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EXECUTIVE SUMMARY

Forest City Enterprises currently spends approximately $150 million in energy costs per annum. This proposal seeks to offset this expense by analyzing the viability of Waste-to-Energy as a potential solution.

The driving components of this proposal are: analysis of types of WTE systems, case studies of urban WTE implementations, and the feasibility of this system in an urban area within the United States:

Waste-to-Energy Systems create energy using incineration, gasification or anaerobic digestion of waste products. This system is particularly efficient because its advantage is many-fold: By using Waste-to-Energy, the cost and environmental hazards of land-filling is significantly mitigated; as recycling is a large part of the pretreatment of waste collected, there is a greater level of reuse of existing materials; and the embodied energy of waste can be harnessed for use by the people who contribute to its levels. The higher the level of waste, the greater the amount of energy created, which allows for not only a sustainable waste management solution, but a lucrative renewable energy creation source.

Case Studies in the implementation of WTE in Linkoping, Sweden; London, UK; and Cleveland, USA, offers a background of the trajectory each city has taken to realize the system. In depth analysis may show what obstacles were faced, the efficiency of each system, and its reception.

Forest City Enterprises’ current portfolio of projects provides the first filter through which urban areas are placed under consideration. By using the analysis of systems and triangulating with the mentioned filter, the project will propose a reasonable domestic urban location in which WTE systems could feasibly work.
INTRODUCTION

BROAD DEFINITION

According to the Central Intelligence Agency, the United States of America consumes 3.741 trillion Kilo-watt Hours of energy per year. The country is ranked first in both total and per capita energy consumption, followed by China and then the European Union. At the federal level, specifically through the bipartisan “Energy Independence and Security Act of 2007” and the latest administration’s proposal for a progressive energy reform policy, funding has been allocated to incentivize energy efficiency as well as the implementation of renewable energy across the country. While many states have expanded on this policy change and have encouraged the use of renewable energy, the resources for energy development have so far been limited to solar, wind, geothermal and tidal forms. The latest energy development research, however, also looks at biomass usage to supplement the previously mentioned resources through waste to energy systems:

Waste to Energy [WTE] is a form of energy production in which the input materials are various waste products, from organic to inorganic substances, and the output is in the form of electricity and heating, among other forms of use. The capital-intensive waste to energy plants can either burn unsorted waste or, more likely, filter the waste to remove various recyclable materials (to be separately reused) to create a refuse-derived fuel or gas, as well as generate heat and electricity. This can be done through incineration, gasification or anaerobic digestion. The fuel or gas goes through a combustion process, in which the heat generated is able to produce steam for further heating and electric current. Because of the various methods of energy generation, WTE plants can process waste and produce energy in various scales, at various time brackets, and ultimately, at various price points. In this proposal, larger plants will be discussed, as they are more cost effective through continuous operation, and therefore also more efficient in energy production.

While waste-to-energy is not widely used in the United States, the systems’ level of popularity has increased significantly in other parts of the world, including the United Kingdom, Sweden, Germany, and China. The systems can be very expensive, with a large upfront cost and no revenue during construction period, as no partial operation can take place. Once constructed,
however, the plants not only manage waste but also generate energy simultaneously, and are able to do so for a very long time.

**SIGNIFICANCE**

Historically, waste to energy plants were considered environmentally hazardous due to its initial unmitigated release of toxins, but given the leaps of advancement in technology, the present WTE plants are far more advanced and much safer: “Studies have shown that communities that employ waste-to-energy technology have higher recycling rates than communities that do not utilize waste-to-energy. The recovery of ferrous and non-ferrous metals from waste-to-energy plants for recycling is strong and growing each year. In addition, numerous studies have determined that waste-to-energy plants actually reduce the amount of greenhouse gases that enter the atmosphere.”5 The use of filtering, recycling, and recovery systems have allowed for much safer waste to energy production, as the major toxic materials are removed from the process early on. These filtered products, while not used in the creation of energy, can be sold to manufacturers to gain an additional revenue stream.

Another misconception is the heightened presence of toxic flue emissions from WTE plants. The perception is that the presence of these plants, and the subsequent emissions causes various life threatening problems. Given the advancements in desulphurization, however, WTE plants have become so safe that they are now located in very dense areas like downtown Stockholm.

Regular power plants use coal, oil, nuclear material, or natural gas as fuel to create energy- in WTE plants, these nonrenewable resources are replaced by municipal solid waste [MSW.]

While coal, oil, and natural gas must be found and recovered to create a viable fuel source, an exponentially less amount of energy needs to be exerted to “find value in what others consider garbage.”6 In the case of Waste to Energy systems, the price of travel to landfills is replaced by the travel to WTE plants, where the waste is sorted and can be effectively recycled, and the land previously used as landfill can be rehabilitated to provide space for further development. In addition, this system is able to reduce greenhouse gas emissions, in two ways: 1] energy production through waste helps to reduce the need for energy created in power plants which use fossil fuels, and have a much higher carbon footprint; 2] the embodied energy from waste processed in a treatment facility would otherwise be dumped in landfills where the untapped energy would be released in the form of uncollected methane gas, which is harmful to the atmosphere.7 By reducing the amount of waste driven into landfills, the use of a WTE system as an alternate mitigates the other issues associated with landfills, including the unsightly big blob of garbage, leaching contaminants into the aquifer, loss of land value of areas around the landfill, and the heightened presence of vermin and scavenger bird populations, among others. The value of WTE, therefore, extends far beyond the actual energy generation, by creating an effective waste management system which is environmentally, economically, and socially efficient.

Forest City Enterprises spends approximately $150 million in energy costs every year, and this significant amount is uncontrolled given the volatility of the energy market: “Energy prices have

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6 Ibid.

7 Ibid.
become increasingly volatile over the past decade, with natural gas and electricity exhibiting the greatest increase in volatility. Barring structural changes, natural gas markets will be at least as volatile or more volatile in the future. By creating its own energy, Forest City may be able to mitigate some of this cost, and if placed near a project, be able to take advantage of this system directly, as well as gain profit by selling the additional energy to the main grid. Keeping this in mind, waste to energy should be considered a strong competitor in the potential solution not only for Forest City but the rest of the world, given that it is able to produce clean power to supply to an escalating demand for energy.

TYPES

INCINERATION

Incineration technology is the oldest and most common form of waste to energy treatment. Upon its arrival, waste products go through a filtration process to remove noncombustible and recyclable materials for reuse. The materials eligible for incineration are then moved into a combustion chamber, in which the plant uses incineration to recover heat through the controlled combustion of feedstock. The heat is used to produce steam, which is then converted into energy through a steam turbine.

Without proper emission controls, however, the combustion of waste releases harmful chemicals like dioxins and carbon monoxide into the atmosphere. Because of the risks to the environment and human health, WTE plants using incineration technologies have historically faced high levels of debate and opposition. The negative impacts, including harmful residuals, Persistent Organic Pollutants [POPs], and the use of special landfills are detailed below:

Incineration results in various types of residuals, including bottom and fly ash, and harmful toxins. In particular, when metals and plastics are combusted through incineration technologies, highly toxic pollutants, including dioxins and furans, can be produced. These toxins are produced in various stages of the incineration process, and while removing plastics and metals may prevent a greater level of these emissions, there is no current way to prevent their production. At best, the toxins can be trapped in filters and ash, but they become hazardous. The filters and ash must be discarded in special landfills, and if further energy recovery is attempted, it must be done through special heat exchangers, which produce even more dioxins.

Because of the hazardous emissions, plants in the past have been placed in isolated areas to reduce the amount of emissions that reach high density or agricultural regions, and so users of the derived energy do not breathe polluted

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10 Ibid.
air or eat toxic food. Long-term exposure of harmful POPs [organic compounds resistant to degradation, such as pesticides] for instance, can lead to a variety of health problems such as cancer, neurological diseases, and render infertility, among others.

Today however, advancements in technology and controlled filtration systems have allowed for the placement of incinerators in dense areas, such as downtown Stockholm, Vienna, London and Quebec. The modern day incinerators have no toxic emissions, no odor problems, and are extremely efficient.11

If correctly monitored, WTE incinerator misconceptions can be debunked. Communication of the WTE process must be detailed and transparent, and opposition in the form of NIMBYism can be mitigated to a point where metropolitan America may be able to accept a WTE incinerator not just in the outskirts of the city, but also in the center.

GASIFICATION

Modern gasification systems fall into one of three categories: 1] moving bed, 2] entrained flow, 3] fluidized bed:

In the “moving bed” design, the feedstock is dry and fed through the top of the gasifier. As the input material reaches the floor of the reactor, it is exposed to controlled levels of oxygen and/or steam in high temperature and pressure, which flow in a counter-current through the floor, or “bed” of the reactor. The end product is syngas and dry ash. This design operates at the lowest possible temperature [400-500° C.] 12

In the “entrained flow” design, the feedstock [which may by dry or wet,] and oxygen flow in the same direction. The end product of syngas rises to the top of the gasifier and ultimately exits the reactor in controlled conditions, while the molten slag is discarded from the bottom of the reactor. This design operates at the highest temperature [1200-1600° C.]13

In the “fluidized bed” design, the feedstock is brought into the reactor from the top, and suspended during the process of gasification by a strong upward flow of oxygen and steam. Syngas and dry ash are created, and are released in the same way as the “moving bed” model. This design operates at [800-1050° C.]14

Gasifiers are large chemical reactors, which subject hydrocarbon materials to high temperatures to create an output of combustible gases like carbon monoxide, hydrogen, and carbon dioxide. In gasification, there is no incineration as the gasifiers have a controlled amount of oxygen allowed. In the high pressure, high temperature, low oxygen environment, the hydrocarbons are cracked or gasified with the addition of oxygen or steam to create the desired gas products.15

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13 Ibid. P. 69
14 Ibid. P. 69-70
and steam environment, the chemical bonds within the hydrocarbon material are broken and reformed into a synthetic gas [syngas] with a lower heating value than natural gas. The syngas then goes to the oxidizer where it is further exposed to oxygen to produce hot flue gases for a boiler to create heat and electricity. Given the economic efficiency of gasifiers and the ready availability of hydrocarbon material [in the form of biomass], “gasification is a ‘breakthrough’ technology [because] it combines the economic advantages of coal with the environmental benefits of natural gas.”15

Gasification is clean burning when controlled properly, and the synthetic gas produced may be used to generate electricity through steam generation in a steam turbine, or further refined and used as a biofuel. The synthetic gas can be refined before use to eliminate harmful toxic emissions. The carbon dioxide created as residual can be captured to prevent emissions as well. The hydrogen and carbon monoxide created as syngas can potentially also fuel vehicles using hydrogen, rather than gasoline, as fuel. Lastly, the residual dry ash can be reused in various materials like concrete, as well as non-fired bricks, as planned in the Cleveland gasification project.

**ANAEROBIC DIGESTION**

Another form of waste to energy conversion is through Anaerobic Digestion [AD]. This form of energy generation effectively uses different types of bacteria to digest organic waste and release combustible biogases like methane and carbon dioxide, which are then used to produce heat, electricity, and biofuel.

AD facilities typically have collection tanks in which dry and wet waste is stored. The waste is then transported into a homogenization tank, which uses large mixers to give the waste a uniform particle condition [5-10 mm.] The uniform feedstock is then plugged into the anaerobic digester tanks, in which the organic material is converted into biogas and digestate.16

The collected biogas goes through a process of biological desulphurization to remove traces of the highly corrosive hydrogen sulphide. The desulphurization takes place upon the introduction of special types of aerobic bacteria, as well as a limited amount of air. The biogas is then vented into a combined heat and power plant system [CHP] and then into a generator, which can produce heat and electricity.17

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15 Ibid.
17 Ibid.
The whole process can be monitored remotely through a Supervisory Control and Data Acquisition [SCADA] system, or its equivalent. If effective, the remote control system is able to respond efficiently to needed adjustments in oxygen, temperature, and bacteria levels.

The biochemical process of anaerobic digestion includes four parts: hydrolysis, acidogenesis, acetogenesis, and methanogenesis, which can occur in the same digestion tank. The four stages are codependent, and if the feedstock is not mixed properly to avoid stratification, digestion can become inhibited at any stage.18

Once the well-mixed feedstock is put into the digestor, the first and fastest stage of hydrolysis occurs. Hydrolysis is the breaking down of the chemical bonds of complex fats, carbohydrates and proteins to derive fatty acids, sugars, and amino acids. The next stage of digestion breaks down the derived components from hydrolysis into alcohols and acetate [organic acid], hydrogen, and carbon dioxide. This step is known as acidogenesis. In acetogenesis, which is the third stage, acetate-forming bacteria must break down the more complex alcohols and organic acids, like ethanol, propanate, and butanate, to form acetate before they can go through the final and lengthiest stage of anaerobic digestion. In methanogenesis, methane gas is produced with the introduction of methane-forming bacteria, which digest acetate, carbon dioxide, and hydrogen to create the end product of methane biogas. Both the methane-producing and acetate-producing bacteria can digest in a mesophilic state, which ranges from 32-47°C. This temperature range is stable and is easy to control. However, it does not produce biogas as quickly as if the bacteria were exposed to the thermophilic range, which ranges from 50-60°C.

The residuals of the AD treatment of organic waste are biogas and digestate. The biogas, upon desulphurization, can be used to substitute natural gas, be used for heating and electricity needs, and after further refinement, be used as bio-fuel. To create biofuel, the biogas is scrubbed to consist of more than 97% methane, which is then injected into the natural gas line distribution and then sold as green gas. The digestate can go through additional processes to be converted into compost, used as a low-level solid fertilizer, and a liquid with high proportions of nutrients, also used as fertilizer in liquid form.

Anaerobic Digestion as a form of waste to energy has multiple benefits, which may affect the environment, energy production, and have economic benefits:19

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18 Ibid.
Environmental: Anaerobic digestion reduces pathogen levels and decreases greenhouse gas emissions. Residues can be used as fertilizer, which reduces dependence on inorganic fertilizing methods. In addition, given the stabilization and recycling of water-based waste, blackwater and greywater systems can replace the use of surface and ground water, providing for better water management. Also, given that AD removes malodorous compounds in enclosed tanks, and, as there is no combustion, there is also no hazardous toxin emission, social acceptance of waste to energy through AD is more widely accepted.

Energy: Biogas created through AD can be used in heat, electricity, and biofuel production, which greatly reduces dependence on nonrenewable resources, particularly those which are imported, leading not only to cost savings but also, if used properly, without carbon footprint. In that energy derived from AD can be used to power its own facility, and given the size of the facility, create surplus energy to contribute to the main power grid, not only is energy created through clean production, but it is also net positive.

Economy: AD plants, particularly those which are self-sufficient, are able to bring in a high level of profit, as without much extra expended energy, it can generate income from waste management and processing, the sale of the surplus power generated, and also the sale of fertilizer created from the residual digestate. It can, like the other processes, also collect annual power tax credits, which are dependent on the amount of energy produced.

INNOVATION AND OUTPUTS

HEATING AND ELECTRICITY

The most commonly associated output of WTE systems is heating and electricity. In every type of WTE, the extracted combustible gases are used to produce steam to generate heat and electricity through a steam turbine generator. Both heat and electricity can then be applied to a closed loop system within the WTE facility, or be injected into the main utility infrastructure.

The incineration method has produced both heat and electricity through burning wood, etc. for centuries. Energy through biomass in the form of wood has had continuous use, particularly in third world countries. In first world and developing countries, however, heating and electricity generated through biomass was succeeded by the burning of fossil fuels during the Industrial Age. Today, to create heat and electricity, WTE is becoming increasingly viable based on the world’s move away from coal and natural gas power production into renewable resources.

COMPRESSED BIOGAS

Biogas is a type of biofuel generated through WTE, which can be compressed in a similar process as natural gas, to be used in vehicles as fuel or buildings as a substitute to natural gas for heating and cooling.

To be refined enough to be injected into the main natural gas grid, raw biogas acquired through WTE, which has roughly 60% methane, must be upgraded and desulphurized to consist of more than 97% methane per unit volume of gas. This gas can then be used to produce electricity, heat water, and heat space.
If compressed, in a similar way as natural gas, biogas can be used to fuel vehicular transportation. Compressed biogas, by itself, or combined with compressed natural gas, needs a special type of engine which is being increasingly manufactured by car producers like Volvo and Volkswagon. In America, about 85,000 vehicles, and about one in five transit buses use compressed biogas. 

By using compressed biogas, greenhouse gas emissions like carbon monoxide [by 90-97%] carbon dioxide [by 25%] and nitrogen oxide [35-60%] are greatly reduced. In addition, the energy typically lost in the transmission of energy from the generator to the user in large electrical systems range from 5-8%, where as in compressed gas transmission systems, this range is reduced to 1-2%. This translates to efficiency and cost savings.


BIOETHANOL

The waste to energy system proposed for Forest City Enterprises in this document will prioritize its outputs to produce heating and electricity, either through steam or biogas. However, given the ease of creating bioethanol from the waste to energy process through recent innovations, understanding this output as a legitimate source of potential revenue is viable:

Bioethanol is a type of alcohol which can be created through the WTE process, and can be used for transportation fuel as well. The feedstock for this ethanol production is organic, and can be agricultural waste such as residuals of sugar cane, potatoes and corn. The ethanol produced can be used by itself to power vehicles, or may be added to gasoline to allow for cleaner emissions.

Bioethanol production is fast growing in the United States, and is particularly used in rural areas to power agricultural equipment. This is fast expanding into the metropolitan areas for vehicular use, as in 2007, given turmoil in the Middle East, and the loss of security, Americans are fast approaching not being able to import oil from that part of the world, “Congress [has given] the ethanol industry another boost, extending tax credits and tariffs while requiring that 7.5 billion gallons (28 billion liters) of the nation’s fuel come from ethanol or biodiesel by 2012.”

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According to the EPA in December 2011, the nation has surpassed this goal and in 2012 is slated to produce 15.2 billion gallons of biofuel, more than twice the initial number.\textsuperscript{23} Given the environment America has for growing crops like corn, which are perfect for the production of bioethanol [1 billion gallons in 2012 of bioethanol will be produced by biomass such as corn\textsuperscript{24}], not to mention the ease with which ethanol can be formed through the anaerobic digestion of various organic waste, coupled with the growing enthusiasm within Congress to find an alternative fuel for vehicles, the production of bioethanol at present would be widely well received, as well as prove to be a legitimate fuel source which may substantially substitute oil in the coming years.

The challenges for bioethanol are as such: “[Bio]ethanol delivers 30 percent fewer miles a gallon than gasoline, but at around $2.80 a gallon in the heartland, it is competitive with $3.20-a-gallon gas. Since the U.S. has no major pipelines for ethanol, transportation by truck, rail, or barge drives up the price elsewhere. But more [bio]ethanol plants are popping up all the time.”\textsuperscript{25} Not only this, but given that pure ethanol has an octane rating of around 113, and can thus allow for more vehicular power because it burns at a much higher compression than gasoline, this form of fuel is becoming increasingly appealing as it allows for power without the price. If the price of transportation and storage is factored out of the price of bioethanol, and one only looks at the price of production, the results are relatively exciting: For every one unit of energy used to produce bioethanol through corn [and this unit may come from any form of renewable energy, reducing GHG emissions and the carbon footprint even more to promote clean production,] 1.3 units of usable energy is produced. If the ethanol is derived from sugarcane, as is done in Brazil, the net energy gain is 1:8. The potential profits gained through the creation of bioethanol are thus substantial, and would be even more so if there were to be the proper infrastructure, as well as mass production of cars with engines required to use this fuel.

PERCEPTION

After the 1970s, when the environmental movement picked up its steam, people become more aware of waste management practices, and the type of waste put into landfills, etc became more toxic given the rise of new industries using hazardous materials. Incidents like the Love Canal, a chemical waste landfill close to Manhattan upon which a school was built, where people suffered chemical burns, were exposed to radioactive elements which cause chromosomal damage and cancer, etc. did not help the public perception of waste management in general, and what before brought apathy eventually became a source of anxiety. “Prior to the rise of the environmental movement in the 1970s, waste facilities aroused little public concern, and rarely were facilities closed due to local opposition. There were several instances in which government and industry abused this general lack of concern, and approached the matter of disposing municipal and industrial wastes with little regard for environmental safeguards.”\textsuperscript{26} Moreover, the public sentiment was not just a fear of the environmental and health risks associated with waste and waste management, but also led to aesthetic complaints. Waste management facilities were removed to the far outskirts of towns, as people did not want their property value to decline given the perception associated with living close to a waste

\textsuperscript{24} Ibid.
\textsuperscript{25} Ibid.
The basic categories of public opposition are as such: health risks, aesthetic factors, economic impact, and social perceptions.  

HEALTH RISKS

The basic reason for most people’s opposition to waste to energy facilities in America is the lack of exposure to the subject, and the subsequent opinion they create based on what may be outdated information. In this case, people may perceive the health risks associated with poorly managed waste treatment facilities with the well-regulated facilities of today. If not well managed, WTE plants do pose the greatest threat of health risks with their emissions of chemicals like sulfur dioxide, hydrocarbons, carbon monoxides, nitrogen oxides and other dioxins, which can pollute the air. However, of course, any kind of waste management has the potential for air pollution, water pollution, greenhouse gas emissions, and ozone depletion, but current advancement of technology to regulate the process and protect its users allows for the creation of energy out of waste while being sensitive to the environment. So much so, that places like Antwerp in Belgium, and Stockholm in Sweden are able to place their WTE facilities in the middle of town, or at least relatively close to residential areas without fear of pollution. They are able to change the public perception by being transparent in their actions and explaining clearly the science behind WTE and the measures taken to make sure the energy created is done through as safe a process as possible.  

AESTHETIC FACTORS

In some cases, particularly for those living closest to the proposed or actual site of the WTE facility, the aesthetics of the plant were of greater concern than the health risks, given a survey conducted in California. The factors in consideration included odor, noise, congestion, and the facility’s appearance. Because these factors can be felt, heard, and smelled, they are the first offense towards creating an opposing argument for the placement of a facility. This risk can be mitigated by creating an appealing modern design for the plant itself; by carefully regulating and filtering gases, particularly those most odorous, which come out of the plant facility; and also by using design and technology to lower noise pollution.

Incentives are also a relatively effective tool—“The survey found that 19% would be happy would be happy for a new waste treatment facility to be built in their area if the local community without any incentive. A further 45% would be satisfied if the facility offered something in return.” In the UK, where these statistics were gathered, as well as many other parts of the world, including the ISVAG WTE treatment facility in Belgium, incentives and further investment in the public relations process of waste to energy is seen as an important calculation to factor into the cost of siting a plant.

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ECONOMIC IMPACT

A primary concern, particularly of residents who live close to a proposed or existing WTE plant, is the effect the facility will have on their property values. There will more than likely be a decline in property value if the plant is seen, heard or smelled, but given proper buffering, which may be required for any industrial factory in the local zoning ordinances, these factors may be mitigated. The residents and commercial properties owners can again gain some type of incentive to offset the decline in the value of their land, etc. The community as a whole, however, also has much to gain from the placement of a WTE plant in their vicinity- because of the plant’s presence, the community is able to derive “revenues through local taxes and/or tipping fees from the importation of waste materials from other communities. Similarly, some Waste- to-Energy projects also propose reduced rates to the host community for garbage disposal and/or energy use.” 32 In addition, as waste is filtered on site to go into energy creation, recyclable materials can be filtered out and refabricated for use. Finally, by placing this waste into the WTE system, landfill costs are greatly reduced if not completely mitigated, which extends the life of existing landfills and minimizes their maintenance and operation costs. Although these cost mitigants do not seem to be great selling points to the developers, the idea of greater recycling efforts and the reduction of land-filling can be highly appealing to the same environmental groups which oppose the placement of the WTE facility.

SOCIAL PERCEPTIONS

The placement of a WTE plant can lead to a certain type of social stigma, and the “feeling of being dumped on, [which] appears to be the greatest source of opposition”33 This social stigma is a main reason for why so many WTE facilities as well as other waste management plants are placed in the far outskirts of a town, as people simply do not want to live near a “dump.” And while this may not be the most empirical argument from opponents, it may be the most effective. The entire perception of waste and its treatment must be altered to allow for a community to accept a WTE plant, and this can be done to an extent by creating systems which are innovative, and appealing enough to make people forget that waste is also being treated in the same facility.

At this point, WTE plants are not placed in metropolitan areas of the United States given perceptions and subsequent oppositions by the areas’ residents. In order to create a successful system in an environment of opposition, it is important to be transparent and sensitive to the concerns the people most directly affected may have. There is a fear and insecurity in many residents of the health risks of these plants, of the possibility of loss of value in their property, and of the social stigma, which comes with living next to a “dump.” By communicating effectively the solutions to their concerns, and the possible benefits they may accrue, there should be no reason for continued animosity.

33 Ibid. P. 9
CASE STUDIES

CLEVELAND, OHIO

BACKGROUND

The City of Cleveland Municipal Solid Waste to Energy Development, now called the Cleveland Recycling and Energy Generation Center, is part of the “Sustainable Cleveland 2019” campaign started by the Office of Sustainability of the City of Cleveland in 2009. The objective of this office is to save the city money while reducing its ecological footprint, and one of its initiatives is through the use of renewable energy. Cleveland Public Power [CPP] is seeking to replace some of its power and energy requirements, “[most of which is] obtained through short and long-term contracts with various regional utilities and other power suppliers through three 138 kV interconnections to the regional grid.” To supply electric power to nearly 80,000 customers, CPP will use 20% of the energy generated by LEEDCo’s proposed offshore windfarm, as well as the energy generated through gasification of municipal waste to reduce the city’s current dependence on outsourced coal-produced power.

Another facet of the Sustainable Cleveland 2019 movement is a rigorous move towards recycling and more efficient waste management: “The City’s goal is to decrease the amounts of waste generated both by the city and within city limits. In 2009, the City saved $254,000 by recycling and diverting 5,800 tons of recyclable material from landfill.” The city plans to change the current rate of recycling of 11% to 70% upon the introduction of the gasification plant, in addition to creating a more efficient waste management system as well as generate power.

The City of Cleveland plans to partner with Princeton Environmental Group for facility design, and Kinsei Sangyo, Co. and Sunpu Opto Semi Conductor Co. for gasification technology and engineering consulting.

Two gasifiers will run in tandem at maximum of 12 hours per day, 365 days of the year. Since it takes between 8-12 hours for the gasifier to generate electricity, one batch at 70 tons of MSW will be processed each day in each gasifier. The clean MSW will go on into a boiler and then a turbine generator to create electricity as well as fuel pellets through the steam generated. Using the best available technology, the plant seeks to meet and then beat the National Source Performance Standards in terms of the emission of harmful pollutants. Extensive emission control analysis has already been performed, and according to CPP, “regardless of air contaminant category, the maximum annual potential emissions from the proposed MSWE.
facility compare very favorably to the actual emissions from other facilities that are currently operating in NE Ohio.\textsuperscript{41}

The estimated cost of the facility is $180 M, and upon the completion of the project, the plant will provide up to approximately 125 employment positions, the members of the region will pay much less in energy and waste management costs, and have a lower overall carbon footprint.

**OPERATION**

The project proposes to use the already existing Ridge Road Transfer Station, which has a capacity of approximately 760,000 tons/year of municipal solid waste [MSW], which is manually collected at 3000 tons/day. The proposal seeks to fully automate the collection system and semi automate a recycling collection system to bring into Ridge Road, where the waste would be sorted for gasification or further reuse or recycle. The recyclable materials will be sold directly to manufacturers or to larger waste utilities as an additional source of revenue. The materials used in the gasification process will generate electric power to be distributed by CPP, and the residual ash will be reprocessed into various construction materials as an additional source of revenue.\textsuperscript{42}

The City of Cleveland is able to spearhead this movement because it owns the MSW as well as the transfer station, and also CPP, which already has access to the main electric grid. It argues that in comparison to incineration and landfill gas, the use of a two-stage gasification process allows for a safer system in which GHG emissions are greatly reduced, and the electricity is able to easily plug into the municipal power grid, so the embodied energy of the waste may be put to use rather than go into a landfill and emit hazardous methane gas.\textsuperscript{43}

**ANALYSIS**

Despite the great potential value added to the economic and sustainability efforts by this gasification system, there has been enormous backlash towards this project. The city has faced delays based on various factors, and has also gotten criticism based on a letter by the federal EPA “criticizing the city’s standards and urging the Ohio Environmental Protection Agency to evaluate the plan.”\textsuperscript{44} The letter was based on outdated data, and the proposed plant no longer poses the same threat. Critics have also stated that the plant could emit toxic elements, like lead and mercury, and while this may be possible, it would only be so if materials containing the elements, which would be filtered out under typical circumstances, were to be gasified. In normal conditions, no lead would be emitted into the air. What the opposition is hearing however, are the words of US Rep. Dennis

\textsuperscript{41} Ibid.
\textsuperscript{42} Ibid.
\textsuperscript{43} Ibid.
Kucinich: “it would produce 500 pounds of lead a year. ‘That’s enough to give lead poisoning to 3,200 children.’”

A possible reason for why this project is facing so many issues is because the City of Cleveland has been opaque about the benefits of the gasification process to the general, as well as about the current state of affairs.

If the public were to be better exposed to the actual system and its potential of benefits through better public relations, which are proactive rather than obligatory, the very same people who are currently in opposition of the project might be its strongest proponents. In the environmentalist point of view, waste to energy through gasification should be a strongly advocated for, particularly in Cleveland, where 90% of the waste generated is not recycled [a factor the plan could reduce to 30%]; where everything goes to an unregulated landfill, which not only takes up usable space but also releases toxins like hydrogen sulphur, nitrogen, and other contaminants; and where most of the electric utility acquired by the city is generated through the burning of coal.

By being transparent about both the benefits of the project, as well as the risks and how the city is working to improve conditions so they may be mitigated, and by reaching out to those who are directly affected rather than the alternative, the project timeline might be much smoother. The best defense is always a good offense.

**LONDON, UNITED KINGDOM**

**BACKGROUND**

The London Metropolitan Area has had a long history of waste to energy through incineration. London’s EcoPark in Edmonton, opened in 1971, and SELCHP in Lewisham, opened in 1994, have, until recently, handled 19 percent of London’s municipal waste and generated electricity. A new plant, developed and managed by Cory Environmental, called the Riverside Resource Recovery [RRR] in Belvedere, went into operation in October 2011.

Currently, London landfills 53% of its municipal solid waste, which is stored in shipping containers and barges across the Thames to counties like Essex and Bedfordshire. Cory Environmental was awarded a 30-year contract in 2002 with the Western Riverside Waste Authority, alongside its existing contracts with the City of London and the Westminster Council,

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45 Ibid.
to manage more than 500,000 tons of municipal waste per year. Four central London boroughs, Lambeth, Wandsworth, Hammersmith and Fulham, and Kensington and Chelsea, are served by this service, and while all waste is filtered to remove and reuse recyclable materials, the rest was, until last year, taken to the Mucking landfill [which has since closed], and is now transported to the RRR instead.  

The opening of the RRR last year is at the end of a long process which began in the early 1990s, with Cory’s first application to develop a WTE site in Belvedere- the proposal was rejected due to a lack of road access as well as because of the proposed size of the plant. Adjustments were made to comply to the Electricity Act of 1989, and another proposal was submitted in 1999 to develop a WTE plant in which the waste is barged in through the Thames, and the plant can serve almost 600,000 tons/year of waste to convert into 66 MW of energy. 

Two years of pubic inquiries, from 2003-2005, were held, particularly given the protests by Greenpeace in 2000, and Friends of the Earth and Londoners Against Incineration in the years following, at the Edmonton Incinerator. In 2006, The Secretary of State for Trade and Industry granted planning consent for the plant, and Cory Environmental moved forward with the project. However, opposition for the RRR continued into 2007, and centered around the possibility of hazardous emissions from the incinerator. The Bexley Council alongside the Mayor of London forced a judicial review of the plant to stall or halt the process, but in February 2007, the review was rejected, and in January 2008, construction began. The plant was completed in early 2011, and hot commissioning, to test the plant’s combustion ability, began in February 2011. The RRR was fully operational beginning in October 2011, and is currently undergoing a series of trials to test the plant’s systems in reliability, performance, and availability.

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**OPERATION**

Pre-filtered waste is barged into the plant in shipping containers, moved into vehicles and taken to the “tipping hall,” where the waste is tipped into the “waste bunker.” The waste is then picked up from the bunkers and put into “hoppers” from where it is placed into the boilers in batches to be incinerated. The incineration process creates heat, which is then converted into energy through the steam turbines referenced before, ash, which is taken offsite to be recycled or otherwise disposed off, and flue gases, which go through numerous filtration processes to be able to meet the environmental regulatory permit requirements [through the Waste Incineration Directive] when emitted. Three parallel incineration lines work in concert, and are able to incinerate 29.8 tons/hour of waste to create a gross output of 72.7 MW of electricity, of which 65.5 MW is viable.  

**ANALYSIS**

Despite opposition from the local government, and even the Mayor of London, this plant is in operation today. A partial explanation for the approval of the facility may be the presence of other WTE facilities in the area, which ironically was the crux of the argument by the opposition. Those opposed were concerned mainly about the hazardous emissions of flue gases into the atmosphere as witnessed in the other WTE facilities in Edmonton and Lewisham, the first preceding the RRR by 40 years, and the second by 17 years. In both cases, the filtration technology is outdated, and in the RRR, particularly after the changes made since to the Waste incineration Directly after having learned from the other two incinerators, emissions are well under control and investment has been made to ensure the health safety of those neighboring the facility.

Given the strong shift in scale between the United States and England, and the greater priority placed on developable land, the use of landfills is becoming an encroaching issue, which further serves to persuade the use of WTE plants. While there are residuals like ash which result in waste incineration, the output not only allows for the removal of waste as well as the creation of electricity from its embodied energy, but also for landfill remediation, which can be carefully developed into usable land.

**LINKOPING, SWEDEN**

**BACKGROUND**

The SymbioCity concept is more than just the production of energy from waste. WTE is considered only one aspect of the holistic urban development of various communities in Sweden, in which waste management occurs at every scale and people are conscious of the amount of energy they consume.

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The movement started as a way to reduce the country’s dependence on oil, and what was once “the most oil dependent country in the industrialized world” has now been able to cut its consumption of oil for heating and electricity by 90%.53

The Swedish system of waste management is to collect household waste from each property through dustbins, containers, and suction systems. This is financed by fees rather than taxes, and filtration starts from the beginning of the process by the user.

Much of Sweden’s waste is incinerated in plants like the Sysav Solid Waste Management plan in Malmo, which produced 1000 GWh annually [approximately 17,000 homes] by combusting the waste collected from approximately 620,000 people from the southern part of Sweden. It also provides approximately 40% of the district heating and cooling requirements of Malmo and its suburbs.54

If the waste is not incinerated for purposes of electricity production, district heating and cooling, organic waste is filtered out and mixed with farm manure to create a slush for anaerobic digestion. The particulates take approximately 30 days to be digested at 36 degrees Celsius, and the methane gas created is refined to create biogas for buses and other vehicles. The digestate is reused as biofertiliser and placed into storage to be used by farms.

Anaerobic Digestion is a major industry in Linkoping, Sweden, where the digestion facility has been in operation for 15 years. There are three production plants, 13 public fueling stations for vehicles, and one bus depot for transit buses. The AD facility is able to accommodate 55,000 tons of class 3 organic waste, which produces 6.5 million metric cubic meters of biogas, and 50,000 tons of bio fertilizer. 55

The Linkoping plant investors and partners include: 56 Tekniska Verken, Linkoping AB, which is a municipal engineering firm which is in charge of waste collection, and manages the city’s energy and water supply.
Sac-Farmek, which is a large food producer
Konvex, which operates recycling for slaughterhouse waste
The Swedish Farmer’s Association
Linkoping biogas AB, owned by Tekniska Verken, and Scan –Farmek.

OPERATIONS
The waste used in the digesters comes from neighboring farms and starting in 2001, Linkoping University Hospital, and two school canteens are restaurants, where macerators and storage tanks were installed. The macerated organic waste is transported to the biogas plant, where the anaerobic digestion takes place.57

Given the production of special biogas motors by car companies like Volkswagon, bio-methane sales in Linkoping represent approximately 6% of the total vehicular fuel volume. Other ways in
which the city is able to gain profit from the presence of its AD facility is through the selling of bio fertilizer. In total, the “Linkoping plant receives 2,764,000 Euros/year selling the biogas as fuel for vehicles and their train.”

ANALYSIS
While most of the waste in various parts of Sweden are incinerated to create heating and electricity, anaerobic digestion is prominent in the rural parts of the country, like in Linkoping.

The SymbioCity model has been refined and in place since the 1970s. Because of this, the lifestyle of people who are responsible for the filtering of their waste, and who see incineration and anaerobic digestion plants, as well understand where their energy is coming from and how much they should consume, allows them to embrace waste to energy as a system which not only removes their waste to allow for more developable land, but also which ensures clean transportation and energy. They perceive the system favorably, which is why it works so well, and has for the last 40 years.

LUBECK, GERMANY

BACKGROUND
The Lubeck Mechanical Biological System + wet Anaerobic Digestion [MBT+wAD] Facility began construction in 2005, and had its commercial startup in 2007. Excluding the land, the facility cost 30 million Euros. The finance life of the facility is 15 years, and it is owned by the local authority waste company of Lubeck, and is operated by HAASE Energietechnik, the company that supplied the AD and odor control technology.

The municipality of Lubeck must pay 90 Euros [13.5 Million Euros/year based on the facility’s 150,000 tons/year capacity] per ton as a gate fee for waste management. The Lubeck plant also currently has a five-year agreement with the neighboring city of Neumunster to supply refuse derived fuel [RDF] for its heat and electricity as part of the public-private partnership negotiation. Revenue can be generated through the previous negotiation of 90 euros/ton of waste management, selling recovered materials for reuse to manufacturer, the generation of heat and electricity through RDF, the energy generated by the AD, the selling of wet and solid digestate, and revenue derived from water remediation. Given that the plant has a net positive environment, there are no energy costs. The plant will be fully amortized in 15 years.

OPERATIONS
The Lubeck facility uses a mechanical biological system [MBT] system in which pretreatment and sorting removes recyclables in a process called materials recovery. In the materials recovery/pretreatment stage, metals, plastics, and glass are removed to be sold and recycled by

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60 Ibid.
62 Ibid.
63 Ibid.
large manufacturers. At this stage, if there is any refuse [such as wood] which can be used to generate biofuel, this waste is also sorted out to and sent to a combustion facility in Neumunster to produce heat and electricity. This biofuel, which replaces approximately 15,000 tpa of fuel, is used to supply heat and power to the town of Neumunster, sufficient to be used by 7,500 homes.64 The organic feedstock left, which can be mixed household waste as well as commercial/industrial waste, is then homogenized to form a slurry, which goes into the anaerobic digester to undergo a biological treatment resulting in biogas and then energy, and digestate, which can be reused as fertilizer.

The AD process takes up to 20 days depending on the temperature and type of bacteria [the hotter the temperature, with thermophillic bacteria, for example, the faster the digestion process.] The digestate residuals are 20% solid organic matter, 20% liquid fertilizer- both are sold for agricultural purposes; and 60% purified water, derived from ultrafiltration and then reverse osmosis, to be reused as recovered water.65

The Lubeck Waste Treatment facility is able to process up to 150,000 tons per annum [tpa] of mixed waste, to generate up to 2 MW of energy [1.9 MW of renewable electricity, and 2.3 MW of heat] per year.66 Fifty percent of the energy created through the Combined Heat and Power Plant is used to power the facility and it monitoring systems, while the other 1 MW plus the energy generated through the safe combustion of the Refuse Derived Fuel [RDF] is plugged into the main energy grid and sold.67

The Lubeck MBT+wAD campus takes up 11 acres of land [located on a landfill site], and contains homogenizers, 3 large digesters, gas engineering facilities for RDF, containerized membrane plant for ultrafiltration and reverse osmosis for water remediation, areas for storage, and docking areas to receive refuse.68 To manage odor, HAASE developed the VocsiBox Odor Prevention Process whereby all ventilation and process air is treated before it is released into the atmosphere, resulting in not only reduced GHG emissions but also insignificant odors.69

ANALYSIS

The Lubeck Waste Treatment Facility is one of a series of MBT+wAD systems in the European Union. As part of the Manchester, UK private finance initiative, for instance, three new MBT+wAD facilities, developed by Viridor, are planned for waste management as well as the generation of 24 MW of energy per year.70

The combination of incineration or gasification for larger, harder to digest, materials, and then anaerobic digestion for homogenized organic feedstock, is effective. In MBT+wAD, materials are well sorted to be as efficient as possible, the RDF may take longer to digest and can create

67 Ibid.
69 Ibid.
energy in the short term, while the organic material can take between 20-25 days and produce a consistent amount of energy long term. In the meantime, waste sorted out for recycling is a source of revenue, and a form of hazardous GHG emissions management. The system is received well by the people of Lubeck and nearby Neumunster because they are able to benefit from the short term incineration or gasification of RDF to provide for their heat and electricity for at least 5 years. Also, because of the odor control system, there is negligible smell, which is a main concern of objection for AD facilities. The plant is also set in a metropolitan area, similar to those in process in Manchester, which makes this system highly attractive for city zones.

**RISKS AND MITIGANTS**

![Diagram showing risks and benefits of waste to energy systems](image)

**MARKET TIMING**

The United States is in the perfect climate to consider waste to energy as a viable option for both waste management and energy production.
Waste Management
As the adjacent graph shows, Municipal Solid Waste generation has increased from the 1960s to 4.43 pounds of waste per person per day, of which only 1.51 pounds is recycled or composted- in 2010, Americans produces approximately 250 million tons of waste, growing steadily from the 88 million tons from the 1960s. Where is this waste going? In 2010, according to the EPA, 34.1% of the waste is recovered and reused, 11.7% is used in WTE combustion, and the vast majority, 54.2% is discarded in landfills. Luckily, landfilling has dropped from 89% in the 1980s, and given the great rise in recycling, composting, and waste to energy through combustion, the use of land fills is diminishing while tipping fees are increasing, and there has been a move to close down as many as possible. Because waste to energy technology, particularly through anaerobic digestion, requires a great amount of filtering, the materials filtered out contribute to the recycling and reuse rates. If WTE were to be implemented, particularly in metropolitan areas, where density also leads to more waste, landfilling [and the tipping fees associated with this] could be greatly diverted, recycling rates would soar, and a new renewable energy source would lead to further cost savings.

Energy Production
Given that the United States currently consumes the highest amount of energy in the world, and that it is greatly dependent on other countries to provide the fuel for this energy, volatile costs have lead to many renewable energy production measures, including the previously mentioned “Energy Independence and Security Act of 2007.”

While these measures have lead to the rise in solar, wind, and tidal power, waste to energy is one system which continues to remain in rural areas, and is just now seeing a rise in metropolitan areas, driven by both waste management and energy production factors.

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72 Ibid. P. 3
At some point, WTE systems will become a requirement rather than a possible facet of managing both the two factors, as seen in London and Sweden. The two countries lack the vast amount of land the United States has, and the lack of space for landfilling almost makes WTE a needed rather than wanted system for waste management, as incineration is highly preferable to landfilling developable areas.

In the United States, the current rise in recycling, decrease in land filling, and the overall increase social consciousness of green living, can be considered optimal conditions in which WTE may move from rural areas to denser, metropolitan areas.

The most advantageous place to site a metropolitan WTE plant in the United States would be an area in which there is movement in the individual and governing bodies for sustainable living; one in which both waste management and energy costs are greatly rising; and an area where density is high and continuing to grow, to a point where landfill diversion is no longer possible without a new waste management system.

While there might be initial backlash from locals based on the mentioned perceptions related to waste to energy systems, given the rise in the necessity of a more effective system, by transparently relating the many assumed and actualized benefits of WTE, including rise in recycling rates, and the negative effects of landfilling in general, a change of opinion favorable to WTE may be eminent.

FINANCIAL RISKS

The main financial risks associated with developing the Waste to Energy plant come from the large upfront costs of land acquisition, construction, and of the placement of technology. The scale of the project affects these risks largely, and it should be known from the onset so the finances can take into account the amount of land, construction time, and operational time required to process a specific amount of waste to generate a specific amount of energy.

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Electrical</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incineration</td>
<td>22%</td>
<td>50%</td>
</tr>
<tr>
<td>Gasification</td>
<td>27%</td>
<td>34%</td>
</tr>
<tr>
<td>Anaerobic Digestion</td>
<td>35%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Figure 14: Energy Conversion Efficiency of WTE systems.

To understand how much land and energy is required to run a Waste to Energy Plant, the first step is to decide on the optimal WTE system. The decision can be made according to various factors, like time required for construction, and the cost of buying and operating the system, as well as its lifespan. The developer can also analyse the ratio of energy output to energy input. Energy input is the amount of energy needed for a WTE system to generate electricity and heat. The energy output is the amount of energy generated, and it should always be greater than the energy input. This is quantifies the energy conversion efficiency. As seen in Figure 1473 Anaerobic Digestion is most efficient in energy conversion to electricity, and is as efficient in thermal conversion as incineration. This makes Anaerobic Digestion the most optimal WTE system.

For an Anaerobic Digestion plant which can supply energy to high density areas, as well as process waste through sorting processes, like in Lubeck, would require approximately 12 acres of land per 150,000 tpa of waste. This plant could run on 1 MW of energy and produce 2 MW with anaerobic digestion alone to create a net positive environment, as seen in the Lubeck plant. The Lubeck plant took 12 months of construction at 30 M Euros in capital expenditures74 and other state of the art AD facilities can expect the same amount of time, though construction costs can vary according to location. Once in operation, the plant would have to undergo quality control tests for 1 year. As soon as the AD facility begins operations, however it is able to generate revenue not only from the generation of electricity [each batch can take up to 25 days] but also from waste management. Operational expenditures at this point can include the price of labor, as individuals would have to collect the refuse, push it through the sorting equipment, if possible remove further waste to be turned into RDF, monitor the homogenizers and digestors, and then the desulphurization tanks for the biogas and its further processing, as well as management of the digestate, and the possible water remediation. All parts of the plant will take training and commissioning, but these costs are greatly offset by the lack of energy costs of running the plant.

Financially, the success of the WTE plant lies in the reduction of upfront and operational costs and the increase of revenue. Public private partnerships can favorably affect costs, and even though the plant would be largely, if not completely privately financed, the city and state may be able to provide subsidies for renewable energy, job growth and the like to offset and leverage the initial investment. On the revenue side, Anaerobic Digestion provides much more than waste management and energy- unlike incineration and gasification, which produces ash, AD provides digestate which can be sold as wet and dry fertilizer. If the company chooses to follow the Lubeck precedent of MBT+wAD, it can also have a small CHP plant which would produce and sell heat and electricity from Refuse Derived Fuel. Everything that is left is recycled or reused, another revenue generator, and a very small portion is carefully landfilled. The amount of profit made from this plant is dependent on how much each revenue generator brings in from with operational and capital expenses are removed- both revenue and expense are site specific.

The greatest financial risk mitigant is the already present market for both waste management and renewable energy. As long as waste is generated, the plant will consistently have an input, and as energy is consumed, there will be a demand for a source of supply. And increased waste from highly dense areas means more energy generation, which translates to higher revenue and favorably affects the company’s bottom line.

MARKET ANALYSIS

CURRENT STATE OF AFFAIRS

On March 6, 2012, Mayor Bloomberg of New York City sent out an RFP for the placement of a WTE plant in the New York Metropolitan Area as part of the city’s sustainability program. According to the New York State Department of Environmental Conservation, which put forth a “Beyond Waste” Plan approximately 20 years ago, in which recycling and reuse, composting,
and energy recovery are seen as preferable in the same order to land filling, while there has been a greater observance of this hierarchy, and “although landfiling is statutorily the management method of last resort, landfills, either instate or out of state, handle the largest proportion of waste disposed.”

In New York City alone, the public and private sectors of the metropolitan area produce upwards of 15 million tons of waste each year, of which more than 10 million tons is exported to landfills out of state, particularly since the closure of the Fresh Kills Landfill in 2001. Since this closure, New York City has exported particularly to Virginia and Pennsylvania, where trash going to landfills has accelerated their closing time frames, and as transfer stations are operating at nearly 100 percent of their permitted capacity, in which the Department of Sanitation has to compete with the private sector waste for transfer and disposal, the city spends a great deal to contract with transfer and waste management firms outside of the five boroughs. To cut these costs, as well as the rise in energy consumption due to population increase and the overall rise in consumption habits of the American user, the RFP from the Bloomberg Administration is being put out at a time of need rather than a time of want in which WTE may seem like a viable possible rather than the current requirement.

**DEMAND**

The Bloomberg administration is clearly showing a want for a waste to energy plant in the New York Metropolitan area. According to the press release announcing the RFP as part of PlanNYC, the city’s sustainability program, the RFP “seeks private sector firms to submit plans for a pilot facility using reliable, cost effective, sustainable and environmentally sound waste to clean energy technology, which will help the city meet its goal of double the amount of waste diverted from landfills...the facility must be located in New York City or within 80 miles of the city and would begin by processing a maximum of 450 tons of waste per day- the city currently processes approximately 10,000 tons of waste per day.” If this pilot is successful, the facility is to be expanded to support 900 tons of waste per day. The release also says the RFP expressly excludes the use of conventional incineration proposals in which the waste would be burned in mass without being filtered, leading not only to a lack of recycling and reuse, but also a great degree of health risks.

Mr. Bloomberg said, “We are using the most comprehensive sustainability program in the nation to green our city, but we have to go further. New Yorkers generate more than 10,000 tons of solid waste every day and too much of it ends up in landfills.”

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77 Ibid.
79 Ibid.
Using less, and recycling more are the most effective ways to address the problem, but this project will help us determine if some of that waste can be converted to safe, clean energy to meet the City’s growing power needs.80

These growing power needs, and the need for waste management is because consumption of waste and power is at an all time high nationwide, and as density increases so do these issues at the local scale. According to the New York Times, the “City gained nearly 70,000 residents in the 15 months ended July 1, 2011, almost matching the growth of the 1990s, when an influx of foreigners set annual records, according to census estimates.”81

With the growing population, rise in the use of electricity, rise in municipal generation rates, and the demand expressed by the Bloomberg Administration for a metropolitan waste to energy plant, the demand is clear and the time for waste to energy implementation has risen.

COMPETITIVE SUPPLY

As discussed, the current waste management treatment within New York City is some recycling and reuse in-city, and the rest, approximately 80% is exported to states like Pennsylvania and Virginia, where the waste is landfilled. By placing a WTE plant in metropolitan New York, not only is the city able to manage its waste in house, where transportation costs are much lower, eventually, it may even be able to import waste from other states to manage through energy conversion. The revenues from waste management are kept within the city, which lowers over all taxes, there is no additional cost of having to pay out of state for waste management, and energy generated offset the costs of having to buy from other sources.

While all of the energy needed to meet demand for the state is created in-state, which means costs savings from having to import energy as well as retaining energy revenue in-state, it should be noted that much of the energy generated is upstate, while most of the energy consumed is downstate, as this is the region in which the state is most dense.82 And while New York State has infrastructure to collect energy through renewable sources such as hydro and wind power, and has initiatives to increase its investment, specifically in wind turbines,83 as a result of environmental requirements, transmission limitations, and reliability standards that require local generation in the downstate region, the power demands of New York City and Long Island must be largely served with generation fueled by natural gas and oil.84

80 Ibid.
83 Ibid. P. 31
84 Ibid. P. 21
There are, however, some initiatives to generate clean energy downstate, such as tidal power in the water around Manhattan Island. Given that both oil and gas are considered natural, nonrenewable resources, there is a strong demand, particularly given New York City’s sustainability program through PlanNYC, to use various types of renewable energy to substitute if not replace burning natural gases.

The local policy then, is trying to move away from the use of coal and oil to generate electricity downstate, as well as find a more effective way, given not only the health hazards and use of developable land, but also the tipping fees and transportation costs associated with land filling, to manage waste within the metropolitan area. Given that waste to energy is two fold and is able to cater to both markets, it is important to consider two factors: the placement of this plant is to be privately held, and the waste management of the Municipal Solid Waste of New York City will be also done so privately, with the city and any private sectors paying on a per ton basis, as...
mentioned in the RFP. In addition, state and local renewable energy incentives will allow for the subsidization of the placement of this plant as a renewable energy business. The state policy is through NYS Energy Research and Development Authority [NYSERDA] which provides grants and renewable energy incentives using: the New Construction Program, which subsidizes industrial businesses which are building in energy efficiency measures in their design, construction and operations of up to $1.575 M not including bonus incentives including if the structure is LEED certified. NYSERDA also offers competitive solicitations in which the company would have to apply via RFP. There are also state incentives by NYSERDA on the management of agricultural waste through anaerobic digestion, which includes grants at a minimum of 40-85% of co-funding. While this may be currently specific to New York State farms, by soliciting the government to place an anaerobic digestion facility, which requires the least amount of energy input to create the greatest amount of energy output at $0.03-0.04/Kwh [much less than most the other types of renewable energy sources,] in a metropolitan area, which can also take waste from farms.

Given the various incentives, and the RFP out for a waste to energy plant, not only is there a demand for this type of industrial use, but the city, state, and federal governments are soliciting and encouraging through fund the placement of a waste to energy system in continually densifying metropolitan New York City.

Forest City Enterprises has a large branch office, in New York City, with various local projects including the newly completed New York by Gehry, and Atlantic Yards in Brooklyn. Both projects either currently or will use a large amount of energy, and can benefit greatly from the placement of a WTE plant in its metropolitan area to offset energy costs both within each project as well as in the greater Forest City portfolio.

SITING THE PROJECT

The RFP mentioned that the WTE site should be in metropolitan New York City or at a maximum 80 away from the city. Given that this project is an industrial use, and requires a large amount of land, placing the project on usable agricultural land would be inefficient. If the project requires a facility which can process 450 tons/day [164,250 tons per annum or TPA] will require approximately 12 acres of land. [This is derived from the amount of land the Lubeck Waste Treatment Facility, operated by Hasse and constructed in 2007, takes in comparison to the 150,000 tpa of waste it processes] The currently industrial land cost in metropolitan New York per square foot is shown in the above graph, and the price

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of the industrial land is dependent on its location as Forest City Enterprises chooses to place. According to the graph, commercial and industrial land command much lower sales prices than residential land. In addition, the city of New York may own some industrial land that has been left unoccupied, in which a public-private partnership may be struck.

In every case, the location of the plant, and the filtration and anaerobic digestion within it, should be considered the end point of waste to energy process. This process begins first with the consumer of both the waste and the energy, much like in the Symbiocity concept, in which he is charged with motivation to properly recycle, either by fee or [more likely, given the fee precedence has not been set] incentive, his waste, and also to be mindful of the amount of energy he uses on a daily basis. Given the density of the area in which this WTE Anaerobic Digestion Treatment Facility would be placed, the growth in municipal waste and the consumption of energy given trends and also population growth, there should be no lack of demand of waste management or energy, in which the market is already existing.

DEVELOPMENT PROGRAM

The optimal development program calls for a plant which is able to process 164,250 tpa of waste, with the option of doubling according to its performance. The amount of land required is a little more than 12 acres for the first phase, and if expanded, another 12 to accommodate the additional digesters, sorters, homogenizers, and combined heat and power plants. The WTE facility has front loaded costs for construction and the placement of state of the art technologies and management systems like the SCADA monitoring system. If it follows the timetable of the Lubeck Waste Treatment Facility, however, it can begin to generate revenues after only 12 months of construction. The capital cost of the facility, excluding land purchase for the first installation can be anywhere from $30-50 million, depending on construction costs. [The capital cost quoted in the Lubeck plant is 30 million Euros, however, construction costs within the United States may be greater than in Germany.] Given that the tipping fees of landfilling nationwide have reached at least $35/ton\(^9^9\) which New York City will pay in addition to transportation to landfills in Pennsylvania and Virginia, revenues from just waste management can reach [at $35/ton/day] at least $5,748,750, which is already greater than a 10% return before operating and capital expenditures. In addition, the current price of electricity per kwh is $0.191,\(^9^0\) and given that anaerobic digestion can cost as little as $0.03/kwh, even if the price of electricity were to be decreased down to $0.10, which is a 52% reduction, the plant would still make $0.07/kwh in profit. This plant can generate more than 2 MW [17,520,000 kwh/year] of electricity and heat per year, meaning that at $0.10/ kwh, the plant can generate $1,226,400/year just on energy in profit. This means more $7 million/year disregarding operation of the waste management. Additional revenues generated could be from the sale of recyclable materials directly to manufacturers and the sale of the residual digestate as fertilizer to farms in the tri-state area. The plant could reasonably generate $10 million/year on the first phase of the project.

\(^9^0\) Refer to Figure 13.
Given that the five boroughs of New York City alone generate 10,000 tons per day, and this plant will be designed to process 450 tons per day, the scope of people who would exclusively use this site could be the 5 boroughs of New York City. As waste is less and less consumed through conscious effort\(^\text{91}\), the WTE treatment facility may be able to process more households in the metropolitan region. As it stands currently, however, the market area for the placement of the site must remain within an 80 miles radius from the City.

Remediated brownfield sites would be preferable, as part of the sustainable goals of the project. One strong option may be the land that used to be the Freshkills Landfill in Staten Island. The area of land is quite large- 2,200 acres, and given that the project would need 24 acres at most, the waste to energy plant would only take up approximately 1% at the most of the remediated land. Given that the site was initial a waste treatment facility as well, there is already placed infrastructure for efficient access to the site.

Information needed to be gathered for the Freshkills site would include the level of land remediation completed, title for the land, the value of the land, its access to infrastructure to the main energy grid, any changes in zoning, and the environmental hazards which may be associated with placing a waste to energy treatment facility within a remediated landfill. Also, given that the site is located near an estuary, studies must be done to understand the ecological repercussions of placing a WTE treatment plant, and the steps the developer may be able to take to mitigate any problems that may arise.

Policy analysis also needs to be vetted out to understand exactly where the city is willing to provide grants and subsidy. Communication with the city is important in order to understand their needs in terms of the possible expansion of the plant. This can then relate to the proposed master plan for the site. There must also be a determination of price per ton and price per kwh, based on the cost of the plant and operating expenses, to ensure an optimal profit margin. Lastly, a good marketing strategy, a transparency in communication with locals residing and

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\(^{91}\) PlanNYC, the city’s sustainability initiative is encouraging individuals and corporations to recycle and reuse resources as much as possible.
working in proximity to the site, and the omnipresent protesters is key to the survival and effectiveness of the project. Lack of proper communication and public relations, protests, neighborhood judicial reviews, etc. could lead to a halt in development plans for years leading to a lack of efficiency and unnecessary costs, as seen in the various case studies analyzed.

**INITIAL LAND USE PLANNING**

Peripheral and complimentary industries related to waste to energy through anaerobic digestion may be another source of revenue. The residuals from the anaerobic digestion, which include wet and solid digestate and water can be converted into digestate and go through a remediation process to be without contaminants, respectively. Solid and liquid fertilizers can be used to grow produce, or crops like hops and cacao to make beer and coffee. The residuals from the crop growth can also contribute to the AD process to create energy. If the Freshkills site is used, these farms would have to be located outside of the original landfill campus to ensure uncontaminated crop growth. As most of the Freshkills site is being remediated into a park, the digestate may also be beneficial to the greater site.

This secondary industrial use, which includes an urban farm, and breweries for beer or coffee, or wineries, can help to create a closed loop system by which the entire campus would be supplied by energy generated by AD, including the factories used for manufacturing plants grown with the residual fertilizer and remediated water in beer, coffee, or wine; and waste is created to give into the AD facility to create more energy. The closed loop system would be self-sustaining, and whatever surplus energy is generated is sold and injected into the main grid.

If the microbrewery, placed in New York, uses the Brooklyn Brewery as a precedent, the secondary industry alone can bring up to $11 million in revenue/year after ten years of operation as the Brooklyn Brewery was able to do. This is in addition to the $6-12 Million from waste management, and maximum $1.2-2.4M in energy revenues, not to mention fertilizer sales. This waste to energy plant has the potential, then, to earn $25.4 M after the expansion.

The secondary industry is very much worth the amount of energy not sold to the main grid, as it has the potential to generate 9 times more revenue than energy revenues alone. Also, this closed loop system is different from other WTE treatment facilities already in place, in addition to its placement in a metropolitan area. The secondary industry may be used as a selling point from the onset of the development of the site.

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CONCLUSION

After studying the different kinds of waste to energy and the case studies associated with each, the perceptions that go along with placing the plant on a site, analyzing the risks and mitigants, and then placing the plant using market analysis this proposal concludes the following:

Waste to Energy is a viable and sustainable solution towards offsetting Forest City Enterprises large annual energy costs. It is able to generate heat and electricity, and has the potential for much more, including Refuse Derived Fuel as bioethanol.

Perceptions towards Waste to Energy as a refuse treatment facility alongside its energy generation capabilities have been historically negative in the United States. These perceptions can be mitigated by strong communication and considerate public relations, incentive programs, and insurance against the loss of land value.

Waste to energy treatment facilities in countries like the Sweden and Germany are accepting, and have incorporated the vacuum waste management systems into their urban planning to a point where it is part of individuals' lifestyle. However others, like the incinerator in London, have faced opposition and years of litigation before construction could begin. In both London and Cleveland, those opposed to the project were uninformed by the developer, and better communication would have facilitated each process.

Given the rise in both waste generation and energy consumption, as well as landfills closing as they have reached capacity, there is a clear demand for a system like waste to energy, which is able to manage waste as well as generate energy to inject into the main grid. The denser the market area, the more waste produced, and thus more energy generated. Ideally a waste to energy site would work best in a metropolitan area. Financial risks may be mitigated by using the right kind of WTE system, in this case Anaerobic Digestion, to allow minimized operational costs with a large amount of revenue through waste management and sorting, and various by-products like fertilizer and remediated black water.

The City of New York has posted an RFP for a waste to energy facility within the metropolitan region of the city. There is an already recognized market demand for WTE, as New York City uses principally nonrenewable resources to generate heat and electricity, has a growing population which currently produces 10,000 tons/day of refuse, and is the number one exporter of refuse to states like Pennsylvania and Virginia. The landfills in those states are quickly reaching their limits and shutdown is eminent, which translates to a diminishing competitive supply of waste management. Remediated industrial land is optimal for the placement of this site, and what used to be the Freshkills Landfill in Staten Island has the land and infrastructure to support a Mechanical Biological Treatment + Anaerobic Digestion facility.

The facility can enjoy further revenues by taking part in a closed loop system by which energy is used by a coffee or beer brewery, which gets its crops from an urban farm using organic fertilizer as a byproduct of the AD process. The Brewery closes the loop by proving the AD plant with organic refuse. The plant can potentially generate up to $25 million per annum.

Forest City Enterprises is in the perfect position to place and operate a WTE AD plant in metropolitan New York. By developing the waste to energy facility, revenues can offset additional energy costs, bring in further land uses, and do so in a clean and sustainable way.