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THE eco/TECH SLUDGE RECYCLING SYSTEM: TWO YEARS OF EXPERIENCE

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ABSTRACT

The eco/Technologies Sludge Recycling System (eco/Tech SRS) was introduced at NAWTEC 10 and has now been operating commercially for two years at the Pioneer Valley Resource Recovery Facility (PVRRF), located in Agawam, Massachusetts. A second system will be installed at the Pittsfield Resource Recovery Facility (PRRF), located in Pittsfield, Massachusetts, in 2004 and EnergyAnswers is now marketing the system to other power plant owners. Presented in this paper is an overview of:

Operating and maintenance history at PVRRF
Market conditions and challenges
Air emissions results
Design enhancements planned for PRRF

The data presented support the potential for waste-to-energy plants, and by extension all solid fuel power plants, to benefit from additional revenue streams while using a waste product to achieve air emissions reductions.

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INTRODUCTION

The patented eco/Technologies' Sludge Recycling System (eco/Tech SRS) is a commercially proven technology that provides resource recovery facilities with a new revenue source and the potential for reduced emissions of nitrogen oxides (NO_x) and small particulates. The eco/Tech SRS offers an environmentally sound cost-effective disposal option for municipal sludge and industrial liquid waste producers. Sludge producers are facing increasing regulatory scrutiny for their traditional non-combustion disposal methods such as land filling, composting and land application due to the uncertainty of the final disposition of heavy metals and trace organics contained in the sludge. Traditional sludge combustion technologies are reliant on expensive fossil fuels with high operating costs, while co-combustion facilities, those that burn sludge along with other solid fuels, have struggled to achieve commercial viability.

With its involvement in numerous projects where co-disposal of sludge with other solid fuels could prove to be environmentally and financially sound, eco/Technologies, LLC (eco/Tech) began an intensive technology development program to identify and resolve the shortcomings that have prevented co-combustion from being commercially successful in the past. A sludge co-combustion system was developed and tested at the Pittsfield Resource Recovery Facility (PRRF) that eventually led to the issuance of operating permits from the Massachusetts Department of Environmental Protection (MADEP) for systems at both PRRF and the Pioneer Valley Resource Recovery Facility (PVRRF). The MADEP permits allow for the displacement of up to 5% MSW, by weight, with an equal amount of dry sludge solids.

The eco/Tech SRS at PVRRF has been operating commercially since April 2002 and has processed over 10 million gallons of sludge during that time. This sludge has ranged in solids content from 2%, for un-thickened secondary clarifier sludge, to over 30% for a special sludge known as "fats, oils & greases" (FOG) from a local ice cream manufacturer.

The PVRRF Sludge Recycling System

The eco/Tech SRS is comprised of three main components; the transportation module, the receiving and mixing module, and the injection module. The role of the transportation module is to convey the liquid sludge from the point of origin to the PVRRF. Typically, sludge transportation in Massachusetts is accomplished by 9,000 gallon tankers, which due to unloading difficulties, are not able to transport sludge higher than 6% solids without the assistance of a positive displacement (PD) blower to push the sludge out of the tanker. Tankers equipped with this device are not common. Even with a pressure assist, it is uncommon to transport municipal liquid sludge at solids over 8% due to the high polymer dose which causes the sludge to act as a jell-like substance, limiting the effectiveness of the blower assist.

To manage the handling difficulties of thickened liquid sludge, eco/Tech developed a special high solids sludge tanker that not only features a PD blower but also conical shaped hopper bottoms to aid in unloading the tanker. The tanker interior is also coated with a special low friction epoxy to facilitate faster unloading and cleaning. Another unique feature of the tanker is an on-board activated carbon odor control system which removes odorous gases from the air vented by the tanker while in transit or when mixing the contents with diffused air prior to unloading. To date, the eco/Tech tanker has been used to carry waste activated sludge (WAS), FOG, and digested sludge with great success.

The main function of the receiving and mixing module is to store and prepare the sludge for combustion. The module, or "tank farm" as it is known at PVRRF, consists of four 50,000 gallon storage tanks. One of the four tanks is designated the receiving tank and all incoming loads are pumped into that vessel. The three remaining tanks are used for storage of the prepared sludge.

Preparation of the sludge for combustion involves near-constant mixing and recirculating in order to keep the sludge solid particles in suspension and evenly distributed through out the storage tank. This is accomplished by passing the sludge through a macerating grinder for particle size reduction, several times if necessary, and by agitating the contents of the tank with diffused air to maintain a homogeneous solution. An additional benefit of the diffused air is that it also provides oxygen to the sludge bacteria, keeping it from becoming anaerobic and thereby odorous.

Serving all of the storage tanks is a blower-assisted activated carbon odor control system that creates a slight vacuum on the tanks, preventing the release of odorous gases. These gases are vented through the carbon bed where most odorous components are removed. Periodically, the carbon bed must be water washed to restore its effectiveness. During back wash cycles, the gases are directed to a full size "stand-by" canister.

The injection module, while being the heart of the system, is incredibly simple but very effective. Sludge is delivered to the 3 injection racks (one for each Enercon combustor at PVRRF) from the tank farm by positive displacement pumps. The sludge pressure at the injection rack varies with solids concentration, viscosity and sludge type (FOG or WAS) and is used by the control system to set the positive or negative pressure differential of the atomizing steam. The sludge and atomizing steam are combined in a dual fluid nozzle and sprayed into the combustor. Control of the differential between the sludge and steam pressures is critical for achieving the best possible atomization of the sludge particles. The injection module also includes instrumentation for monitoring sludge and steam temperature and flow as well as a "purge" cycle for clearing plugs from the sludge nozzle. For ease of maintenance, the sludge lance and nozzle assembly is mounted on a retractor device which inserts and retracts the lance assembly from the combustor at the touch of a button.

The controls for the tank farm equipment and the injection racks have been fully integrated into the facility's existing Bailey Net 90 DCS. Dedicated screen pages for the new systems were created and complement the logic and appearance of the pages used by control room personnel for the balance-of-plant. Approximately 100,000 gallons of various sludge is received and combusted per week in a system that is now a routine part of the facility's operation.

Though at first it may appear to be counter-intuitive to spray up to 10 g.p.m. of water into a municipal waste combustor, the quenching effect of the water can be compensated for by adjusting the amount of recirculating flue gas (RFG) that is used in an Enercon unit for cooling, and by ensuring that the heating value of the sludge is the highest possible. The quenching effect of the water can also be easily reduced by substituting a high energy fuel, such as used tires, for a small portion of the MSW if allowed by permit. The use of FOG, ice cream waste, and municipal treatment plant clarifier skimmings, which all contain oils and greases, are excellent additions to the sludge mixture that will significantly reduce any quench effect of water in the sludge. Lastly, depending on permit conditions, additional MSW can be combusted to offset any heat losses if the facility does not have a tonnage limitation.

The following equations illustrate the effect that co-combusting sludge has on the combustors at PVRRF, assuming that no additional fuels are being combusted:

Given:

Equation 1
Reference Heat Input per 136 ton per day Combustor =
(11,333 lbs of MSW/hr)(4,500 btu/lb) = 51,000,000 btu/hr

Equation 2
Dry Sludge Solids Injection Rate (limited by permit to 5% of MSW) = (11,333 lbs of MSW/hr)(5%) = 567 lbs/hr Sludge Solids

Equation 3
Equivalent Sludge Injection Rate at 15% Solids = (567 lbs/hr)/(15%) = 3780 lbs of Liquid Sludge per hr, or 453 gallons per hour at an assumed 8.34 lb/gallon.

Equation 4
Water Content of Sludge = (3,780 lbs/hr liquid sludge) - (567 lbs/hr sludge solids) = 3,213 lbs/hr of water.

Calculations:

Equation 5
The heat provided by the dry sludge solids:
H1 = (8,400 btu/lb)(567 lb/hr) = 4,763,000 btu/hr

Equation 6
Reduction in heat input by MSW replaced by sludge solids:
H2 = (-4,500 btu/lb)(567 lb/hr) = -2,552,000 btu/hr

Equation 7
Heat required to raise the temperature of the sludge from 70 deg. F to 212 deg. F:
H3 = (-1 btu/lb - deg F)(3,213 lbs/hr)(212 - 70 deg. F) = -456,000 btu/hr

Equation 8
Heat required to vaporize the water content of the sludge at 212 deg. F:
H4 = (-970 btu/lb)(3,213 lbs/hr) = -3,117,000 btu/hr

Equation 9
Heat required to raise the temperature of the sludge water vapor from 212 deg. F to 1,850 deg. F:
H5 = (-0.48 btu/lb - deg. F)(3,213 lbs/hr)(1,850 - 212) =
- 2,526,000 btu/hr.

Equation 10
Heat required to raise the temperature of the atomizing steam from 500 deg. F to 1850 deg. F:
H6 = (-0.48 btu/lb - deg. F)(350 lb/hr atomizing steam)(1,850 - 500 deg. F) = -227,000 btu/hr

Equation 11
Total heat loss: H7 = H1 + H2 + H3 + H4 + H5 + H6 =
4,763,000 btu/hr - 2,552,000 btu/hr - 456,000 btu/hr -
3,117,000 btu/hr - 2,526,000 btu/hr - 227,000 btu/hr
= -4,115,000 btu/hr heat loss

Equation 12
Reduction in RFG flow based on a gas temperature of 400 deg. F:
H8 = (-4,115,000)/((0.24 btu/lb - deg. F)(1,850 - 400 deg. F))
= 11,800 lb/hr reduction in RFG gas flow.

Based on an RFG design flow rate of 80,148 lb/hr, the calculated reduction in gas flow is approximately 15%, based on a sludge solids level of 15%.

Operation and Maintenance History

Since April 2002, over 10,000,000 gallons of sludge has been received and combusted at the PVRRF. At an average of 5.5% solids, this represents 2,300 tons of dry material. The majority of this material has been WAS from treatment plants in western Massachusetts with the remainder being FOG from three local ice cream factories. The industry response to the PVRRF capacity coming on line has been enthusiastic - there has been no shortage of material to fill the system. However, many of the local sludge sources produce sludge at an average of just 5% solids or less, versus a system target of 10 - 15%. After 11 months of near full capacity operation, which validated the capability of the eco/Tech SRS to handle high flows, a decision was made to put in place a 6% minimum solids content level for deliveries to PVRRF. Consequently, gallons delivered per month has decreased from an average of 594,000 in 2002 to 376,000 in 2003, but the dry tons per month average fell only 18 tons to 97 tons per month due to an overall higher solids level per gallon. Sourcing liquid sludge in the desired range of 10 - 15% continues to the project's major challenge. Market conditions will be discussed in greater detail in a later section of this paper.

The following table summarizes the types of liquid sludge that have been combusted, or qualified for combustion, at the PVRRF:

Table 1
Summary of Liquid Sludge Types

Sludge Type	Percent Solids
Waste Activated (WAS)	2- 10%
Digested Sludge	19%
FOG	13 - 30%
Paper Mill [(a)]	10%
Textile Mill [(b)]	7%
Coal Pile Slurry [(c)]	20%

(a) Currently qualified for the PRRF, included for comparison purposes only
(b) Qualification pending approval
(c) Qualified but not yet combusted

Through two years of operation, rotating equipment reliability has been exceptional and has exceeded expectations. To date, only one sludge transfer pump, which is used to move sludge from tank to tank, has required service as a result of a worn stator and rotor. These parts likely experienced rapid wear as a result of running without cooling liquid briefly during the start-up phase of the project.

The pipe liner grinders have also run very well and have not needed any servicing other than removing foreign material from the drop-out chamber every 600 hours of use. The holes in the pipe liner shear plates are measured during the inspection and have not shown any signs of wear.

The three sludge injection pumps ran nearly continuously for the first year of system operation without showing any noticeable wear. After the incoming sludge quantity was reduced in March 2003, the number 3 combustor sludge system continued to run around the clock while the other two units were operated on an as needed basis. After approximately 6,000 hours of service, the number 3 sludge injection pump was rebuilt and a new rotor and stator was installed.

Instrumentation, controls and valves on the injection racks and retractors have operated without incident in a very harsh environment. No service other than routine preventive maintenance has been required.

One component of the system - the cap and spiral at the end of the dual fluid steam atomizing nozzle - is subject to wear and therefore is considered a wear part requiring replacement on a regular basis. The cap threads on to the end of the nozzle assembly, with an outlet hole of approximately 5/8". The combined steam and sludge solution exits the tip at a very high velocity to serve as the second stage of atomization. The hole in the outlet cap has worn away at a rate of approximately 1/8" of diameter per 100 hours of use. When the outlet hole exceeds 1" in diameter the cap is removed and replaced.

Wearing at a similar rate as the cap is the spiral which provides mechanical pre-atomization of the sludge. The spiral, which is threaded into the nozzle sludge outlet, is easily replaced when a new nozzle cap is installed.

Caps and spirals are inspected and measured on a weekly basis and are routinely replaced when worn beyond acceptable limits. The low cost of the components permits frequent replacement while still retaining an over all low maintenance cost per dry ton, as shown in ***Table 2***.

Table 2
Summary of O & M Costs

	2002 Actual	2003 Actual	2004 Projected
Labor	$39,900	$49,400	$46,900
Contracted Lab Fees	$8,700	$6,400	$7,300
Parts	$22,100	$23,700	$30,900
Dry Tons Processed	1,149	1,158	1,714
Cost/Dry Ton	$62	$69	$50
Cost/Dry Ton w/o Labor	$27	$26	$22

These operating and maintenance costs compare very favorably with the anticipated operating costs of $75 - $100 per dry ton. Cost per dry ton, less labor charges, has also been included since the amount of time spent by the operator on the eco/Tech SRS continues to decline. The operator has been assigned additional non-SRS duties though his time continues to be charged to the eco/Tech SRS.

The sole component of the eco/Tech SRS that did not meet all original design expectations is the granulated activated carbon (GAC) odor control system. However, it must be stressed that while performance of the system did not initially meet eco/Tech's expectations, it has worked well enough to ensure that the PVRRF has not received a single odor complaint from the public since the eco/Tech SRS was brought on line!

Using olefactory sense as a guide, the GAC system works well with capturing hydrogen sulfide ($H2S$) odor emitted from the sludge storage tanks, but has not worked as well with capturing compounds such as mercaptans which are known for their characteristic "rotting cabbage" odor. To complicate the issue, not all sludge delivered to PVRRF generates mercaptan compounds and it has been shown that the potential to create these odors also varies with the seasons, with periods of hot, humid weather being most likely to result in the generation of mercaptans. In 2003, PVRRF installed an Ondeo-Nalco Eco-Sorb odor neutralizing system, which has proven to be an effective backstop for eliminating any odorous compounds that may pass through the GAC system. Future eco/Tech SRS systems will either utilize this tandem system, a bio-filter, or send odorous gases to a combustion chamber.

One operational challenge of the GAC system is the need for periodic water backwashes to regenerate the carbon. Back washing is a 24 hour process, and may be necessary 4 to 6 times per year. Unfortunately, when a back wash is needed in the winter months, a number of time consuming freeze protection measures must be taken to protect the equipment, which is located out doors at PVRRF.

Like most waste-to-energy plants, the PVRRF has experienced corrosion of carbon steel in the bag houses, particularly in the lower hopper and side wall areas where ash accumulates. Since the eco/Tech SRS came on-line, there is an indication that the rate of corrosion has increased as a result of the additional amount of water vapor passing through the bag house. During the 2002 and 2003 annual maintenance inspections, the corroded carbon steel plates were replaced or clad as necessary with plates made from 304 stainless steel. There has been no further corrosion in any of the areas that have been rebuilt using stainless steel.

Emissions Tests Results

Since the eco/Tech SRS came on-line at PVRRF, there have been two 21H emissions tests, one in December 2002 and one in September 2003. Sludge flow during the tests ranged from 4 to 7.6 g.p.m. per unit. For comparison purposes, the pre-SRS "base case" test took place in March of 2002. Results of the tests for particulate matter and metals, with sludge, and without sludge, are presented in ***Table 3.*** It should be noted that each PVRRF combustion train is equipped with a dry lime absorption reactor and fabric filter baghouse. The facility is not equipped with SNCR or carbon injection systems.

Of most significance is a reduction in the amount of PM_{10} emissions, which are currently less than 20% of the previous value and a reduction in NO_x emissions (described below). The data also indicates that co-combustion of sludge has no significant adverse impact on the emission of the multiple metals. It is interesting to note that mercury emissions magnitude declined during the two sludge 21H tests, while dioxin/furans emissions were higher than the base emissions case, but were still 50% below the permitted level.

The facility's continuous emission monitoring system (CEMS) continuously tracks the emissions of sulfur dioxide (SO2), nitrogen oxides (NO_x) and carbon monoxide (CO). This data is totaled and reported to the MA DEP on a monthly basis. The data for thirty-five months is shown in ***Table 4***, and graphically in ***Graphs 1 and 2.*** The data indicates that SO2 emission level is not impacted by either sludge volume in gallons, or by the tons of dry sludge solids.

There is evidence that NO_x emissions are reduced, with the reduction varying with the volume of liquid sludge combusted. This indication is most evident in the April to June, 2002 time period and the May - October, 2003 time period, when changes in sludge volume clearly resulted in reductions in NO_x emissions. This data indicates that NO_x emissions can be positively impacted by the volume of sludge injected, which appears to be aiding in controlling peak combustor temperatures. Interestingly, there is very little correlation between the level of NO_x emissions and tons of dry sludge solids combusted, despite a high level of nitrogen contained in the sludge (see ***Table 5***).

Using the reported NO_x values from January 2001 to March 2002, a pre-sludge baseline yields an average of .217 LBS/MMBTU. During months with high sludge flow (over 650,000 gallons) such as July, September and December, 2002 the average NO_x emissions dropped 9.6% to .196 LBS/MMBTU. The greatest reduction from baseline emissions occurred in October 2002, when a 14.3% reduction was achieved. These demonstrated NO_x reductions will likely be even greater as maximum monthly flow nears the design limit of 900,000 gallons. It should be noted that this reduction was achieved at a facility equipped with flue gas recirculation, which consistently achieves NO_x emission levels well below MACT limits without supplemental NO_x control.

Table 3

HISTORY OF 21H TESTING RESULTS
PIONEER VALLEY RESOURCE RECOVERY FACILITY

PARAMETER	**Base Case No SRS Mar-02 Test Result**	**SRS Operational Dec-02 Test Result**	**Sep-03 Test Result**	**Emission Limits**
Particulate Matter, PM10, gr/dscf	5.52×10^{-3}	3.30×10^{-3}	1.08×10^{-3}	R O*
Particulate Matter, Total, gr/dscf	0.0044	0.0125	0.004	0.03
Total Tetra through Octa Dioxins/Furans, lb/hr	1.01×10^{-6}	2.10×10^{-6}	3.54×10^{-6}	6.1×10^{-6}
Multiple Metals (lb/MM BTU)				
Antimony	3.32×10^{-6}	1.03×10^{-5}	5.00×10^{-6}	R O*
Arsenic	5.96×10^{-7}	7.80×10^{-7}	2.17×10^{-6}	R O*
Beryllium	5.17×10^{-8}	5.86×10^{-8}	1.00×10^{-7}	6.25×10^{-7}
Cadmium	6.68×10^{-6}	6.14×10^{-6}	3.73×10^{-6}	R O*
Chromium	8.38×10^{-6}	3.47×10^{-6}	5.58×10^{-6}	R O*
Copper	1.19×10^{-5}	1.95×10^{-5}	8.43×10^{-6}	R O*
Lead	2.45×10^{-5}	5.24×10^{-5}	3.05×10^{-5}	1×10^{-3}
Manganese	6.25×10^{-6}	8.53×10^{-5}	2.14×10^{-5}	R O*
Mercury	1.03×10^{-4}	4.81×10^{-5}	4.44×10^{-5}	2.4×10^{-4}
Molybdenum	7.24×10^{-6}	4.51×10^{-6}	4.93×10^{-6}	R O*
Nickel	1.52×10^{-5}	3.20×10^{-6}	7.01×10^{-6}	R O*
Selenium	7.34×10^{-7}	2.36×10^{-6}	2.32×10^{-6}	R O*
Tin	1.18×10^{-5}	1.60×10^{-5}	3.07×10^{-5}	R O*
Vanadium	1.04×10^{-7}	4.43×10^{-7}	1.03×10^{-7}	R O*
Zinc	6.99×10^{-5}	1.39×10^{-4}	9.89×10^{-5}	R O*

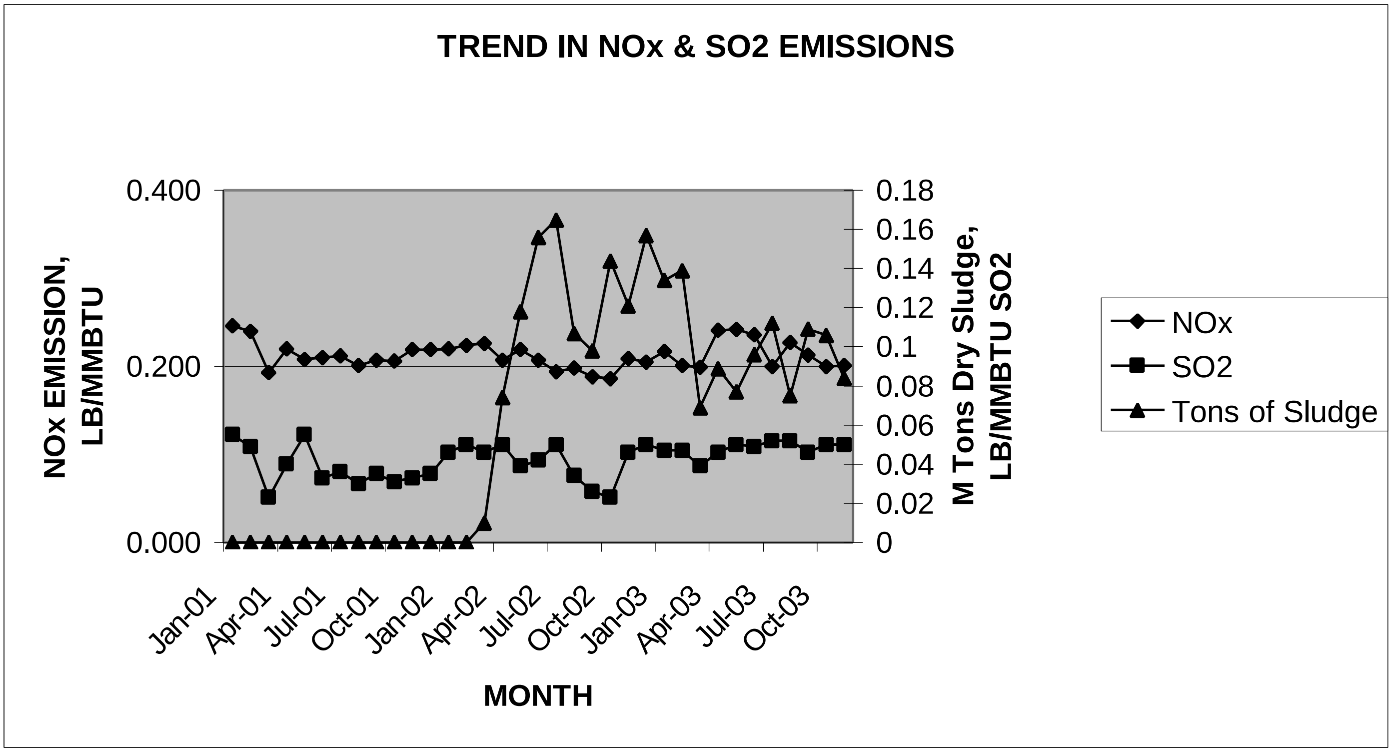
*Report only

Table 4

TRENDS IN NITROGEN OXIDE, SULFUR OXIDE AND CARBON MONOXIDE EMISSIONS
JANUARY 2001 TO NOVEMBER 2003
PIONEER VALLEY RESOURCE RECOVERY FACILITY

MONTH	NOx EMISSION LB/MMBTU	SO2 EMISSION LB/MMBTU	CO EMISSION LB/MMBTU	MM GALLONS SLUDGE	M Dry TONS SLUDGE
Jan-01	0.246	0.055	0.011	0	0
Feb-01	0.240	0.049	0.012	0	0
Mar-01	0.193	0.023	0.022	0	0
Apr-01	0.220	0.040	0.032	0	0
May-01	0.208	0.055	0.030	0	0
Jun-01	0.210	0.033	0.024	0	0
Jul-01	0.212	0.036	0.012	0	0
Aug-01	0.201	0.030	0.033	0	0
Sep-01	0.207	0.035	0.033	0	0
Oct-01	0.206	0.031	0.041	0	0
Nov-01	0.219	0.033	0.028	0	0
Dec-01	0.219	0.035	0.029	0	0
Jan-02	0.220	0.046	0.026	0	0
Feb-02	0.224	0.050	0.025	0	0
Mar-02	0.226	0.046	0.023	0.0625	0.01
Apr-02	0.207	0.050	0.056	0.396	0.074
May-02	0.219	0.039	0.043	0.562	0.118
Jun-02	0.207	0.042	0.041	0.622	0.156
Jul-02	0.194	0.050	0.045	0.819	0.165
Aug-02	0.198	0.034	0.036	0.576	0.107
Sep-02	0.188	0.026	0.038	0.684	0.098
Oct-02	0.186	0.023	0.039	0.612	0.144
Nov-02	0.209	0.046	0.039	0.369	0.121
Dec-02	0.205	0.050	0.035	0.675	0.157
Jan-03	0.217	0.047	0.032	0.387	0.134
Feb-03	0.201	0.047	0.043	0.513	0.139
Mar-03	0.199	0.039	0.040	0.315	0.069
Apr-03	0.241	0.046	0.036	0.322	0.089
May-03	0.242	0.050	0.026	0.342	0.077
Jun-03	0.236	0.049	0.028	0.45	0.096
Jul-03	0.200	0.052	0.038	0.36	0.112
Aug-03	0.227	0.052	0.029	0.365	0.075
Sep-03	0.213	0.046	0.040	0.45	0.109
Oct-03	0.200	0.050	0.042	0.378	0.106
Nov-03	0.201	0.050	0.043	0.329	0.084

Graph 1



Graph 2

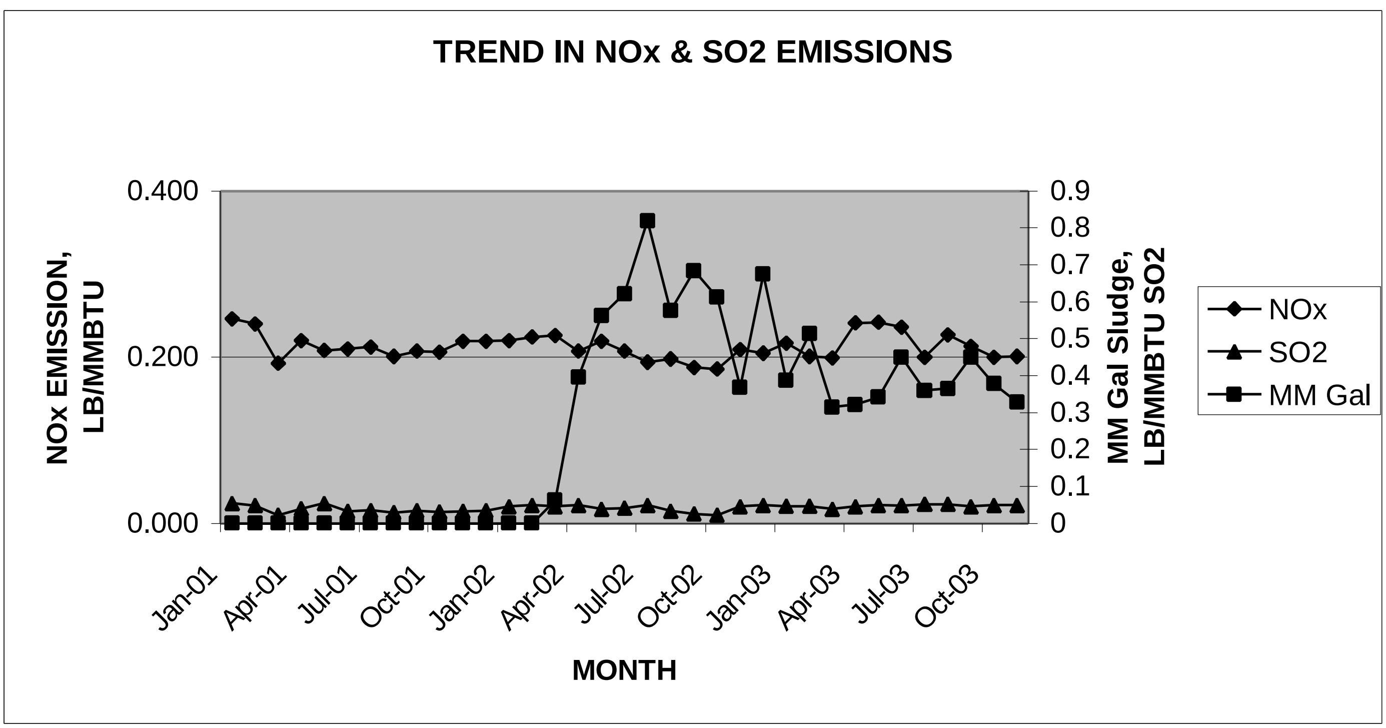


Table 5
Ultimate Analysis - Dry Sludge

Constituent	Percent	ASTM Method
Ash	.98	D-3174
Carbon	46.6	D-5373
Hydrogen	6.44	D-5373
Nitrogen	5.39	D-5373
Oxygen	39.96	D-5373
Sulfur	.63	D-1552

Source: Northampton, MA

Beyond NO_x and particulates, no significant problems were observed with respect to dioxin/furan and carbon monoxide emissions. ***Table 4*** suggests an increase in dioxin/furan emissions; however, the variations are statistically insignificant in comparison with the standard deviation of test results over many years of operation. In all cases, emissions were fractions of the permit limit.

Similarly, carbon monoxide (CO) emissions, which are considered a surrogate indication of dioxin/furan emissions, indicated a statistically insignificant change as shown on ***Table 4***, using monthly average continuous emission monitor results for all three units exhausting through a single stack at the facility. For the 14 months prior to the commencement of sludge co-combustion, CO emissions averaged 0.026 lb/mmBtu compared to the permit limit of 0.11. For the first 21 months of sludge co-combustion, the average was 0.038, which is well within the standard deviation experience depending on variations in facility operation.

Given that sludge co-combustion to date has been with solids content well below design, these results are extremely good. Currently, minor modifications are being made to the distribution of underfire air to compensate for the lower solids material. Initial indications are very encouraging and even better results are expected in 2004.

Market Conditions and Challenges

The greatest challenge to date for the PVRRF SRS has not been a technical issue but rather one of market conditions and the deliberate pace at which municipal wastewater treatment plants modernize and replace equipment. There has not been any shortage of material for combustion in the market area served by the PVRRF. In fact, within 40 miles of the facility, over 100,000 gallons of liquid municipal sludge is produced each day. However, most of the sludge is in the low solids range of 4 to 8%, by weight. Ideally, liquid sludge would be produced at the design solids for processing in the SRS, which is 10- 15%, but within the local market, the highest solid content liquid sludge available is approximately 8%.

To raise the overall solids level, additional sludge types such as FOG and ice cream waste have been added to the mix. These materials have the benefits of high solids (up to 30%), good pumping ability, and a higher heating value than wastewater treatment plant sludge. Research also continues to find other liquid materials suitable for processing in the eco/Tech SRS such as paper mill sludge, textile mill sludge, off spec food waste and liquid restaurant waste. The volume of these materials is several times that of the municipal sludge volume produced in the area. Currently, the methods of disposal for these producers include landfilling, composting or land application.

Another market factor that warrants attention is the apparent unavailability of cost-effective equipment for producing thicker liquid sludge than what is currently produced. Existing thickening equipment, such as gravity belt thickeners (GBT), produce a maximum solids of about 9%. Up to this time, there has been little reason for sludge producers to produce sludge any thicker than that since the current haulers fleet of sludge tankers can't unload it at the disposal facility. Using current methods, if sludge is to be thickened any further, it is "de-watered" by pressing it into a cake of about 25% solids. This cake-like material is hauled in box trailers, or roll-off containers since it is not pumpable without special equipment.

In order to achieve eco/Tech's objectives, several de-watering equipment manufacturers have been invited to develop proposals for a hybrid press. This press would be able to produce liquid sludge in the range desired by PVRRF that is not produced by conventional equipment. One equipment supplier has refined their design and submitted a proposal for what could be the first piece of thickening equipment to produce high solids liquid sludge. When used with eco/Tech's proprietary sludge tanker mentioned previously, the sludge producer will be able to reduce transportation costs significantly, due to the higher solids payload, while also obtaining competitive disposal prices at the PVRRF. Several municipal treatment plants in Western Massachusetts have expressed interest in pursuing these technologies and the resulting benefits.

Design Enhancements – Setting the Stage

eco/Tech is now marketing the SRS to other owners of power plants in the U.S. Meanwhile, design work for the next SRS to be installed at the PRRF, will begin in 2004. Experience gained through two years of operating experience at PVRRF will be incorporated into the design. Several changes will enhance the system performance, such as the use of a bio-filter, or combustion of odorous gases as an alternative to carbon for odor control. Sludge heaters, being tested at PVRRF, will become standard equipment at PRRF. Several other changes will simplify the instruments and control systems.

Research into alternative fluids that can be combusted in the eco/Tech SRS will continue in parallel with the PRRF design process. For example, it has been demonstrated that adding a small amount of used lubricating or cooking oil, can completely offset any heat loss due to evaporating water in the sludge. It is likely that this capability will be incorporated into subsequent eco/Tech SRS projects. Research also continues to refine nozzle designs that will further optimize nozzle performance.

CONCLUSION

Since the eco/Tech SRS began operating in 2002, over 10,000,000 gallons of liquid sludge has been successfully combusted at the PVRRF. There has been no odor complaints from the public. The PVRRF has become a local, cost competitive, alternative for sludge producers who previously had transported sludge out of the area, incurring substantial transportation costs in the process. From a technical point of view, the eco/Tech SRS has been a tremendous success due to its simplicity and low operating costs. Additional work with sludge producers and design firms will result in higher incoming sludge solids content, which will further improve economics for both the resource recovery facility and the sludge producer.