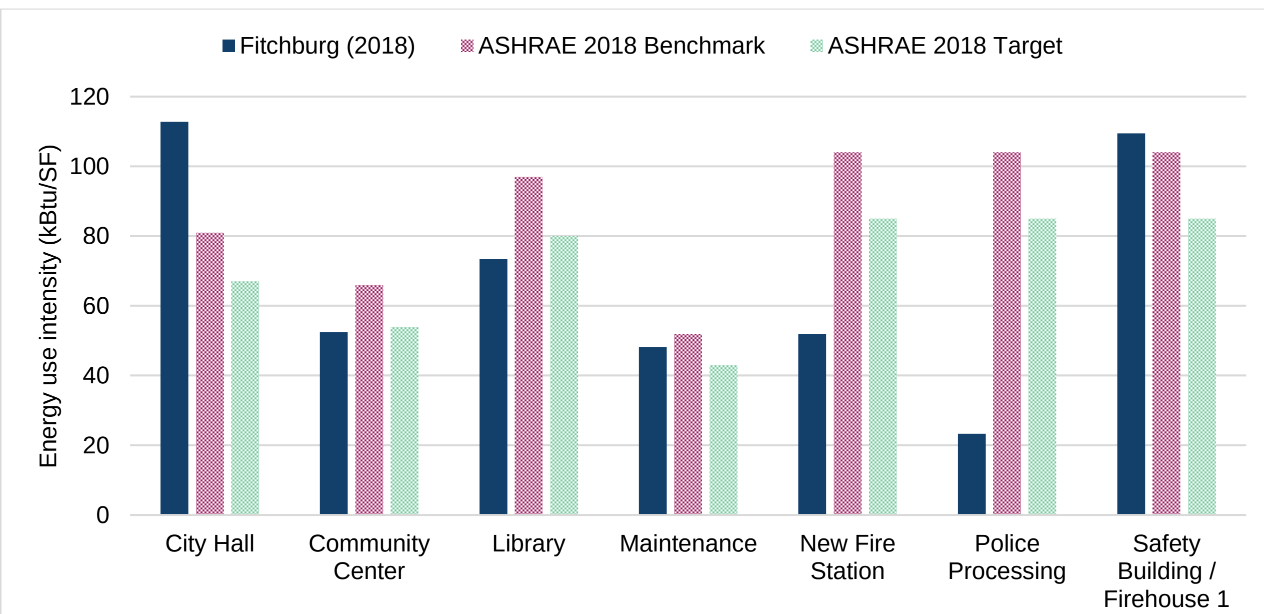


Table 3 illustrates the current renewable energy consumption in the City. On-site solar currently makes up around 9 percent of total electricity use in Fitchburg – leaving significant potential for future development. Currently, there are three 90 kW solar installations (one on the Library, one on the Storage Shed, and one on the new Fire Station), a 55.8 kW solar installation on City Hall, and a 9.9 kW array on the Maintenance Building. The PV array on the Maintenance Building exports the electricity that it produces to MG&E, which pays Fitchburg a set rate per kWh that the system produces. The array on the Maintenance building was installed in 2011 and the export agreement may expire ten years after the interconnection date. Fitchburg will need to review its agreement with MG&E to confirm the expiration date and determine how the City will use the array after the agreement expires. Fitchburg also purchases a portion of the electricity consumed at City Hall and its Public Works building through MG&E's Green Power Tomorrow tariff. Under this program, Fitchburg pays a premium per kWh that it purchases, and MG&E allocates a corresponding portion of the renewable energy that it produces or purchases to the Green Power Tomorrow program.

Table 3: Fitchburg renewable energy summary - current production (as of 2019)

RENEWABLE ENERGY QUICK FACTS	
On-site net metered solar (kWh)	412,673
On-site export-metered solar (kWh)	12,739
Green Power Tomorrow purchases (kWh)	20,826
Total renewable energy purchased/production (kWh)	446, 238
Percent of total gross electricity	**9.0%**

Table 4 illustrates the current vehicle fuel usage, carbon emissions, and fuel cost by department. The police department has the most significant energy footprint, driven largely by the need to idle to maintain car functions while not in motion and the high relative mileage. This significant use presents an excellent opportunity for conversion to hybrid vehicles as will be outlined below.

Table 4: Fitchburg vehicle fuel usage by department (2018)

Department	Number of vehicles	Gallons	CO_2 (metric tons)	Fuel cost
Police	21	32,188	274	$86,700
Public Works	20	20,410	201	$50,360
Emergency Vehicles	16	10,070	132	$42,470
Parks & Rec	16	10,896	101	$30,480
Utilities	11	5,347	55	$21,850
Administration	6	986	8	$2,390
Total	90	79,897	771	$234,250

FITCHBURG RECOMMENDATIONS FOR NEAR-TERM IMPLEMENTATION

Our analysis found energy investments that have a strong return on investment and significant energy savings potential. While the City has made commendable efforts on building-level efficiency, there are additional building upgrades, such as LED lighting retrofits and the implementation of HVAC controls, the City can still make. The upgrades are outlined in more detail below and can reduce municipal carbon emissions by as much as 5 percent. By converting all streetlights to LEDs, the City could cut annual streetlight electricity use in half – reducing utility costs and saving around 215 tons of CO_2e annually. In the fleet department, the City should prioritize converting police vehicles to hybrids as they offer a payback around one year and lead to a 45 percent decline in lifetime carbon emissions. Lastly, by adding solar arrays to 5 sites, the City can reduce total fossil fuel electricity consumption by an additional 7 percent.

Table 5 summarizes the estimated carbon and energy cost savings that Fitchburg would see if they implemented the recommended near-term actions in each major opportunity area and the following sections provide additional detail on each opportunity.

Table 5: Fitchburg impact summary – estimated annual carbon and energy cost savings

Near-term Opportunity	CO_2e Reduction (metric tons)	Percent Carbon Reduction	Energy Cost Savings	Percent Energy Cost Reduction
Building efficiency	213	10%	$30,585	11%
Streetlights	217	51%	$31,350	51%
Fleet	130	17%	$43,605	19%
Solar	235	-	$33,900	-
Total opportunity	795	17%	$139,440	18%

Energy efficiency opportunities

Our analysis focused on near-term measures that not only have an energy or cost savings, but also may reduce maintenance costs, improve occupant comfort, or increase staff productivity. We also considered the ease and cost of implementation when prioritizing our recommendations.

To identify these opportunities, we conducted high-level walk-throughs for two buildings: the Fitchburg City Hall and Community/Senior Center. We took note of major end-uses and process and spoke with building staff to understand building operations. The following provides a walk-through summary for each building with additional detail on energy savings potential below.

Fitchburg City Hall

The City Hall was built in 1989 and houses municipal operations, police department, and TV station.

Observations:

- Most lighting is fluorescent or metal halide, can lights have been retrofitted with LEDs.
- There is difficulty cooling the TV Station data server.
- The main hallway is relatively dark.
- Police garage lights are always on.
- Lighting in open offices tend to burn out.
- Boiler plant is completely off in the summer.
- There are some cold spots in open office areas in the summer.

Recommendations:

LED retrofit: Upgrade metal halide and fluorescent lamps to LEDs. Fitchburg's facilities staff had concerns about how occupants may react to the look of LED lamps. One way to address that would be to test different LED fixtures and conduct an occupant survey on how it looks. Sun Prairie has done a similar test at their City Hall. It's also an opportunity to correct lighting levels in the main hallway. LED lights also have longer service than fluorescent lamps.

Lighting controls: When upgrading to LED, consider adding occupancy controls in various rooms, particularly for small rooms. Large meeting rooms with multiple occupancy sensors would work as well. Consider integrated light fixtures, complete with occupancy sensors and photosensors. Garage lights should have occupancy sensors or integrated fixtures as well.

TV station lighting and equipment: Consider upgrading all TV lighting to LEDs for large savings. Electronic Theatre Controls, the lighting contractor for Fitchburg's TV station, can provide more information on the potential savings from upgrading to LEDs. Consider moving the AV data server into a smaller room with a dedicated split system. Servers require 24/7 cooling and should be placed away from exterior windows that can cause large heat fluctuations.

Boiler hot water: A previous energy audit recommended turning off the boiler plant in the summer to save energy, which saves about $5,000 a year. However, the building air system was designed to reheat during the summer to temper the air, which has led to occupant cold calls. A possible reason for using so much heating energy is that the two installed boilers can't modulate to low enough heating level. There are two recommendations: (1) implement hot water temperature reset to lower hot water temperature in the summer and (2) install small, full condensing boiler to operate in the summer.

Fitchburg Community Center

The Fitchburg Community Center was built in the 1980's. It is connected to the City Hall and was expanded in 2009.

Observations:

- LED lights have been installed in senior center and some other spaces.
- Boilers upgraded in 2008. Not many occupant complaints regarding heating, ventilation, and air conditioning (HVAC) system since then.

Recommendations:

LED retrofit and lighting controls: Complete upgrade to LED. Consider vacancy sensors for small rooms and occupancy and daylighting sensors for some of the conference and meeting rooms. Consider light fixtures that can be purchased with integrated occupancy controls and photosensors.

HVAC controls: Check if there are simple control sequences that can implement through the BAS to save energy. Refer to the supply air temperature reset and demand-controlled ventilation (DCV) strategies outlined in the main report.

Energy Saving Potential

For each measure identified, we calculated the total savings and payback. Calculations were based on a combination of resources, including the Wisconsin Technical Reference Manual, the International Energy Conservation Code, and internal research and expertise. References and assumptions for energy saving calculations and cost data are in Appendix E. For more complicated measures, we developed simple energy models to quantify levels of impact. For details and definitions on the measures, please refer to the Main Report of the energy plan that has descriptions of the measures.

Table 6 provides detail on the energy efficiency opportunities for each building and includes energy costs savings and simple payback. Measures are organized by simple payback to identify measures that will recover capital costs quickly. As Table 6 shows, LED lighting are estimated to have the most significant savings. While the measures are listed below separately, we recommend that lighting controls be implemented with LED upgrades to reduce total upfront costs. The savings listed below for controls are based on a building already upgraded to LEDs and the incremental costs below assume that the controls and LED upgrades are completed at the same time. Controls implemented on their own would have a higher upfront cost. The next two measures with a large energy saving potential are the air handling unit (AHU) temperature reset and hot water temperature reset. We did not model adding a summer boiler to City Hall, but expect that installing a boiler will *increase* the building's energy consumption compared to current operation, although will likely result in greater staff comfort and would use less energy than the last energy audit determined was used for boiler heat in the summer.

Table 6: Energy saving measures for Fitchburg walk-through buildings

Building	Cost	Electric savings (kWh)	Gas savings (therms)[1]	Total energy savings	Cost savings	Simple payback (years)
City Hall						
HVAC AHU reset	$290	5,540	600	1.6%	$970	0.3
Lighting controls - daylighting	$130	3,800	-80	0.1%	$370	0.3
Lighting controls - occupancy	$320	8,950	-200	0.2%	$860	0.4
Lighting controls - garage	$170	4,070	-90	0.1%	$390	0.4
HVAC boiler reset	$1,220	0	2,060	4.1%	$1,240	1.0
LED lighting - task tuning	$950	5,660	-130	0.1%	$550	1.7
DCV - assembly space	$1,820	1,840	980	2.0%	$790	2.3
LED lighting retrofit - interior	$22,000	83,680	-1,870	2.0%	$8,090	2.7
DCV - office space	$2,580	1,240	620	1.3%	$510	5.1
City Hall Total	**$29,480**	**114,800**	**1,890**	**11.5%**	**$13,760**	
Community Center						
Lighting controls - daylighting	$80	2,370	-50	0.2%	$230	0.3
Lighting controls - occupancy	$200	5,580	-120	0.5%	$540	0.4
HVAC AHU reset	$190	2,840	310	3.1%	$500	0.4
LED lighting - task tuning	$490	3,530	-80	0.3%	$340	1.4
LED lighting retrofit - interior	$10,060	31,700	-710	2.9%	$3,060	3.3
DCV - assembly space	$1,490	1,000	530	4.3%	$430	3.5
HVAC boiler reset	$1,220	0	570	4.4%	$340	3.6
DCV - office space	$260	80	40	0.3%	$30	7.6
Community Center Total	**$13,990**	**47,100**	**480**	**16.1%**	**$5,470**	
Grand Total	**$43,470**	**161,900**	**2,370**		**$19,230**	

Finally, while we did not visit every building in Fitchburg's municipal operations, we did see similar building types in the other communities' walk-throughs. For those buildings for which we were unable to conduct walk-throughs, we asked community representatives to provide some details on particular end-uses in each building. By using that feedback and leveraging information gathered during other communities' site visits, we were able to estimate savings for the other Fitchburg buildings. These savings are summarized in Table 7. However, these results are not based on a site walk-through and should be confirmed based on further review of building equipment and conditions.

Table 7: Energy saving measures for Fitchburg – non-site walk-through buildings

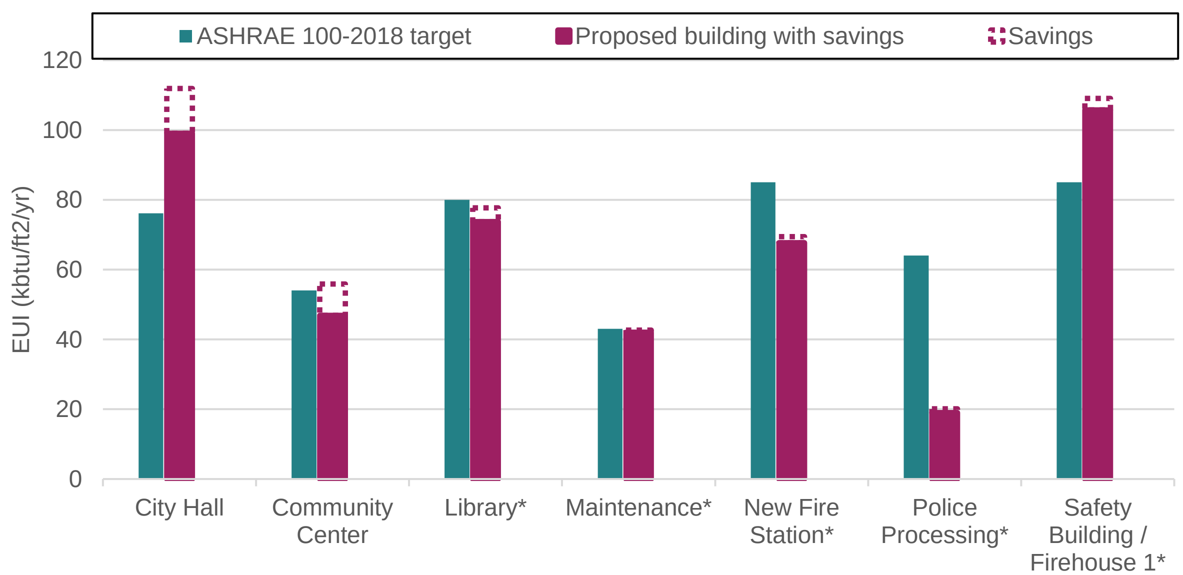
Building	Cost	Electric savings (kWh)	Gas savings (therms)	Total energy savings	Cost savings	Simple payback (years)
Library						
HVAC AHU reset	$100	19,380	0	2.2%	$2,130	0.0
LED lighting retrofit - interior	$7,930	25,000	0	2.9%	$2,750	2.9
Library Total	**$8,030**	**44,380**	**0**	**5.1%**	**$4,880**	
Maintenance						
Lighting controls - daylighting	$50	1,560	-30	0.1%	$150	0.3
Lighting controls - garage	$290	7,000	-160	0.5%	$680	0.4
LED lighting - task tuning	$1,420	4,000	-90	0.3%	$390	3.7
LED lighting retrofit - interior	$4,380	10,350	-230	0.7%	$1,000	4.4
Maintenance Total	**$6,140**	**22,910**	**-510**	**1.6%**	**$2,210**	

[1] Negative values reflect an increase in heating demand due to interactive effects – in all cases, total savings is still positive.

Building	Cost	Electric savings (kWh)	Gas savings (therms)	Total energy savings	Cost savings	Simple payback (years)
New Fire Station						
HVAC AHU reset	$190	2,690	290	2.5%	$470	0.4
Police Processing						
LED lighting retrofit - interior	$1,850	5,730	-130	5.2%	$550	3.3
Safety Building / Firehouse 1						
Lighting controls - occupancy	$30	920	-20	0.1%	$90	0.4
Lighting controls - garage	$230	5,480	-120	0.5%	$530	0.4
LED lighting - task tuning	$70	420	-10	0.0%	$40	1.8
LED lighting retrofit - interior	$5,920	26,580	-590	2.4%	$2,570	2.3
Safety Building / Firehouse 1 Total	**$6,250**	**33,400**	**-740**	**3.0%**	**$3,230**	
Grand Total	**$22,460**	**109,120**	**-1,090**		**$11,350**	

Figure 3 shows the EUI of each building if all energy efficiency measures are implemented along with an ASHRAE Standard 100-2018 benchmark value for comparison. The figure shows that the energy measures outlined for the City Hall and Community Center help bring them much closer to the ASHRAE 100 benchmark values for their respective building types.[2] The Fitchburg Library is a newer building and already meets the target EUI, but some improvements could still be made. We expect that the other buildings would see small energy reductions, but we conservatively estimated energy savings as we did not conduct a walk-through for these buildings.

Figure 3: Fitchburg building EUI savings



* denotes buildings for which a walk-through was not performed. See accompanying text above for additional detail

[2] For buildings with multiple functions, we used a blended target EUI to account for the different use types within the building.

Street Lighting Opportunities

Converting streetlights to LEDs has a large energy saving potential. In addition to reduced energy use annually, LEDs also last longer and thus reduce lifetime maintenance costs. The lights can also improve lighting quality, improve perception of safety, and reduce light pollution.

Table 8 illustrates the lifetime energy savings, carbon savings and cost savings associated with converting one high-pressure sodium fixture to a LED fixture. This standard lifetime analysis assumes that streetlights are owned by the municipality and serves to illustrate potential savings from a conversion. The upfront cost in Table 8, which includes both labor cost and material cost, is estimated from conversations with city officials who have implemented LED retrofits in the last few years. The Wisconsin Technical Resource Manual estimates the cost per fixture to be slightly higher. However, as LED costs are rapidly decreasing, we opted to use cost estimates from recent installations in an attempt to accurately represent current costs. The cost savings reported represent avoided maintenance costs and avoided energy costs. Table 8 illustrates that the higher the wattage of the fixture, the more economically beneficial it becomes to convert the fixture to a LED. Appendix B provides more details on the assumptions made for these calculations.

Table 8: LED lifetime cost analysis – cost per fixture

Lighting type	Lifetime energy savings (kWh)	Lifetime CO_2e savings (metric tons)	Upfront cost	Lifetime cost savings	Payback period (years)
70 W	3,430	2.6	$249	$275	6.8
100 W	7,750	5.9	$249	$670	3.9
150 W	9,480	7.2	$299	$800	3.6
250 W	16,070	12.2	$399	$1,315	3.3
400 W	23,800	18.1	$499	$1,930	3

Table 9 illustrates the potential electricity, carbon, and energy cost savings from converting all streetlights to LEDs. Based on the wattage of current streetlights, we calculated the energy use from LED-equivalent bulbs and subtracted this from 2018 streetlight electricity usage. Using this energy savings value, we applied a standard carbon factor and electricity rate to estimate the carbon and cost savings.

As a note, the cost savings reported below represent potential energy cost savings, assuming a standard kWh charge for electricity usage. However, almost all of Fitchburg's fixtures are owned by MGE or Alliant and the city is under a payment arrangement with the utility for the use of those fixtures in the City. Thus, the exact costs savings for upgrading those fixtures owned by MGE or Alliant may ultimately be different based on the rate structure. Our analysis did not attempt to replicate the payment structures under those agreements. Rather, this analysis can serve as the basis of conversations with MGE or Alliant about how to structure the LED rates in order to yield similar cost savings for the City.

Table 9: Fitchburg streetlights - annual savings

STREETLIGHT ANNUAL SAVINGS	
Number of lights	1,016
Energy savings (kWh)	285,000
CO_2e savings (metric tons)	217
Energy cost savings	$31,350

Fleet Opportunities

The market for alternative fuel vehicles is rapidly developing. In the next five years, several new options will exist for municipal fleets, but at this point, the largest two opportunities are police and light-duty vehicles. A few niche alternatives exist for other vehicle types, but each of them has a substantial incremental upfront cost – making them less of a viable option. Based on conversations with the collaborating communities, we left these high incremental cost options out of our final recommendations, but our completed analysis can be found in the main report.

Table 10 illustrates the payback period for police vehicles and light-duty vehicles, assuming 14,000 miles driven for police vehicles and 3,500 miles driven for light-duty vehicles. As the numbers illustrate, hybrid police vehicles present a great opportunity for conversion – with a payback period around one year and a lifetime carbon reduction of between 35 and 50 percent. Although light-duty vehicles have negative lifetime savings, increasing the miles driven per vehicle would greatly improve these numbers. Once a vehicle hits around 10,000 to 15,000 miles driven a year, the cost of an electric car breaks even with a conventional car. For more details on the lifetime cost calculations, see Appendix C.

Table 10: Fitchburg lifetime cost analysis - relevant alternative fleet vehicles

		Vehicle Lifetime	Incremental vehicle cost	Annual cost savings	Lifetime savings	Payback period	Lifetime CO_2e reduction
Police	Hybrid patrol SUV	8	$3,500	$1,640	$10,200	**1.2**	41%
	Hybrid patrol sedan	8	$3,500	$2,170	$14,560	**1**	55%
	Electric motorcycle	8	$390	$825	$8,600	**<1**	35%
Light duty	Passenger vehicle	15	$8,600	$350	-$3,700	-	43%
	Plug-in hybrid SUV	15	$10,000	$215	-$7,000	-	35%
	Plug-in hybrid van	15	$9,000	$240	-$5,650	-	35%

Table 11 illustrates the savings from converting all light-duty and police vehicles in the Fitchburg municipal fleet. The three departments have at least one vehicle that can be converted. The transition to hybrid police vehicles leads to the largest benefit – around a 45 percent reduction in both carbon emissions and fuel costs.

Table 11: Fitchburg annual potential fuel savings - adoption of light-duty and police vehicles

Department	Number of vehicles	CO_2e (metric tons) Current	CO_2e (metric tons) Alternative	Fuel cost Current	Fuel cost Alternative
Police	20	274	152	$86,700	$47,465
Administration	4	8	7.6	$2,390	$1,655
Parks & Recreation	2	101	93	$30,480	$26,845

Solar Energy Opportunities

The solar energy analysis included an in-depth look at five different sites in the city of Fitchburg. The arrays on the Fire Station, Community Building, and Well 5 are roof panels while Well 10 and Well 11 had ample land available and are therefore ground-mounted arrays. Ground-mounted solar arrays offer a high degree of visibility for the project within the community. Visibility of the system enables the City to effectively lead by example in its transition to renewable energy. At the same time, system visibility of a ground-mounted array also may affect the neighbors of the site and the community by creating a visual change and affecting potential current and future use of the site. Fitchburg may seek to engage the owners of the neighboring properties during the project development process in order to identify any concerns and build support for the project.

Table 12 summarizes the electricity potential of each array. The recommended PV system size for each location considers the site's current electric consumption and the size and configuration of an array that each site could support. MG&E currently allows for advantageous net metering of distributed solar PV arrays if the overall system capacity does not exceed 100 kW AC. All recommended systems are sized below the 100-kW threshold. If Fitchburg proceeds with installing arrays at one, or more, of the sites identified, the City's selected solar installation contractor will need to conduct a detailed analysis of the site and recommend a system configuration per the contractor's professional expertise. By adding these solar arrays, an additional 7 percent of the City's electricity use could be offset, bringing renewables above 16 percent of the City's total electricity use in 2018. Appendix F provides more detail on each array.

Table 12: Fitchburg summary of solar potential by site

Site Name	Address	Annual consumption (2018, kWh)	Potential PV capacity (kW DC)	Estimated production (kWh)	Savings
Community Building	5510 Lacy Rd	167,400	37.2	46,131	28%
Fire Station	5791 Lacy Rd	139,600	65.1	92,315	66%
Well #5	6042 McKee Rd	584,164	23.3	31,501	5%
Well #10	2689 Granite Cir	249,014	66.9	94,532	38%
Well #11	5212 Lacy Rd	284,557	31.0	43,728	15%
Total		**1,140,178**	**223.5**	**308,207**	**27%**

Table 13 provides a summary of estimated costs of the recommended PV arrays. The estimated cost for the systems of $1,818 per kW is based on current data for the Dane County market for commercial PV installations. A seven percent premium was added to the cost of the installation on the Community

Building to reflect installation challenges that may be encountered due to the complexity of the building's roof. Since the cost estimates reflect market data, exact costs may vary by solar contractor.

Focus on Energy offers rebates for commercial-scale solar installations through a competitive request for proposal under its Renewable Energy Competitive Incentive Program (RECIP). The RECIP grants, which are not guaranteed, typically provide rebates that cover between 10 percent and 40 percent of the system cost. This analysis conservatively assumes a 15 percent rebate amount.

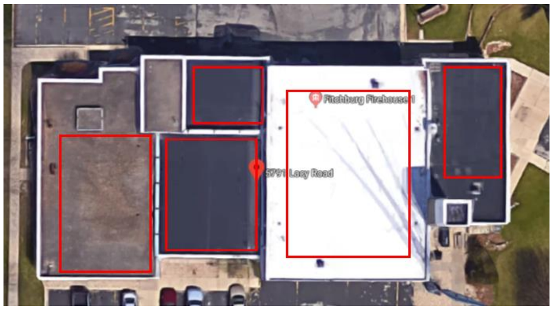
Table 13: Estimated cost of recommended Fitchburg PV arrays

Site Name	Total cost	Focus on Energy rebate	Net cost
Community Building	$72,575	$10,886	$61,689
Fire Station	$127,005	$19,051	$107,954
Well #5	$45,359	$6,804	$38,555
Well #10	$130,634	$19,595	$111,039
Well #11	$60,479	$9,072	$51,407
Total	**$436,052**	**$65,408**	**$370,644**

Table 14 provides a summary description of the array at each site as well as an aerial view of the arrays. The red outlines represent where the arrays would sit.

Table 14: Fitchburg description of potential PV arrays

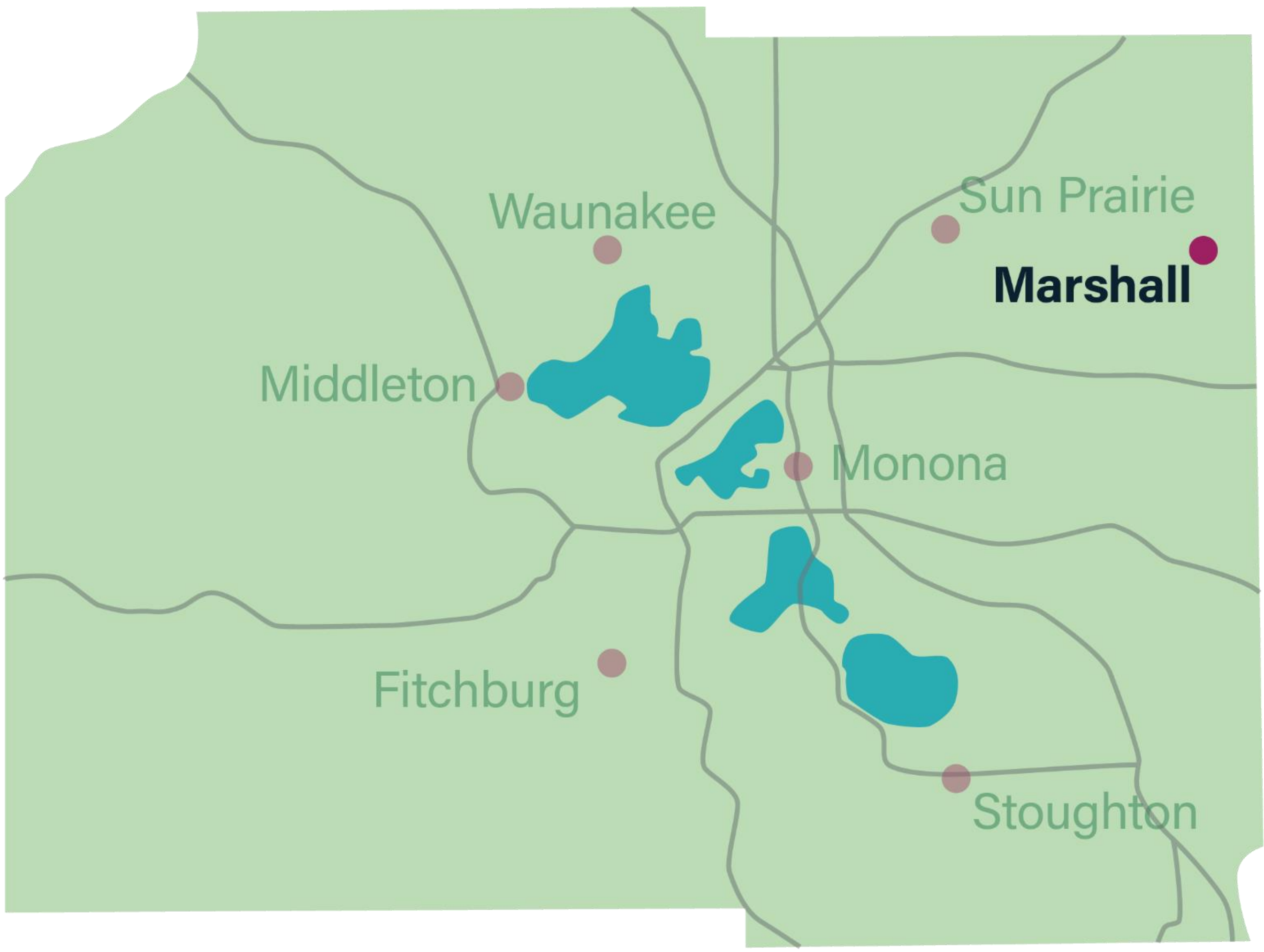
Description of site	Aerial views with potential PV mounting
The **Community Building** offers four areas that may be able to house solar panels. The array is oriented based on the layout of the roof and avoids existing roof penetrations and oriented roof segments that are less desirable for solar gain. The analysis assumes flush-mounted racking for all four sections. City staff noted that the design of the solar array at the neighboring City Hall was impacted by design restrictions for the area. Fitchburg may review zoning and other requirements in order to determine what restrictions may exist on the design of the array.	

Description of site	Aerial views with potential PV mounting
The **Fire Station** has a flat roof, with minimal penetrations and equipment. An array could be configured in five segments. Panel efficiency can be enhanced by racking the panels with a south-facing 20-degree tilt in order to maximize insolation potential and available space. Panel rows may be spaced to allow for a 0.3 ground coverage ratio (GCR).	
Well #5 is a high user of electricity, representing approximately 11 percent of the City's total consumption. The well is housed in a small building that has a roof with few penetrations and there is minimal open space surrounding the building. The size of the roof and lack of space for a ground mounted system prevent installation of an array that would provide the majority of the facility's energy consumption. A modest array could be configured in three segments. Panel efficiency can be enhanced by racking the panels with a south-facing 20-degree tilt in order to maximize insolation potential and available space. Panel rows may be spaced to allow for a 0.3 GCR.	
The building that houses **Well #10** is too small to support a solar array that would generate a meaningful amount of electricity for the facility. However, the property where the well is located features considerable unobstructed open space that could be used for a ground-mounted solar array.	

Description of site	Aerial views with potential PV mounting
Well #11 is a high user of electricity, representing approximately nine percent of the City's total consumption. There is open space to the north of the building, where a PV array could be sited. The size of the roof and limitations on space for a ground mounted system prevent installation of an array that would provide the majority of the facility's energy consumption; however, a PV system at this location can support the City's progress toward its municipal renewable energy goals.	

MARSHALL

COMMUNITY-SPECIFIC MUNICIPAL ENERGY PLAN



Wisconsin Office of Energy Innovation Grant

MARSHALL BACKGROUND

The village of Marshall is the smallest community in the collaboration with a 2017 population of 3,973 residents. The Village is generally seeing a trend of growth, with an influx of people from Madison and more families. With this growth, Marshall is working to define a community identify of which tourism may be a key part. The Village recently adopted a municipal goal to meet 60 percent renewable energy by 2030, 80 percent by 2035, and 100 percent by 2040. One future development may be a new village hall, which not only allows for better utilization of existing space but also presents a great opportunity to showcase the village's energy commitment through a high performing building. A unique aspect of Marshall is the existence of a privately-owned dam, which may be a future source of clean electricity. This chapter provides a detailed summary of the Marshall energy plan. We begin by summarizing Marshall's energy profile to provide a baseline understanding of current energy consumption, costs and carbon emissions for 2018. We then delve into our recommendations for near terms investments or action, split out into four categories: building energy efficiency, street lighting opportunities, fleet opportunities, and renewable energy opportunities, including solar and hydropower.

COMMUNITY ENERGY PROFILE

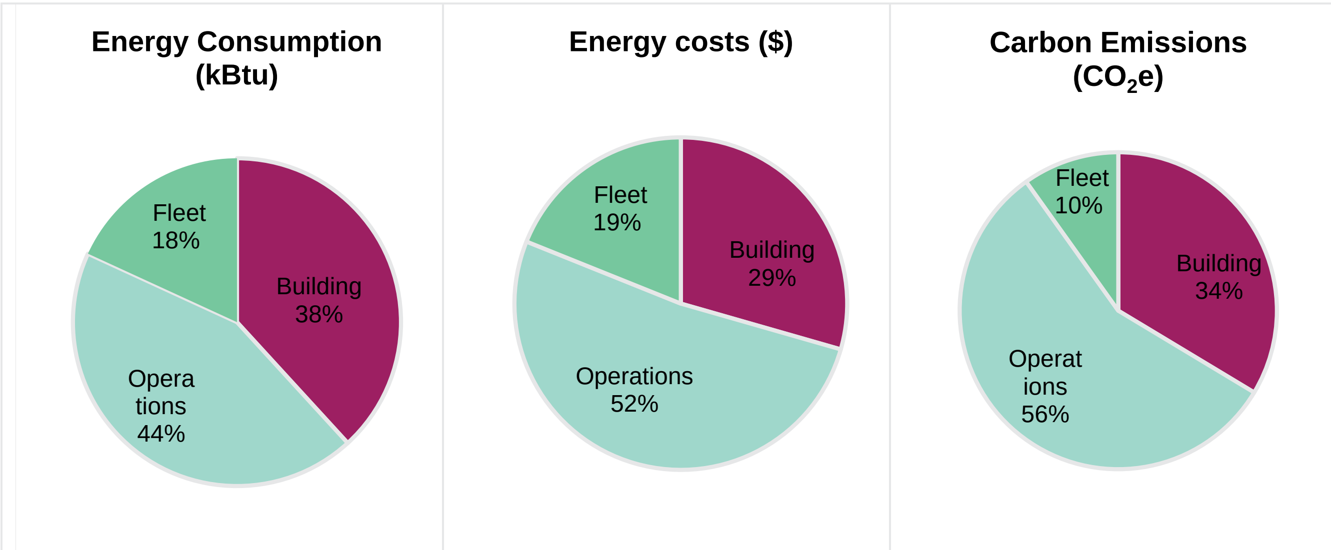
The three main energy inventory elements for Marshall's energy profile include buildings, operations, and municipal fleet. Table 43Table 15 provides details by category on what was included in development of the Marshall energy profile, based on the data provided by Marshall staff.

Table 15: Marshall inventory elements (2018 baseline)

Buildings	Operations	Fleet
Public Safety Building Municipal Building Community Library Municipal Garage	Wastewater Treatment Plant Wells/Pumps/Lifts Street lighting Parks and Recreation Other operations	3 Police vehicles 5 Heavy-Duty vehicles 4 Pickups 3 Other (one is a fuel can used for multiple pieces of equipment)

Figure 4 shows the percent contribution of each source to total energy use, cost, and carbon emissions. The cost and carbon intensity of the different fuels (electricity, natural gas, gasoline, and diesel) can significantly impact the contribution of each source to the total.

Figure 4: Marshall energy consumption, cost and carbon emissions (2018)



Breaking these elements down further, Table 16 details the annual energy use, carbon emissions, and energy cost associated with each building and operation use type. The buildings are listed individually; if there were multiple meters per building, we aggregated the values up to the building level. If there were multiple meters for operation data, it was aggregated by use type such as streetlights and wells, pumps, and lifts.

Table 16: Marshall baseline energy, carbon and cost data by building and operation use type (2018)

	Use/building	Net Electricity (kWh)	Natural gas (therms)	Carbon emissions (CO_2e metric tons)	Percent of total CO_2e	Energy cost
Building	Community Library	69,400	4,819	78	8%	$10,525
Building	Municipal Building	95,800	6,483	107	12%	$14,430
Building	Municipal Garage	19,706	2,063	26	3%	$3,405
Building	Public Safety Building	126,480	5,451	125	12%	$17,185
Operations	Other operations	1,623	-	1	0.10%	$180
Operations	Parks and Rec	28,471	-	22	2%	$3,130
Operations	Street lights	70,085	-	53	5%	$7,710
Operations	Treatment Plant	409,929	11,190	372	37%	$51,805
Operations	Well/pumps/lifts	152,995	398	119	12%	$17,070
	Fleet	-	-	99	10%	$29,255
	Total	**974,489**	**30,404**	**1,002**		**$154,695**

Currently, less than 1 percent of the total electricity use is from renewable energy. The Village installed a 7.8 kW solar PV array at its Wastewater Treatment Plant in 2008; however, the system requires maintenance to repair its tracking system and inverters. The Village is working with a solar installer to repair the system.

Figure 5 illustrates the energy use intensity (EUI) of Marshall buildings over the past several years and compares the values to an ASHRAE 100-2018 benchmark value. The year over year comparisons can serve as a method of measurement and verification – both to review the impact of energy efficiency investments and to identify operational changes that may impact overall energy use. Similarly, comparing to ASHRAE's benchmark value can serve as a way to benchmark against buildings of similar use types and identify potential efficiency opportunities. The ASHRAE values represent a typical building type and do not account for buildings that may house multiple village departments or functions.

Figure 5: Marshall EUI benchmarking and comparison to ASHRAE benchmark

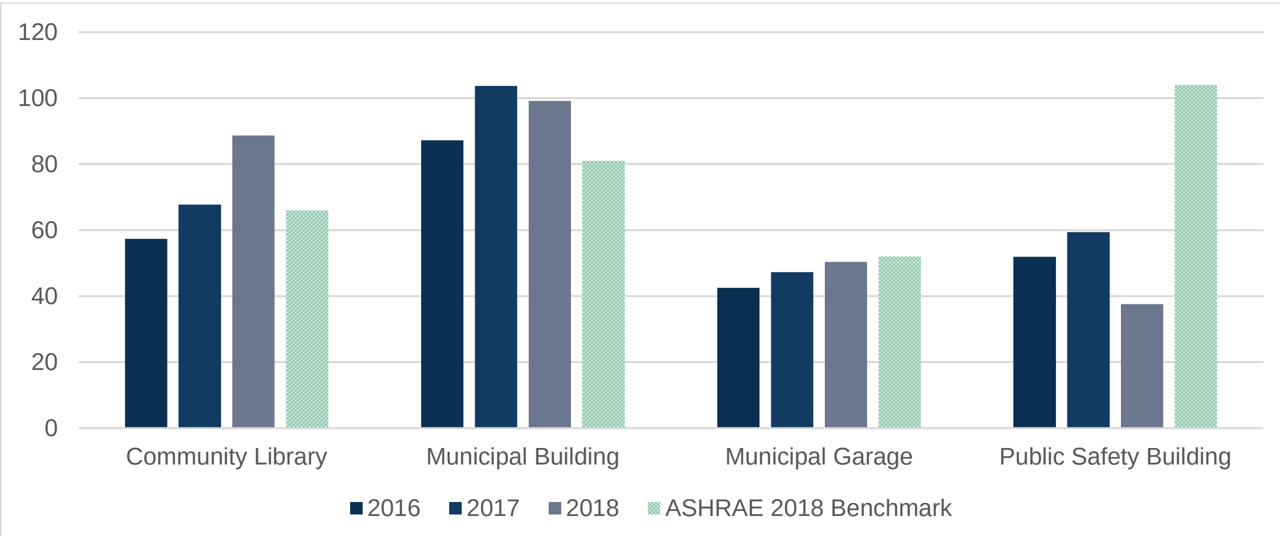


Table 17 illustrates the current vehicle fuel usage, carbon emissions, and fuel cost by vehicle department. The police department has the most significant energy footprint, driven largely to idle to maintain car functions while not in motion and the high relative mileage. This significant use presents an excellent opportunity for conversion to hybrid vehicles as will be outlined below.

Table 17: Marshall vehicle fuel usage by vehicle type (2018)

Department	Number of vehicles	Gallons (gasoline or diesel)	CO_2e (metric tons)	Fuel cost
Police	3	4,835	41	$11,945
Heavy-duty	5	1,802	18	$5,560
Pickups	4	2,537	22	$6,010
Other	3	1,958	18	$5,740
Total	15	11,132	99	$29,255

MARSHALL RECOMMENDATIONS FOR NEAR-TERM IMPLEMENTATION

Our analysis found energy investments that have a strong return on investment and significant energy savings potential. Implementing simple energy efficiency improvements to Marshall's four municipal buildings can reduce building energy consumption by as much as 11 percent. By converting village-owned streetlights to LEDs, the Village could half those lights' electricity consumption – reducing utility costs and saving around 25 tons of CO_2eannually. For fleet, the Village should prioritize converting the three police vehicles to hybrids as they offer a payback around one year and lead to a 40 percent decline in lifetime carbon emissions. Lastly, the addition of the two recommended solar panels would account for 48 percent of the total municipal electricity use and contribute significantly to the Village's goal to hit 60 percent renewable energy by 2030.

Table 18 summarizes the carbon and energy cost savings that the Village would see if they implemented the recommended near-term actions in each major opportunity area and the following sections provide detail on each of the opportunities.

Table 18: Marshall impact summary – estimated annual carbon and energy cost savings

Near-term Opportunity	CO_2e Reduction (metric tons)	Percent Carbon Reduction	Energy Cost Savings	Percent Energy Cost Reduction
Building efficiency	51	15%	$7,085	16%
Streetlights	26	49%	$3,775	49%
Fleet	17	17%	$4,975	17%
Solar	357	-	$51,550	-
Total opportunity	451	45%	$67,385	44%

Energy efficiency opportunities

Our analysis focused on near-term measures that not only have an energy or cost savings, but also may have possible benefits of reducing maintenance costs, improving occupant comfort, or increasing staff productivity. We also considered the ease and cost of implementation when prioritizing our recommendations.

To identify these opportunities, Slipstream conducted high-level walk-through for three buildings: the Marshall Municipal Building, the Marshall Public Works building, and the Marshall Library. We took note of major end-uses and processes and spoke with village staff to understand building operations. The following provides a walk-through summary for each building with additional detail on energy savings potential below.

Marshall Municipal Building

The Marshall Municipal Building was built in 1962 and houses the Village municipal operations and police department. There's an expansion that added more municipal offices.

Observations

- Very old building with challenges due to age of building and configuration, including HVAC operation and building security.
- Exit signs still have incandescent lights.
- LED light test fixture installed, and an LED upgrade is planned for all lights.
- Expansion is served by an attic furnace and small wall air conditioner.
- Boiler controls are pneumatic.
- New remote terminal unit (RTU) serves the old building but only has a single thermostat.

Recommendations

LED Retrofit and Lighting Controls: When completing upgrade to LED, consider replacing light switches with switches with vacancy sensors to turn off lights when rooms are unoccupied. Many of the rooms are small and ideal for sensor coverage.

LED Exit Signs: Upgrade exit sign lamps to LED. This is a small item that should be easy replacement with a quick payback.

Building Upgrades vs. New Building Investment: Given the desire for a new building in 2022 or 2023, consider holding off on major building energy efficiency upgrades to save capital investment for new construction. Refer to the new construction design guidelines in the Policies section of the main report for recommendations for new construction.

Marshall Municipal Garage

The Marshall Municipal Garage was built in the 1992.

Observations

- LED lights have been installed throughout.
- No lighting occupancy sensors have been installed due to concern about lights going out while people are working.
- There are reportedly high electrical bill charges in the summer, and it’s not clear what’s causing the high bill.
- Many of the appliances are old, including a vintage refrigerator and electric water cooler.

Recommendations

Lighting controls: Although concern for lights going out while someone is working is valid, occupancy controls for lighting fixtures can still be installed on some of the light fixtures. This will keep all lights from going out. Use task lighting for small tasks to improve light quality and limit reliance on light from the ceiling. Integrated controls in the fixtures also can reduce or turn off lights in parts of the garage that aren’t in use.

Replace appliances: Upgrade to ENERGY STAR rated appliances.

Monitor energy usage: Monitor utility bills to try to determine potential causes for increased electricity uses. Consider additional electric submeters to track energy usage.

Marshall Community Library

The Marshall Community Library was built in 2002.

Observations

- Significant lighting as typical for a library. Linear fluorescent T12 lamps and CFLs.
- All lighting in the main library is on during daylight hours.
- There are plenty of windows and potential for daylighting.
- Radiant floor heating system installed. There are complaints in the spring and fall of the space being uncomfortably warm as it warms up during the day. This results in more air conditioning use to try to cool the space.

Recommendations:

LED retrofit: Upgrade all lighting fixtures to LED lighting. LED lighting will provide better quality light suitable for library reading areas while using significantly less energy.

Lighting controls: If upgrading lighting fixtures to LED, consider integrated lighting fixtures complete with occupancy sensors, photosensors, and continuous dimming capability. These fixtures can automatically take advantage of light from windows throughout the library and reduce or turn off lighting if no one is in that part of the library. Consider task tuning to ensure spaces are not over lit.

Radiant floor heating controls: Radiant floor heating is considered one of the most comfortable and energy efficient ways to heat an open plan building. Currently, the library radiant floor heating system is controlled through regular thermostats on the wall. Because of this, the floor overheats and continues to radiate heat for hours even after the heating water loop is turned off. This in turn requires more air conditioning energy.

To avoid this issue, the ASHRAE Handbook for Systems and Equipment, 2016, recommends controlling the floor temperature through a floor temperature sensor, and not a wall air temperature sensor. ASHRAE recommends maintaining the floor between 80°F to 84°F when heating. Consult a mechanical contractor regarding installing a slab temperature sensor in the floor. Estimated savings are $8,000 to $10,000 a year.

HVAC controls: Check if there are simple control sequences that can implement through the building automation system (BAS) to save energy. Refer to the supply air temperature reset and demand-control ventilation strategies outlined in the main report.

Energy Saving Potential

For each measure identified, we calculated the total savings and payback. Calculations were based on a combination of resources, including the Wisconsin Technical Reference Manual, the International Energy Conservation Code, and internal research and expertise. References and assumptions for energy saving calculations and cost data are in Appendix E. For more complicated measures, we developed simple energy models to quantify levels of impact. For details and definitions on the measures, please refer to the Main Report of the energy plan that has descriptions of the measures.

Table 19 illustrates these results for the Municipal Garage, Municipal Building, and Community Library. Measures are organized by simple payback to identify measures that will recover capital costs quickly. For both the Library and Municipal Building, LED lighting are estimated to have the most significant electricity savings. While the measures are listed below separately, we recommend that lighting controls be implemented with LED upgrades to reduce total upfront costs. The savings listed below for controls are based on a building already upgraded to LEDs and the incremental costs below assume that the controls and LED upgrades are completed at the same time. Controls implemented on their own would have a higher upfront cost.

The radiant floor controls in the Library would also generate large electricity and natural gas savings. This is a control issue that causes the building to simultaneously heat and cool in the spring and fall and causes some thermal comfort issues. Payback is not given as typical cost data is unavailable for this unique measure. The implementation of an air handling unit (AHU) temperature reset and a demand-controlled ventilation (DCV) system could generate additional savings for the Library. The AHU temperature reset schedule should be easy to implement through BAS or rooftop unit controls. DCV would require carbon dioxide sensors within the library space.

The Municipal Garage would see additional energy savings from lighting controls, but as the building already has LED lighting there are limited general measures that could be applied. Replacing the old appliances such as the refrigerator and water cooler may impact overall electrical usage, since these are “always-on” appliances and newer appliances are significantly more efficient. Below, a modern replacement for a seven cubic foot refrigerator is shown to pay back in just over two years.

Table 19: Energy saving measures for Marshall walk-through buildings

Building	Cost	Electric savings (kWh)	Gas savings (therms)	Total energy savings	Cost savings	Simple payback (years)
Community Library						
Lighting controls - daylighting	$140	4,210	-90	0.7%	$410	0.3
Lighting controls - occupancy	$30	880	-20	0.1%	$90	0.4
HVAC AHU reset	$100	1,100	120	2.2%	$190	0.5
LED lighting - task tuning	$300	2,190	-50	0.4%	$210	1.4
LED lighting retrofit - interior	$4,470	14,080	-310	2.4%	$1,360	3.3
DCV - assembly space	$870	580	310	4.7%	$250	3.5
DCV - office space	$210	70	30	0.5%	$30	7.6
Custom - radiant floor		4,300	880	14.6%	$1,000	N/A
Community Library Total	**$5,850**	**27,420**	**860**	**25.6%**	**$3,530**	

Building	Cost	Electric savings (kWh)	Gas savings (therms)	Total energy savings	Cost savings	Simple payback (years)
Municipal Building						
Lighting controls - occupancy	$80	2,330	-50	0.3%	$230	0.4
LED lighting retrofit - exit signs	$160	1,870	-40	0.2%	$180	0.9
LED lighting - task tuning	$170	1,050	-20	0.1%	$100	1.7
LED lighting retrofit - interior	$5,300	16,720	-370	2.1%	$1,620	3.3
DCV - assembly space	$80	50	30	0.3%	$20	3.5
DCV - office space	$50	20	10	0.1%	$10	7.6
Municipal Building Total	**$5,840**	**22,040**	**-450**	**3.1%**	**$2,150**	
Municipal Garage						
Lighting controls - garage	$70	1,720	-40	0.9%	$170	0.4
Custom - refrigerator replacement	$360	1,650	-40	0.8%	$160	2.3
Municipal Garage Total	**$430**	**3,370**	**-70**	**1.7%**	**$330**	
Grand Total	**$12,120**	**52,820**	**340**		**$6,010**	

Finally, while we did not visit the Marshall Public Safety building, we did see similar buildings in the walk-throughs with other communities. By using that feedback and leveraging information gathered during other communities' site visits, we were able to estimate savings for the Public Safety building. These savings are summarized in Table 20. However, these results are not based on a site walk-through and should be confirmed based on further review of building equipment and conditions.

Table 20: Energy saving measures for Marshall – non-site walk-through buildings

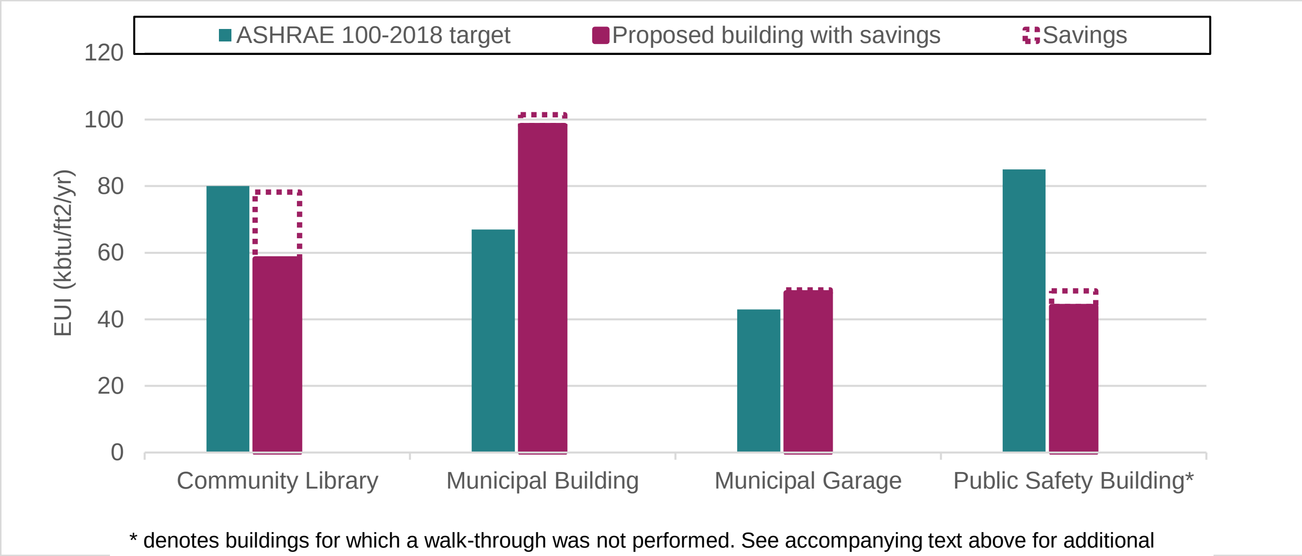
Building	Cost	Electric savings (kWh)	Gas savings (therms)	Total energy savings	Cost savings	Simple payback (years)
Public Safety Building						
HVAC AHU reset	$100	3,180	340	3.6%	$560	0.2
DCV - assembly space	$420	560	300	2.5%	$240	1.7
HVAC boiler reset	$610	0	450	3.5%	$270	2.3
Total	**$1,060**	**3,740**	**1,090**	**9.6%**	**$1,060**	

Figure 6 shows the EUI of each building if all energy efficiency measures are implemented, and an ASHRAE Standard 100-2018 benchmark value for comparison. Our analysis shows that the energy measures outlined above for the Library significantly reduces the energy efficiency below the ASHRAE 100 target values.

The Municipal Building has a high EUI likely due to the age of the building, so even though the recommended measures save an estimated $2,150, the measures only reduce the energy use by 3 percent. As about two-thirds of the building usage is heating energy and upgrading the old heating system could be very costly, we recommend that the Village strongly weigh future space utilization needs and the potential for near-term investment in a new municipal building.

There are limited improvements to be made to the Municipal Garage, although a deeper audit may uncover the reason for the unusually high energy bills. We expect that the Public Safety building would see some notable energy reductions from the measures above, but we conservatively estimated energy savings because we did not conduct a walk-through.

Figure 6: Marshall building EUI savings



Street Lighting Opportunities

Converting streetlights to LEDs has a large energy saving potential. In addition to reduced energy use annually, LEDs also last longer and thus reduce lifetime maintenance costs. The lights can also improve lighting quality, improve perception of safety, and reduce light pollution.

Table 21 illustrates the lifetime energy savings, carbon savings and cost savings associated with converting one high-pressure sodium fixture to a LED fixture. This standard lifetime analysis assumes that streetlights are owned by the municipality and serves to illustrate potential savings from a conversion. The upfront cost in Table 21, which includes both labor cost and material cost, is estimated from conversations with city officials who have implemented LED retrofits in the last few years. The Wisconsin Technical Resource Manual estimates the cost per fixture to be slightly higher. However, as LED costs are rapidly decreasing, we opted to use cost estimates from recent installations in an attempt to accurately represent current costs. The cost savings reported represent avoided maintenance costs and avoided energy costs. The results illustrate that the higher the wattage of the fixture, the more economically beneficial it becomes to convert the fixture to a LED. Appendix B provides more details on the assumptions made for these calculations. Appendix B provides more details on the assumptions made for these calculations.

Table 21. LED lifetime cost analysis – cost per fixture

Lighting type	Lifetime energy savings (kWh)	Lifetime CO_2e savings (metric tons)	Upfront cost	Lifetime cost savings	Payback period (years)
70 W	3,430	2.6	$249	$275	6.8
100 W	7,750	5.9	$249	$670	3.9
150 W	9,480	7.2	$299	$800	3.6
250 W	16,070	12.2	$399	$1,315	3.3
400 W	23,800	18.1	$499	$1,930	3

Table 22 illustrates the potential electricity, carbon, and energy cost savings from converting Marshall's streetlights to LEDs. As only village-owned lights are metered, the baseline energy profile only includes the village-owned lights' usage and thus, we only include these savings in our overall summary of potential impact. To calculate these savings, we used the wattage of the current village streetlights to identify equivalent LED replacements and calculate an estimated new electricity usage. We then subtracted this from the reported 2018 streetlight usage.

We-Energies-owned streetlights are unmetered, but the utility identifies the type of lights within the Village. Based on that information, we calculated the energy savings that would be possible by converting these to LEDs. However, we did not include energy cost savings as the lights are billed under a payment arrangement with the utility and thus, the exact savings for upgrading the fixtures would be based on the rate structure. The energy savings for We Energies-owned lights are not included in the summary of potential opportunities.

Table 22: Marshall streetlights - annual savings (relative to 2018 baseline)

	Village-owned	We Energies-owned
Number of lights	96	147
Energy savings (kWh)	34,325	54,100
CO_2e savings (metric tons)	26	41
Cost savings	$3,775	-

Fleet Opportunities

The market for alternative fuel vehicles is rapidly developing. In the next five years, several new options will exist for municipal fleets, but at this point, the largest opportunity for Marshall is police vehicles. A few niche alternatives exist for other vehicle types, but each of them has a substantial incremental upfront cost – making them less of a viable option. In initial conversations that Slipstream had with Marshall, we discussed the possibility of compressed natural gas (CNG) as an option for heavy-duty vehicles; however, given the low number of heavy-duty vehicles that the Village operates and the high costs for retrofitting both vehicles and the public work garage to accommodate CNG vehicles, we did not pursue this as a viable near-term option. Based on conversations with the collaborating communities, we left these high incremental cost options out of our final recommendations.

Table 23 illustrates the payback period for police vehicles, assuming 14,000 miles driven. As the numbers illustrate, hybrid police vehicles present a great opportunity for conversion – with a payback period around one year and a lifetime carbon reduction of between 40 and 55 percent. For more information on the lifetime cost calculations, refer to Appendix C.

Table 23: Marshall lifetime cost analysis – relevant alternative fleet vehicles

	Vehicle Lifetime	Incremental vehicle cost	Annual cost savings	Lifetime savings	Payback period	Lifetime CO_2e reduction
Hybrid patrol SUV	8	$3,500	$1,640	$10,200	**1.2**	41%
Hybrid patrol sedan	8	$3,500	$2,170	$14,560	**1**	55%

Table 24 illustrates the cost and carbon savings the transition to hybrid police vehicles would generate. As shown, the transition to hybrid police vehicles has a significant impact – around a 40 percent reduction in both carbon emissions and fuel costs.

Table 24: Marshall carbon and cost savings - conversion of police vehicles to hybrids

HYBRID POLICE VEHICLES – POTENTIAL SAVINGS	
CO_2e Savings (metric tons)	17
Cost Savings	$4,975

Renewable Energy Opportunities

The village representatives were interested in exploring solar PV investments, similar to other communities. Unique to Marshall, the village also identified a potential opportunity to use an existing hydroelectric dam on the Maunesha River to generate electricity for the Village's operations. To this end, we conducted an in-depth analysis of two sites for solar as well as the potential of the hydroelectric dam. Our results are summarized below.

Solar

As the wastewater treatment plant has ample land around the building, we modeled a ground-mounted array. We modeled a roof-mounted array for the library installation that makes use of the majority of the roof. Ground-mounted solar arrays can offer a high degree of visibility for the project within the community. Visibility of the system enables the Village to effectively lead by example in its transition to renewable energy. At the same time, system visibility of a ground-mounted array also may affect the neighbors of the site and the community by creating a visual change and affecting potential current and future use of the site. While the geographic separation between the WWTP and surrounding residential areas and the nature of the current function of the property may limit concerns by neighboring property owners about adding a PV array, the Village may seek to engage the owners of the neighboring properties during the project development process in order to identify any concerns and build support for the project.

Table 25 summarizes the capacity and production potential for each of these arrays. The recommended PV system size for each location considers the site's current electric consumption and the size and configuration of an array that each site could support. The CGS NM rate offered by WE Energies allows for net metering for customer-owned generation facilities with generating capacity of less than 300 kW. Both arrays are designed to be eligible for the CGS NM rate and to minimize the

Village's loss due to disadvantageous rates for over production. By adding these arrays, renewables would make up 48 percent of the village's total 2018 electricity use – contributing significant to the village's goal for 60 percent renewable energy by 2030. Appendix F provides more detail on each array.

Table 25: Marshall summary of solar potential by site

Site name	Address	Annual consumption (2018 kWh)	Potential PV capacity (kW DC)	Estimated production (kWh)	Percent energy savings
WWTP	616 West Karem Dr	409,929	290.3	403,981	99%
Library	605 Waterloo Rd	69,400	46.5	64,654	93%
Total		**479,329**	**336.8**	**468,635**	**97.8%**

Table 26 details the estimated cost for the recommended PV arrays. The estimated cost for the systems of $1,818 per kW is based on current data for the Dane County market for commercial PV installations. Since the cost estimates reflect market data, exact costs may vary by solar contractor. Focus on Energy offers rebates for commercial-scale solar installations through a competitive request for proposal under its Renewable Energy Competitive Incentive Program (RECIP) program. The RECIP grants, which are not guaranteed, typically provide rebates that cover between 10 percent and 40 percent of the system cost. This analysis conservatively assumes a 15 percent rebate amount.

Table 26: Estimated cost of recommended Marshall PV arrays

Site Name	Total cost	FoE rebate	Net cost
WWTP	$566,083	$84,912	$481,171
Library	$90,718	$13,608	$77,110
Total	**$656,801**	**$98,520**	**$558,281**

Table 27 provides a summary description of the array at each site as well as an aerial view of the arrays. The red outlines represent where the arrays would sit.

Table 27: Marshall description of potential PV arrays

Description of site	Aerial views with potential PV mounting
The **Wastewater Treatment Plant** is located on land with significant open space to the north of its operating facilities. The location of the potential system is approximately equivalent to the location of a PV system previously proposed by an installation contractor. It should be noted that the proposed PV array is located on a separate parcel of land that adjoins the parcel for the WWTP; however, the Village owns both parcels. Marshall will need to determine whether it will need to take any further action to join the parcels in order to interconnect the array with the WWTP's electric meter through WE Energies.	
The roof of the **Community Library** appears to have minimal roof penetrations and equipment, as well as limited shading obstructions to the south of the array. A roof-mounted array may be installed in three sections in order to optimize use of the roof space. Due to the relatively flat tilt of the roof, the model assumes a racked array with 20 degree fixed-tilt panels that is oriented ten degrees to the west of due south, in-line with the orientation of the building. The assumed ground coverage ratio is 0.3.	

Hydroelectric Power

Marshall identified a potential opportunity to use an existing hydroelectric dam on the Maunesha River, within the Village boundary, to generate electricity for the Village's operations. The current owner of the dam has approached the Village concerning the possibility of transferring ownership of the dam to the Village.

The electrical generation potential from a hydroelectric dam is calculated using the flow rate of water through the dam, the height of the dam, and the dam's operating efficiency. The operating efficiency depends both on the specific turbine that is used and on the changes in water levels during the year. In our analysis, we found a widely varied set of values for the flow rate of water through the dam. Additionally, we were unable to determine the dam's operational efficiency. Due to these unknowns, we could not definitively establish the optimal values to apply, but for purposes of providing the Village a thorough review, Slipstream modeled a likely range of production scenarios.

For the flow rate of water, we identified three divergent sources of information that are orders of magnitude different from one another. The Wisconsin DNR Dam Safety report suggests a flow rate of 43 m^3/s, while the USGS field data from 16 tests over 25 years indicates an average flow rate of 0.314

m^3/s.[3,4] Non-scientific observations from a Wisconsin river paddling website suggested a flow rate of 8.5 m^3/s.[5] Marshall may consider conducting independent tests or using additional third-party data to determine the correct flow rate to use for its production estimate. In our analysis, we modeled flow rates that matched each of these sources as well as for the mid-points between each of the found values.

The type, age, and maintenance history of the turbine were not known, and we recommend a review by a hydroelectric engineer in order to determine the efficiency of the equipment. For analysis purposes, we applied three efficiency values between 0.5 and 0.9.

Table 28 illustrates the wide range in potential electric production from the dam based on scenarios of varying flow rates and efficiency levels. For all scenarios, we assumed that the annual average water height on the dam is 1.675m, which is half of the maximum water height for the dam. We also assumed that the dam will operate year-round. Based on our understanding of seasonal variations in flow rates of similar-sized rivers and using a conservative estimate of turbine efficiency, we estimate that flow rate of 4.4 m^3/s with either the 0.5 or 0.75 efficiency levels (highlighted in yellow) provide a range for the most likely actual electricity production potential for the dam. However, to ensure a fully-informed decision by the Village, we recommend that Marshall consult with a hydroelectric engineer to estimate total production. In addition to the summary provided below, we also developed a spreadsheet that Marshall may use for its own review of the opportunity.

Table 28: Annual electricity production scenarios for Marshall Grist Mill dam (kWh)

	Flow rate (m^3/s)				
Efficiency factor	**0.314**	**4.4**	**8.5**	**25.75**	**43**
0.5	22,599	317,176	611,754	1,853,255	3,094,756
0.75	33,898	475,765	917,631	2,779,882	4,642,134
0.9	40,678	570,918	1,101,157	3,335,859	5,570,560

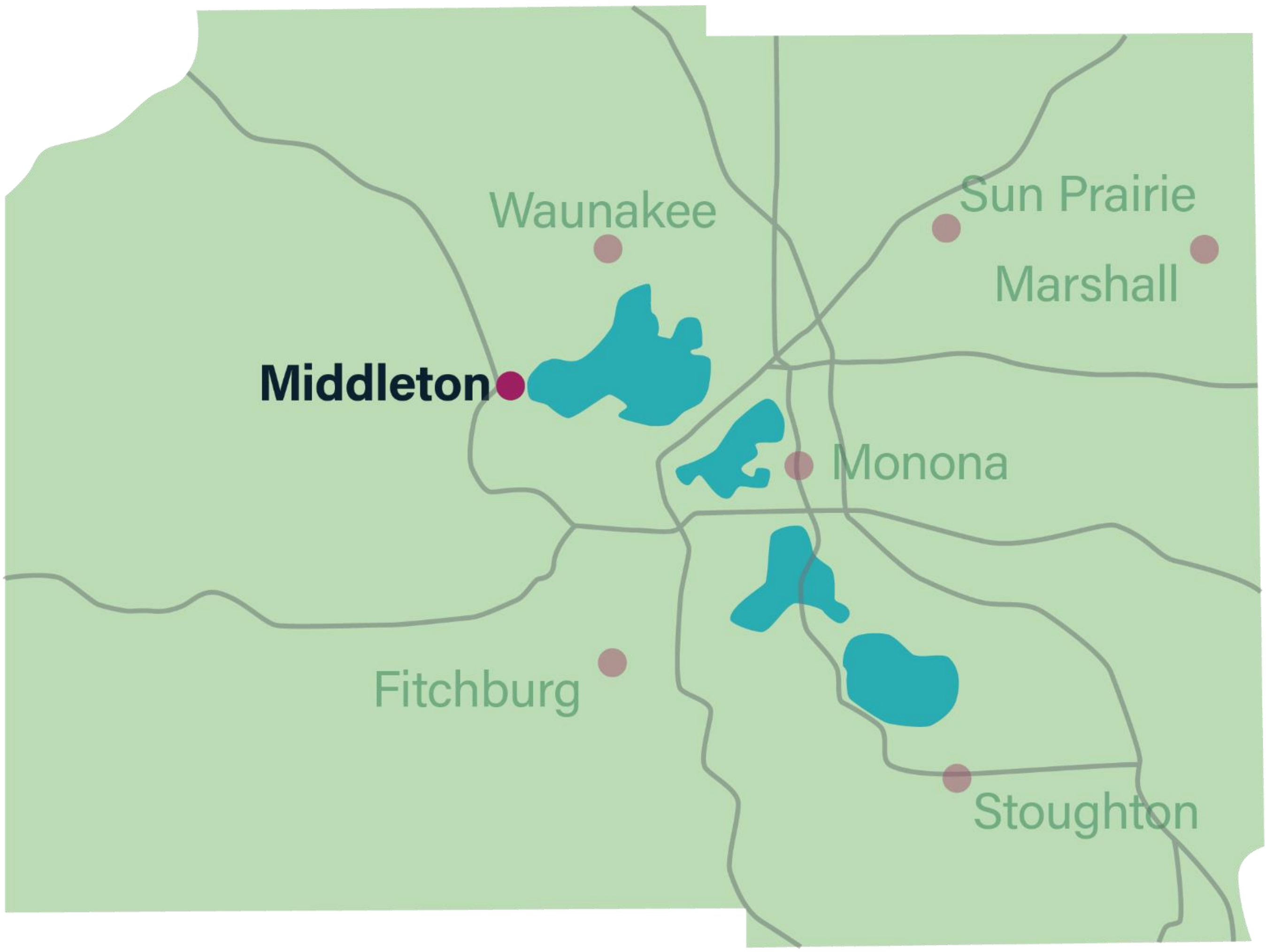
As the Village evaluates the dam's potential to generate electricity, we recommend that it considers how it will approach interconnecting the dam with the electric grid. Many customer-owned renewable energy tariffs require that the renewable energy system be co-located with the facility to which it supplies power. Figure 7 shows the location of the dam as well as the locations of Village facilities that consume significant amounts of electricity. The dam is not co-located with the Village's existing electricity use but is positioned within less than 0.75 miles of all major electricity consuming facilities in the Village.

[3] Wisconsin Department of Natural Resources (2018). *Detailed Information for Dam Marshall.* Madison, WI: Wisconsin Department of Natural Resources. Retrieved from: https://dnr.wi.gov/damsafety/damReport.aspx
[4] U.S. Department of the Interior (2019). *Streamflow Measurements for the Nation USGS 05425830 Maunesha River – QW Site-Near Sun Prairie, WI.* Washington, DC: U.S. Geological Survey. Retrieved from: https://waterdata.usgs.gov/nwis/measurements?site_no=05425830&agency_cd=USGS&format=html_table_expanded
[5] Wisconsin River Trips (2019). *Maunesha River.* Retrieved from https://www.wisconsinrivertrips.com/segments/maunesha-river

Figure 7: Locations and annual electricity use of Marshall facilities

We recommend the Village engage its electric utility early in its deliberations about the opportunity in order to address questions about the dam not being attached to municipal facilities, as well as potential over-production of electricity by the dam. One benefit of this energy planning collaboration is the willingness to share experiences; as mentioned in one of the collaborations in-person meetings, Marshall may engage city of Stoughton staff who maintain Stoughton's existing hydroelectric facility in order to better understand the operations and maintenance requirements that would need to be resourced if it acquires the dam.

MIDDLETON
COMMUNITY-SPECIFIC MUNICIPAL ENERGY PLAN



Wisconsin Office of Energy Innovation Grant

MIDDLETON BACKGROUND

The city of Middleton has positioned itself as a leader in supporting clean energy, both within city operations as well as community-wide. Middleton is part of the Energy Independent Communities, which is a voluntary agreement between the State of Wisconsin and communities that adopt the goal of generating 25 percent of their energy from renewable energy sources locally by 2025. The City has a goal to reduce energy use 15 percent by 2030 and 50 percent by 2050. The City is also striving to hit 100 percent renewable electricity by 2035 and 100 percent renewable energy by 2040. There are a number of currently installed solar PV generating about 7 percent of city electricity usage. They recently signed a contract with MGE to purchase a 500-kW portion of a 5 MW PV installation through the utility's Renewable Energy Rider program. In terms of energy reduction investments, they have gone through a number of buildings already to change out lighting to LEDs and install variable frequency drives. The City is also planning for significant development as it reviews options for updating its community campus plan, which includes a revamping or new construction for the City Hall, Senior Center and Library.

This chapter provides a detailed summary of the Middleton energy plan. We begin by summarizing Middleton's energy profile to provide a baseline understanding of current energy consumption, costs and carbon emissions for 2018. We then delve into our recommendations for near terms investments or action, split out into four categories: building energy efficiency, street lighting opportunities, fleet opportunities, and solar energy opportunities.

COMMUNITY ENERGY PROFILE

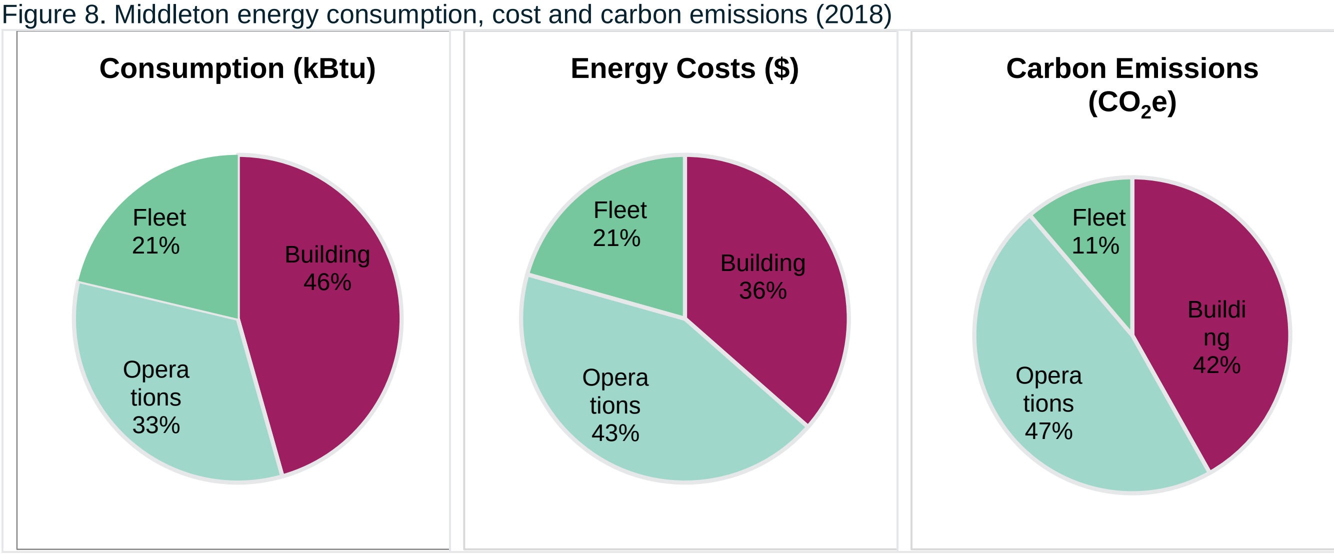
The three main energy inventory elements for Middleton's energy profile include buildings, operations, and municipal fleet. Table 29 provides details by category on what was included in development of the Middleton energy profile, based on the data provided by Middleton staff.

Table 29: Middleton inventory elements (2018 baseline)

Buildings	Operations	Fleet
Airport Municipal Operations Center City Hall EMS Department Fire Department Golf Course- Clubhouse Library Police Department Senior Center Tourism Department	Non-street lighting Parks and Recreation Pool Streetlights Wells/pumps/lifts Other operation	21 Police vehicles 7 Light-duty vehicles 3 Emergency vehicles 18 Heavy-duty vehicles 27 Pickups 37 Other

Figure 8 illustrates the percent contribution of each source to total energy use, cost, and carbon emissions. The cost and carbon intensity of the different fuels (electricity, natural gas, gasoline, and diesel) can significantly impact the contribution of each source to the total.

Figure 8. Middleton energy consumption, cost and carbon emissions (2018)



Breaking these elements down further, Table 30 details the annual energy use, carbon emissions, and energy cost associated with each building and operation use type. The buildings are listed individually; if there were multiple meters per building, we aggregated the values up to the building level. If there were multiple meters for operation data, it was aggregated by use type such as non-street lighting and wells, pumps, and lifts. Middleton installed a net-metered PV array on Terrace Avenue. The amount of electricity Middleton used for streetlighting, as shown in the table, reflects the amount of net electricity that Middleton purchased from the utility, with any reductions from solar panel production included as part of that amount. Middleton also hosts PV arrays on its police department building and on its operations center; however both systems use export meters, rather than net meters.

Table 30: Middleton baseline energy, carbon and cost data by building and operation use type (2018)

	Use/building	Net Electricity (kWh)	Natural gas (therms)	Carbon emissions (CO_2e metric tons)	Percent of total CO_2e	Energy cost
Buildings	Airport	39,776	1,265	37	1%	$5,135
	Municipal Operations Center	274,270	16,095	294	6%	$39,825
	City Hall	197,472	9,858	203	4%	$27,635
	EMS Department	116,545	8,847	136	3%	$18,130
	Fire Department	297,367	20,974	338	7%	$45,295
	Golf Course Clubhouse	100,752	3,975	98	2%	$13,470
	Library	251,996	10,345	247	5%	$33,925
	Police Department	466,426	16,355	442	10%	$61,120
	Senior Center	120,341	5,314	120	3%	$16,425
	Tourism Department	11,855	1,418	17	0.4%	$2,155
Operations	Non-street lighting	60,036	-	46	1%	$6,605
	Other operations	146,440	-	111	2%	$16,110
	Parks and Recreation	203,751	2,986	171	4%	$24,205
	Pool	105,481	8,452	125	3%	$16,675
	Streetlights	626,558	-	477	10%	$68,920
	Wells/pumps/lifts	1,556,511	9,289	1,235	27%	$176,790
	Fleet			518	11%	$150,930
	Total	**4,575,577**	**115,173**	**4,615**		**$723,350**

Figure 9 illustrates the energy use intensity (EUI) of Middleton buildings over the past several years and provides an ASHRAE 100-2018 benchmark value for comparison. The year over year comparisons can serve as a method of measurement and verification – both to review the impact of energy efficiency investments and to identify operational changes that may impact overall energy use. Similarly, comparing to ASHRAE's benchmark value can serve as a way to benchmark against buildings of similar use types and identify potential efficiency opportunities. The ASHRAE values represent a typical building type and do not account for buildings that may house multiple city departments or functions.

Figure 9: Middleton EUI benchmarking and comparison to ASHRAE benchmark

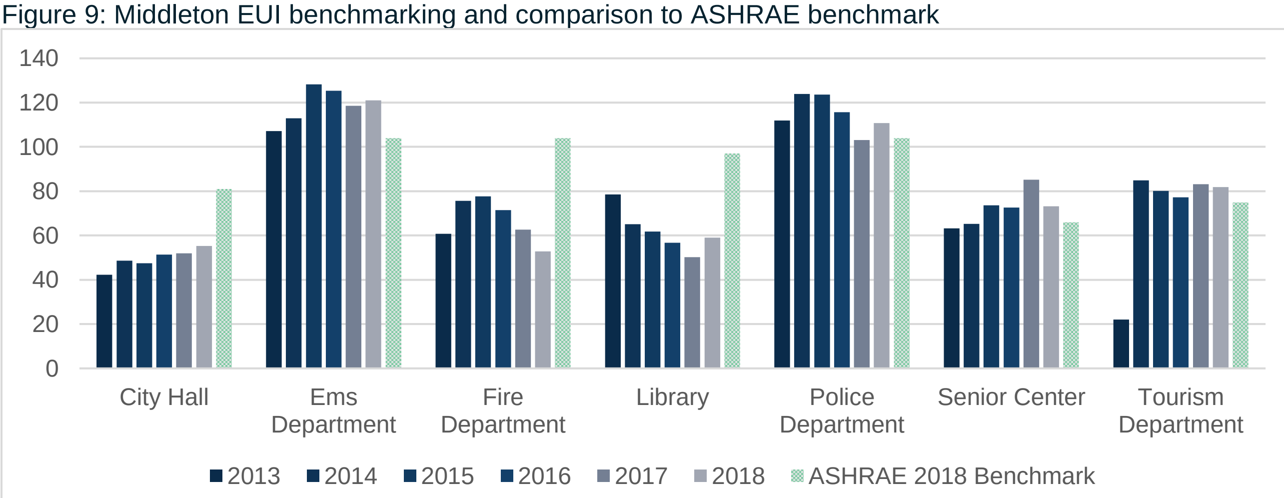


Table 31 illustrates the current and planned renewable energy consumption in the city. Upon completion of Middleton's currently planned and budgeted solar installations, as well as activation of its Renewable Energy Rider agreement with MG&E, renewable energy will provide approximately 27 percent of total electricity use in Middleton. The City currently has two installed solar arrays, a 100-kW installation on the police department and a 16-kW installation on a parking structure on Terrace Avenue. There are plans to add another 144 kW between the Senior Center, the City Garage, and the EMS Department in the coming year. The remainder of its renewable energy will come from a 5 MW solar array that MG&E is developing at the Middleton Airport. Middleton has executed an agreement with MG&E to use the Renewable Energy Rider to obtain the energy produced by a 500-kW portion of this development.

Table 31: Middleton renewable energy summary - current and planned production (as of 2019)

RENEWABLE ENERGY QUICK FACTS	
On-site net metered solar (kWh) - estimated[6]	246,079
On-site export metered solar (kWh)	113,880
Renewable Energy Rider (kWh) - estimated	920,528
Total renewable energy purchased/production	1,280,487
Percent of total gross electricity	**27%**

Table 32 illustrates the current vehicle fuel usage, carbon emissions, and fuel cost by vehicle type. The police department has the most significant energy footprint, driven largely by the need to idle to maintain car functions while not in motion and the high relative mileage. This significant use presents an excellent opportunity for conversion to hybrid vehicles as will be outlined below.

Table 32: Middleton vehicle fuel usage by vehicle type (2018)

Department	Number of vehicles	Gallons (gasoline or diesel)	CO_2e (metric tons)	Fuel cost
Police	21	20,190	172	$49,865
Light-duty	7	1,225	10	$3,025
Emergency Vehicles	3	5,490	47	$13,560
Pickups	27	12,885	110	$31,830
Heavy-duty	18	8,100	83	$24,300
Other	37	10,705	97	$28,350
Total	113	58,595	518	$150,930

[6] Includes both the current net-metered array and the three planned arrays.

MIDDLETON RECOMMENDATIONS FOR NEAR-TERM IMPLEMENTATION

Our analysis found energy investments that have a strong return on investment and significant energy savings potential. Implementing simple energy efficiency improvements to Middleton's municipal buildings can reduce building energy consumption by as much as 8 percent. Converting all streetlights would cut current streetlight electricity by 45 percent and reduce carbon emissions by around 210 tons. In the fleet department, the City should prioritize converting police vehicles to hybrids as they offer a payback around one year and lead to a 40 percent decline in lifetime carbon emissions. Lastly, by adding additional solar arrays to 3 sites, Middleton can increase the percent of renewable energy to 32 percent of total electricity.

Table 33 summarizes the carbon and energy cost savings that the City would see if they implemented the recommended near-term actions in each major opportunity area. The following sections provide additional detail on each opportunity.

Table 33: Middleton impact summary – estimated annual CO_2e and energy cost savings

Near-term Opportunity	CO_2e Reduction (metric tons)	Percent Carbon Reduction	Energy Cost Savings	Percent Energy Cost Reduction
Building efficiency	148	8%	$20,580	8%
Streetlights	210	44%	$30,265	44%
Fleet	72	14%	$27,250	18%
Solar	313	-	$45,120	-
Total opportunity	743	16%	$123,215	17%

Energy efficiency opportunities

Our analysis focused on near-term measures that not only have an energy or cost savings, but also may reduce maintenance costs, improve occupant comfort, or increase staff productivity. We also considered the ease and cost of implementation when prioritizing our recommendations.

To identify these opportunities, Slipstream conducted high-level walk-throughs for two buildings: the Middleton Police Department and Middleton EMS Department. We took note of major end-uses and process and spoke with building staff to understand building operations. The following provides a walk-through summary for each building with additional detail on energy savings potential below.

Middleton Police Department

The Middleton Police Department was built in 1989.

Observations

- There are many energy efficient building systems installed, including a heat recovery wheel, full condensing boilers with low temperature hot water system, and a large solar array.
- There is a planned LED upgrade.
- HVAC system has a sophisticated building automation system (BAS).

Recommendations

Lighting controls: If upgrading lighting fixtures to LED, consider adding vacancy sensor light switches to small rooms and integrated lighting fixtures complete with occupancy sensors, and photosensors in large open areas. These fixtures will automatically dim or shut off lights to reduce lighting energy in unoccupied rooms.

HVAC controls: Check to see if there are control sequences to implement through the BAS to save energy. Refer to the supply air temperature reset and hot water temperature reset strategies in the main report.

Demand-controlled ventilation (DCV): Install carbon dioxide sensors in open office areas and large meeting rooms to lower outside air intake when rooms are unoccupied.

Middleton EMS

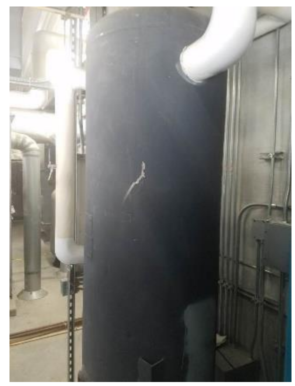
The Middleton EMS building was built in 2008.

Observations

- Some LED lighting installed and plan to upgrade to LED lighting.
- Large uninsulated hydronic hot water storage tank on the garage mezzanine.
- Some exterior lights were on during the day.
- Garage has efficient gas infrared heaters and ceiling fans installed.

Recommendations

LED retrofit and lighting controls: Complete upgrade to LED. Consider vacancy sensors for small rooms and occupancy and daylighting sensors for some of the conference and meeting rooms. Consider light fixtures that can be purchased with integrated occupancy controls and photosensors.



Insulate hot water tank: Install insulation for hot water tank. Elastomeric closed-cell insulation similar to Armacell ArmaFlex or Fiberglass Blanket insulation is recommended.[7]

HVAC controls: Check if there are simple control sequences that can be implemented through the BAS to save energy. Refer to the supply air temperature reset and hot water temperature reset strategies outlined in the main report.

DCV: Install carbon dioxide sensors in the meeting room to lower outside air intake when rooms are unoccupied.

Energy Savings Potential

For each measure identified, we calculated the total savings and payback. Calculations were based on a combination of resources, including the Wisconsin Technical Reference Manual, the International Energy Conservation Code, and internal research and expertise. References and assumptions for energy saving calculations and cost data are in Appendix E. For more complicated measures, we developed simple energy models to quantify levels of impact. For details and definitions on the measures, please refer to the Main Report of the energy plan that has descriptions of the measures.

Table 34 provides additional detail on the energy efficiency opportunities for each building and includes energy costs savings and simple payback. Measures are organized by simple payback to identify measures that will recovers capital costs quickly.

The completion of the already-planned upgrades to LED lighting are estimated to generate the largest energy savings for both buildings. While the measures are listed below separately, we recommend that lighting controls be implemented with LED upgrades to reduce total upfront costs. The savings listed

[7] http://www.armacell.us/products/aparmaflexsaaparmaflexfssa/

below for controls are based on a building already upgraded to LEDs and the incremental costs below assume that the controls and LED upgrades are completed at the same time. Controls implemented on their own would have a higher upfront cost.

Implementing DCV in the police department can generate significant savings, but this involves adding carbon dioxide sensors to open areas and integrating those with the BAS. The next biggest energy saver is air handling unit (AHU) temperature reset which should be easy to implement with the BAS system for the two buildings. Hot water temperature reset can applied to the EMS Building boiler system to save significant heating energy as well. There is also an uninsulated hot water buffer tank in the mechanical penthouse that wastes considerable energy and we recommend be insulated.

Table 34: Energy saving measures for Middleton walk-through buildings

Building	Cost	Electric savings (kWh)	Gas savings (therms)[8]	Total energy savings	Cost savings	Simple payback (years)
EMS Department						
Lighting controls - daylighting	$70	2,120	-50	0.2%	$200	0.3
Lighting controls - occupancy	$70	2,000	-40	0.2%	$190	0.4
HVAC AHU reset	$100	1,300	140	1.5%	$230	0.4
Lighting controls - garage	$80	1,900	-40	0.2%	$180	0.4
DCV - assembly space	$340	460	240	2.0%	$200	1.7
LED lighting - task tuning	$320	1,800	-40	0.2%	$170	1.8
Custom - uninsulated tank	$1,310	0	1,160	9.1%	$700	1.9
HVAC boiler reset	$610	0	500	3.9%	$300	2.0
DCV - office space	$240	150	80	0.6%	$60	3.8
EMS Department Total	**$3,140**	**9,720**	**1,950**	**17.9%**	**$2,240**	
Police Department						
Lighting controls - daylighting	$70	2,240	-50	0.1%	$220	0.3
Lighting controls - occupancy	$300	8,440	-190	0.3%	$820	0.4
HVAC AHU reset	$290	3,430	370	1.6%	$600	0.5
DCV - assembly space	$1,800	2,420	1,280	4.5%	$1,030	1.7
LED lighting - task tuning	$840	4,770	-110	0.2%	$460	1.8
HVAC boiler reset	$1,220	0	890	3.0%	$530	2.3
LED lighting retrofit - interior	$14,400	64,690	-1,440	2.6%	$6,250	2.3
Police Department Total	**$18,920**	**85,970**	**750**	**12.3%**	**$9,910**	
Grand Total	**$22,060**	**95,700**	**2,690**		**$12,140**	

Finally, while we did not visit every building in Middleton's municipal operations, we did see similar building types in the walk-throughs with other communities. For those buildings for which we were unable to conduct walk-throughs, we asked community representatives to provide some details on particular end-uses in each building. By using that feedback and leveraging information gathered during other communities' site visits, we were able to estimate savings for the other Middleton buildings. We also included a custom measure where we evaluated the savings potential for changing out the furnaces to rooftop units for the Middleton Senior Center. These savings are summarized in Table 35.

[8] Negative values reflect an increase in heating demand due to interactive effects – in all cases total savings is still positive.

However, these results are not based on a site walk-through and should be confirmed based on further review of building equipment and conditions.

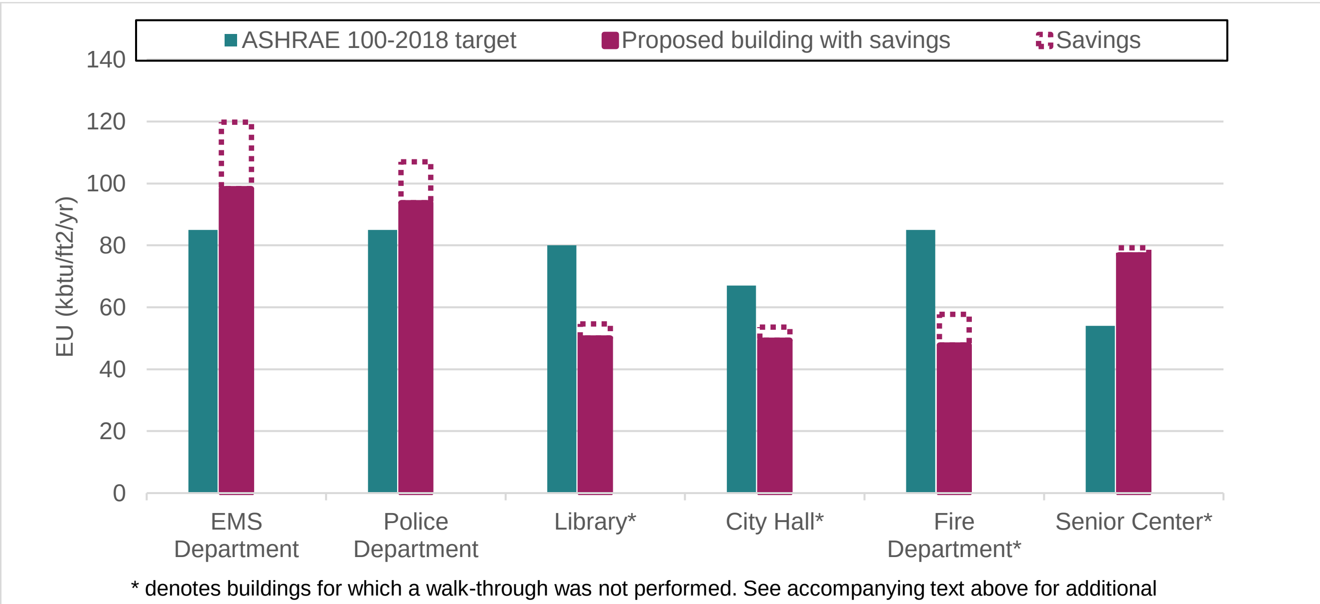
Table 35. Energy saving measures for Middleton – non-site walk-through buildings

Building	Cost	Electric savings (kWh)	Gas savings (therms)	Total energy savings	Cost savings	Simple payback (years)
City Hall						
HVAC AHU reset	$290	3,700	400	3.2%	$650	0.4
HVAC boiler reset	$1,220	0	740	4.5%	$440	2.8
City Hall Total	**$1,090**	**3,700**	**1,140**	**7.8%**	**$1,090**	**1.6**
Fire Department						
Lighting controls - daylighting	$100	2,950	-70	0.4%	$280	0.4
Lighting controls - occupancy	$100	2,780	-60	0.4%	$270	0.4
Lighting controls - garage	$70	1,760	-40	0.2%	$170	0.4
HVAC AHU reset	$190	1,800	190	3.0%	$320	0.6
DCV - assembly space	$470	640	340	4.2%	$270	1.7
LED lighting - task tuning	$440	2,510	-60	0.3%	$240	1.8
LED lighting retrofit - interior	$4,900	19,820	-440	2.8%	$1,910	2.6
DCV - office space	$340	210	110	1.3%	$90	3.8
HVAC boiler reset	$1,220	0	390	4.5%	$230	5.3
Fire Department Total	**$3,830**	**32,460**	**360**	**17.2%**	**$3,790**	**1.9**
Library						
HVAC AHU reset	$190	3,960	430	3.2%	$690	0.3
DCV - assembly space	$1,560	1,050	550	3.3%	$450	3.5
HVAC boiler reset	$1,840	0	330	1.9%	$200	9.3
Library Total	**$1,340**	**5,010**	**1,310**	**8.4%**	**$1,340**	**4.4**
Senior Center						
Lighting controls - occupancy	$40	1,160	-30	0.1%	$110	0.4
LED lighting - task tuning	$70	520	-10	0.1%	$50	1.4
Custom - RTU retrofit	n/a	21,300	-480	2.6%	$2,060	
Senior Center Total	**$2,240**	**22,970**	**-520**	**2.8%**	**$2,220**	**0.9**
Grand Total	**$8,490**	**64,140**	**2,290**		**$8,430**	**2.2**

Figure 10 shows the EUI of each building if all energy efficiency measures are implemented along with an ASHRAE Standard 100-2018 benchmark value for comparison.

Our analysis shows that the energy measures outlined above for the Middleton EMS and Middleton Police Department help bring them much closer to the ASHRAE 100 target values for their respective building types. This is particularly true for the Middleton EMS Department, which has a significantly higher energy use than its recommended target energy use. The police department is a well-designed building, but Figure 10 shows it may be worthwhile to consider the measures above or even a further study to understand why it uses more energy the benchmark target value. We expect that the other Middleton buildings would see some mild energy reductions from the measures above, but we conservatively estimated energy savings as we did not conduct a walk-through.

Figure 10: Middleton building EUI savings



Street Lighting Opportunities

Converting streetlights to LEDs has a large energy saving potential. In addition to reduced energy use annually, LEDs also last longer and thus reduce lifetime maintenance costs. The lights can also improve lighting quality, improve perception of safety, and reduce light pollution.

Table 36 illustrates the lifetime energy savings, carbon savings and cost savings associated with converting one high-pressure sodium fixture to a LED fixture. This standard lifetime analysis assumes that streetlights are owned by the municipality and serves to illustrate potential savings from a conversion. The upfront cost in Table 36 ,which includes both labor cost and material cost, is estimated from conversations with city officials who have implemented LED retrofits in the last few years. The Wisconsin Technical Resource Manual estimates the cost per fixture to be slightly higher. However, as LED costs are rapidly decreasing, we opted to use cost estimates from recent installations in an attempt to accurately represent current costs. The cost savings reported represent avoided maintenance costs and avoided energy costs. Appendix B provides more details on the assumptions made for these calculations.

Table 36: LED lifetime cost analysis

Lighting type	Energy savings (kWh)	CO_2e savings (metric tons)	Upfront cost	Cost savings	Payback period (years)
70 W	3,430	2.6	$249	$275	6.8
100 W	7,750	5.9	$249	$670	3.9
150 W	9,480	7.2	$299	$800	3.6
250 W	16,070	12.2	$399	$1,315	3.3
400 W	23,800	18.1	$499	$1,930	3

Table 37 illustrates the potential electricity, carbon, and energy cost savings from converting all streetlights to LEDs. Based on the wattage of current streetlights, we calculated the energy use from LED-equivalent bulbs and subtracted this from 2018 streetlight electricity usage. Using this energy savings value, we applied a standard carbon factor and electricity rate to estimate the carbon and cost savings.

As a note, the cost savings reported below represent potential energy cost savings, assuming a standard kWh charge for electricity usage. However, around a quarter of Middleton's fixtures are owned by MGE or Alliant and about another 55 percent of Middleton's fixtures are maintained by one of the utilities. For these lights, the city is under a payment arrangement with the utility. Thus, the exact costs savings for upgrading those fixtures may ultimately be different based on the rate structure. Our analysis did not attempt to replicate the payment structures under those agreements. Rather, this analysis can serve as the basis of conversations with MGE or Alliant about how to structure the LED rates in order to yield similar cost savings for the City.

Table 37: Middleton streetlights - annual savings

STREETLIGHT ANNUAL SAVINGS	
Number of lights	1,229
Energy savings (kWh)	275,124
CO_2e savings (metric tons)	210
Cost savings	$30,265

Fleet Opportunities

The market for alternative fuel vehicles is rapidly developing. In the next five years, several new options will exist for municipal fleets, but at this point, the largest two opportunities are police and light-duty vehicles. A few niche alternatives exist for other vehicle types, but each of them has a substantial incremental upfront cost – making them less of a viable option. Based on conversations with the collaborating communities, we left these high incremental cost options out of our final recommendations, but our completed analysis can be found in the main report.

Table 38 illustrates the payback period for police vehicles and light-duty vehicles, assuming 14,000 miles driven for police vehicles and 3,500 miles driven for light-duty vehicles. As the numbers illustrate, hybrid police vehicles present a great opportunity for conversion – with a payback period around one year and a lifetime carbon reduction of between 35 and 55 percent. Although light-duty vehicles have less favorable payback periods, increasing the miles driven per vehicle would greatly improve these numbers. Once a vehicle hits around 10,000 to 15,000 miles driven a year, the net lifetime cost breaks even compared to a conventional car.

Table 38: Middleton lifetime cost analysis – relevant alternative fleet vehicles

		Vehicle Lifetime	Incremental vehicle cost	Annual cost savings	Lifetime savings	Payback period	Lifetime CO_2e reduction
Police	Hybrid Patrol SUV	8	$3,500	$1,640	$10,200	**1.2**	41%
	Hybrid Patrol Sedan	8	$3,500	$2,170	$14,560	**1**	55%
	Electric Motorcycle	8	$390	$825	$8,600	**<1**	35%
Light-duty	Passenger Vehicle	15	$8,600	$350	-$3,700	-	43%
	Plug-in Hybrid SUV	15	$10,000	$215	-$7,000	-	35%

Table 39 illustrates the savings from converting all light-duty and police vehicles in the Middleton municipal fleet. The transition to hybrid police vehicles leads to a large benefit – over a 40 percent reduction in both carbon emissions and fuel costs. Appendix C provides more detail on the assumptions used in these calculations.

Table 39: Middleton potential annual fuel savings - adoption of light-duty and police vehicles

		CO_2e (metric tons)		Fuel cost	
Department	Number of vehicles	Current	Alternative	Current	Alternative
Police	21	172	104	$49,865	$24,460
Light-duty	7	10	6	$3,025	$1,180

Solar Energy Opportunities

The solar analysis analyzed the potential for new solar arrays at three sites in Middleton. The arrays on the wells are ground-mounted arrays to maximize the size of the installation while the array on the golf course club is a roof-mounted array.

Table 40 summarizes the production potential for each array. The recommended PV system size for each location considers the site's current electric consumption and the size and configuration of an array that each site could support. MG&E currently allows for advantageous net metering of distributed solar PV arrays if the overall system capacity does not exceed 100 kW AC. All recommended systems are sized below the 100-kW threshold. These arrays would increase renewable municipal electricity use to 30 percent of total use – helping meet its goal to be 100 percent renewable by 2035.

Table 40: Middleton summary of solar potential by site

Site Name	Address	Annual consumption (2018, kWh)	Potential PV capacity (kW DC)	Estimated production (kWh)	Savings
Golf Course Clubhouse	1322 Pleasant Valley Rd	100,752	31.6	40,193	40%
Well #6	8490 Greenway Blvd	278,746	24.8	31,509	11%
Well #8	3222 West Point Rd	218,916	80.6	110,649	51%
Total		598,414	137	182,351	30%

Table 41 provides an estimated cost for each of the solar arrays. The estimated cost for the systems of $1,818 per kW is based on current data for the Dane County market for commercial PV installations. A 10 percent premium was added to the cost of the installation on the Golf Course clubhouse to reflect installation challenges that may be encountered due to the complexity of the building's roof. Since the cost estimates reflect market data, exact costs may vary by solar contractor.

Focus on Energy offers rebates for commercial-scale solar installations through a competitive request for proposal under its Renewable Energy Competitive Incentive Program (RECIP) program. The RECIP grants, which are not guaranteed, typically provide rebates that cover between 10 percent and 40 percent of the system cost. This analysis conservatively assumes a 15 percent rebate amount.

Table 41. Estimated cost of recommended Middleton PV arrays

Site Name	Total cost	FoE rebate	Net cost
Golf Course Clubhouse	$63,200	$9,480	$53,720
Well #6	$45,088	$6,763	$38,325
Well #8	$146,500	$21,975	$124,525
Total	**$254,788**	**$38,218**	**$216,570**

Table 42 provides a summary description of the array at each site as well as an aerial view of the arrays. The red outlines represent where the arrays would sit.

Table 42: Middleton description of potential PV arrays

Description of site	Aerial views with potential PV mounting
The **Golf Course Clubhouse** roof offers five areas that may be able to house solar panels. The analysis assumes flush-mounted racking for all four sections. On-site shading analysis should be conducted to assess the self-shading of four of the five roof sections, which may be affected by shading. Customizing a PV array to fit the roof of the clubhouse may add to the expense of the system.	
The open space to the south **of Municipal Well #6** has unobstructed south-facing sun exposure. A fixed-tilt ground-mounted or pole-mounted PV system could be installed in the space. The model used for this analysis assumed a 30 degree south-facing tilt for the panels and a ground coverage ratio (GCR) of 0.5, which would allow for two rows of two-deep panels on the site. In reviewing this option, Middleton should consider the possibility of development in the lot south of the proposed array. Development in this space could reduce the amount of insolation available to the system and therefore reduce the cost-effectiveness of the project.	

Description of site	Aerial views with potential PV mounting
Municipal Well #8 has four areas, with unstructured south-facing sun exposure, on open land that are well-suited for ground-mounted or pole-mounted PV arrays. The model assumed a 30 degree south-facing tilt for the panels and GCRs between 0.45 and 0.47 for the three portions of the array. (The southern-most portion of the array would be a single row and thus the GCR does not apply.) In reviewing this option, Middleton should consider the possibility of additional building in the lot to the south and east of the array. Development in this space could reduce the amount of insolation available to the system and therefore reduce the cost-effectiveness of the project.	

MONONA

COMMUNITY-SPECIFIC MUNICIPAL ENERGY PLAN

Wisconsin Office of Energy Innovation Grant

MONONA BACKGROUND

The city of Monona, with a population of 8,104, has a long history of investing in energy efficiency and solar power as well as tracking data to meet their sustainability goals. Monona is part of the Energy Independent Communities, which is a voluntary agreement between the State of Wisconsin and communities that adopt the goal of generating 25 percent of their energy from renewable energy sources locally by 2025. Just recently, the City enacted a goal to reduce energy use 15 percent by 2030, to hit 100 percent renewable electricity by 2030, and to reach 100 percent renewable energy by 2040. The City is unique in that it is surrounded by Madison and Lake Monona, which inhibits the level of new development that it expects to see. For solar investments, all municipal rooftops already have solar panels installed, which offers a challenge unique amongst the collaborating communities and requires Monona to explore other options in alternative energy development.

This chapter provides a detailed summary of the Monona energy plan. We begin by summarizing Monona's energy profile to provide a baseline understanding of current energy consumption, costs and carbon emissions for 2018. We then delve into our recommendations for near terms investments or action, split out into four categories: building energy efficiency, street lighting opportunities, fleet opportunities, and solar energy opportunities.

COMMUNITY ENERGY PROFILE

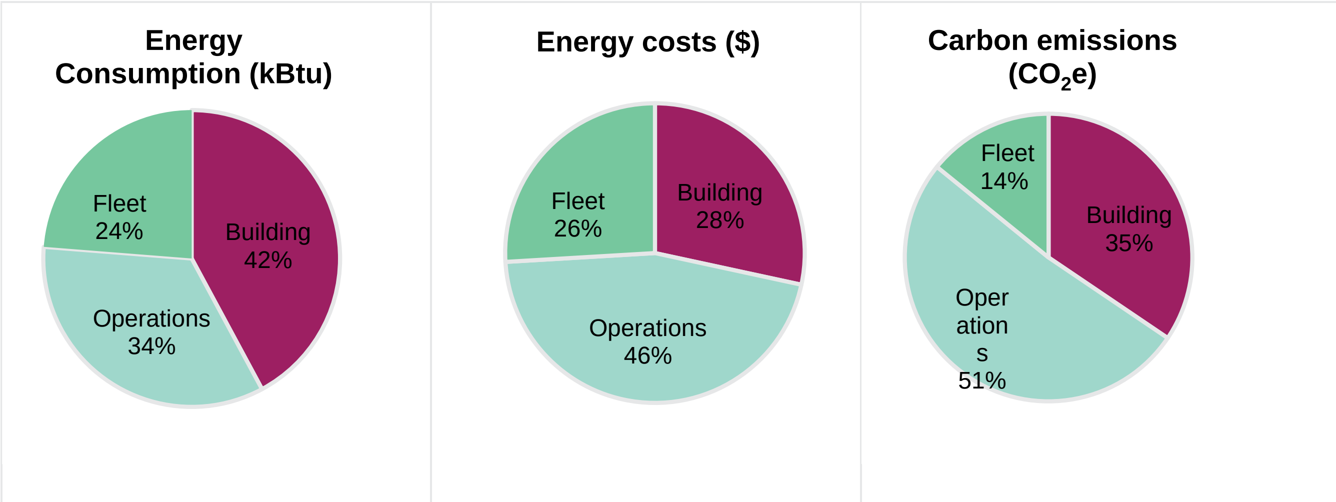
The three main energy inventory elements for Monona's energy profile include buildings, operations, and municipal fleet. Table 43 provides details by category on what was included in development of the Monona energy profile, based on the data provided by Monona staff.

Table 43: Monona inventory elements (2018 baseline)

Buildings	Operations	Fleet
City Hall	Wells/Pumps/Lifts	12 Police vehicles
Library	Street Lighting	4 Administration vehicles
Community Center	Parks & Rec Facilities	5 Parks & Recreation vehicles
Public Works Garage	Non-street lighting	30 Public Works vehicles
	Pool	8 Emergency vehicles

Figure 11 illustrates the percent contribution of each source to total energy use, cost, and carbon emissions. The cost and carbon intensity of the different fuels (electricity, natural gas, gasoline, and diesel) can significantly impact the contribution of each source to the total.

Figure 11: Monona energy consumption, cost and carbon emissions (2018)



Breaking these elements down further, Table 44 details the annual energy use, carbon emissions, and energy cost associated with each building and operation use type. The buildings are listed individually; if there were multiple meters per building, we aggregated the values up to the building level. If there were multiple meters for operation data, it was aggregated by use type such as non-street lighting and wells, pumps, and lifts. Monona's City Hall, Library, Public Works Garage, and one well host net-metered PV systems. The amount of electricity used by these, as shown in the table, reflects the amount of net electricity that Monona purchased from the utility, with any reductions from solar panel production included as part of that amount.

Table 44: Monona baseline energy, carbon and cost data by building and operation use type (2018)

	Use/building	Net Electricity (kWh)	Natural gas (therms)	Carbon emissions (CO_2e metric tons)	Percent of total CO_2e	Energy cost
Buildings	City Hall	234,065	17,233	270	13%	$36,085
	Community Center	141,125	10,532	163	8%	$21,845
	Library	154,202	12,723	185	9%	$24,595
	Public Works Garage	46,618	15,303	117	5%	$14,310
Operations	Non-street lighting	7,163	-	5	0.2%	$790
	Parks and Rec	88,438	979	73	3%	$10,315
	Pool	82,100	13,424	134	6%	$17,085
	Street lights	694,670	-	529	25%	$76,415
	Wells	409,379	635	315	15%	$45,410
	Lift Stations	47,788	49	36	1.5%	$5,285
	Water Towers	4,627		3.5	0.5%	$510
	Fleet	-	-	302	14%	$88,490
	Total	**1,910,175**	**70,878**	**2,133**		**$341,140**

Figure 12 illustrates the energy use intensity (EUI) of Monona buildings over the past several years and provides an ASHRAE 100-2018 benchmark value for comparison. The year over year comparisons can serve as a method of measurement and verification – both to review the impact of energy efficiency investments and to identify operational changes that may impact overall energy use. Similarly, comparing to ASHRAE's benchmark value can serve as a way to benchmark against buildings of similar use types and identify potential efficiency opportunities. It's important to note that the ASHRAE values represent a typical building type and do not account for buildings that may house multiple city departments or functions, such as the Monona City Hall which also houses its police department and likely drives a higher EUI.

Figure 12: Monona EUI benchmarking and comparison to ASHRAE benchmark

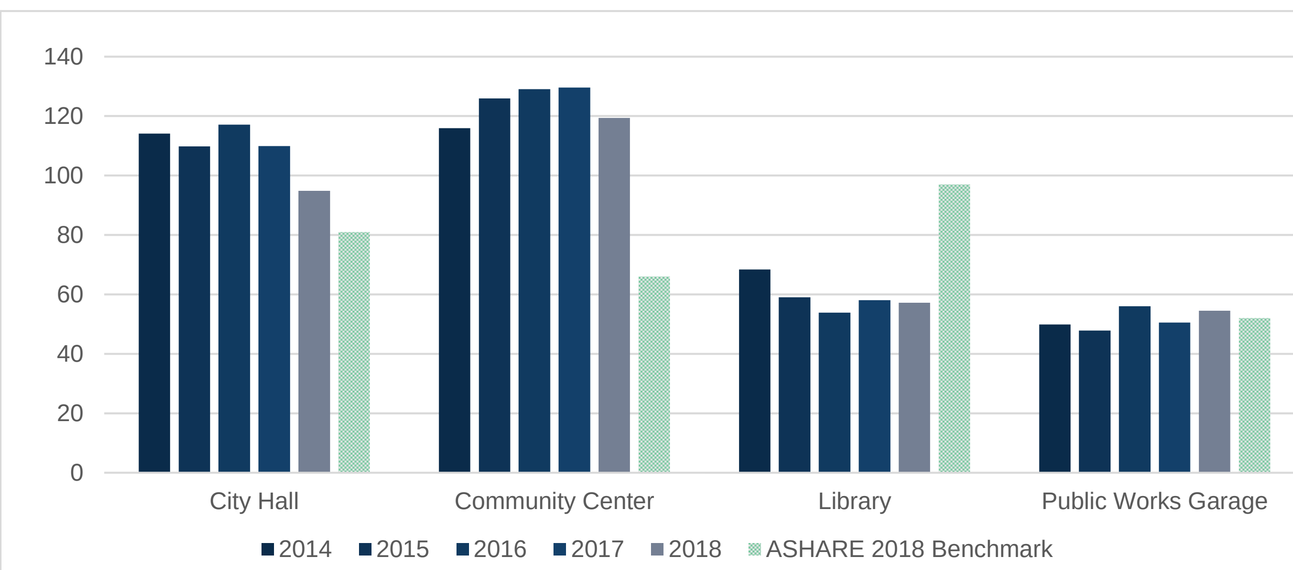


Table 45 illustrates the current renewable energy consumption in the city. On-site solar currently makes up around 7 percent of total electricity use in Monona – leaving significant potential for additional renewable energy development or purchases.

Table 45: Monona renewable energy summary - current production (as of 2019)

Building	Capacity (kw)	Annual production (kWh)
Public Works Garage	56	59,810
Library	47	34,445
Drinking Water Treatment Plant	29	32,684
City Hall	25	17,285
Total	157	144,224

Table 46 illustrates the current vehicle fuel usage, carbon emissions, and fuel cost by department. The police department has the most significant energy footprint, driven largely by the need to idle to maintain car functions while not in motions and the high relative mileage. This significant use presents an excellent opportunity for conversion to hybrid vehicles as will be outlined below.

Table 46: Monona vehicle fuel usage by department (2018)

Department	Number of vehicles	Gallons (gasoline or diesel)	CO2e (metric tons)	Fuel cost
Police	12	14,216	121	$33,790
Public Works	30	11,884	115	$35,105
Emergency Vehicles	8	4,581	43	$12,935
Parks & Rec	5	1,720	15	$4,310
Administration	4	988	8	$2,350
Total	**59**	**33,389**	**302**	**$88,490**

MONONA RECOMMENDATIONS FOR NEAR-TERM IMPLEMENTATION

Our analysis found energy investments that have a strong return on investment and significant energy savings potential. Implementing simple energy efficiency improvements to Monona's municipal buildings can reduce building energy consumption by as much as 7 percent. By converting all streetlights to LEDs, the City could cut annual streetlight electricity use in half – reducing utility costs and saving around 145 tons of CO_2e annually. In the fleet department, Monona should prioritize converting police vehicles to hybrids as they offer a payback around one year and lead to a 40 percent decline in lifetime carbon emissions. Lastly, as Monona has minimal on-site opportunities for solar, we provided an analysis below on options for replacing an existing PV system that has a contract that is expiring.

Table 47 summarizes the carbon and energy cost savings that the City would see if they implemented the recommended near-term actions in each major opportunity area. The following sections provide details on each opportunity.

Table 47: Monona impact summary – estimated annual CO_2e and energy cost savings

Near-term Opportunity	CO_2e Reduction (metric tons)	Percent Carbon Reduction	Energy Cost Savings	Percent Energy Cost Reduction
Building Efficiency	70	11%	$10,180	12%
Streetlights	144	27%	$20,820	27%
Fleet	48	16%	$13,890	16%
Total opportunity	262	12%	$44,890	13%

Energy efficiency opportunities

Our analysis focused on near-term measures that not only have an energy or cost savings, but also may reduce maintenance costs, improve occupant comfort, or increase staff productivity. We also considered the ease and cost of implementation when prioritizing our recommendations.

To identify these opportunities, Slipstream conducted high-level walk-through for two buildings: the Monona Community Center and Monona Library. We took note of major end-uses and process and spoke with building staff to understand building operations. The following provides a walk-through summary for each building with additional detail on energy savings potential below.

Monona Community Center

The Monona Community Center was built in 1963. It includes a senior center, computer lab, event space, and small gym.

Observations

- The community center exterior walls facing the pool were built in a "California" style to match the pool. The walls are 3" to4" thick and the windows are single pane, leading to high heat loss through the wall.
- Condensation on storage room windows due to single pane window and HVAC system.
- The air handling unit (AHU) is original to the building and due for replacement but it is expensive to retrofit.
- LED lighting has been installed in the senior center and some other spaces.
- Current event space has metal halide lamps with limited dimming controls.

Recommendations

Event space lighting: Upgrading the event space lighting to LED integrated lighting package will reduce energy and allow flexibility for lighting events. Modern event space lighting and LED lamps can allow easy control, wireless control, different lighting "scenes", and even some color control to increase the value of the space.

Event space window replacement: Replacing the single pane windows with double pane windows will lower energy usage and improve the thermal comfort of the event space. The current wall likely gets very cold in the winter and the cold "radiates" to people near it.

Lighting controls: If upgrading lighting fixtures to LED, consider adding vacancy sensor light switches to small rooms and integrated lighting fixtures complete with occupancy sensors, photosensors in large open areas. These fixtures will automatically dim or shut off lights to reduce lighting energy in unoccupied rooms.

Building upgrades vs. new building investment: Given the desire for a more modern community center for Monona, consider holding off on major building energy efficiency upgrades to save capital investment for new construction. Refer to the new construction design guidelines in the Policies section of the main report for recommendations for new construction.

Monona Library

The Monona Library was built in 1964 and expanded in 2001.

Observations

- LED retrofit is scheduled.
- There is a lot of window and skylight in the upstairs library allowing in lots of daylight. However, lights in the library appear to be on all the time during the day.
- Occupancy sensors are planned for city council chamber.
- AHU in the basement would be costly to replace and mechanical room has limited doorway width.
- Four of the rooftop units (RTUs) are single zone and the fifth unit is variable air volume (VAV).

Recommendations

LED retrofit and lighting controls: Complete upgrade to LED. Add daylighting controls for main library space with continuous dimming to reduce light levels in the library, making provisions for bookshelves, particularly for skylight lighting. Consider vacancy sensors for small rooms. Consider light fixtures that can be purchased with integrated occupancy controls and photosensors.

Supply air temperature reset (HVAC AHU reset): Implement supply air temperature reset based on outside air temperature for RTUs. This will increase the temperature of supply air when it is cold outside, saving energy. Refer to the general recommendations section in report for more details.

Demand-controlled ventilation (DCV): Install carbon dioxide sensors in the single zone RTUs to lower outside air intake when rooms are unoccupied. Install the carbon dioxide sensors within the children's library area to adjust the outdoor air level for the VAV RTU.

Energy Saving Potential

For each measure identified, we calculated the total savings and payback. Calculations were based on a combination of resources, including the Wisconsin Technical Reference Manual, the International Energy Conservation Code, and internal research and expertise. References and assumptions for energy saving calculations and cost data are in Appendix D. For more complicated measures, we developed simple energy models to understand levels of impact. For details and definitions on the measures, please refer to the Main Report of the energy plan that has descriptions of the measures.

Table 48 provides additional detail on the energy efficiency opportunities for each building and includes energy costs savings and simple payback. Measures are organized by simple payback to identify measures that will recovers capital costs quickly.

Fully upgrading to LED lighting is estimated to generate the largest electricity savings in the Monona Community Center and Library. LED lighting is already planned for the Library and some LED fixtures are already installed in the Community Center. While the measures are listed below separately, we recommend that lighting controls be implemented with LED upgrades to reduce total upfront costs. The savings listed below for controls are based on a building already upgraded to LEDs and the incremental costs below assume that the controls and LED upgrades are completed at the same time. Controls implemented on their own would have a higher upfront cost.

The cost savings for the Community Center's event space lighting LED upgrade with new lighting controls was broken out in a custom model to show the savings for upgrading the space, as upgrades to the event space may make it more marketable. There is also significant savings for changing the windows to single pane in the event space. However, window replacement is costly, as shown by the 20-year payback, and we recommend checking with a contractor on pricing to see if it will recover cost.

In the library, additional energy savers are the AHU temperature reset and hot water temperature reset. The AHU measure should be relatively easy to implement at the rooftop AHU's packaged controls. The hot water temperature reset system will need to be evaluated based on the existing boiler controls.

Table 48: Energy saving measures for Monona walk-through buildings

Building	Cost	Electric savings (kWh)	Gas savings (therms)[9]	Total energy savings	Cost savings	Simple payback (years)
Community Center						
Lighting controls - daylighting	$50	1,410	-30	0.1%	$140	0.3
Lighting controls - occupancy	$50	1,330	-30	0.1%	$130	0.4
HVAC boiler reset	$610	0	870	5.1%	$520	1.2
LED lighting - task tuning	$170	1,200	-30	0.1%	$120	1.4
LED lighting retrofit - interior	$3,630	11,460	-260	0.8%	$1,110	3.3
Custom - Event Space Lighting	$1,000	2,500	-80	0.1%	$230	4.4
Custom - Event Space Window Replacement	$14,150	5,330	180	2.1%	$690	20.4
Community Center Total	**$19,660**	**23,240**	**630**	**8.3%**	**$2,940**	

[9] Negative values reflect an increase in heating demand due to interactive effects – in all cases total savings is still positive.

Library						
Lighting controls - daylighting	$300	9,050	-200	0.6%	$870	0.3
Lighting controls - occupancy	$100	2,840	-60	0.2%	$270	0.4
HVAC AHU temp reset	$480	3,550	380	3.0%	$620	0.8
LED lighting - task tuning	$700	5,130	-110	0.4%	$500	1.4
HVAC boiler reset	$610	0	460	2.7%	$270	2.2
LED lighting retrofit - interior	$9,810	30,920	-690	2.2%	$2,990	3.3
DCV - assembly space	$930	630	330	2.1%	$270	3.5
Library Total	**$12,930**	**52,110**	**100**	**11.3%**	**$5,800**	
Grand Total	**$32,590**	**75,350**	**740**		**$8,730**	

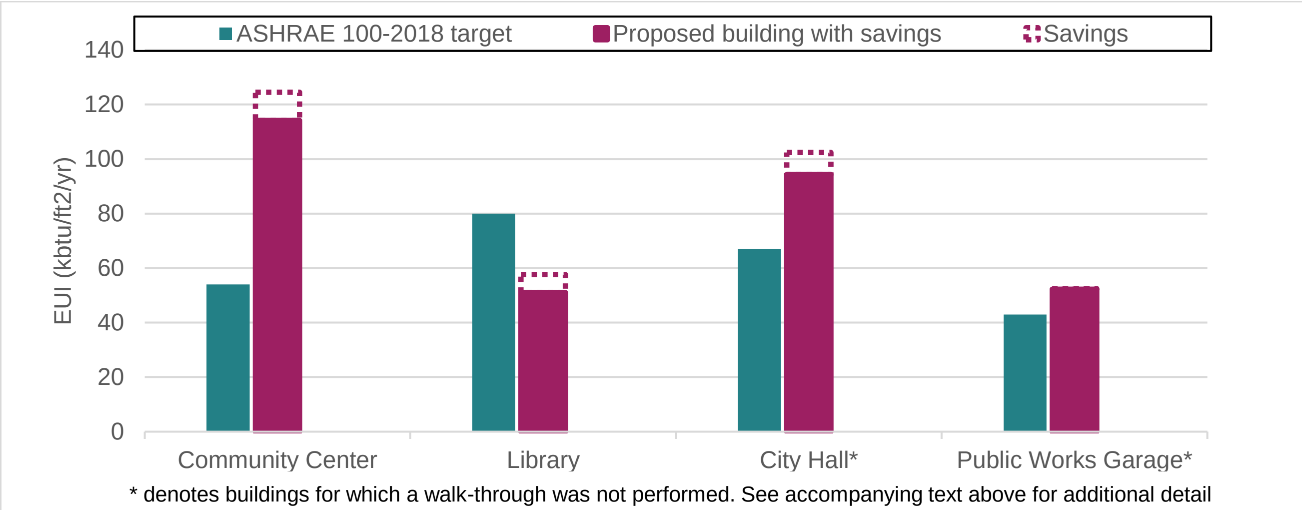
Finally, while we did not visit every building in Monona's municipal operations, we did see similar building types in the walk-throughs with other communities. For those buildings for which we were unable to conduct walk-throughs (the City Hall and the Public Works Garage), we asked community representatives to provide some details on particular end-uses in each building. By using that feedback and leveraging information gathered during other communities' site visits, we were able to estimate savings for the other Monona buildings. These savings are summarized in Table 49. However, these results are not based on a site walk-through and should be confirmed based on further review of building equipment and conditions.

Table 49: Energy saving measures for Monona – non-site walk-through buildings

Building	Cost	Electric savings (kWh)	Gas savings (therms)	Total energy savings	Cost savings	Simple payback (years)
City Hall						
Lighting controls - daylighting	$80	2,460	-50	0.1%	$240	0.3
Lighting controls - occupancy	$80	2,310	-50	0.1%	$220	0.4
HVAC AHU temp reset	$290	3,420	370	1.7%	$600	0.5
HVAC boiler reset	$1,220	0	1,460	5.1%	$880	1.4
LED lighting - task tuning	$330	2,090	-50	0.1%	$200	1.7
DCV - assembly space	$450	300	160	0.6%	$130	3.5
DCV - office space	$320	100	50	0.2%	$40	7.6
City Hall Total	**$2,770**	**10,680**	**1,890**	**7.9%**	**$2,310**	
Public Works Garage						
Lighting controls - garage	$40	990	-20	0.1%	$100	0.4
LED lighting retrofit - interior	$2,710	6,410	-140	0.5%	$620	4.4
Public Works Garage Total	**$2,750**	**7,400**	**-160**	**0.6%**	**$710**	
Grand Total	**$5,520**	**18,070**	**1,720**		**$3,020**	

Figure 13 shows the EUI of each building if all energy efficiency measures are implemented along with an ASHRAE Standard 100-2018 benchmark value for comparison. Our analysis shows that the energy measures outlined above for the Monona Community Center have a significant impact on energy use compared to the ASHRAE 100 target values for a similar building. However, due to the age of the building and equipment, it still uses a high amount of energy for its building type. The Monona Library has a newer addition and already meets the target EUI, but some further improvements could be made. We expect that other buildings would see some mild energy reductions, but we conservatively estimated energy savings because we did not conduct a walk-through.

Figure 13: Monona building EUI savings



Street Lighting Opportunities

Converting streetlights to LEDs has a large energy saving potential. In addition to reduced energy use annually, LEDs also last longer and thus reduce lifetime maintenance costs. The lights can also improve lighting quality, improve perception of safety, and reduce light pollution.

Table 50 illustrates the lifetime energy savings, carbon savings and cost savings associated with converting one high-pressure sodium fixture to a LED fixture. This standard lifetime analysis assumes that streetlights are owned by the municipality and serves to illustrate potential savings from a conversion. The upfront cost in Table 51, which includes both labor cost and material cost, is estimated from conversations with city officials who have implemented LED retrofits in the last few years. The Wisconsin Technical Resource Manual estimates the cost per fixture to be slightly higher. However, as LED costs are rapidly decreasing, we opted to use cost estimates from recent installations in an attempt to accurately represent current costs. The cost savings reported represent avoided maintenance costs and avoided energy costs. The results illustrate that the higher the wattage, the more economically beneficial it becomes to convert the fixture to a LED. Appendix B provides more details on the assumptions made for these calculations.

Table 50: LED lifetime cost analysis – cost per fixture

Lighting type	Energy savings (kWh)	CO_2e savings (metric tons)	Upfront cost	Cost savings	Payback period (years)
70 W	3,430	2.6	$249	$275	6.8
100 W	7,750	5.9	$249	$670	3.9
150 W	9,480	7.2	$299	$800	3.6
250 W	16,070	12.2	$399	$1,315	3.3
400 W	23,800	18.1	$499	$1,930	3

Table 51 illustrates the potential electricity, carbon, and energy cost savings from converting all streetlights to LEDs. Based on the wattage of current streetlights, we calculated the energy use from LED-equivalent bulbs and subtracted this from 2018 streetlight electricity usage. Using this energy savings value, we applied a standard carbon factor and electricity rate to estimate the carbon and cost savings.

As a note, the cost savings reported below represent potential energy cost savings, assuming a standard kWh charge for electricity usage. However, all of Monona's fixtures are maintained by MGE and the city is under a payment arrangement with the utility for the fixtures. Thus, the exact costs savings for upgrading those fixtures maintained by MGE may ultimately be different based on the rate structure. Our analysis did not attempt to replicate the payment structures under those agreements in depth. However, for lights maintained by MGE, the monthly fixed charge for maintenance is the same for both LED and HPS lights. Thus, the cost savings under the current rate structure would only include energy costs savings - and no maintenance cost savings – making the savings similar to the value reported below.

Table 51: Monona streetlights - annual savings (relative to 2018 baseline)

STREETLIGHT ANNUAL SAVINGS	
Number of lights	1016
Energy savings (kWh)	189,290
CO_2e savings (metric tons)	144
Energy cost savings	$20,820

Fleet Opportunities

The market for alternative fuel vehicles is rapidly developing. In the next five years, several new options will exist for municipal fleets, but at this point, the largest two opportunities are police and light-duty vehicles. A few niche alternatives exist for other vehicle types, but each of them has a substantial incremental upfront cost – making them less of a viable option. Based on conversations with the collaborating communities, we left these high incremental cost options out of our final recommendations, but our completed analysis can be found in the main report.

Table 52 illustrates the payback period for police vehicles and light-duty vehicles, assuming 14,000 miles driven for police vehicles and 3,500 miles driven for light-duty vehicles. As the numbers illustrate, hybrid police vehicles present a great opportunity for conversion – with a payback period around one year and a lifetime carbon reduction of between 40 and 50 percent. Although light-duty vehicles have less favorable payback periods, increasing the miles driven per vehicle would greatly improve these numbers. Once a vehicle hits around 10,000 to 15,000 miles driven a year, the net lifetime cost breaks even compared to a conventional car. For additional details on the lifetime cost calculations, see Appendix C.

Table 52: Monona lifetime cost analysis - alternative fleet vehicles

		Lifetime	Incremental vehicle cost	Annual cost savings	Lifetime savings	Payback period	Lifetime CO_2e reduction
Police	**Hybrid Patrol SUV**	8	$3,500	$1,640	$10,200	**1.2**	41%
Police	**Hybrid Patrol Sedan**	8	$3,500	$2,170	$14,560	**1**	55%
Light-duty	**Passenger Vehicle**	15	$8,600	$350	-$3,700	-	43%
Light-duty	**Plug-in Hybrid SUV**	15	$10,000	$215	-$7,000	-	35%
Light-duty	**Plug-in Hybrid Van**	15	$9,000	$240	-$5,650	-	35%

Table 53 illustrates the savings from converting all light-duty and police vehicles in the Monona municipal fleet. The administration department has relatively low savings potential, as the vehicle with the most mileage, a pickup truck, does not have a cost-effective alternative at this time. The transition to hybrid police vehicles leads to the largest benefit – around a 40 percent reduction in both carbon emissions and fuel costs.

Table 53: Monona potential annual fuel savings - adoption of light-duty and police vehicles

		CO_2e (metric tons)		Fuel cost	
Department	Number of vehicles	Current	Alternative	Current	Alternative
Police	12	121	74	$33,790	$20,470
Administration	3	8.4	7	$2,350	$1,780

Solar Energy Opportunities

The City of Monona has established aggressive goals for its transition to use of renewable energy, but the City has little to no roof or land space available for new solar arrays on municipal properties. However, Monona did interconnect solar arrays at four facilities in early 2014 and the nature of the contract provides options for the disposition of the system after six years.

The terms of the initial agreement allowed a third-party to own the arrays and lease the needed roof space from the City. The agreement provided that the City would receive the electricity that the systems produced and would purchase the renewable energy credits for that electricity from the system owners. The agreement established the terms of this structure for the first six years of operation, and the City now faces three options for the disposition of the system at the end of the initial six-year period:

1. Renew the existing agreement structure under the terms provided.
2. Purchase the system from the owner as-is.
3. Require that the owner remove the system from Monona's properties.

Given the City's commitment to renewable energy, it was assumed that, under Option 3, the City would purchase and install new, comparable systems as those that would be removed. As shown in Table 54, the analysis found that Monona would achieve a faster payback on the arrays by purchasing the existing panels from the current owner. However, it would obtain more renewable energy and obtain greater income from the system throughout the useful lives of the systems by removing and replacing the existing panels. Renewing the current agreement required the smallest amount of capital investment but resulted in ongoing negative cash flows.

Table 54: Monona financial analysis of current arrays - comparison of options moving forward

	Lifetime income	2033 cumulative income	Break-even year
Renew through year 20	$(53,215)	$(53,215)	-
Purchase existing*	$50,390	$11,960	2031
Remove and replace	$18,280	$(82,300)	2042

* The manufacturer of the inverters (TenK solar) is out of business and therefore any malfunction may be difficult to address in the future. The costs here do not reflect the potential failing of system prior to end of life.

Certain factors contributed significantly to the findings.

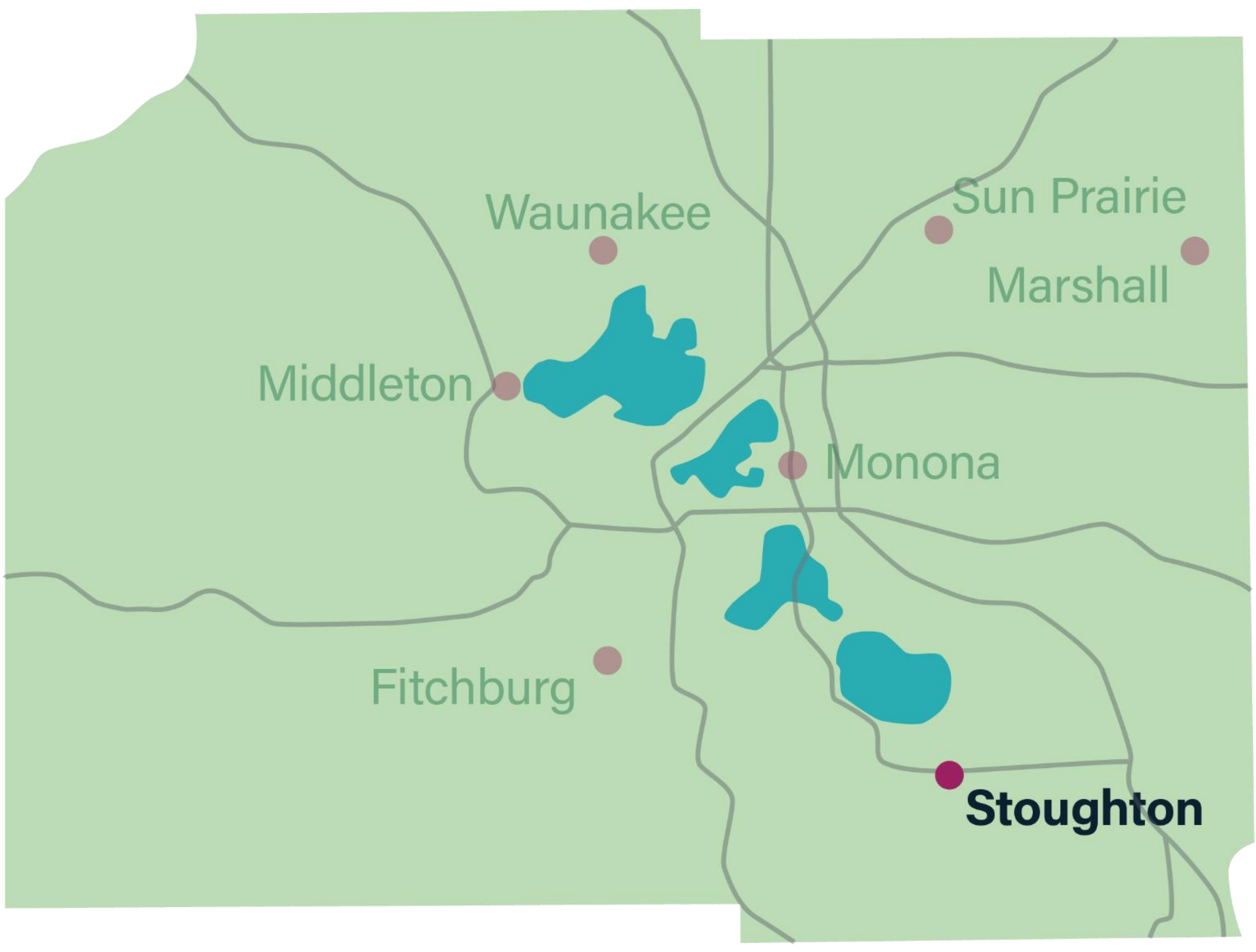
1. The existing panels' electricity output have degraded more quickly than expected
2. The preliminary price estimates that the current system owner has offered to sell the systems to the City are below the current market costs.
3. While new systems have higher initial costs than purchasing the existing system, new equipment will produce more electricity and degrade less quickly than the current panels. New equipment would also be warrantied against malfunctions.

To achieve its renewable energy goals, Monona must obtain renewable energy from sources outside of municipally-owned facilities. Under Wisconsin's current regulatory structure, the City may only purchase electricity from the local utility (MG&E). MG&E offers several paths through which customers may purchase renewable electricity. Each option offers different cost structures, limitations, and sources of renewable electricity. Monona may access one, or more, of these structures to obtain additional renewable electricity and achieve its goals. Table 55 provides a summary of Monona's options for purchasing renewable energy from MG&E.

Table 55: Monona review of renewable energy opportunities

Other opportunities	Description	Maximum purchase (kWh)	Percent of current electricity use	Electricity cost change
MG&E Renewable Energy Rider	Develop new solar array or access existing array – utilize local partnership or off-take from existing project	1,910,000	100%	Negotiated pricing with utility
Shared Solar purchase	Customer purchases share of electricity from local solar array	460,525	24%	Investment: $69,079 FY increase: $283 ($0.109/kWh)
Green Power Tomorrow purchase	Customer pays renewable energy premium for each kWh that it purchases.	1,910,000	100%	FY increase: $19,100

STOUGHTON
COMMUNITY SPECIFIC MUNICIPAL ENERGY PLAN



Wisconsin Office of Energy Innovation Grant

STOUGHTON BACKGROUND

Stoughton is a city of around 13,000 residents in a largely rural area south of Madison. The City's electricity is supplied by the Stoughton Municipal utility which is part of the WPPI Energy, the regional power company that serves many municipal utilities. In this collaboration and throughout the discussions, Stoughton's mayor played an active role. In addition, a WPPI representative was consistently active in the discussions. The City's municipal buildings have shifted in recent years, with the City Hall moved out of the historic Opera House and the construction of a new public works facility.

This chapter provides a detailed summary of the Stoughton energy plan. We begin by summarizing Stoughton's energy profile to provide a baseline understanding of current energy consumption, costs and carbon emissions for 2018. We then delve into our recommendations for near terms investments or action, split out into four categories: building energy efficiency, street lighting opportunities, fleet opportunities, and solar energy opportunities.

COMMUNITY ENERGY PROFILE

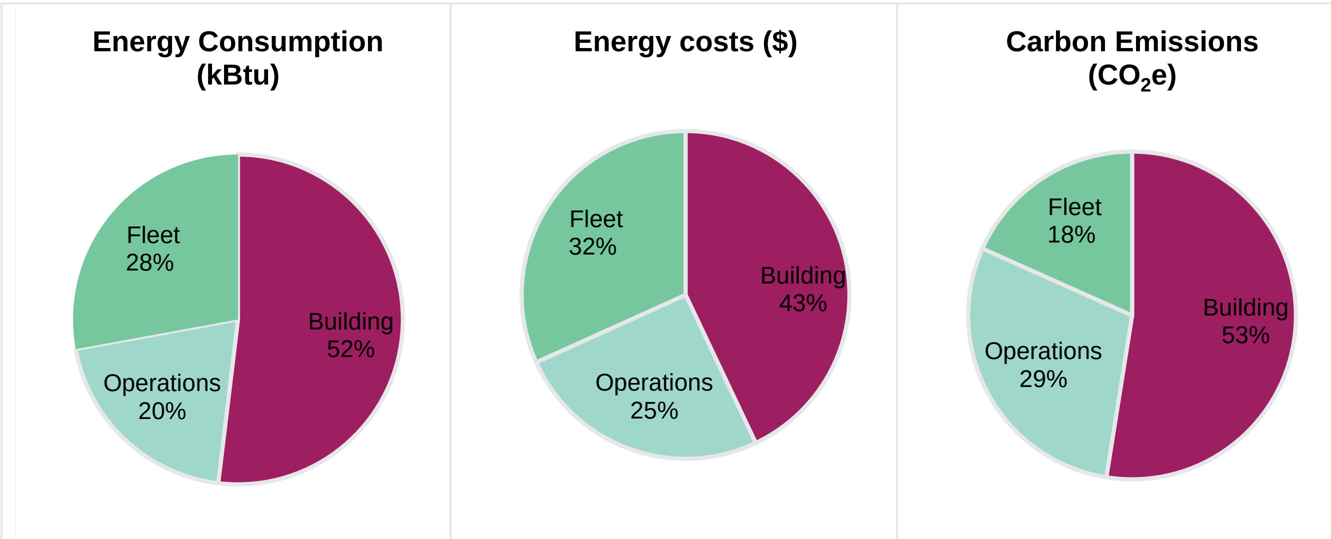
The three main energy inventory elements for Stoughton's energy profile include buildings, operations, and municipal fleet. Table 56 provides details by category on what was included in development of the Stoughton energy profile, based on the data provided by Stoughton staff.

Table 56: Stoughton inventory elements (2018 baseline)

Buildings	Operations	Fleet
Chamber of Commerce City Hall/Opera House Fire Department Library Public Safety Public Works Senior Center Stoughton EMS Stoughton Utilities Youth Center	Stoughton Wastewater Treatment Center	11 Police vehicles 1 Light-duty vehicles 10 Emergency vehicles 29 Heavy-duty vehicles 26 Pickups 17 Other

Figure 14 illustrates the percent contribution of each source to total energy use, cost, and carbon emissions. The cost and carbon intensity of the different fuels (electricity, natural gas, gasoline, and diesel) can significantly impact the contribution of each source to the total.

Figure 14: Stoughton energy consumption, cost and carbon emissions (2018)



Breaking these elements down further, Table 57 details the annual energy use, carbon emissions, and energy cost associated with each building and operation use type. The buildings are listed individually; if there were multiple meters per building, we aggregated the values up to the building level. Stoughton hosts a net-metered PV system at Nordic Ridge park. The amount of electricity used by Stoughton, as shown in the table, reflects the amount of net electricity that Stoughton purchased from the utility, with any reductions from solar panel production included as part of that amount.

Table 57: Stoughton baseline energy, carbon and cost data by building and operation use type (2018)

Use/building	Net Electricity (kWh)	Natural gas (therms)	Carbon emissions (CO_2e metric tons)	Percent of total CO_2e	Energy cost
Chamber of Commerce	11,155	2,172	20	1%	$2,530
City Hall/Opera House	179,320	27,162	281	13%	$36,020
Fire Department	126,517	10,642	153	7%	$20,300
Library	171,240	8,540	176	8%	$23,960
Public Safety	-	7,959	42	2%	$4,775
Public Works	11,365	4,199	31	1%	$3,770
Stoughton EMS	91,203	-	69	3%	$10,030
Stoughton Senior Center	129,012	8,117	141	6%	$19,060
Stoughton Utilities	166,920	12,898	196	9%	$26,100
Youth Center	53,502	1,878	51	2%	$7,010
Wastewater Treatment Center	735,329	15,883	644	29%	$90,415
Fleet	-	-	404	18%	$113,510
Total	**1,675,563**	**99,450**	**2,208**		**$357,480**

Figure 15 illustrates how the baseline energy use intensity (EUI) of each Stoughton building compares to the ASHRAE 100-2018 target and benchmark value for similar use buildings. This comparison serves as a helpful benchmarking exercise, but it's important to note that the ASHRAE values represent a typical building type and do not account for buildings that may house multiple city departments or functions. We excluded the Opera House/City Hall as the building no longer houses both functions – making the 2018 data less representative for the future.

Figure 15: Stoughton EUI benchmarking and comparison to ASHRAE target and benchmark

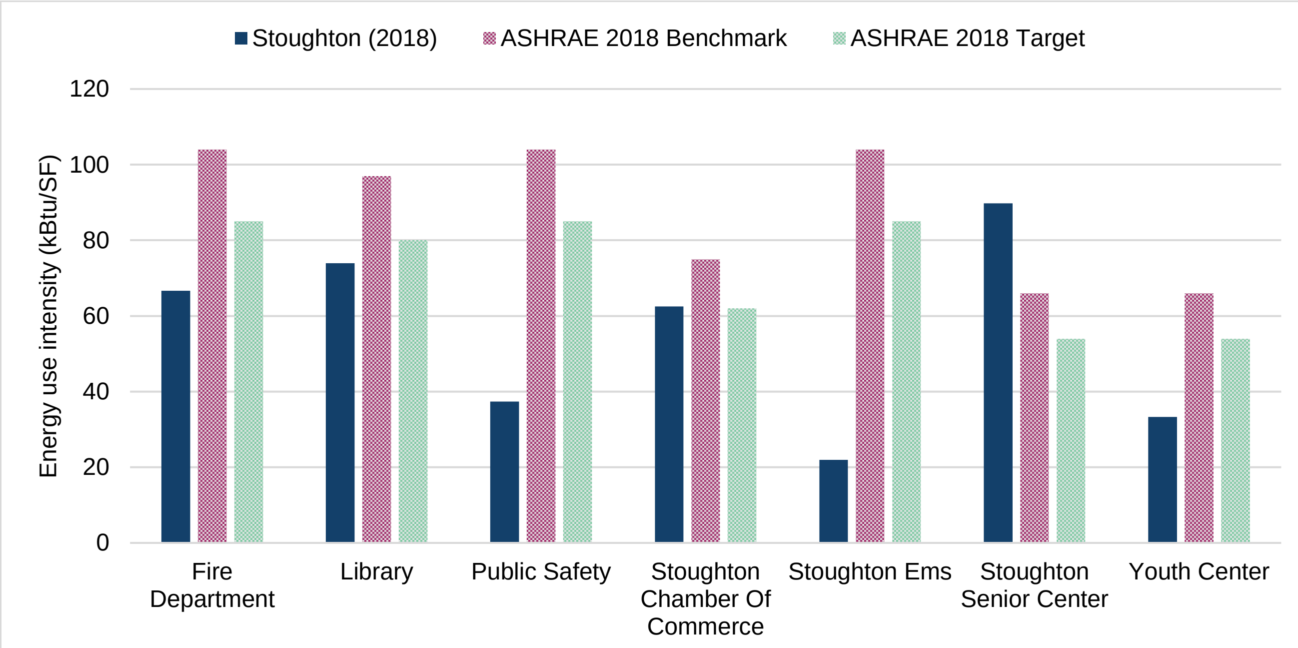


Table 58 illustrates the current renewable energy consumption in the city. Solar energy currently makes up around 70 percent of total electricity use in the City, most of which comes from purchases through Stoughton Utilities' Choose Renewable program. Stoughton currently has three on-site solar installations: a 6.8 kW installation on Stoughton Utilities, a 3.6 kW installation on Nordic Ridge, and a new 99 kW installation on the Public Works building.

Table 58: Stoughton renewable energy summary - current production (as of 2019)

RENEWABLE ENERGY QUICK FACTS	
On-site net metered solar (kWh)	124,585
Choose Renewable Program (kWh)	1,130,400
Total renewable energy purchased/production (kWh)	1,254,985
Percent of total gross electricity	**70%**

Table 59 illustrates the current vehicle fuel usage, carbon emissions, and fuel cost by vehicle type. This includes both Stoughton Utility and city vehicles. The police department has the most significant energy footprint, driven largely by the need to idle to maintain car functions while not in motion and the high relative mileage. This significant use presents an excellent opportunity for conversion to hybrid vehicles as will be outlined below.

Table 59: Stoughton vehicle fuel usage by vehicle type (2018)

Department	Number of vehicles	Gallons (gasoline or diesel)	CO_2e (metric tons)	Fuel cost
Police	11	13,200	112	$33,130
Light-duty	1	185	2	$465
Emergency vehicles	10	4,195	38	$8,990
Pickups	29	7,275	62	$18,260
Heavy-duty	26	8,685	88	$23,975
Other	18	10,855	102	$28,685
Total	95	44,395	404	$113,505

STOUGHTON RECOMMENDATIONS FOR NEAR-TERM IMPLEMENTATION

Our analysis found energy investments that have a strong return on investment and significant energy savings potential. Implementing simple energy efficiency improvements to Middleton's municipal buildings can reduce building energy consumption by as much as 5 percent. Stoughton has committed to converting all streetlights to LEDs, which would cut current streetlight electricity by 40 percent and reduce carbon emissions by around 195 tons. In the fleet department, the City should prioritize converting police vehicles to hybrids as they offer a payback around one year and lead to a 40 percent decline in lifetime carbon emissions. Lastly, by adding solar arrays to 3 sites, Stoughton can reduce fossil fuel electricity consumption by an additional 10 percent.

Table 60 summarizes the carbon and energy cost savings that the City would see if they implemented the recommended near-term actions in each major opportunity area. The following sections provide additional detail on each opportunity.

Table 60: Stoughton impact summary – estimated annual carbon and energy cost savings

Near-term Opportunity	CO_2e Reduction (metric tons)	Percent Carbon Reduction	Energy Cost Savings	Percent Energy Cost Reduction
Building efficiency	110	9%	$15,780	10%
Streetlights	193	41%	$27,865	41%
Fleet	42	10%	$13,305	12%
Solar	224	-	$32,310	-
Total opportunity	569	**26%**	$89,260	**25%**

Energy efficiency opportunities

Our analysis focused on near-term measures that not only have an energy or cost savings, but also may have possible benefits of reducing maintenance costs, improving occupant comfort, or increasing staff productivity. We also considered the ease and cost of implementation when prioritizing our recommendations.

To identify these opportunities, Slipstream conducted high-level walk-through for three buildings: the Stoughton Senior Center, Stoughton Fire Department, and Stoughton Opera House. We took note of major end-uses and process and spoke with building staff to understand building operations. The following provides a walk-through summary for each building with additional detail on energy savings potential below.

Stoughton Senior Center

The Stoughton Senior Center was built in 1976 and was a former bank. Today it's a senior center with a small kitchen, multipurpose gathering spaces, woodshop, and offices.

Observations

- LED lighting retrofits were underway and about 33 percent complete.
- Recent HVAC upgrades changed the system to energy efficient variable air volume (VAV) system.
- Lights are on in offices when unoccupied.
- Lights are always on in garage
- Transformer is old and due for replacement.

Recommendations:

Garage LED retrofit and lighting controls: Install new LED integrated fixtures with occupancy sensors. These can dim lights when people are not present and automatically turn on as people return to their cars or enter the garage.

LED retrofit and lighting controls: Complete upgrade to LED. Consider vacancy sensors for small rooms on the top floor and occupancy sensors for the large spaces in the basement.

HVAC controls: Consider adding a supply air temperature reset schedule to new VAV system to save more energy. This will increase the supply air temperature when its warmer outside. More advanced temperature resets can increase temperature when there is load cooling within the building.

Demand-controlled ventilation (DCV): Consider installing carbon dioxide sensors in the main large lounge area to lower outside air intake levels when there are only a few people in the space and to increase outside air intake when the space is fully occupied.

Transformer replacement: Replacing a 150-kVA transformer built before 1996 with a NEMA premium transformer can save 3,000 kWh per year.[10] An additional 100 to 300 kWh of savings can be captured if the transformer can be downsized to match the current building electrical load.

[10] National Grid. Transformer Replacement Program Implementation Manual, version 2. Page 19. https://www.nationalgridus.com/media/pronet/transformer-replacement-program-implementation-manual.pdf

Stoughton Fire Department

The Stoughton Fire Department is a volunteer fire department built in 2008.

Observations

- The building has many high-performance design technologies incorporated, including heat recovery ventilation, radiant floor garage heating, and garage destratification fans.
- Trucks bay light fixtures to be changed to LED
- Many rooms are unoccupied throughout the day. Installing lighting and ventilation controls will reduce energy when unoccupied.

Recommendations

LED retrofit and lighting controls: Upgrade to LED. As the volunteer fire department is mostly unoccupied, energy savings from lighting controls should be significant. Install vacancy sensors for small rooms and occupancy sensors for the large training room. Buy integrated fixtures with occupancy sensors and photosensors for the truck bay to take advantage of the clear garage doors.

HVAC controls: Confirm supply air temperature reset and hot water temperature reset control sequences are incorporated in the HVAC controls.

DCV: Install carbon dioxide sensors in the main training room to lower outside air intake when rooms are unoccupied.

Stoughton Opera House

The Stoughton Opera House is an historic building from 1900 that has been renovated for performances 8 to 9 months of the year. The building previously housed the City Hall offices, which moved to a separate building in 2019.

Observations

- The opera house has all incandescent lights to maintain the historic color and look to the theater. Stoughton is working with Electronic Theatre Controls (ETC) to upgrade stage lighting.
- There are major heating and cooling issues due to thermostat locations and HVAC ductwork zoning. There has been observable discomfort by performers and audience members.

Recommendations

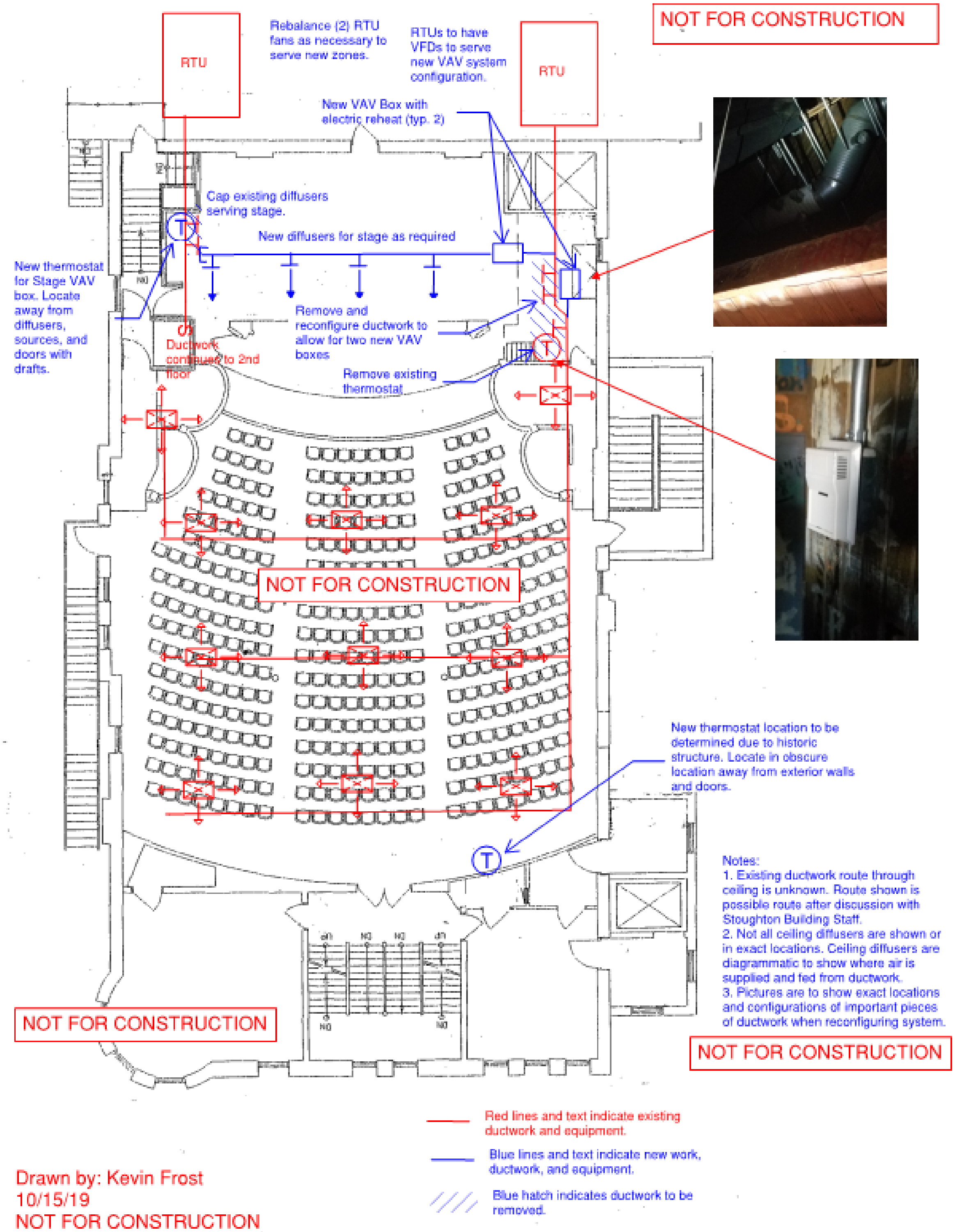
LED theater lighting: The theater has two historic chandeliers, wall sconces, and aisle lighting, all with incandescent lamps. They have remained that way because incandescent lights provide the historic look for the theater. However, the LED replacement for a 40 W incandescent is 6 W, meaning an 85 percent reduction in lighting energy can be accomplished by changing to LED equivalent lights. LED lighting can be color corrected, so it is recommended to consult a lighting professional to see if options exist to maintain the historic look of theater with LED bulbs.

LED stage lighting: The Opera House stage lighting is all incandescent. ETC, Stoughton's stage lighting supplier, suggests installing S4WRD retrofit to existing directional stage lighting to convert the lamps to LED. The S4WRD replaces the 575-watt S4 lights with a 155-watt LED lamp. These replace the lamp base, so the rest of the fixture can be reused. They cost around $599 but could save as much as $600 in electricity cost a year. Consult with ETC for additional options.

VAV system upgrade: The Opera House HVAC system consists of two rooftop units ducted into the opera house. One Rooftop Unit serves the stage and the upper seating area, and the other unit serves the stage and lower seating area. However, one thermostat is on the stage and the other is in the upstairs seating area, meaning that the lower seating area seating area tends to overheat in the winter, once even leading an audience member to faint.

One solution would be to convert the system to a VAV system. Figure 16 shows one possible way this could be accomplished, although careful study of the current system is still required. Challenges would include limited ceiling space, locating a new thermostat in historic walls, upgrading the rooftop terminal units, and not having hot water for a reheat. Another option is to add a dedicated unit for the stage. Either solution could potentially use more energy for cooling, but the occupant discomfort issues would be addressed.

Figure 16: Stoughton Opera House: floor plan with recommendations and operating notes



Energy Saving Potential

For each measure identified, we calculated the total savings and payback. Calculations were based on a combination of resources, including the Wisconsin Technical Reference Manual, the International Energy Conservation Code, and internal research and expertise. References and assumptions for energy saving calculations and cost data are in Appendix E. For more complicated measures, we developed simple energy models to quantify levels of impact. For details and definitions on the measures, please refer to the Main Report of the energy plan that has descriptions of the measures.

Table 61 provides additional detail on the energy efficiency opportunities for each building and includes energy costs savings and simple payback. Measures are organized by simple payback to identify measures that will recovers capital costs quickly.

LED lighting upgrades are estimated to generate the most electricity savings for all three buildings. While the measures are listed below separately, we recommend that lighting controls be implemented with LED upgrades to reduce total upfront costs. The savings listed below for controls are based on a building already upgraded to LEDs and the incremental costs below assume that the controls and LED upgrades are completed at the same time. Controls implemented on their own would have a higher upfront cost.

For the Stoughton Opera House lighting, we looked at both upgrading the incandescent theater lighting and the stage lighting. The stage lighting savings listed represent replacing 10 lights. This number can be easily multiplied to actual number of stage lights to be replaced to see what the annual savings would be. These lights take some time to recover investment, but there are other benefits to upgrading stage lighting to LED.

Implementing DCV in all three buildings can lead to some significant savings. The savings are high particularly for the volunteer fire department, which often is unoccupied, and the Opera House, which has a high outside air intake requirement during shows. The Opera House does present some challenges as a carbon dioxide sensor is difficult to add to historic walls, but a portion of the savings could be achieved by adding the carbon dioxide sensor to the return duct if the walls are not an option. The next biggest energy saver is air handling unit temperature reset which should be easy to implement with the packaged AHU controls for all three buildings.

Table 61: Energy saving measures for Stoughton walk-through buildings

Building	Upfront Cost	Electric savings (kWh)	Gas savings (therms)[11]	Total energy savings	Cost savings	Simple payback (years)
City Hall / Opera House						
HVAC AHU temp reset	$190	3,120	340	1.5%	$550	0.4
LED lighting retrofit - exit signs	$160	1,870	-40	0.1%	$180	0.9
Custom - Seating Area Lighting	$1,550	8,330	-120	0.5%	$840	1.8
DCV - assembly space	$580	390	210	0.7%	$170	3.5
Custom - Stage Lighting (10 fixtures)	$5,990	5,640	-120	0.2%	$550	11.0
Custom - VAV System	$0	0	0	0.0%	$0	
City Hall / Opera House Total	**$8,470**	**19,350**	**260**	**3.0%**	**$2,280**	
Fire Department						
HVAC AHU temp reset	$100	2,580	280	2.5%	$450	0.2
Lighting controls - occupancy	$280	7,950	-180	0.6%	$770	0.4
Lighting controls - garage	$100	2,510	-60	0.2%	$240	0.4
DCV - assembly space	$680	910	480	3.5%	$390	1.7
LED lighting - task tuning	$630	3,590	-80	0.3%	$350	1.8
LED lighting retrofit - interior	$4,340	17,560	-390	1.4%	$1,700	2.6
Fire Department Total	**$6,130**	**35,100**	**60**	**8.7%**	**$3,890**	
Stoughton Senior Center						
HVAC AHU temp reset	$110	1,630	180	1.9%	$290	0.3
Lighting controls - occupancy	$100	3,210	-70	0.3%	$310	0.4
Lighting controls - garage	$70	1,690	-40	0.2%	$160	0.4
LED lighting - task tuning	$200	1,450	-30	0.1%	$140	1.4
LED lighting retrofit - interior	$5,870	18,520	-410	1.8%	$1,790	3.3
DCV - assembly space	$430	290	150	1.3%	$120	3.5
HVAC boiler reset	$1,220	0	500	4.2%	$300	4.0
Stoughton Senior Center Total	**$8,000**	**26,790**	**280**	**9.9%**	**$3,110**	
Grand Total	**$22,600**	**81,250**	**590**		**$9,290**	

Finally, while we did not visit every building in Stoughton's municipal operations, we did see similar building types in the walk-throughs with other communities. For those buildings for which we were unable to conduct walk-throughs, we asked community representatives to provide some details on particular end-uses in each building. By using that feedback and leveraging information gathered during other communities' site visits, we were able to estimate savings for the other Stoughton buildings. These savings are summarized in Table 62. However, these results are not based on a site walk-through and should be confirmed with further review of building equipment and conditions.

[11] Negative values reflect an increase in heating demand due to interactive effects – in all cases total savings is still positive.

Table 62: Energy saving measures for Stoughton – non-site walk-through buildings

Building	Cost	Electric savings (kWh)	Gas savings (therms)[12]	Total energy savings	Cost savings	Simple payback (years)
Library						
Lighting controls - daylighting	$60	1,880	-40	0.2%	$180	0.3
Lighting controls - occupancy	$60	1,770	-40	0.2%	$170	0.4
HVAC AHU temp reset	$190	2,210	240	2.3%	$390	0.5
LED lighting - task tuning	$220	1,600	-40	0.1%	$150	1.4
HVAC boiler reset	$1,220	0	250	1.9%	$150	8.1
Library Total	**$1,750**	**7,740**	**370**	**4.7%**	**$1,040**	
Public Safety						
Lighting controls - daylighting	$130	3,830	-90	0.6%	$370	0.3
Lighting controls - occupancy	$130	3,610	-80	0.6%	$350	0.4
Lighting controls - garage	$20	570	-10	0.1%	$60	0.4
HVAC AHU temp reset	$480	2,340	250	4.6%	$410	1.2
DCV - assembly space	$150	210	110	1.6%	$90	1.7
LED lighting - task tuning	$570	3,260	-70	0.5%	$310	1.8
DCV - office space	$110	70	30	0.5%	$30	3.8
HVAC boiler reset	$1,220	0	360	5.0%	$220	5.6
LED lighting retrofit - interior	$0	0	0	0.0%	$0	
Public Safety Total	**$2,810**	**13,890**	**510**	**13.4%**	**$1,830**	
Stoughton EMS						
Lighting controls - daylighting	$40	1,090	-20	0.4%	$110	0.3
Lighting controls - occupancy	$40	1,030	-20	0.4%	$100	0.4
DCV - assembly space	$220	290	160	5.0%	$130	1.7
LED lighting - task tuning	$160	930	-20	0.3%	$90	1.8
LED lighting retrofit - interior	$3,510	14,190	-320	5.1%	$1,370	2.6
DCV - office space	$160	100	50	1.6%	$40	3.8
Stoughton EMS Total	**$1,850**	**17,630**	**-180**	**12.8%**	**$1,830**	
Youth Center						
Lighting controls - daylighting	$90	2,650	-60	0.9%	$260	0.3
Lighting controls - occupancy	$90	2,500	-60	0.9%	$240	0.4
LED lighting - task tuning	$310	2,260	-50	0.8%	$220	1.4
LED lighting retrofit - interior	$3,320	10,480	-230	3.7%	$1,010	3.3
Youth Center Total	**$3,810**	**17,880**	**-400**	**6.3%**	**$1,730**	
Grand Total	**$12,500**	**56,850**	**390**		**$6,490**	

Figure 17 shows the EUI of each building if all energy efficiency measures are implemented along with an ASHRAE Standard 100-2018 benchmark value for comparison.

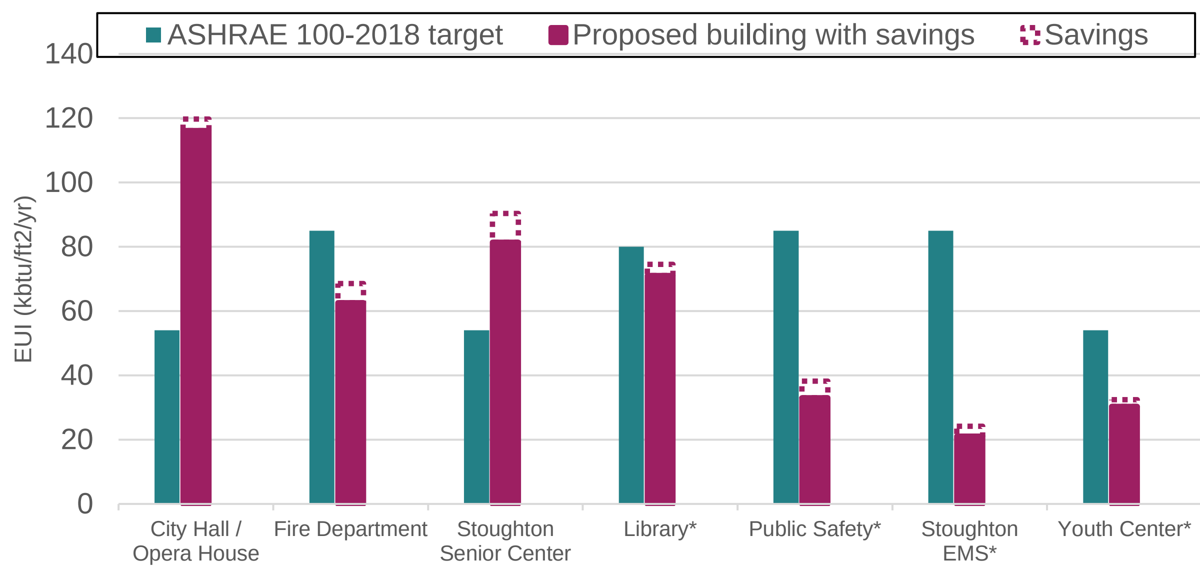
Our analysis shows that the energy measures outlined above for the Stoughton Senior Center helps bring the building much closer to the ASHRAE 100 target values. The Stoughton fire department is a well-designed energy efficient building, but the low-hanging fruit mentioned above helps reduce the energy by 8 percent. The Stoughton Opera House is the oldest building in the study. Additionally, the utility data does include its operation as a City Hall which explains it's high energy use. If energy

[12] Negative values reflect an increase in heating demand due to interactive effects – in all cases total savings is still positive.

remains high, it is recommended to consult an energy auditor for further study into how reduce the energy use of the historic building.

We expect that the other Stoughton buildings would see some mild energy reductions based on the common measures identified, but we conservatively estimated energy savings because we did not conduct a walk-through. The new City Hall and Public Works buildings are not included as they were opened very recently. The Public Safety building and EMS building show a low EUI due to some missing utility data.

Figure 17: Stoughton building EUI: reductions from energy efficiency measures



* denotes buildings for which a walk-through was not performed. See accompanying text above for additional detail

Street Lighting Opportunities

Converting streetlights to LEDs has a large energy saving potential. In addition to reduced energy use annually, LEDs also last longer and thus reduce lifetime maintenance costs. The lights can also improve lighting quality, improve perception of safety, and reduce light pollution.

Table 63 illustrates the lifetime energy savings, carbon savings and cost savings associated with converting one high-pressure sodium fixture to a LED fixture. This standard lifetime analysis assumes that streetlights are owned by the municipality and serves to illustrate potential savings from a conversion. The upfront cost in Table 63, which includes both labor cost and material cost, is estimated from conversations with city officials who have implemented LED retrofits in the last few years. The Wisconsin Technical Resource Manual estimates the cost per fixture to be slightly higher. However, as LED costs are rapidly decreasing, we opted to use cost estimates from recent installations in an attempt to accurately represent current costs. The cost savings reported represent avoided maintenance costs and avoided energy costs. Table 63 illustrates that the higher the wattage of the fixture, the more economically beneficial it becomes to convert the fixture to a LED. Appendix B provides more details on the assumptions made for these calculations.

Table 63: LED lifetime cost analysis - cost per fixture

Lighting type	Lifetime energy savings (kWh)	Lifetime CO_2e savings (metric tons)	Upfront cost	Lifetime cost savings	Payback period (years)
70 W	3,430	2.6	$249	$275	6.8
100 W	7,750	5.9	$249	$670	3.9
150 W	9,480	7.2	$299	$800	3.6
250 W	16,070	12.2	$399	$1,315	3.3
400 W	23,800	18.1	$499	$1,930	3

Forty percent of the lights in Stoughton have already been converted to LEDs and Stoughton has committed to converting all lights to LEDs in the near future. Therefore, Table 64 illustrates the additional electricity, carbon, and energy cost savings the City will see from converting the rest of the lights to LEDs. To calculate these savings, we used the lights' current wattage to estimate 2018 electricity use and future electricity use if all lights were converted to a LED equivalent. These additional savings represent around a 40 percent decline in streetlight electricity.

Table 64: Stoughton streetlights - annual savings

STREETLIGHT ANNUAL SAVINGS	
Number of lights	814
Energy savings (kWh)	253,330
CO_2e savings (metric tons)	193
Energy cost savings	$27,865

Fleet Opportunities

The market for alternative fuel vehicles is rapidly developing. In the next five years, several new options will exist for municipal fleets, but at this point, the largest two opportunities are police and light-duty vehicles. A few niche alternatives exist for other vehicle types, but each of them has a substantial incremental upfront cost – making them less of a viable option. Based on conversations with the collaborating communities, we left these high incremental cost options out of our final recommendations, but our completed analysis can be found in the main report.

Table 65 illustrates the payback period for police vehicles and light-duty vehicles, assuming 14,000 miles driven for police vehicles and 3,500 miles driven for light-duty vehicles. As the numbers illustrate, hybrid police vehicles present a great opportunity for conversion – with a payback period around one year and a lifetime carbon reduction of between 40 and 55 percent. Although light-duty vehicles have less favorable payback periods, increasing the miles driven per vehicle would greatly improve these numbers. Once a vehicle hits around 10,000 to 15,000 miles driven a year, the net lifetime cost breaks even compared to a conventional car. For more details on the lifetime cost analysis, see Appendix C.

Table 65: Stoughton lifetime cost analysis – relevant alternative fleet vehicles

		Lifetime	Incremental vehicle cost	Annual cost savings	Lifetime savings	Payback period	Lifetime CO_2e reduction
Police	**Hybrid Patrol SUV**	8	$3,500	$1,640	$10,200	**1.2**	41%
	Hybrid Patrol Sedan	8	$3,500	$2,170	$14,560	**1**	55%
Light-duty	**Passenger Vehicle**	15	$8,600	$350	-$3,700	-	43%
	Plug-in Hybrid Van	15	$9,000	$240	-$5,650	-	35%

Table 66 illustrates the savings from converting all light-duty and police vehicles in the Stoughton municipal fleet. The transition to hybrid police vehicles leads to the largest benefit – around a 40 percent reduction in both carbon emissions and fuel costs. Stoughton only has one light-duty vehicle, so the impact from converting this type of vehicle is not significant.

Table 66: Stoughton potential annual fuel savings - adoption of light-duty and police vehicles

		CO_2e (metric tons)		Fuel cost	
Department	Number of vehicles	Current	Alternative	Current	Alternative
Police	11	112	70	$33,130	$20,060
Light-duty	1	1.5	1.1	$465	$230

Solar Energy Opportunities

In addition to the three solar PV installations currently operational, which total 109 kW in demand, we also examined the potential solar production at three sites in the city of Stoughton. Each of the arrays are roof-mounted arrays on city-owned buildings.

Table 67 summarizes the potential solar production from each of these sites. The recommended PV system size for each location considers the site's current electric consumption and the size and configuration of an array that each site could support. The Customer-Owned Generation Systems (greater than 20 kW) rate offered by Stoughton Utilities allows for net metering for customer-owned generation facilities with generating capacity of less than 100 kW. The three arrays are designed to be eligible for this rate and to minimize the City's loss due to disadvantageous rates for over-production. By adding these arrays, the City could receive an additional 10 percent of its total electricity from renewable sources. This would increase the total percent of electricity from renewables to 80 percent.

Table 67: Stoughton summary of solar potential by site

Site name	Address	Annual consumption (2018, kWh)	Potential PV capacity (kW DC)	Estimated production (kWh)	Savings
Fire Station	401 E Main St	126,517	98.6	119,704	95%
WWTP	700 Mandt Pkwy	735,329	24.5	33,942	5%
Library	304 S 4th St	171,240	19.5	27,338	16%
Total		**1,033,086**	**142.6**	**180,984**	**17.5%**

Table 68 provides a summary of the estimated cost for each of these arrays. The estimated cost for the systems of $1,818 per kW is based on current data for the Dane County market for commercial PV installations. Since the cost estimates reflect market data, exact costs may vary by solar contractor.

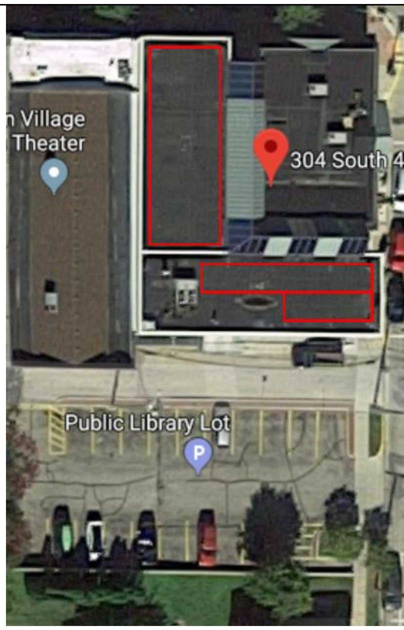
WPPI offers rebates for commercial-scale solar installations through a competitive request for proposal program. The rebates, which are not guaranteed, are limited to a maximum of 50 percent of the total installed cost of the project or $125,000. This analysis assumes a rebate amount equal to 40 percent of the total project cost. Customers who receive grants from WPPI for solar installations may be required to transfer ownership of the renewable energy credits resulting from the project to WPPI.

Table 68: Estimated cost of recommended Stoughton PV arrays

Site Name	Total cost	WPPI rebate	Net cost
Fire Station	$192,323	$76,929	$115,394
WWTP	$47,779	$19,112	$28,667
Library	$38,101	$15,240	$22,861
Total	**$278,203**	**$111,281**	**$166,922**

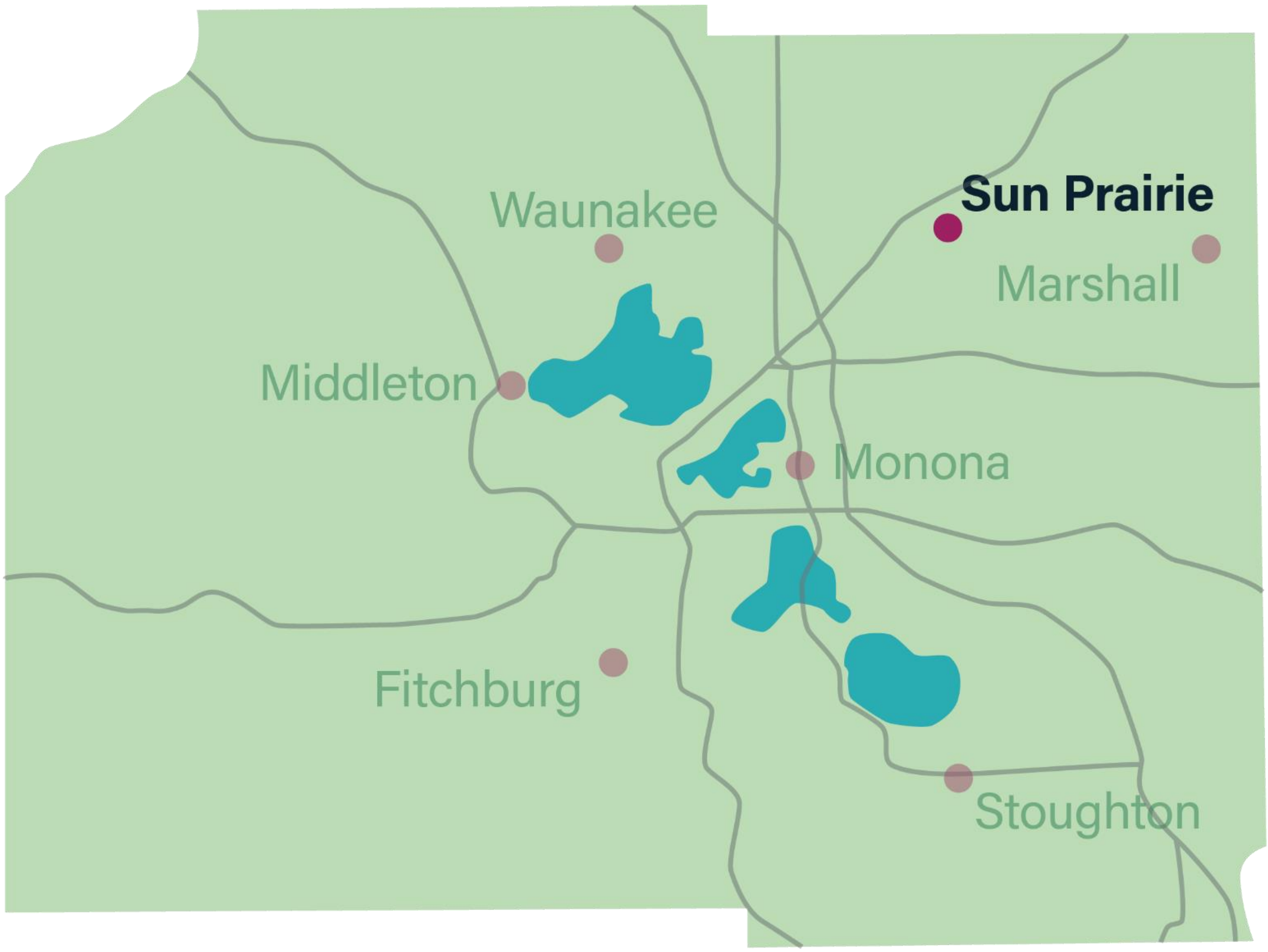
Table 69 provides a summary description of the array at each site as well as an aerial view of the arrays. The red outlines represent where the arrays would sit.

Table 69: Stoughton description of potential PV arrays

Description of site	Aerial views with potential PV mounting
The **Fire Station** appears to have a large, flat roof that with minimal obstructions, as well as a section with a pitched roof that is oriented East-West. The pitched roof does not appear to have any penetrations or equipment on it. The portions of the array on the flat roof sections were modeled as racked, fixed-tilt panels, oriented due south, with a GCR of 0.3 and a 20-degree tilt. The portions of the array on the pitched roof sections were modeled as flush-mounted panels.	
The **Wastewater Treatment Plant** has a flat roof with at least six penetrations. There are four areas of the roof that appear to be sufficiently open to support PV arrays. The arrays were modeled as racked, fixed-tilt panels, oriented slightly (3.5 degrees) west of due south, with a GCR of 0.3 and a 20-degree tilt.	
The **Library** has two section suitable to solar arrays: the west section and a portion of the south section of the roof. The array on the flat roof sections were modeled as racked, fixed-tilt panels, oriented due south, with a GCR of 0.3 and a 20-degree tilt. City staff advised that Stoughton also owns the green space to the south of the parking lot. While trees currently create too much shading to locate solar panels in this space, the City may investigate opportunities to increase the capacity of the system by creating solar parking coverage in the parking lot. Locating panels on shading structures may add cost to the project but would also provide opportunities for community engagement concerning use of renewable energy.	

SUN PRAIRIE

COMMUNITY-SPECIFIC MUNICIPAL ENERGY PLAN



Wisconsin Office of Energy Innovation Grant

SUN PRAIRIE BACKGROUND

Sun Prairie is a growing city of over 30,000 residents east of Madison. The city's electricity is supplied by the Sun Prairie Municipal utility which is part of the WPPI Energy, the regional power company that serves many municipal utilities. The WPPI representative for Sun Prairie utilities played an active role in this collaboration. The city's gas is supplied by both Alliant Energy and WE Energies. The City has taken a proactive role in investing in sustainable energy systems, including a recently installed 80 kW solar system on its City Hall as well as a new PV installation on the newly constructed Westside building. Sun Prairie is part of the Energy Independent Communities, which is a voluntary agreement between the State of Wisconsin and communities that adopt the goal of generating 25 percent of their energy from renewable energy sources locally by 2025. Recently, the City partnered with the Madison Metro Bus system to create an express bus route from Sun Prairie to the Capitol.

This chapter provides a detailed summary of the Sun Prairie energy plan. We begin by summarizing Sun Prairie's energy profile to provide a baseline understanding of current energy consumption, costs and carbon emissions for 2018. We then delve into our recommendations for near terms investments or action, split out into four categories: building energy efficiency, street lighting opportunities, fleet opportunities, and solar energy opportunities.

COMMUNITY ENERGY PROFILE

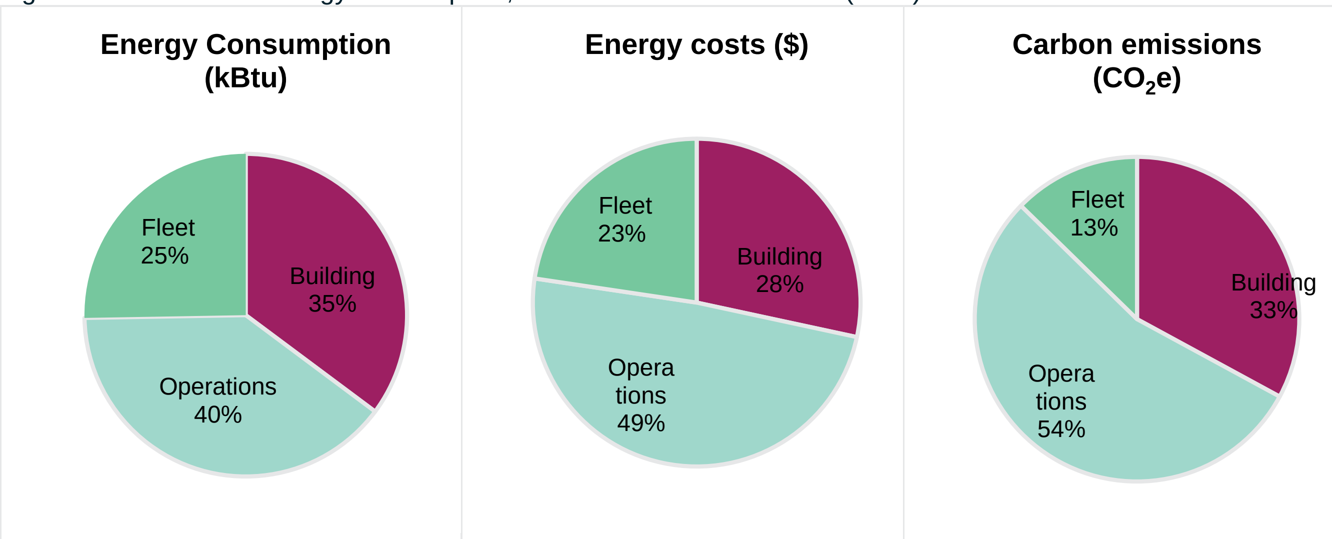
The three main energy inventory elements for Sun Prairie's energy profile include buildings, operations, and municipal fleet. Table 70 provides details by category on what was included in development of the Sun Prairie energy profile, based on the data provided by Sun Prairie staff.

Table 70: Sun Prairie inventory elements (2018 baseline)

Buildings	Operations	Fleet
Aquatic Center City Garage City Hall EMS East Fire Department Library Museum Public Works Sun Prairie Utilities Westside Community Building	Lift Stations Parks and Recreation Streetlights Wastewater Treatment Plant	28 Police vehicles 18 Light-duty vehicles 16 Emergency vehicles 23 Heavy-duty vehicles 45 Pickups 64 Other

Figure 18 shows the percent contribution of each source to total energy use, cost, and carbon emissions. The cost and carbon intensity of the different fuels (electricity, natural gas, gasoline, and diesel) can significantly impact the contribution of each source to the total.

Figure 18: Sun Prairie energy consumption, cost and carbon emissions (2018)



Breaking these elements down further, Table 71 details the annual energy use, carbon emissions, and energy cost associated with each building and operation use type. The buildings are listed individually; if there were multiple meters per building, we aggregated the values up to the building level. If there were multiple meters for operation data, it was aggregated by use type such as streetlights and lifts. Sun Prairie's City Hall hosts a net-metered PV system. The amount of electricity used by City Hall, as shown in the table, reflects the net amount of electricity that Sun Prairie purchased from the utility, with any reductions from solar panel production included as part of that amount.

Table 71: Sun Prairie baseline energy, carbon and cost data by building and operation use type (2018)

	Use/building	Net Electricity (kWh)	Natural gas (therms)	Carbon emissions (CO_2e metric tons)	Percent of total CO_2e	Energy cost
Buildings	Aquatic Center	152,000	14,736	194	3%	$25,560
	City Garage	10,126	1,859	18	0.3%	$2,230
	City Hall	609,824	16,862	554	8%	$77,200
	EMS East	43,832	3,908	54	0.8%	7,165
	Fire Department	111,575	7,236	123	2%	$16,615
	Library	479,680	21,159	478	7%	$65,460
	Museum	16,193	1,655	21	0.3%	$9
	Public Works	45,520	10,096	88	1%	$11,065
	Westside Community	558,680	36,645	620	9%	$83,440
	Sun Prairie Utilities	263,022	17	200	3%	$28,940
Operations	Parks and Recreation	30,851	4,096	45	1%	$5,850
	Streetlights	2,053,880	-	1,564	22%	$225,925
	Treatment Plants	2,648,344	43,755	2,249	31%	$317,570
	Lifts	34,832	-	27	0.4%	$3,830
	Fleet			906	13%	$255,775
	Total	**7,058,359**	**162,024**	**7,141**		**$1,129,400**

Figure 19 illustrates how the baseline energy use intensity (EUI) of each Sun Prairie building compares to the ASHRAE 100-2018 target and benchmark value for similar use buildings. A few buildings were excluded as good benchmark comparisons did not exist. Additionally, it's important to note that the ASHRAE values represent a typical building type and do not account for buildings that may house multiple city departments or functions, such as the Westside Community Building which includes community spaces, EMS, fire and police department and parks department offices.

Figure 19: Sun Prairie EUI benchmarking and comparison to ASHRAE benchmark and target

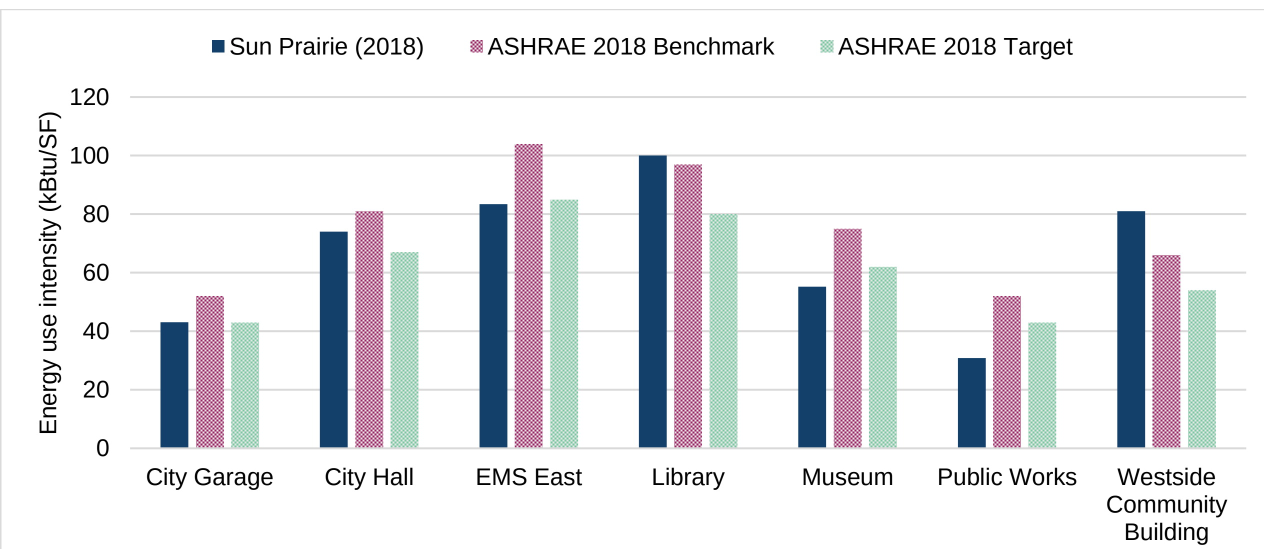


Table 72 illustrates the current renewable energy consumption in the city. On-site solar currently makes up around 4 percent of total electricity use in Sun Prairie – leaving potential for future developments. The city has two planned or installed on-site solar arrays: an 80 kW installation on City Hall and a forthcoming 130 kW installation on the Westside Community Building.

Table 72: Sun Prairie renewable energy summary - current production (as of 2019)

RENEWABLE ENERGY QUICK FACTS	
On-Site net metered solar (kWh)	261,780
Percent of gross municipal electricity	4%

Table 73 illustrates the current vehicle fuel usage, carbon emissions, and fuel cost by vehicle type. This includes both Sun Prairie utility and city vehicles. The police department has the most significant energy footprint, driven largely by the need to idle to maintain car functions while not in motion and the high relative mileage. This significant use presents an excellent opportunity for conversion to hybrid vehicles as will be outlined below.

Table 73: Sun Prairie vehicle fuel usage by vehicle type (2018)

Department	Number of vehicles	Gallons	CO_2e (metric tons)	Fuel cost
Police	28	37,515	319	$89,280
Light-duty	18	3,045 (+ 590 kWh)	26	$7,245
Emergency Vehicles	16	13,610	125	$35,915
Pickups	45	20,495	174	$48,775
Heavy-duty	23	9,175	94	$26,980
Other	64	28,020	167	$47,625
Total	195	111,860	905	$255,820

SUN PRAIRIE RECOMMENDATIONS FOR NEAR-TERM IMPLEMENTATION

Our analysis found energy investments that have a strong return on investment and significant energy savings potential. Implementing simple energy efficiency improvements to Sun Prairie's municipal buildings can reduce building energy consumption by almost 7 percent. By converting all streetlights to LEDs, Sun Prairie could cut annual streetlight electricity use in half – reducing utility costs and saving around 145 tons of carbon annually. In the fleet department, the City should prioritize converting police vehicles to hybrids as they offer a payback around one year and lead to a 40 percent decline in lifetime carbon emissions. Lastly, by adding solar arrays to 2 sites, the City can reduce fossil fuel electricity consumption by an additional 24 percent.

Table 74 summarizes the carbon and energy cost savings that the City would see if they implemented the recommended near-term actions in each major opportunity area. The following sections provide additional detail on each opportunity.

Table 74: Sun Prairie impact summary – estimated annual CO_2e and energy cost savings

Near-term Opportunity	CO_2e Reduction (metric tons)	Percent Carbon Reduction	Energy Cost Savings	Percent Energy Cost Reduction
Building efficiency	226	10%	$32,570	11%
Streetlights	738	47%	$106,605	47%
Fleet	141	16%	$41,365	16%
Solar	1,424	-	$205,620	-
Total opportunity	2,529	**35%**	$386,160	**34%**

Energy efficiency opportunities

Our analysis focused on near-term measures that not only have an energy or cost savings, but also may have possible benefits of reducing maintenance costs, improving occupant comfort, or increasing staff productivity. We also considered the ease and cost of implementation when prioritizing our recommendations.

To identify these opportunities, Slipstream conducted high-level walk-through for three buildings: the Sun Prairie City Hall, Sun Prairie Library, and Sun Prairie Westside Building. We took note of major end-uses and process, and spoke with building staff to understand building operations. The following provides a walk-through summary for each building with additional detail on energy savings potential below.

Sun Prairie City Hall

The Sun Prairie City Hall was built in 1994. It includes the city municipal functions as well as the eastside police department.

Observations

- HVAC system is water source heat pump system, which is ahead of its time given the age of the building.
- Planned upgrade to LED lighting. Currently testing different fixtures to choose best replacements.
- Offices had lighting occupancy sensors, but some have been removed or don't function.
- The first and second floors have potential for daylighting controls.

Recommendations

LED retrofit and lighting controls: Complete upgrade to LED. Consider vacancy sensors on light switches for small rooms and offices, similar to previous installation. Modern vacancy sensors may have improved over outdated design. Consider integrated light fixtures complete with occupancy sensors, photosensors, and wireless controls for meeting rooms and open offices on the 1st and 2nd floor. It will be easiest to add integrated light fixtures when upgrading to LED.

Task tuning: When upgrading lighting systems to LED and they include lighting controls, consider having a lighting contractor or representative task tune the system to match lighting levels to space lighting levels recommended by the Illuminating Engineering Society (IES). LED lamps tend to have higher lighting quality and appear "too bright". Lowering light levels slightly will save energy and increase occupant comfort.

Heat pump end of life replacement: Consider buying CEE Tier 2 or better heat pumps when replacing individual units at end of life. Refer to the 2109 CEE Commercial Unitary Air-Conditioning and Heat Pumps Specification for cooling and heating efficiency ratings.

Sun Prairie Library

The Sun Prairie Library was built in 1999. The building contains the library as well as a small TV station.

Observations

- There are a significant number of light fixtures throughout the library.
- LED lamps installed when old lamps burned out.
- Lights were on near windows.
- Previous roof leaks were identified.
- Difficulty maintaining temperature in children's room.

Recommendations

LED retrofit: Complete upgrade to LED. Consider de-lamping the large pendent light fixtures to reduce the amount of energy used. There are likely more lamps than required to light the space.

Lighting controls: Consider photosensors to harvest daylighting in perimeter spaces and the TV station office area. Consider vacancy sensors on to light switches for small rooms and offices.

HVAC controls: Consider adding a supply air temperature reset schedule to existing RTUs to save energy. This will increase the supply air temperature when its warmer outside.

Demand-controlled ventilation (DCV): Install carbon dioxide sensors in the main library area to lower outside air intake at the rooftop units when areas are unoccupied.

Reroofing: Consider adding additional roof insulation if the roof needs to be replaced.

Sun Prairie Westside Community Building

The Sun Prairie Westside Community Building was built in the mid-2000’s and houses the westside police department, fire department, EMS, parks and recreations department, and event spaces.

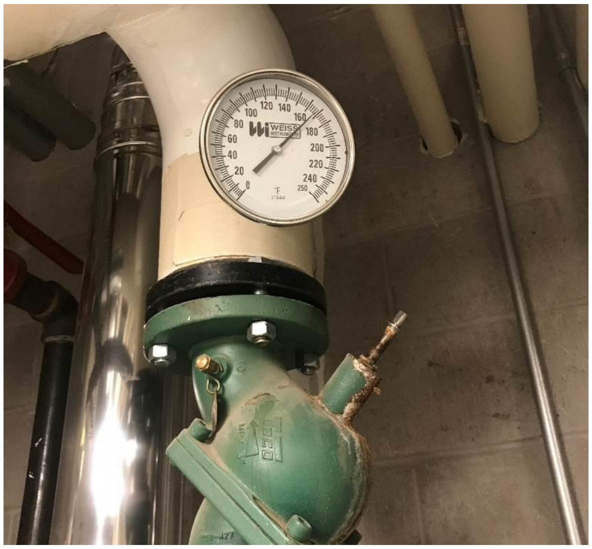
Observations

- Well-designed building with good daylighting.
- Boiler was operating at 170 degrees in the summer.
- LED upgrades are planned for the near future.
- Thermal discomfort issues due to atrium glass.

Recommendations

LED retrofit: Complete upgrade to LED. Consider integrated light fixtures that complete with occupancy sensors, photosensors, and wireless controls for meeting rooms, open offices, and event spaces throughout the building. Consider full networked controls for event space lighting with wireless control to provide additional lighting flexibility for events.

HVAC controls: Implement supply air temperature reset and hot water temperature reset controls to save energy. The heating hot water system in particular was operating at 170 degrees during the middle of a summer day. In the summer, heating hot water supply temperature can be reduced to 150 degrees to save energy. This can be implemented with a boiler control sequence to reduce hot water temperature based on outdoor air temperature. Refer to the general section of the report for more information.



DCV: Install carbon dioxide sensors in the event spaces and large meeting areas to lower outside air intake at the air handling units (AHU) when rooms are unoccupied.

Destratification fans: Consider installing ceiling fans in the atrium to help push hot air down and away from the parks and recreation offices.

Energy Saving Potential

For each measure identified, we calculated the total savings and payback. Calculations were based on a combination of resources, including the Wisconsin Technical Reference Manual, the International Energy Conservation Code, and internal research and expertise. References and assumptions for energy saving calculations and cost data are in Appendix E. For more complicated measures, we developed simple energy models to quantify levels of impact. For details and definitions on the measures, please refer to the Main Report of the energy plan that has descriptions of the measures.

Table 75 provides additional detail on the energy efficiency opportunities for each building and includes energy costs savings and simple payback. Measures are organized by simple payback to identify measures that will recovers capital costs quickly. Completion of the already-planned upgrades to LED lighting are estimated to save the most electricity out of all measures we analyzed. While the measures are listed below separately, we recommend that lighting controls be implemented with LED upgrades to reduce total upfront costs. The savings listed below for controls are based on a building already upgraded to LEDs and the incremental costs below assume that the controls and LED upgrades are completed at the same time. Controls implemented on their own would have a higher upfront cost.

The next biggest energy saver is hot water temperature reset for the Library and Westside building. These controls will lower the boiler temperature in the summer, particularly for the Westside building which is operating at 170 degrees in the summer. Energy saving potential is also high for HVAC AHU temperature reset, which can be implemented through the existing AHU controls for each building. Finally, additional savings can be gained with DCV.

Table 75: Energy saving measures for Sun Prairie walk-through buildings

Building	Cost	Electric savings (kWh)	Gas savings (therms) [13]	Total energy savings	Cost savings	Simple payback (years)
City Hall						
Lighting controls - daylighting	$130	4,030	-90	0.1%	$390	0.3
Lighting controls - occupancy	$340	9,490	-210	0.3%	$920	0.4
LED lighting - task tuning	$980	6,000	-130	0.2%	$580	1.7
DCV - assembly space	$750	630	330	0.9%	$270	2.8
LED lighting retrofit - interior	$25,910	89,770	-2,000	2.8%	$8,670	3.0
City Hall Total	**$28,110**	**109,920**	**-2,100**	**4.3%**	**$10,830**	**1.6**
Library						
Lighting controls - daylighting	$120	3,710	-80	0.1%	$360	0.3
Lighting controls - occupancy	$120	3,500	-80	0.1%	$340	0.4
LED lighting - task tuning	$430	3,160	-70	0.1%	$310	1.4
HVAC AHU temp reset	$1,340	4,370	470	1.6%	$760	1.8
LED lighting retrofit - interior	$19,090	60,200	-1,340	1.8%	$5,820	3.3
DCV - assembly space	$570	380	200	0.6%	$160	3.5
HVAC boiler reset	$1,840	0	820	2.1%	$490	3.8

[13] Negative values reflect an increase in heating demand due to interactive effects – in all cases total savings is still positive.

Building	Cost	Electric savings (kWh)	Gas savings (therms) [13]	Total energy savings	Cost savings	Simple payback (years)
Library Total	**$23,510**	**75,320**	**-80**	**6.4%**	**$8,240**	**2.1**
Westside Community Building						
HVAC AHU temp reset	$290	4,190	450	1.1%	$730	0.4
HVAC boiler reset	$1,220	0	3,000	5.5%	$1,800	0.7
DCV - assembly space	$1,110	1,290	680	1.3%	$550	2.0
LED lighting retrofit - interior	$18,060	70,700	-1,580	1.5%	$6,830	2.6
Westside Community Building Total	**$20,670**	**76,180**	**2,560**	**9.5%**	**$9,920**	**1.4**
Grand Total	**$72,290**	**261,430**	**380**		**$28,980**	**1.8**

Finally, while we did not visit every building in Sun Prairie's municipal operations, we did see similar building types in the walk-throughs with other communities. For those buildings for which we were unable to conduct walk-throughs, we asked community representatives to provide some details on particular end-uses in each building. By using that feedback and leveraging information gathered during other communities' site visits, we were able to estimate savings for the other Sun Prairie buildings. These savings are summarized in Table 76. However, these results are not based on a site walk-through and should be confirmed based on further review of building equipment and conditions.

Table 76: Energy saving measures for Sun Prairie – non-site walk-through buildings

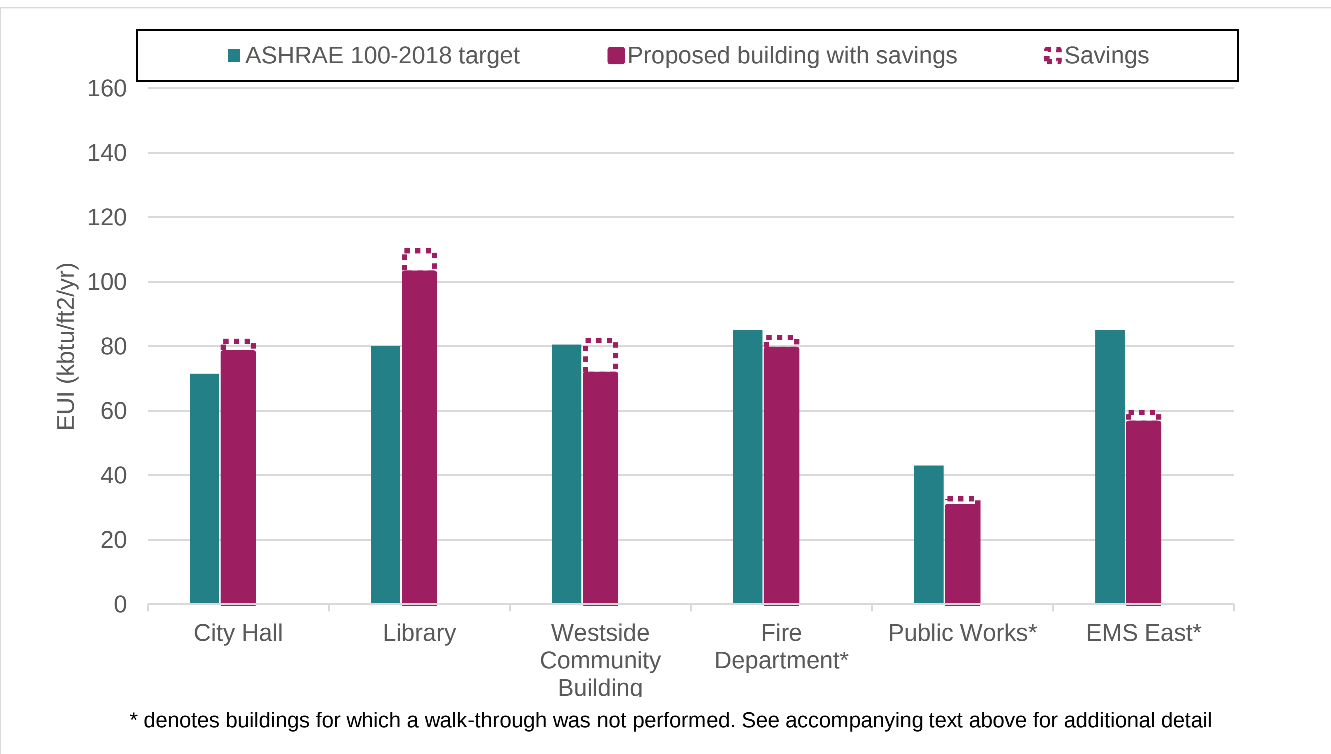
Building	Cost	Electric savings (kWh)	Gas savings (therms)	Total energy savings	Cost savings	Simple payback (years)
EMS East						
Lighting controls - daylighting	$40	1,300	-30	0.4%	$130	0.3
Lighting controls - occupancy	$40	1,220	-30	0.4%	$120	0.4
Lighting controls - garage	$20	390	-10	0.1%	$40	0.4
HVAC AHU temp reset	$190	790	90	2.9%	$140	1.4
DCV - assembly space	$50	70	40	1.0%	$30	1.7
LED lighting - task tuning	$190	1,100	-20	0.3%	$110	1.8
DCV - office space	$40	20	10	0.3%	$10	3.8
LED lighting retrofit - interior	$0	0	0	0.0%	$0	
EMS East Total	**$570**	**4,890**	**50**	**5.5%**	**$570**	**1.4**
Fire Department						
Lighting controls - daylighting	$20	700	-20	0.1%	$70	0.3
Lighting controls - occupancy	$20	660	-10	0.1%	$60	0.4
Lighting controls - garage	$20	520	-10	0.1%	$50	0.4
DCV - assembly space	$140	190	100	1.5%	$80	1.7
LED lighting - task tuning	$100	590	-10	0.1%	$60	1.8
HVAC AHU temp reset	$480	1,060	120	2.1%	$190	2.6
DCV - office space	$100	60	30	0.5%	$30	3.8
LED lighting retrofit - interior	$0	0	0	0.0%	$0	
Fire Department Total	**$880**	**3,780**	**190**	**4.4%**	**$530**	**1.6**

Building	Cost	Electric savings (kWh)	Gas savings (therms)	Total energy savings	Cost savings	Simple payback (years)
Public Works						
Lighting controls - occupancy	$90	2,540	-60	0.3%	$250	0.4
HVAC AHU temp reset	$290	4,160	450	5.3%	$730	0.4
Lighting controls - garage	$250	6,020	-130	0.6%	$580	0.4
LED lighting - task tuning	$410	1,150	-30	0.1%	$110	3.7
LED lighting retrofit - interior	$3,610	8,530	-190	0.9%	$820	4.4
Public Works Total	**$4,650**	**22,390**	**40**	**7.3%**	**$2,490**	**1.9**
Grand Total	**$6,100**	**31,060**	**280**		**$3,580**	**1.6**

Figure 20 shows the EUI of each building if all energy efficiency measures are implemented along with an ASHRAE Standard 100-2018 benchmark value for comparison.

Our analysis shows that the recommended efficiency measures can move the building's EUI towards the ASHRAE 100 target values for their respective building types. The Westside Community Building uses a significant amount of energy partly because it serves so many different functions, including 24/7 public safety functions. However, this also means there's more potential energy savings for this building. We expect that the other buildings would see some mild energy reductions, but we conservatively estimated energy savings because we did not conduct a walk-through.

Figure 20: Sun Prairie building EUI savings



Street Lighting Opportunities

Converting streetlights to LEDs has a large energy saving potential. In addition to reduced energy use annually, LEDs also last longer and thus reduce lifetime maintenance costs. The lights can also improve lighting quality, improve perception of safety, and reduce light pollution.

Table 77 illustrates the lifetime energy savings, carbon savings and cost savings associated with converting one high-pressure sodium fixture to a LED fixture. This standard lifetime analysis assumes that streetlights are owned by the municipality and serves to illustrate potential savings from a conversion. The upfront cost in Table 77 , which includes both labor cost and material cost, is estimated from conversations with city officials who have implemented LED retrofits in the last few years. The Wisconsin Technical Resource Manual estimates the cost per fixture to be slightly higher. However, as LED costs are rapidly decreasing, we opted to use cost estimates from recent installations in an attempt to accurately represent current costs. The cost savings reported represent avoided maintenance costs and avoided energy costs. Appendix B provides more details on the assumptions made for these calculations.

Table 77: LED lifetime cost analysis - cost per fixture

Lighting type	Lifetime energy savings (kWh)	Lifetime CO_2e savings (metric tons)	Upfront cost	Lifetime cost savings	Payback period (years)
70 W	3,430	2.6	$249	$275	6.8
100 W	7,750	5.9	$249	$670	3.9
150 W	9,480	7.2	$299	$800	3.6
250 W	16,070	12.2	$399	$1,315	3.3
400 W	23,800	18.1	$499	$1,930	3

Table 78 illustrates the potential electricity, carbon, and energy cost savings from converting all streetlights to LEDs. Based on the wattage of current streetlights, we calculated the energy use from LED-equivalent bulbs and subtracted this from 2018 streetlight electricity usage. Using this energy savings value, we applied a standard carbon factor and electricity rate to estimate the carbon and cost savings.

Table 78: Sun Prairie streetlights - annual savings

STREETLIGHT ANNUAL SAVINGS	
Number of lights	2,615
Energy savings (kWh)	969,125
CO_2e savings (metric tons)	738
Energy cost savings	$106,605

Fleet Opportunities

The market for alternative fuel vehicles is rapidly developing. In the next five years, several new options will exist for municipal fleets, but at this point, the largest two opportunities are police and light-duty vehicles. A few niche alternatives exist for other vehicle types, but each of them has a substantial incremental upfront cost – making them less of a viable option. Based on conversations with the collaborating communities, we left these high incremental cost options out of our final recommendations, but our completed analysis can be found in the main report.

Table 79 illustrates the payback period for police vehicles and light-duty vehicles, assuming 14,000 miles driven for police vehicles and 3,500 miles driven for light-duty vehicles. As the numbers illustrate, hybrid police vehicles present a great opportunity for conversion – with a payback period around one year and a lifetime carbon reduction of between 40 and 55 percent. Although light-duty vehicles have less favorable payback periods, increasing the miles driven per vehicle would greatly improve these numbers. Once a vehicle hits around 10,000 to 15,000 miles driven a year, the net lifetime cost breaks even compared to a conventional car. For more details on the lifetime cost analysis, see Appendix C.

Table 79: Sun Prairie lifetime cost analysis – relevant alternative fleet vehicles

		Lifetime	Incremental vehicle cost	Annual cost savings	Lifetime savings	Payback period	Lifetime CO_2e reduction
Police Vehicle	Hybrid Patrol SUV	8	$3,500	$1,640	$10,200	**1.2**	41%
	Hybrid Patrol Sedan	8	$3,500	$2,170	$14,560	**1**	55%
Light-duty	Passenger Vehicle	15	$8,600	$350	-$3,700	-	43%
	Plug-in Hybrid SUV	15	$10,000	$215	-$7,000	-	35%
	Plug-in Hybrid Van	15	$9,000	$240	-$5,650	-	35%

Table 80 illustrates the savings from converting all light-duty and police vehicles in the Sun Prairie municipal fleet. The transition to hybrid police vehicles leads to the largest benefit – over a 40 percent reduction in both carbon emissions and fuel costs. Within the police vehicles, we do not include the conversion of the police pickup ad within the light-duty vehicles, we do not model the conversion of the Ford Transit van.

Table 80: Sun Prairie potential annual fuel savings - adoption of light-duty and police vehicles

		CO_2e (metric tons)		Fuel cost	
Department	Number of vehicles	Current	Alternative	Current	Alternative
Police	27/28	319	187	$89,280	$52,040
Light-duty	17/18	26	17	$7,225	$3,100

Solar Energy Opportunities

In addition to the two solar PV installations currently operational, which total 210 kW in demand, we also provided an in-depth analysis of two different sites in Sun Prairie. The analysis modeled a ground-mounted array on the library and a roof-mounted array on two buildings at the Wastewater Treatment Plant. Ground-mounted solar arrays offer a high degree of visibility for the project within the community. Locating a solar array at the library would ensure that the system would be seen by many residents as they visit the library. Visibility of the system enables the City to effectively lead by example in its transition to renewable energy. At the same time, system visibility of a ground-mounted array also may affect the neighbors of the site and the community by creating a visual change and affecting potential current and future use of the site. The City may seek to engage the owners of the neighboring properties during the project development process in order to identify any concerns and build support for the project.

Table 81 summarizes the potential solar production at each site. The recommended PV system size for each location considers the site's current electric consumption and the size and configuration of an array that each site could support. The Customer-Owned Generation Systems (Greater than 20 kW) rate offered by Sun Prairie Utilities allows for net metering for customer-owned generation facilities with generating capacity of less than 100 kW. The capacities of both arrays significantly exceeds the 100 kW threshold. The electric tariff requires that, for systems with capacity greater than 100 kW, the customer negotiate a buy-back rate with the utility. The addition of these arrays could greatly increase the percent renewable electricity in the city – up from 4 to 27 percent. This would allow Sun Prairie to meet its goal to power 25 percent of its municipal operations from renewable energy by 2025.

Table 81: Sun Prairie summary of solar potential by site

Site name	Address	Annual consumption (2018, kWh)	Potential PV capacity (kW DC)	Estimated production (kWh)	Savings
Library	1350 Linnerud Dr	479,680	338.7	469,394	98%
WWTP	3040 Bailey Rd	2,648,344	937.9	1,230,117	46%
Total		**3,128,024**	**1,276.6**	**1,699,511**	**54%**

Table 82 provides a summary of estimated costs of the recommended PV arrays. The estimated cost for the systems of $1,818.10 per kW is based on current data for the Dane County market for commercial PV installations. Since the cost estimates reflect market data, exact costs may vary by solar contractor.

WPPI offers rebates for commercial-scale solar installations through a competitive request for proposal program. The rebates, which are not guaranteed, are limited to a maximum of 50 percent of the total installed cost of the project or $125,000. This analysis assumes a rebate amount equal to 40 percent of the total project cost. Customers who receive grants from WPPI for solar installations may have to transfer ownership of the renewable energy credits from the project to WPPI.

Table 82: Estimated cost of recommended Sun Prairie PV arrays

Site Name	Total cost	WPPI rebate	Net cost
Library	$660,432	$125,000	$535,432
WWTP	$1,828,887	$125,000	$1,703,887
Total	**$2,489,319**	**$250,000**	**$2,239,319**

Table 83 provides a summary description of the array at each site as well as an aerial view of the arrays. The red outlines represent where the arrays would sit.

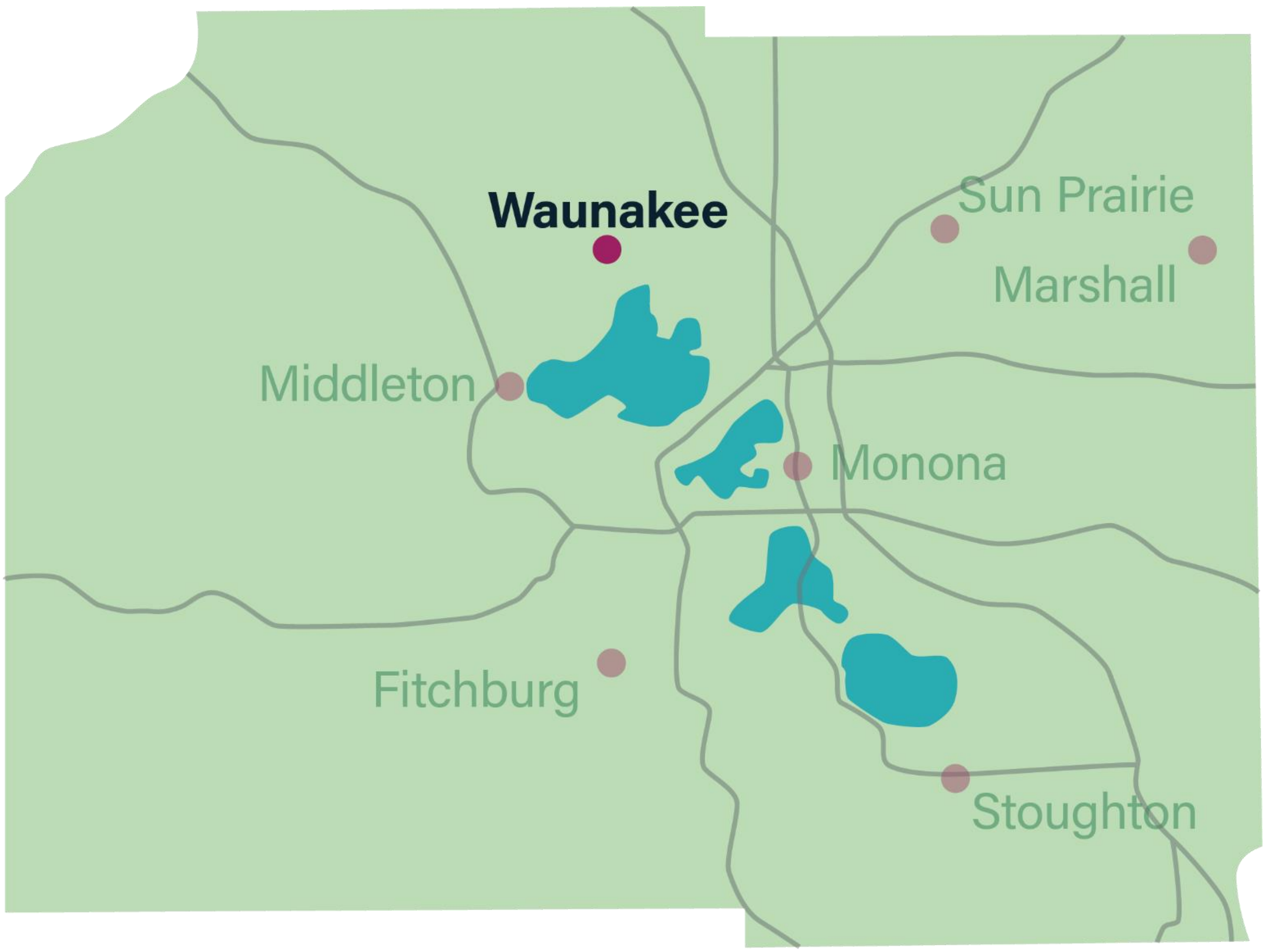
Table 83: Sun Prairie description of potential PV arrays

Description of site	Aerial views with potential PV mounting
The **Library** has open space on all sides, on which ground-mounted solar arrays could be installed. The model assumes racked, fixed-tilt panel, oriented in line with the building, at 30 degrees east of due south. Tilt is assumed to be 20 degrees and the GCR is 0.3. An array to the west of the building could take the place of one of the outlined segments. Alternatively, Sun Prairie may investigate installing shaded solar car parking or solar flags in its parking lot.	
The **Wastewater Treatment Plant** provides ample roof and land space to install solar arrays. To maximize the solar electricity produced to power the WWTP, we modeled a PV system with arrays on the roofs of two buildings and three ground-mounted sections. To distribute the cost of the project across a longer time period and/or to optimize access to grants and rebates, the City may choose to install the system in phases. The **north west building** has a pitched roof that is oriented east-west and has minimal penetrations or other obstructions. The modeled system includes flush-mounted arrays on both the east and west portions of the roof. The estimated capacity of the arrays on the roof of the northwest array would be 238.2 kW and is projected to produce 277,952 kWh per year.	 

Description of site	Aerial views with potential PV mounting
The **east building** has a pitched roof that is oriented east-west and has minimal penetrations or other obstructions. The modeled system includes flush-mounted arrays on both the east and west portions of the roof. The estimated capacity of the arrays on the roof of the northwest array would be 119.1 kW DC and is projected to produce 135,613 kWh per year.	
The **three ground-mounted** sections of the array would have racked, fixed-tilt panels, oriented due south. The model assumes a tilt of 20 degrees and a GCR of 0.3. The combined capacity of the three ground-mounted sections is 476.3 kW DC and is estimated to generate 695,202 kWh per year.	

WAUNAKEE

COMMUNITY-SPECIFIC MUNICIPAL ENERGY PLAN



Wisconsin Office of Energy Innovation Grant

WAUNAKEE BACKGROUND

The village of Waunakee has a growing population of close to 14,000 residents. The recently adopted comprehensive plan encourages commercial and industrial developers to implement more sustainable practices. Similarly, the Village recently built a new library with a 34-kW solar system and a green roof. With shifting space utilization in the near-future, such as the upcoming move of the Village Hall to the old library building, there is ample opportunity for incorporating energy savings practices in both buildings and operations.

This chapter provides a detailed summary of the Waunakee energy plan. We begin by summarizing Waunakee's energy profile to provide a baseline understanding of current energy consumption, costs and carbon emissions for 2018. We then delve into our recommendations for near terms investments or action, split out into four categories: building energy efficiency, street lighting opportunities, fleet opportunities, and solar energy opportunities.

COMMUNITY ENERGY PROFILE

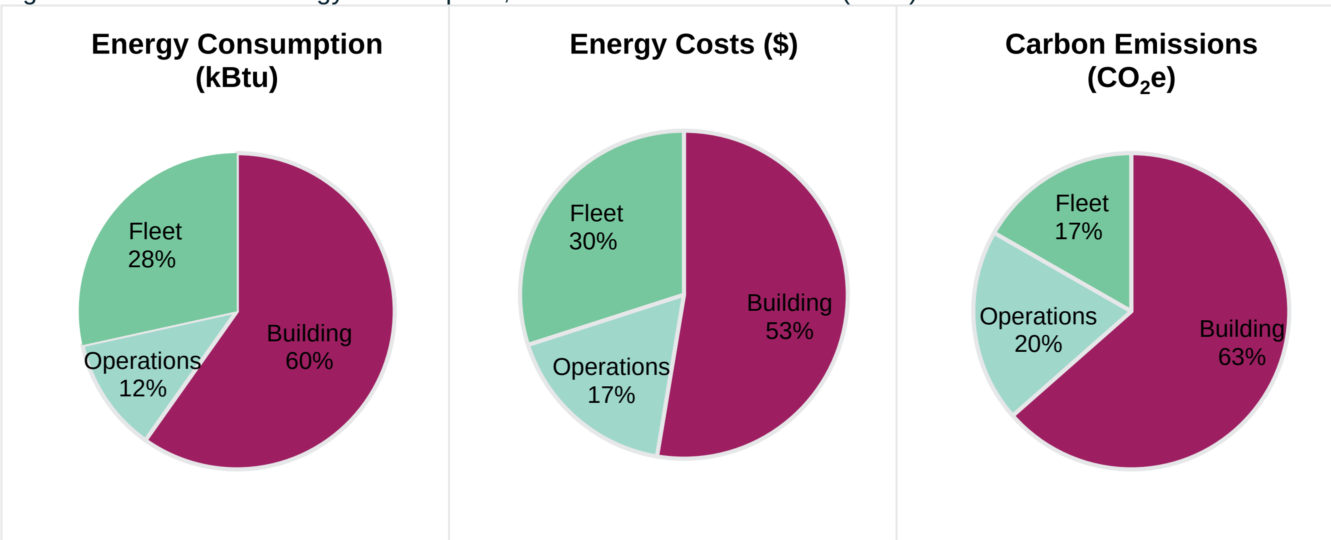
The three main energy inventory elements for Waunakee's energy profile include buildings, operations, and municipal fleet. Table 84 provides details by category on what was included in development of the Waunakee energy profile, based on the data provided by Waunakee staff.

Table 84: Waunakee inventory elements (2018 baseline)

Buildings	Operations	Fleet
Library Police Department Public Works Village Center/Senior Center Village Hall Waunakee Area EMS Waunakee Area Fire District Waunakee Utilities	Streetlights Wells/pumps/lifts Centennial Park	10 Police vehicles 1 Light-duty vehicles 12 Heavy-duty vehicles 21 Pickups 72 Other

Figure 21 provides a breakdown of each element to total energy use, cost, and carbon emissions. The cost and carbon intensity of the different fuels (electricity, natural gas, gasoline, and diesel) can significantly impact the contribution of each source to the total.

Figure 21: Waunakee energy consumption, cost and carbon emissions (2018)



Breaking these elements down further, Table 85 details the annual energy use, carbon emissions, and energy cost associated with each building and operation use type. The buildings are listed individually; if there were multiple meters per building, we aggregated the values up to the building level. If there were multiple meters for operation data, it was aggregated by use type such as streetlights and wells, pumps, and lifts.

Table 85: Waunakee baseline energy, carbon and cost data by building and operation use type (2018)

	Building/Use	Net Electricity (kWh)	Natural Gas (therms)	CO_2e dioxide equivalent (metric tons)	Percent of total CO_2e	Energy Cost
Buildings	Library	99,520	2,747	90	4%	$12,595
	Police Department	117,360	10,698	146	7%	$19,330
	Public Works	61,020	12,113	111	5%	$13,980
	Village/Senior Center	524,160	25,975	537	25%	$73,240
	Village Hall	73,680	5,114	83	4%	$11,175
	Waunakee Area EMS	90,160	4,264	91	4%	$12,475
	Waunakee Area Fire District	85,680	6,959	102	5%	$13,600
	Waunakee Utilities	179,328	11,820	199	9%	$26,820
Operati	Parks and Recreation	11,659	999	14	1%	$1,880
	Streetlights	524,173	-	399	10%	$57,660
	Wells/pumps/lifts	-	1,788	10	0.5%	$1,075
	Fleet			359	17%	$104,255
	Total	**1,766,740**	**82,477**	**2,141**		**$348,085**

Figure 22 illustrates how the baseline energy use intensity (EUI) of each Waunakee building compares to the ASHRAE 100-2018 target and benchmark value for similar use buildings. A few buildings were excluded as good benchmark comparisons did not exist. Additionally, it's important to note that the ASHRAE values represent a typical building type and do not account for buildings that may house multiple village departments or functions.

Figure 22: Waunakee EUI benchmarking and comparison ASHRAE target and benchmark

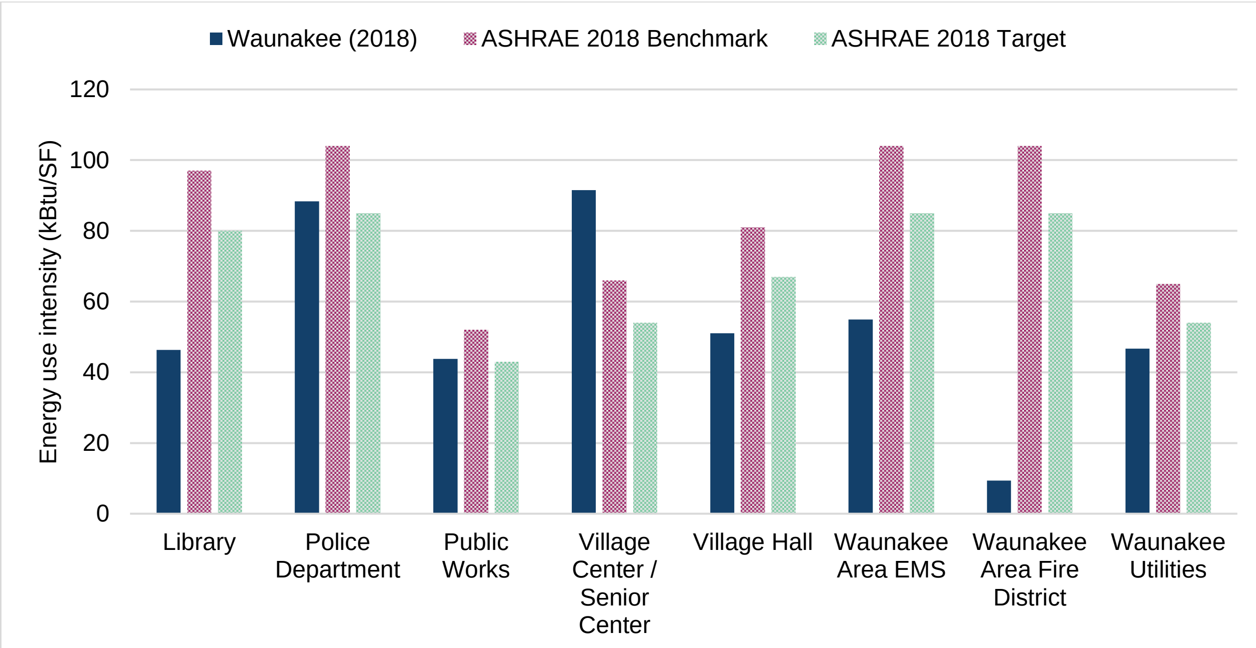


Table 86 illustrates the current renewable energy consumption in the city. On-site solar currently makes up around 10 percent of total electricity use in the Village – leaving potential for future developments. Waunakee has one on-site solar array: a new 34 kW installation on the Library.

Table 86: Waunakee renewable energy summary - current production (as of 2019)

RENEWABLE ENERGY QUICK FACTS	
On-site net metered solar (estimated kWh)	42,000
Purchased RECs (kWh)	144,000
Total renewable energy purchase/production (kWh)	186,000
Percent of gross municipal electricity	**10%**

Table 87 illustrates the current vehicle fuel usage, carbon emissions, and fuel cost by vehicle type. This includes both Waunakee utility- and village-owned vehicles.

Table 87: Waunakee vehicle fuel usage by vehicle type (2018)

Department	Number of vehicles	Gallons	CO_2e (metric tons)	Fuel cost
Police	10	11,390	97	$28,130
Light-duty	1	980 kWh	1	$110
Pickups	21	10,020	87	$25,260
Heavy-duty	12	5,400	54	$15,960
Other	72	13,780	120	$34,790
Total	116	40,590	359	104,250

WAUNAKEE RECOMMENDATIONS FOR NEAR-TERM IMPLEMENTATION

Our analysis found energy investments that have a strong return on investment and significant energy savings potential. Implementing simple energy efficiency improvements to Waunakee's municipal buildings can reduce building energy consumption by as much as 5 percent. Converting all streetlights to LEDs, which would cut current streetlight electricity by 40 percent and reduce carbon emissions by around 200 tons. In the fleet department, the city should prioritize converting police vehicles to hybrids as they offer a payback around one year and lead to a 40 percent decline in lifetime carbon emissions. Lastly, by adding additional solar arrays to 2 sites, the city can reduce fossil fuel electricity consumption by an additional 8 percent.

Table 88 summarizes the carbon and energy cost savings that the Village would see if they implemented the recommended near-term actions in each major opportunity area. The following sections provide details on each of the opportunities.

Table 88: Waunakee impact summary – estimated annual carbon and energy cost savings

Near-term Opportunity	CO_2e reduction (metric tons)	Percent Carbon Reduction	Energy cost savings	Percent Energy Cost Reduction
Building efficiency	54	4%	$7,940	4%
Streetlights	200	50%	$28,805	50%
Fleet	40	11%	$11,520	11%
Solar	143	-	$20,695	-
Total opportunity	437	**20%**	$68,960	**20%**

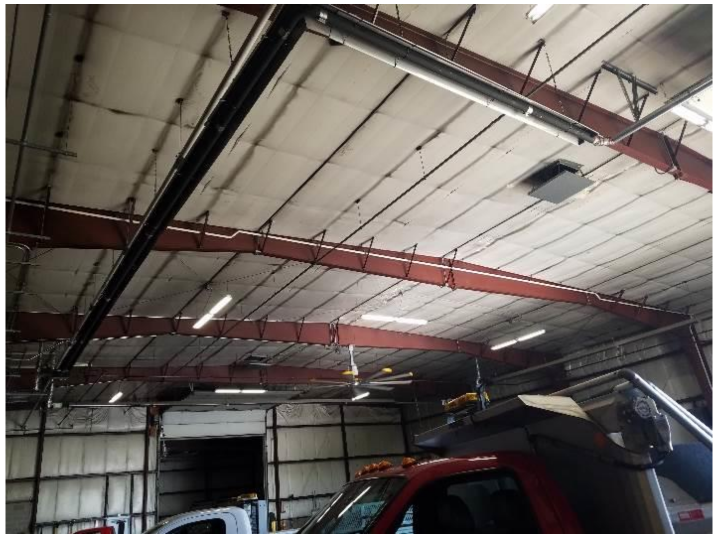
Energy efficiency opportunities

Our analysis focused on near-term measures that not only have an energy or cost savings, but also may have possible benefits of reducing maintenance costs, improving occupant comfort, or increasing staff productivity. We also considered the ease and cost of implementation when prioritizing our recommendations.

To identify these opportunities, Slipstream conducted high-level walk-through for three buildings: the Waunakee Public Works building, Waunakee Police Department, and the old Waunakee Library, which will be upgraded into a new village hall. We took note of major end-uses and process, and spoke with building staff to understand building operations. The following provides a walk-through summary for each building with additional detail on energy savings potential below.

Waunakee Public Works

The Waunakee public works building was built in 1965 and expanded in 2000.



Observations

- Sophisticated building automation system (BAS) with some untapped potential.
- Good use of infrared gas heaters and destratification fans in the garage spaces.
- Some unit heaters were nearing end of life.
- Most lighting has sensors, but not all in use.
- Small room lights were always on.

Recommendations

Garage LED retrofit and lighting controls: Upgrade fixtures to LED. Consider replacing high-bay fixtures with networked controlled fixtures with occupancy sensors. These fixtures can be wirelessly adjusted, giving remote flexibility for the hard to reach light fixtures.

Vacancy lighting controls: Upgrade fixtures to LED. Consider replacing high-bay fixtures with networked controlled fixtures with occupancy sensors. These fixtures can be wirelessly adjusted, giving remote flexibility for the hard to reach light fixtures.

Waunakee Police Department

The Waunakee Police Department was originally built in 1978 and was remodeled into a police station in 2007.

Observations

- Fluorescent lighting throughout.
- IT closet has trouble cooling. It is served by one of the central rooftop units.
- Thermal comfort issues, with people trying to adjust thermostats throughout the day.

Recommendations

LED retrofit and lighting controls: Upgrade to LED. Install vacancy sensors for small rooms, offices, and storage closets.

IT closet cooling: Servers require 24/7 cooling and should have a dedicated air conditioning system to cool the space. Consider installing a dedicated ductless split system to serve the IT closet. It should reduce the energy load on the central rooftop unit.

HVAC controls: Consider adding a supply air temperature reset schedule to existing roof terminal units (RTU) to save energy. This will increase the supply air temperature when its warmer outside.

Building upgrades vs. new building investment: Given the age of the original building, consider holding off on major building energy efficiency upgrades to save capital investment if new construction is planned in the future.

Waunakee Old Library renovation

The Waunakee Library was built in 1984, but was vacated for a new library that opened this year. It will be renovated into a new village hall as early as 2020.

Observations

- Lighting is all fluorescent with limited lighting controls.
- Old library used multiple furnace A/C units for heating and air conditioning which are in good condition.
- Existing furnaces are 92 percent efficient.
- Major renovation will be the easiest time to upgrade building systems.

Recommendations

LED retrofit and lighting controls: Upgrade lighting and lighting controls. Install all new LED fixtures for new village hall layout. Install integrated light fixtures with photosensors and occupancy sensors in open office areas. Install wall switch vacancy sensors in new offices. Consider networked lighting controls for better flexibility and control of building lighting.

A/C unit replacement: Depending on how the new HVAC system is configured, consider investing in CEE Advanced Tier air conditioning units. These units should have a SEER rating of 18 or greater and can save around $300 a month in energy bills. When retrofitting the existing furnace system, be careful with system zoning. Make sure furnace units serve similar spaces for better temperature control, reduce temperature complaints, and save energy. Consider thermostat location carefully.

Consider implementing new furnaces or units with economizer capability and demand control ventilation, although these upgrades would require more upfront investment.

New construction upgrades: Consider setting a new energy target from ASHRAE 100-2018 Energy Efficiency in Existing Buildings. The recommended ASHRAE 100-2018 EUI is 67 kbtu/gsf-yr. Several upfront steps can help ensure the building meets the target, including: adding a requirement to report predicted building EUI at design milestones in the contract, sharing it with the design and construction team, using energy models throughout the entire design process to estimate an EUI, and using it as guidance when making any construction decisions.

In addition to a broad EUI target, consider trying to exceed the Wisconsin energy code on lighting power density, lighting controls, and any new HVAC equipment. This can both lower energy consumption and cost. For example, targeting a lower lighting power density (W/sf) can lead to lower upfront costs by using lamps with better light output so fewer fixtures are needed. By leveraging Focus on Energy for energy efficiency rebates, upfront costs can be lowered.

After the construction is completed, track electricity and gas usage to see if the building meets the projected energy targets, and use that data to improve the building and keep energy bills low.

Energy Saving Potential

For each measure identified, we calculated the total savings and payback. Calculations were based on a combination of resources, including the Wisconsin Technical Reference Manual, the International Energy Conservation Code, and internal research and expertise. References and assumptions for energy saving calculations and cost data are in Appendix E. For more complicated measures, we developed simple energy models to quantify levels of impact. For details and definitions on the measures, please refer to the Main Report of the energy plan that has descriptions of the measures.

Table 89 provides additional detail on the energy efficiency opportunities for each building and includes energy costs savings and simple payback. Measures are organized by simple payback to identify measures that will recovers capital costs quickly.

Upgrading to LED lighting is estimated to save the most electricity out of all measures we analyzed. While the measures are listed below separately, we recommend that lighting controls be implemented with LED upgrades to reduce total upfront costs. The savings listed below for controls are based on a building already upgraded to LEDs and the incremental costs below assume that the controls and LED upgrades are completed at the same time. Controls implemented on their own would have a higher upfront cost.

The next biggest energy saver is air handling unit (AHU) temperature reset and demand-controlled ventilation (DCV) for the Police Department. The AHU temperature reset should be easy to implement with the packaged rooftop unit controls. DCV can be implemented by adding carbon dioxide sensors to large conference areas.

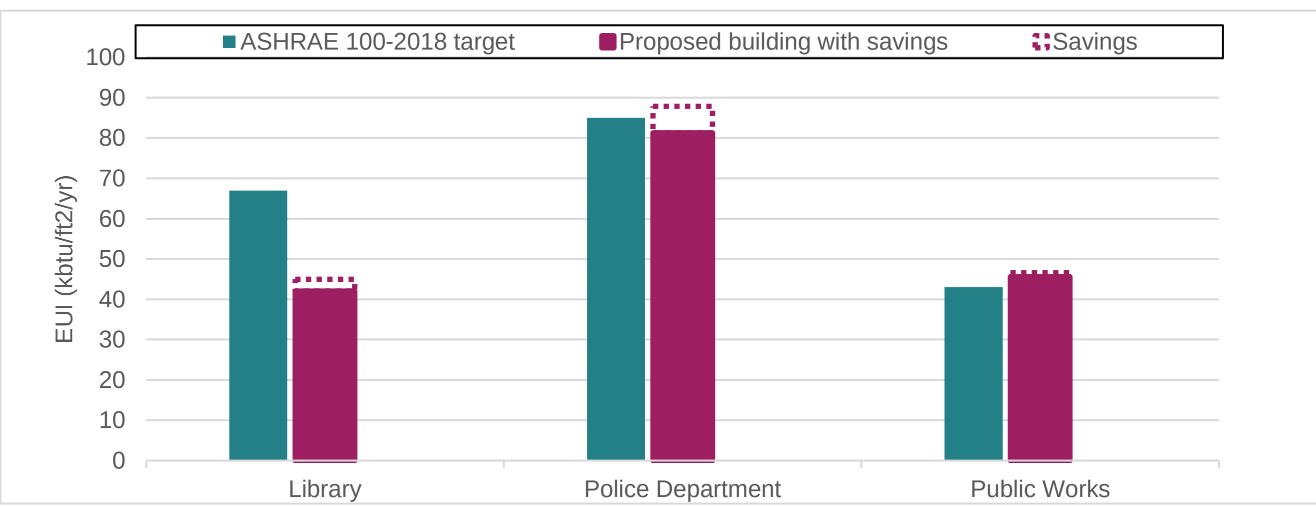
The old Waunakee Library is planned to be renovated into a new village hall. We recommend upgrading systems the lighting and occupancy sensor lighting controls, as the building is being updated to new functions. We also recommend considering upgrading A/C units to a more efficient model. There are limited upgrades to be made to the envelope, including walls and windows, because the age of the building suggests sufficient insulation and the windows are already double-paned; any upgrades would be incremental and would not yield a favorable payback.

Table 89: Energy saving measures for Waunakee walk-through buildings

Building	Cost	Electric savings (kWh)	Gas savings (therms)[14]	Total energy savings	Cost savings	Simple payback (years)
Library to Village Hall Renovation						
Custom - Lighting	$9,890	28,970	-720	4.8%	$2,760	3.6
Custom - A/C Replacement	$2,030	2,580	0	1.6%	$280	7.1
Library Total	**$11,920**	**31,550**	**-720**	**6.4%**	**$3,040**	
Police Department						
Lighting controls - daylighting	$160	1,200	-30	0.1%	$120	0.3
Lighting controls - occupancy	$40	4,510	-100	0.4%	$440	0.4
HVAC AHU reset	$480	1,830	200	2.0%	$320	1.5
DCV - assembly space	$480	650	340	2.8%	$280	1.7
LED lighting - task tuning	$450	2,550	-60	0.2%	$250	1.8
LED lighting retrofit - interior	$4,810	21,610	-480	1.9%	$2,090	2.3
Police Department Total	**$6,420**	**32,330**	**-130**	**7.4%**	**$3,480**	
Public Works						
HVAC AHU reset	$20	700	80	0.7%	$120	0.2
Lighting controls - occupancy	$40	1,070	-20	0.1%	$100	0.4
LED lighting - task tuning	$170	480	-10	0.0%	$50	3.7
LED lighting retrofit - interior	$5,000	11,820	-260	1.0%	$1,140	4.4
Public Works Total	**$5,230**	**14,080**	**-220**	**1.9%**	**$1,420**	
Grand Total	**$23,570**	**77,970**	**-1,070**	**15.8%**	**$7,940**	**2.3**

Figure 23 shows the EUI of each building if all energy efficiency measures are implemented along with an ASHRAE Standard 100-2018 benchmark value for comparison. The energy measures outlined above for the Waunakee buildings help bring them much closer to the ASHRAE 100 target values for their respective building types.

Figure 23: Waunakee building EUI savings



[14] Negative values reflect an increase in heating demand due to interactive effects – in all cases total savings is still positive.

Street Lighting Opportunities

Converting streetlights to LEDs has a large energy saving potential. In addition to reduced energy use annually, LEDs also last longer and thus reduce lifetime maintenance costs. The lights can also improve lighting quality, improve perception of safety, and reduce light pollution.

Table 90 illustrates the lifetime energy savings, carbon savings and cost savings associated with converting one high-pressure sodium fixture to a LED fixture. This standard lifetime analysis assumes that streetlights are owned by the municipality and serves to illustrate potential savings from a conversion. The upfront cost in Table 90 , which includes both labor cost and material cost, is estimated from conversations with city officials who have implemented LED retrofits in the last few years. The Wisconsin Technical Resource Manual estimates the cost per fixture to be slightly higher. However, as LED costs are rapidly decreasing, we opted to use cost estimates from recent installations in an attempt to accurately represent current costs. The cost savings reported represent avoided maintenance costs and avoided energy costs. Appendix B provides more details on the assumptions made for these calculations.

Table 90: LED lifetime cost analysis – cost per fixture

Lighting type	Lifetime energy savings (kWh)	Lifetime CO_2e savings (metric tons)	Upfront cost	Lifetime cost savings	Payback period (years)
70 W	3,430	2.6	$249	$275	6.8
100 W	7,750	5.9	$249	$670	3.9
150 W	9,480	7.2	$299	$800	3.6
250 W	16,070	12.2	$399	$1,315	3.3
400 W	23,800	18.1	$499	$1,930	3

Table 91illustrates the potential electricity, carbon, and energy cost savings from converting all streetlights to LEDs. Based on the wattage of current streetlights, we calculated the energy use from LED-equivalent bulbs and subtracted this from 2018 streetlight electricity usage. Using this energy savings value, we applied a standard carbon factor and electricity rate to estimate the carbon and cost savings.

Table 91: Waunakee streetlights - annual savings

STREETLIGHT ANNUAL SAVINGS	
Number of lights	965
Energy savings (kWh)	261,855
CO_2e savings (metric tons)	200
Cost savings	$28,805

Fleet Opportunities

The market for alternative fuel vehicles is rapidly developing. In the next five years, several new options will exist for municipal fleets, but at this point, the largest two opportunities are police and light-duty vehicles. A few niche alternatives exist for other vehicle types, but each of them has a substantial incremental upfront cost – making them less of a viable option. Based on conversations with the collaborating communities, we left these high incremental cost options out of our final recommendations, but our completed analysis can be found in the main report.

Table 92 illustrates the payback period for police vehicles and light-duty vehicles, assuming 14,000 miles driven for police vehicles and 3,500 miles driven for light-duty vehicles. As the numbers illustrate, hybrid police vehicles present a great opportunity for conversion – with a payback period around one year and a lifetime carbon reduction of between 40 and 55 percent. Although light-duty vehicles have less favorable payback periods, increasing the miles driven per vehicle would greatly improve these numbers. Once a vehicle hits around 10,000 to 15,000 miles driven a year, the net lifetime cost breaks even compared to a conventional car. For more details on the lifetime cost analysis, see Appendix C.

Table 92: Waunakee lifetime cost analysis – relevant alternative fleet vehicles

		Lifetime	Incremental vehicle cost	Annual cost savings	Lifetime savings	Payback period	Lifetime CO_2e reduction
Police Vehicles	**Hybrid Patrol SUV**	8	$3,500	$1,640	$10,200	**1.2**	41%
	Hybrid Patrol Sedan	8	$3,500	$2,170	$14,560	**1**	55%
Light duty	**Passenger Vehicle**	15	$8,600	$350	-$3,700	-	43%
	Plug-in Hybrid SUV	15	$10,000	$215	-$7,000	-	35%

Table 93 illustrates the savings from converting all light-duty and police vehicles in the Waunakee municipal fleet. The only light-duty vehicle in the municipal fleet is already electric, so there are no potential savings there. The transition to hybrid police vehicles leads to a large benefit – over a 40 percent reduction in both carbon emissions and fuel costs.

Table 93: Waunakee potential annual fuel savings - adoption of light-duty and police vehicles

HYBRID POLICE VEHICLES – POTENTIAL SAVINGS	
CO_2e savings (metric tons)	40
Cost savings	$11,520

Solar Energy Opportunities

The solar energy analysis included an in-depth look at two sites in the village of Waunakee. We modeled rooftop arrays on both the Village Center and Public Works building.

Table 94 summarizes the potential solar production at each site. The recommended PV system size for each location considers the site's current electric consumption and the size and configuration of an array that each site could support. The Customer-Owned Generation Systems (Greater than 20 kW) rate offered by Waunakee Utilities allows for net metering for customer-owned generation facilities with generating capacity of less than 100 kW. The arrays are designed to be eligible for this rate and to minimize the Village's loss due to disadvantageous rates for over-production.

Table 94: Waunakee summary of solar production by site

Site name	Address	Consumption (kWh)	PV capacity (kW DC)	Production (est. kWh)	Savings
Village Center	333 S Madison St	524,160	74.4	85,533	16%
Public Works	504 Moravian Valley Rd	61,020	43.4	60,610	99%
Total		**585,180**	**117.8**	**146,143**	**25%**

Table 95 provides and estimated cost for each of the recommended PV arrays. The estimated cost for the systems of $1,818.10 per kW is based on current data for the Dane County market for commercial PV installations. A seven percent premium was added to the estimated total cost of the Village Center system to reflect added complexity due to the layout of the building's roof. Since the cost estimates reflect market data, exact costs may vary by solar contractor.

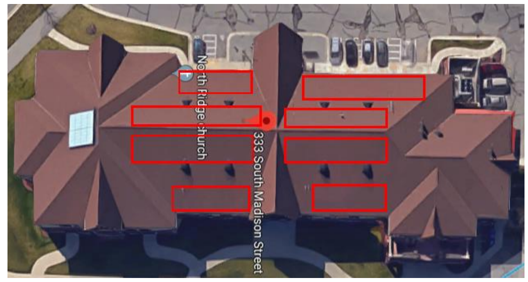
WPPI offers rebates for commercial-scale solar installations through a competitive request for proposal program. The rebates, which are not guaranteed, are limited to a maximum of 50 percent of the total installed cost of the project or $125,000. This analysis assumes a rebate amount equal to 40 percent of the total project cost. Customers who receive grants from WPPI for solar installations may have to transfer ownership of the renewable energy credits from the project to WPPI.

Table 95: Estimated cost for recommended Waunakee PV arrays

Site name	Recommended PV capacity (DC)	Total cost (est.)	WPPI rebate (est.)	Net cost (est.)
Village Center	74.4	$141,150	$58,060	$87,090
Public Works	43.4	$84,671	$33,868	$50,803
Total	**117.8**	**$225,821**	**$91,928**	**$133,893**

Table 96 provides a summary description of the array at each site as well as an aerial view of the arrays. The red outlines represent where the arrays would sit.

Table 96: Waunakee description of potential PV arrays

Description of site	Aerial views with potential PV mounting
The **Village Center** has a complex roof layout. The best opportunities for mounting solar panels on the roof are on the east and west facing roof segments, toward the middle (north-south) of the building. The ridges on the roof, as well as several penetrations in each section, will need to be accommodated when developing a final design for the system. The modeled system includes eight array segments, which would be flush-mounted on the roof and would not overlap with the existing roof penetrations.	
The **Public Works** building has a large, slightly pitched roof that includes open sections with no roof penetrations or equipment. Given the mild pitch and the available space on the north side of the roof, the Village may consider installing a racked, roof-mounted system. The system model assumes south-facing orientation and fixed-tilt racking with a tilt of 30 degrees. The system capacity is estimated to produce an amount of electricity equal to the building's 2018 total energy consumption. Additional roof space is available to increase the size of the system, if needed.