

MADISON MUNICIPAL OPERATIONS AND BUILDING ENERGY ANALYSIS – FINAL DRAFT

for the 2015-2016 Budget Cycle



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Submitted by



MADISON
MUNICIPAL BUILDING ENERGY ANALYSIS



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EXECUTIVE SUMMARY

This high-level energy and cost analysis is intended to quantify energy management strategies identified to help the City of Madison achieve its Georgetown University Energy Prize (GUEP) reduction goal for municipal buildings over the 2-year implementation period. This report also is designed to inform discussion and decision making relative to budgeting for the remainder of 2015 and 2016. In order to estimate potential energy savings, implementation costs, and paybacks, strategy bundles categories have been applied to individual buildings on the basis of general applicability determined from limited site visits and staff interviews and building square footage. Table 1 offers estimated savings, cost, and payback by department and building for aggregated measures across categories. Appendix A includes a full summary table of all buildings and an indication of which bundles have been applied to each to estimate the aggregated buildings numbers presented in Table 1.

The recommendations were developed using utility data and energy use indexes, information gathered from department staff, and limited site visits conducted in March and June 2015. Because the site visits were targeted and did not include all 53 City buildings, recommendations are necessarily extrapolated to all relevant buildings using benchmark end use information and engineering best practices as well as specific information gathered from City staff and during site visits. Some City buildings were not considered in the analysis or Table 1 for a number of reasons:

- In process of re-design or major renovation
- Slated for sale or demolition
- Leased
- Operated by entities besides the City.

These buildings are noted in Appendix B along with a rationale for excluding them.

The framework for this report is to give a snapshot of City facilities by department, acknowledge efficiency efforts already underway, present a utility analysis as a backdrop, and describe and provide a first order quantification of applicable recommendations. The package identified represents good energy management by combining both implementation scope and applicable buildings to balance shorter and longer term projects, which helps achieve an overall payback this is palatable and within an expected range. In addition to presenting overall package estimates, this analysis also compares estimated savings from the overall package compared to City GUEP goals and identifies options for refining the best approach for moving forward. Next steps and subsequent refinements to strategies will continue beyond this initial analysis in the coming months.

The complete package of strategies analyzed in this process is estimated to save \$1,067,900 at a cost of \$12.4 million for a 12-year simple payback. Incentives for a variety of measures are available from Focus on Energy and could defray a portion of implementation costs. For this analysis, where incentives are

available, the assumption is that they would reduce first costs from 5 to 20 percent, depending on the measure. The paybacks in Table 1 reflect this assumption.

Energy savings that could be realized if all of these efforts are implemented are estimated to be on the order of **50.4 million** kBtu, which is 18 percent below 2014 baseline energy consumption and would exceed the projected municipal savings for the City's Georgetown University Energy Prize goal by 40 percent. During the program plan development phase of the GUEP, a target reduction of 37 million kBtu by the end of 2016 was identified.

Table 1 presents estimated savings, costs, and payback for each building included in the analysis and totaled by department. Appendix A includes a similar table that also indicates which strategies are applied to each building.

Table 1: Estimated Cost and Savings by Department

<i>Building</i>	<i>Cumulative Summary</i>			
	Savings (\$)	Cost (\$)	Savings (kBtu)	Payback (yrs)
Engineering				
Engineering Services Building	\$2,900	\$56,800	148,000	20
Fairchild	\$3,900	\$320,800	407,000	82
Engineering Sub-total	\$6,800	\$377,600	555,000	56
Fire				
Station #2	\$800	\$8,300	48,000	10
Station #3	\$2,800	\$55,100	229,000	20
Station #4	\$1,900	\$43,200	132,000	23
Station #5	\$3,200	\$55,300	321,000	17
Station #6	\$2,100	\$49,600	169,000	24
Station #7	\$1,400	\$46,500	108,000	33
Station #8	\$1,400	\$37,300	84,000	27
Station #11	\$2,000	\$42,900	143,000	21
Station #12	\$1,800	\$11,600	88,000	6
Station #13	\$200	\$4,500	4,000	23
Fire Sub-total	\$17,600	\$354,300	1,326,000	20
Library				
Alicia Ashman	\$2,200	\$21,100	96,000	10
Central Library	\$6,200	\$39,300	160,000	6
Goodman South	\$800	\$4,000	20,000	5
Monroe Street	\$1,600	\$17,700	85,000	11
Sequoia Branch	\$3,000	\$16,100	118,000	5
Library Sub-total	\$13,800	\$98,200	361,000	7

<i>Building</i>	<i>Cumulative Summary</i>			
	Savings (\$)	Cost (\$)	Savings (kBtu)	Payback (yrs)
Metro				
Metro Maintenance	\$77,100	\$541,800	6,000,000	7
Monona Terrace	\$18,900	\$345,400	687,000	18
Parks				
Goodman Pool	\$300	\$1,000	7,000	3
Olbrich Gardens	\$25,900	\$328,800	2,469,000	13
Warner Park Community	\$12,600	\$224,000	684,000	18
Parks Maintenance	\$7,300	\$82,500	371,000	11
Warner Park Shelter Maint.	\$6,900	\$60,900	63,000	9
Parks Sub-total	\$53,000	\$697,200	3,594,000	13
Police				
East District Police	\$3,400	\$63,000	197,000	19
West District Police	\$3,200	\$81,100	245,000	25
South District Police	\$4,300	\$48,400	224,000	11
North District Police	\$3,100	\$35,300	135,000	11
Police Training Facility	\$9,900	\$187,300	457,000	19
Police Sub-total	\$23,900	\$415,100	1,258,000	17
Streets				
East Streets Maintenance	\$14,500	\$932,700	1,579,000	64
Transfer Station	\$5,900	\$97,200	590,000	16
West Streets Maintenance	\$8,600	\$474,500	839,000	55
West Streets Storage	\$200	\$11,500	25,000	58
Streets Sub-total	\$29,200	\$1,515,900	3,033,000	52
Traffic Engineering/ Parking				
Capitol Square North	\$25,800	\$184,100	925,000	7
Government East	\$16,900	\$117,300	612,000	7
Overture Center	\$15,200	\$117,000	530,000	8
State Street Capitol	\$36,200	\$194,400	1,366,000	5
State Street Frances	\$15,400	\$95,400	562,000	6
State Street Lake	\$11,300	\$106,600	402,000	9
Traffic Operations	\$17,400	\$224,900	668,000	13

<i>Building</i>	<i>Cumulative Summary</i>			
	Savings (\$)	Cost (\$)	Savings (kBtu)	Payback (yrs)
Traffic Engineering/ Parking Sub-total	\$138,200	\$1,039,700	4,397,000	8
Water Utility				
John B. Heim Administration	\$4,300	\$20,200	164,000	5
Paterson Maintenance	\$7,000	\$65,600	313,000	9
Paterson Vehicle Storage	\$6,400	\$77,600	260,000	12
Pump Stations	\$2,300	\$23,700	111,000	10
Water Utility Sub- total	\$20,000	\$187,100	848,000	9
Total (Buildings)	\$398,500	\$5,572,300	22,845,000	14
Water Distribution	\$326,900	\$1,361,000	12,052,000	4
Street Lights	\$342,500	\$5,488,200	16,461,000	16
Grand Total	\$1,067,900	\$12,421,500	51,358,000	12

In addition to considering energy efficiency on a building-by-building basis, the City also could consider individual strategies for economies of scale and more rapid implementation. Table 2 presents the same savings estimates captured in the previous table but totals them by measure category rather than by building. Again, Appendix A provides a complete building summary with savings and measure categories that were applied to each.

Table 2: Estimated Cost and Savings by Category

<i>Building</i>	<i>kWh saved</i>	<i>therms saved</i>	<i>kBtu saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Interior Lighting	1,755,200	0	5,989,000	\$179,800	\$1,014,500	6
HVAC	250,200	65,500	7,404,000	\$75,400	\$2,560,700	34
Controls	430,200	33,600	4,828,000	\$73,200	\$923,200	13
Plug Load	264,100	0	901,000	\$31,500	\$308,800	10
Envelope	133,900	32,700	3,727,000	\$38,900	\$764,900	20
Water Distribution	3,532,140	0	12,052,000	\$326,900	\$1,361,000	4
Street Lights	4,824,300	0	16,461,000	\$342,500	\$5,488,200	16
Total*	11,190,058	131,800	51,362,000	\$1,068,200	\$12,421,300	12
*Totals do not match exactly with Table 1 because of rounding in calculations.						

APPROACH AND NEXT STEPS

The package of strategies analyzed and summarized in this report exceed the City's GUEP reduction goal for municipal buildings, and the consultant and the City can work together to make informed, prioritized, and pragmatic decisions about the best use of implementation resources over the next few months. There are several factors that will necessarily influence decision making, some of which are outlined below. Others may evolve and also should be considered. Simple sensitivity analyses are included in this section to address the criteria outlined below and to demonstrate the impacts related to each of the criterion.

City of Madison's Internal Goals

Because the overall package of strategies presented here exceeds the City's GUEP reduction goal for municipal buildings, it has options for prioritizing how to achieve its goal and meet its GUEP commitment. For example, capital expenditures may need to have a particular payback (within 10 years), implementation costs may need to fall within certain limits, or industry best practices that produce balance over time may all be factors. These internal filters for decision making can be applied, along with the criteria described below, to dial in a reasonable approach to implementation.

Prioritization

There are a number of ways to modify outcomes to meet City goals, primary among them are adding or eliminating strategy scope or eliminating buildings from full scope consideration. While all strategies here have long-term value, certain strategies have much higher paybacks than others (HVAC and envelope improvements, for example) and could be removed to improve overall payback. In addition, certain buildings with particularly long paybacks or other factors also can be removed to improve overall estimates.

Three simple sensitivity analyses included in Table 3 demonstrate the impacts related to adjustments related to scope and buildings.

Table 3: Scope and Building Adjustment Examples

	<i>kBtu Saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Package w/out HVAC & Envelope Improvements	40,230,700	\$953,900	\$9,095,700	10
Package w/out Street Light Upgrade	32,080,200	\$725,700	\$6,933,100	10
Package w/out Buildings with Paybacks Beyond 15 Years	44,310,000	\$968,900	\$9,292,800	10

Realistic Execution

Finally, on the basis of internal City capacity, community contractor capacity, and funding, there are some strategies that are more realistic to implement in the remainder of 2015 and 2016. Rules of thumb suggest it is reasonable to expect the following three strategies could be implemented in this timeframe:

- Building lighting upgrades
- Street light upgrades
- Water process upgrades (50 percent of target)

The impacts of implementing these strategies to the level indicated are estimated in Table 4.

Table 4: Execution Adjustment Example

	<i>kBtu Saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Package of Building Lighting, Street Lights, and Half of Water Process Scope	28,475,700	\$685,750	\$7,183,200	11

Next Steps

The following sections include the baseline for all of the estimates in this analysis, including basic facility descriptions by department, utility baseline, and detailed strategy descriptions and related savings and cost analyses.

Over the next 2 months and on the basis of the detailed information provided and the approach determined using the criteria described above (or other criteria determined to be relevant by City staff), the analysis will be refined to target strategies and buildings that meet the City goals.

FACILITIES AND OPERATIONS OVERVIEW

The City of Madison employs almost 2,800 Full Time Equivalent (FTE) staff members (in 2014) and operates almost 3.2 million square feet of building space. The City facilities receive both natural gas and electricity services to over 460 separate electric meters. Madison Gas and Electric provides all natural gas service and the majority of electricity service to City facilities. A small portion of electricity is supplied by Alliant Energy. The table below provides a summary of the municipal facilities occupied and operated by the city, broken down by agency. Generally, the facilities are operated by the occupying agency, however various assistance is provided by both Facilities Operations (FO) and Facilities Management (FM).

A detailed table of all City buildings by department, with square footages and notes on operations, is provided in Appendix A.

As part of this analysis, a number of buildings were selected for high-level site visits in March and June of 2015 on the basis of their energy use intensities (EUIs) (higher), their total energy consumption, staff suggestions, and an effort to get a sense for various building types.

Engineering

Engineering includes Madison Municipal Building, a general office building and shop, and one maintenance building. Madison Municipal Building will be undergoing a major renovation that includes a focus on energy efficiency and is therefore not included in this analysis. The Engineering Services Building is often used as a test case for technologies and operational efficiencies that can be applied to other City buildings. An addition is currently being planned for the Engineering Services shop and the main boiler will be replaced as part of the project. Heating and cooling for the Engineering Services building are provided by a single rooftop unit (RTU) and boiler that serves a variable air volume (VAV) distribution system. The system is controlled by a building automation system (BAS) that includes scheduling for unoccupied hours, temperature resets, and occupancy sensors and CO2 sensors for adjusting airflow when a space is occupied.

Table 5: Engineering Building Details

<i>Building</i>	<i>Square Footage</i>	<i>EUI (kBtu/sq ft)</i>
Engineering Services Building	42,742	53.93
Fairchild	52,329	40.00

Fire

This department has one vehicle Maintenance building and 13 individual fire stations that are maintained and monitored by FO. FM supports design and construction administration (including punch list and close-out) for all new construction and substantial renovations. Fire Stations 12 and 13 are LEED NC Platinum (2010) and EBOM Gold (2014) Certified, respectively. Fire Station 1 is currently being remodeled, Fire Stations 9 and 10 are in need of major remodel or replacement, and the Fire Maintenance building is slated to be demolished. There is a variety of HVAC systems in these buildings, although and most have residential style split system furnaces and air conditioners. Most of the HVAC systems are controlled by local thermostats and new equipment, such as boilers, are controlled by the BAS. Most lighting has been upgraded to T8 fluorescents.

Table 6: Fire Building Details

<i>Building</i>	<i>Square Footage</i>	<i>EUI (kBtu/sq ft)</i>
Station #2	6,225	113.80
Station #3	8,372	112.55
Station #4	10,328	76.34
Station #5	8,399	228.80

<i>Building</i>	<i>Square Footage</i>	<i>EUI (kBtu/sq ft)</i>
Station #6	11,874	79.25
Station #7	12,539	61.23
Station #8	10,054	67.25
Station #10	5,959	118.45
Station #11	11,204	103.83
Station #12	12,500	49.76
Station #13	13,724	12.30

Fleet Services

Fleet Services has a vehicle maintenance building that is 52,840 square feet and is maintained and monitored by FO. This building is schedule to be sold or demolished and a new facility built and is not included in this analysis.

Health

This department has a single building, East Health Hawthorne, which is leased and is scheduled to be vacated in the next 5 years and is not included in this analysis.

Library

There are nine libraries, four of which are in leased buildings. Libraries has its own facilities and maintenance staff and manages its own operations, with some support from FM for design, construction, and administration (including punch list and close-out) for all new construction and substantial renovation projects. The Central Library (EBOM Gold, 2014), Goodman South Library (CI Gold, 2010), and Sequoya Branch Library (CI Silver 2010) are all LEED Certified. These three buildings are on a central Honeywell BAS, including controls for temperature setpoints and equipment schedules. Most libraries have upgraded T8 fluorescent or LED lighting with occupancy sensors and some daylight controls. The Central Library lighting is scheduled by a lighting control system.

Heating and cooling systems are a combination of roof-top units, furnaces, chillers, and boilers. Also, plug loads can be higher for these buildings given the number of computers.

Table 7: Library Building Details

<i>Building</i>	<i>Square Footage</i>	<i>EUI (kBtu/sq ft)</i>	<i>Leased</i>
Alicia Ashman	11,829	85.19	
Central Library	119,200	59.52	
Goodman South	12,010	83.99	
Lakeview	9,335	55.67	X

<i>Building</i>	<i>Square Footage</i>	<i>EUI (kBtu/sq ft)</i>	<i>Leased</i>
Meadowridge	17,565	25.08	X
Monroe Street	2,300	146.58	
Pinney	11,200	97.84	X
Sequoia Branch	20,000	131.98	

Metro Transit

Metro Transit manages its own operations with minimal support from FM for design and construction administration (including punch list and close-out) for all new construction and substantial renovations. It has one facility – the Metro Maintenance building – that is 282,500 square feet with an EUI of 160 kBtu per square foot, which indicates high energy use. The Metro Maintenance building has offices, maintenance shop, and bus storage space. Heating is provided by 2 large boilers that serve a network of 17 heating ventilator (HV) make-up air units. There are 18 exhaust fans to purge vehicle exhaust and assist with ventilation needs. Most equipment is controlled manually as the pneumatic control system is no longer functional. Only a few spaces have split system air conditioners. Other equipment includes a new variable frequency drive (VFD) air compressor, cyclone vacuum system, and wash station.

Monona Terrace

Monona Terrace is a conference and convention center with dedicated staff that manages operations with some support from FM for design and construction administration for all substantial renovations. Monona Terrace is LEED EB Silver (2007) Certified and is currently working toward Gold level recertification. The EUI for the building is 48 kBtu per square foot. Monona Terrace has district steam and chillers with air handlers that serve a VAV system. VAV boxes are being converted to direct digital controls (DDC).

Parks

Parks facilities include a newer maintenance/administration building, out buildings for storage and maintenance equipment, a pool building, and Olbrich Gardens, which includes the conservancy (heated like a tropical rainforest). There is a planned upgrade for mechanical systems and an additional educational center at Olbrich Gardens in 2015. Goodman Pool and Olbrich Gardens have the highest EUIs of any City facilities. Parks has its own maintenance staff but also gets some support from FM for design and construction administration (including punch list and close-out) for all new construction and substantial renovations. The maintenance/administration building is LEED NC Silver (2010) Certified.

There are a variety of HVAC systems and the main buildings have some building automation. Some out building, shelter, path, and parking lighting has been converted to LED.

Table 8: Parks Building Details

<i>Building</i>	<i>Square Footage</i>	<i>EUI (kBtu/sq ft)</i>
Goodman Pool	6,117	292.17
Olbrich Gardens	47,553	207.61
Warner Park Community	31,200	85.75
Parks Maintenance	43,300	99.22
Warner Park Shelter Maint.	35,000	23.99

Police

The Police department has four stations, a storage facility, and a training facility that are maintained and monitored by FO with support from FM for design and construction administration (including punch list and close-out) for all new construction and substantial renovations. The stations have standard efficiency boilers (older and newer units), DX air conditioning, and VAV air distribution systems. Lighting is mostly T8 fluorescents and there are occupancy sensors in some spaces.

Table 9: Police Building Details

<i>Building</i>	<i>Square Footage</i>	<i>EUI (kBtu/sq ft)</i>
East District Police	14,640	87.94
West District Police	12,100	92.74
South District Police	11,237	125.86
North District Police	8,195	102.28
Police Training Facility	39,186	71.93

Senior Center

The Madison Senior Center occupies space in a larger multifamily building (about 20,000 square feet) in downtown Madison. This space is maintained by FO and has an EUI of 52 kBtu per square foot.

Streets and Recycling

Streets and Recycling maintains streets and also handles residential waste and recycling. Streets facilities are maintained by FM. The East Streets Maintenance facility has a dual duct HVAC system that is in need of replacement.

Table 10: Streets Building Details

<i>Building</i>	<i>Square Footage</i>	<i>EUI (kBtu/sq ft)</i>
East Streets Maintenance	149,234	42
Transfer Station	28,800	60
West Streets Maintenance	75,922	44
West Streets Storage	22,953	30

Traffic Engineering/Parking

Traffic Engineering is responsible for street traffic management and six parking garages. This department manages its own operations with some support from FO. There are plans to phase in LED lighting in the parking garages over the next couple of years to replace high pressure sodium fixtures and also to install CO2 monitoring. The parking garages have cashier booths that are heated with full-size natural gas furnaces.

Table 11: Traffic Engineering/parking Building Details

<i>Building</i>	<i>Square Footage</i>	<i>EUI (kBtu/sq ft)</i>
Capitol Square North	324,500	7.34
Government East	206,700	6.19
Overture Center	206,200	5.30
State Street Capitol	342,720	9.29
State Street Frances	168,139	7.99
State Street Lake	187,850	5.81
Traffic Operations	37,877	50.17

Water Utility

Madison Water Utility has an administration building, storage and maintenance buildings, and 22 well sites. Water supply and distribution operations consist of groundwater well pumps, water treatment, tank and tower water storage, and booster pumps that provide pressurized potable water throughout the city. Well sites vary in age and typically have one or two booster pumps. Approximately 30 to 50 percent of the pumps are controlled by VFDs.

Table 12: Water Utility Facility Details

<i>Building</i>	<i>Square Footage</i>	<i>EUI (kBtu/sq ft)</i>
Utility Building		
John B. Heim Administration	25,148	151.35
Paterson Maintenance	22,000	99.44
Paterson Vehicle Storage	26,038	75.84
Pump Stations	n/a	n/a

CURRENT INITIATIVES

The City has taken good first steps toward improving the energy efficiency of its operations. The following is a summary of some of these efforts.

HVAC and Mechanical Equipment

City-wide, many of the boilers and hot water heaters have been replaced with condensing and modulating models to improve efficiency and allow for easier operations. For newer buildings and recent renovations, the City also is installing better insulation, windows, and air sealing. In locations with significant hot water use, solar hot water systems have been installed. Solar photovoltaic (PV) systems also have been installed in various locations. Additionally, many pumps and fans throughout the City are set up with variable frequency drives (VFDs) while newer DX cooling systems have variable speed compressors.

Lighting

The majority of lighting throughout City buildings has been upgraded to higher efficiency T8 linear fluorescent fixtures or LED fixtures. Additionally, the Engineering Services Building has been a testing ground for various LED technologies, and LED upgrades to traffic signals and street lights are being made.

Controls

Many buildings operated by the City are controlled by a building automation system (BAS). The Engineering Services Building is used to test different operations and controls. This building is set up with an occupancy schedule that adjusts the heating and cooling temperatures accordingly as well as motion and CO2 sensors. The goal is to have all City buildings on the BAS system in the near future and to have the same level of control as the Engineering Services Building.

In addition, the City also has added lighting controls in many location. Whenever lighting is upgraded within a facility, motion sensors are installed with the replacement. Along with upgrading street lights

from HID to LED, in many instances motion sensors have been installed and stepped dimming ballasts have been implemented.

Data Tracking and Monitoring

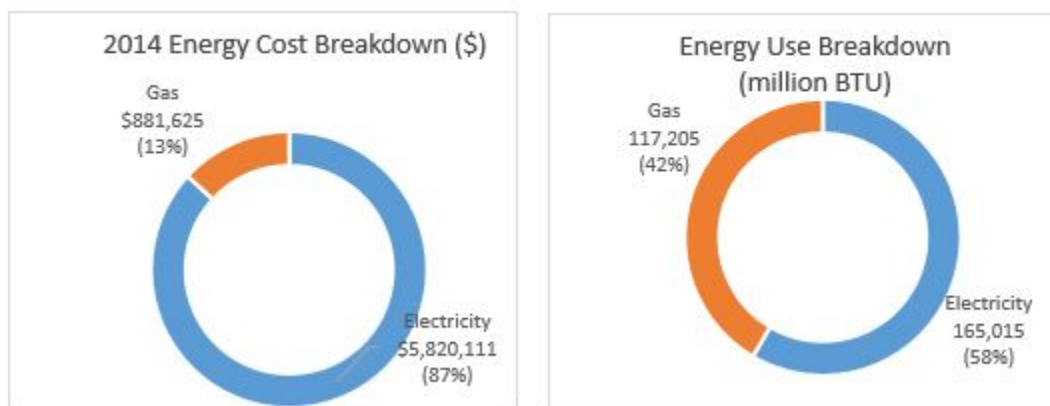
There are a number of ways the City can track and monitor its data, including the following:

- EnergyCAP (historical data for most buildings dating back to 2009)
- Energy Stewards – limited participation and engagement
- Portfolio manager
- BAS system has some capabilities –SOME buildings have pulse meters
- Pilot with Madison Gas and Electric where the City has a web interface using the pulse meters to see 15 minute data in order to better manage demand.

ENERGY ANALYSIS

Current Overall Performance

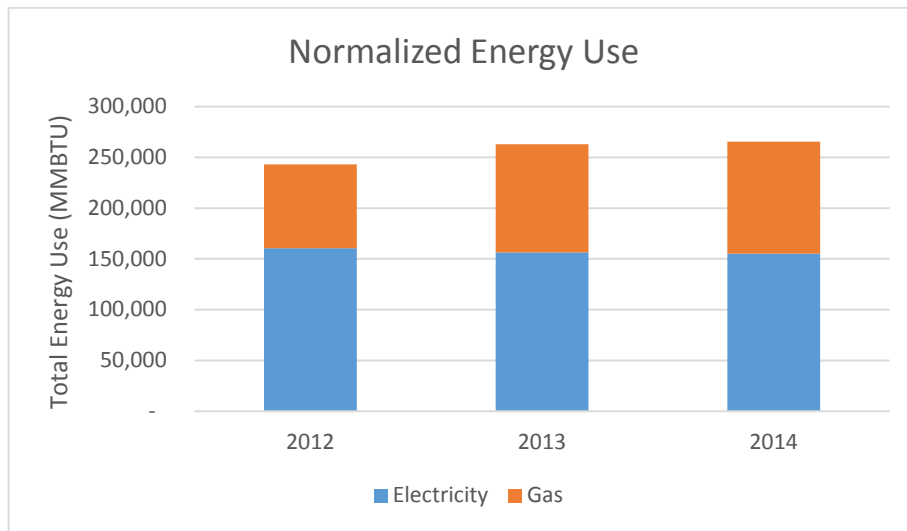
In 2014, the City of Madison spent \$6.7 million on electricity and natural gas utilities, about 87 percent of which was spent on electricity serving the City's nearly 3.176 million square feet of facilities and assets, including streetlights. The remaining 13 percent was for natural gas consumption. The estimated energy unit costs in 2014 were \$0.12 per kWh for electricity and \$0.75 per therm for natural gas. For comparison, in 2013, the City spent \$7 million on electricity and natural gas, 90 percent of which was spent on electricity and 10 percent on natural gas.



The total energy consumption in 2014 was 282 million BTU, split almost 60/40 between electricity and natural gas, respectively.

Based on weather normalized data, the City observed an 8% increase in energy consumption from 2012 to 2013 followed by a 1% increase from 2013 to 2014.

Figure 2: Energy Use Comparison 2012-2014



The following two charts compare energy use within the different City agencies. Operations for the Water Utility consumed almost 40 percent of the electricity city-wide in 2014, about 2 times greater than the next largest contributing agency, Traffic Engineering/Parking. The majority of use for the Traffic agency is streetlights and traffic signals. Monona Terrace is the next largest at 8 percent of total electricity consumption.

When evaluating natural gas consumption, the Metro Department represented 31 percent of total consumption in 2014 largely due to the age and inefficiency of the Metro Maintenance building. The other largest contributor to natural gas consumption is the Parks Department at 19 percent of total consumption.

Building Level Energy Use

At the building level, Tables 11 and 12 list the top 10 buildings for 2014 with the highest total energy use and energy use intensity (EUI), respectively. From a total energy use perspective, the Metro Maintenance building is by far the largest consumer at 16 percent of total energy use for the city. This is likely due to the age and inefficiency issues mentioned earlier that are contributing to the significant natural gas consumption for the Metro agency. Overall, the top 10 buildings made up almost 40 percent of total energy use in the city in 2014.

The average EUI for all City buildings is 89 kBtu per square foot while the average for the top 10 buildings is 175 kBtu per square foot – over twice as high as the overall average. Goodman Pool has the highest EUI at 292 kBtu per square foot; however, this value includes all building and process loads, such as pool water heating.

Figure 3: 2014 Electricity Use by Department

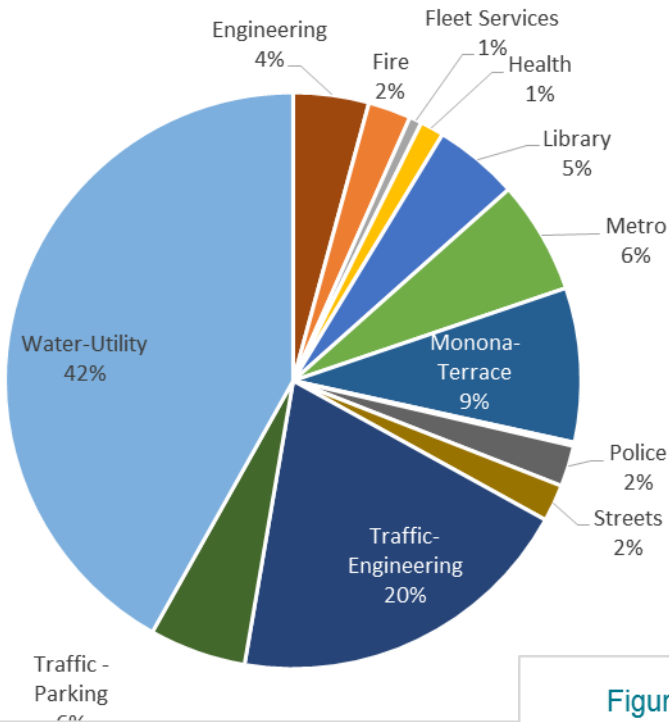


Figure 4: 2014 Natural Gas Use by Department

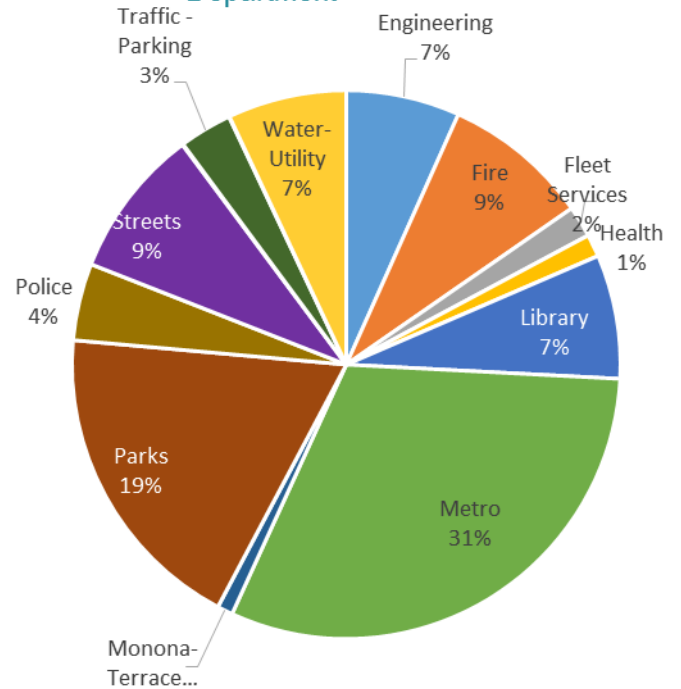


Table 13: Top 10 Energy Users

<i>Building</i>	<i>Square Footage</i>	<i>2014 Total Energy Use (MMBtu)</i>	<i>Percentage of Total</i>
Metro Maintenance	282,250	45,541	16%
Monona Terrace	303,000	14,461	5%
Olbrich Gardens	47,553	10,160	4%
Madison Municipal Building	74,154	6,912	2%
Central Library	119,200	7,402	3%
East Streets Maintenance	149,234	6,761	2%
Parks Maintenance	43,300	4,467	2%
Fire Station #1	24,000	2,504	1%
West Streets Maintenance	75,922	3,736	1%
Administration - John B Heim	25,148	3,846	1%
Total		105,792	37%

Table 14: Top 10 Energy Use Intensities

<i>Building</i>	<i>Square Footage</i>	<i>2014 EUI (kBtu/sf)</i>	<i>Percentage of Average</i>
Goodman Pool	6,117	292	167%
Fire Station #5	8,399	229	131%
Olbrich Gardens	47,553	208	119%
East Health Hawthorne	11,500	181	103%
Metro Maintenance	282,250	160	91%
Admin- JOHN B. HEIM	25,148	151	87%
Monroe Street Library	2,300	147	84%
Sequoia Branch	20,000	132	75%
South District Police	11,237	126	72%
Fire Station #9	5,564	124	71%
Average		175	

RECOMMENDED ENERGY CONSERVATION STRATEGIES

Approach

Given the objective of this analysis, which is to inform the budgeting process with an eye toward efficiency upgrades that can be implemented in 2015 and 2016, this section describes a number of applicable conservation measures that were developed on the basis of interviews with City staff members, limited building site visits in March and June of 2015, analysis of building energy use, and industry standards. The estimated savings and costs for the measures here were developed using benchmark end-use data for similar building types, industry rules of thumb for potential savings, cost ranges for implementation, and availability of incentives from the utility. In addition, based on information gathered during the interview and site visits, the savings and

costs have been applied to reflect estimated level of effort per building given existing projects already completed or partially completed and relative applicability. These estimates are necessarily high-level because of the variations among buildings and uses therein. In addition, costing information for process (water distribution) measures is evolving and the numbers provided will necessarily be revised once all the information is available. Furthermore, the costs estimated for this level of analysis include neither design/engineering cost factors nor operation and maintenance cost savings, which will be added during future phases of the analysis based on prioritization guidance provided by the City and additional technical guidance from the consultant. Next steps will include refining the approach as well as specific related categories of measures.

The recommended measures are bundled into six categories.

- Lighting (street light conversion a subset)
- Heating, Ventilation, and Cooling (HVAC)
- Controls
- Plug Loads
- Envelope Improvements
- Process (related to water distribution)

Table 11 (also included as Table 1 in the Executive Summary) summarizes estimated savings, cost, and payback by department. A detailed table of building level savings, cost, and payback estimates is provided in Appendix B.

Table 15: Estimated Cost and Savings by Department

<i>Building</i>	<i>Cumulative Summary</i>			
	Savings (\$)	Cost (\$)	Savings (kBtu)	Payback (yrs)
Engineering				
Engineering Services Building	\$2,900	\$56,800	148,000	20
Fairchild	\$3,900	\$320,800	407,000	82
Engineering Sub-total	\$6,800	\$377,600	555,000	56
Fire				
Station #2	\$800	\$8,300	48,000	10
Station #3	\$2,800	\$55,100	229,000	20
Station #4	\$1,900	\$43,200	132,000	23
Station #5	\$3,200	\$55,300	321,000	17
Station #6	\$2,100	\$49,600	169,000	24
Station #7	\$1,400	\$46,500	108,000	33
Station #8	\$1,400	\$37,300	84,000	27

<i>Building</i>	<i>Cumulative Summary</i>			
	Savings (\$)	Cost (\$)	Savings (kBtu)	Payback (yrs)
Station #11	\$2,000	\$42,900	143,000	21
Station #12	\$1,800	\$11,600	88,000	6
Station #13	\$200	\$4,500	4,000	23
Fire Sub-total	\$17,600	\$354,300	1,326,000	20
Library				
Alicia Ashman	\$2,200	\$21,100	96,000	10
Central Library	\$6,200	\$39,300	160,000	6
Goodman South	\$800	\$4,000	20,000	5
Monroe Street	\$1,600	\$17,700	85,000	11
Sequoia Branch	\$3,000	\$16,100	118,000	5
Library Sub-total	\$13,800	\$98,200	361,000	7
Metro				
Metro Maintenance	\$77,100	\$541,800	6,000,000	7
Monona Terrace	\$18,900	\$345,400	687,000	18
Parks				
Goodman Pool	\$300	\$1,000	7,000	3
Olbrich Gardens	\$25,900	\$328,800	2,469,000	13
Warner Park Community	\$12,600	\$224,000	684,000	18
Parks Maintenance	\$7,300	\$82,500	371,000	11
Warner Park Shelter Maint.	\$6,900	\$60,900	63,000	9
Parks Sub-total	\$53,000	\$697,200	3,594,000	13
Police				
East District Police	\$3,400	\$63,000	197,000	19
West District Police	\$3,200	\$81,100	245,000	25
South District Police	\$4,300	\$48,400	224,000	11
North District Police	\$3,100	\$35,300	135,000	11
Police Training Facility	\$9,900	\$187,300	457,000	19
Police Sub-total	\$23,900	\$415,100	1,258,000	17
Streets				
East Streets Maintenance	\$14,500	\$932,700	1,579,000	64
Transfer Station	\$5,900	\$97,200	590,000	16
West Streets Maintenance	\$8,600	\$474,500	839,000	55
West Streets Storage	\$200	\$11,500	25,000	58
Streets Sub-total	\$29,200	\$1,515,900	3,033,000	52

<i>Building</i>	<i>Cumulative Summary</i>			
	Savings (\$)	Cost (\$)	Savings (kBtu)	Payback (yrs)
Traffic Engineering/ Parking				
Capitol Square North	\$25,800	\$184,100	925,000	7
Government East	\$16,900	\$117,300	612,000	7
Overture Center	\$15,200	\$117,000	530,000	8
State Street Capitol	\$36,200	\$194,400	1,366,000	5
State Street Frances	\$15,400	\$95,400	562,000	6
State Street Lake	\$11,300	\$106,600	402,000	9
Traffic Operations	\$17,400	\$224,900	668,000	13
Traffic Engineering/ Parking Sub-total	\$138,200	\$1,039,700	4,397,000	8
Water Utility				
John B. Heim Administration	\$4,300	\$20,200	164,000	5
Paterson Maintenance	\$7,000	\$65,600	313,000	9
Paterson Vehicle Storage	\$6,400	\$77,600	260,000	12
Pump Stations	\$2,300	\$23,700	111,000	10
Water Utility Sub-total	\$20,000	\$187,100	848,000	9
Total (Buildings)	\$398,500	\$5,572,300	22,845,000	14
Water Distribution	\$326,900	\$1,361,000	12,052,000	4
Street Lights	\$342,500	\$5,488,200	16,461,000	16
Grand Total	\$1,067,900	\$12,421,500	51,358,000	12

Each category is described in its own section here and necessarily includes a variety of conservation measures that are applicable for City buildings. In addition, there is a table in each category that includes those buildings for which the measure may be applicable along with the estimated savings, cost, and payback for the measures in the category. These estimates are based on building square footage, building energy use data, building type, level of measure applicability (high, medium, or low), and potential for incentives.

Lighting Upgrades

For most commercial buildings, lighting is a significant portion of utility costs. Depending on the age and envelope of the building, electricity for lighting is typically 30 to 40 percent of total electricity use. Savings from upgrades to lighting typically pay back first costs in 3 to 7 years depending on the technologies used, the systems replaced, and the availability of utility rebates. The table below presents

estimated savings, costs, and simple payback for applicable City buildings based on building type and inferred level of opportunity.

Lighting opportunities that were identified during site visits and from interviews with City staff members include the following:

- T12 linear fluorescents replacement
- T8 linear fluorescent replacement
- Parking garage high intensity discharge (HID) replacement

Other exterior lighting also could be targeted for additional savings but is not included in this analysis. Once priority buildings are identified, exterior lighting can be included in lighting refinements.

Table 16: Estimated Saving by Building - Lighting

<i>Building</i>	<i>kWh saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Total	1,755,200	\$179,800	\$1,014,500	6
Station #11	5,900	\$700	\$6,700	10
Station #12	17,900	\$1,300	\$7,500	6
Monroe Street	2,400	\$400	\$1,400	4
Metro Maintenance	267,000	\$25,400	\$80,000	3
Warner Park Community	28,600	\$4,100	\$18,700	5
Parks Maintenance	26,800	\$3,500	\$26,000	7
Warner Park Shelter Maint.	2,100	\$4,100	\$21,000	5
East District Police	8,900	\$800	\$8,800	11
West District Police	10,000	\$600	\$7,300	13
South District Police	9,500	\$1,000	\$6,700	6
North District Police	7,400	\$800	\$4,900	6
Police Training Facility	12,300	\$1,800	\$23,500	13
Capitol Square North	257,100	\$24,500	\$161,000	7
Government East	169,100	\$16,000	\$102,500	6
Overture Center	146,200	\$14,400	\$102,300	7
State Street Capitol	374,000	\$34,300	\$170,000	5
State Street Frances	153,700	\$14,600	\$83,400	6
State Street Lake	108,500	\$10,700	\$93,200	9
Traffic Operations	82,700	\$11,800	\$18,800	2
Paterson Maintenance	31,800	\$3,900	\$26,400	7
Paterson Vehicle Storage	21,600	\$3,700	\$31,200	8
Pump Stations	11,700	\$1,400	\$13,200	10

Street Lighting

The City has an inventory of street lights that fall into three categories: utility owned and maintained (primarily residential), City owned and maintained (downtown), and City owned but utility maintained (underground residential). An effort to begin upgrading the lights to LED began about 4 years ago. This is a concerted project that the City could undertake to complete sooner rather than later for economies of scale and to capture early savings. With more than 12,000 street lights and an estimated energy savings of 25 percent from using LED technologies, estimated savings are outlined in Table 17.

Table 17: Estimated Saving by Building – Street Lighting

<i>Facility</i>	<i>kWh saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Street Lights	4,824,300	\$342,500	\$5,488,200	16

Heating, Ventilation, and Cooling Improvements

Heating, ventilation, and cooling (HVAC) systems in commercial buildings can be varied and complex and often account for as much as 50 percent of a building's energy use (electricity and natural gas combined). Because building systems vary so widely, estimated savings from improvements vary widely also depending on the types of existing systems, types of upgrades, and availability of utility rebates. For example, equipment upgrades to higher efficiency units may save 5 to 15% of energy used while re- or retro-commissioning (including scheduling) savings may range from 5 to 30%. In addition, costs for measures such as tighter scheduling and equipment optimization tend to have lower costs and paybacks, while equipment replacement tends to have much higher costs and paybacks.

HVAC improvements involve any project aiming to improve the efficiency of an HVAC system and can include installing continuous environmental management systems, replacing or retrofitting individual components of a system (boiler, furnace, heat pump, air-side economizers, etc.), equipment tune-ups, and scheduling adjustments.

For this analysis, the following are considered:

- Boiler replacements
- Chiller replacements
- Boiler upgrades/controls
- Furnace replacement
- VFDs/motors
- Heater/thermostat relocation
- Programmable thermostats
- Chiller optimization
- Retro-commissioning

Table 18: Estimated Saving by Building – HVAC Improvements

<i>Building</i>	<i>kWh saved</i>	<i>therms saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Total	250,200	65,500	\$75,400	\$2,560,700	34
Fairchild	3,200	2,700	\$2,600	\$251,200	98
Station #3	2,300	1,300	\$1,300	\$40,200	31
Station #4	1,100	500	\$500	\$24,800	47
Station #5	1,600	1,900	\$1,700	\$40,300	24
Station #6	1,100	700	\$700	\$28,500	43
Station #7	1,100	500	\$500	\$30,100	59
Station #8	1,300	300	\$400	\$24,100	56
Station #11	1,000	800	\$700	\$26,900	38
Monroe Street	1,500	300	\$500	\$11,000	22
Metro Maintenance	103,400	19,600	\$23,400	\$140,000	6
Olbrich Gardens	44,500	11,000	\$13,100	\$228,300	18
Warner Park Community	9,700	3,000	\$3,700	\$149,800	41
East District Police	6,300	500	\$1,000	\$35,100	36
West District Police	14,200	800	\$1,400	\$58,100	40
South District Police	6,700	700	\$1,300	\$27,000	22
North District Police	5,300	300	\$800	\$19,700	24
Police Training Facility	10,600	1,300	\$2,600	\$94,000	36
East Streets Maintenance	10,700	9,400	\$8,200	\$716,300	88
Transfer Station	4,800	3,000	\$3,000	\$69,100	23
West Streets Maintenance	7,800	4,900	\$4,700	\$364,400	78
Traffic Operations	12,000	2,000	\$3,300	\$181,800	56

Controls

In addition to HVAC system upgrades, energy savings can be achieved by a number of control strategies and technologies applied in a systematic way to a building or collection of buildings. Controls can improve operations from 5 to 15 percent. Cost and payback can vary depending on types of strategies used and whether or not new technologies must be installed.

For this analysis, the following control strategies are considered:

- Operational standards
- Building automation system integration, training, and utility data monitoring
- Automated demand response
- Direct digital control upgrades
- Lighting controls

Table 19: Estimated Saving by Building - Controls

<i>Building</i>	<i>kWh saved</i>	<i>therms saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Total	430,200	33,600	\$73,200	\$923,200	13
Station #3	3,900	400	\$900	\$8,000	9
Station #4	3,500	400	\$700	\$9,800	13
Station #5	2,800	700	\$900	\$8,000	9
Station #6	3,600	500	\$800	\$11,300	14
Station #7	1,800	200	\$300	\$6,000	17
Station #8	2,200	100	\$400	\$4,800	13
Alicia Ashman	7,600	300	\$1,200	\$11,200	10
Monroe Street	1,600	100	\$300	\$2,200	6
Sequoia Branch	9,600	400	\$1,400	\$9,500	7
Metro Maintenance	77,200	10,800	\$14,800	\$134,100	9
Monona Terrace	93,100	300	\$9,500	\$143,900	15
Olbrich Gardens	31,000	4,900	\$7,100	\$45,200	6
Warner Park Community	16,300	1,100	\$3,200	\$29,600	9
Parks Maintenance	7,600	1,000	\$1,800	\$20,600	11
Warner Park Shelter Maint.	600	200	\$1,600	\$16,600	11
East District Police	4,200	200	\$500	\$7,000	13
West District Police	4,800	100	\$400	\$5,700	15
South District Police	4,500	200	\$700	\$5,300	8
North District Police	3,500	100	\$500	\$3,900	8
Police Training Facility	13,000	900	\$2,700	\$37,200	14
East Streets Maintenance	18,000	3,400	\$4,600	\$141,800	31
Transfer Station	8,100	1,100	\$1,700	\$13,700	8
West Streets Maintenance	13,100	1,700	\$2,900	\$72,100	25
Capitol Square North	13,000	0	\$1,300	\$23,100	18
Government East	8,600	100	\$900	\$14,700	17
Overture Center	7,400	100	\$800	\$14,700	19
State Street Capitol	18,900	300	\$1,900	\$24,400	13
State Street Frances	7,800	100	\$800	\$12,000	14
State Street Lake	5,500	100	\$600	\$13,400	21
Traffic Operations	7,400	700	\$1,600	\$5,400	3
John B. Heim Administration	12,100	500	\$1,700	\$11,900	7
Paterson Maintenance	9,100	1,000	\$1,900	\$20,900	11
Paterson Vehicle Storage	6,200	1,000	\$1,800	\$24,700	14
Pump Stations	2,600	600	\$1,000	\$10,500	11

Plug Load Management

Electricity use associated with plug loads is increasing, especially in commercial buildings. Plug load includes anything beyond HVAC and process equipment that uses electricity, such as computers, office equipment, space heaters, chargers, etc. Plug load can be as much as 25 percent of a building's electricity use. Making sure that devices are not drawing power unnecessarily is the key to reducing plug load, both during occupied and unoccupied times. There are a number of ways to address plug load, including policies that require sleep settings and shut-down protocols; however, some of the simplest and easiest to implement strategies include purchasing smart strips that reflect motion or occupancy and shut power down to electronic equipment after a set period of inactivity or overnight and weekends. Estimated savings for these devices alone is estimated in the table below.

Table 20: Estimated Saving by Building – Plug Load

<i>Building</i>	<i>kWh saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Total	264,100	\$31,500	\$308,800	10
Engineering Services Building	9,700	\$1,200	\$14,100	12
Fairchild	1,700	\$300	\$17,300	64
Station #2	2,700	\$400	\$2,100	5
Station #3	2,900	\$400	\$2,800	7
Station #4	2,700	\$400	\$3,400	10
Station #5	2,100	\$300	\$2,800	9
Station #6	2,700	\$300	\$3,900	12
Station #7	2,800	\$300	\$4,100	13
Station #8	3,300	\$400	\$3,300	8
Station #11	2,600	\$300	\$3,700	12
Station #12	7,700	\$500	\$4,100	8
Station #13	1,100	\$200	\$4,500	28
Alicia Ashman	5,700	\$700	\$3,900	6
Central Library	46,800	\$6,200	\$39,300	6
Goodman South	5,800	\$800	\$4,000	5
Monroe Street	1,200	\$200	\$800	4
Sequoia Branch	14,400	\$1,700	\$6,600	4
Metro Maintenance	30,700	\$2,900	\$46,600	16
Monona Terrace	29,000	\$2,900	\$50,000	17
Goodman Pool	2,100	\$300	\$1,000	4
Olbrich Gardens	6,200	\$700	\$7,800	11
Warner Park Community	6,500	\$900	\$10,300	11
Parks Maintenance	6,100	\$800	\$14,300	18
Warner Park Shelter Maint.	200	\$500	\$5,800	12
East District Police	7,100	\$700	\$4,800	7

<i>Building</i>	<i>kWh saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
West District Police	8,000	\$500	\$4,000	9
South District Police	7,600	\$800	\$3,700	4
North District Police	6,000	\$700	\$2,700	4
Police Training Facility	11,500	\$1,700	\$12,900	8
John B. Heim Administration	21,200	\$2,600	\$8,300	3
Paterson Maintenance	3,600	\$600	\$7,300	12
Paterson Vehicle Storage	2,400	\$300	\$8,600	30

Envelope Improvements

Building envelope includes walls, windows, doors, roofs, and floors and if maintained properly keeps more conditioned air in and hot or cold air out, reducing the load on the HVAC systems and the energy used by those systems. If a building's envelope is to be improved, these upgrades should proceed significant investment in new high efficiency HVAC equipment. An improved envelope generally means greater occupant comfort as well. Typical envelope opportunities include improving air and water barrier systems, sealing air leakage, enhancing insulation systems, and upgrading windows and doors.

The Department of Energy estimates that a building's envelope can affect between 25 and 40 percent of building energy use and envelope improvements can result in energy savings of as much as 20 to 30 percent of total building energy costs.

Typical envelope improvements include the following:

- Sealing air leaks
- Insulating or adding more insulation
- Upgrading inefficient windows and doors

Table 21: Estimated Saving by Building – Envelope Improvements

<i>Building</i>	<i>kWh saved</i>	<i>therms saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Total	133,900	32,700	\$38,900	\$764,900	20
Engineering Services Building	7,400	900	\$1,600	\$42,700	26
Fairchild	1,300	1,100	\$1,100	\$52,300	49
Station #2	900	400	\$400	\$6,200	15
Station #3	500	300	\$300	\$4,200	16
Station #4	400	200	\$200	\$5,200	23
Station #5	300	400	\$300	\$4,200	12
Station #6	400	300	\$300	\$5,900	22

<i>Building</i>	<i>kWh saved</i>	<i>therms saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Station #7	500	200	\$200	\$6,300	30
Station #8	500	100	\$200	\$5,000	28
Station #11	400	300	\$300	\$5,600	19
Alicia Ashman	1,500	200	\$300	\$5,900	19
Monroe Street	600	100	\$200	\$2,300	11
Metro Maintenance	19,100	12,700	\$10,600	\$141,100	13
Monona Terrace	63,000	300	\$6,500	\$151,500	23
Olbrich Gardens	7,700	5,700	\$5,000	\$47,600	10
Warner Park Community	2,000	600	\$800	\$15,600	20
Parks Maintenance	1,900	1,200	\$1,200	\$21,700	18
Warner Park Shelter Maint.	100	300	\$800	\$17,500	23
East District Police	2,600	200	\$400	\$7,300	18
West District Police	3,000	200	\$300	\$6,100	20
South District Police	2,800	300	\$500	\$5,600	11
North District Police	2,200	100	\$300	\$4,100	12
Police Training Facility	4,400	500	\$1,100	\$19,600	18
East Streets Maintenance	2,200	2,000	\$1,700	\$74,600	44
Transfer Station	2,000	1,300	\$1,200	\$14,400	12
West Streets Maintenance	1,600	1,000	\$1,000	\$38,000	39
West Streets Storage	200	200	\$200	\$11,500	52
Traffic Operations	2,500	400	\$700	\$18,900	28
Paterson Maintenance	1,100	600	\$600	\$11,000	18
Paterson Vehicle Storage	800	600	\$600	\$13,000	23

Water Distribution Upgrades (Process)

Within a water system, energy is used for raw water extraction and conveyance, treatment, distribution, and storage. Of those functions, 80 percent of the energy consumption typically is used for pumping and distributing water, while the remaining 20 percent is used for treatment (Goldstein and Smith 2002). There are several opportunities related to the water system that make sense for the City, including optimization and controls, infrastructure upgrades, and end user conservation.

System Optimization/Controls

The existing SCADA controls system offers the opportunity to optimize the City's water distribution system with relatively low cost improvements to coordinate zones and optimize system pressures and crossover operations. Costs savings have been estimated based on a projected 9 percent reduction in electricity for the water distribution system. A payback of about 3 years is anticipated based on

relatively low cost items, such as enhancements to the existing SCADA platform, programming updates, and related control system hardware (e.g., sensors).

Infrastructure Upgrades

Infrastructure upgrades necessarily include larger capital improvement projects – opportunities that have a greater upfront cost than system optimization efforts. For budgetary pricing efforts, these infrastructure upgrades are defined according to three types of capital improvement projects:

1. Variable speed motor drive installations
2. Premium efficiency motor replacements
3. Distribution valving modifications

Utility cost savings for these opportunities were determined using engineering calculations for each of the three project types that projected a total count of the three project types for the entire water distribution system.

End User Reduction Program

Finally, there is an opportunity to realize energy savings by implementing water conservation programs throughout the City. Conserving water will reduce the embedded energy costs associated with water supply and distribution operations – Madison’s water supply has an energy intensity of 1,800 kWh/million gallons. Taking advantage of the smart water meter system in the City and the Cool Choices residential competition that will be taking place in fall 2015, the costs and savings were estimated for an assumed 1 percent reduction in water consumption community-wide. To achieve this savings, assumed implementation costs would include one full time employee to manage the water conservation program plus additional program costs to provide incentives and rebates to water utility customers for installing water conserving fixtures and equipment.

Total estimated savings, cost, and payback for this category are provided in Table 20. The cost values, and therefore paybacks, will be revised once additional information becomes available over the next few weeks.

Table 22: Estimated Saving – Water Distribution Upgrades

<i>Project</i>	<i>kWh saved</i>	<i>Total Savings (\$)</i>	<i>Total Cost (\$)</i>	<i>Simple Payback (years)</i>
Total	3,532,100	\$326,900	\$1,361,000	4
Optimization	1,478,300	\$173,100	\$519,100	3
Infrastructure	1,889,600	\$134,200	\$559,400	4
Reduction	164,300	\$19,700	\$282,500	14

Appendix A – Estimated Savings, Cost, and Payback by Building

Table A1: Comprehensive Building and Measures List

Building	Cumulative Summary				Measures				
	Savings (\$)	Cost (\$)	Savings (kBtu)	Payback (yrs)	Interior Lighting	HVAC	Controls	Plug Load	Envelope
Engineering									
Engineering Services Building	\$2,900	\$56,800	148,000	20	No	No	No	Yes	Yes
Fairchild	\$3,900	\$320,800	407,000	82	No	Yes	No	Yes	Yes
Engineering Sub-total	\$6,800	\$377,600	555,000	56					
Fire									
Station #2	\$800	\$8,300	48,000	10	No	No	No	Yes	Yes
Station #3	\$2,800	\$55,100	229,000	20	No	Yes	Yes	Yes	Yes
Station #4	\$1,900	\$43,200	132,000	23	No	Yes	Yes	Yes	Yes
Station #5	\$3,200	\$55,300	321,000	17	No	Yes	Yes	Yes	Yes
Station #6	\$2,100	\$49,600	169,000	24	No	Yes	Yes	Yes	Yes
Station #7	\$1,400	\$46,500	108,000	33	No	Yes	Yes	Yes	Yes
Station #8	\$1,400	\$37,300	84,000	27	No	Yes	Yes	Yes	Yes
Station #11	\$2,000	\$42,900	143,000	21	Yes	Yes	No	Yes	Yes
Station #12	\$1,800	\$11,600	88,000	6	Yes	No	No	Yes	No
Station #13	\$200	\$4,500	4,000	23	No	No	No	Yes	No
Fire Sub-total	\$17,600	\$354,300	1,326,000	20					
Library									
Alicia Ashman	\$2,200	\$21,100	96,000	10	No	No	Yes	Yes	Yes

Building	Cumulative Summary				Measures				
	Savings (\$)	Cost (\$)	Savings (kBtu)	Payback (yrs)	Interior Lighting	HVAC	Controls	Plug Load	Envelope
Central Library	\$6,200	\$39,300	160,000	6	No	No	No	Yes	No
Goodman South	\$800	\$4,000	20,000	5	No	No	No	Yes	No
Monroe Street	\$1,600	\$17,700	85,000	11	Yes	Yes	Yes	Yes	Yes
Sequoia Branch	\$3,000	\$16,100	118,000	5	No	No	Yes	Yes	No
Library Sub-total	\$13,800	\$98,200	361,000	7					
Metro									
Metro Maintenance	\$77,100	\$541,800	6,000,000	7	Yes	Yes	Yes	Yes	Yes
Monona Terrace	\$18,900	\$345,400	687,000	18	No	No	Yes	Yes	Yes
Parks									
Goodman Pool	\$300	\$1,000	7,000	3	No	No	No	Yes	No
Olbrich Gardens	\$25,900	\$328,800	2,469,000	13	No	Yes	Yes	Yes	Yes
Warner Park Community	\$12,600	\$224,000	684,000	18	Yes	Yes	Yes	Yes	Yes
Parks Maintenance	\$7,300	\$82,500	371,000	11	Yes	No	Yes	Yes	Yes
Warner Park Shelter Maint.	\$6,900	\$60,900	63,000	9	Yes	No	Yes	Yes	Yes
Parks Sub-total	\$53,000	\$697,200	3,594,000	13					
Police									
East District Police	\$3,400	\$63,000	197,000	19	Yes	Yes	Yes	Yes	Yes
West District Police	\$3,200	\$81,100	245,000	25	Yes	Yes	Yes	Yes	Yes
South District Police	\$4,300	\$48,400	224,000	11	Yes	Yes	Yes	Yes	Yes
North District Police	\$3,100	\$35,300	135,000	11	Yes	Yes	Yes	Yes	Yes
Police Training Facility	\$9,900	\$187,300	457,000	19	Yes	Yes	Yes	Yes	Yes
Police Sub-total	\$23,900	\$415,100	1,258,000	17					
Senior Center	\$0	\$0	0	0	No	No	No	No	No
Streets									

<i>Building</i>	<i>Cumulative Summary</i>				<i>Measures</i>				
	Savings (\$)	Cost (\$)	Savings (kBtu)	Payback (yrs)	Interior Lighting	HVAC	Controls	Plug Load	Envelope
East Streets Maintenance	\$14,500	\$932,700	1,579,000	64	No	Yes	Yes	No	Yes
Transfer Station	\$5,900	\$97,200	590,000	16	No	Yes	Yes	No	Yes
West Streets Maintenance	\$8,600	\$474,500	839,000	55	No	Yes	Yes	No	Yes
West Streets Storage	\$200	\$11,500	25,000	58	No	No	No	No	Yes
Streets Sub-total	\$29,200	\$1,515,900	3,033,000	52					
Traffic Engineering/ Parking									
Capitol Square North	\$25,800	\$184,100	925,000	7	Yes	No	Yes	No	No
Government East	\$16,900	\$117,300	612,000	7	Yes	No	Yes	No	No
Overture Center	\$15,200	\$117,000	530,000	8	Yes	No	Yes	No	No
State Street Capitol	\$36,200	\$194,400	1,366,000	5	Yes	No	Yes	No	No
State Street Frances	\$15,400	\$95,400	562,000	6	Yes	No	Yes	No	No
State Street Lake	\$11,300	\$106,600	402,000	9	Yes	No	Yes	No	No
Traffic Operations	\$17,400	\$224,900	668,000	13	Yes	Yes	Yes	No	Yes
Traffic Engineering/ Parking Sub-total	\$138,200	\$1,039,700	4,397,000	8					
Water Utility									
John B. Heim Administration	\$4,300	\$20,200	164,000	5	No	Yes	Yes	Yes	No
Paterson Maintenance	\$7,000	\$65,600	313,000	9	Yes	No	Yes	Yes	Yes
Paterson Vehicle Storage	\$6,400	\$77,600	260,000	12	Yes	No	Yes	Yes	Yes
Pump Stations	\$2,300	\$23,700	111,000	10	Yes	0	Yes	No	No

<i>Building</i>	<i>Cumulative Summary</i>				<i>Measures</i>				
	Savings (\$)	Cost (\$)	Savings (kBtu)	Payback (yrs)	Interior Lighting	HVAC	Controls	Plug Load	Envelope
Water Utility Sub-total	\$20,000	\$187,100	848,000	9					
Total (Buildings)	\$398,500	\$5,572,300	22,845,000	14					
Water Distribution	\$326,900	\$1,361,000	12,052,000	4					
Street Lights	\$342,500	\$5,488,200	16,461,000	16					
Grand Total	\$1,067,900	\$12,421,500	51,358,000	12					

Appendix B – Detailed Building Information

Table B1: Buildings Not Included in Analysis

<i>Building</i>	<i>Rationale for Excluding from Analysis</i>
Madison Municipal Building	Currently in pre-design phase of major renovation.
Fire Maintenance	Slated for demolition.
Fire Station #1	Currently being remodeled.
Fire Station #9	Needs to be completely remodeled or demolished.
Fire Station #10	Needs to be completely remodeled or demolished.
Fleet Service Building	Slated for sale or demolition.
Police Storage Facility	Slated for sale or demolition.
Senior Center	Not included based on staff feedback from Engineering that not a good upgrade candidate.
East Health Hawthorne	Leased and will be vacated in 5 years.
Lakeview Library	Leased.
Meadowridge Library	Leased.
Pinney Library	Leased.
Hawthorne Library	Leased.

Table B2: Comprehensive Building List

<i>Building</i>	<i>Square Footage</i>
Engineering	
Engineering Services Building	42,742
Fairchild	53,329
Madison Municipal Building	74,154
Fire	
Fire Maintenance	
Station #1	24000
Station #2	6,225
Station #3	8,372
Station #4	10,328
Station #5	8,399
Station #6	11,874
Station #7	12,539
Station #8	10,054
Station #9	5564
Station #10	5,959
Station #11	11,204
Station #12	12,500
Station #13	13,724
Fleet Services	
Fleet Services	52,840
Health	
East Health Hawthorne	11,500
Library	
Alicia Ashman	11,829
Central Library	119,200
Goodman South	12,010
Lakeview	9,335
Meadowridge	17,565
Monroe Street	2,300
Pinney	11,200
Hawthorne	
Sequoia Branch	20,000
Metro	
Metro Maintenance	282,250
Monona Terrace	303,000

<i>Building</i>	<i>Square Footage</i>
Parks	
Goodman Pool	6,117
Olbrich Gardens	47,553
Warner Park Community	31,200
Parks Maintenance	43,300
Warner Park Shelter Maint.	35,000
Police	
East District Police	16,460
West District Police	12,100
South District Police	11,237
North District Police	8,195
Police Storage Facility	10,000
Police Training Facility	39,186
Traffic Engineering/Parking	
Capitol Square North	234,500
Government East	206,700
Overture Center	206,200
Parking General	
State Street Capitol	342,720
State Street Frances	168,139
State Street Lake	187,850
Traffic Operations	37,877
Water Utility	
Utility Building	
John B. Heim Administration	25,148
Paterson Maintenance	22,000
Paterson Vehicle Storage	26,038
Pump Stations	