Cleveland Public Power
Count on it

SUPPLEMENT FOR THE FEASIBILITY ASSESSMENT REPORT

OF

MUNICIPAL SOLID WASTE

TO

ELECTRIC POWER FACILITY

PREPARED BY:

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CITY OF CLEVELAND
Mayor Frank G. Jackson

October 11, 2009

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1. Executive Summary

In December of 2006, Cleveland Public Power (CPP) completed a five-year strategic business plan that, among other things, recommended the diversification of its power supply mix and recommended the pursuit of local electric generation.

In order to meet the goals of the strategic plan, CPP engaged RNR Consulting to conduct a feasibility study for a Municipal Solid Waste to Energy (MSWE) facility at the City of Cleveland's Ridge Road Transfer Station. The proposed MSWE Facility would utilize gasification and steam compression technologies obtained through Princeton Environmental Group ("PEG"), Inc., and the Kinsei Sangyo Company and generate electricity. If this technology is viable, CPP would not only meet the goal of diversifying its power supply mix and generate power locally but also utilize a renewable source of energy to generate electricity.

RNR Consulting assembled a team of engineers and project managers experienced in technical analyses of gasification technologies, environmental permitting and regulations, traffic studies, financial analysis and community assessments. The Consulting Team, with guidance from CPP's executive leadership and stakeholders, conducted data research through discussions with PEG, reviews of consultant presentations provided by CPP, analysis of existing data on waste collection, contacts with other national and Ohio sites/projects utilizing similar technologies, and discussions and interviews with municipalities for potential MSW agreements. In addition, the Consultant Team conducted intensive industry research regarding the potential economic development opportunities that could result from the success of the MSWE project.[1]

Recommendations from the study included, developing a conceptual layout for facility design, developing a public relations campaign to educate the public on the MSWE facility's benefits and conducting site visits. Based on these recommendations,

[1] Feasibility Assessment Report of Municipal Solid Waste to Electric Power Facility

Cleveland sent a delegation to Japan and China on a fact-finding trip. The purpose of the trip was to supplement the Feasibility Study findings and further understand the gasification technology by:

- Visiting facilities with strong similarities while identifying the feasibility of the proposed project
- Evaluating the economic impact
- Physically observe the gasification technology

The supplemental Report to the Feasibility Study includes an overview of the Japan and China Trip and details the delegation's views, concerns and impressions of the Kinsei Gasification Technology. The following topics are included in the report:

- Trip Itinerary
- Trip Objectives
- Kinsei Gasifier Technology
- Energy Computation formulas
- Economic Development
- Environmental Impact of the proposed Kinsei Gasification Technology
- Photographs relating to the trip
- Outcome of the Trip including impressions, concerns and the benefits of the Kinsei Gasification Technology
- Project Approach and Methodology
- Conclusions and Recommendations

Based on the interviews with the delegation members, nine delegates from the United States traveled together with different thoughts and mixed feelings, but came back with a clear recommendation: move forward to the next phase of the project. The delegation members voiced that the technology would work for the City of Cleveland and at the same time benefit the City in many ways including the creation of new jobs. The economic development potential of the project was confirmed after meeting with a number of advanced energy companies that expressed interest in locating to Cleveland. For instance, the Cleveland delegation met with Scott and Quang Ke of Sunpu – Opto

LED Technology Enterprise a company that focuses on developing LED chip design, LED taping, LED lighting and LED display products and met with Hiroyasu Moriguchi of Marubeni a company that manufactures industrial machinery, to discuss setting up U.S offices in Cleveland, OH. The discussions with these companies confirmed the project's economic development aspirations.

2. Japan and China Trip Overview

The trip to Japan and China was an important follow-up to the MSWE Feasibility study findings. The main purpose of the visit included reviewing gasification facilities in Japan and China. The trip also provided an opportunity for the delegation to ask questions concerning the gasification technology and at the same time confer with the plants management teams and other potential economic development partners. *Attachment A* displays the b*usiness cards from both the Japan and China hosting groups.*

2.1. The Delegation

Below are Cleveland delegates that traveled to Japan and China.

Delegate	***Title***	***Organization***
1. Ivan Henderson	Interim Assistant Director of Public Utilities and Commissioner	Cleveland Public Power
2. Ronnie Owens	Commissioner	Waste Collection
3. Valarie McCall	Chief of Government Affairs	Office of the Mayor
4. Matt Zone	City Councilman	City of Cleveland
5. Jose Hernandez	Consulting Engineer	Cleveland Division of Water
6. Larry Marquis	Project Manager	American Municipal Power Inc. (AMP)
7. Richard Stuebi	Fellow for Energy and Environmental Advancement	The Cleveland Foundation
8. Rahim Rahim	Company Owner/Entrepreneur	RNR Consulting

Delegate	Title	Organization
9. *Peter Tien*	President	Princeton Environmental Consulting

Figure 1: Kinsei Sangyo Facility in Japan[2]

2.2. Trip Itinerary

The trip lasted seven days and included a tour of four facilities, three in Japan and one in China as listed below:

- Kinsei Sangyo Co., Ltd, which is the manufacturer of the gasification technology,
- Marutoku Environmental Services, which is a waste processing facility,
- BML Corporation, which uses gasification to dispose biomedical and hazardous wastes.
- Shanghai Pucheng Thermal Power Plant located in Shanghai, China, which utilizes an incineration process to convert Municipal Solid Waste to power.

[2] Kinsei Group Photo - Courtesy of Cleveland Councilman Matt Zone. Included are representatives from the Kinsei Sangyo Co., Ltd, the Marutoku Facility, Kinsei's Managing Director and his advisor and delegates from Cleveland, Ohio

The delegation left from Cleveland, Ohio on August 22, 2009 and departed from Shanghai, China on August 29, 2009.

Below is an outline of the itinerary.

Itinerary for the Japan / China Trip [3]	
August 22, 2009	
7:30 AM	Depart Cleveland, OH
8:53 AM	Arrive Newark, NJ (Continental Airlines)
11:10 AM	Depart Newark, NJ
1:53 PM (8/23)	Arrive Tokyo, Japan
August 23, 2009	
1:53 PM	Arrive Tokyo Narita Airport, Tokyo, Japan
4:30 PM	Hotel Check-In
6:00 PM	Delegate Briefing

[3] Itinerary Courtesy of Cleveland Councilman Matt Zone (Times listed in the itinerary are local times for those places)

Itinerary for the Japan / China Trip [3]

August 24, 2009	
8:00 AM	Breakfast
8:30 AM	Hotel Check- In
9:00 AM – 10:30 AM	Travel to Ueno Train Station/take train to Takasaki City, Japan
10:30 AM - 12:00 PM	Arrive at Kinsei Sangyo Co., Ltd ♦ Greetings by Masamoto Kaneko, President of Kinsei Sangyo Co., Ltd ♦ Facility Tour ♦ Overview of the Kinsei Gasification Technology
12:00 PM	Lunch
1:00 PM	♦ GB-30 Demonstration ♦ Company history presentation by Kinsei Sangyo
1:30 PM	♦ Discussions with plant management
2:00 PM	♦ Demonstration of the Kinsei Gasification Technology
6:30 PM	Hotel Check-In
7:00 PM	Delegate Briefing
August 25, 2009	
8.00 AM	Breakfast
8:30 AM – 2:00 PM	Depart Takasaki by bus to visit Marutoku Environmental Services/Arrive at the Marutoku Services ♦ Toured the Marutoku facility ♦ Discussions with the Marutoku operating staff & engineers ♦ Question & Answer Session
3:30 PM	Depart Marutoku
August 26, 2009	
8:00 AM	Breakfast
8:30 AM	Hotel Check-out /Takasaki City

Itinerary for the Japan / China Trip [3]	
9:30 AM – 12:00 PM	Travel to Kinsei Sangyo Co., Ltd ♦ Arrive at Kinsei Sangyo Co., Ltd ♦ Technology Overview & System Discussions ♦ Question and Answer Session
12:00 PM	Lunch
1:00 PM	Depart Kinsei by bus
2:30 PM	Arrive at BML Corporation ♦ Introductions & Tour of the Facility ♦ Overview of the Gasification Technology for Medical Waste
4:30 PM	Travel by bus to Ueno Train Station
5:00 PM	Travel by train from Takasaki City, Japan to Tokyo, Japan
6:30 PM	Hotel Check-In
August 27, 2009	
9:00 AM	Breakfast
10:00 AM	Hotel Check-out / travel by bus to Narita International Airport
11:30 AM	Arrive at Narita International Airport
2:00 PM	Depart Tokyo, Japan
4:05 PM	Arrive Shanghai, China through Nippon Airlines
5:00 PM	Travel to the hotel by bus
6:00 PM	Hotel Check-In
August 28, 2009	
8:00 AM	Breakfast
8:30 AM	Travel by bus to Shanghai Pucheng Thermal Power Energy Plant
9:30 AM – 12:00 PM	Arrive at Pucheng Thermal Power Energy Plant Introductions & tour of the facility Welcome and greetings by: ♦ *Yi Chiang Chen, General Manager*

Itinerary for the Japan / China Trip [3]

	♦ *Lu Zhong, Deputy General Manager & Plant Manager* ♦ Overview of Waste to Energy Process ♦ Tour of the facility
12:00 PM	Travel by bus to meet with Shanghai Si Fang Boiler Company Management
12:30 PM	Lunch at Si Fang Boiler Company
1:00 PM – 1:40 PM	Overview of Si Fang Boiler Company (A member of China's Fortune 500) ♦ *Cao Jian Feng, Professorship Senior Engineer* ♦ *Zhu Ying Yue, Manager Engineer*
1:40 PM - 2:10 PM	Overview of Hang Zhou Steam Turbine Company ♦ *Liao Wei Bing, Foreign Trade Department, Assistant Manager Engineer* ♦ *Zhang Yi, Foreign Trade Department, Project Manager Engineer*
2:10 PM - 2:40 PM	Overview of Shanghai Environmental Engineer Design & Research Institute ♦ *Meeting with Wang Xu, the Vice President of the company*
2:40 PM - 3:40 PM	Tour the Shanghai Si Fang Boiler Works Company
3:40 PM - 4:30 PM	Overview of Sunpu-Opto Company
<u>August 29, 2009</u>	
11:00 AM	Hotel Check-Out
12:00 PM	Travel by bus to Shanghai/Pu-Dong International Airport, China
3:45 PM	Board the Continental Airlines from Shanghai, China to Cleveland, OH
10:21 PM	Arrive at the Cleveland International Airport

2.3. Trip Objectives

As noted earlier, the main objective of this trip was to investigate the Kinsei Gasifier Technology, which is intended to be the core element of the Cleveland MSWE Project. The delegation was in a position to observe how the technology worked and to ask questions that had arisen during the feasibility assessment. Below are other objectives for to the visit.

- Inspect Kinsei facilities to validate gasification technology.
- Observe the technology in operation.
- Conduct a field inspection.
- Interview Kinsei personnel to answer questions on the proposed technology.
- Identify proposal strengths and weaknesses through the existing facilities.
- Identify environmental impact to communities.
- Confer with the Gasification Plant Management and potential economic development partners.

3. Kinsei Gasification Technology

Kinsei Sangyo Co., Ltd Japan

3.1. Kinsei Gasifier Technology

Gasification can be defined as the thermal conversion of carbon-based materials, using a limited amount of air or oxygen, to produce synthesis gas, or syngas. Gasification can be used to convert municipal solid waste and other organic waste into useful products, alternative fuels, and clean renewable energy. The process involves gasifying MSW under controlled conditions to turn organic matter into syngas (synthetic gas), which is then combusted to generate steam that drives turbines to produce energy. The Kinsei Sangyo Co., Ltd has received several awards on the performance of the gasification Process such as: (See Attachment B)

- Invention of Dry Distillation Gasification Incineration Device – Sponsored by Institute of Invention Corporation
- Dry Distillation Gasification Incineration Device
- Small and Medium Sized Enterprise Research Center Corporation Prize
- Invention of Dry Distillation Gasification Incineration Device – Certificate of Merit

The technology has the potential to revolutionize the way solid waste is managed, transforming waste that is currently an economic and environmental liability into a valuable commodity and resource. Although gasification technology has been used for many years, Cleveland would be the first application in the United States that employs discrete components that deliver utility in a number of spheres (e.g. brick manufacturing use of syngas to generate electricity, and waste management).

Cleveland's approach would be the first of its kind in the United States that employs discrete components that deliver utility in a number of spheres.

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Figure 2: Kinsei Gasification System in Japan[4]

3.2. Technical Details

1. Gasification of waste occurs in separate chamber from combustion where auxiliary fuel is used for start-up for about 45 seconds.
2. Air burners at the bottom of gasification chamber produce heat and air, which is modulated into the bottom of the bed to maintain precise temperature. (The control system is made by Honeywell, which is a patented system).
3. The material bed "shrinks" as it gasifies, leaving residue of ash.
4. Syngas, which is produced during the gasification process, rises to the top, which will further go through combustion and clean up.
5. Full gasification of waste batch occurs in 3-12 hours (*depending upon chamber size and waste characteristics*)
6. Temperature is slowly increased (from about 800C to about 1000 – 1200C) during gasification process to optimize syngas production.
7. The gasification process becomes self-fueling from syngas until the waste batch is fully gasified.
8. Most combustible wastes are layered at the bottom, and the high moisture content wastes are layered at the top where they then dry as lower layers are gasified.

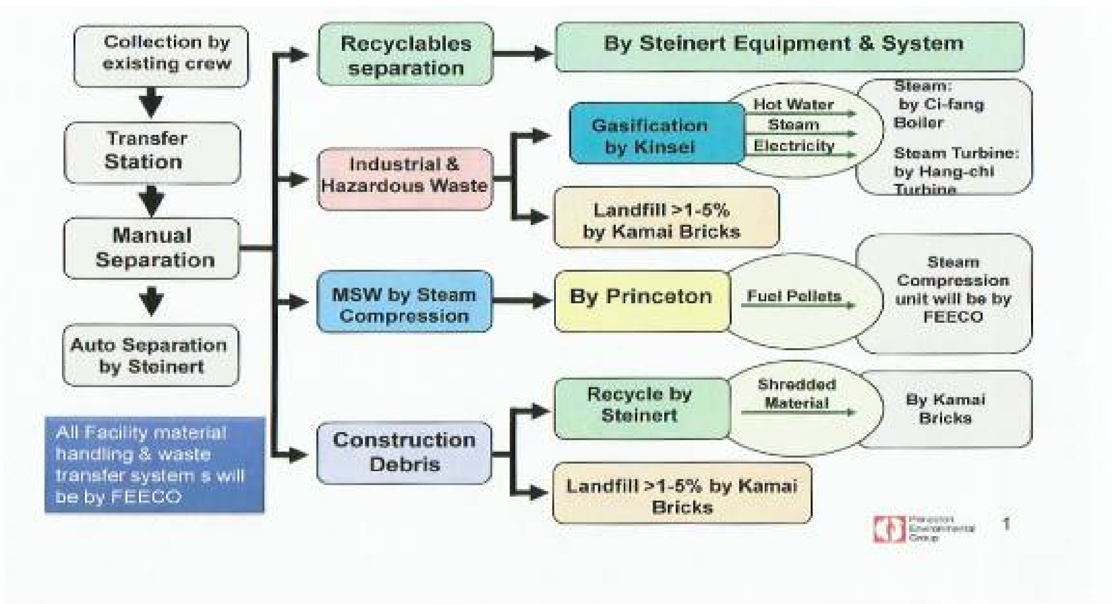
[4] Kinsei Gasification System in Japan – Photo Courtesy of Cleveland Councilman Matt Zone

9. Typically, there are multiple gasifiers for parallel operations such that while one gasifier is processing, the other one is scheduled to start.

In addition to the gasification technology described above, PEG also proposed crushing and shredding of construction debris and adding brick manufacturing to utilize the residual ash.

The integrated approach as proposed by PEG is shown in the diagram below.

Figure 3: PEG Process for proposed MSWE Facility



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3.3. Energy Computations

RNR Consulting in collaboration with a Consulting Engineer who is a licensed P.E. and graduate mechanical engineer from the Cleveland Division of Water conducted independent research to understand how much energy is likely to be produced by gasification of MSW. Below are the findings from this research:

3.3.1. Gibbs Free Energy

The formula:

$\Delta G = \Delta H - T\Delta S$

The change in G is equal to the change in enthalpy (H) subtracted by the Temperature (T) multiplied by the change in entropy (S). Enthalpy can be best described as the available energy within a fluid. Entropy can be best described as the disorder within a system (energy lost).

How it affects the Syngas powered electricity plant:

The Gibbs free energy formula provides several insights into Syngas creation. If **ΔG** is negative the process favors products, if **ΔG** is positive the reactants are favored. Furthermore, if **ΔH** is negative, energy is given off, if **ΔH** is positive than energy is absorbed by the reactants. For the Syngas electric plant this means:

1) For Syngas generation, **ΔG & ΔH** of the trash should be **negative** as their potential decreases as the Syngas is produced.

2) During the process in which Syngas is burned to heat the steam used to power the turbine, the **ΔG & ΔH** of the steam should be positive as the energy of the steam should increase from the burning Syngas.

3.3.2. Syngas

Syngas is synthetic natural gas, having a similar structure and similar properties as natural gas. According to several different Syngas power producers in Europe as well as calculated experimental data from several universities, Syngas has approximately ½ the energy density per volume as natural gas, 0.0182 Mega Joules/ Liter. However, Syngas burns more efficiently than natural gas due to its molecular structure. The Hydrogen is not as tightly bound in Syngas as in natural gas. In simple terms the fuel components that make up Syngas are easier to get to than in methane therefore it burns more efficiently. The make up of Syngas from municipal waste varies depending on the process and composition of the waste. This comparison between Syngas, natural gas, and coal includes averages values of syngas:

Composition:	Coal-Gas[1]	Bio-Gas[2]	Nat. Gas[3]
Hydrogen (H_2)	14.00%	18.00%	--
Carbon Monoxide (CO)	27.00%	24.00%	--
Carbon Dioxide (CO_2)	4.50%	6.00%	--
Oxygen (O_2)	0.60%	0.40%	--
Methane (CH_4)	3.00%	3.00%	90.00%
Nitrogen (N_2)	50.90%	48.60%	5.00%
Ethane (C_2H_6)	--	--	5.00%
HHV (Btu/scf)	163	135	1,002

((1) Steam - Its generation and use, Babcock and Wilcox, pp. 5-20 and 5-21 discussion of coal producer gas. (2) HMI International. Data derived from a fixed bed updraft gasifier design. (3) Steam -- Babcock and Wilcox, p. 5-19.)

The table below shows the average composition of municipal waste in the continental United States from the EPA and can be used to better determine the actual enthalpy and entropy values for Syngas at different temperatures. The composition of MSW is listed below:

Properties of Municipal Solid Waste										
Year	**Percentile**	**Subtotal**	**Paper**	**Textiles**	**Garden Trimmings**	**Food Wastes**	**Plastics**	**Leather and Rubbers**	**Others**	**Incombustibles**
1995	100	84.62	32.17	6.21	5.82	17.94	18.27	0.88	3.34	15.38
1996	100	84.48	30.95	5.05	5.89	18.97	17.83	1.08	4.72	15.51
1997	100	87.5	29.13	5.8	4.86	24.9	19.57	1.13	2.11	12.5
1998	100	86.58	32.77	5.27	4.81	18.29	20.14	0.83	4.54	13.42
1999	100	90.17	35.83	5.2	4.89	21.83	19.85	0.6	1.97	9.83
2000	100	87.34	26.37	6.06	3.36	27.76	22	1.35	0.44	12.66
2001	100	89.38	26.55	4.81	4.06	27.32	21.1	0.48	5.06	10.62
2002	100	90.43	30.01	3.65	4.43	23.34	20.23	0.6	8.17	9.57
2003	100	92.98	32.97	3.78	3.88	27.19	21.36	0.22	3.58	7.02
2004	100	93.57	31.56	4.9	4.91	29.76	20.6	0.87	0.98	6.43
2005	100	95.97	38.64	2.38	1.93	38.15	13.78	0.43	0.67	4.03
2006	100	97.64	44.3	1.84	1.74	34.57	14.63	0.19	0.36	2.36
2007	100	97.61	41.75	3.2	1.83	32.86	17.13	0.51	0.33	2.39
2008	100	97.84	44.54	2.63	1.99	30.56	17.28	0.36	0.48	2.16

Source: EPA and Local Environmental Protection Bureaus
Note: 2005 the *Physical Composition* analysis on moisture base

3.3.3. Formula for Calculating Efficiency of System

(1) Efficiency of Gasification Process alone:

The most simplistic engineering perspective that can be used to evaluate the efficiency of the MSWE facility is to look at the gasification process alone since the steam heater, condenser, regenerators, and steam turbine are all proven technology with rather high efficiencies that do not depend on the fuel type powering them. Several gasification plants operating in Europe and independent university studies agree that on average Syngas has about half the energy density per volume as methane. The energy densities per volume of Syngas and the Kerosene used to produce it are as follows:

Energy density of Syngas per L = 0.0139 MJ/L

Energy density of Kerosene per L = 33 MJ/L

In real world applications, all fluid fuels have a reclamation point (the amount of energy that can be utilized from the potential of the fluid.). Syngas does not have a constant composition as it varies depending on the waste it is created from and as such has no accepted value for reclamation. With no accepted values for Syngas other than its energy density per volume, it is impossible to accurately estimate the amount of heat that is recycled by the system. Based on the previous listed the following assumptions were used in calculating this efficiency:

1) All energy can be reclaimed for both the kerosene and syngas:

2) No heat is recycled to heat the waste necessary to create Syngas.

174.6L of syngas must be created from 1 L of kerosene for system to “break even”. In other words, it takes 174.6L of Syngas to match the energy input of 1 L of Kerosene.

3.3.4. Energy Calculation for the Gasification Process[5]

Assumptions:

600 tons/day or 25 tons/hour or 50,000 lbs/hour

8000 – 10,000 with an average of 9,000 Btu/lb

Princeton assumption of 341 days/year of operation

Gasifier operates at 1700 °F

Flue gas temperature 225 °F

Boiler pressure 250 PSI

Density of air 0.075 lbs/cubic feet

Gasifier efficiency 90%

Specific heat of air is 0.25 Btu/lb

1 Boiler HP = 33,520 Btu

1 Boiler HP generates 34.5 lb of steam

Total Btu available = 25 X 2000 X 9000 = 450,000,000 Btu/hour

Gasifier efficiency 90% = 450,000,000 X 90% = 405,000,000 Btu/hour

Flow from the gasifier to the boiler = 405,000,000/(0.075X 0.25X60X1,700) = 211,764 SCFM

BTU transfer to boiler = 211,764.7 X 0.075 X 0.25 X 60 X 1475(gasifier T – Flue Gas T) = 351,397,058 Btu/hour

Boiler HP generated = 351,397,058/ 33,520 = 10,483 Boiler HP

Steam generated = 10,483 X 34.5 = 361,670 lbs of steam

Efficiency of generator depends on manufacturer design and size. Usually efficiency of this size is between 15 lb – 20 lb of steam to generate 1 kWh. If we use the average number of 17 lb of steam for 1 kWh:

[5] The energy calculations originated from discussions held between the Consulting Engineer from Cleveland Division of Water and URS Corporation. They contain assumptions regarding equipment and process efficiencies and should not be in any way assumed to be accurate for the proposed Gasification Process for Cleveland.

Average 361,670/17 = 21,275 kWh or 851 kWh/ton or **19.87 MW**

851 kWh/ton X 600 tons/day X 341 day/year = 174,114,600 kWh/year / 8760 hours/year = 19,876 KW or **19.87 MW**

361,670/20 = 18,083 kWh or 723 kWh/ton or **16.88 MW**

361,670/15 = 24,111 kWh or 964 kWh/ton or **22.51 MW**

Gasification Efficiency for Direct Burning[6]:

$$\eta_{th} = \frac{(H_g \times Q_g) + (Q_g \times \rho_g \times C_p \times \Delta T)}{H_S \times M_S} \times 100\%$$

$\eta_{th} = gasification\_efficiency(\%)$

$\rho_g = density\_of\_the\_gas(kg/m^3)$

$C_p = specific\_heat\_of\_the\_gas(kJ/kg°K)$

$\Delta T = temperature\_difference\_between\_gas\_at\_burner\_inlet\_and\_fuel\_entering\_gasifier(°K)$

$Q_g = volume\_of\_gas(m^3/s)$

$H_g = heating\_value\_of\_gas(kJ/m^3)$

$H_S = lower\_heating\_value\_of\_gasifier\_fuel(kJ/m^3)$

$M_S = gasifier\_solid\_fuel\_consumption(kg/s)$

[6] The efficiency formula originated from Consulting Engineer from Cleveland Division of Water's internet research. They are calculations for coal gasification processes and should not be in any way assumed to be accurate for the proposed Gasification Process for Cleveland.

3.4. Solid Waste Processing Facility Designs [7]

Facility design for solid waste processing offers flexibility in making design considerations. As the City considers space and location of the facility, questions on the design of the facility are going to be a major issue. A model facility design in Figure 5 shows a truck dumping trash in a dumpster, which is then picked up by mechanical claws and emptied in an incinerator. The claw assembly allows for ease of movement in picking up trash, hauling it to the incinerator and returning to collect more trash. ***It should be noted that the City of Cleveland will not use this process.***

Figure 4: A five-ton claw that picks up three tons per grab

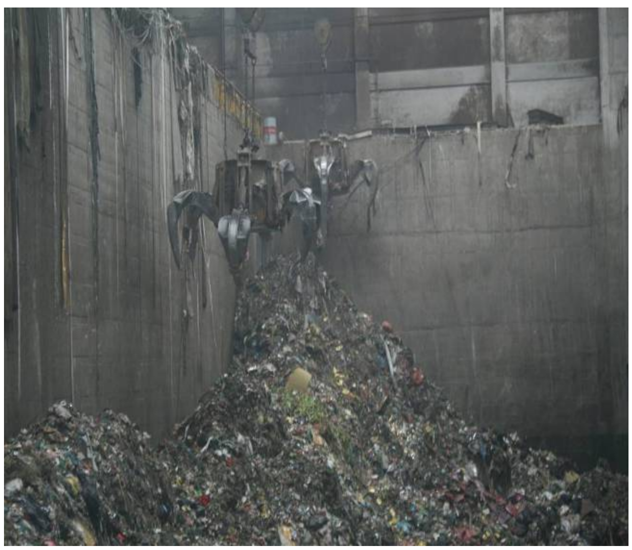

Figure 5: A model facility

[7] Facility Processing Designs – Photo Courtesy of Cleveland Councilman Matt Zone

The following figure shows a dumpster at the BML Corporation facility lifted by a crane, which will then dump the trash in to a gasifier. The chain mechanism consists of multiple flattened chains that lift the dumpster from the ground and carry it to the gasifier.

Figure 6: Dumpster lifted by a crane

Figure 7: Mechanism for the delivery and return of the chains and dumpsters at the Marutoku facility

Marutoku Facility, Japan

The Marutoku Facility, which utilizes Kinsei Sangyo's patented gasification technology, is a well-known waste processing facility located in an environmentally sensitive area in Japan. The Marutoku facility has been in operation for seven (7) years. The facility engages in hazardous/industrial waste collection, separation, gasification, and disposal. The plant operates two 60-ton gasifiers per day under five employees, two shifts of two full-time operators and one part-time employee. However, the number of employees does not include the feedstock preparation staff.

BML Facility, Japan

The BML Facility, which has been in operation since April 2006, is located in Tokyo Japan adjacent to residential neighborhoods. It uses gasification technology to process and dispose biomedical, and hazardous wastes.[8] The BML facility has two gasifiers and is a clean well-kept facility. The delegates were also impressed by the operation and the general facility layout.

***Figure 8:* Biomedical waste packaged in brown boxes**[9]

[8] BML Company Literature

[9] Biomedical Waste - Photo Courtesy of Cleveland Councilman Matt Zone

Figure 9: Hazardous waste packaged in black boxes

3.5.Shanghai Pu-Tung Trash to Energy Technology

The purpose of the trip to Shanghai Pu-Tung facility in China was to observe the sorting process used to produce syngas from MSW and the production of power from the syngas. The plant has been in operation for six years and has three boilers and two steam turbines. The delegates visited Shaghai, China to observe the gasification process. The Pu-Tung Trash to Energy facility is 90% compliant with the EU standards and has had no known incidents. The Pu-Tung facility is the first trash to energy conversion facility in China and utilizes an incineration process to convert MSW to power. It incinerates more than 1000 tons of trash per day converting about 17 MW of energy.

Figure 10: A Shanghai Pu-Tung model facility

4. Economic Development

The City has undertaken reforms and steps towards improving the economic condition of Cleveland by promoting advanced energy portfolio standards to help support the local advanced energy economy and to promote the use of clean energy resources. The City thus serves as a foundation to nurture the growth of the advanced energy technology industry. The City's through its economic development team, has also managed to assist businesses to grow through research and discoveries into new companies and jobs.

One of the trip objectives was to confer with the project technology members and to meet other potential economic development partners. These firms were targeted based on their likelihood to provide social and environmental benefits, including employing local residents and paying them higher wages, at reasonable costs. Not only would this development opportunity give Cleveland residents opportunities and real access to jobs, but also facilitate the development of local advanced energy companies. Below is a brief outline of some of the companies that expressed interest in establishing offices in Cleveland.

Kinsei Sangyo Co., Japan

Kinsei Sangyo Company is a privately owned company in Japan founded in 1967 by Masamoto Kaneko who is the president. Kinsei Sangyo Company has been in operation for 42 years; and develops, designs, and manufactures incinerators such as the Dry Distillation Gasification Combustion Systems, patented in Taiwan, Singapore, Korea, Indonesia, China and European Union. The company has over two hundred gasifiers in operation, which are mainly located in Japan, and is seeking to set up offices in Cleveland. This will benefit both Kinsei Sangyo Company, which will extend its market share in North America and the City of Cleveland advantage of economic development and creation of jobs.

Figure 11:A Kinsei Sangyo Company Gasification System

Figure 12: The delegation at the Kinsei Sangyo Company

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Sunpu-Opto – LED Manufacturer, China

Sunpu was established in 1990 and has become a top LED technology enterprise that focuses on developing LED chip design, LED taping, LED lighting and LED display products. In the market, Sunpu LED is mainly used in traffic lights, display, indoor lighting, outdoor lighting, automobile, decoration, mobile phone, PDA backlight just to name a few. Sunpu specializes on independent innovation to realize green, energy-saving light.[10]

Cleveland Public Power is adapting new energy – saving lighting by launching their new Energy Efficiency and Conservation unit. During the 11th Congressional District Caucus Parade on Labor Day, CPP provided consumers with education on how they can expect significant savings through Energy Efficiency & Conservation. The consumers were given the opportunity to enter into a drawing to receive a "whole house lighting makeover" to replace all incandescent light bulbs with compact fluorescent light bulbs. CPP also intends to initiate a pilot program where it will measure the consumer's power usage with the more efficient compact fluorescent light bulbs and compare it to their prior usage with incandescent bulbs[11].

LED, which is mainly used in traffic lights and indoor lighting among others, would benefit the City of Cleveland at this time as it seeks to launch its new energy efficiency and conservation unit. The LED technology would have the following economic advantages for Cleveland:

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[10] LED Manufacturer – Company Literature
[11] http://cppcountonit.wordpress.com/2009/09/04/join-cpp-at-the-11th-congressional-district-caucus-parade-on-labor-day/

- It is compatible with the current sentiment of supporting renewable energy.
- LED technology also reduces carbon since LED requires less energy.
- The LED light bulbs have are low maintenance since the lifetime is as much as 10 times longer than conventional lighting. This in turn reduces overhead and material costs.

HTC (Hangzhou Steam Turbine) – Multi-Stage Industrial Steam Turbine, China

Hangzhou Steam Turbine Co. Ltd, established in 1958, is the biggest industrial steam turbines producer in China. It is the key research and production base for industrial steam turbine in China. The corporation introduced the designing and manufacturing technology of industrial steam turbines from Siemens, Germany in 1970.[12]

HTC can benefit the City of Cleveland in creation of jobs and in the design and manufacturing of the steam turbines for the MSWE Project. This can also bring businesses from other states generating revenue for the City.

[12] Hangzhou Steam Turbine Co. Ltd. Literature

Shanghai Si – Fang Boiler Works (SFBW), China

Shanghai Si – Fang Boiler Works located in China, was founded in 1931. The company specializes in industrial boilers and pressure vessels. The first water tube boiler was manufactured in SFBW, which makes the company a cradle of industrial boilers in China. SFBW is a licensed boiler works company through the General Office of National Quality Supervision Inspection Quarantine and certified by quality system of GB/T 19001-2000 – ISO 9001:2000. The company has also obtained certificates of authorization from the American Society of Mechanical Engineers (ASME).

SFBW's products cover a variety of quality and high efficiency and energy-saving boilers, which include:

- Corner-tube boiler
- Oil/gas fired boiler
- Double drums boiler with traveling grate
- Biomass fired boiler
- Waste heat boiler
- Thermal recovery steam generator for oil fields
- Municipal solid refuse incineration boiler

The company has more than seventy years in experience in designing and manufacturing boilers and pressure vessels and has exported its products to different parts of the world including: Canada, Australia, Germany, Japan, Iran and many others. The company expressed strong desire to set up offices here in Cleveland, which would be a great opportunity for job creation.

Figure 13: The Delegates with the Shanghai Si – Fang Boiler Works Company staff

Figure 14: A boiler at the manufacturing plant in SFBW

5. Environmental Impacts

5.1. Gasification is an Environmental Solution

With the increased challenge to reduce landfills and promote environmental sustainability, gasification technology may offer a solution. The technology can enhance the City of Cleveland's energy portfolio by:

- Creating less air emissions –gasification plants produce significantly lower quantities of air pollutants
- Using less water - gasification plants use significantly less water than traditional coal-based power generation plants, and can be designed so that they recycle their process water.
- Gasification generates less waste than most traditional energy technologies
- Gasification can reduce the environmental impact of waste disposal utilizing waste products as feedstock and generating valuable products such as decorative bricks, from materials that would otherwise be disposed as wastes.
- Several tests have shown that gasification's byproducts are less hazardous and therefore readily marketable.
- According to the U.S. Department of Energy, gasification offers the cleanest and most efficient means of producing electricity. It also offers the lowest cost option for capturing Carbon Dioxide (CO_2) from power generation.

The following figure shows a Kinsei gasifier located in a residential area. This facility is a testament to the fact that environmental safety is not compromised by having a waste processing facility close to a residential area.

Figure 15: A Kinsei gasifier facility in close proximity to a residential community

6. Gasification Photographs[13]

Photographs

Figure 16: Kinsei Model System in Japan in close proximity to a residential area

[13] Photographs Courtesy of Cleveland Councilman Matt Zone

Figure 17: Kinsei Gasification Facility in Japan in close proximity to a residential area

Figure 18: A Kinsei Gasification Plant

The photograph above was taken to capture the height of the Kinsei manufacturing plant. It was noted that the proposed MSWE Plant in Ridge Road has sufficient height to accommodate the proposed gasification system.

Figure 19: Packaged Trash in Kinsei Gasification Chamber

Figure 20: Gasification Chamber under intense heat of about 1200 degrees centigrade and above

Figure 21: Ash and organic and non-organic remnants from gasification process – The ash can be utilized to produce decorative bricks, road paving materials and thus generating additional revenue for the City.

Figure 22: Ash and organic and non-organic remnants from gasification process

Figure 23: A kinsei gasification system

Figure 24: Sample of a brick made from the Ash

Figure 25: Sample of tire remnants after undergoing the gasification process, which comprises of about 17% tire ash

7. The Outcome of the Japan/China Trip

7.1. Impressions

Interviews were conducted with many of the trip delegates. The delegates indicated that the trip to Japan and China was successful. We have included quotes, gathered during the delegate interviews, to provide an indication of their impressions:

- "Eliminated any doubts of the gasification technology viability in Cleveland" (*Larry L. Marquis, Vice President of Project Development, American Municipal Power Inc.*)
- "Better understanding and a higher comfort level that the technology can work for the City of Cleveland" (*Matt Zone, Councilman, City of Cleveland)*
- "gasification technology is an applied and working technology" (*Jose N Hernandez, Consulting Engineer, Department of Public Utilities Division of Water)*
- "The gasification technology can be tailored to suit the needs of the City of Cleveland"(*Jose N Hernandez, Consulting Engineer, Department of Public Utilities Division of Water)*
- "It works. The sorting process was phenomenal"(*Ronnie M Owens, Commissioner, Department of Public Service, Division of Waste Collection and Disposal)*
- "Looks feasible" *(Jose N Hernandez, Consulting Engineer, Department of Public Utilities Division of Water)*
- "The gasification technology is a feasible project for the City of Cleveland" (*Larry L. Marquis, Vice President of Project Development, American Municipal Power Inc.*)

- "Eliminated any doubts of the gasification technology viability in Cleveland" (*Larry L. Marquis, Vice President of Project Development, American Municipal Power Inc*)
- "The trip to Japan provided a better understanding of the gasification technology in action" (*Richard Stuebi, Fellow for Energy and Environmental Advancement, Cleveland Foundation)*

7.2. Benefits

Listed below are quotes from the delegate interviews in which the delegates voiced their thoughts regarding the potential benefits of the MSWE facility based on their observations

- "There is a reduction in waste collection cost" *(Ivan Henderson, Commissioner, Cleveland Public Power)*
- "Landfill reduction" (*Ronnie M Owens, Commissioner, Department of Public Service, Division of Waste Collection and Disposal)*
- "Acquisition of a system that will provide green energy for the City of Cleveland" *(Larry L. Marquis, Vice President of Project Development, American Municipal Power Inc*)
- "Generation of revenue from recyclables" (*Matt Zone, Councilman, City of Cleveland)*
- "Create Jobs" *(Ivan Henderson, Commissioner, Cleveland Public Power)*
- "Increased efficiency in the way waste is collected and processed" (*Ronnie M Owens, Commissioner, Department of Public Service, Division of Waste Collection and Disposal)*
- "gasification uses less oxygen" (*Ronnie M Owens, Commissioner, Department of Public Service, Division of Waste Collection and Disposal)*
- "The syngas produced will be used to generate energy more efficiently" (*Ronnie M Owens, Commissioner, Department of Public Service, Division of Waste Collection and Disposal)*
- "Every ton of waste material used in pellets reduces the rising costs associated with waste disposal**"** (*Ronnie M Owens, Commissioner, Department of Public Service, Division of Waste Collection and Disposal)*
- "The trip provided opportunity to see each system component from start to finish" (*Matt Zone, Councilman, City of Cleveland)*

7.3. Concerns

During the interviews, the delegates provided the questions and concerns that they had before the embarking on the trip and the new questions generated by their observations during the trip. The table on the following page provides the list of the delegate's questions both before and after the site visits:

Questions and Concerns before and after the Japan / China Trip	
Questions before the Japan / China Trip	Questions after the Japan / China Trip
♦ What is the credibility of the Gasification Process in Japan/China? ♦ What makes the Kinsei gasification process different from other gasification processes? Is it unique? ♦ What is the efficiency of the Kinsei gasification process? ♦ Where will the Kinsei gasification equipment for Cleveland be manufactured? ♦ What are the expected air emissions from the system? ♦ What level of operation, maintenance, staffing and training is needed? ♦ What other installations does Kinsei have? What is their size? What is their feedstock composition? ♦ What is the expected maintenance schedule and recurring maintenance cost for the equipment? ♦ What are the Kinsei's requirements before designing a gasification system? ♦ What is the difference between the processes we were shown in Japan / China and what we are proposing? ♦ What is the maximum recommended feedstock moisture level? ♦ What kind of MSW conditioning or pretreatment is required before gasification?	♦ What would the general operational scheme/layout be for the Cleveland system? ♦ What is the expected parasitic energy load? ♦ What will be the net power generation capacity? ♦ What will be the net excess steam generation capacity? ♦ What are the measured emissions from installed Kinsei gasification systems? ♦ Who, how, where will the equipment be manufactured? ♦ What information does Kinsei require for the Waste Composition Study prior to design? ♦ What are the type and energy requirements of the steam compression process? ♦ How will the City address any noise from the plant and odor that might come from the garbage on the floor? ♦ How will the City mitigate any potential water run-off from the plant? ♦ What is the overall impact of traffic on immediate neighborhood? ♦ How will the City communicate support and acceptance of the gasification technology system? ♦ There have been incidents of explosions in municipal trash incinerators that eventually shut down; for instance, in Akron Ohio, in 1984 where an explosion killed three people. How will the City and the EPA change the perception of the public assuring them that the gasification process is a safe and practical technology? ♦ Will the City be in a position to acquire the amount of feedstock needed to generate energy? ♦ How will the city finance the MSWE Project?

Questions and Concerns before and after the Japan / China Trip	
♦ What types of waste cannot be gasified? ♦ What is the minimum feedstock bulk energy content? ♦ What is the gasification ash composition? ♦ What is the composition of the syngas? ♦ Is there any wastewater generated from the gasification process? ♦ What safety/control devices are needed? ♦ What are the equipment failure modes? What are the measured emissions from the Kinsei gasification units?	

8. Financial Analyses

RNR Consulting reviewed the financial data contained in the Feasibility Assessment report in order to update it with information acquired from the facility visits in Japan and China. In addition, we developed two Net Present Value (NPV) models, one with brick manufacturing assuming 100% financed by the City and the other with brick manufacturing assuming 50% financed by the City and 50% financed by Federal and/or State grants. The financial data analysis is represented in Attachment C. Following is a discussion of the updates made to the financial data contained in the Feasibility Assessment report:

8.1. <u>Initial Capital Outlay</u>

After reviewing the financial data from the Feasibility Assessment Report and discussing the findings with the Commissioner of CPP, the Initial Capital Outlay was reduced by 6%.

8.2. <u>Revenue from Fuel Pellets</u>

Revenue prices for the fuel pellets were increased from $22 per ton to $45 per ton. The initial price was derived from research conducted for the MSWE Feasibility Assessment; however, during the site visits, the delegation verified that the fuel pellets created through the steam compression process generates a heating value (Btu per lb) similar to coal. Based on this finding, RNR Consulting verified the average 2008 market price of fuel in Ohio at $41.40[14] per ton. Additionally, PEG estimated a fuel pellet price of $45 per ton. Therefore, for purposes of the NPV analysis, RNR Consulting utilized a fuel pellet price of $45 per ton. Data for average coal prices are presented below as reference[15]:

[14] Prices of coal were obtained from the Energy Information Administration website at www.eia.doe.gov

[15] The table was obtained from the Energy Information Administration website at www.eia.doe.gov

Table 31. Average Sales Price of Coal by State and Coal Rank, 2008
(Dollars per Short Ton)

Coal-Producing State	Bituminous	Subbituminous	Lignite	Anthracite	Total
Alabama	71.31	-	-	-	71.31
Alaska	-	W	-	-	W
Arizona	W	-	-	-	W
Arkansas	W	-	-	-	W
Colorado	W	W	-	-	32.67
Illinois	40.30	-	-	-	40.30
Indiana	34.95	-	-	-	34.95
Kansas	W	-	-	-	W
Kentucky Total	51.32	-	-	-	51.32
Eastern	56.63	-	-	-	56.63
Western	35.53	-	-	-	35.53
Louisiana	-	-	W	-	W
Maryland	42.19	-	-	-	42.19
Mississippi	-	-	W	-	W
Missouri	W	-	-	-	W
Montana	-	W	W	-	12.31
New Mexico	W	W	-	-	33.16
North Dakota	-	-	12.92	-	12.92
Ohio	41.40	-	-	-	41.40
Oklahoma	47.72	-	-	-	47.72
Pennsylvania Total	50.52	-	-	60.76	50.77
Anthracite	-	-	-	60.76	60.76
Bituminous	50.52	-	-	-	50.52
Tennessee	48.94	-	-	-	48.94
Texas	-	-	18.16	-	18.16
Utah	26.39	-	-	-	26.39
Virginia	84.57	-	-	-	84.57
West Virginia Total	60.21	-	-	-	60.21
Northern	43.95	-	-	-	43.95
Southern	65.87	-	-	-	65.87
Wyoming	W	W	-	-	11.39
U.S. Total	**51.40**	**12.31**	**16.50**	**60.76**	**31.26**

- = No data are reported.
W = Data withheld to avoid disclosure.

Note: • An average sales price is calculated by dividing the total free on board (f.o.b) rail/barge value of the coal sold by the total coal sold. Excludes mines producing less than 10,000 short tons, which are not required to provide data. Excludes silt, culm, refuse bank, slurry dam, and dredge operations. Totals may not equal sum of components because of independent rounding.

Source: • Energy Information Administration Form EIA-7A, "Coal Production Report," and U.S. Department of Labor, Mine Safety and Health Administration, Form 7000-2, "Quarterly Mine Employment and Coal Production Report."

8.3. <u>Revenue from Electricity</u>

Based on the Feasibility Assessment Report, RNR Consulting utilized the rate of $0.070/KWh to calculate the NPV. This may be a conservative estimate because the City of Cleveland could potentially sell this electricity for higher rates than current market value since it will be purchased by Cleveland Public Power. The City may also be able to realize higher revenues from this electricity since it is generated from a renewable resource.

9. Project Approach and Methodology

The following methodology includes an outline of the preliminary recommendations acquired from the interviews conducted.

Cleveland Public Power
Methodology and Approach to the Municipal Solid Waste to Electric Project

Strategic Goals and Objectives

✓ Define Mission Statement

- Support Kinsei Gasification Technology for the conversion of MSW into Clean, sustainable Energy and other products

✓ Conduct Situation Analysis

- Complete the Cleveland Waste Stream Assessment
- Complete assessment of other potential MSW sources
- Evaluate and test the MSW Ash
- Financial Analysis of the City's MSW Budget
- Conduct Financial and Operational Analysis on the City's other Divisions
- Conduct the facility's conceptual design and verify costs
- Determine market availability of the MSW by Products
- Conduct Public acceptance surveys of the MSW Project
- Conduct a SWOT Analysis
- Conduct a PEST Analysis

✓ Develop an Implementation Approach

- Establish a project work plan
- Obtain Air Permits for the MSWE Facility
- Establish the project's financing plan
- Plan and Build from existing technology
- Establish supportive infrastructure plan
- Develop public communications program plan
- Set Up demonstration Plants
- Conduct critical gasification tests
- Determine performance of the gasifiers
- Develop Resource Allocation Plans
- Address any financial and regulatory barriers that may hinder Project kick-off

✓ Develop a Strategic Plan

- Develop a Project Life Cycle Plan
- Develop Short Term Goals
- Develop Long Term Goals
- Develop a plan to Maintain the Goals

Implement and continue to update the Strategic Plan

↑

Overall Objective

Provide the City of Cleveland's Residence with a flexible, reliable, and a clean energy technology that can turn MSW into energy, and other valuable products such as decorative bricks, and fuel pellets.

↑

Achievement of the City's Goal in Becoming a GREEN SUSTAINABLE CITY BY 2019

10. Preliminary Conclusions

As noted earlier, the proposed MSWE Facility that would be located at Ridge Road will be utilized for processing the MSW, generating electricity, fuel pellets, and decorative bricks and sorting recyclables. It was expressed by the delegates interviewed that one of the main advantages of the Kinsei gasification technology to the City of Cleveland is how the Municipal Solid Waste will be handled and disposed. The Municipal Solid Waste will not be "wasted" but conserved for energy and natural resources that will eventually generate revenue. Thus, the acquisition of a system that would provide energy for the City of Cleveland, while at the same time conserving our environment and promoting a "green" City would be a great investment for the City.

The trip to Japan and China was beneficial to the City in many ways. The delegates had questions and concerns regarding the technology; however, they returned to Cleveland with enthusiasm to take the next steps in exploring the gasification technology. Some of the questions asked as noted earlier will require more analysis and consultation with the Princeton Environmental Group/Kinsei Sangyo Co., Ltd. It is also essential to note that as the City moves forwards more questions may arise; however, each one will be addressed along the way.

In conclusion, the delegates voiced the following recommendations that are critical for the MSWE Project (*These are not necessarily in order of priority*):

- Get the necessary air permits.
- Acquire project funding.
- Acquire community support.
- Conduct preliminary site investigation and facility layout planning in order to outline the Facility Design.
- Complete the Cleveland Waste Stream Assessment, including assessment of other potential source areas.

- Determine the facility's conceptual design and cost.
- Secure funding for initial engineering designers to obtain air permits necessary to construct the facility. The air emissions are required to meet Ohio and the U.S EPA standards. (Attachment D consists of a list of anticipated environmental permitting needs that may be required for the Municipal Solid Waste to Energy Facility acquired from Princeton Environmental Group)
- Test the ash. The purpose of testing the ash is to get a clear understanding of the Municipal Solid Waste composition after undergoing the gasification process.
- Conduct a trip to Japan to negotiate the terms.
- Obtain project financials from PEG/KSL in order to substantiate the total cost of the project including the Net Present Value.
- Communicate the project benefits with the City of Cleveland residents.
- Confirm energy input and output diagrams (with scientific data) from the City of Cleveland and Kinsei Sangyo Co., Ltd
- Confirm Safety Precautions and Standard Operating Procedures for Gasification and Hazmat in accordance with U.S. Law.