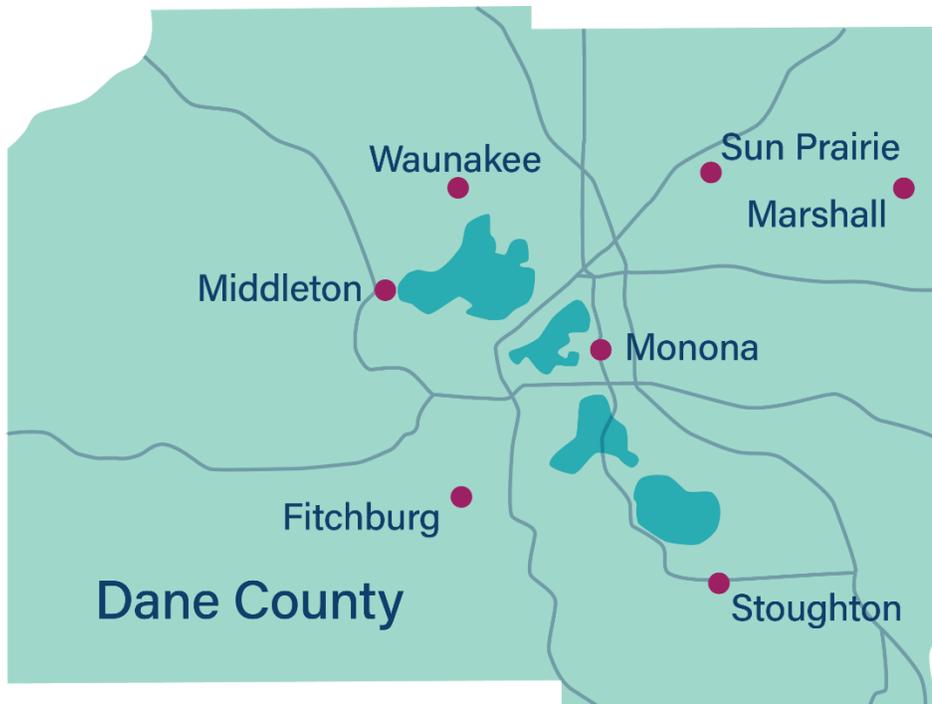




FEBRUARY 2020

Municipal Energy Plan - Seven Community Collaboration

Community Specific Chapters



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Authors:

Jeannette LeZaks
Maddie Koolbeck
Dan Streit
Kevin Frost

Project contact:

Jeannette LeZaks, jlezaks@slipstreaminc.org

Acknowledgements

Slipstream would like to acknowledge the efforts of the many staff that contributed to the analyses in these energy plans including Lee Shaver, Gabi Kim, Jennifer Li, and Syed Abbas.

We also want to acknowledge the invaluable insight and input from the community staff and partners, including those from the following communities:

Fitchburg: Phil Grupe, Sonja Kruesel, Kevin Richmond, Ellen Geisler

Marshall: Jason Pitzer, Adam Ruechel

Middleton: Kelly Hilyard, Abby Attoun-Tucker, Captain Steve Britt, Steve Wunsch

Monona: Brad Bruun, Caitin Hartnett, and Elisa Guerrero

Stoughton: Mayor Tim Swadley, Jill Weiss, Martin Briggs, Rodney Scheel, Bill Brehm, Cory Neeley (WPPI Representative)

Sun Prairie: Sarah Sauer, Tim Semmann, Sandy Xiong, Scott Coulliard, Scott Kugler

Waunakee: Todd Schmidt, Bill Frederick, Lt. Joe Peterson, Clint Cry (WPPI Representative for Sun Prairie and Waunakee)

A NOTE ON THE THREE PARTS TO THE ENERGY PLAN

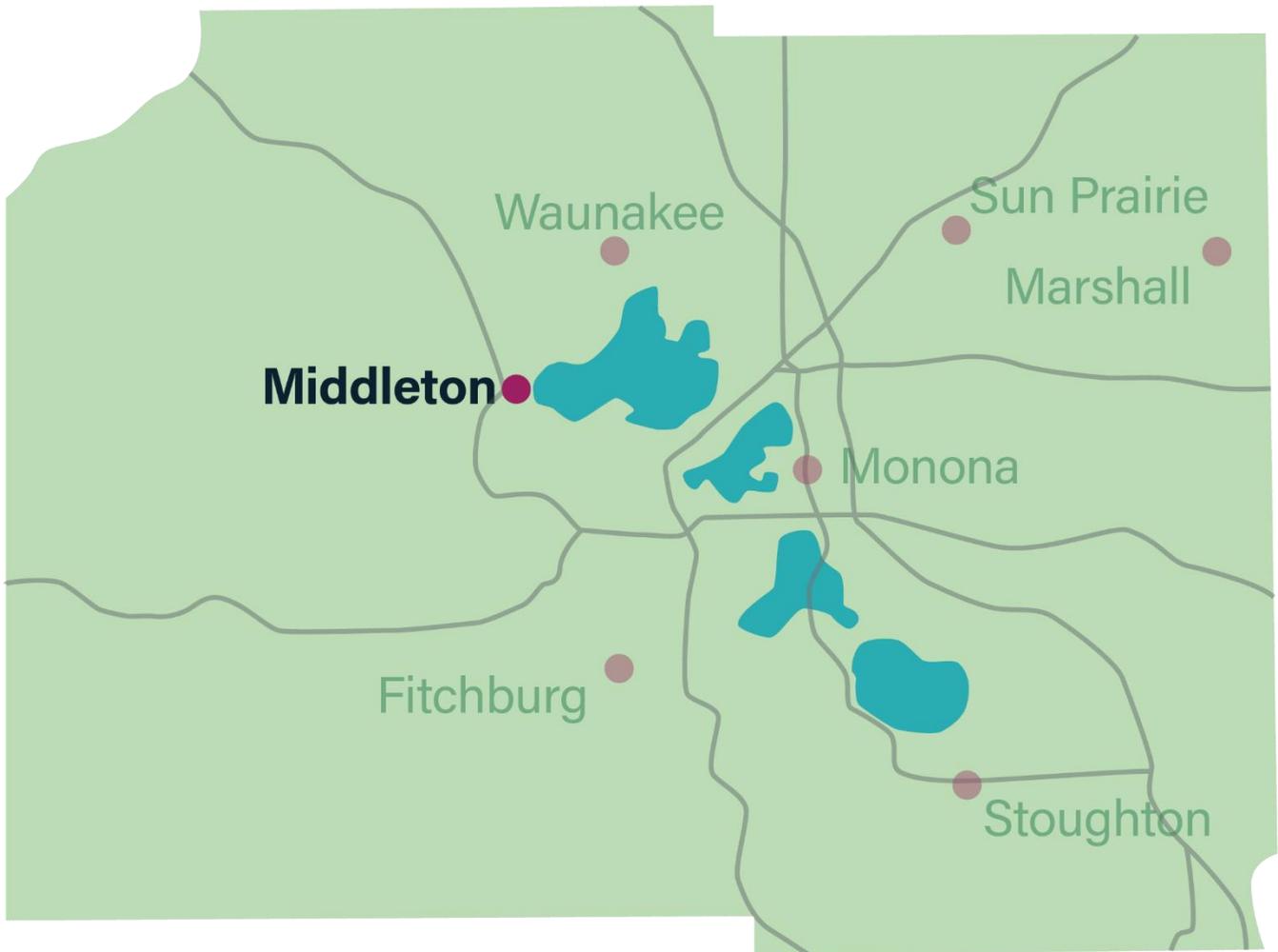
We divided the energy plan into three parts: a main report, community-specific reports (this document), and appendices. All three documents comprise the final energy plans developed for the Seven Community Energy Planning Collaboration of the Wisconsin Office of Energy Innovation Planning Grant.

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.



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

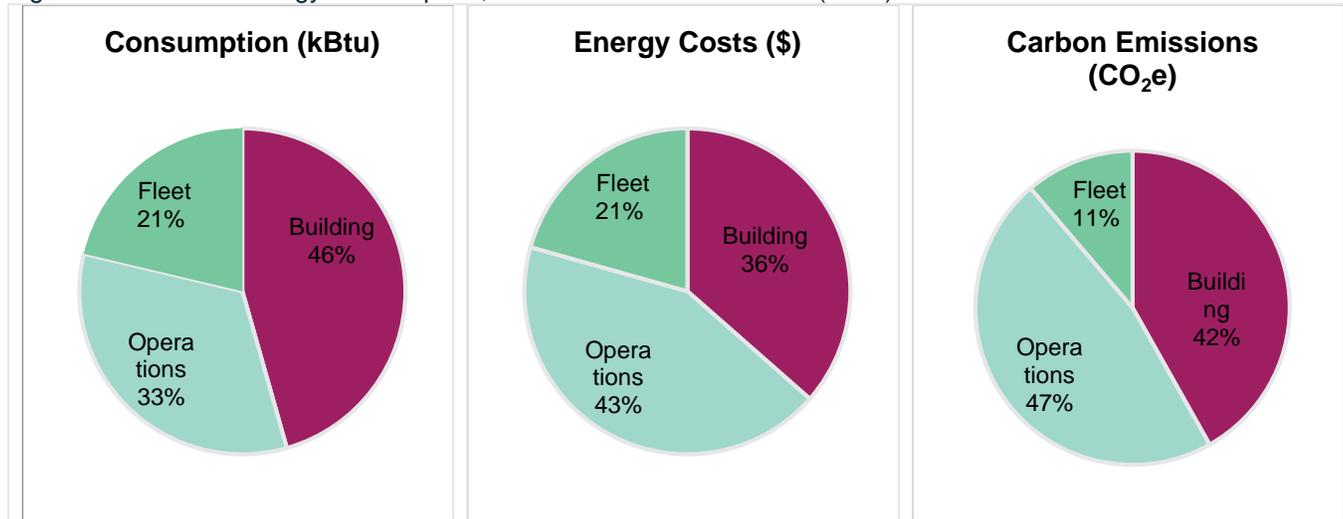
The three main energy inventory elements for Middleton's energy profile include buildings, operations, and municipal fleet. Table 29 provides details by category on what was included in development of the Middleton energy profile, based on the data provided by Middleton staff.

Table 29: Middleton inventory elements (2018 baseline)

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

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 ₂ e metric tons)	Percent of total CO ₂ e	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

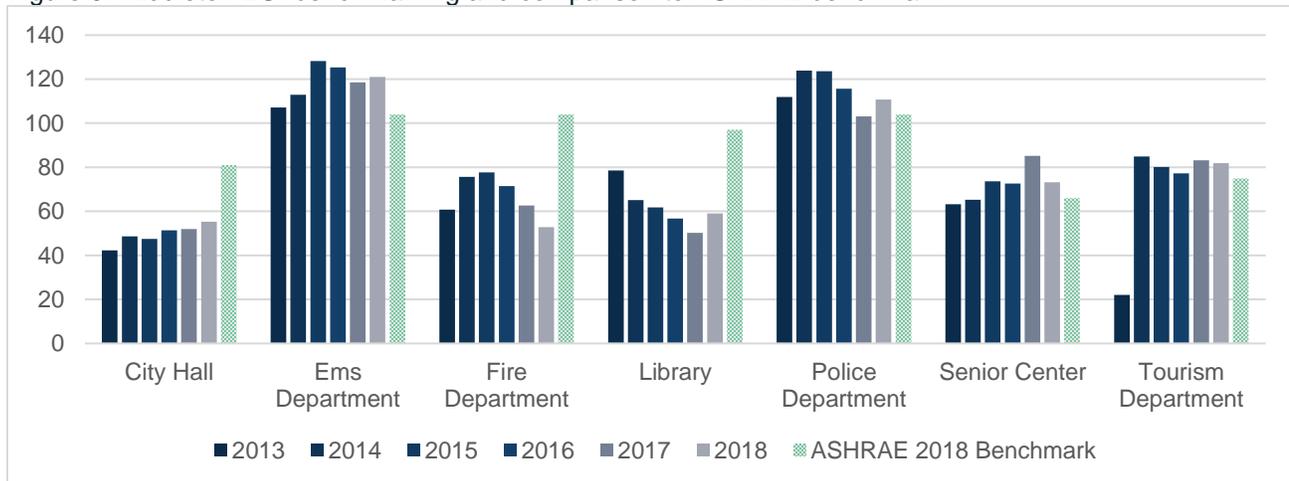


Table 31 illustrates the current and planned renewable energy consumption in the city. Upon completion of Middleton’s currently planned and budgeted solar installations, as well as activation of its Renewable Energy Rider agreement with MG&E, renewable energy will provide approximately 27 percent of 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 ₂ e (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 CO₂e and energy cost savings

Near-term Opportunity	CO ₂ e 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.

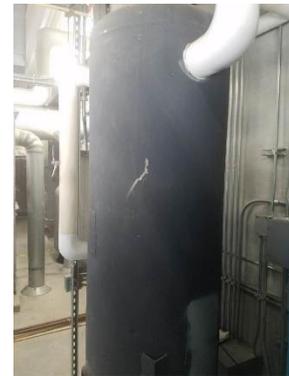
Recommendations

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.

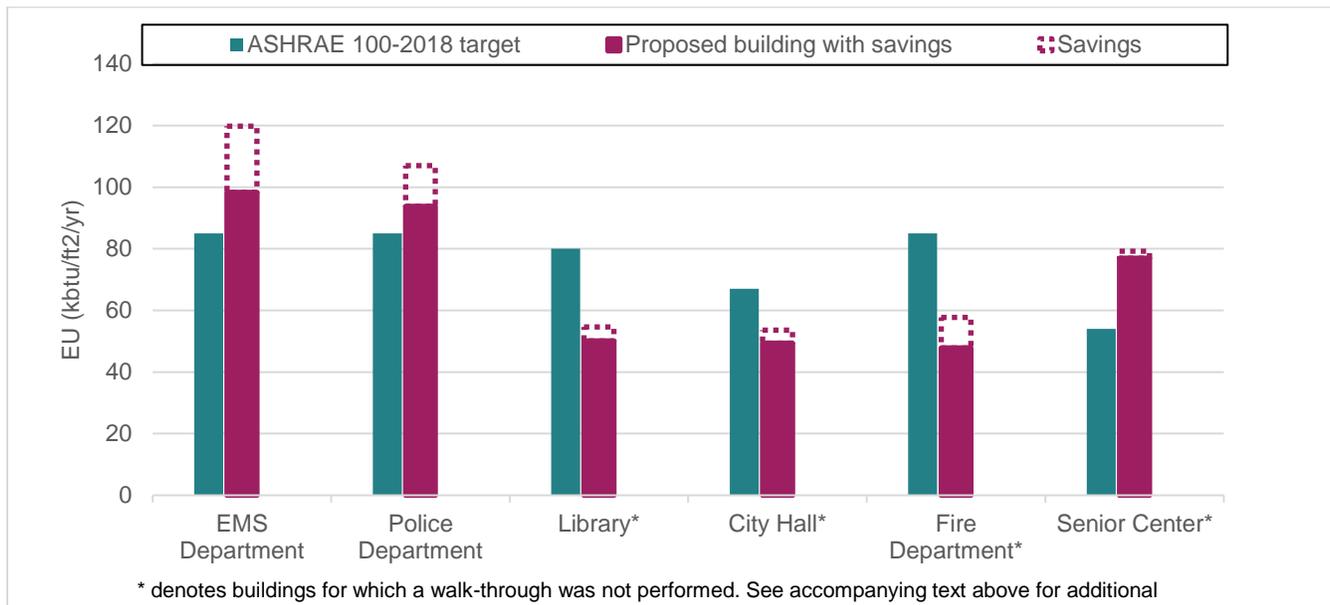
Table 35. Energy saving measures for Middleton – non-site walk-through buildings

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 ₂ e 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 ₂ e 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 ₂ e 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

Department	Number of vehicles	CO ₂ e (metric tons)		Fuel cost	
		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
<p>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.</p>	
<p>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.</p>	

Description of site

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.

Aerial views with potential PV mounting

