Report

WalCoMet WWTF Digester Gas Utilization Study

Prepared for:

Walworth County Metropolitan Sewerage District
975 W. Walworth Avenue
Delavan, WI 53115

Prepared by:

Earth Tech
4135 Technology Parkway
Sheboygan, WI 53083

June 2004

WALCOMET WWTF
DIGESTER GAS UTILIZATION STUDY

GENERAL

Currently the Walworth County Metropolitan Sewerage District (WalCoMet) Wastewater Treatment Facility (WWTF) utilizes the biogas generated during anaerobic digestion to fuel two existing gas-engine driven primary effluent pumps and a gas-engine driven sand filter feed pump as well as provide fuel to the digester boiler/heat exchanger units. Digester gas in excess of that required to operate the pumps or heat the digesters is flared off by the waste gas burner. The existing gas engines are approaching their design lives and require a substantial amount of maintenance to keep in working order.

With recent attention given to the production and utilization of renewable energy and energy conservation, WalCoMet retained Earth Tech to conduct a digester gas utilization study to determine the most beneficial use of the digester gas generated during the anaerobic digestion process. This study was partially funded through a grant from Wisconsin Focus on Energy.

DIGESTER GAS PRODUCTION AND DIGESTER HEATING REQUIREMENTS

As part of the gas utilization study, gas production rates for the anaerobic digestion process were estimated based on plant data collected for the 12 month period March 2003 through February 2004. Based on the current average sludge loadings and volatile solids reduction, it is estimated that 16.5 ft^3 of digester gas is produced per pound of volatile solids destroyed in the digesters. With an assumed energy value of 650 Btu/ft^3, it is estimated that on average, digester gas with a fuel value of 1,080,800 Btu/hr is generated. Anaerobic digester operating data and digester gas production calculations are presented in Attachment A.

Heating requirements for the raw sludge and the digesters were also calculated. The heating requirements are tabulated in the Table 1.

TABLE 1
ANAEROBIC DIGESTER HEATING REQUIREMENTS

	Winter Conditions	Summer Conditions
Raw Sludge to Digesters	249,100 Btu/hr	113,200 Btu/hr
Digester No.1	67,200 Btu/hr	34,000 Btu/hr
Digester No.2	67,200 Btu/hr	34,000 Btu/hr
Digester No.3	69,500 Btu/hr	35,700 Btu/hr
Total Heating Requirements	453,000 Btu/hr	216,900 Btu/hr

The average annual heating requirement for the raw sludge and the digesters is 334,900 Btu/hr. Calculations of digester heating requirements are presented in Attachment B.

DIGESTER GAS UTILIZATION ALTERNATIVES

Alternatives for best utilizing the digester gas generated in the anaerobic digestion process at the wastewater treatment facility were identified. In each alternative, the existing digester heat exchangers continue to utilize digester gas to provide heating requirements of the anaerobic digesters. The alternatives are as follows:

Alternate No. 1

The facility has two gas-engine driven primary effluent pumps and a gas-engine driven sand filter feed pumps. However, the existing engines are past the end of their design life and require substantial efforts to maintain and keep operating properly. Under this alternative, the existing engines would be replaced with new gas engines. The new engines would be capable of burning digester gas. Figure 1 is a schematic of Alternate No. 1.

Alternate No. 2

This alternate consists of installing a digester gas-fired microturbine system to generate electrical power from the excess digester gas. The microturbine system would include two microturbine generators, gas treatment and compression equipment, a heat recovery unit, and electrical equipment to feed the generated electricity into the plant's electrical system. Heat from the microturbine system would be recovered and used to provide a portion of the total heating requirements for the anaerobic digesters.

In addition to the microturbine generating system, this alternate would include removing the existing gas-fired engines on the pumps. The existing pumps are equipped with electric motors which will allow their continued use without additional modifications. A schematic of Alternate No. 2 is presented in Figure 2.

In developing this alternative, several options were investigated for locations of the new microturbine generating systems. The first option was to locate the new microturbine generating system equipment in the Heat Exchanger Room of the existing Digester Control Building. However, the elevated ambient temperature of this area (which has an adverse impact on microturbine generators) and lack of adequate space for the gas handling and compression equipment associated with the microturbine generating system make this option not viable. This option was eliminated from further consideration.

The second option for locating the microturbine generating system considers locating the new microturbine generating system in the existing Chemical Room of the Administration & Filtration Building. In order to install the microturbine generating system equipment in this area, several modifications to the existing structure would be required. First, in order to meet code requirements, the space would need to be divided into 2 separate areas, one for the microturbine generators and heat recovery unit, and one area for the gas treatment and compression equipment, which would be classified as a Class 1, Division 2 hazardous rated area (electrical classification). In addition to providing a separation of areas, an exterior exit would need to be provided for the area in which the gas treatment and compression equipment is located.

The third option for locating the microturbine generating system considers locating the new microturbine generating system in a new building located adjacent to the existing digesters. The building would be provided with separate areas for the microturbines and heat recovery unit and the gas treatment and compression equipment.

Attachment C includes a summary of the digester gas production and gas utilization for each alternate.

EVALUATION OF DIGESTER GAS UTILIZATION ALTERNATIVES

For each alternate, capital construction costs, annual energy costs, and annual operation and maintenance costs were estimated. The estimated capital, annual, and present worth costs for each alternate are summarized in Table 2. Calculations of the estimated costs for each alternate are included in Attachment D.

Capital construction costs for Alternate 2 assume a financial assistance contribution from the Wisconsin Focus On Energy (WFOE) Program. The amount of the contribution was estimated in accordance with the guidelines presented in WFOE's Renewable Energy Implementation Grant program.

Annual energy costs for Alternate 1 includes estimates of the electrical energy required to operate the primary effluent and sand filter feed pumps during periods when the plant has insufficient gas volume. Per the plant's operating experience, the existing primary effluent and sand feed pumps are required to be operated electrically during the period from April to December for approximately 10 hours per day. In calculating the annual energy costs for the microturbine generating system alternates, annual energy costs includes estimates of the electrical energy required to operate the existing primary effluent and sand filter feed pumps as electric motor driven pumps. Since constructing new primary clarifiers, the need to pump the primary effluent has been eliminated and the primary effluent pumps are now used only as a recirculation pump for the biotowers. According to current plant operation, only one pump, on average, is needed. Therefore annual energy costs are based on the assuming a single primary effluent pump in operation. In addition, an estimate of 15 hp for operating the gas treatment and compression equipment is included for the microturbine generating system alternates.

Operation and maintenance costs for the alternates include an assumed allowance for labor required to operate the pumps on a daily basis. In addition, allowances for major equipment maintenance are included in the O&M costs. For the gas engines, data from the plant was utilized to estimate the annual O&M costs and for the microturbine generating system, estimated costs for contracted maintenance services from the system supplier were assumed.

In evaluating options under Alternate No.2, the impact to the plant operation during construction would be an important consideration. While Option 3 has a higher capital cost, Option 3 would require substantially less disruption to the plant operation than Option 2, which requires extensive remodeling of the existing space in the Administration & Filtration Building. Option 2 also requires installation of site piping across the existing plant access roads in congested areas. In addition, Option 3 incorporates provisions for an additional future microturbine generator as the conditions at the WWTF change.

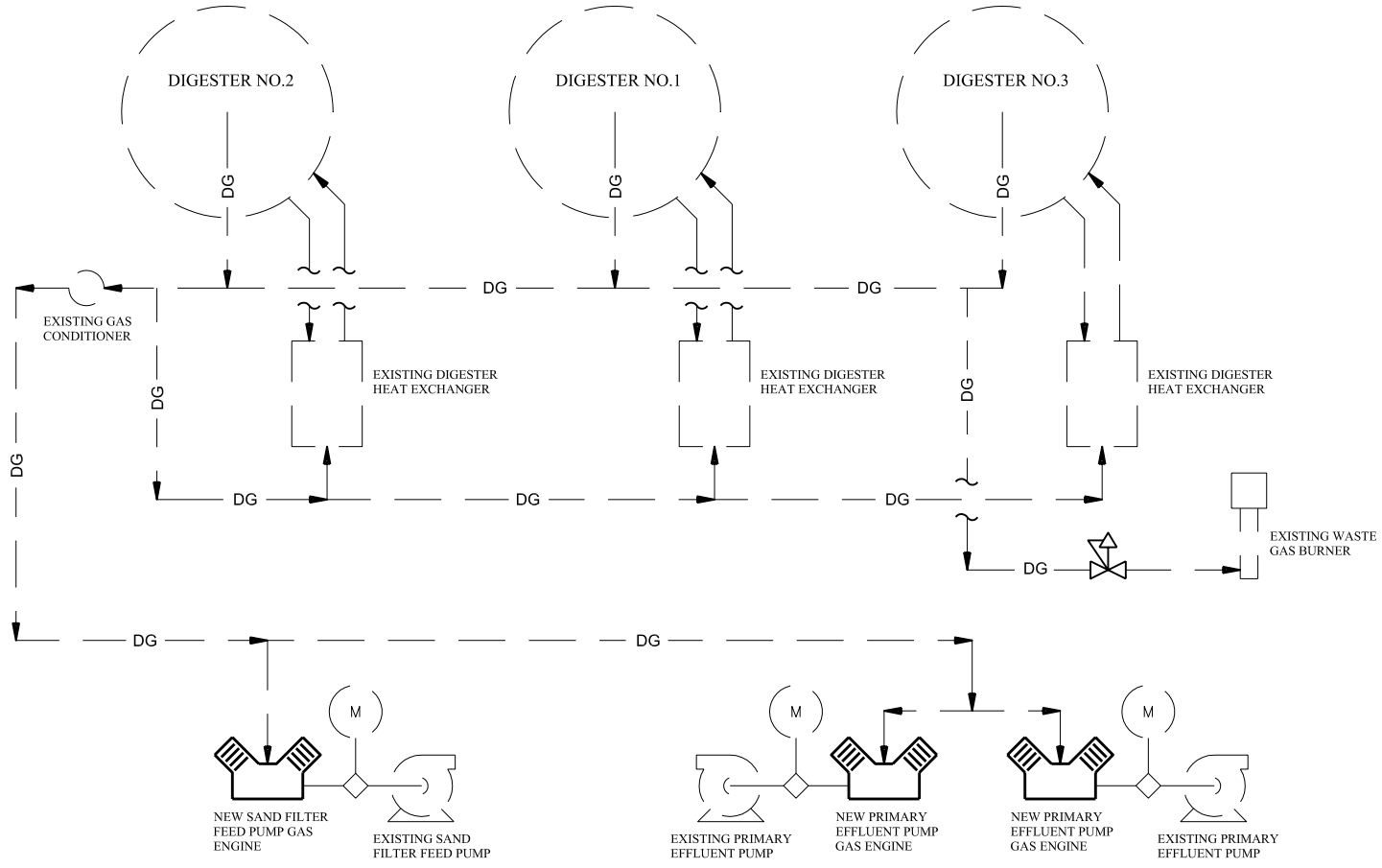
TABLE 2
EVALUATION OF DIGESTER GAS UTILIZATION ALTERNATIVES

Alternate	No. 1	No. 2 Option 1	No. 2 Option 2	No. 2 Option 3
Capital Construction Cost	$198,000	Alternate/Option considered Not Viable and Eliminated from Consideration	$686,700	$739,800
Annual Energy Costs	$0		$1,400	$1,400
Annual O&M Costs	$44,500		$16,600	$16,600
Present Worth	$713,400		$898,300	$951,400

RECOMMENDATION

Alternate 1 yields both the lowest present worth and capital costs among the alternates considered. For WalCoMet to entertain Alternate No. 2 (installation of a microturbine generating system and removal of the pump engines) at this time, it would be driven by reasons other than purely financial, such as environmental stewardship. Alternate No. 2 yields the most beneficial use of the gas generated by the anaerobic digestion process as evidenced by the lower fuel value of the excess digester gas as shown by the calculations contained in Attachment C. Alternate 2 would help reduce the peak energy use at the plant. By reducing magnitude of the electrical energy usage peaks, electrical energy demand charges may be substantially reduced. Alternate 2 is also the state-of-the-art technology for reuse of digester gas and would project a positive, proactive energy conservation program for the WalCoMet WWTF.

As WalCoMet engages in future facility planning to address plant-wide renovation or expansion activities, the concept of installing a microturbine generating system should be revisited. When combined with other physical or operational improvements to your solids processing systems, the economics may change to support this type of system. Especially if you are to consider conversion to a temperature phased anaerobic digestion (TPAD) process, greater quantities of biogas would be produced. Combined with changes in energy costs and future grants or incentives by utilities, the economic feasibility for this system may be more favorable in the future.



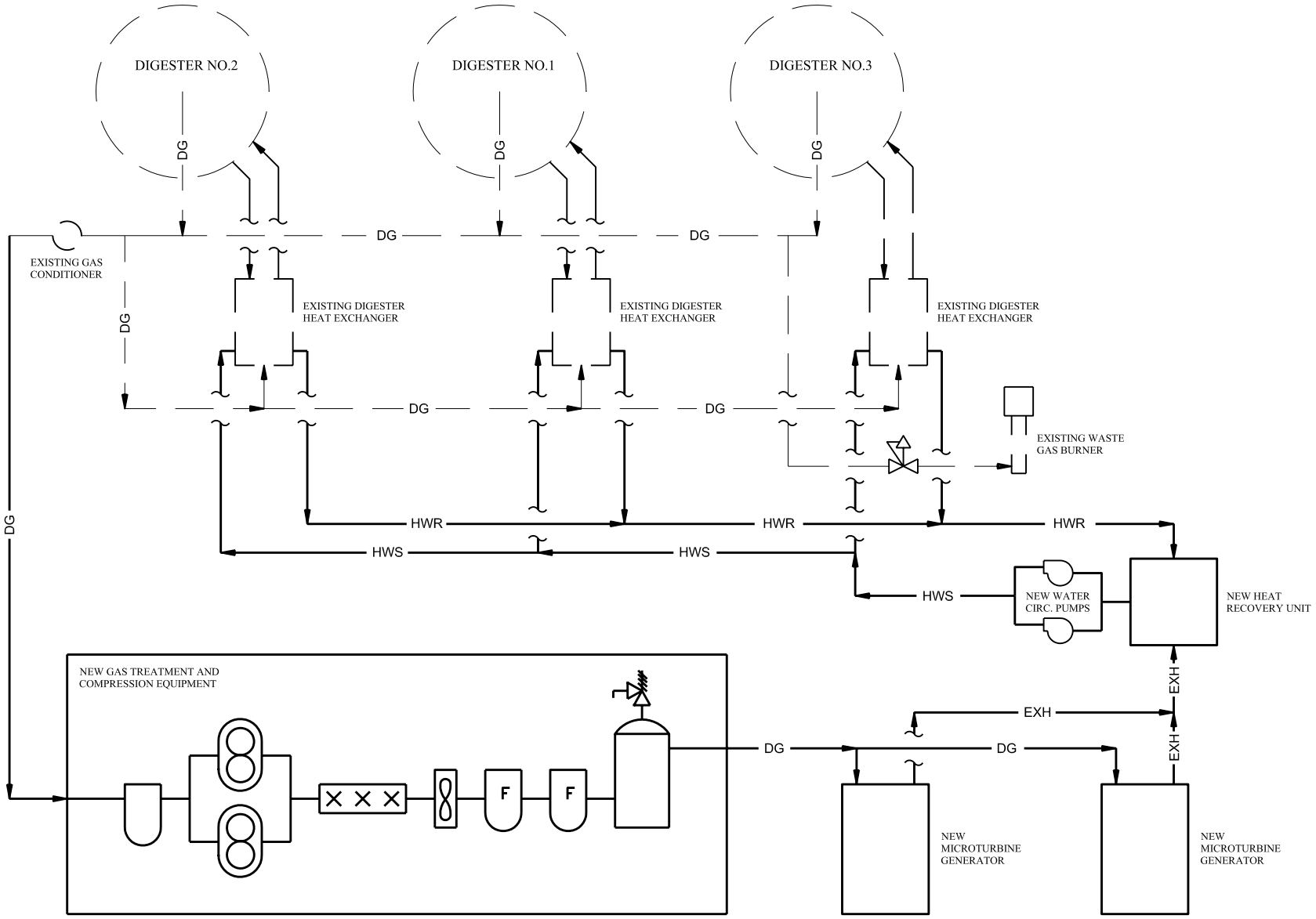
EARTH TECH

Figure 1

Alternate 1
Gas Engine Driven Pumps

WalCoMet WWTF

Digester Gas Utilization Study



EARTH TECH

Figure 2

Alternate 2

Microturbine Generating System

WalCoMet WWTF

Digester Gas Utilization Study

Attachment A

Current Anaerobic Digester Operating Data

and

Digester Gas Production

Attachment A
Anaerobic Digester Operating Data and Digester Gas Production Calculations

Month	Raw Sludge Feed to Digesters, x 1000 gal. Digester No.1	Digester No.2	Digester No.3	Total	Raw Sludge TS	Raw Sludge lbs/d	Sludge Percent VS	Raw Sludge VS lbs	VS Destroyed lbs
Mar-03		174.38	76.70	251.08					
Apr-03		95.29	146.02	241.31	6.77%	136,248	71.96%	98,044	57,846
May-03		138.62	210.33	348.95	6.13%	178,398	71.77%	128,036	75,541
Jun-03		213.54	259.36	472.90	4.82%	190,100	71.52%	135,960	80,216
Jul-03		238.21	269.95	508.16	5.06%	214,446	67.58%	144,922	85,504
Aug-03		231.09	243.49	474.58	4.37%	172,964	70.89%	122,615	72,343
Sep-03		234.90	261.31	496.21	4.45%	184,158	67.49%	124,289	73,330
Oct-03		219.62	239.05	458.67	4.29%	164,106	71.61%	117,516	69,334
Nov-03	146.30	36.41	237.12	419.83	4.71%	164,915	71.42%	117,782	69,492
Dec-03	179.67		222.65	402.32	5.14%	172,465	73.10%	126,072	74,382
Jan-04	157.20		186.09	343.29	6.10%	174,645	74.06%	129,342	76,312
Feb-04	172.89		167.65	340.54	5.78%	164,158	75.59%	124,087	73,211
Total	656.06	1,582.06	2,519.72	4,757.84		1,916,604		1,368,665	807,512
Average	164.02	175.78	209.98	396.49	5.24%	174,237	71.54%	124,424	73,410

Raw Sludge Feed to Digesters =	13,035	gpd
Raw Sludge TS to Digesters =	5,738	lbs/d
Raw Sludge VS to Digesters =	4,098	lbs/d
Average VS Reduction =	59%	
Average VS Destoyed =	2,418	lbs/d
Estimated Gas Production Rate =	16.5	cu.ft/lb VSd
Estimated Gas Volume =	39,905	cu.ft/d
Assumed Fuel Value =	650	Btu/cu.ft
Estimated Energy Value =	1,080,770	Btu/hr

Attachment B

Anaerobic Digester Heating Requirements

Attachment B
Anaerobic Digester Heating Requirements

	Units	Design Average Winter	Summer
Design Temperatures:			
Raw Sludge	deg F	40	70
Mesophilic Sludge Digester Temperature	deg F	95	95
Exterior Ambient Temperature	deg F	15	85
Above Grade Interior Ambient Temperature	deg F	65	85
Below Grade Interior Ambient Temperature	deg F	55	65
Earth Next to Wall	deg F	32	62
Earth Next to Floor	deg F	42	48
Heat Transfer Coefficients:			
Cover Heat Transfer Coefficient	Btu/hr/sf/degF	0.10	0.10
Above Grade Exterior Wall Heat Transfer Coefficient	Btu/hr/sf/degF	0.07	0.07
Below Grade Exterior Wall Heat Transfer Coefficient	Btu/hr/sf/degF	0.12	0.12
Above Grade Interior Wall Heat Transfer Coefficient	Btu/hr/sf/degF	0.86	0.86
Below Grade Interior Wall Heat Transfer Coefficient	Btu/hr/sf/degF	0.86	0.86
Floor Heat Transfer Coefficient	Btu/hr/sf/degF	0.12	0.12

MESOPHILIC DIGESTION HEATING REQUIREMENTS

	Units	Design Average	
Heat Req'mts for Raw Sludge	Btu/hr	249,135	113,243
Heat Req'mts for Digester No. 1	Btu/hr	67,242	33,965
Heat Req'mts for Digester No. 2	Btu/hr	67,242	33,965
Heat Req'mts for Digester No. 3	Btu/hr	69,419	35,680
Total Heating Requirements	Btu/hr	453,037	216,853

RAW SLUDGE HEATING REQUIREMENTS

	Units	Design Average
Raw Sludge to Digesters	gal/d	13,035
Raw Sludge VSS	lb/d	4,098

	Units	Design Average Winter	Summer
Volume of Sludge Feed	gal/d	13,035	13,035
Weight of Sludge Feed	lbs/hr	4,530	4,530
Specific Heat of Sludge	Btu/lb/deg F	1.0	1.0
Heat Req'd For Incoming Raw Sludge	Btu/hr	249,135	113,243

Attachment B
Anaerobic Digester Heating Requirements

DIGESTER HEATING REQUIREMENTS

	Units	Design Average Winter	Design Average Summer
Digester No. 1			
Diameter of Digester	ft	45	45
Portion of Digester w/ Exterior Wall	deg	248	248
Portion of Digester w/ Interior Wall	deg	112	112
Top of Wall Elevation	ft	900.33	900.33
Grade Elevation Around Digesters	ft	884.50	884.50
Bottom of Wall Elevation	ft	872.00	872.00
Bottom of Cone Elevation	ft	868.58	868.58
High Liquid Level	ft	896.25	896.25
Low Liquid Level	ft	892.00	892.00
Average Liquid Level	ft	894.13	894.13
Average Liquid Volume of Basin	gal	276,807	276,807
Grit and Scum Volume Allowance		10%	10%
Effective Digestion Volume of Digester	gal	249,126	249,126
Cover Surface Area of Digester	sq.ft	1,590	1,590
Above Grade Exterior Wall Surface Area of Digester	sq.ft	937	937
Below Grade Exterior Wall Surface Area of Digester	sq.ft	1,217	1,217
Above Grade Interior Wall Surface Area of Digester	sq.ft	423	423
Below Grade Interior Wall Surface Area of Digester	sq.ft	550	550
Floor Surface Area of Digester	sq.ft	1,609	1,609
Heat Req'd for Digester			
Cover Heat Loss	Btu/hr	12,723	1,590
Above Grade Exterior Wall Heat Loss	Btu/hr	5,249	656
Below Grade Exterior Wall Heat Loss	Btu/hr	9,203	4,821
Above Grade Interior Wall Heat Loss	Btu/hr	10,922	3,641
Below Grade Interior Wall Heat Loss	Btu/hr	18,912	14,184
Floor Heat Loss	Btu/hr	10,231	9,073
Total Conduction Heat Loss	Btu/hr	67,242	33,965

Attachment B
Anaerobic Digester Heating Requirements

DIGESTER HEATING REQUIREMENTS

	Units	Design Average Winter	Design Average Summer
Digester No. 2			
Diameter of Digester	ft	45	45
Portion of Digester w/ Exterior Wall	deg	248	248
Portion of Digester w/ Interior Wall	deg	112	112
Top of Wall Elevation	ft	900.33	900.33
Grade Elevation Around Digesters	ft	884.50	884.50
Bottom of Wall Elevation	ft	872.00	872.00
Bottom of Cone Elevation	ft	868.58	868.58
High Liquid Level	ft	896.25	896.25
Low Liquid Level	ft	892.00	892.00
Average Liquid Level	ft	894.13	894.13
Average Liquid Volume of Basin	gal	276,807	276,807
Grit and Scum Volume Allowance		10%	10%
Effective Digestion Volume of Digester	gal	249,126	249,126
Cover Surface Area of Digester	sq.ft	1,590	1,590
Above Grade Exterior Wall Surface Area of Digester	sq.ft	937	937
Below Grade Exterior Wall Surface Area of Digester	sq.ft	1,217	1,217
Above Grade Interior Wall Surface Area of Digester	sq.ft	423	423
Below Grade Interior Wall Surface Area of Digester	sq.ft	550	550
Floor Surface Area of Digester	sq.ft	1,609	1,609
Heat Req'd for Digester			
Cover Heat Loss	Btu/hr	12,723	1,590
Above Grade Exterior Wall Heat Loss	Btu/hr	5,249	656
Below Grade Exterior Wall Heat Loss	Btu/hr	9,203	4,821
Above Grade Interior Wall Heat Loss	Btu/hr	10,922	3,641
Below Grade Interior Wall Heat Loss	Btu/hr	18,912	14,184
Floor Heat Loss	Btu/hr	10,231	9,073
Total Conduction Heat Loss	Btu/hr	67,242	33,965

Attachment B
Anaerobic Digester Heating Requirements

DIGESTER HEATING REQUIREMENTS

	Units	Design Average Winter	Design Average Summer
Digester No. 3			
Diameter of Digester	ft	45	45
Portion of Digester w/ Exterior Wall	deg	240	240
Portion of Digester w/ Interior Wall	deg	120	120
Top of Wall Elevation	ft	900.33	900.33
Grade Elevation Around Digesters	ft	885.00	885.00
Bottom of Wall Elevation	ft	872.00	872.00
Bottom of Cone Elevation	ft	868.58	868.58
High Liquid Level	ft	896.00	896.00
Low Liquid Level	ft	892.50	892.50
Average Liquid Level	ft	894.25	894.25
Average Liquid Volume of Basin	gal	278,294	278,294
Grit and Scum Volume Allowance		10%	10%
Effective Digestion Volume of Digester	gal	250,465	250,465
Cover Surface Area of Digester	sq.ft	1,590	1,590
Above Grade Exterior Wall Surface Area of Digester	sq.ft	872	872
Below Grade Exterior Wall Surface Area of Digester	sq.ft	1,225	1,225
Above Grade Interior Wall Surface Area of Digester	sq.ft	436	436
Below Grade Interior Wall Surface Area of Digester	sq.ft	613	613
Floor Surface Area of Digester	sq.ft	1,609	1,609
Heat Req'd for Digester			
Cover Heat Loss	Btu/hr	12,723	1,590
Above Grade Exterior Wall Heat Loss	Btu/hr	4,882	610
Below Grade Exterior Wall Heat Loss	Btu/hr	9,263	4,852
Above Grade Interior Wall Heat Loss	Btu/hr	11,246	3,749
Below Grade Interior Wall Heat Loss	Btu/hr	21,074	15,805
Floor Heat Loss	Btu/hr	10,231	9,073
Total Conduction Heat Loss	Btu/hr	69,419	35,680

Attachment C

Digester Gas Utilization Alternates
Digester Gas Production and Digester Gas Utilization

Attachment C
Digester Gas Utilization Alternatives
Digester Gas Production and Utilization

	Alternate No.1 New Gas Engines		Alternate No.2 Option 1 Microturbines		Alternate No.2 Option 2 Microturbines		Alternate No.2 Option 3 Microturbines	
Digester Gas Production								
Raw Sludge to Digesters	5,738	lb/d	5,738	lb/d	5,738	lb/d	5,738	lb/d
Raw Sludge Volatile Solids	4,098	lb/d	4,098	lb/d	4,098	lb/d	4,098	lb/d
Volatile Solids Reduction	59%		59%		59%		59%	
Volatile Solids Destroyed	2,418	lb/d	2,418	lb/d	2,418	lb/d	2,418	lb/d
Digester Gas Production Rate	16.5	scf/lb VS_d	16.5	scf/lb VS_d	16.5	scf/lb VS_d	16.5	scf/lb VS_d
Digester Gas Production	39,905	scf/d	39,905	scf/d	39,905	scf/d	39,905	scf/d
Digester Gas Fuel Value	650	Btu/scf	650	Btu/scf	650	Btu/scf	650	Btu/scf
Fuel Value of Dig. Gas Produced	1,080,770	Btu/hr	1,080,770	Btu/hr	1,080,770	Btu/hr	1,080,770	Btu/hr
Digester Gas Utilization								
Dig. Heating Req'mt - Summer	216,853	Btu/hr	216,853	Btu/hr	216,853	Btu/hr	216,853	Btu/hr
Dig. Heating Req'mt - Winter	453,037	Btu/hr	453,037	Btu/hr	453,037	Btu/hr	453,037	Btu/hr
Dig. Heating Req'mt - Average	334,945	Btu/hr	334,945	Btu/hr	334,945	Btu/hr	334,945	Btu/hr
Heat Recovery Credit	0	Btu/hr	288,000	Btu/hr	288,000	Btu/hr	288,000	Btu/hr
Adj. Heating Requirement	334,945	Btu/hr	46,945	Btu/hr	46,945	Btu/hr	46,945	Btu/hr
Utilization System								
Gas Engine Pumps								
Primary Effluent Pump(s)	2							
Sand Filter Feed Pump(s)	2							
Fuel Consumption	15,918	cu.ft/d						
	431,101	Btu/hr						
Microturbines								
Fuel Consumption @ 30kW			433,000	Btu/hr	433,000	Btu/hr	433,000	Btu/hr
No. of Units			2		2		2	
Total Fuel Consumption			866,000	Btu/hr	866,000	Btu/hr	866,000	Btu/hr
Operating Capacity			100%		100%		100%	
Electrical Energy Produced			60	kW	60	kW	60	kW
Heat Recovery			288,000	Btu/hr	288,000	Btu/hr	288,000	Btu/hr
Fuel Value of Excess Dig. Gas	**314,723**	**Btu/hr**	**167,824**	**Btu/hr**	**167,824**	**Btu/hr**	**167,824**	**Btu/hr**

Attachment D

Estimated Capital Construction Costs, Energy Costs, and Operation and Maintenance Costs

Attachment D
Digester Gas Utilization Alternatives
Estimated Capital Construction Costs, Energy Costs, and Operation and Maintenance Costs

	Alternate No.1 New Gas Engines	**Alternate No.2 Option 1 Microturbines**	**Alternate No.2 Option 2 Microturbines**	**Alternate No.2 Option 3 Microturbines**
Estimated Capital Construction Costs				
Remove existing gas engines	$15,000		Not Req'd	Not Req'd
Misc. gas piping removal	N/A	Alternate/Option	Not Req'd	Not Req'd
New gas engines		Not Viable		
No. of Units	3			
Equipment cost	$40,000	Eliminated from		
Installation	$10,000	Further Consideration		
Subtotal	$150,000			
Microturbine system equipment			$166,000	$166,000
Installation			$75,000	$75,000
Digester gas piping mods.			$15,000	$10,000
New hydronic heating loop			$75,000	$25,000
Misc. modications to existing heat exchangers			$30,000	$30,000
Building costs:				
Modification of existing space				
Architectural/Structural			$96,875	
Mechanical			$9,688	
Electrical			$14,531	
Subtotal			$121,094	
New building				
Architectural/Structural				$180,000
Mechanical				$18,000
Electrical				$13,500
Subtotal				$211,500
Subtotal Est'd Capital Const. Costs	$165,000		$482,094	$517,500
Contractor's O&P, Cont., Engr	20%		50%	50%
Total Est'd Capital Const. Costs	$198,000		$723,141	$776,250
Anticipated WFOE Imp. Grant			($33,626)	($33,626)

Attachment D
Digester Gas Utilization Alternatives
Estimated Capital Construction Costs, Energy Costs, and Operation and Maintenance Costs

	Alternate No.1 New Gas Engines		Alternate No.2 Option 1 Microturbines	Alternate No.2 Option 2 Microturbines		Alternate No.2 Option 3 Microturbines	
Estimated Energy Costs							
Electrical Costs							
Pumping:			Alternate/Option				
Primary Effluent Pump(s)	40	hp	Not Viable	40	hp	40	hp
No. of Units	1			1		1	
Sand Filter Feed Pump(s)	30	hp	Eliminated from	30	hp	30	hp
No. of Units	1		Further Consideration	1		1	
Total Pumping HP	70	hp		70	hp	70	hp
Estimated Operating Time	10	hrs/d		24	hrs/d	24	hrs/d
	150	d/yr		365	d/yr	365	d/yr
Microturbine System				15	hp	15	hp
Estimated Operating Time				24	hrs/d	24	hrs/d
				365	d/yr	365	d/yr
Electrical Energy Required	78,225	kWH/yr		554,727	kWH/yr	554,727	kWH/d
Electrical Energy Production	0	kWH/yr		525,600	kWH/yr	525,600	kWH/d
Net Electrical Energy Required	78,225	kWH/yr		29,127	kWH/yr	29,127	kWH/d
Average Energy Rate	$0.049	/kWH		$0.049	/kWH	$0.049	/kWH
Total Estimated Energy Cost	$3,802	per year		$1,416	per year	$1,416	per year

Attachment D
Digester Gas Utilization Alternatives
Estimated Capital Construction Costs, Energy Costs, and Operation and Maintenance Costs

	Alternate No.1 New Gas Engines		Alternate No.2 Option 1 Microturbines	Alternate No.2 Option 2 Microturbines		Alternate No.2 Option 3 Microturbines	
Estimated Operation and Maintenance Costs							
Gas engines							
No. of units in operation	2		Alternate/Option				
Assume operation labor req'mt	7	hr/wk	Not Viable				
Assume labor costs	$25	/hr					
O&M allowance	$1.50	/hr of oper.	Eliminated from				
Operating time	24	hr/d	Further Consideration				
	365	d/yr					
Estimated annual O&M costs	$44,480	per year					
Microturbine system							
Assume operation labor req'mt				7	hr/wk	7	hr/wk
Assume labor costs				$25	/hr	$25	/hr
O&M allowance				$7,500		$7,500	
Estimated annual O&M costs				$16,600		$16,600	
Total estimated O&M costs	$44,480	per year		$16,600	per year	$16,600	per year

Attachment D
Digester Gas Utilization Alternatives
Estimated Capital Construction Costs, Energy Costs, and Operation and Maintenance Costs

	Alternate No.1 New Gas Engines	**Alternate No.2 Option 1 Microturbines**	**Alternate No.2 Option 2 Microturbines**	**Alternate No.2 Option 3 Microturbines**
Present Worth Costs				
Equal Series Present Worth				
Interest (discount) Rate	5.875%	Alternate/Option	5.875%	5.875%
Period	20 years	Not Viable	20 years	20 years
Estimated Annual Energy Costs	$3,802		$1,416	$1,416
Estimated Annual O&M Costs	$44,480	Eliminated from	$16,600	$16,600
Subtotal	$48,282	Further Consideration	$18,016	$18,016
Present Worth Factor	11.5872		11.5872	11.5872
Present Worth Cost	$559,451		$208,751	$208,751
Estimated Capital Costs	$198,000		$689,515	$742,624
Total Present Worth	$757,451		$898,266	$951,375