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Berlin Memorial School
34 South St.
Berlin, MA 01503

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INTRODUCTION

This report presents the recommendations resulting from the retrocommissioning study performed at the Berlin Memorial School, in Berlin, MA. This study was completed by Guardian Energy Management Solutions (Guardian).

Retrocommissioning is commonly used as a way of identifying strategies for reducing energy consumption and costs associated with the operation of a facility. While this is always a goal of the process, this study is primarily focused on improving the ability of the HVAC systems to properly serve the spaces. The target building is the Berlin Memorial School.

STUDY DESCRIPTION

The Guardian team conducted visits to the building in November, 2017 and April, 2018. Information gathered on these visits included documentation review, site observation, equipment testing, and energy management system (EMS) investigation. Documentation obtained included construction and control documents, equipment lists and utility billing information.

The study included a point-to-point test of all EMS control points, functionality testing of all HVAC equipment, airflow testing of all diffusers and a survey of the flowrates of all plumbing fixtures.

FACILITY DESCRIPTION

The Berlin Memorial School is a two-story, 59,000 square foot facility originally built in 1953, which underwent a major renovation in 1999. Primary spaces include classrooms, hallways, a gymnasium/auditorium, a cafeteria, and office spaces. The building is heated with (2) 273 MBH pellet boilers that maintain (2) 600 gallon tanks with 180°F water. This water supplies the HHW loop in the school, along with a 91 gallon indirect DHW storage tank. The boilers have a 2,693 MBH oil fueled boiler as backup, and the HHW tank has a 60 gallon 4.5 kW electric DHW heater as backup. Zone level heating is primarily provided by (18) unit ventilators and finned tube radiators. Fresh air is provided by (2) 6,000 cfm AHUs with hot water coils. The gymnasium has a separate system, and is heated and ventilated using (2) H+V units that also have hot water coils. There are (10) exhaust fans (EFs): (2) classroom EFs, (3) Toilet EFs, (1) Janitorial EF, (1) Dishwasher EF, (1) Kitchen Hood, (1) Kiln EF, and (1) Music Room EF.

UTILITY ANALYSIS

Utility data for FY 2017 was gathered for electrical and fuel oil consumption.

Utility End Use Analysis		
2017 Electricity Use (kWh):		**Notes/Comments:**
242,560	Total	Based on utility analysis
70,756	Lighting	Based on utility analysis
48,512	Motors	Estimated
84,896	Cooling	Estimated
36,384	Plug Load	Estimated
2,012	DHW	Based on utility analysis
2017 Fuel Oil Use (Gallons):		**Notes/Comments:**
17,288	Boilers (HWH)	Based on utility analysis

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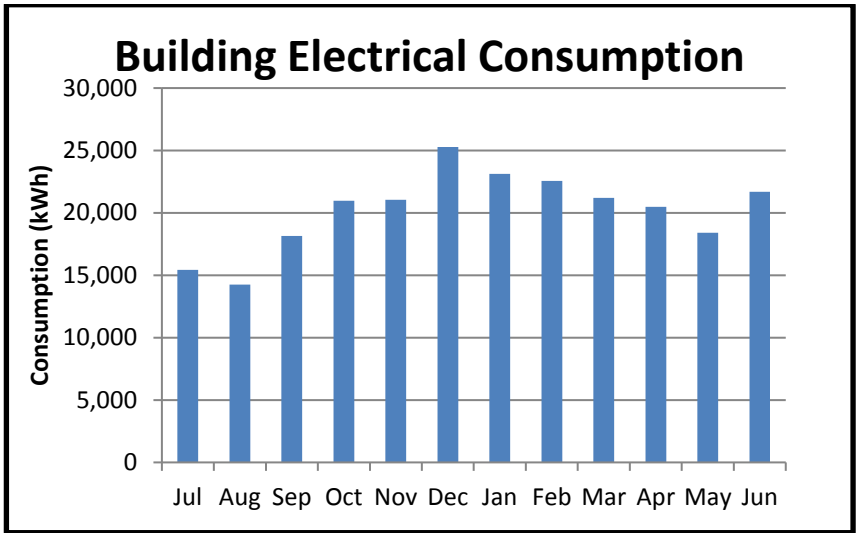
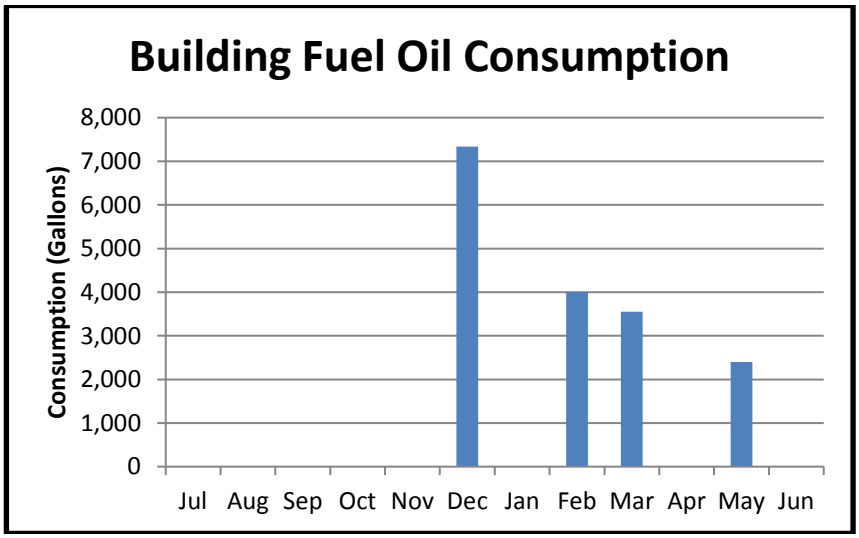
The electricity usage for the building is fairly typical of a facility of this use type. The peak usage in the winter months is most likely due to increased lighting and the use of portable electric heaters, many of which were observed during out audit. The usage peak in the winter is also emphasized by the decrease in the summer months, which is indicative of a school with a summer holiday break. Note that June also has a marked peak. This is the only fully occupied month with both electric hot water heat and extensive air conditioning requirements.



The FY17 fuel oil usage is typical of a building of this type and age. The chart marks oil purchases, and not direct consumption, which explains the peaks.



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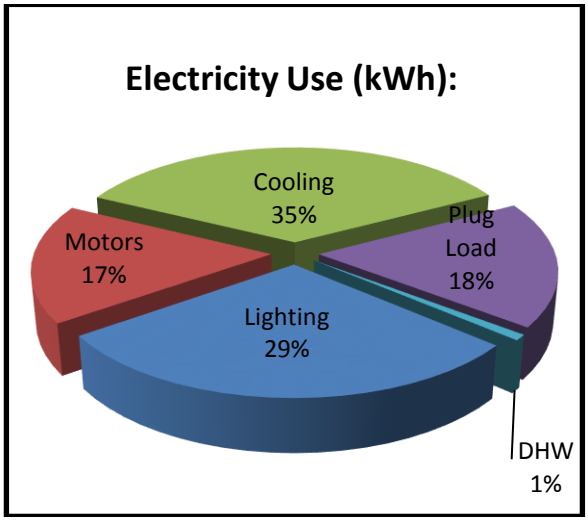
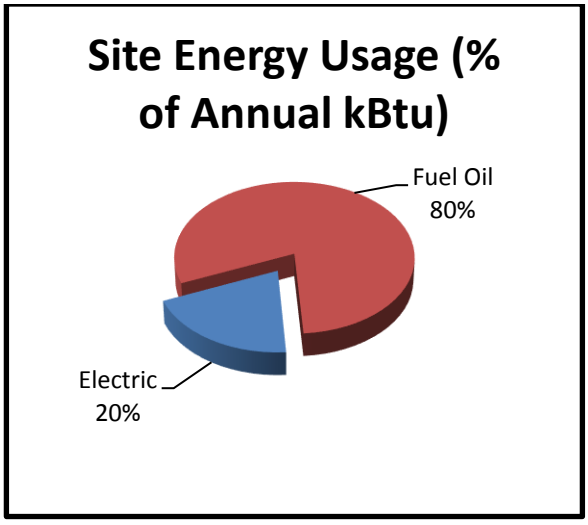
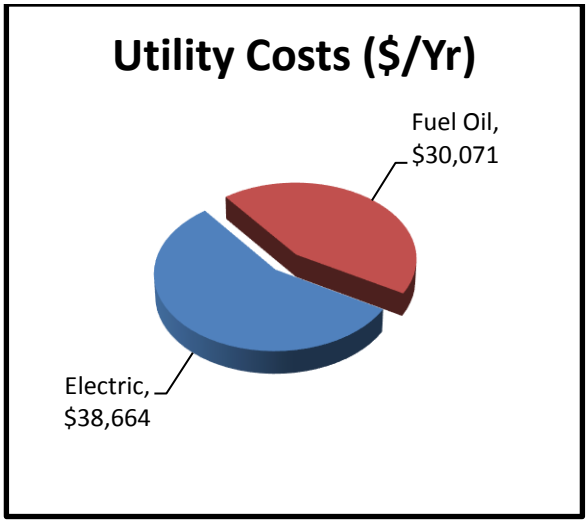






The EPA Portfolio Manager benchmarking tool provides a site Energy Use Intensity (EUI) for qualifying building types. The EUIs are provided in kBtu/ft^2/year. While public safety buildings are not a categorized building type, office buildings are, and this is the basis for the table 2 below.

Facility Benchmarking								
Building Name	Building Area	Total Cost	Electric	Fuel Oil	Total Energy	Site EUI	National Avg. EUI	ECI
	(SF)	($)	(kWh)	(Gallons)	(kBtu)	(kBtu/SF/Yr)	(kBtu/SF/Yr)	($/SF/Yr)
Berlin Memorial	59,000	$89,166	242,560	23,857	3,213,601	54.5	130.7	$ 1.51

The building EUI is significantly lower than the national average. This is an indication of energy efficiency, and also likely due to the building's lower than average worker density and usage pattern when compared to an average U.S. school building.

HVAC EQUIPMENT DESCRIPTION

A survey of all HVAC equipment was conducted to assess general condition, deferred maintenance, and issues that affect equipment efficiency. A narrative describing the audit of the major equipment is below. Details of all assessed equipment are also included as well as a truncated version of this table detailing replacement costs and estimated energy cost savings. As all items on the audit are either very recently installed, or at or near the end of their ASHRAE rated service life, refurbishment is not recommended.

RTU-1

RTU-1 is the rooftop unit that serves the Music Room. It is a constant volume system with a 4 Ton DX cooling coil. It was built in July 1999, and is original to the building. RTU-1 appears to be well maintained and is in good condition for its age. Rooftop units are rated by ASHRAE with a (15) year life expectancy. The cooling coil appeared to be in fair condition. Typical to the RTUs on the building, there has been some coil damage from hail and vandalism. The air filters showed some build up, and we recommend that they get replaced.

There are (2) components that degrade with time in a way that predominantly will affect the performance. The cooling coil can lose 3-6% efficiency every year if not maintained to the manufacturer's recommendations. Regular cleaning and maintenance can return the coil to its original efficiency. The air filters in the unit can inhibit proper airflow if not regularly changed. Replacing the filters every 3-6 months is recommended.


RTU-1 filter


RTU-1 coil


RTU-1 hail damage

RTU-2

RTU-2 is the rooftop unit that serves the 2nd floor offices. It is a constant volume system with a 3 Ton DX cooling coil. It was built in August 1998, and is original to the building. Rooftop units are rated by ASHRAE with a (15) year life expectancy. RTU-2 appears to be well maintained and is in good condition for its age. The cooling coil appeared to be in fair condition. Typical to the RTUs on the building, there has been some coil damage from hail and vandalism. The air filters showed some build up, and we recommend that they get replaced.

There are (2) components that degrade with time in a way that predominantly will affect the performance. The cooling coil can lose 3-6% efficiency every year if not maintained to the manufacturer's recommendations. Regular cleaning and maintenance can return the coil to its original efficiency. The air filters in the unit can inhibit proper airflow if not regularly changed. Replacing the filters every 3-6 months is recommended.

While investigating the unit, it was observed that the hot water valve actuator was disconnected from the valve and placed on the opposite side of the access hatch. We re-connected it and it tested fine while maintaining the appropriate temperature range in the served spaces.

RTU-3

RTU-3 is the rooftop unit that serves the Library. It is a constant volume system with a 7.5 Ton DX cooling coil. It was built in August 1998, and is original to the building. Rooftop units are rated by ASHRAE with a (15) year life expectancy. RTU-3 appears to be well maintained and is in good condition for its age. The fan belt appeared to be cracking slightly and squeaking loudly, replacement and re-tensioning are recommended. The cooling coil appeared to be in fair condition. Typical to the RTUs on the building, there has been some coil damage from hail and vandalism. The air filters showed some build up, and we recommend that they get replaced, and that the cooling coil is cleaned as recommended by the manufacturer. During the audit, the barometric relief blade was observed to be disconnected and resting in the opening it was intended to block. It was replaced into its intended position.

There are (3) components that degrade with time in a way that predominantly will affect the performance. The cooling coil can lose 3-6% efficiency every year if not maintained to the manufacturer's recommendations. Regular cleaning and maintenance can return the coil to its original efficiency. The fan belt can lose significant efficiency if not properly tensioned, and all belts should be replaced annually to ensure optimal performance. The air filters in the unit can inhibit proper airflow if not regularly changed. Replacing the filters every 3-6 months is recommended.

The 1 HP supply fan motor was recently upgraded, and meets the current NEMA premium motor rating.


RTU-3 hail damage


RTU-3 general condition

RTU-3 barometric relief damper

AHU-1+2

AHU-1+2 are the air handling units that serve the gymnasium. They are constant volume heating and ventilations, built in 1999, and are original to the building. Air handling units are rated by ASHRAE with a (15) year life expectancy. AHU-1+2 appear to be in fair condition for their age. The belts and coils appear to be in good condition and the unit needs routine cleaning and new air filters. Due to the lack of safe access to AHU-2, only AHU-1 was opened and surveyed.

There are (3) components that degrade with time in a way that predominantly will affect the performance. The heating coil can lose 3-6% efficiency every year if not maintained to the manufacturer's recommendations. Regular cleaning and maintenance can return the coil to near its original efficiency. Fan belts can lose significant efficiency if not properly tensioned, and all belts should be replaced annually to ensure optimal performance. The air filters in the unit can inhibit proper airflow if not regularly changed. Replacing the filters every 3-6 months is recommended.

The 3 HP supply fan motor appears to be original to the installation. It has a rated efficiency of 85.5%, and the NEMA premium efficiency minimum for this size motor is currently 89.5%.


AHU-1 general condition


AHU-2 access across drop ceiling

HVAC-1

HVAC-1 is the Split System A/C unit that serves the 2nd floor offices. It is a constant volume system with a 3 Ton DX cooling coil. It was built in July 1998, and is original to the building. Split systems units are rated by ASHRAE with a (15) year life expectancy. HVAC-1 appears to be well maintained and is in good condition for its age. The cooling coil appeared to be in good condition, and seasonal maintenance would restore it to the original efficiency. The air filters showed some build up, and we recommend that they get replaced.

There are (3) components that degrade with time in a way that predominantly will affect the performance. The cooling coil can lose 3-6% efficiency every year if not maintained to the manufacturer's recommendations. Regular cleaning and maintenance can return the coil to its original efficiency. The air filters in the unit can inhibit proper airflow if not regularly changed. Replacing the filters every 3-6 months is recommended. The belts on the unit showed some cracking. Replacement and re-tensioning are recommended.

HVAC-1 condenser

HVAC-1 filter

HVAC-2

HVAC-2 is the Split System A/C unit that serves the kitchen and Cafeteria. It is a constant volume system with a 10 Ton DX cooling coil. It was built in August, 1998 and is original to the building. Split systems units are rated by ASHRAE with a (15) year life expectancy. HVAC-2 appears to be well maintained and is in good condition for its age. Typical to the equipment on the roof, there has been some coil damage from hail and vandalism. The air filters showed some build up, and we recommend that they get replaced.

There are (3) components that degrade with time in a way that predominantly will affect the performance. The cooling coil can lose 3-6% efficiency every year if not maintained to the manufacturer's recommendations. Regular cleaning and maintenance can return the coil to its original efficiency. The air filters in the unit can inhibit proper airflow if not regularly changed. Replacing the filters every 3-6 months is recommended. The belts on the unit showed some cracking. Replacement and re-tensioning are recommended.

HVAC-2 general condition


HVAC-2 condenser

B-1+2

B-1+2 are 273 MBh, wood pellet fired boilers that serve the entire building. They were installed in 2016. They have a rated efficiency of 83.4%, with an operating stack temperature of 286°F and 292°F respectively. Pellet fired boilers are not specifically rated by ASHRAE, but the equivalent system is rated with a (25) year life expectancy.

B-1+2 are the primary boilers for the building. They are configured to operate lead/lag and have an outdoor air temperature reset in place. There is a primary hot water loop that circulates between the boilers. This loop is then used to heat a secondary loop that maintains temperature in (2) 180 gallon buffer tanks that, in turn, heat the water in the building hot water loop.

During the audit, the hot water bypass damper on B-1 was observed clicking constantly, and appeared to be stuck, attempting to rotate. Immediate efforts to resolve the issue were unsuccessful. The unit appeared to be operating normally otherwise. During the previous audit, it had been observed that the flue stack for these boilers had some welding that was insufficient, poorly executed, and due to this, had leaks. It was observed that all of the welds on the stack have been re-welded, and now are all in good condition.


B-1+2 flue welds

B-3

B-3 is a 2,693 MBh, oil fired boiler that serve the entire building. It was built in 2013. It has a rated efficiency of 87.0%. During the audit, the combustion gas was analyzed using a Bacharach Fyrite Intech, and found to be 79.9%. Thorough soot removal and cleaning of the boiler sections and burner can bring the boiler back to its original efficiency.
B-3 is configured to act as a backup to B-1+2. It is commanded to run any time that the outdoor air temp is lower than 45°F. Unlike B1+2, B-3 is not connected to the buffer tanks, servicing the building hot water loop directly, injecting additional hot water into the loop during colder periods.

Exhaust Fans

The exhaust fan motors all appear to be original to the building, manufactured in the 1998-1999 time period. They are generally in good condition for their age, though replacing and re-tensioning the fan belts is recommended.

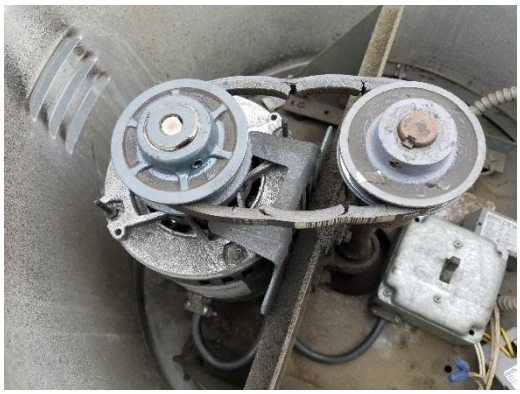
ASHRAE rates electric motors with an (18) year life expectancy. The majority of these motors are fractional HP in size, and the increase in efficiency to the new motor will be a minor consideration.

The fan belts on these units are in a variety of conditions. Annual replacement and tensioning are recommended.


EF-5 belt and general fan condition


EF-6 belt and general fan condition


EF-7 belt and general fan condition


EF-11 belt and general fan condition

UH-1

The unit heater in the mechanical room is a 172 MBH hot water unit heater, original to the 1999 building. ASHRAE rates hot water unit heaters with a (20) year life expectancy. While replacing this heater will not result in a significant energy efficiency upgrade, it is nearing the end of its useful life.

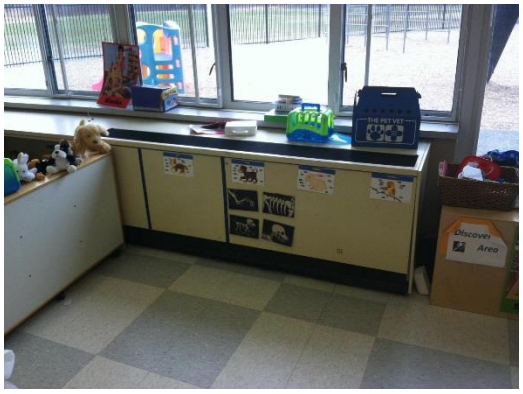
UH-1 general condition

CUV-1-3

The unit ventilators in the building come in three sizes: 55, 70 and 80 MBH. They are original to the building, and have an ASHRAE rated 20 year lifespan.

The unit ventilators were generally found to be in fair condition for their age. Many had filters that needed changed, and coils and internal compartments that needed cleaning.

There are (2) components that degrade with time in a way that predominantly will affect the performance. The cooling coil can lose 3-6% efficiency every year if not maintained to the manufacturer's recommendations. Regular cleaning and maintenance can return the coil to its original efficiency. The air filters in the unit can inhibit proper airflow if not regularly changed. Replacing the filters every 3-6 months is recommended.



CUV general condition

CUV filter (typical)

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HVAC EQUIPMENT DETAILS AND REPLACEMENT COSTS

The table below details the equipment as detailed on the drawings, the details of the actual equipment found on site, and the costs (labor and materials) to replace each unit with recommended replacement units. These costs are budgetary in nature, and we are not recommending the replacement of all equipment.

Tag	Equip Type	Drawing Model Number	Model Number	Size	Replacement Cost	Est Energy Cost Savings
CH-A	Cabinet Heater	Trane Model H	Trane Model H	40 MBH, 400 cfm	$2,500	<$10
CH-B	Cabinet Heater	Trane Model H	Trane Model H	60 MBH, 600 cfm	$2,500	<$10
CUV-A	Unit Ventilator	Not Specified	Unlabeled Unit Vent	70 MBH, 1,000 cfm	$10,800	<$10
CUV-B	Unit Ventilator	Not Specified	Unlabeled Unit Vent	55 MBH, 750 cfm	$10,200	<$10
CUV-C	Unit Ventilator	Not Specified	Unlabeled Unit Vent	80 MBH 1,250 cfm	$11,200	<$10
EF-1	Exhaust Fan	GB-100	GB-100	2,000 cfm	$3,200	<$10
EF-2	Exhaust Fan	BCF-212	BCF-212	3,000 cfm	$4,200	<$10
EF-3	Exhaust Fan	BCF-212	BCF-212	4,000 cfm	$4,500	<$10
EF-4	Exhaust Fan	GB-70	GB-70	200 cfm	$2,800	<$10
EF-5	Exhaust Fan	GB-80	GB-80	200 cfm	$3,000	<$10
EF-6	Exhaust Fan	GB-80	GB-80	500 cfm	$3,000	<$10
EF-7	Exhaust Fan	GB-120	GB-120	1,000 cfm	$3,500	<$10
EF-8	Exhaust Fan	CUBE-240	CUBE-240	6,000 cfm	$6,800	<$10
EF-9	Exhaust Fan	GB-80	GB-80	500 cfm	$3,000	<$10
EF-10	Exhaust Fan	GB-80	GB-80	500 cfm	$3,000	<$10
DHW	Domestic HW	Not Specified	ETT065KD 110	60 gal, 9,000 watt	$4,400	<$10
B-1, B-2	Boiler	H.B. Smith L028A	Froling P4 Pellet	273 MBH	$41,000	<$10
B-3	Boiler	Not on Drawings	Vitrond 200	2,693 MBH	$82,000	<$10
SF-1	Exhaust Fan	AIS-18-B	AIS-18-B	2,000 cfm	$4,500	<$10
UH-1	Unit Heater	Not on Drawings	UHSA168S8DAADF	172 MBH	$2,800	<$10
RTU-1	Rooftop	TCD049	TCD049	51.4 MBH	$12,600	$60
RTU-2	Rooftop	TCD091	TCD091	86 MBH	$19,800	$70
RTU-3	Rooftop	TCD037	TCD037	42.4 MBH	$12,100	$50
HVAC-1	Air Handler	TTA030/TWE030	TTA030/TWE030	30 MBH, 2,000 cfm	$15,600	$125
HVAC-2	Air Handler	TTA0120/TWE0120	TTA0120/TWE0120	120 MBH, 4,000 cfm	$22,900	$200
AHU-1	Air Handler	Climate Changer	Trane Climate Changer	6,000 cfm	$24,200	$250
AHU-2	Air Handler	Climate Changer	Trane Climate Changer	6,000 cfm	$24,200	$250
HWP-1	Pump	Taco FM-2307	B&G 2AAB	5 HP	$5,200	<$10
HWP-2	Pump	Taco FM-2307	B&G 2AAB	5 HP	$5,200	<$10
P-1	Pump	Not on Drawings	B&G ecocirc XL 40-275		$5,200	<$10
P-2	Pump	Not on Drawings	B&G ecocirc XL 65-130		$5,500	<$10
P-3	Pump	Not on Drawings	B&G	1/2-1/3 HP	$2,200	<$10
FTA-1	Fin Tube	Dunham-Bush S412	Dunham-Bush 6SA	0.9 MBH finned tube	$ 500/ft.	<$10
MAU-1	Make up Air	SSCBL-600	Reznor SSCBL-600	0.6 MBH, 6,000 cfm	$32,900	$50

The major equipment was also compared against industry standard, both in terms of usable service life and current applicable energy efficiency requirements. This table is included below.

Tag	Equip Type	Age	Service Life	Rated Eff	2018 Code	Size
RTU-1	Rooftop	20 yr	15 yr	12 SEER	10.8 EER	4 Ton
RTU-2	Rooftop	20 yr	15 yr	12 SEER	10.8 EER	7.5 Ton
RTU-3	Rooftop	20 yr	15 yr	10 EER	10.8 EER	3 Ton
AHU-1	Air Handing Unit	20 yr	15 yr	N/A	N/A	6,000 CFM
AHU-2	Air Handing Unit	20 yr	15 yr	N/A	N/A	6,000 CFM
HVAC-1	Air Handing Unit	20 yr	15 yr	8.9 EER	11.2 EER	5 Ton
HVAC-2	Air Handing Unit	20 yr	15 yr	9.4 EER	11.2 EER	10 Ton
B-1	Boiler	2 yr	25 yr	83.40%	N/A	273 MBH
B-2	Boiler	2 yr	25 yr	83.40%	N/A	273 MBH
B-3	Boiler	5 yr	25 yr	87.00%	82.00%	2,693 MBH

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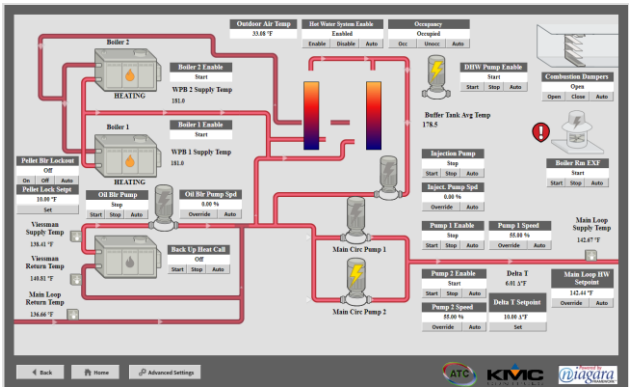
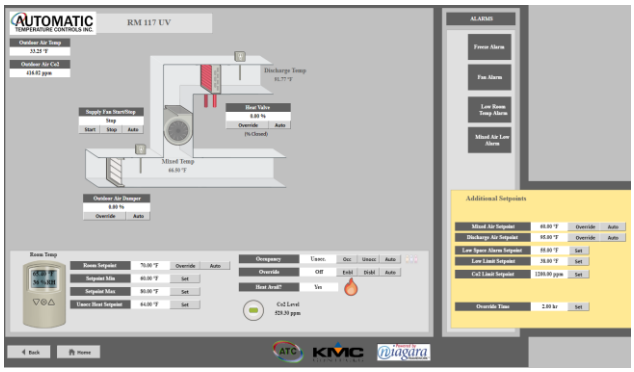
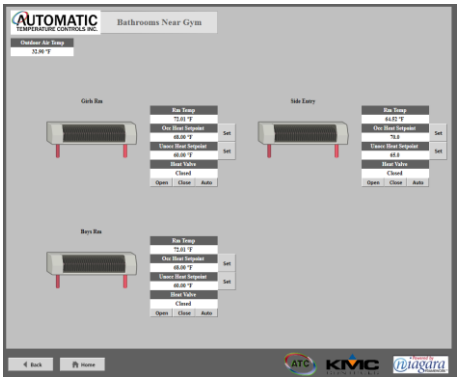
While we are not recommending the wholesale replacement of all equipment at or near the end of the usable service life, one pathway to do so would be to hire a design firm to create a Request for Proposal (RFP) package, detailing the requirements of the project, which can then be used to send the project out to bid. These packages include equipment narratives and detailed instructions for creating the bid package, and also can include as-built HVAC and electrical drawing sets when deemed necessary. A budgetary estimate for hiring a design team to create an RFP package such as this would be roughly $14,000 with a drawing set. The majority of this fee is for the as-built drawings, and a package that does not include drawings would be more economical.

ENERGY MANAGEMENT SYSTEM

The Energy Management System (EMS) is a KMC-Controls BacNet compliant DDC system installed in 2013. ASHRAE rates electronic controls systems with a (15) year life expectancy. The system allows for the automated operation of all major HVAC systems in the building. This includes equipment operating schedules, environmental setpoints ranges, and operational sequences, which dictate the operational behavior of the equipment based on a series of inputs from sources such as environmental sensors, timers, and other HVAC equipment.







The control sequences were analyzed for completeness and for energy efficiency additions, both in terms of additional points and advanced programming. With the exception of the small number of changes included in the Recommended Measures section, the sequences were found to be complete and appropriate for the building.

A point-to-point test was conducted of the building EMS system. This consisted of verifying that the output control points operated the intended equipment as expected when a range of commands were sent, and that input measurement points reported readings that were within acceptable ranges, and that the reported readings varied appropriately with changing conditions.

Berlin Memorial School Point-to-Point Checkout				Notes
RTU-1		**PASS**	**FAIL**	
SF-S	fan status	X		
MOT-S	motion status	X		
MAD-O	mixed air damper output	X		
SF-C	fan command	X		
HTG-O	heating valve output		X	Actuator Failed Test
DX1-C	stage 1 cooling	X		
RA-T	return air temp	X		
DA-T	discharge air temp	X		
MA-T	mixed air temp		X	No response to open damper
RM-SP	room setpoint	X		
RM-T	room temperature	X		
RM-RH	room relative humidity	X		
RCO2-L	return co2 level	X		
DX1-C	stage 1 cooling command	X		
RTU-2		**PASS**	**FAIL**	
SF-S	fan status	X		
MOT-S	motion status	X		
MAD-O	mixed air damper output	X		
SF-C	fan command	X		
HTG-O	heating valve output	X		
DX1-C	stage 1 cooling	X		
RA-T	return air temp	X		
DA-T	discharge air temp	X		
MA-T	mixed air temp	X		
RM-SP	room setpoint	X		
RM-T	room temperature	X		
RM-RH	room relative humidity	X		
RCO2-L	return co2 level	X		
DX1-C	stage 1 cooling command	X		
RM203A-C	room 203 A baseboard valve		X	No response to commands
RM203B-C	room 203 B baseboard valve		X	No response to commands
RM203A-T	room 203 A temperature	X		
RTU-3		**PASS**	**FAIL**	
SF-S	fan status	X		
MOT-S	motion status	X		
MAD-O	mixed air damper output	X		
SF-C	fan command	X		
HTG-O	heating valve output	X		
DX1-C	stage 1 cooling	X		
RA-T	return air temp	X		
DA-T	discharge air temp	X		
MA-T	mixed air temp	X		
FTR-C	fin tube radiator command	X		
RM-SP	room setpoint	X		
RM-T	room temperature	X		
RM-RH	room relative humidity	X		
RCO2-L	return co2 level	X		
DX1-C	stage 1 cooling command	X		
DX2-C	stage 2 cooling command	X		
RM221-T	room temperature	X		
RM223-T	room temperature	X		
RM221-C	room 221 baseboard valve	X		
RM223-C	room 223 baseboard valve	X		
AHU-1		**PASS**	**FAIL**	
SF-S	fan status	X		
MOT-S	motion status	X		
SF-C	fan command	X		
RA-T	return air temperature	X		
MA-T	mixed air temperature	X		

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Berlin Memorial School Point-to-Point Checkout (cont)		PASS	FAIL	Notes
AHU- 1 (cont)				
MAD-O	mixed air damper output	X		
HTG-O	heating valve output	X		
DA-T	discharge air temp	X		
RM-T	room temperature	X		
RM-SP	room setpoint	X		
RM-RH	room relative humidity	X		
RCO2-L	return air co2 level	X		
AHU-2		**PASS**	**FAIL**	
SF-S	fan status	X		
MOT-S	motion status	X		
SF-C	fan command	X		
RA-T	return air temperature	X		
MA-T	mixed air temperature	X		
MAD-O	mixed air damper output	X		
HTG-O	heating valve output		X	Open when commanded closed
DA-T	discharge air temp	X		
RM-T	room temperature	X		
RM-SP	room setpoint	X		
RM-RH	room relative humidity	X		
RCO2-L	return air co2 level	X		
HVAC-1		**PASS**	**FAIL**	
SF-S	fan status	X		
MOT-S	motion status	X		
MOAD-C	minimum outdoor air damper	X		
SF-C	fan command	X		
HTG-O	heating valve output	X		
DX1-C	stage 1 cooling	X		
RA-T	return air temp	X		
DA-T	discharge air temp	X		
MA-T	mixed air temp	X		
FTR-C	fin tube radiator command	X		
RM-SP	room setpoint	X		
RM-T	room temperature	X		
RM-RH	room relative humidity	X		
CO2-L	co2 level	X		
HVAC-2		**PASS**	**FAIL**	
SF-S	fan status	X		
MOT-S	motion status	X		
MOAD-C	minimum outdoor air damper	X		
SF-C	fan command	X		
HTG-O	heating valve output	X		
DX1-C	stage 1 cooling	X		
RA-T	return air temp	X		
DA-T	discharge air temp	X		
MA-T	mixed air temp	X		
FTR-C	fin tube radiator command		X	No response to command
RM-SP	room setpoint	X		
RM-T	room temperature	X		
RM-RH	room relative humidity	X		
CO2-L	co2 level	X		
Boilers		**PASS**	**FAIL**	
B1-F	boiler 1 fault	X		
B1-S	boiler 1 status	X		
EF-C	exhaust fan command		X	No response to commands
EF-S	exhaust fan status	X		
LW-A	low water alarm	X		
B2-EN	boiler 2 enable	X		
DSF-C	destrat fan hall command	X		

Berlin Memorial School Point-to-Point Checkout (cont)		PASS	FAIL	Notes
Boilers (cont)				
P2-EN	pump 2 enable	X		
B3-EN	boiler 3 enable	X		
B2S-T	boiler 2 supply temp	X		
BLDGR-T	building return temp	X		
VS-T	Viesmann boiler supply temp	X		
RM-T	room temp boiler room	X		
B1S-T	boiler 1 supply temp	X		
VR-T	Viesmann boiler return temp	X		
BLDGS-T	building supply temp	X		
HWL-T	hot water loop temp	X		
DHW-T	domestic hot water temp	X		
OA-T	outdoor air temp	X		
P2-S	pump 2 speed	X		
HW Pumps		**PASS**	**FAIL**	
P2-S	pump 2 status	X		
EF5-S	exhaust fan status	X		
EF7-S	exhaust fan status	X		
P1-S	pump 1 status	X		
P1-C	pump command	X		
P2-C	pump command	X		
EF5-C	exhaust fan command	X		
EF7-C	exhaust fan command	X		
GL-C	girls room rad valve command	X		
B-T	boys room temp	X		
GL-T	girls room temp	X		
HWR-T	hot water return temp	X		
	comp hot water supply temp	X		
P2-O	pump 1 speed	X		
P1-O	pump 2 speed	X		
LF-A	low fuel alarm	X		
B&G Pumps		**PASS**	**FAIL**	
P2-S	pump 2 status	X		
P5-S	pump 5 status	X		
P5-C	pump 5 command	X		
P5-O	pump 5 speed output	X		
CAD-C	combustion air damper output	X		
VR-T	veisman return temp	X		
HWL-T	hot water loop temp	X		
VS-T	veisman supply temp	X		
Unit Ventilators (typical, no issues found)		**PASS**	**FAIL**	
SF-S	fan status	X		
MA-T	mixed air temperature	X		
DA-T	discharge air temperature	X		
RM-T	room temperature	X		
RM-SP	room temp setpoint	X		
RM-RH	room relative humidity	X		
CO2-L	co2 level	X		
HTG-O	heating valve output	X		
MAD-O	mixed air damper output	X		
MOT-S	motion status	X		
SF-C	fan command	X		
Exhaust Fans		**PASS**	**FAIL**	
EF4-C	exhaust fan command	X		
EF10-C	exhaust fan command	X		
EF11-C	exhaust fan command		X	EF hums slightly, no air
EF4-S	exhaust fan status	X		
EF10-S	exhaust fan status	X		
EF11-S	exhaust fan status	X		

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Hallway Heat		PASS	FAIL	Notes
CUH1-C	cabinet unit heater 1 command	X		
CUH1-S	cabinet unit heater 1 status	X		
CUH1-T	cabinet unit heater 1 temperature	X		
HBB-C	hallway baseboard command	X		
HBB-T	hallway baseboard temp	X		
DBB-T	data baseboard temp	X		
DBB-C	data baseboard command	X		
1st Floor Bathrooms		**PASS**	**FAIL**	
BR-T	boys room temp	X		
BR-C	boys room baseboard command		X	Valve stuck closed
GR-T	girls room temp	X		
GR-C	girls room baseboard command	X		
RM128-T	room 128 temp	X		
RM130-T	room 130 temp	X		
HCUH-T	hall cab unit heater temp	X		
RM128-C	room 128 baseboard command	X		
RM130-C	room 130 baseboard command	X		
HCUH-C	hall cab unit heater baseboard	X		
2nd Floor Bathrooms and Exhaust		**PASS**	**FAIL**	
EF2-S	exhaust fan status	X		
EF3-S	exhaust fan status	X		
EF1-S	exhaust fan status	X		
GBR-T	girls bathroom temp		X	RR by Gym valve stuck open
2nd Floor Bathrooms and Exhaust		**PASS**	**FAIL**	
BBR-T	boys bathroom temp		X	RR by Gym valve stuck open
HCUH-T	hall cab unit heater temp	X		
EF1-C	exhaust fan command	X		
EF2-C	exhaust fan command	X		
EF3-C	exhaust fan command	X		

AIRFLOW TESTING

A survey was conducted, measuring the supply airflow from each of the diffusers connected to RTU-1, RTU-2, and RTU-3 when the zone damper was locked at 100% open. The total CFM of each unit was within expected ranges, and the systems appeared to be generally well balanced.

EQUIPMENT MAINTENANCE

All HVAC equipment requires some level of regular maintenance. A 1-page review of the manufacturer's recommended maintenance has been included in Appendix B for reference. These checklists are meant only to supplement the manufacturer's official documentation, which will accompany this report in pdf form.

Frequently, regular servicing is done through a service contract with a 3rd party. While many levels of contracts are available, a base contract, involving quarterly equipment checks and filter monitoring/replacement, along with annual belt replacement and tensioning would cost approximately $12,200 annually for this building.

WATER FIXTURE EFFICENCY

The fixtures in the facility generally do not meet low-flow standards. The EPA has published guidelines under the WaterSense program that guide facility owners through the selection of water efficient equipment. See the Appendix C for the Berlin Memorial Building Water Fixture Survey for building information, as well as details regarding the EPA WaterSense program.

Berlin Memorial School Water Fixture Survey					
Room Description	**Fixture Description**	**GPM GPF**	**Source of Flow Data**	**Notes**	**Low Flow Recommendation**
1st Men's	H/C Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
1st Men's	Toilet	1.5	Flushometer	Zurn 307458 or 65571	Dual Flush 1.28/1.0 gpf
1st Men's	Urinal	1.0	Flushometer	Sloan A-19-A	0.5 gpf
1st Men's	High Sink	0.5	Aerator	Chicago Fosset	WaterSense Compliant
1st Men's	Low sink	???		Chicago Fosset, no Aerator	1.5 gpm
1st Women's	H/C Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
1st Women's	Middle Toilet	1.5	Flushometer	Zurn 307458 or 65571	Dual Flush 1.28/1.0 gpf
1st Women's	Left Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
1st Women's	High Sink	???		No aerator	1.5 gpm
1st Women's	Low sink	???		No aerator	1.5 gpm
Kitchen Staff Bathroom	Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Kitchen Staff Bathroom	Sink	1.5	Aerator	Model Jacuzzi	WaterSense Compliant
Kitchen	Sanitizing Sink	???		No aerator	1.28 gpm pre-rinse spray
Kitchen	Prep sink	2.5	Aerator	Seco model HS-11-1	1.28 gpm pre-rinse spray
Kitchen	Stove utility sink	2.5	Aerator	Seco model HS-11-1	1.28 gpm pre-rinse spray
Kitchen	D/W utility sink	2.5	Aerator	Seco model HS-11-1	1.28 gpm pre-rinse spray
Kitchen	Prep Sink	???		Excessive sediment	1.28 gpm pre-rinse spray
Kitchen	Dishwashing area	???		Hose line with spray nozzle	1.28 gpm pre-rinse spray
Kitchen	Dishwashing area	???		Hobart dishwasher	EnergyStar Dishwasher
Teacher Lounge	Sink	2.2	Aerator	Excessive sediment	1.5 gpm
Health Office	Sink	2.2	Aerator	Model A112.18.1	1.5 gpm
Lounge Men's	Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Lounge Men's	Sink	2.0	Aerator	Excessive sediment	1.5 gpm
Lounge Women's	Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Lounge Women's	Sink	2.0	Aerator	Excessive sediment	1.5 gpm
Library	Sink	2.0	Aerator		1.5 gpm
Music Room 103	Sink	2.0	Aerator		1.5 gpm
Computer Room 111	Sink	2.0	Aerator	Non-functioning bubbler	1.5 gpm
Kindergarten 132	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm
Boy's by Room 128	Boys Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Boy's by Room 128	Boys Sink	2.0	Aerator		1.5 gpm
Girl's by Room 128	Girls Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Girl's by Room 128	Girls Sink	2.0	Aerator		1.5 gpm
Girl's by Room 128	Girls Sink	2.0	Aerator		1.5 gpm
Preschool Room 128	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm
Projects Room 112	Sink	2.0	Aerator	Fon-functioning bubbler	1.5 gpm
Boy's by Room 114	H/C Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Boy's by Room 114	Toilet	1.5	Flushometer	Sloan A-15-A	Dual Flush 1.28/1.0 gpf
Boy's by Room 114	Right Urinal	1.0	Toilet Rating	Unable to disassemble	0.5 gpf
Boy's by Room 114	Left Urinal	1.0	Flushometer	Sloan A-19-A	0.5 gpf
Boy's by Room 114	Left Sink	0.5	Aerator		WaterSense Compliant
Boy's by Room 114	Middle Sink	0.5	Aerator		WaterSense Compliant
Boy's by Room 114	Right Sink	???		No aerator	1.5 gpm
Men's by Room 114	Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Men's by Room 114	Sink	???		No aerator	1.5 gpm
Women's by Room 114	Toilet	???		Unable to disassemble	Dual Flush 1.28/1.0 gpf
Women's by Room 114	Sink	???		No aerator	1.5 gpm
Girl's by Room 114	H/C Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Girl's by Room 114	Left Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Girl's by Room 114	Middle Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf

Room Description	Fixture Description	GPM GPF	Source of Flow Data	Notes	Low Flow Recommendation
Girl's by Room 114	Right Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Girl's by Room 114	Left Sink	0.5	Aerator		WaterSense Compliant
Girl's by Room 114	Middle Sink	0.5	Aerator		WaterSense Compliant
Girl's by Room 114	Right Sink	0.5	Aerator		WaterSense Compliant
Grade 2 Room 116	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm
Grade 2 Room 117	Sink	1.8	Aerator	Functioning bubbler	1.5 gpm
Grade 1 Room 123	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm
Grade 1 Room 119	Sink	1.8	Aerator	Functioning bubbler	1.5 gpm
Boy's by Room 119	Boys Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Boy's by Room 119	Boys Sink	2.0	Aerator		1.5 gpm
Girl's by Room 119	Girls Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Girl's by Room 119	Girls Sink	2.0	Aerator		1.5 gpm
Art Room 202	Sinks by Window	2.2	Aerator	Left Aerator	1.5 gpm
Art Room 203	Sinks by Window	2.0	Aerator	Middle Aerator	1.5 gpm
Art Room 204	Sinks by Window	2.2	Aerator	Right Aerator	1.5 gpm
Art Room 202	Sinks by Teacher	2.2	Aerator	Left Aerator	1.5 gpm
Art Room 203	Sinks by Teacher	2.0	Aerator	Middle Aerator	1.5 gpm
Art Room 204	Sinks by Teacher	N/A	Aerator	Right Aerator (Aerator Missing)	1.5 gpm
Art Room 202	Sink	2.0	Aerator		1.5 gpm
Grade 4 Room 206	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm
Grade 4 Room 207	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm
Grade 3 Room 220	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm
Grade 3 Room 219	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm
Boy's by Room 209	H/C Toilet	1.5	Flushometer	Sloan A-15-A	Dual Flush 1.28/1.0 gpf
Boy's by Room 209	Toilet	1.6	Toilet Rating		Dual Flush 1.28/1.0 gpf
Boy's by Room 209	Left Urinal	1.0	Flushometer	Sloan A-19-A	0.5 gpf
Boy's by Room 209	Right Urinal	1.0	Flushometer	Sloan A-19-A	0.5 gpf
Boy's by Room 209	Left Sink	???		No aerator	1.5 gpm
Boy's by Room 209	Middle Sink	0.5	Aerator		1.5 gpm
Boy's by Room 209	Right Sink	???		No aerator	1.5 gpm
Men's by Room 209	Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Men's by Room 209	Sink	???		door locked	1.5 gpm
Women's by Room 209	Toilet	1.6	Toilet Rating	Unable to disassemble	Dual Flush 1.28/1.0 gpf
Women's by Room 209	Sink	???		no aerator	1.5 gpm
Girl's by Room 209	H/C Toilet	1.6	Toilet Rating	unable to disassemble	Dual Flush 1.28/1.0 gpf
Girl's by Room 209	Left Toilet	1.6	Toilet Rating	unable to disassemble	Dual Flush 1.28/1.0 gpf
Girl's by Room 209	Middle Toilet	1.6	Toilet Rating	unable to disassemble	Dual Flush 1.28/1.0 gpf
Girl's by Room 209	Right Toilet	1.5		Sloan A-15-A	Dual Flush 1.28/1.0 gpf
Girl's by Room 209	Left Sink	???		No aerator	1.5 gpm
Girl's by Room 209	Middle Sink	???		No aerator	1.5 gpm
Girl's by Room 209	Right Sink	0.5	Aerator		WaterSense Compliant
Grade 5 Room 214	Sink	1.8	Aerator	Non-functioning bubbler	1.5 gpm
Grade 5 Room 213	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm
Grade 6 Room 211	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm
Grade 6 Room 212	Sink	2.0	Aerator	Functioning bubbler	1.5 gpm

The estimated total costs to replace all of the fixtures in the building with WaterSense compliant fixtures would be $7,500. The Berlin Memorial School sources water from a well, and does not pay a per gallon fee. Due to this, the paybacks are long enough that cost savings would not be a motivating factor, and savings information has not been calculated.

SUMMARY OF RECOMMENDATIONS

Financial Analysis							
ECM	**ECM Description**	**Total Project Cost [$]**	**Total Estimated Incentive [$]**	**Final Cost [$]**	**Annual Cost Savings [$]**	**Simple Rate of Return**	**Payback [years]**
1	Gymnasium Destratification Fans	$3,500	$0	**$3,500**	**$105**	3.0%	33.4
2	Gymnasium H+V Units DCV	$32,000	$2,500	**$29,500**	**$1,357**	4.6%	21.7
3	Domestic Hot Water Storage	$1,000	$0	**$1,000**	**$269**	26.9%	3.7
4	Classroom Exhaust Fans DCV	$15,800	$2,500	**$13,300**	**$4,897**	36.8%	2.7
5	Music Room RTU	$1,200	$0	**$1,200**	**N/A**	N/A	N/A
6	Exhaust Fan Cover	$14,600	$0	**$14,600**	**N/A**	N/A	N/A
	Totals	**$52,300**	**$5,000**	**47,300**	**$5,303**	**14.0%**	**7.1**

Annual Savings Data								
		Electric Rate ($0.13/kWh)		**Fuel Oil Rate ($2.45/gal)**				
ECM	**ECM Description**	**Electric Savings [kWh]**	**Electric Savings [$]**	**Oil Savings [gal]**	**Oil Savings [$]**	**MMBtus Saved**	**% MMBTU Savings**	**Total Cost Savings [$]**
1	Gymnasium Destratification Fans	656	$105	0	$0	2	0%	$105
2	Gymnasium H+V Units	2,859	$458	367	$899	61	1%	$1,357
3	Domestic Hot Water Storage	936	$150	49	$120	10	0%	$269
4	Classroom Exhaust Fans	3,838	$614	1,748	$4,283	256	5%	$4,897
5	Music Room RTU	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	Exhaust Fan Cover	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Totals	**8,289**	**$1,326**	**2,164**	**$5,303**	**329**	**6%**	**$6,629**

RECOMMENDATIONS

Measure 1 – Gymnasium Destratification Fans

The destratification fans in the gymnasium are controlled by a wall switch. This can result in excessive use, when left on during unoccupied periods. We recommend adding occupancy sensors to the gymnasium, and programming the destratification fans to activate only when the space is occupied.

Measure 2 – Gymnasium H+V Units

The H+V unit fans only activate when there is a call for heat. This can lead to poor ventilation in warmer months, and over ventilating in the cooler months. We recommend CO_2 sensors be located in the room, along with replacing the AHU fan motors with NEMA Premium rated motors, and adding VFDs to control the new AHU fans. This will allow for programming demand controlled ventilation for the room. This will ensure that appropriate CO_2 levels are maintained in the space without bringing in excess outside air.

Measure 3 – Domestic Hot Water Storage

The DHW heater and Indirect DHW tank were observed at 145°F. Recommend lowering the temperature to an optimized 120°F to minimize heat loss.

Measure 4 – Classroom Exhaust Fans

The unit vents in the classrooms operate off of demand controlled ventilation, but the associated exhaust fans do not ramp down flow to match damper position. Exhausted air remains constant. The issue with this, is that if the outside air from the unit ventilators is being reduced, then the excess exhausted air needs to be accounted for somewhere else, and it normally occurs through infiltration of untreated air through air gaps, windows and doors. To mitigate this issue, the operation of the building exhaust fans will then be tied to the OA dampers on the unit vents. We recommend that the exhaust fan motors be replaced with NEMA Premium rated motors, and that VFDs are added to control the operation of the fans, based on the aggregate position of the OA dampers on the unit ventilators.

Measure 5 – Music Room RTU

The music room RTU mixed air temperature (MAT) sensor is no longer operational and needs to be replaced. This is considered a comfort issue, and not primarily an energy saving measure.

Measure 6 – Exhaust Fan Cover

EF-9 on the roof has a downblast style cover, sending exhaust air directly into the intake for a nearby RTU. We recommend replacing the downblast style cover with one that directs the exhaust away from nearby air intake vents. This is not an energy saving measure.

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Retro-Commissioning Corrective Actions Log
Site: Berlin Memorial School
Main Point of Contact: Steve Pusateri

Issue #	Equip Tag	Issue Description	Recommended Action	Action Taken	Issue Status	Resolution Date
BB-Café-1	Café Baseboard	4/16/18 - Could not activate or control	4/16/18 - Troubleshoot valve/control point		Open	
UV-214-1	UV-214	4/16/18 - Freeze Stat did not reset	4/16/18 - Will observe again tomorrow and troubleshoot as necessary	4/17/18 - Freeze Stat reset, system operating normally	Closed	4/17/2018
UV-219-1	UV-219	4/16/18 - Freeze Stat did not reset	4/16/18 - Will observe again tomorrow and troubleshoot as necessary	4/17/18 - Freeze Stat reset, system operating normally	Closed	4/17/2018
UV-207-1	UV-207	4/16/18 - Graphic shows OA damper unit at 30%, text by graphich says 0%. Supply Air Temp stable at 68F, indicating damper at 0%	4/16/18 - Ensure proper graphic associated with appropriate condition		Open	
UV-111-1	UV-111	4/16/18 - Mixed Air Temp sensor not working	4/16/18 - replace sensor		Open	
CONV1-1	CONV-1	4/16/18 - Convection unit in upstairs boys bathroom may have a heating valve actuator that is wired backwards. Appreared to heat when commanded closed, and not heat when commanded open.	4/16/18 - re-wire valve actuator		Open	
203-A-1	Thermo - 203A	4/16/18 - Thermostat in 203A reporting 591F on the BAS.	4/16/18 - Replace thermostat		Open	
RTU-1-1	RTU-1	4/17/18 - Mixed Air Damper Icon on BAS does not change when damper adjusts.	4/17/18 - Add Icon to BAS		Open	
RTU-2-1	RTU-2	4/17/18 - Heating valve actuator physically disconnected from the heating valve. Actuates fine.	4/17/18 - Reconnect and test	4/17/18 - Reconnected the actuator to the heating valve. Tests normally.	Closed	4/17/2018
RTU-1-2	RTU-2	4/17/18 - Heating valve misaligned in actuator. Damper set to actuate between -50% and 50%.	4/17/18 - Troubleshoot further	4/17/18 - Adjusted the damper in the acuator. Tested fine.	Closed	4/17/2018
RTU-2-2	RTU-2	4/17/18 - Mixed Air Damper is 100% open and will not take commands from BAS	4/17/18 - Will continue to troubleshoot	4/17/18 - Could not replicate issue. Tested fine	Closed	4/17/2018
BB-203-1	BB-203-1	4/17/18 - Baseboard in 203 is controlled by a local thermostat. Set to 68F on holiday when observed. Baseboard can conpete with cooling coil of RTU-2 during the shoulder seasons.	4/17/18 - Replace local thermostat with a networked thermostat that can be controlled by the BAS,		Open	

Issue #	Equip Tag	Issue Description	Recommended Action	Action Taken	Issue Status	Resolution Date
BB-203A-1	BB-203A	4/17/18 - Baseboard in 203a is controlled by a local thermostat. Set to 68F on holiday when observed. Baseboard can conpete with cooling coil of RTU-2 during the shoulder seasons.	4/17/18 - Replace local thermostat with a networked thermostat that can be controlled by the BAS,		Open	
EF-11-1	EF-11	4/17/18 - Fan bet is badly cracking.	4/17/18 - Replace fan belt		Open	
EF-3-1	EF-3	4/17/18 - Fan only makes a quiet humming noise when commanded to run. Fan does not operate	4/17/18 - Fan does not spin. Recommend troubleshooting fan and motor.		Open	
Boiler-1-1	Boiler 1	4/17/18 - Boiler by-pass valve observed clicking constantly, as if attempting and failing to actuate	4/17/18 - Troubleshoot/replace actuator		Open	
EMS-1	EMS	4/18/18 - Building HVAC scheduling does not currently match occupied times. Current Occupied Times: 1st Floor M-F: 4:30AM-9:00PM 2nd Floor M-F: 5:00AM-9:00PM Gymnasium M-F: 5:30AM-9:00PM	4/18/18 - Recommend adjusting the the 1st and 2nd floors to coincide, and adjust all three to better fit occupancy pattern of building		Open	
BB-Office-1	BB-Office	4/18/18 - The HW valve for the baseboard in the pricipal's office is stuck open	4/18/18 - Recommend troubleshooting/replacing valve	4/18/18 - Adjusted the valve to partially open to mitigate overheating for now	Open	

RTU-2 Maintenance

	Monthly	Annually
Fan Belt adjustment	X	
Filter inspection/replacement	X	
Check return air Smoke Detector	X	
Check Drain Pan	Cooling Season	
Inspect Coils for debris and damage	Cooling Season	
Inspect F/A-R/A Damper Hinges and Pins	X	
Manually rotate condenser to ensure free movement	Cooling Season	
Verify Fan mounting hardware is tight	X	
Check Supply Fan motor bearings. Repair/replace as necessary	X	
Check Fan shaft bearings. Replace bearings as necessary	X	
Check Supply Fan belt. Replace as necessary	X	
Verify Fan mounting hardware is tight	X	
Verify Terminal connections are tight	X	
Remove corrosion present on external surfaces and repaint	X	
Generally inspect unit for unusual conditions	X	
Clean Coils		X

For details and additional considerations, please see maintenance manual

AHU-1 Maintenance

	Monthly	Annually
Check the unit wiring connections insulation	X	
Inspect the cooling coils for dirt and debris, clean as needed	X	
In cooling mode, check suction and discharge pressure.	X	
Check unit superheat		Cooling Season
Remove accumulation of dust/dirt from unit casing		Cooling Season
Remove any corrosion and re-paint.		Cooling Season
Check condition of gasket around control panel doors.		Cooling Season
Inspect control panel wiring connections and insulation		Cooling Season
Check refrigerated piping and fittings for leaks		Cooling Season
Inspect condenser coils for dirt and debris, clean as needed		Cooling Season

For details and additional considerations, please see maintenance manual

B-1, 2, 3 Maintenance

	Monthly	Bi-Annually
Clean Boiler with cleaning brushes		Heating Season
Wet-clean the boiler		Heating Season
Check the operating pressure		Heating Season
Refill with boiler water and purge system		Heating Season
Check general condition of heating system	Heating Season	
Visual inspection and function check of heating system	Heating Season	
Check fuel and water-carrying components for leaks, corrosion or aging	Heating Season	
Check combustion chamber and heating surfaces for contamination	Heating Season	
Check the burner	Heating Season	
Check the flue gas and venting system	Heating Season	
Check operating pressure and inlet pressure of the diaphram expansion vessel for heating systems	Heating Season	
Check the functgion of indirect-fired heater and ionization rod	Heating Season	
Check the control panel setting	Heating Season	

For details and additional considerations, please see maintenance manual

DHW Heater Maintenance

	Bi- Annually	Annually
Drain Tank and inspect for Lime deposits	X	
Open T&P Valve and ensure that seat moves freely		X
Check Vent system for damage and/or blockage		X

DHW Burner Maintenance

	Bi-Annually	Annually
Clean Blower wheel and motor, replace is necessary	X	
Check the Ignitor	X	

For details and additional considerations, please see maintenance manualS

FC-2,3 and ACCU-2,3 Maintenance

	Monthly	**Annually**
Check outdoor unit for debris and damage	X	
Verify Terminal connections are tight	X	
Check Air Filter. Clean and replace as necessary	X	

For details and additional considerations, please see service manual

Unit Heater Maintenance

	Monthly	**Annually**
Clean Heating Coil	X	
Clean Casing	X	
Clean Motor/Fan Assembly	X	
Purge hot water coil to avoid air locked condition		X

For details and additional considerations, please see maintenance manual

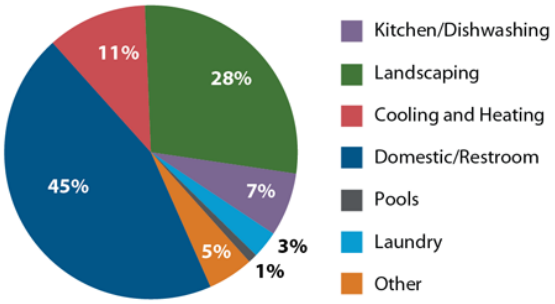
Saving Water in

Educational Facilities

Commercial and institutional buildings use a large portion of municipally supplied water in the United States. With so many businesses making up the commercial and institutional sector, there are great opportunities to conserve water. *WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities* promotes water-efficient techniques that can be applied across a wide range of facilities with varying water needs.

Approximately 6 percent of total water use in commercial and institutional facilities takes place in educational facilities, such as schools, universities, museums and libraries in the United States.[1] The largest uses of water in educational facilities are restrooms, landscaping, heating and cooling, and cafeteria kitchens.

End Uses of Water in Schools



Created by analyzing data from: New Mexico Office of the State Engineer, American Water Works Association (AWWA), AWWA Research Foundation, and East Bay Municipal Utility District.

THE BUSINESS CASE FOR WATER EFFICIENCY

Over the past 10 years, the costs of water and wastewater services have risen at a rate well above the consumer price index. Facility managers can expect these and other utility costs to continue to increase in order to offset the costs of replacing aging water supply systems.

Operating costs and environmental impacts are influenced by water use. Industry estimates suggest that implementing water-efficient practices can decrease operating costs by approximately 11 percent and energy and water use by 10 and 15 percent, respectively.[2]

Many campuses have found it necessary to expand their facilities in order to keep up with the needs of a growing student body. Today's students are also looking for schools to demonstrate sustainable principles. Additionally, meeting voluntary green standards such as LEED® certification can be achieved through water efficiency in building design.

New building codes often require installation of water-efficient plumbing fixtures and appliances, which use at least 20 percent less water than standard models.

Putting Water Efficiency to Work

A university in Texas focused on recovering and reusing alternative water sources to reduce its use of municipally supplied water. This allowed the university to successfully decrease its campus' potable water use from 1 billion gallons to 668 million gallons, or more than 33 percent. The onsite alternative water sources identified include air handler condensate, single-pass cooling water, rainwater, and foundation groundwater.

When upgrading educational facilities, the age and functionality of some water-using technology may call for replacement or retrofit. If is necessary to replace this equipment, upgrading to water-efficient models can save money, with a relatively short payback period. Implementing water-efficient practices on campus grounds and fields can reduce both water bills and maintenance costs.

WaterSense at Work provides guidance that will help educational facilities get an A+ in water efficiency.

USING WATERSENSE AT WORK

More information on operations, maintenance, and user education of equipment and processes within educational facilities can be found in the following sections of *WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities*:

- Section 1: Getting Started
- Section 2: Water Use Monitoring and Education
- Section 3: Sanitary Fixtures and Equipment
- Section 4: Commercial Kitchen Equipment
- Section 5: Outdoor Water Use
- Section 6: Mechanical Systems
- Section 7: Laboratory and Medical Equipment
- Section 8: Onsite Alternative Water Sources

Look for the Label

- Install WaterSense labeled showerheads, toilets, bathroom faucets, and flushing urinals where appropriate.
- WaterSense labeled products have been independently certified to be at least 20 percent more water-efficient and perform as well or better than standard models.
- Check automatic sensors on faucets, toilets, and urinals to ensure they are operating properly and avoid unnecessary water use.

Water Landscapes Wisely

- Design water-smart landscapes that provide beautiful surroundings while reducing water needed for irrigation.
- Improve irrigation efficiency by hiring a professional certified through a WaterSense labeled program to audit an existing system or design and install a water-efficient system.
- Cut down on water loss from evaporation, wind, and runoff by replacing existing clock timers with WaterSense labeled irrigation controllers.

Keep Cooling Towers Cool

- Implement energy-efficiency measures to reduce the need for building and equipment cooling and heating, which will reduce amount of water required by these systems.
- Keep indoor temperatures at a comfortable setting while increasing the efficiency of cooling towers, evaporative coolers, and boilers by using alternative sources of water, such as air handler condensate and captured rainwater.
- Monitor cooling tower and boiler water chemistry to minimize the mineral buildup in the system and maximize the number of times water can be recycled through the system.

For more information or to download a copy of *WaterSense at Work*, visit the WaterSense website at **www.epa.gov/watersense/commercial**.

[1]Dziegielewski, et al. 2000. *Commercial and Institutional End Uses of Water*. American Water Works Association Research Foundation.
[2]2009. *Water Use in Buildings SmartMarket Report*. McGraw-Hill Construction.

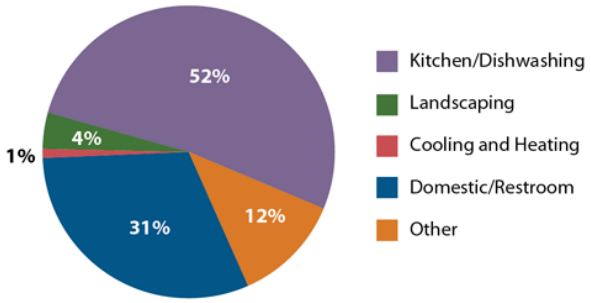
Saving Water in

Restaurants

Commercial and institutional buildings use a large portion of municipally supplied water in the United States. With so many businesses making up the commercial and institutional sector, there are great opportunities to conserve water. *WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities* promotes water-efficient techniques that can be applied across a wide range of facilities with varying water needs.

Water used in hospitality and food service establishments accounts for approximately 15 percent of the total water use in commercial and institutional facilities in the United States.[1] The largest uses of water in restaurants are associated with equipment and processes that take place in the kitchen. Restrooms follow kitchens as the second highest water use in restaurants.

End Uses of Water in Restaurants



Created by analyzing data from: New Mexico Office of the State Engineer, American Water Works Association (AWWA), AWWA Research Foundation, and East Bay Municipal Utility District.

THE BUSINESS CASE FOR WATER EFFICIENCY

Over the past 10 years, the costs of water and wastewater services have risen at a rate well above the consumer price index. Restaurant owners can expect these and other utility costs to continue to increase in order to offset the costs of replacing aging water supply systems.

Operating costs and environmental impacts are influenced by water use. Industry estimates suggest that implementing water-efficient practices in commercial facilities can decrease operating costs by approximately 11 percent and energy and water use by 10 and 15 percent, respectively.[2] Because food service facilities use hot water for many tasks, reducing water use can provide real benefits by decreasing energy bills.

To maximize savings on utility bills, restaurant owners can benefit from assessing some of the most water-intensive equipment used in kitchens. Equipment such as dipper wells and wok stoves, for example, can use quite a bit of water due to a continuous flow. If it is necessary to replace existing food service equipment, upgrading this equipment with water-efficient models can save money, with a relatively short payback period.

Putting Water Efficiency to Work

After upgrading its kitchen with high-efficiency pre-rinse spray valves, a Boston University cafeteria successfully reduced its water use by more than 48,000 gallons per year, a 63 percent decrease. With cost savings from water and sewer fees alone, a restaurant's simple payback period for replacing old, inefficient pre-rinse spray valves could be as short as one month.

Restaurant owners will also benefit from water-efficiency measures through increased customer satisfaction. In general, consumers have shown a preference for businesses that have made a commitment to reducing their environmental impact. With some customers seeking green restaurants, demonstrating environmental sustainability through water efficiency is a smart way to gain a competitive edge. *WaterSense at Work* provides guidance on water-efficient operation of restaurants and institutional cafeterias, allowing for a more competitive and environmentally sustainable business.

USING WATERSENSE AT WORK

More information on operations, maintenance, and user education of equipment and processes within restaurants and other food service facilities can be found in the following sections of *WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities*:

- Section 1: Getting Started
- Section 2: Water Use Monitoring and Education
- Section 3: Sanitary Fixtures and Equipment
- Section 4: Commercial Kitchen Equipment
- Section 5: Outdoor Water Use
- Section 6: Mechanical Systems
- Section 7: Laboratory and Medical Equipment
- Section 8: Onsite Alternative Water Sources

Run an Efficient Kitchen

- Upgrading dishwashers, ice machines, and steam cookers to ENERGY STAR® qualified models will reduce water and energy use by at least 10 percent. These models typically use less water by reusing water throughout cycles.
- Maximize the efficiency of pre-rinse spray valves, food disposal systems, or equipment that relies on a boiler—such as combination ovens, steam kettles, and steam cookers—to use significantly less water.
- Consider replacing equipment that discharges water continuously (e.g., dipper wells or wok stoves) with efficient models or turn off when not in use.
- Educate users on proper dishware prep and loading techniques to reduce the overall water used.

Look for the Label and Other Areas of Savings

- Install WaterSense labeled toilets, bathroom faucets, and urinals where applicable. These products have been independently certified to be at least 20 percent more water-efficient and perform as well or better than standard models.
- Check automatic sensors on faucets, toilets, and urinals to ensure they are operating properly and avoid unnecessary water use.
- Onsite alternative water sources from one source can be treated and reused in another application (e.g., irrigation, toilet flushing, decorative water fixtures).

For more information or to download a copy of *WaterSense at Work*, visit the WaterSense website at **www.epa.gov/watersense/commercial**.

[1]Dziegielewski, et al. 2000. *Commercial and Institutional End Uses of Water*. American Water Works Association Research Foundation.
[2]2009. *Water Use in Buildings SmartMarket Report*. McGraw-Hill Construction.

WaterSense® Labeled

Flushometer-Valve Toilets

Flushometer-valve toilets are usually found in commercial, institutional, or industrial facilities. Switching to a WaterSense labeled flushometer-valve toilet could save a typical business nearly $1,000 over the lifetime of the toilet.

Flushometer-valve toilets, also known as flushometer-valve water closets in plumbing standards, are typically found in such places as airports, theaters, stadiums, schools, and office buildings. The water closet has two main components—the toilet bowl and the flushometer valve.

The U.S. Environmental Protection Agency (EPA) estimates that about 26 percent, or 7 million, of the 27 million flushometer-valve toilets currently installed in commercial and institutional facilities nationwide flush at volumes higher than the 1.6 gallons per flush (gpf) federal standard—some as much as 3.0 to 7.0 gpf.

SMART FLUSHING

EPA's specification sets the maximum flush volume for WaterSense labeled flushometer-valve toilets at 1.28 gpf, or 20 percent less water than the federal standard. The maximum flush volume applies to both single- and dual-flush toilets.

WaterSense has also incorporated a minimum flush volume of 1.0 gpf to ensure plumbing systems have adequate flow to function effectively. Facility managers should consult a plumbing engineer if they have questions about using WaterSense labeled flushometer-valve toilets in their building.

Valves and bowls can be tested and labeled separately or as a complete system. To ensure that the individual components can be used in combination to meet WaterSense's requirements for efficiency and performance, consult the product information provided by the manufacturer and choose a flushometer valve and toilet fixture that have compatible flush volumes, as indicated on the WaterSense website.

WATERSENSE SAVINGS

By replacing old, inefficient flushometer-valve toilets with WaterSense labeled models, a 10-story office building with 1,000 occupants can save nearly 1.2 million gallons of water and more than $10,000 in water costs per year. Of those savings, nearly 870,000 gallons of water and $7,600 in water costs per year can be achieved by replacing the toilets in the women's restrooms alone.

If commercial facilities nationwide replaced all of their older, inefficient flushometer-valve toilets with WaterSense labeled models, we could save nearly 39 billion gallons of water per year. That's equivalent to nearly one full day's flow of water over Niagara Falls!

LOOK FOR THE WATERSENSE LABEL

Like all WaterSense labeled products, flushometer-valve toilets are independently certified for performance and efficiency. For more information, visit www.epa.gov/watersense.

EPA-832-F-13-003
December 2015

WaterSense® Labeled

Urinals

Urinals can account for a significant portion of indoor water use in commercial and institutional settings. A typical office building could reduce its water use from old, inefficient urinals by 26,000 gallons per year or more. While the current federal standard for commercial urinals is 1.0 gallon per flush (gpf), some older urinals use as much as five times that amount!

FLUSH WITH EFFICIENCY

Replacing these inefficient fixtures with WaterSense labeled flushing urinals can save between 0.5 and 4.5 gallons per flush, without sacrificing performance. The WaterSense label helps purchasers easily identify high-performing, water-efficient products. Installing WaterSense labeled flushing urinals will not only reduce water use in facilities, but also save money on water bills.

WaterSense labeled flushing urinals use no more than 0.5 gpf and comply with existing standards for flushing urinals. To ensure adequate performance, urinals must also be independently certified to ensure that they flush effectively and have properly functioning drain traps before they can earn the WaterSense label.

WATERSENSE SAVINGS

Replacing just one older, inefficient urinal that uses 1.5 gpf with a WaterSense labeled model could save a facility more than 4,600 gallons of water per year. Nationwide, if all older, inefficient urinals were replaced, we could save nearly 36 billion gallons annually. That's equal to the amount of water that flows over Niagara Falls in 21 hours!

Each WaterSense labeled flushing urinal can save a facility more than 4,600 gallons of water per year.

LOOK FOR THE WATERSENSE LABEL!

Whether looking to reduce water use in a new facility or to replace old, inefficient fixtures in men's restrooms, builders, designers, managers, and other specifiers can look for the WaterSense label to identify high-performing, water-efficient urinals. For more information or a list of WaterSense labeled products, visit www.epa.gov/watersense.

TO FLUSH OR NOT TO FLUSH?

While there are also urinals that don't use water available on the market today, the WaterSense specification is only for flushing urinals. WaterSense has posted clarification guidance for its partners on non-water-using urinals; for more information, please visit www.epa.gov/watersense/partners/urinals_final.html.

WaterSense® Labeled

Bathroom Sink Faucets & Accessories

Most of us know we can save water if we turn off the tap while brushing our teeth (as much as 3,000 gallons per year!), but did you know that there are products that will help save water when you turn on the tap too? WaterSense labeled faucets and faucet accessories (e.g., aerators) are high-performing, water-efficient fixtures that will help you reduce water use in your home and save money on water bills.

FAUCET FLOWS

WaterSense labeled bathroom sink faucets and accessories that use a maximum of 1.5 gallons per minute can reduce a sink's water flow by 30 percent or more from the standard flow of 2.2 gallons per minute without sacrificing performance. We could save billions of gallons nationwide each year by retrofitting bathroom sink faucets with WaterSense labeled models.

All products bearing the WaterSense label complete a third-party certification process to ensure they meet U.S. Environmental Protection Agency (EPA) criteria. Faucets and faucet accessories—products that can be attached easily to existing faucets to save water—that obtain the WaterSense label have demonstrated both water efficiency and the ability to provide ample flow.

WATERSENSE SAVINGS

Replacing old, inefficient faucets and aerators with WaterSense labeled models can save the average family 700 gallons of water per year, equal to the amount of water needed to take 40 showers. Since these water savings reduce demands on water heaters, households will also save enough energy to run a hairdryer 10 minutes a day for a year. Achieving these savings can be as easy as twisting on a WaterSense labeled aerator, which can cost as little as a few dollars. If every home in the United States replaced existing faucets and aerators with WaterSense labeled models, we could save nearly $1.2 billion in water and energy costs and 64 billion gallons of water across the country annually—equivalent to the annual household water needs of more than 680,000 American homes.

WaterSense labeled bathroom faucets and aerators can save the average family 700 gallons of water per year.

LOOK FOR THE WATERSENSE LABEL!

Whether replacing an older, inefficient faucet, or looking to reduce water in your bathroom, choose a WaterSense labeled sink faucet or faucet accessory. WaterSense labeled models are available at a wide variety of price points and styles. In many areas, utilities offer rebates and vouchers that can lower the price further. For more information or a list of WaterSense labeled products, visit www.epa.gov/watersense.

WaterSense® Labeled

Pre-Rinse Spray Valves

Pre-rinse spray valves—often used in commercial and institutional kitchens—are designed to remove food waste from dishes prior to dishwashing. By switching to a WaterSense labeled pre-rinse spray valve, a commercial or institutional kitchen can save more than $115 annually in energy and water costs.

About 970,000 food service establishments in the United States use approximately 51 billion gallons of water each year to rinse dishes with pre-rinse spray valves. In fact, pre-rinse spray valves can account for nearly one-third of the water used in the typical commercial kitchen. The federal standard for commercial pre-rinse spray valves is 1.6 gallons per minute (gpm), but manufacturers have now developed models that use significantly less water. Replacing standard pre-rinse spray valves with WaterSense labeled models offers a significant opportunity for water and cost savings.

THE WATERSENSE LABEL

The U.S. Environmental Protection Agency's specification sets the maximum flow rate for WaterSense labeled pre-rinse spray valves at 1.28 gpm, or 20 percent less water than the federal standard, and includes spray force criteria and lifecycle testing to ensure performance in commercial kitchens. All WaterSense labeled models are required to include spray force on product packaging or in literature to help purchasers select products most suitable for their applications. WaterSense labeled pre-rinse spray valves are independently certified to ensure efficient cleaning while using less water.

WATERSENSE SAVINGS

Replacing one pre-rinse spray valve with a WaterSense labeled model can save a typical commercial kitchen more than 7,000 gallons of water per year. That's equivalent to the amount of water needed to wash nearly 5,000 racks of dishes. Because kitchens use hot

water to rinse dishes, installing a WaterSense labeled pre-rinse spray valve can reduce a commercial kitchen's annual natural gas use by more than 6,400 cubic feet per year. That's enough energy to run its convection oven 12 hours a day for three weeks.

A commercial kitchen that replaces one pre-rinse spray valve with a WaterSense labeled model could save as much as $115 to $240 per year, as it could reduce water costs by $65 per year and energy costs by $50 per year (natural gas) or $175 per year (electricity). The facility could see payback on the investment in as little as four to eight months.

START SAVING TODAY

Restaurant equipment purchasers can now look for the WaterSense label. If all commercial food service establishments in the U.S. installed and used a WaterSense labeled pre-rinse spray valve, we could save more than $225 million in water and energy costs across the country annually. Visit www.epa.gov/watersense for more information.