

## **Rutgers New Brunswick Undergraduate Students**

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Cover pages should be submitted along with the proposals **on or before April 2, 2012** to via email to [bea@marine.rutgers.edu](mailto:bea@marine.rutgers.edu).

**Proposal Title:** Cogeneration Plant Power from Food Waste and Anaerobic Digestion

**Total number of pages (not counting cover pages):** 14

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#### **200 word (maximum) summary of the proposal or video:**

With interest and investment in waste to energy systems increasing by the month, organic “waste” can and should be treated as a commodity – i.e. a product with monetary value on the market – and an increasingly valuable one at that. At the present time, our University incurs significant operating costs in having its organic wastes hauled to external sites that are finding environmentally beneficial and profitable uses for it. Given the opportunity presented by our large campus community here in New Brunswick, the authors of this proposal suggest that the University first partner with local institutions to consolidate their organic waste streams. With a combined waste stream of approximately 29 tons per day during the Spring and Fall semesters and 19 tons per day during the summer and winter breaks, the authors of this proposal demonstrate how installing and operating an anaerobic digester that feeds the campus cogeneration plant with refined biogas to produce energy would be a viable investment. Despite significant capital and operating costs, a digester system producing biogas, electricity, recoverable heat and marketable compost would be a cost effective and profitable method of disposing the University’s organic waste as well as generating alternative energy.

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## **I. Introduction**

The disposal and alternate uses of organic “waste” have recently resurfaced as hot topics within the environmental sustainability arena. With interest in alternate uses having been piqued across the nation in recent years, investment decisions for such projects are often dependent on the ability to secure consistent streams of feedstock for the long term. Organic “waste” can thus be treated as a commodity – i.e. a product with monetary value on the market – and an increasingly valuable one at that.

Despite the increasing consideration of organic waste as a valuable resource, the University has yet to develop a program for its beneficial reuse on campus. Instead, at the present time, the University (a) pays a local farmer to haul its dining hall food waste (10.25 tons/day) to a farm - 105 miles away in Strausstown, PA - where it is treated and used as pig feed; (b) pays to have the organic fraction of waste captured in our student centers (.3 tons/day) hauled away to a composting facility in Delaware (c) hauls the animal manure from campus farms (.4 tons/day) to an external composting site and (d) does not capture organic waste in residence halls or office buildings. While methods a-c are environmentally friendlier alternatives to landfilling the waste, the potential environmental and economic benefits of utilizing organic waste on campus are not at all being realized by our University.

To that end, the analysis in this proposal suggests that the operation of an anaerobic digester that offsets a portion of the campus cogeneration plant’s natural gas consumption with refined biogas would achieve both environmental and economic benefits for the University.

## **II. Brief Background**

Presently, the cogeneration plant on campus uses natural gas (~98% methane) purchased from PSE&G as its main source of fuel. Anaerobic digestion - or the degradation of organic matter in the absence of oxygen - produces a biogas rich in methane (~75% by volume) which could then be purified and used in place of natural gas. In addition, given an appropriately long digestion time (> 20 days) and high temperature (>120°F), residual materials from the digester can be directly combined with a bulking agent such as wood chips and sold as compost or fertilizer additive (Eftoda, 2004).

## **III. Logistics**

The significant drop offs in waste production during the summer and winter sessions have been commonly cited as major reasons for not moving ahead with anaerobic digestion at Rutgers. However, this perspective neglects the opportunity for the University to capitalize on the organic material produced by organizations in New Brunswick that are associated or highly integrated with the Rutgers campuses – namely, Robert Wood Johnson University and St. Peter’s Hospitals, Elijah’s Promise Soup Kitchen, Harvest Moon Brewery, numerous local eateries and neighboring food markets. In order to further balance the digester to cope with the summer decrease, the University’s yard waste and the organic waste stream from summer venues such as Somerset Patriots Stadium could be used to supplement the community waste stream and maintain digester operations at 66% or greater.

The business model of including community and area partners in an anaerobic digestion operation was adopted very successfully in October of 2011 by the [University of Wisconsin at Oshkosh for the operation of their campus digester](#) (follow hyperlink for article). As a result, this project has been widely recognized for its innovative approach to waste management in the community surrounding the University.

The proposed plan is to utilize a University purchased truck to continue the daily pickups of the food waste generated, ground and stored at each of the dining halls. This truck will also be used to pick up organic wastes from the New Brunswick area.

#### IV. Economic Analysis

For the purpose of this analysis, the University continuing to haul away its organic wastes is referred to as the “do nothing” option, whereas installing and operating a digester for organic wastes generated at and near the University is the actionable option.

This analysis differs from ones done in past, in that considerations for capital as well as operation and maintenance (O&M) costs are much more comprehensive. As a result, these costs are significantly higher and more in line with the actual costs of installing and operating a digester in a sub-urban area. The parameters used for this analysis are outlined in Table 1 and are discussed below (detailed calculations in Appendix B).

**Table 1.** Parameters of digester system.

Parameter	Value
Organic waste generated - from animal farms, dining halls, student centers, campus housing, hospitals and local eateries and markets.	29 short tons/day
Compost produced – residuals from digester, treated sufficiently for land application.	888 short tons/year
CH <sub>4</sub> produced – using data from literature	82,000 ft <sup>3</sup> /day
Energy produced - 1000 BTU/ft <sup>3</sup>	12,300 kWh/day
Power generated – 50% efficient reciprocating engine	511 kW
Waste heat generated -	170,000 therm/year

## Organic Waste and Value Added Product Production

According to farm, dining and facilities staff, the amount of organic waste generated in the animal farms, dining halls and student centers amounts to approximately 11 tons per day. We assume that approximately 18 tons of organic waste can be collected from the aforementioned entities on campus and in New Brunswick.

Compost production, biogas production and methane content of biogas after thermophilic digestion (120° F) of food waste for 28 days were based on the widely cited paper from UC Berkeley (Zhang et al 2007).

The heating value of the methane (1035 BTU/ft<sup>3</sup>) was then obtained from an Energy Information Association calculator. The energy and power produced was then calculated based on the 50% efficiency of a reciprocating engine. An American Society of Heating and Refrigeration and Air-Conditioning Engineers publication (ASHRAE, 2004) was then used to determine the amount of waste heat recoverable from the engine of which 30% is used for heating the digester itself.

## Costs and Revenues

The cost of the do nothing scenario is estimated to be \$108,000/per year, which is the amount paid to the farmer.

Unlike a previous report submitted to the REI, the capital costs of this digester are *explicitly for non-farm based systems*. Such systems are significantly more expensive because they include both pre and post-processing machinery (hoppers, grinders, conveyors, compost processing, etc.) and are constructed inside of negative pressure buildings to prevent odor problems.

The information used for this analysis uses the relationship for capital costs developed in a report that compiled case studies of digesters built and operated in non-farm settings (California EPA, 2008). Key to reducing the large capital costs of this system, a NJ Renewable Energy Incentive Program Grant of \$1,500,000 was included in the analysis. Entities are eligible for this grant up to \$2.5 M for combined heat and power (CHP) projects or 40% of the total costs if and only if the project is in a Smart Growth Area and the project owner pays into the Societal Benefits Charge. The latter matter was double checked with University facilities department to confirm that the University does indeed pay the SBC charge on the account that serves the cogeneration plant and this would be eligible for the grant. Furthermore, the area around the cogeneration plant in Piscataway is indeed designated a Smart Growth Area by the State (see Appendix D).

Maintenance costs were assumed to start at \$20/ton (\$173,000/year) and increase by 2% every year; this is inclusive of annual labor, maintenance, materials, testing and insurance costs.

For accepting approximately 18 tons of waste from the community, the system also collects \$45/ton as a tipping fee while costing \$30/ton for the labor and fuel associated with doing so.

The revenue generated by the system stems from the biogas that offsets natural gas, compost and waste heat that are produced. Since it directly substitutes for natural gas consumption, the dollar value of methane produced in the biogas is equivalent to the cost of natural gas used at the central plants - \$1.07/therm. The value of the waste heat captured from the engine is also priced at this level. The compost was also assigned a value of \$.50/lb, which is based on half of what it sells for at local garden centers.

Lastly, in order to claim the rights to the renewable energy generated, the purchase of Class I Renewable Energy Certificates was included at the current rate of \$2/MWh (as of March 30<sup>th</sup>, 2012).

**Table 2.** Costs and revenues from digester system.

Cost	Value
Cost to Do Nothing	\$108,500/year
Total capital cost of digester system – pre-development, construction, all equipment, building and collection truck	\$6,000,000
Renewable Energy Incentive Program Grant	\$1,500,000
Maintenance cost - increasing by 2% per year	\$173,000/year
Tipping fees	\$89,000/year
Value of biogas	\$327,000/year
Value of compost	\$70,000/year
Value of waste heat captured	\$181,000/year
Cost of Class I Renewable Energy Certificates (RECs)	\$9,000/year

## Economic Analysis

The economic analysis for the project was done using a Minimum Attractive Rate of Return (MARR) of 8%, assuming a useful life of 25 years for the digester, \$0 Salvage Value and a 2% increase in maintenance costs per year.

As Table 3 indicates, **the economic analysis for the installation and operation of a digester suggests that it would be a better alternative than the current methods of organic waste disposal.** These calculations are detailed in Appendix B.

Table 3. Value of economic indicators and their significance.

Indicator – Value	Significance
Net Present Value (NPV) of Do Nothing: - \$1,158,215.8	This metric quantifies the value of the investment after 25 years at the given MARR. Projects with NPV < 0 are <b>not</b> acceptable.
Net Present Value (NPV) of Digester: \$292,000	This metric quantifies the value of the investment after 25 years at the given MARR. Projects with NPV > 0 are acceptable.
Discounted Payback Period: 21 years	This metric uses the University's defined Minimum Attractive Rate of Return (MARR) of 8% to determine when the investment pays itself back.
Incremental Rate of Return (IRR): 11.5%	This is the most commonly used metric by businesses in the United States to determine the rate of return on the additional investment required between two options. An IRR > MARR indicates an acceptable project.

## **V. Regulatory Environment for Biomass Projects**

Needless to say, any future decisions will also be influenced by the regulatory environment for alternative energy within the State. On this count, the government of New Jersey recognizes and is fully supportive of cost-effective growth of biomass to energy technology.

The NJ Energy Master Plan, released on December 6<sup>th</sup> 2011, affirms that “energy from waste is an attractive option” and calls for the State to “consider opportunities to support further use of biomass as an energy source and consider innovative mechanisms for the development of new plants that can make use of a variety of biomass types to produce electricity as well as fuels” (NJ EMP, 2011).

“In light of the fact that the tonnage of food waste generated per year in New Jersey is greater than the combined tonnage of old newspapers, glass containers and aluminum cans (three of the most commonly recognized recyclable materials), food waste recycling represents a great opportunity for achieving recycling gains in this state” – NJ Solid Waste Management Plan Update, 2006

Furthermore, New Jersey’s Solid Waste Management Plan Update of 2006 calls for the establishment of programs designed to encourage the increased recycling of food waste. In 2010, the New Jersey Department of Environmental Protection, Bureau of Recycling and Planning, developed a recycling demonstration program in 2010 that provided matching grants to colleges and universities that seek to establish food waste recycling systems on their campuses. The program was funded through the Recycling Tax established in the Recycling Enhancement Act, which includes a provision for funding recycling research and demonstration projects at the State’s colleges and universities (NJ DEP, 2012).

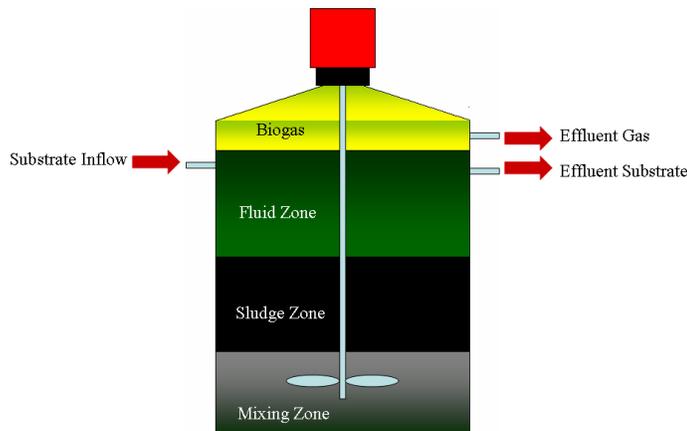
## **VI. Conclusions**

The authors of this proposal can understand the concerns the University has for an anaerobic digestion system - high capital costs, fluctuating waste streams, technology risks, siting concerns and operational challenges from odor and transportation being chief among them. These are undoubtedly some issues beyond the scope of this proposal. However, the New Jersey Office of Clean Energy does offer a feasibility study incentive that would partially offset the cost of doing a comprehensive go or no-go evaluation. The feasibility study for an expected system between .5 and 1 MW would qualify for the lesser of \$50,000 or 50% of the cost of the study.

Throughout the country, there are only a handful of Universities that own and operate an anaerobic digester. It is our hope that the recent leadership of the University of Wisconsin serves as reassurance that a University can cope with a seasonal fluctuation of organic waste and still operate successfully. Given the University’s progressive stance on recycling, the installation of an anaerobic digester could have significant potential to further improve our waste management as well as alternative energy production.

## Appendices

### A. Schematic



**Anaerobic Digester**

### B. Formulas, Assumptions and Calculations (Numbers correspond to Appendix E)

1) Dining Hall Waste Production per Day –

$$20,500 \text{ lbs/day} \times 1 \text{ short ton}/2000 \text{ lbs} = \mathbf{10.25 \text{ short tons/day (8 months of the year)}}$$

2) Animal Farm Waste Production per Day –

$$150 \text{ tons/year} \times 1 \text{ year}/365 \text{ days} = \mathbf{.41 \text{ short tons/day (year round)}}$$

3) Student Center Waste Production per Day –

$$35.82 \text{ short tons}/3.75 \text{ months} \times 1 \text{ month}/30 \text{ days} = \mathbf{.3184 \text{ shorts tons/day (8 months of the year)}}$$

4) Local Waste Production per Day - 18 short tons/day (*assumed to be from RWJUH school and hospital, Local New Brunswick eateries & breweries, dorms and campus apartments and desk side organics recycling*)

5) Total Mass per Day –

$$28.98 \text{ short tons/day} \times 907.18 \text{ kg/short ton} = \mathbf{26,289.49 \text{ kg/day (at peak)}}$$

6) Total Volume per Day –

$$28.98 \text{ tons/day} \times 1 \text{ m}^3/1.201 \text{ tons} = \mathbf{24.13 \text{ m}^3/\text{day}}$$

7) Digester Mass and Volume with residence time of 28 days –

$M = 28.98 \text{ tons/day} \times 28 \text{ days} = \mathbf{811.42 \text{ tons}}$

$V = 24.13 \text{ m}^3/\text{day} \times 28 \text{ days} \times 1.1 \text{ (design factor)} \sim 743.18 \text{ m}^3 = \mathbf{196,326.98 \text{ gallons}}$

**8) Volatile Solids (VS) of Total Waste (TW)-**

$$[1 - \text{Moisture Content (=TS)}] \times [\% \text{ VS of Total Solids (TS)}] \times \text{TW}$$

$$(\text{MC} = 70\%, \text{VS/TS} = 90\%, \text{TS} = (1 - .7) \times (26,289.49 \text{ kg TW/day}) = 7,886.85 \text{ kg/day})$$

$$\text{VS/TW} = (1 - .7) \times (26,289.49 \text{ kg TW/day}) \times (.9) = 7,098.16 \text{ kg VS/day} = \mathbf{7,098,163.6 \text{ g VS/day}}$$

**9) Value of compost grade residual solids -**

value/ton (~ \$80) x tons produced/year = **\$ 71,080.57**

$$\text{tons produced (kg/day)} = (\text{non VS}) + (\text{VS not degraded})$$

$$(\text{VS destruction} = 80\% ^1, \text{VS/TW} = 7,098,163.6 \text{ g VS/day}, \text{VS/TS} = 90\% \rightarrow \text{non VS} = 10\% \text{ of TS})$$

$$\begin{aligned} \text{tons produced} &= (.1 \times \text{TS}) + [(1-.8) \times \text{VS/TW}] = (.1 \times 7,886.85 \text{ kg TS/day}) + (.2 \times 7,098.16 \text{ kg} \\ &\text{VS/day}) = 2,208.32 \text{ kg/day} \times 1 \text{ short ton}/907.18 \text{ kg} \times 365 \text{ days/year} = \mathbf{888.51 \text{ tons/year}} \end{aligned}$$

(1) (Zhang, 2007)

**10) Peak ft<sup>3</sup> of CH<sub>4</sub> produced -**

$$\text{ft}^3/\text{g VS}^{(1)} \times \text{g VS} \times \% \text{CH}_4^{(1)}$$

$$435 \text{ mL/g VS} \times 1 \text{ ft}^3/28,316.85 \text{ mL} \times 7,098,163.6 \text{ g VS/day} \times .75 = \mathbf{81,780.84 \text{ ft}^3 \text{ CH}_4/\text{day (at peak)}}$$

**11) Energy Generation –**

$$\text{ft}^3/\text{day} \times \text{BTU}/\text{ft}^3^{(2)} \times \text{kWh}/\text{BTU}^{(2)} \times 50\% \text{ efficiency of engine}^{(4)}$$

$$81,780.84 \text{ ft}^3 \text{ CH}_4/\text{day} \times 1,025 \text{ BTU}/\text{ft}^3 \text{ CH}_4 = \mathbf{83,825,364.44 \text{ BTU/day}}$$

$$\mathbf{83,825,364.44 \text{ BTU/day}} \times 1\text{kWh}/3,412 \text{ BTU} \times .5 = \mathbf{12,283.90 \text{ kWh/day (at peak)}}$$

\*30 % of waste heat from turbine is used for digester heating – not gas produced from the digester

(2) (United States Energy Information Administration, 2012)

(4) ([http://njchp.rutgers.edu/files/Reciprocating\\_Engines.pdf](http://njchp.rutgers.edu/files/Reciprocating_Engines.pdf))

12) Value of CH<sub>4</sub> produced –

$$\text{BTU/day} \times 365 \text{ days/year} \times 1 \text{ therm}/100,000 \text{ BTU} \times \$1.07/\text{therm}^3 = \mathbf{83,825,364.44}$$

$$83,825,364.44 \times 365 \times 1/100,000 \times 1.07 = \mathbf{\$ 327,379.96}$$

(3) (University Facilities Department, 2012)

13) Power Generation –

$$\text{kWh/day} \times 1 \text{ day}/24 \text{ hours} = \mathbf{511.83 \text{ kW (at peak)}}$$

14) Value of heat produced (\$) -

$$\begin{aligned} & \text{BTU/kWh} \times \text{kWh/day} \times 365 \text{ days/year} \times 1 \text{ therm}/100,000 \text{ BTU} \times 70\% \times \$1.07/\text{therm} \\ & 5,400 \text{ BTU/kWh} \times 12,283.90 \text{ kWh/day} \times 365 \text{ days/yr} \times 1 \text{ therm}/100,000 \text{ BTU} \times .7 \times \$1.07/\text{therm} = \\ & \qquad \qquad \qquad = \mathbf{\$ 181,344.70} \end{aligned}$$

15) NJ REIP Rebate Amount -

$$(\$3/\text{W} \times 500,000 \text{ W}) + (\$2/\text{W} \times 11,800 \text{ W}) = \mathbf{\$1,523,658.71}$$

**Economic Analysis was done: Investing at MARR of 8%, assuming a useful life of 25 years for the digester, \$0 Salvage Value and a 2% increase in maintenance costs per year.**

23) Discounted Payback

Digester	$4,566,540.03 = [(660,232.69 - (2,188,969.11 (A/P, 8\%, 25)))(P/A, 8\%, N)]$
	$4,566,540.03 = [(660,232.69 - (2,188,969.11 (.0937)))(P/A, 8\%, N)]$
	$4,566,540.03 = [(455,126.28)(P/A, 8\%, N)]$
	$10.03 = ((1+i)^N - 1)/(i(1+i)^N)$
	$10.03 = (1.08^N - 1)/(0.08(1.08)^N)$
	$10.03 = (1/0.08) - (1/(0.08(1.08)^N))$
	$10.03 = (12.5) - (12.5/(1.08^N))$
	$10.03 - 12.5 = -12.5/(1.08^N)$
	$1.08^N = -12.5/(10.03 - 12.5) = -12.5/(-2.47)$
	$1.08^N = 5.06 \rightarrow N \times \ln(1.08) = \ln(5.06)$
	$N = 21.07 \text{ years}$

24) Net Present Value

Do Nothing	$= -108,500(P/A, 8\%, 25)$
	$= -108,500(10.6748)$
	$\mathbf{\$ -1,158,215.8}$
Digester	$= -4,566,540.03 + 660,232.69 (P/A, 8\%, 25) - [172,706 \times [1 - (P/F, 8\%, 25)(F/P, 2\%, 25)]/.06]$
	$= -4,566,540.03 + 660,232.69 (10.6748) - (172,706 \times [1 - (.1460)(1.6406)]/.06]$
	$= -4,566,540.03 + 7,047,851.92 - 2,188,969.11$
	$= \mathbf{\$292,342.78}$

**25) Incremental Rate of Return**

PW of equivalent uniform annual costs = PW of equivalent uniform annual benefits

Year	Alternative		Increment
	Do Nothing	Digester	Digester – Do Nothing
0	0	-4,566,540.03	-4,566,540.03
1	-108,500	+455,277.32	+563,777.32
2	-108,500	+455,277.32	+563,777.32
.	.	.	.
.	.	.	.
.	.	.	.
24	-108,500	+455,277.32	+563,777.32
25	-108,500	+455,277.32	+563,777.32

**For digester:**

$$A = (7,047,851.92 - 2,188,969.11) (A/P, 8\%, 25) = 4,858,882.81 \times (.0937) = \mathbf{\$ 455,277.32}$$

PW of costs = PW of benefits

$$4,566,540.03 = 563,777.32 \times (P/A, i, 25)$$

$$(P/A, i, 25) = 4,566,540.03 / 563,777.32 = 8.10$$

From tables,  $i = 11.5\%$  and since  $i (11.5\%) > \text{MARR} (8\%)$ , the investment is the better alternative.

**C. Eligibility Guidelines for New Jersey’s Renewable Energy Incentive Program**

New Jersey’s Clean Energy Program offers rebates through its Renewable Energy Incentive Program (REIP) for behind-the-meter sustainable biomass projects that incorporate either power generation or combined heat and power (CHP) technology. Rebates are based on a \$-per-watt formula related to the system’s capacity, and cannot exceed 30% of the project cost for power generation or 40% of the project cost for CHP.

REIP offers incentives for new equipment only. This would apply to both the installation of a system where none previously existed and or the replacement of an existing system. In the latter case, rebates would be applied only to the cost of new equipment and not to the value of any existing facilities. Eligible installed system cost includes all key system components, installation and applicable interconnection costs. These costs must be documented by vendor invoices and proof of customer payment. REIP rebates are payable in full upon project completion.

## D. Smart Growth Area Designation



STATE OF NEW JERSEY  
**TAKING CARE OF BUSINESS** Site Evaluator

Find a Location **Results**

Results:  
Piscataway Township, Middlesex County

**Environmental** +  
**Economic Growth / Planning** -

- Smart Growth Areas
- Endorsed Plans
- Designated Centers
- Cores
- Nodes
- Critical Environmental Sites
- Historic and Cultural Sites
- Planning Areas
- CAFRA Area
- Pinelands Area
- Highlands Area
- Meadowlands District
- Sewer Service Areas

**Work Force / Demographic** +  
**HMFA** +

**Map** | Map | Aerial Photos

Legend

- Smart Growth Areas
- Nodes

## E. Calculations Spreadsheet

#	Parameter	Value	Value	Value	Notes
1)	Dinig Hall Waste Production - (short tons/day) - 8 months of the year	10.25			
2)	Animal Farm Waste Production - (short tons/day) - year round	0.41			
3)	Student Center Waste Production - (short tons/day) - 8 months of the year	0.32			
4)	Local Waste Production - (short tons/day) - year round	18.00			
5)	Total Mass - (short tons/day) & (kg/day)	28.98	26,289.49		
6)	Total Volume - (m3/day)	24.13			
7)	Digester Sizing w/ RT = 28 days - (tons) & (m3) & (gallons)	811.42	743.18	196,326.98	
8)	VS/TW - (g VS/day)	7,098,163.60			
	Moisture Content	0.70			
	TS (kg/day)	7,886.85			
	VS/TS	0.90			
9)	compost value - (\$/year) = kg/day x 1 short ton/907.18 kg x 365 days/year x \$80/ton vs destruction	0.80		71,080.57	
	residual solids - kg/day = (.1 x TS = non VS) + [(1-.8) x VS/TW]	2,208.32			
	value/ton - (\$/ton)	80.00			
10)	peak ft3 of CH4 produced - (ft3 CH4/day)	81,780.84			
	ft3 CH4/g VS	0.02			
	CH4 Content	0.75			
11)	peak energy generation - (BTU/day) & (kWh/day)	83,825,364.44	12,283.90		
	BTU/ft3	1,025.00			- waste heat from turbine is used for digester heating
	BTU/kWh	3,412.00			
12)	value of CH4 produced (\$)			327,379.96	
	therm/year	305,962.58			-100,000 BTU/therm
	\$/therm	1.07			
13)	peak power generation - (kW)		511.83		
14)	value of heat produced - (\$)			181,344.70	
	BTU/kWh - est. from AHRAE publication_2004	5,400.00			
	therm/year = BTU/kWh x kWh/day x 365d/year x 1 therm/100,000 BTU x 70%	169,481.03			
	\$/therm	1.07			
15)	NJ REIP Rebate amount - (\$)	\$ 1,523,658.71	2,426,079.50	1,523,658.71	
16)	Digester Capital Costs - (\$ - capital cost) & (\$ - O&M cost/MT) & (\$ - O&M cost/year) - from 'current ad tech used for msw' paper	\$ 6,065,198.74	\$ 18.00	\$ 172,706.75	
	p 75 -> capital costs (\$M 2007) = 1.717*(X^.5581); X = 1000 metric tons/y ----->	9.59			
	p 76 -> operating costs (\$ 2007/m ton) = 315.62*(X^-.617); X = 1000 metric tons/y				
17)	Net tipping fee from external waste suppliers (\$/year)			89,394.71	
	amount picked up - (metric ton/year)	5,959.65			
	charge to external customer - (\$/metric ton)	45.00			
	transportation cost - (\$/metric ton)	30.00			
18)	cost of truck	\$ 25,000.00			
19)	NJ Class I REC			8,967.25	
	REC value - (\$/MWh)	2.00			
	energy production (MWh/year)	4,483.63			
20)	net annual operating savings			487,525.94	
20 b)	savings from compost + gas + heat + tipping fee - REC's			660,232.69	
21)	total capital cost	4,566,540.03			
22)	simple payback period (years)		9.37		
23)	discounted payback period (years)		21.07		
24 a)	NPV for do nothing			(1,158,215.80)	over 25 years using 8% as MARR
24 b)	NPV for digester			292,342.78	over 25 years using 8% as MARR
25)	Incremental Analysis		Since $i$ (11.5%) > MARR (8%), the investment in the digester is the better alternative.		

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