

Pollution Control Modifications to Lower Costs at Largo's Heat Drying Facility

Robert A. Velasco, Leland E. Dicus, and Craven R. Askew

Facility History

In 1977, the city of Largo Water Reclamation Facility expanded the two-train, 6-million-gallon-per-day (MGD) plant into a three-train, 9-MGD plant and included a sludge odor control system, a heat drying facility, and improvements to the aerobic digesters (Askew et. al, 2004 and Velasco et. al, 2007). The heat drying facility consisted of a wood chip burner, a furnace, a three-pass rotary dryer, a solids settling chamber, and a venturi scrubber.

In 1985, the Florida Department of Environmental Regulation (FDER) [now the Florida Department of Environmental Protection (FDEP)] issued a consent order because of ongoing operating problems and odor complaints. In 1986, the facility was shut down and the solids were stabilized with lime and land applied.

In 1987, the city and its consulting engineer, CDM, developed a solids processing plan for the water reclamation facility. As part of the plan, improvements to the existing biosolids facility included a new belt filter press, an additional pelletizing train, a common regenerative thermal oxidizer (RTO), two product silo bins, a truck loading facility, dust collection equipment, and a scale. In 1991, these improvements were completed and the facility was placed in operation. As a result, the facility dramatically reduced odors and improved its performance.

In 1999, the city separated the biosolids facility from plant operations to improve its operation further, reorganizing the operations group to include a lead foreman and a dedicated group of operators. Since the reorganization, the biosolids operations group has implemented several equipment and operating modifications to improve the performance of the facility.

Facility Modifications

Table 1 shows a series of modifications implemented by the biosolids team between fiscal years 2000 and 2006. Equipment and operational modifications were made to the solids dewatering system, heat drying system, emission controls system, solids conveyance, and product storage system.

The combined effect of these process improvements increased the performance of the solids heat drying facility substantially from fiscal year 2000 to 2006. Total gas consumption decreased by 20 percent, while production increased from 0.40 to 0.80 tons per hour. The RTO modification had a substantial impact on the facility in terms of gas and power consumption. This article will focus on the RTO mechanical improvements and discuss the impact to the city's heat drying facility.

Existing Facility

The existing water reclamation facility utilizes the heat drying facility to produce marketable fertilizers. The facility produces approximately 2,800 tons per year of Class AA pelletized solids using one of two identical pelletizing trains with a direct fired furnace (Peabody, Model M-10) rated at 12 million British thermal units (Btu) per hour, a three-pass rotary dryer (Baker-Rullman, Model SD85-25) and a cyclonic settling chamber to collect the solids. The common RTO currently limits the operation to only one pelletizing train.

Robert A. Velasco P.E., is a project manager in the Tampa office of the consulting engineering firm CDM. Leland E. Dicus, P.E., is the city engineer for the city of Largo. Craven R. Askew is the biosolids foreman for the city of Largo. This article was presented as a technical paper at the 2008 Water Resources Conference in May.

Emissions control equipment is utilized to reduce atmospheric emissions. Exhaust gas from the settling chamber is conveyed to dual cyclones and a venturi scrubber/cyclonic separator to remove additional particulate and prevent solids carryover. The exhaust gas is treated through a common three-chamber RTO (Huntington Energy System Inc., Model #65) to control volatile organic compounds and odor emissions.

The RTO operates at a thermal efficiency of approximately 93 percent. The RTO chamber operates at approximately 1,150°F with a residence time greater than one sec-

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Table 1 - Summary of Process Improvements FY 2000 to 2006.

Description	Process Effect
Solids Dewatering	
Polymer Substitution	Improves Production and Reduces O&M Cost
Static Mixer Control	Improves Production and Reduces O&M Cost
Upgrade Filter Presses	Improves Dewatering and Production
Solids Heat Drying/Pelletizing	
Increase Heat Dryer Flow	Improves Production and Control
Decrease Dryer Outlet Temperature	Reduces Gas Consumption
Upgrade Furnace Gas Feed Control	Reduces Gas Consumption and Improves Control
Emission Controls	
Decrease RTO Chamber Set Point	Reduces Gas Consumption
Upgrade RTO Ceramic Media	Improves Thermal Efficiency and Reduces Pressure Loss
14" Recirculation Line	Improves Startup Operation
Upgrade RTO Control Panel	Improves Control and Efficiency
Add VFD Control to RTO Fan	Reduces Electrical Usage and Improves Control
Valve Drive Replacement	Reduces Pressure and Increases Flow
Add RTO Fan Lube Oil Cooling System	Reduces Cost and Improves Bearing Life
Add RTO Fan Lube Oil Cooling System	Reduces Cost and Improves Bearing Service Life
Solids Conveyance	
Upgrade Pugmill Mixer Blades	Improves Mixing and Improves Blade Life
Upgrade to Shaftless Screw Conveyors	Improves Feed Mixing and Improves Blade Life
Product Storage	
Add Recycle Screw on Silo	Improves Control and Reduces Risk of Hot Spots

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ond. The combustion chamber temperature is maintained by two natural burners rated for a total of 2 million Btu per hour.

An induced draft fan (Robinson Industries, Model RB1212 SWSI), located at the discharge of the RTO, conveys the exhaust gas through the RTO and stack. The flow rate through the RTO is controlled using the pressure at the RTO inlet.

System Operation

Figure 1 illustrates the typical operation of the three-chamber RTO (Epcon Industries 2007). In Cycle 1, the exhaust gas passes through the ceramic media in Chamber 1. The exhaust gas adsorbs the heat energy that

was stored in the ceramic media from the previous cycle and pre-heats the exhaust gas. The exhaust stream then enters the burner reactor chamber, where the volatile organic compounds and odorous compounds are broken down for a minimum of one second. As the hot exhaust stream passes through Energy Recovery Chamber 2, the ceramic media mass absorbs the heat energy and is pre-heated for the next cycle. The same process is repeated for Cycles 2 and 3 using different energy recovery chambers by operating the valves. Cycles 1, 2, and 3 are continuously repeated throughout the operation of the RTO.

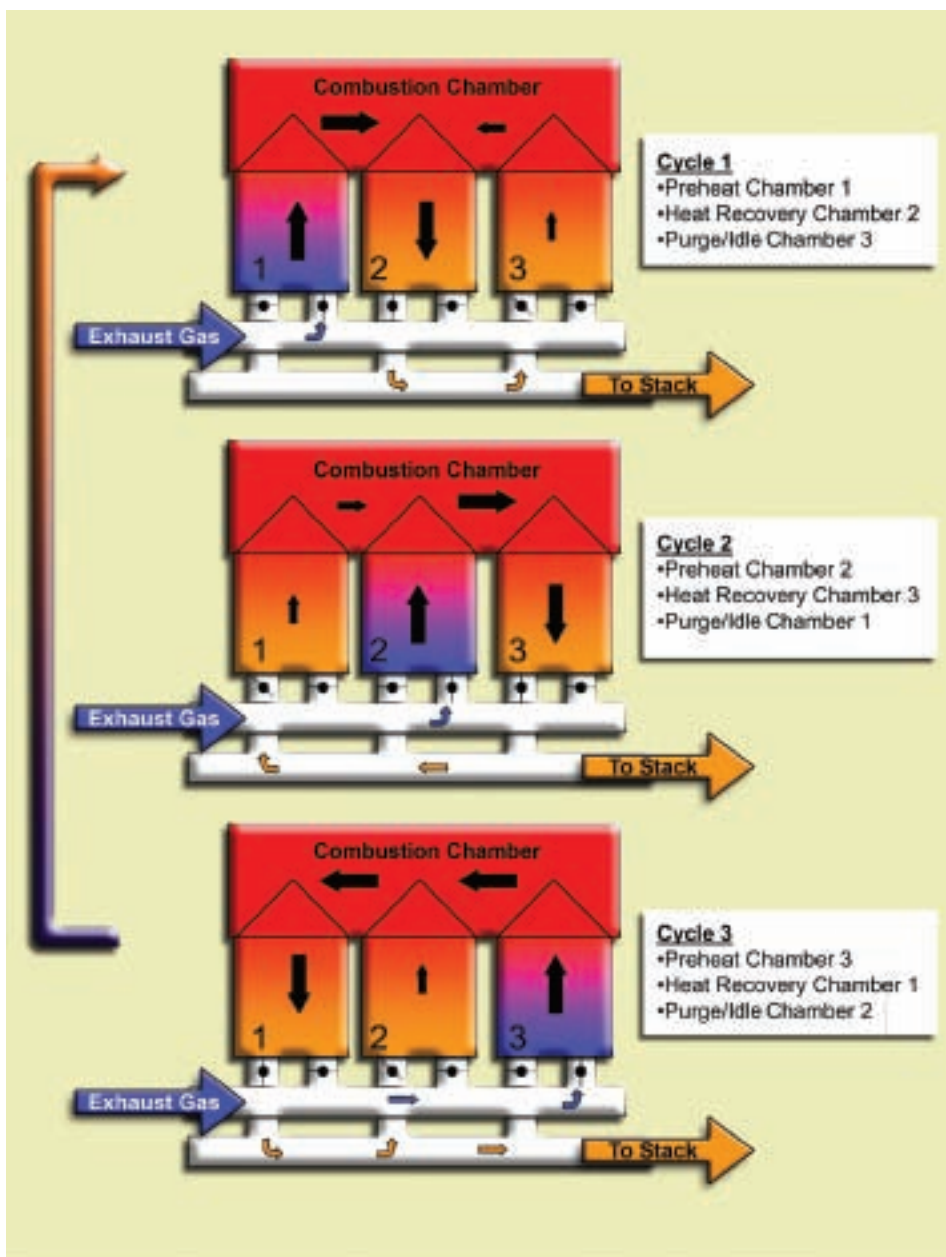
The entire process is controlled automatically by a programmable logic controller (PLC), which is programmed for automatic

start-up, shutdown, ramping of chamber temperature, monitoring of safety interlocks, burnout cycle, operation of all inlet and bypass dampers, operation of the low-fire gas recirculation system and dampers, and fault annunciation. The PLC regulates the temperature rise at a rate of approximately 500°F per hour.

The RTO thermocouples are controlled by the PLC. Five of the thermocouples—one located on the top dome, one on the bottom dome, and three spaced along the central chamber—are used to control the chamber temperatures. The other thermocouples that are located in the outlet manifold or outlet duct are used to control the bake out cycle. Each energy recovery chamber also has two thermocouples on the chamber's hot face and just inside the cold face.

The energy recovery chambers will gradually accumulate fine particulate matter that is not removed by the venturi particulate scrubber and cyclone separator. To help prevent build-up of these deposits, the RTO incorporates a bake-out function in which the temperature of the ceramic media is raised to a minimum temperature of 1,200°F (at reduced gas flow) to burn off the deposited material. Only the organic or volatile fraction will be burned off (oxidized to CO₂ and H₂O vapor), and the inorganic fraction will remain. Only one energy recovery chamber can be burned at any time.

Figure 1 - Typical Operation of a Three-Chamber Regenerative Thermal Oxidizer.



System Modifications

The RTO mechanical improvements were implemented in February 2000 to improve the performance of the RTO. The system improvements included the ceramic media upgrade, control system upgrades, installation of a variable frequency drive (VFD), installation of a stack recirculation duct, replacement of existing valve drives, and rebuilding the existing Valv-Tech valves. The RTO modifications were conducted by Huntington Environmental Systems under the direct supervision of the city.

Ceramic Media Replacement

The RTO contained approximately 2,000 cubic feet of one-inch ceramic saddle media. The ceramic saddles often became plugged up to 50 percent with fine particulates, causing thermal degradation of the ceramic saddles, increased pressure loss and reduced thermal efficiency. The city had to conduct routine bake-outs to reduce the pluggage and improve thermal efficiency.

To alleviate these operation problems, the city replaced the one-inch saddles with approximately 1,470 cubic feet of 25-cpsi monolith ceramic block to reduce the fre-

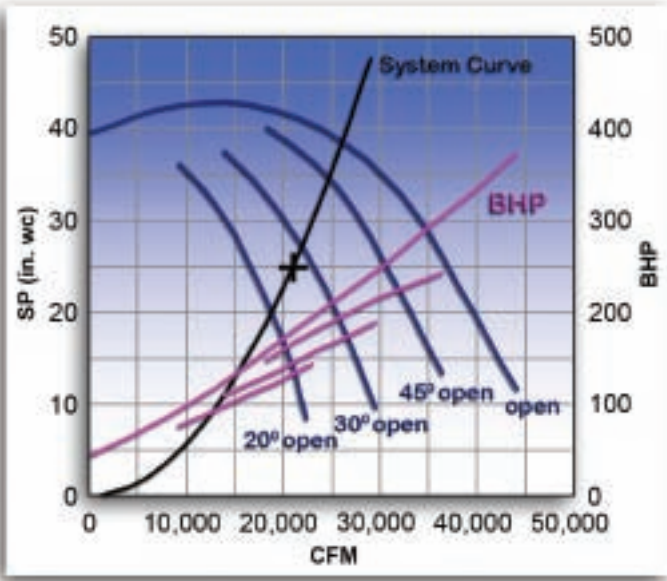


Figure 2 - System Curve with 1-inch Saddles.

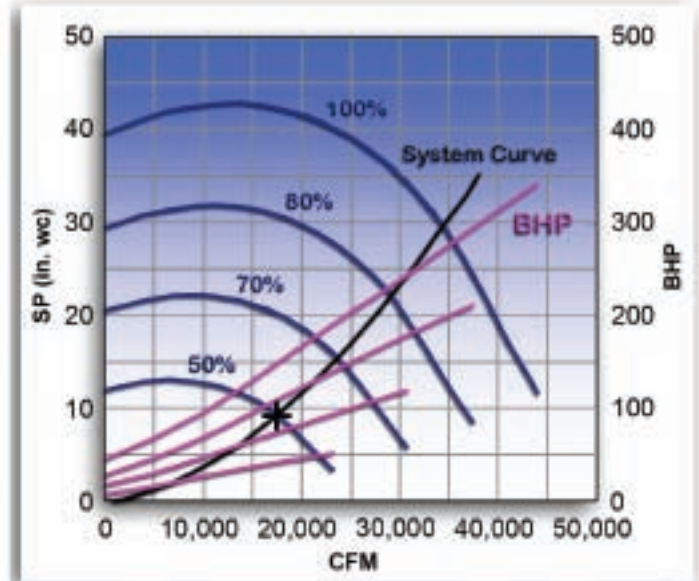


Figure 3 - System Curve with Monolith Block.

quency of bake-outs and improve the thermal efficiency.

Control System Modifications

The control system consisted of an Allen Bradley SLC 100 processor, relay logic, Honeywell UDC controllers, Chessel six-pen chart recorder, Honeywell M890 analog

flame relays, and fully manual controls. The modifications were made to update the control system and facility communication to the main plant SCADA system.

The existing control system was modified with a new 72"×72"×20" control panel consisting of an Allen Bradley SLC 5/04 processor and a TCP Model TCS 100-540122

operator interface operating with Wonderware in a Windows environment. A 14-inch panel mounted VGA monitor was also included to monitor the RTO performance at the control panel.

An Allen Bradley interface was supplied for remote communication to the PLC and

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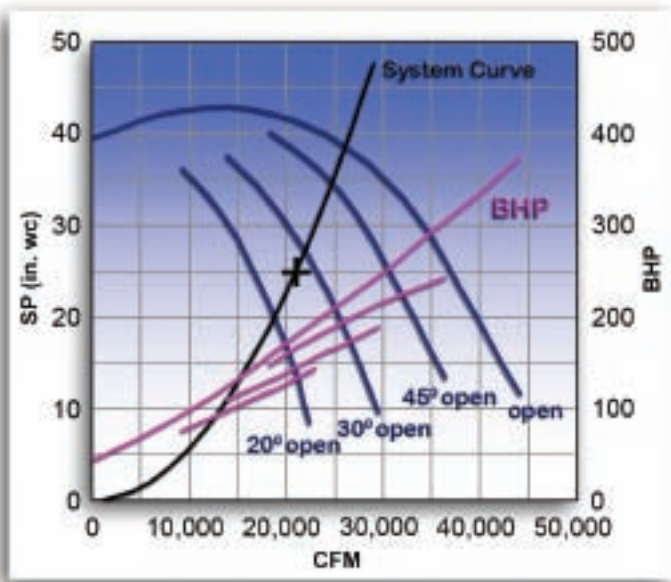


Figure 4 - Power Usage of Saddles vs. Monolith Block.

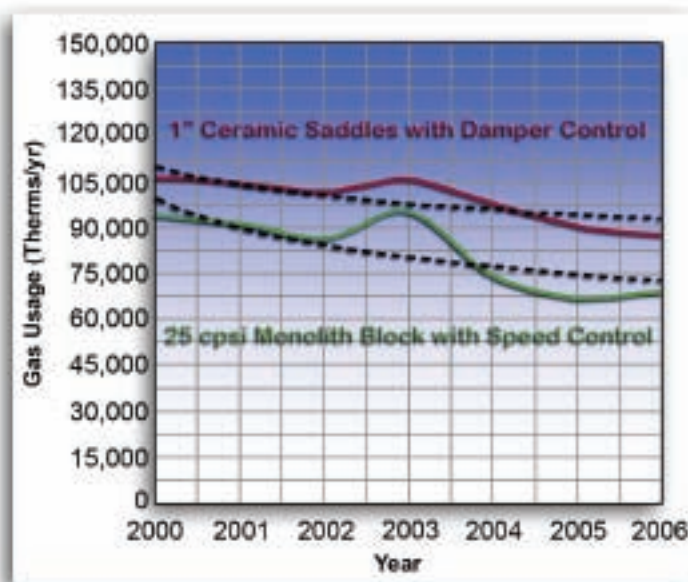


Figure 5 - Gas Usage of Saddles vs. Monolith Block.

Description	June 1998	July 2000	% Change
Inlet Temperature (°F)	146	125	N/A
Stack Temperature (°F)	270	233	N/A
Chamber Temperature (°F)	1,372	1,315	N/A
Flowrate (acfm)	21,000	17,500	-17%
Gas Usage (ft ³ /hr)	2,320	2,003	-14%
Thermal Efficiency	92.9%	93.8%	+1.0%
RTO Heat Rate (MMBtu/hr)	2.50	2.15	14%
Heat Ratio (BTU/SCF)	2.94	2.75	7.0%

Table 2 – Summary of Gas Usage for June 1998 and July 2000

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the plant SCADA system. Honeywell M890 analog flame relays and manual controls were replaced with Honeywell digital relays. A Chessel three-pen chart recorder was added to monitor the inlet, central chamber, and exhaust temperatures.

Recirculation Ductwork System

A 14-inch stainless steel duct from the stack breaching to the inlet of the RTO was installed for recirculation during startup. The duct contains an electrically actuated two-position valve to provide a closed-loop mode of operation whenever the RTO is in standby or in the operating mode.

The system modification heats the ceramic monolith block to evaporate any water from the deposition of particulate materials and the destruction of organic materials, thereby improving the performance and reducing the frequency of bake-outs. The recirculation of heat gas reduces the amount of gas used during standby and start-

up operation.

Variable Frequency Drive

An Allen Bradley 1336 VFD was installed on the RTO exhaust fan to improve flow control. The drive was installed to replace the operation of the inlet vortex damper and has reduced the electrical energy used, improved inlet pressure and flow control, and extended service life of the fan bearings. A pulsing, proportional signal is utilized to control the existing (not used with VFD operation) inlet damper actuator in the event the VFD fails.

Valve Drive Replacement

The valve drive system was replaced with the center valve drive modification. The modification has created a larger opening, reduced system pressure drop, and increased flow.

Valve Rebuild

The existing Valv-Tech valves installed on the RTO were rebuilt for improved operability.

ty. This included the installation of the new drive side bearings and drive side packing.

Modification Impacts

Power Usage Impact

Figures 2 and 3 illustrate the two distinct operating points on each system curve. The operating point is the intersection of the system curve and fan curve as shown by the “+” symbol. The operating point with the ceramic saddles is shown to be approximately 25 inches at 21,000 actual cubic feet per minute (acfm). In comparison, the operating point is approximately 12 inches at 21,000 acfm for the monolith block.

The difference between the ceramic saddles and monolith block systems shows a net decrease in brake horsepower (HP) from 140 to 50 HP. By the decreasing the flow to 17,500 acfm, the brake horsepower can be subsequently reduced to 40 HP.

Figure 4 illustrates the power usage between the one-inch ceramic saddles and the 25-cpsi monolith block from fiscal years 2000 to 2006. The top curve represents the power usage associated with the one-inch ceramic saddles. The lower curve shows the power usage with monolith modification. Both power usage curves are time weighted to the total number of operating hours per year.

The vertical spread between the curves shows the amount of power conserved and is directly proportional to the cost saved. In general, both curves show a steady decline in power usage. A slight decrease in gas usage is evident after fiscal year 2003, which is attributed to the reduction in the chamber set point temperature from 1,350°F to 1,150°F.

Gas Usage Impact

Table 2 shows the comparison of the RTO operating conditions during June 1998 and July 2000 during stack testing conditions. The June 1998 data represents the operating conditions before the modifications, and the July 2000 data shows the operating conditions after the modifications (Environmental Engineering Consultants Inc. 1998 and Environmental Engineering Consultants Inc. 2000).

The data shows the impact of the monolith block installation. The typical thermal efficiency had increased from approximately 92.9 to 93.8 percent due to the improved heat transfer. As a result, the gas feed and RTO heat input decreased from 2,300 to 2,000 ft³/hr and 2.50 to 2.15 MMBTU/hr, respectively.

The June 1998 flow data was normalized to the July 2000 flow for a direct comparison of gas usage. The data was normalized by comparing the heat ratio, which is the ratio of the heat input to standard flow. The ratio shows a 7 percent reduction in gas consumption resulting from the monolith block upgrade. An additional reduction of 7 percent is attained by decreasing the flow from 21,000 to 17,500 acfm. As a result, a gas reduction of approximately 1.4×10⁶ ft³/yr was achieved.

Figure 5 illustrates the difference in gas usage between the one-inch saddles and the monolith block. Both curves are time weighted based on the actual number of annual operating hours. The difference between the curves indicates the amount of gas conserved. In both cases, there is a steady reduction in gas usage over time, but a noticeable decrease in consumption is shown for fiscal year 2003 due to the reduction in the RTO set-point temperature.

Financial Impact

Table 3 shows the financial impact of the RTO modification for fiscal years 1999 and 2000. The power costs substantially decreased from \$42,000 to \$15,000, resulting in a \$27,000 annual savings. The gas costs were not as pronounced, but did decrease from \$76,000 to \$62,000. The combined savings resulted in an approximately \$40,000 savings, despite a 15 percent increase in natural gas rates.

Table 4 shows the financial impact of the RTO improvements. From fiscal years 2000 to 2006, the city conserved approximately 120,000 therms of gas and 2,100 megawatt hours of power. This has resulted in a net savings of approximately \$270,000 and a six-year payback based on \$260,000 monolith block and VFD capital investment. A total net savings of \$470,000 is expected over the 20-year service life, depending on utility costs,

the annual production rate, and operation of the heat dryer.

Conclusions

The city of Largo has implemented several cost-effective and energy conservation modifications to improve the performance of its drying facility. To date, the RTO modifications have had a substantial impact on the operating cost.

The city is currently implementing additional key process improvements to enhance the performance of the heat drying facility (Velasco et. al, 2007). A SCADA system will increase the facility operation and reliability. The three existing dust collectors on the product silos and truck loading area will be replaced with a common dust collector. The existing venturi scrubbers will be replaced in-kind to improve the collection efficiency and particulate carryover to the RTO. The non-recirculating exhaust gas configuration will be upgraded to recirculate gas from the inlet of the RTO to the furnace.

The improvements are expected to reduce emissions, decrease power and gas consumption, recover heat energy, and reduce operating costs by approximately \$110,000 per year.

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Table 3 – Financial Impact for FY 1999 and 2000.

Description	FY 1999	FY 2000	Change
Operating Time(hrs)	5,247	4,240	-1,007
Gas Usage Rate (\$/Therm)	\$0.58	\$0.66	+\$0.084
RTO Gas Consumption (Therm/yr)	131,175	93,916	-37,259
Net Cost	\$76,000	\$62,000	-\$14,000
Electrical Costs(¢/kWh)	7.4	7.5	+0.1
Power Usage (kWh/yr)	519,453	192,496	-326,957
Net Cost	\$42,000	\$15,000	-\$27,000
Total Net Cost	\$118,000	\$77,000	-\$41,000

Table 4 – Long Term Financial Impact for FY 2006 to 2020.

Description	To Date FY 2006	Service Life FY 2020
Gas Usage Conserved (Therms)	120,000	-
Gas Usage with Improvement	\$550,000	\$960,000
Gas Usage without Improvements	\$650,000	\$1,140,000
Net Savings	\$100,000	\$180,000
Power Usage Conserved (MWh)	2,100	-
Fan Cost with Improvements	\$110,000	\$190,000
Fan Cost without Improvements	\$280,000	\$480,000
Net Savings	\$170,000	\$290,000
Total Net Savings	\$270,000	470,000