The facility personnel implemented several of these recommendations and are now saving 20.5% of their baseline energy usage every year

Aurora Medical Center - Oshkosh
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Feasibility Study

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Executive Summary

Aurora Medical Center located in Oshkosh, Wisconsin is a 470,000 square foot acute care hospital, with construction completed in 2003. To evaluate the 24 Energy Conservation Measures (ECMs) listed in this report, we conducted several onsite visits between December 2009 and March 2010. In addition to the site visits, we had extensive communications with the staff.

Our main resource for construction cost estimates was RS Means 2010. Other material cost estimates were provided by equipment representatives. We included an estimate of engineering fees for those items which will require additional engineering design.

Average fuel costs were calculated using the latest 12 months of bills. The average natural gas cost was $0.61/therm, and the average electrical cost was $0.074/kWh.

The following abbreviations are used throughout this report:

- ACH: Air Changes per Hour
- CFM: Cubic Feet per Minute
- ECM: Energy Conservation Measure
- HP: Horsepower
- HW: Hot Water
- OA: Outside Air
- RTU: Rooftop Unit
- VAV: Variable Air Volume Box
- VFD: Variable Frequency Drive

Summary of the ECMs:

Item	Electrical Savings (kWh)	Natural Gas Savings (Therms)	Utility Cost Reduction ($)	Construction Cost ($)	Simple Payback (Years)
ECM-01 Install VFDs on large HW heating pumps	73,518	0	$5,470	$14,000	2.56
ECM-02 Install VFDs on small HW heating pumps	17,155	0	$1,276	$17,070	13.38
ECM-03 Install servo motors and VFDs on boilers	23,000	65,350	$18,866	$40,000	2.12
ECM-04 Install a smaller boiler for summer operations	0	12,200	$7,442	$178,233	23.95
ECM-05 Replace electric reheat coils in VAV boxes in clinic	964,768	-40,037	$46,970	$301,730	6.42
ECM-06 Change AHU fan speed control to eliminate air from entering relief dampers	0	21,168	$12,913	$16,000	1.24
ECM-07 Verify current OA ventilation code requirements	301,862	35,280	$43,979	$6,000	0.14
ECM-08 Improve accuracy and repeatability of outside air flow measurement	301,862	35,280	$43,979	$69,832	1.59
ECM-09 Add AHU discharge air temperature and duct static pressure reset	315,428	36,333	$45,505	$8,000	0.18

Item	Electrical Savings (kWh)	Natural Gas Savings (Therms)	Utility Cost Reduction ($)	Construction Cost ($)	Simple Payback (Years)
ECM-10 Limiting demand during peak usage	100 kW Demand	0	$1,000	$1,000	1.00
ECM-11 Improve building pressurization	0	21,167	$12,913	$14,740	1.14
ECM-12 Install VAV discharge air temperature sensors after reheat coils	0	918	$560	$72,500	129.46
ECM-13 Add a chilled water temperature and pump static pressure reset	65,142	0	$4,821	$2,000	0.41
ECM-14 Install a mid-size chiller	40,284	0	$2,981	$349,448	117.23
ECM-15 Add a VFD to one of the existing large centrifugal chillers	97,416	0	$7,209	$85,000	11.79
ECM-16 Reduce chilled water pump speed during the winter	11,750	0	$869	$500	0.58
ECM-17 Switch isolation rooms to 6 ACH and reduce exhaust when not being used for isolation	3,190	581	$591	$3,020	5.11
ECM-18 Plant deciduous trees on the south side of the building	6,554	0	$485	$2,500	5.15
ECM-19 Tint or install blinds on windows that face southwest	169	0	$12	$233	19.42
ECM-20 Install temperature sensors, connected to the BAS, on the condenstate trap piping [10 PSI]	0	1,210	$738	$1,000	1.36
ECM-20 60 PSI	0	3,180	$1,940	$1,000	0.52
ECM-20 100 PSI	0	4,838	$2,951	$1,000	0.34
ECM-21 Install VFDs on the domestic water booster pumps	81,687	0	$6,044	$23,000	3.81
ECM-22 Replace 32 wattt lamps with 28 watt lamps	293,508	0	$21,720	$0	0.00
ECM-23 Operating Room unoccupied mode	9,947	1,282	$1,518	$2,120	1.40
ECM-24 Improve cooling tower control	13,988	0	$1,035	$1,000	0.97

ECM-01 Install VFDs on large HW heating pumps

Intent:

Reduce pump energy by varying the speed of the pumps to maintain system pressure at its setpoint.

Scope of Work:

The scope of work for this project is to add VFDs to the two 30 HP hot water pumps, close the manual bypass valve on the three-way hot water valves in the system, and add two differential pressure sensors for control feedback. The pumps shall continue to operate in a lead/lag manner, with pump speed modulated to maintain system pressure at its setpoint. The differential pressure setpoint will be automatically adjusted, with feedback from all automatic HW valves, to keep the most open HW valve at 90% open.

Savings Estimate:

The annual power consumed by one HW pump is

30 HP x 0.746 kW/HP x 0.75 load factor x 8760 hours/year = 147,036 kWh/year.

If we assume an average of a 1/3 reduction in pump speed for the entire year, that equates to a theoretical reduction in power of 70%. A conservative power reduction is closer to 50%, so we used this value for the savings calculation.

147,036 kWh/year x 50% (reduction) = 73,518 kWh x $0.0744/kWh = **$5,470/year**

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Parts - 30 HP VFD	2	$4,000	$8,000
Labor - 30 HP VFD	2	$1,250	$2,500
Controls - Comm Link to VFD	2	$500	$1,000
Controls - Diff Pressure Sensors	2	$1,000	$2,000
Controls - Programming (Hours)	4	$125	$500
Total Construction Cost			**$14,000**

Simple Payback:

$14,000 / $5,470 = **2.56 years**.

ECM-02 Install VFDs on small HW heating pumps

Intent:

Reduce pump energy by varying the speed of the pumps to maintain system pressure at its setpoint.

Scope of Work:

The scope of work for this project is to add VFDs to the four 2 HP and two 3 HP hot water pumps, close the manual bypass valve on the three-way hot water valves in the system, and add two differential pressure sensors for control feedback. The pumps shall continue to operate in a lead/lag manner, with pump speed modulated, with feedback from all automatic HW valves, to maintain the system pressure at its setpoint. The differential pressure setpoint will be automatically adjusted to keep the most open HW valve at 90% open.

Savings Estimate:

The annual power consumed by the three HW pump is

7 HP x 0.746 kW/HP x 0.75 load factor x 8760 hours/year = 34,309 kWh/year.

If we assume an average of a 1/3 reduction in pump speed for the entire year, that equates to a theoretical reduction in power of 70%. A conservative power reduction is closer to 50%, so we used this value for the savings calculation.

34,309 kWh/year x 50% (reduction) = 17,155 kWh x $0.0744/kWh (12 month avg) = **$1,276 savings/year**

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Parts - 2 HP VFD	4	$1,080	$4,320
Labor - 2 HP VFD	4	$600	$2,400
Parts - 3 HP VFD	2	$1,200	$2,400
Labor - 3 HP VFD	2	$600	$1,200
Controls - Comm Link to VFD	6	$500	$3,000
Controls - Diff Pressure Sensors	3	$1,000	$3,000
Controls - Programming (Hours)	6	$125	$750
Total Construction Cost			**$17,070**

Simple Payback:

$17,070 / $1,276 = **13.38 years**.

ECM-03 Install servo motors and VFDs on boilers (Linkageless Control)

Intent:

Increase the boiler efficiency, especially at part load, by improving the burner's ability to adjust the natural gas and air flow. This upgrade will also reduce the number of cycles during the summer, which is caused by the boiler's inability to modulate down to low enough capacity when the load is small.

Scope of Work:

Remove the existing mechanical linkage between the air and gas valves, replace with separate actuators and add a VFD to the blower motor. From a payback perspective, this retrofit should be performed on only one boiler, and this boiler should always be the lead boiler.

Savings Estimate:

This facility used 575,000 therms throughout 2009. Our previous experience with this type of retrofit results in a 4%-6% reduction in annual gas usage. At a 4% reduction, the annual gas savings will be:

575,000 therms/year x 4% reduction = 23,000 therms/year x $0.61/therm (12 month avg) = $14,030/year.

The 40 HP fan motor will use less power because its speed can be reduced during most operating conditions.

40 HP x 0.746 kW/HP x 25% reduction x 8,760 hours/year = 65,350 kWh/year x $0.074 = $4,836/year.

The total annual savings is $14,030 + $4,836 = **$18,866/year.**

Construction Cost Estimate:

A proposal from PBBS Corporation shows the total cost of this project is **$40,000**.

Simple Payback:

$40,000 / $18,866 = **2.12 years.**

ECM-04 Install a smaller boiler for summer operations

Intent:

Install a smaller boiler so that it can operate during the summer when the load is small and the existing boilers cycle several times per hour. This upgrade should not be performed if the advanced burner control (ECM-03) is added to one of the existing boilers.

Scope of Work:

Install a 7,500 MBH high pressure natural gas steam boiler, and connect it to the existing main steam piping.

Savings Estimate:

This facility uses less than 1,000 therms per day during the summer, for approximately 122 days. If we assume a 10% reduction in natural gas usage due to the installation of this smaller boiler, the annual savings are:

1,000 therms/day x 122 days/year x 10% reduction = 12,200 therms/year x $0.61/therm = **$7,442/year.**

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Parts - Steam Boiler (MBH)	6375	$15	$95,625
Install - Steam Boiler (MBH)	6375	$5	$31,875
Steam and Gas Piping - 4" (ft)	200	$90	$18,000
Insulation - 4" (ft)	100	$18	$1,800
Electrical	10.00%	$147,300	$14,730
Engineering	10%	$162,030	$16,203
Total Construction Cost			**$178,233**

Simple Payback:

$178,233 / $7,442 = **23.95 years.**

ECM-05 Replace electric reheat coils in VAV boxes in clinic with hot water coils

Intent:

Use a less costly fuel source for reheat energy in the clinic spaces.

Scope of Work:

Remove existing electric reheat coils, add hot water piping infrastructure from nearby hot water converter, add reheat coils and control valves to 130 VAV boxes, and add modulating VAV control from the existing VAV controllers. This scope of work is based on the ability to add this load onto an existing HW converter which appears to have enough excess capacity.

Savings Estimate:

The average VAV box size is 800 CFM, with an average minimum reheat CFM of 525 CFM. These VAV boxes normally operate from 6:00am through 11:00pm, Monday through Saturday. The reduction in electrical energy is:

17 hours/day x 6 days/week x 52 weeks/year x 130 VAVs x 525 CFM/VAV x 1.08 x [72°F-55°F] x 1kW/3413 btu x 50% load factor = 973,671 kwh x $0.074/kWh = $72,052

The increase in natural gas energy is:

17 hours/day x 6 days/week x 52 weeks/year x 130 VAVs x 525 CFM/VAV x 1.08 x [72°F-55°F] x 1/0.83 efficiency x therm/100,000 btu x 50% load factor = 40,037 therms x $0.61/therm = $24,423

The increase in pump energy is:

17 hours/day x 6 days/week x 52 weeks/year x 3 HP x 0.746 kW/HP x 0.75 load factor = 8,903 kWh x $0.074/kWh = $659

The net annual savings for this item is: $72,052 - $24,423 - $659 = **$46,970/year**.

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Demo Electric Reheat Coils	130	$60	$7,800
Piping 4" (ft)	750	$50	$37,500
Insulation 4" (ft)	750	$10	$7,500
Piping 3/4" (ft)	2,500	$15	$37,500
Insulation 3/4" (ft)	2,500	$6	$15,000
Parts - HW Coil	130	$500	$65,000
Install - HW Coil and fittings	130	$500	$65,000
Parts - Control Valve	130	$150	$19,500
Controls - Programming and wiring	130	$150	$19,500
Engineering	10%	$274,300	$27,430
Total Construction Cost			**$301,730**

Simple Payback:

$301,730 / $46,970 = **6.42 years**.

ECM-06 Change AHU fan speed control to eliminate air from entering relief dampers

Intent:

The existing return fan speeds are controlled by building pressure sensors. There are many situations where the return fan does not return a balanced quantity of air, and outside air is drawn in through the relief dampers. The intent of this item is to modify the control of the return fan to ensure air always exits the building at the relief dampers. This project will improve building pressurization.

Scope of Work:

Add different pressure sensors to each RTU to measure the pressure in the ductwork after the return fan, with respect to an outdoor air reference. Change the control of the return fan speed to maintain this new pressure at its setpoint, which will be slightly above neutral.

Savings Estimate:

Total CFM	500,000	
% Over Ventilation	3.00%	
Supply Temp (deg F)	55.0	
Avg Gas Cost ($/therm)	$0.61	
Avg Electric Cost ($/kWh)	$0.074	
Month	Avg DB Temp (deg F)	Heating Energy (MBH)
Jan	20.2	419,437
Feb	24.1	336,390
Mar	32.7	268,777
Apr	46.8	95,645
May	56.4	0
Jun	66.8	0
Jul	72.1	0
Aug	69.4	0
Sep	62.2	0
Oct	49.1	71,112
Nov	37.2	207,619
Dec	25.3	357,968
Total		1,756,948
Annual Cost Savings	$12,913	

Construction Cost Estimate:

Adding a pressure sensor to each of the 16 RTUs, and modifying the programming will cost approximately $1,000 per unit, for a total construction cost of **$16,000**.

Simple Payback:

$16,000 / $12,913 = **1.24 years.**

ECM-07 Verify current OA ventilation code requirements

Intent:

Determine the correct amount of ventilation needed at each AHU.

Scope of Work:

Recalculate OA CFM quantities for all spaces. Adjust the minimum OA CFM setpoint at each AHU to achieve these new values.

Savings Estimate:

Total CFM	500,000		
% Over Ventilation	5.00%		
Supply Temp (deg F)	55.0		
Avg Gas Cost ($/therm)	$0.61		
Avg Electric Cost ($/kWh)	$0.074		
Month	Avg DB Temp (deg F)	Heating Energy (MBH)	Cooling Energy (MBH)
Jan	20.2	699,062	0
Feb	24.1	560,650	0
Mar	32.7	447,962	0
Apr	46.8	159,408	0
May	56.4	0	28,123
Jun	66.8	0	229,392
Jul	72.1	0	343,505
Aug	69.4	0	289,267
Sep	62.2	0	139,968
Oct	49.1	118,519	0
Nov	37.2	346,032	0
Dec	25.3	596,614	0
Total		2,928,247	1,030,255
Annual Cost Savings	$43,979		

Assumption: Sensible cooling energy calculated only. Total cooling will be greater than the values shown.

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Engineering - Re-calculation of OA Quantities	1	$6,000	$6,000
Total Construction Cost			**$6,000**

Simple Payback:

$6,000 / $43,979 = **0.14 years**.

ECM-08 Improve accuracy and repeatability of outside air flow measurements.

Intent:

Accurately measure outside air quantities and reduce the amount of wasted energy.

Scope of Work:

Replace existing outside air measuring devices with more accurate hot wire anemometer style airflow measuring stations.

Savings Estimate:

Total CFM	500,000		
% Over Ventilation	5.00%		
Supply Temp (deg F)	55.0		
Avg Gas Cost ($/therm)	$0.61		
Avg Electric Cost ($/kWh)	$0.074		
Month	Avg DB Temp (deg F)	Heating Energy (MBH)	Cooling Energy (MBH)
Jan	20.2	699,062	0
Feb	24.1	560,650	0
Mar	32.7	447,962	0
Apr	46.8	159,408	0
May	56.4	0	28,123
Jun	66.8	0	229,392
Jul	72.1	0	343,505
Aug	69.4	0	289,267
Sep	62.2	0	139,968
Oct	49.1	118,519	0
Nov	37.2	346,032	0
Dec	25.3	596,614	0
Total		2,928,247	1,030,255
Annual Cost Savings	$43,979		

Assumption: Sensible cooling energy calculated only. Total cooling will be greater than what is shown here.

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Demo Existing Pitot Airflow Measuring Stations	16	$60	$960
Parts - New Hot Wire AFMS	16	$3,000	$48,000
Install - New AFMS	16	$500	$8,000
Controls - Programming and wiring	16	$500	$8,000
Engineering	8%	$64,960	$4,872
Total Construction Cost			**$69,832**

Simple Payback:

$69,832 / $43,979 = **1.59 years**.

ECM-09 Add AHU discharge air temperature and duct static pressure reset

Intent:

Use the feedback from the VAV boxes to automatically adjust the discharge air temperature setpoint and duct static pressure setpoint to reduce and optimize the total amount of energy used.

Scope of Work:

Add logic to reset the main discharge air temperature setpoint for each RTU between 55°F and 60°F, as the outside air temperature varies between 75°F and 20°F. All of these values shall be easily accessible and adjustable from the operator workstation.

Add logic to determine the most open VAV box damper for each RTU. If the maximum damper position is greater than 90% open, the duct static pressure setpoint shall increase, with the maximum static pressure setpoint being the present setpoint. If this maximum damper position is less than 90%, the duct static pressure setpoint shall decrease, with the minimum static pressure setpoint being 1/2 of the present setpoint.

Add logic to increase the main discharge air temperature setpoint by up to 5°F if the duct static pressure setpoint is at the minimum value, and the most open VAV box damper remains less than 90% open. A return air high humidity routine must be added to override this logic when the humidity levels are higher than 60%.

Savings Estimate:

From our experience with other Aurora facilities, we believe these units can operate with 5°F warmer discharge temperatures for 12 hours each day. The reheat energy saved during these periods of lighter load will be:

425,000 CFM (hospital total CFM) x 30% minimum x 1.08 x 5°F increase x 12 hours/day x 365 days/year x 1/0.83 boiler efficiency x 1 therm/100,000 btu = 36,333 therms x $0.61/therm = $22,163/year.

The cooling energy savings will be:

425,000 CFM x 30% minimum x 1.08 x 5°F increase x 12 hours/day x 120 days/year x 1 ton/12,000 btu x 1 kW/ton (total system) = 82,620 kWh x $0.074/kWh = $6,114/year.

The fan energy savings will be:

570 HP x 0.746 kW/HP x 0.5 load factor x 25% reduction due to decrease in static x 12 hours/day x 365 days/year = 232,808 kWh x $0.074/kWh = $17,228

Therefore, the total savings is $22,163 + $6,114 + $17,228 = **$45,505/year.**

Construction Cost Estimate:

This item does not require adding new hardware to the DDC systems. It will require approximately 4 hours of programming per AHU. The construction cost is:

16 units x 4 hours/unit x $125/hour = **$8,000.**

Simple Payback:

$8,000 / $45,505 = **0.18 years.**

ECM-10 Limiting demand during peak usage

Intent:

Reduce demand charges by turning equipment off or reducing energy consumption during electrical peak times.

Scope of Work:

Add a program to reduce the facility's energy consumption when approaching a predetermined demand limit. The following are a few ideas:

- Avoid starting an additional chiller
- Raise the discharge air temperature a few degrees on non-critical AHUs
- Avoid operating the dishwasher's internal electric heaters during these times
- Turn off unnecessary lights

Savings Estimate:

Assume a 100kW reduction:

100 kW x $10/kW = **$1,000/year** (no ratchet)

Construction Cost Estimate:

8 hours of programming time x $125/hour = **$1,000**

Does not include procedural changes pertaining to the dishwasher and lighting.

Simple Payback:

$1,000 / $1,000 = **1.00 years.**

ECM-11 Improve building pressurization

Intent:

Positively pressurize the first floor to improve comfort, and eliminate wasted relief air.

Scope of Work:

Add four bleed sensors, one at each major compass direction, to determine the building pressure level on the first floor. Control all relief dampers in unison to maintain the building pressure slightly positive.

Savings Estimate:

We predict the savings will be similar to those calculated in ECM-06 because the relief air quantity can be reduced in winter by 3% and this would help to pressurize the building:

21,167 therms x $0.61/therm = **$12,913/year.**

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Parts - Bleed Sensors	4	$2,000	$8,000
Install - Bleed Sensors	4	$1,000	$4,000
Controls - Programming (hours)	12	$125	$1,500
Engineering - Including reviewing trend data (hours)	8	$155	$1,240
Total Construction Cost			**$14,740**

Simple Payback:

$14,740 / $12,913 = **1.14 years.**

ECM-12 Install VAV discharge air temperature sensors after reheat coils

Intent:

Even when they are closed, several reheat valves have been discovered to leak hot water through them and waste both heating and cooling energy. As the control valves get older, this will occur more frequently. The intent is to install inexpensive discharge air sensors on all VAV boxes with hot water reheat coils, and use this sensor to generate an alarm when the valve does not appear to be closing completely.

Scope of Work:

Add discharge air temperature sensors to existing VAV boxes with hot water reheat coils. The existing VAV controls have a spare input that can be used for this. Approximately 15 VAV boxes are already completed.

Savings Estimate:

The average VAV box size in the entire facility is 900 CFM, with a 300 CFM minimum. There are approximately 500 VAV boxes with hot water reheat coils. If we assume a 10% failure rate on these valves each year, and it would take 4 weeks to find and fix a leaking valve without the discharge air temperature sensors, then the savings will be:

10% x 500 VAV boxes x 1.08 x 300 CFM/box x [62°F – 55°F] x 24 hours/day x 7 days/week x 4 weeks x 1/0.83 boiler efficiency x 1 therm/100,000 btu = 918 therms x $0.61/therm = **$560/year**.

Construction Cost Estimate:

The parts cost for the sensor is $20, and the labor cost to have a technician install one sensor is $125. Therefore, the total cost to install discharge air sensors on all VAV boxes with reheat coils is: 500 x ($20 + $125) = **$72,500**

Simple Payback:

$72,500 / $560 = **129 years**.

ECM-13 Add a chilled water temperature and pump static pressure reset

Intent:

Increase the chilled water temperature and decrease the differential pressure setpoint whenever possible to save chiller and pump energy.

Scope of Work:

Feedback from all chilled water valves shall first adjust pump differential pressure setpoint between a minimum and maximum value, and shall then adjust the chilled water setpoint when the pressure setpoint has reached its limits.

Savings Estimate:

The existing chiller plant uses approximately 1,000,000 kWh per year. A rule of thumb for increasing the chilled water temperature setpoint states that raising the chilled water setpoint 1°F, will reduce total chiller energy by 1 ½%. If we assume that the average chilled water setpoint can be 3°F higher during the cooling season, then the chiller plant savings will be:

1,000,000 kWh/year x (3 * 1.5) %reduction = 45,000 kWh x $0.074 = $3,330

The reduction in the main building chilled water pumps is:

40 HP x 0.746 kW/HP x 0.75 load factor x 25% reduction due to lower static setpoint x 24 hours/day x 30 days/month x 5 months = 20,142 kWh x $0.074/kWh = $1,491

Therefore, the total annual savings is **$4,821/year**.

Construction Cost Estimate:

All of the control hardware is present. The construction cost is for a technician's time to make the programming changes.

16 hours x $125/hour = **$2,000.**

Simple Payback:

$2,000 / $4,821 = **0.41 years.**

ECM-14 Install a mid-size chiller

Intent:

Improve part load efficiency by adding a mid sized chiller.

Scope of Work:

Add a 400 ton chiller to the existing chiller plant. Modify control logic to utilize the new chiller when the outside air temperature is lower than 80°F.

Savings Estimate:

Reduced evaporator and condenser pump energy:

(55 existing HP – 30 new HP) x 0.746 kW/HP x 24 hours/day x 30 days/month x 3 months/year = 40,284 kWh/year

Reduce chiller energy:

A new smaller chiller will have minimal reduction in energy versus the existing centrifugals. The existing 750 ton chillers are very efficient (0.451 kW/ton at 50% load) when using condenser water reset. When the outside air temperature is lower than 80F, the wet bulb temperature will be low enough to provide 75°F condenser water.

Total savings:

40,284 kWh x $0.074/kWh = **$2,981**

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Parts - New Chiller (ton)	400	$468	$187,200
Labor - Install Chiller (ton)	400	$135	$54,000
Piping - 6" (ft)	100	$80	$8,000
Insulation - 6" (ft)	100	$12	$1,200
Parts - New Evaporator Pump (GPM)	800	$16	$12,800
Labor - New Evaporator Pump (GPM)	800	$8	$6,400
Parts - New Condenser Pump (GPM)	800	$16	$12,800
Labor - New Condenser Pump (GPM)	800	$8	$6,400
Electrical	10%	$288,800	$28,880
Engineering	10%	$317,680	$31,768
Total Construction Cost			**$349,448**

Simple Payback:

$349,448 / $2,981 = **117.23 years.**

ECM-15 Add a VFD to one of the existing large centrifugal chillers

Intent:

Improve part load efficiency by adding a variable frequency drive to one large chiller.

Scope of Work:

Add a VFD to one of the large centrifugal chillers to take advantage of the part load during the shoulder seasons and the cooler condenser water temperatures.

Savings Estimate:

Assume 25% reduction in chiller energy at part load:

25% X 400 tons x 0.451kW/ton x 24 hours/day x 30 days/month x 3 months/year = 97,416 kWh x $0.074/kWh = **$7,209/year.**

Construction Cost Estimate:

Budget price from Trane is **$85,000**. Incentive money may be available through the custom program.

Simple Payback:

$85,000 / $7,209 = **11.79 years.**

ECM-16 Reduce chilled water pump speed during the winter

Intent:

The intent of this item is to reduce the amount of chilled water pump energy used for freeze protection in the winter.

Scope of Work:

The chilled water pumps currently operate at 50% speed during the winter to protect the chilled water coils from freezing. The chilled water control valves are overridden to 50%. The intent of this item is to adjust the speed of these pumps based on outside air temperature, with a minimum speed of 25% and a maximum speed of 50%. The chilled water valve position will be determined by their distance from the main pumps. The valves that are closest to the pumps will be at 25% open, and the valves that are furthest away will be at 100% open.

Savings Estimate:

If we assume the average pump speed will be 37.5%, the pump energy savings will be:

40 HP x 0.746 kW/HP x [(0.5^2)-(0.375^2)] x 24 hours/day x 30 days/month x 5 months = 11,750 kWh x $0.074/kWh = **$869/year**

Assumes the reduction in speed will approach a square relationship for savings instead of the theoretical cube relationship.

Construction Cost Estimate:

4 hours of programming x $125/hour = **$500.**

Simple Payback:

$500 / $869 = **0.58 years.**

ECM-17 Switch isolation rooms to 6 ACH and reduce exhaust when not being used for isolation

Intent:

Reduce the amount of energy used by negative isolation rooms when they are being used as normal patient rooms.

Scope of Work:

Add a local switch to allow the nursing staff to switch the mode of these rooms between isolation room and normal patient room. The systems will continue to operate as they presently do when the switch is positioned to isolation room. When the switch is positioned to normal patient room, the VAV supply CFM will reduce to 6 ACH, and the existing modulating exhaust damper will reduce the exhaust quantity while still maintaining the space under a negative pressure. A new cooling only VAV damper will be added to reduce the quantity of exhaust from the room, so the toilet exhaust quantity can remain at the appropriate rate.

For the savings and construction cost estimates, we used a typical 260 square foot isolation room with 550 CFM of supply air, and 650 CFM of exhaust (550 CFM from the room, and 100 CFM from the toilet room).

Savings Estimate:

Reheat Energy

(550 CFM – 235 CFM) x 1.08 x (75°F - 55°F) x 8,760 hours/year x 50% used as a normal patient room x 1/0.83 efficiency x therm/100,000 btu = 359 therms/year x $0.61/therm = $219/year.

Fan Energy

(550 CFM – 235 CFM) x (50 HP/40,000 CFM) x 0.746 kW/HP x 8760 hours/year x 50% used as a normal patient room = 1,286 kWh/year x $0.074/kWh = $95/year

Reduced Ventilation Air Energy

Total CFM	315		
% Of Year	50.00%		
Supply Temp (deg F)	55.0		
Avg Gas Cost ($/therm)	$0.61		
Avg Electric Cost ($/kWh)	$0.074		
Month	Avg DB Temp (deg F)	Heating Energy (MBH)	Cooling Energy (MBH)
Jan	20.2	4,404	0
Feb	24.1	3,532	0
Mar	32.7	2,822	0
Apr	46.8	1,004	0
May	56.4	0	177
Jun	66.8	0	1,445
Jul	72.1	0	2,164
Aug	69.4	0	1,822
Sep	62.2	0	882
Oct	49.1	747	0
Nov	37.2	2,180	0
Dec	25.3	3,759	0
Total		18,448	6,491
Annual Cost Savings	$277		

Total Annual Savings – Not including minimal exhaust fan electrical savings.

$219 + $95 +$277 = **$591/year**

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Parts - Cooling Only VAV box - 315 CFM	1	$300	$300
Labor - Install Cooling Only VAV box	1	$300	$300
Controls - VAV controller	1	$500	$500
Controls - Local switch	1	$300	$300
Controls - Programming (hours)	4	$125	$500
Balancing (hours)	4	$125	$500
Engineering (hours)	4	$155	$620
Total Construction Cost			**$3,020**

Simple Payback:

$3,020 / $591 = **5.11 years**

ECM-18 Plant deciduous trees on the south side of the building

Intent:

Reduce the cooling load by adding trees that will block direct sunlight from windows.

Scope of Work:

Plant trees along the first floor corridor outside the mechanical shop.

Savings Estimate:

512 kWh/year x [24/15 windows size ratio] x 8 windows = 6,554 kWh x $0.074/kWh = **$485/year.**

Construction Cost Estimate:

5 trees x $500/tree = **$2,500.**

Simple Payback:

$2,500 / $485 = **5.15 years.**

ECM-19 Tint or install blinds on windows that face southwest

Intent:

Reduce the cooling load in spaces with high solar gains.

Scope of Work:

Install 3M Prestige 40 window film on all southwest facing windows without blinds.

Savings Estimate:

We used a typical 3'x5' window facing southwest for our analysis. The maximum cooling requirement for this window [assuming it is two layers of clear glass with a shading coefficient of 0.82] is 2,766 btuh. This same window with the window film [shading coefficient becomes 0.42] has a load of 1,414 btuh.

Reduction in cooling energy:

(2,766-1,414) btuh x 6 hour average/day x 30 days/month x 5 months/year x ton/12,000 btu x 1kW/ton (avg chiller plant) = 101 kWh

Reduction in fan energy:

60 CFM reduction x average 1 HP/800 CFM x 6 hours/day x 30 days/month x 5 months/year = 68 kWh

Therefore, the total annual savings is:

101 kWh + 68 kWh = 169 kWh/year x $0.074/kWh = **$12/year**

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Parts - Window Film (sq ft)	15	$12.00	$180
Labor - Install Film (sq ft)	15	$3.50	$53
Total Construction Cost			**$233**

Simple Payback:

$233 / $12 = **19.42 years.**

ECM-20 Install temperature sensors, connected to the BAS, on the condensate trap pipes

Intent:

Reduce the amount of wasted steam energy caused by trap failures that are not identified immediately.

Scope of Work:

Install strap-on temperature sensors to the condensate pipe immediately after the trap, connect this sensor to the existing DDC system, and setup the system to alarm whenever this temperature is greater than a setpoint which signifies the trap has failed.

Savings Estimate:

¾" @ 10 PSI = 70 lbs/hr x 960 btu/lb x 1/80% boiler efficiency 1 therm/100,000 btu x 24 hours/day x 30 days/month x 2 months = 1,210 therms x $0.61 = **$738/year**

¾" @ 60 PSI = 184 lbs/hr x 960 btu/lb x 1/80% boiler efficiency 1 therm/100,000 btu x 24 hours/day x 30 days/month x 2 months = 3,180 therms x $0.61 = **$1,940/year**

¾" @ 100 PSI = 280 lbs/hr x 960 btu/lb x 1/80% boiler efficiency 1 therm/100,000 btu x 24 hours/day x 30 days/month x 2 months = 4,838 therms x $0.61 = **$2,951/year**

Construction Cost Estimate:

$1,000 per trap.

Simple Payback:

Trap on a 10 PSI system: $1,000 / $738 = **1.36 years.**

Trap on a 60 PSI system: $1,000 / $1,940 = **0.52 years.**

Trap on a 100 PSI system: $1,000 / $2,951 = **0.34 years.**

ECM-21 Install VFDs on the domestic water booster pumps

<u>Intent:</u>

Reduce wasted pump energy when the domestic water load is small by slowing down the pumps.

<u>Scope of Work:</u>

Add VFDs and a variable speed control package to this existing packaged booster pump system.

<u>Savings Estimate:</u>

50% reduction x 25 HP x 0.746 kW/HP x 8,760 hrs/year = 81,687 kWh x $0.074/kWh = **$6,044/year.**

<u>Construction Cost Estimate:</u>

Parts price from B&G is $16,000. Installation of electrical is $1,500/VFD x 3 VFDs = $4,500. Installing pressure transducer and controller is $2,500. Total construction cost:

$16,000 + $4,500 + $2,500 = **$23,000.**

<u>Simple Payback:</u>

$23,000 / $6,044 = **3.81 years.**

ECM-22 Replace 32 watt lamps with 28 watt lamps

Intent:

Reduce lighting and cooling energy by reducing the wattage on light bulbs.

Scope of Work:

When 32 watt lamps fail, replace with new 28 watt lamps.

Savings Estimate:

There are approximately 5,000 2'x4' fixtures at this facility. The lighting energy reduction is:

5,000 fixtures x 3 bulbs/fixture x (32 watts – 28 watts) x kW/1000 watts x average 12 hours/day x 365 days/year = 262,800 kWh/year

Reduction in cooling energy:

5,000 fixtures x 3 bulbs/fixture x (32 watts – 28 watts) x 3.412 btu/watt x average 12 hours/day x 30 days/month x 5 months x ton/12,000 btu x 1 kW/ton (average chiller plant consumption) = 30,708 kWh/year

Total energy savings:

(262,800 + 30,708) kWh x $0.074/kWh = **$21,720/year.**

Construction Cost Estimate:

Zero. The cost of lamps are similar, and the labor to replace is already required to replace the failed lamps.

Simple Payback:

Instant.

ECM-23 Operating Room standby mode

Intent:

Reduce the intense energy usage of the operating rooms when they are not occupied.

Scope of Work:

The operating rooms will operate on a normal time of day schedule, for example: 5:00am to 5:00pm. During the remaining hours, air changes will be reduced to 50%, the return air dampers will continue to operate to maintain the space pressure at a positive level, and both space temperature and humidity will be maintained at the existing setpoints. Add an occupancy sensor to each room that immediately increases the ACH rate, with a 30 minute delay after no occupancy has been detected before it returns to the reduced rate.

For our savings and construction cost estimates, we used a typical 625 square foot operating room, with two nominal 1,500 CFM VAV boxes (one with a reheat coil and one cooling only). The staff indicated that the existing VAV boxes provide 24 ACH to these rooms, and they reduce it to 12 ACH in the one room that presently has an occupancy sensor.

Savings Estimate:

Reduced Fan Energy

(2,250 CFM – 1,125 CFM) x (60 HP/35,000 CFM) x 0.746 kW/HP x 8760 hours/year x 50% reduction = 6,302 kWh/year x $0.074/kWh = $466/year

Reduced Reheat Energy

(2,250 CFM – 1,125 CFM) x 1.08 x (75°F - 55°F) x 8760 hours/year x 1/0.83 efficiency x therm/100,000 btu x 50% reduction = 1,282 therms x $0.61 = $782/year.

Reduced Cooling Energy

(2,250 CFM – 1,125 CFM) x 1.08 x (75°F - 55°F) x 12 hours/day x 30 days/month x 5 months/year x ton/12,000 btu x 1kW/ton = 3,645 kWh x $0.074 = $270/year.

Total Energy Savings

$466 + $782 + $270 = **$1,518/year.**

Construction Cost Estimate:

Item	Quantity	Unit Cost	Sub-Total
Controls - Occupancy Sensor	1	$500	$500
Controls - Programming (hours)	4	$125	$500
Balancing (hours)	4	$125	$500
Engineering (hours)	4	$155	$620
Total Construction Cost			**$2,120**

Simple Payback:

$2,120 / $1,518 = **1.40 years.**

ECM-24 Improve cooling tower control

<u>Intent:</u>

Reduce the cooling tower fan energy when one chiller is operating by taking advantage of both tower cells.

<u>Scope of Work:</u>

Modify the existing tower programming to enable one cooling tower, followed by the second cooling tower, followed by starting the first fan at minimum speed, followed by starting the second fan at minimum speed, followed by ramping up both tower fans in parallel.

<u>Savings Estimate:</u>

50 HP (one existing fan) x 25% (two fans running at less than ½ speed) x 0.746 kW/HP x 1,500 hrs/year = 13,988 kWh/year x $0.074 = **$1,035/year.**

<u>Construction Cost Estimate:</u>

8 hours of programming and testing x $125/hr = **$1,000.**

<u>Simple Payback:</u>

$1,000 / $1,035 = **0.97 years.**