Waste to Watts

An Act Concerning the Reclassification of Trash-to-Energy Facilities as Class I Renewable Energy Sources (Connecticut H.B. 5118)

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Waste-To-Energy Fall 2012 Workshop Group

Faculty Advisor	Shadan Azali, The Earth Institute
Team Leaders	Jeffrey Irvine Alana Miller
Team Members	Jen Croft Kelsie DeFrancia Haakon Gløersen Xuan Li Krystal Lin Monica Pham Jacques Prevert Rumanyika Frank Reig Katharine Targett

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Cover Photo Credit: ARUP “Rubbish In – Resources Out”

Preface

This report concludes two semesters of work for the Workshop in Applied Earth Systems Management, as part of the Master of Public Administration in Environmental Science and Policy at Columbia University's School of International and Public Affairs, in conjunction with the Earth Institute. For the workshop, each team studies a piece of legislation that has been proposed but not yet enacted. Our project examined Connecticut Raised Bill No. 5118, "An Act Concerning the Reclassification of Trash-to-Energy Facilities as Class I Renewable Energy Sources," which proposes to reclassify waste-to-energy (WtE) facilities from Class II renewable energy sources to Class I renewable energy sources.

For the first semester, the group members researched the scientific problems that the bill seeks to address, as well as the environmental impacts resulting from the proposed legislation. For the second semester, the group examined the possibilities of implementing the policy under a hypothetical scenario where the bill had passed into law. This report reviews findings from both semesters and outlines an implementation plan.

Table of Contents

List of Acronyms and Abbreviations

BSD	The Bridgeport Sanitation Division
BTU	British Thermal Unit
CAIR	The Clean Air Interstate Rule
CCE	Citizens Campaign for the Environment
CEO	Chief Executive Officer
Class I Renewable Energy	As defined by Connecticut: Energy derived from solar power, wind power, a fuel cell, methane gas from landfills, ocean thermal power, wave or tidal power, low emission advanced renewable energy conversion technologies, a run-of-the-river hydropower facility.
Class II Renewable Energy	As defined by Connecticut: Energy derived from a trash-to-energy facility, a biomass facility that began operation before July 1, 1998, provided the average emission rate for such facility is equal to or less than .2 pounds of nitrogen oxides per million BTU of heat input for the previous calendar quarter, or a run-of-the-river hydropower facility provided such facility has a generating capacity of not more than five megawatts, does not cause an appreciable change in the river flow, and began operation prior to July 1, 2003.
CLEERGAS	Covanta Low Emission Energy Recovery Gasification
CLF	The Conservation Law Foundation
CO_2	Carbon dioxide
CO	Carbon monoxide

CRRA	The Connecticut Resources Recovery Authority
DEEP	Department of Energy and Environmental Protection
ERC	The Energy Recovery Council
EPC	The Engineering, Procurement of Materials and Construction
FCC	The Fairfield County Coalition
kWh	Kilowatt-hours
Municipal Bond	A debt security issued by a state, municipality or county to finance its capital expenditures. Municipal bonds are exempt from federal taxes and from most state and local taxes, especially if you live in the state in which the bond is issued.
MWh	Megawatt-hours
MSW	Municipal Solid Waste
NEPOOL-GIS	The New England Power Pool Generation Information System
NIMBY	Not-in-my-backyard
NO_x	Nitrogen oxide
RPS	Renewable Portfolio Standard
PM	Particulate matter
PPA	Power purchasing agreement
PURA	Public Utilities Regulatory Authority
REC	Renewable Energy Credit

RRA	Resources Recovery Authority
SO_x	Sulfur dioxide
S&P	Standard & Poor's
SWMP	Solid Waste Management Plan
Thermal Gasification	A waste-to-energy technology that utilizes high temperatures and minimal oxidation to transform waste material into gas that can be used as fuel, while producing other byproducts.
Tipping Fee	The charge levied upon a given quantity of waste received at a waste processing facility.
TPD	Tons per day
UI	The United Illuminating Company
US EPA	The U.S. Environmental Protection Agency
WtE	Waste-to-Energy. A process in which solid waste is converted into thermal energy to generate steam that drives turbines for electricity generators.

Executive Summary

The status quo of waste disposal and energy production in Connecticut causes a host of environmental concerns. The state suffers from an asthma rate of 9.2% among adults and 11.3% among children, both of which are higher than the national average.[i,ii] Health officials have called asthma in Connecticut an epidemic.[iii] Asthma is exacerbated by air pollution, including ground level ozone, and Connecticut is among the smoggiest states in the nation. Additionally, much of Connecticut is also vulnerable to the environmental impacts of climate change. Being a low-lying coastal state, rising sea levels and flooding are particularly concerning.[iv]

Central to these environmental concerns are current methods of waste disposal and energy production, through landfills and fossil fuel combustion. Landfills release methane, a major greenhouse gas, and trucking trash in diesel trucks across long distances releases carbon dioxide and significant air pollution. Fossil fuel combustion also releases greenhouse gas emissions and air pollution, including nitrogen oxide (NO_x) and particulate matter (PM). By avoiding the amount of trash sent to landfills, and displacing the energy created from fossil fuels, the state could potentially alleviate these environmental concerns.

Currently in Connecticut, the cleanest forms of renewable energy are considered "Class I" sources, making them eligible for economic incentives that allow them to compete against fossil fuels and traditional energy. A recently proposed piece of legislation, Connecticut Raised House Bill No. 5118, "An Act Concerning the Reclassification of Trash-To-Energy Facilities as Class I Renewable Energy Sources" seeks to make waste-to-energy (WtE) a Class I renewable energy source, allowing WtE facilities to receive renewable energy credits, or RECs, for the energy they produce. This bill would radically reshape what is considered a Class I energy source, since the highest ranking is currently reserved for some of the cleanest forms of renewable energy, including solar power, wind power, fuel cells, and low-emission biomass facilities.

Promoting WtE as a low-emission renewable energy source suggests that Connecticut Raised Bill No. 5118 would help address the problems of global climate change and local air pollution. The legislation proposes a solution to these environmental problems by giving additional monetary value to WtE through renewable energy credits. We analyzed the environmental impact of the legislation under the assumption that it would lead to an increase in the percentage of trash incinerated at WtE facilities, thereby reducing the amount of waste sent to out-of-state landfills and displacing fossil fuel energy production.

Our analysis found that while the bill may have been created to promote a cost-efficient waste-management strategy, the legislation is capable of reducing greenhouse gas emissions and air pollution, thereby helping to address climate change and local air pollution for the state of Connecticut. We emphasized, however, that the reduction would be relatively small overall.

Assuming the bill had passed, our group explored possible design options for the implementation of the bill. The bill states that any revenue generated from the sale of Class I renewable energy credits goes to the municipalities that utilize a waste-to-energy facility, and it does not stipulate how these municipalities must spend the revenue. We developed four primary options for using this revenue. The first was for municipalities to use the revenue to reinvest in programs unrelated to waste-to-energy. This option however would not utilize the opportunity to its fullest potential nor would it likely reduce air pollution and greenhouse gas emissions. The second option was to retrofit an existing plant, but this is currently cost prohibitive. The third option was to use the revenue to build a new "mass-burn" facility using the most basic incineration WtE technology. However, this method is the least efficient and creates a significant amount of emissions. Finally, we considered using the new revenue to build a new low-emission facility.

After considering the options, we created a hypothetical scenario where we, as a coalition of municipalities, use funding, in part provided by the legislation, to construct a thermal gasification WtE facility in Bridgeport, Connecticut. In order to create such a facility, our group outlined the organizational structure of the Fairfield County Coalition of Municipalities. An Executive Board and a CEO, along with legal and administrative directors and other staff, will run the coalition. The coalition will also contract with other organizations that will build and manage the plant, purchase electricity, provide waste as fuel, and dispose of secondary waste.

Fairfield County Coalition logo. Design by Kelsie DeFrancia.

We also created a financial plan and established a budget for the creation and operation of our plant. In the budget, we detailed revenue projections, estimates for construction and operating costs, and the assumptions and forecast methods used to create these projections. In order to fund the project, the coalition will issue 20-year municipal bond certificates in order to borrow money to fund the $107 million in upfront capital costs. With the new revenue from RECs on top of electricity production and waste disposal fees, we project to have a $1.5 million surplus in the first year, which we can reinvest in our county.

We developed a performance management plan to assess the new WtE facility and ensure it minimized environmental problems, maintained positive community relations, and maximized safety, efficiency, quality and revenue. Finally, we created a master calendar detailing a schedule of the outputs that need to take place to achieve the first year outputs and goals. In the calendar, we identified the permits and contracts we would need to secure in order to construct and run our WtE facility.

Ultimately, by increasing WtE production to replace fossil fuels and avoid landfilling waste, our program has the potential to address the environmental problems of air pollution and climate change, and to provide a cost-effective waste management strategy for the state.

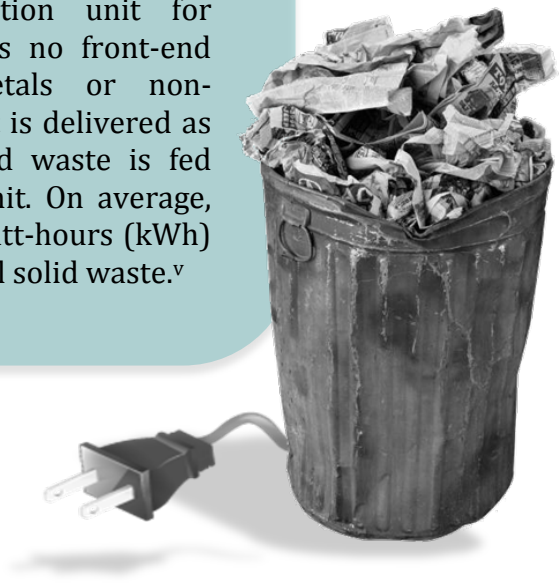
Introduction

Newly introduced legislation in Connecticut (H.B. 5118) would reclassify the electricity produced by waste-to-energy (WtE) facilities as a Class I renewable energy source, making the energy eligible for monetary incentives. In Connecticut, Class I designation and associated incentives are currently reserved for some of the cleanest forms of renewable energy, including wind and solar. The bill is promoted by supporters as a way to reduce air pollution and greenhouse gas emissions by incentivizing WtE over landfilling and fossil fuels. Finally, the bill also states that money generated from the sale of Class I renewable energy would go to the municipalities that utilize WtE facilities.[iv] This money could help abate the cost of waste disposal, so the bill is also promoted as a cost-effective waste management strategy.

The first part of this paper includes a scientific analysis of the environmental problems of air pollution and climate change and examines whether or not expanding waste-to-energy production through the bill could address these environmental concerns. The second part of the paper consists of a hypothetical program design, assuming that the bill has passed.

What is Waste-to-Energy?

As the name implies, waste-to-energy is the process of converting trash to create heat or electricity. In the United States, the most widely used technology is "mass burn," where waste is fed directly into a combustion unit for incineration.[1] Generally, there is no front-end separation of recyclable metals or non-combustible material from what is delivered as trash to the facility – unsorted waste is fed directly into the combustion unit. On average, mass burn generates 544 kilowatt-hours (kWh) of electricity per ton of municipal solid waste.[v]



The Legislation

An Act Concerning the Reclassification of Trash-To-Energy Facilities as Class I Renewable Energy (Connecticut Raised Bill No. 5118, from now on referred to as Connecticut H.B. 5118) seeks to amend the Connecticut General Statutes to reclassify waste-to-energy (WtE) from Class II to Class I renewable energy, making waste-to-energy eligible to receive renewable energy credits, or RECs.[vi] The purpose of the reclassification is to reflect the environmental value of such electricity and make it competitive against other sources. This value is monetized through RECs that can be bought and sold on the open market. RECs are currently desirable because of a state law, the Renewable Portfolio Standard (RPS), which requires utilities in Connecticut to get 20% of their electricity from Class I renewable sources by 2020. Any revenue that is derived from the sale of Class I RECs would be directed to the municipalities that utilize the waste-to-energy facility.

Including Connecticut, 26 states recognize WtE with some classification as a renewable resource.[vii] Of these states, only California, Connecticut, Iowa, Pennsylvania, Maryland and Maine include WtE in their renewable portfolio standards.[viii] In 2011, Maryland passed a bill similar to Connecticut's H.B. 5118, which added WtE to the state's first tier of renewable energy.[ix] Currently, the state of Connecticut has six operating WtE facilities, the third most in the United States, after Florida and New York.[x]

What are Renewable Energy Credits?

Renewable energy credits (RECs) are awarded to renewable energy producers by the state government and then companies and institutions purchase RECs from these facilities to comply with state requirements for renewable energy production and demonstrate their commitment to sustainability. RECs are similar to stock certificates that can be traded for cash. RECs certify that 1 megawatt-hour of electricity was produced by a renewable energy source. The purpose of RECs is to provide a subsidy to encourage the development and use of renewable energy sources. For example, a wind farm can earn RECs for the amount of electricity it produces and sell those RECs on the open market, which allows it to be more competitive with non-renewable energy sources.[xi]

Political Implications and Consequences

While the designation of WtE as a Class I renewable energy source implies Connecticut H.B. 5118 was proposed for reasons of energy and environmental policy, the political supporters of the bill proposed and supported it primarily as a cost-effective waste-management solution. In 2010, Connecticut supplied

68% of its total municipal solid waste to WtE facilities.[xii] The falling price of natural gas has made WtE less competitive on the electricity market and has forced facilities to raise waste disposal fees, or "tipping fees", which WtE facilities charge for accepting trash. This has consequentially put pressure on already cash-strapped municipality waste-disposal budgets. Many supporters testified before the legislature stating that dedicating REC revenue for municipalities that utilize WtE facilities will help these municipalities pay waste disposal fees.

Beyond making waste-to-energy more competitive and providing revenue to municipalities, the additional monetary value given to Connecticut's WtE production could have several unintended consequences. If the value of Class I RECs increases as Connecticut moves towards meeting its 2020 RPS requirements, it may incentivize Connecticut communities to build new facilities that incinerate trash imported from other states. More specifically, townships near the New York City (NYC) region could profit tremendously. Trash management is a billion-dollar business in NYC with upwards of $300 million spent solely in transporting trash to distant landfills located hundreds of miles away from New York.[xiii] New facilities built near the border of Connecticut and New York would generate strong revenue streams from the ensuing Class I RECs and the endless supply of solid waste.

Connecticut H.B. 5118 could also have consequences at the national level. If it passed and successfully demonstrated positive benefits for Connecticut municipalities, it may convince the federal government to pass similar legislation in the future. Local governments are always looking for opportunities to ease budget constraints, and the ability to generate revenue for government coffers by selling Class I waste-to-energy RECs could potentially prompt calls for a nationally recognized REC standard. Just as California has consistently influenced national environmental legislation by setting higher gas-mileage standards for automobiles, Connecticut could potentially change the entire waste-management industry.[xiv] [xv]

What is a Renewable Portfolio Standard?

Purchasing RECs allows utilities to comply with Connecticut's Renewable Portfolio Standard (RPS), which requires utilities to acquire at least 20% of their electricity from Class I renewable power sources with an additional 3% from either Class I or Class II sources by January 1, 2020. Connecticut utilities that use Class I energy sources are rewarded RECs but those that do not produce enough Class I renewable energy to meet the standard must purchase RECs on the open market. Electric providers that fail to comply with the RPS during a year must pay $0.055 per kilowatt-hour to the Public Utilities Regulatory Authority (PURA).[xv]

Lastly, Connecticut H.B. 5118 may unintentionally undermine traditionally clean, low- and zero-emission renewables by supporting polluting technology. The bill offers no distinction between the types of WtE plants that are eligible for Class I RECs and it is absent of any mechanism to influence the retrofitting and updating of current facilities. Since this legislation would place WtE facilities in a category alongside the cleanest energy sources, some argue these plants should at least be equipped with the cleanest incineration technologies. Most incineration in Connecticut is accomplished with the mass-burn method, which incinerates all of the trash received and which creates more emissions than even coal combustion. Only one plant in the state sorts non-combustible material out of the waste stream before burning, which increases efficiency.[xvi] In the future, if similar legislation is proposed in other states, it should include provisions for adapting WtE facilities with newer, more sustainable technologies before considering WtE among the best of renewable energy sources.

Political Controversy

Considering the intricacies of the bill described above, it is no surprise that the proposal is highly controversial in Connecticut. On one hand, cash-strapped municipalities and struggling WtE facilities are desperately looking for a solution to their budgetary concerns. On the other hand, environmentalists and community groups worry about the pollution potentially emitted from facilities and about the unintended consequences the bill could have on the renewables market. As such, dozens of individuals representing a variety of interests have testified on the bill.

Proponents	Opponents
CT Governor Dannel P. Malloy	Elected municipal officials
Citizens Campaign for the Environment	Central CT Solid Waste Authority
CT Department of Energy and Environmental Protection	CT Resources Recovery Authority
The Sierra Club	CT Council of Small Towns
Conservation Law Foundation	Energy Recovery Council

Table 1. The proponents and opponents of Connecticut H.B. 5118

Supporting Arguments

The stakeholders that support Connecticut H.B. 5118 include municipal officials, the waste management industry, and members of the labor market. They primarily argue the bill would make waste disposal more economical for municipalities.[xvii] Supporters also contend that energy from trash is reliable, clean, and renewable, and they emphasize that WtE facilities must meet environmental standards and use emissions-control technology. [xviii,xix] Additionally, they claim that although Connecticut should aim to reduce the amount of waste it generates, trash creation is inevitable and so it should be utilized instead of wasted in landfills.[xx]

Opposing Arguments

The chief opponents to Connecticut H.B. 5118 are Connecticut Governor Dannel P. Malloy's administration, non-profit environmental groups, and the Connecticut Department of Energy and Environmental Protection (DEEP). Environmental groups contend that trash

incineration constitutes a threat to public health because WtE facilities emit significant amounts of toxic air pollutants, including mercury, lead, cadmium, and dioxin, which the groups say undermines the environmental and public health basis for the division between Class I and Class II energy sources.[xxi]

Furthermore, environmental opponents claim that reclassifying WtE as a Class I renewable source would shift the focus away from truly renewable energy sources, such as solar and wind, and thus deter investment in these technologies. They claim that a surplus of RECs in the market will depress REC prices, harming current Class I renewable energy sources that rely on revenue from the credits.[xxii]

Opponents also claim that subsidizing WtE would incentivize the production of more waste instead of reducing waste and recycling, which goes against Connecticut's solid waste management objectives. [xxiii] Ultimately, opponents assert that trash is not a naturally renewable resource and that waste incineration should primarily be considered a means of solid waste disposal, not energy production.[xxiv]

Power of Stakeholders

There is limited information available to assess the stakeholders' respective budgets and the money they have spent on lobbying WtE issues. However, Paul Nonnenmacher, Director of Public Affairs for Connecticut Resource Recovery Authority (CRRA), asserts that the environmental groups that lobbied against the bill hold the upper hand. This claim is bolstered by the fact that the bill did not make it out of the Environment Committee in the Connecticut General Assembly. Nonnenmacher states the power of the environmental groups is bolstered by strong "Not-in-my-backyard" or NIMBY sentiment of Connecticut residents, who oppose certain projects primarily due to the projects' proximity to their residences. Additionally, CRRA, a main proponent of the bill, suffered political embarrassment in the early 2000s because of its working relationship with Enron. This has reduced the agency's image and political influence.

Partisan politics also play a key role in this debate and the Governor's opposition greatly diminishes the bill's chance of passage. The administration and both houses of the General Assembly are controlled by Democrats, so if the Governor's office remains in opposition, it is unlikely that a majority in the House or Senate will buck party leadership by voting for the bill. Nonnenmacher suggests that the administration and environmental groups would need to drop their opposition if the bill were to have a chance of passing. Governor Malloy's administration is currently seeking solutions outside of this legislation and established a working group to create new plans for the state's recycling and waste disposal challenges. They believe no decisions should be made before the working group's study has been completed.

Solution to Environmental Problems

Putting politics aside, we performed an analysis to determine the extent to which, if passed, Connecticut H.B. 5118 could help address two important environmental problems: local air pollution and global climate change. Both of these environmental problems are of particular concern for Connecticut and are caused in part by the status quo of waste disposal and energy production.

For air pollution, we focused our analysis on nitrogen oxide and particulate matter because these two air pollutants cause a long list of adverse health effects.[xxvi] Most waste is transported to landfills in diesel trucks; the burning of diesel emits nitrogen oxides (NO_x) and fine particulate matter (PM) that consists of more than 40 toxic air contaminants. [xxvii] Nitrogen oxides, along with fine particles, play a major role in atmospheric reactions that form smog and ground-level ozone, both of which contribute to health problems, especially during the summer months.[xxviii] Particulate matter can be readily inhaled, and, due to its small size, it is not filtered in vehicles' exhaust. As a result, particulate matter penetrates deeply into the human cardiovascular system where it can cause significant damage. [xxix] According to the Connecticut Department of Environmental Protection, when inhaled, these pollutants can cause health effects such as bronchitis and even heart attacks. In addition, diesel particulate matter is a probable carcinogen.[xxx]

Greenhouse-gas emissions, namely carbon dioxide (CO_2) and methane (CH_4), are a concern for Connecticut because they contribute to climate change on a global scale. A warming climate will likely induce sea-level rise and more frequent and more severe storms for Connecticut, putting the state at an increased risk of coastal flooding.

Status Quo of Waste Disposal and Energy Production

In evaluating the effect of Connecticut H.B. 5118 on the environmental problems of air pollution and climate change, it is important to consider Connecticut's status quo for waste disposal and energy

Emission Intensities

	NO_x (kg)	PM (kg)	CO_2e (tons)
WtE (per MWh)	2.45	0.037	1.18
CT fossil fuel weighted average (per MWh)	1.41	0.097	0.62
Waste Trucking (per mile)	0.0162	0.00078	0.00485
Landfilling (per ton MSW)	--	--	0.79

Table 2. Smokestack measurements of air pollution and carbon dioxide emissions from waste-to-energy compared to status quo fossil fuel combustion.[xxv]

production. A baseline allows evaluation of WtE's environmental impact beyond the smokestack, taking into consideration the emissions that would be avoided by diverting municipal solid waste (MSW) from landfills to WtE and the changes to total emissions that would occur if new energy production from WtE caused fossil-fuel energy production to decrease.

Landfills emit a significant amount of methane and carbon dioxide, and we estimate that one year of Connecticut's MSW in landfills emits 378,466 metric tons of carbon dioxide equivalents (CO_2e) annually. Most of this comes from out-of-state landfills, as Connecticut plans to become the first state to have zero active landfills by 2015.[xxxiii] The transportation of MSW to out-of-state landfills by diesel trucks also emits both air pollution and greenhouse gases. We estimate this transportation process produces 193,360 metric tons of CO_2e.

As far as energy production, in 2010 Connecticut's fossil fuel-powered electricity plants released 8,973,000 metric tons of CO_2e. In this report, our calculations focus on the amount of fossil fuel energy and emissions that WtE could potentially replace by burning the trash that Connecticut presently transports to landfills.

Assumptions for Environmental Impact Analysis

To analyze the potential environmental impact of reclassifying WtE as Class I, we made two primary assumptions. First, we assumed that the 259,124 tons of annual MSW that Connecticut currently sends to landfills (8% of total MSW) will be used for WtE. We estimate this would reduce the state's waste hauling to by 13,399,912 miles annually. Based on the average efficiency of WtE plants, the additional energy produced by combusting this waste will provide the state with 142,517 MWh of new electricity.[xxxiv]

Connecticut Status Quo			
Waste disposal[xxxi]		**Energy generation**[xxxii]	
3,179,224.36 tons in 2010		33,349,623 MWh in 2010	
Waste-to-energy	68%	**Nuclear**	50%
Recycled	24%	**Fossil fuels**	44%
Landfilled in state	1%	**Renewables**	3%
Landfilled out of state	7%	**Waste-to-energy**	3%

Table 3. How Connecticut disposes of waste and produces energy.

Secondly, we assumed that Connecticut's total power consumption will remain constant and the new waste-derived electricity will replace an equal amount of power generation from Connecticut's fossil fuels. Our calculations replace coal, oil, and natural gas in quantities that are proportionate to Connecticut's fossil fuel-derived energy portfolio. This means that each waste-to-energy MWh replaces 177 kWh of coal, 27 kWh oil, and 796 kWh of natural gas production. We assumed that WtE would not replace Connecticut's nuclear power generation because nuclear power plants are well established and unlikely to come offline. We assumed WtE was also unlikely to replace existing renewable energy production because the state has a legal commitment to utilize an increasing percentage of renewable energy.[xxxv]

Under these assumptions, we evaluated the bill's impact on the status quo air pollution (NO_x emissions and PM emissions) and greenhouse-gas emissions. This analysis compares the emissions per unit of energy production of WtE with those of the fossil fuels it replaces. Although each fossil fuel emits these compounds at different rates, we simplified the comparison by using a weighted average of the replaced fossil fuels. Additionally, our analysis accounts for the emissions avoided by diverting 259,124 tons of waste from landfills to waste-to-energy, including emissions from trucks used to haul waste to out-of-state landfills and the methane emissions released as the MSW biodegrades in landfills.

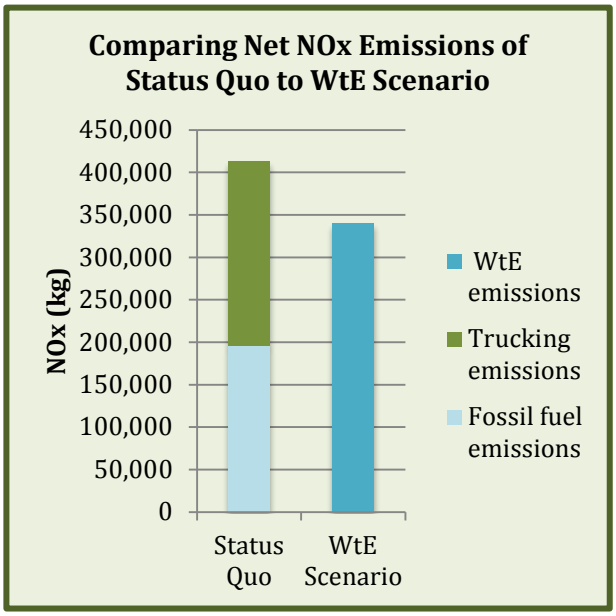
Global Warming Potential and CO_2 Equivalents

The IPCC developed a measure called Global Warming Potential in order to consider a gas's future impact over the lifetime of the gas in the atmosphere. Global Warming Potential can calculate a gas's impact over different time frames and is calculated as the gas's radiative forcing over its lifetime in the atmosphere, relative to carbon dioxide's effect over the same time period. Radiative forcing measures a gas's immediate impact on atmospheric warming. Methane, for example, has a Global Warming Potential of 62 at the 20-year horizon, meaning each molecule of methane is 62 times more potent as a greenhouse gas than carbon dioxide over 20 years. To compare greenhouse gases with different Global Warming Potentials in a standard unit, the IPCC and other groups use carbon dioxide equivalents (CO_2e), which equal the amount of carbon dioxide emissions that would cause the same radiative forcing as any other gas regardless of its Global Warming Potential.[xxxvi]

Findings of Environmental Impact Analysis

We found that WtE emits greater quantities of NO_x and greenhouse gases per MWh, but fewer PM per MWh than Connecticut's current fossil fuel mix. The graphs below compare the emission intensities of each pollutant for Connecticut's fossil fuels, WtE, waste trucking and landfilling.

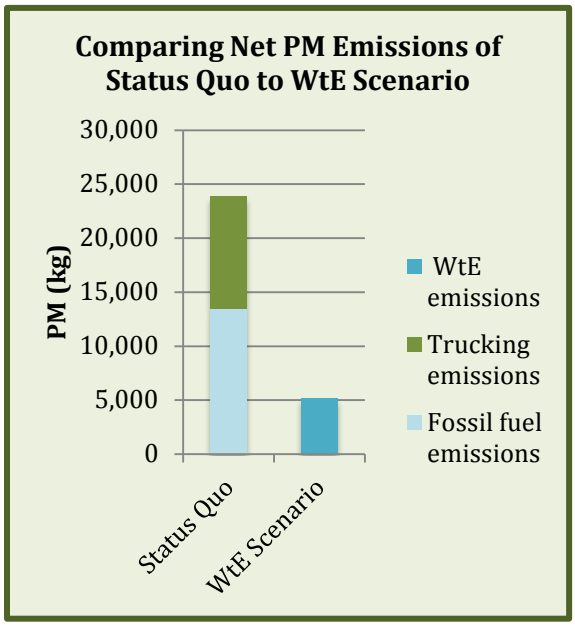
Based on smokestack emissions alone, WtE creates more NO_x and greenhouse gases than the status quo portfolio of fossil fuels. However, once we take into account the avoided emissions from landfills and trucking, our analysis shows that Connecticut H.B. 5118 could reduce overall emissions of all three pollutants relative to the status quo. The graphs below show the inputs and outputs leading to net emission reductions of the air pollutants NO_x and PM.



Graph 1 The net reduction in nitrogen oxide emissions with increased waste-to-energy production, as compared to the status quo.

To complete our net-emissions analysis of greenhouse gases, we needed to select an appropriate value for greenhouse gas emissions from landfills. The decomposition of one ton of MSW produces between 0.05 and 0.1 tons of methane (CH_4), depending on the waste composition, the climate and landfill engineering. We took the average of this range, 0.075 tons of methane or 1.725 tons of carbon dioxide equivalent (CO_2e) per ton MSW (using a global warming potential of 23).[xxxvii] The table below displays the inputs and outputs leading to net emission reductions of greenhouse gas emissions.

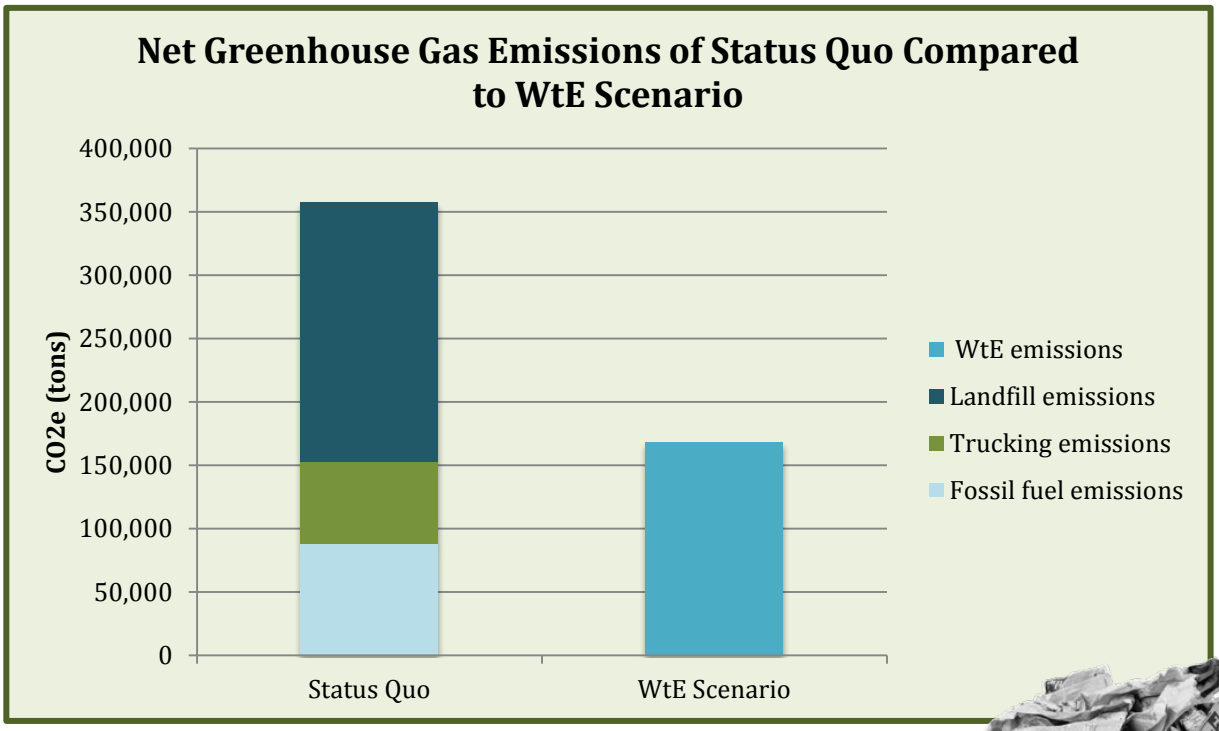
Landfills can decrease their greenhouse gas emissions by flaring the excess methane, which converts the CH_4 to the less potent greenhouse gas CO_2, or by capturing and combusting methane to produce energy. These methods reduce landfill emissions to 0.48 tons CO_2e per ton MSW.[xxxviii] According to the United States Environmental Protection Agency, approximately 25% of the landfills in the U.S. are equipped with methane-capture technology that results in energy generation.[xxxix] Even if we assume that all of the landfills that take Connecticut's waste were equipped with methane-capture technology, the net emission reductions from Connecticut H.B. 5118 would still exceed 109,000 tons CO_2e.



Graph 2. The net reduction in PM emissions with increased waste-to-energy production, as compared to the status quo.

Conclusion of Environmental Impact Analysis

In conclusion, WtE technology performs two vital functions: it produces electricity while simultaneously eliminating the need for landfills and long-distance waste hauling. Our analysis found that expanding waste-to-energy production reduces NO_x, PM, and greenhouse gas emissions relative to the status quo. The proposed legislation would have the greatest environmental impact if it led to the incineration of 100% of Connecticut's trash, eliminating the need to transport that trash to landfills. If the legislation led to this result, total greenhouse-gas emissions in Connecticut would decrease by 0.3%, while the total amount of renewable energy generated would increase to 14.5% of the state mandated quantity of renewable energy necessary by 2020.[xl]



Graph 3. The net reduction in greenhouse gas emissions with increased waste-to-energy production, as compared to the status quo.

Program Design

After concluding that, under certain assumptions, Connecticut H.B. 5118 could potentially address the environmental concerns of air pollution and climate change, our group began a hypothetical scenario in which the bill has passed. The purpose of this exercise is to examine, were the bill to pass, what programmatic elements would need to go into place. We wanted to look at the program design options for how the new law could be implemented and ultimately develop one option into a full program design with staff, a budget, a timeline and a performance management system.

Program Design Options

Since Connecticut H.B. 5118 amends existing statues, the legislation requires minimal implementation on the part of state agencies, as Connecticut's Public Utilities Regulatory Authority (PURA) already regulates the RPS requirement, maintains the REC market, and certifies facilities as Class I or Class II.[xli] The only part of the bill that is not specifically prescribed is how municipalities should use the REC revenue. Thus, keeping the program goals in mind, we took the position of a hypothetical coalition of municipalities, the Fairfield County Coalition of Municipalities (FCC), and identified three options for how the revenue should be used: 1. Pay waste-disposal fees, 2. Retrofit the existing Bridgeport WtE facility, or 3. Build a new WtE facility.

Our first option was to earmark REC revenues to offset the rising cost of waste-disposal tipping fees charged by WtE facilities. Although this option has the benefit of helping municipalities pay tipping fees, it does not truly address the program goals of the bill because it would merely perpetuate the status quo without adding new environmental benefits.

The second option we considered was to retrofit the existing WtE facility located within the coalition's county, in Bridgeport, CT. This facility, run by Wheelabrator Technologies, utilizes mass-burn technology, the least efficient and most polluting form of WtE technology.[xlii] Therefore, increasing the efficiency of this plant through retrofitting to an advanced technology would help achieve Connecticut H.B. 5118's environmental goals. Although this option would help increase support for WtE in the local community and has a shorter timescale than building a new plant,[xliii] retrofitting is an expensive process and new WtE technologies have not been proven on the scale of Bridgeport's existing WtE facility. As a result, we decided the FCC would not pursue retrofitting.

Finally, our third alternative option was to build a new, mass-burn WtE facility. We decided the new facility should also be located in Bridgeport because the city offers several industrial zones ideal for a plant. Additionally, Bridgeport has one of the highest unemployment rates in the state, and the community would therefore

benefit from the creation of jobs at the new WtE facility. In addition to creating new jobs, this option has the potential to generate significant revenue for Fairfield County if Fairfield were to take advantage of its new trash disposal capacity by accepting waste from places like New York City. This would take full advantage of the new REC while also helping Connecticut meet its RPS standards. The downside of this option is that construction of a new plant has a much longer timescale than retrofitting and the import of trash from other states would create air pollution in the local community, raising environmental justice concerns. Additionally, the stakeholders opposed to Connecticut H.B. 5118 would likely mount significant opposition to a new mass-burn facility.

Chosen Program Design

To avoid the issues presented by a new mass-burn facility, we decided FCC could best meet the program goals of Connecticut H.B. 5118 by building a new, low-capacity, low-emission WtE facility in Bridgeport using thermal gasification technology. This represents a compromise between the option of retrofitting using new technology and building a new plant with traditional mass-burn technology. We believe this proposal would gain community support because of the environmental advantages of gasification technology over mass-burn incineration. While gasification does result in some emissions, it would introduce minimal air pollution to the local community and would be beneficial over the status quo. Additionally, this program maintains the benefits of job creation and new revenue for Fairfield County, while adding capacity to process half of the waste that Connecticut currently sends to out-of-state landfills. We believe it would prove to be a smart investment of current REC revenue, while also generating additional REC revenue in the future.

Waste-to-Energy Technologies

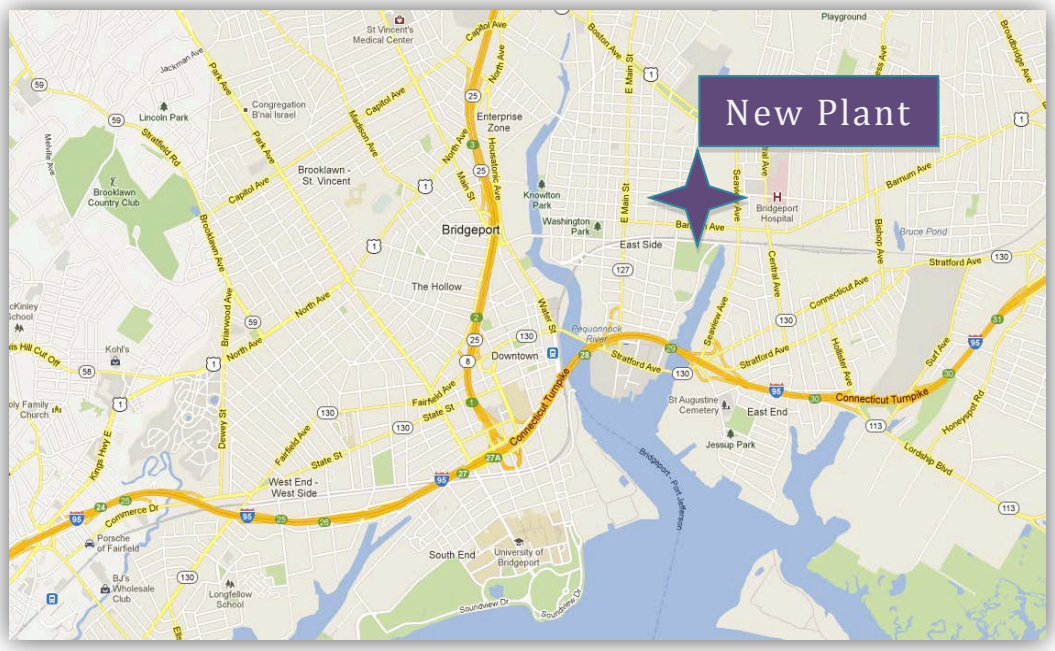
While incineration is the most common form of waste-to-energy, new technologies are also being developed to make waste-to-energy more efficient and more environmentally-friendly. The technology used in our proposed plant is *thermal gasification*, which converts biomass and plastic wastes into a gas called syngas through gasification and partial oxidation. The syngas can be converted to methanol, synthetic gasoline, or used directly as a natural gas substitute. While not yet widely available on the United States market, thermal gasification can offer lower levels of particulate matter, nitrogen oxide, and sulfur dioxide, compared to mass-burn and can generate up to 685 kWh of electricity.[xliv]

Location

We decided to build the new WtE plant on a 28-acre brownfield plot located at 939 Arctic Street on Bridgeport's East Side (See Map 1). Brownfield plots are the sites of former industrial facilities that are available for re-use but that may have remaining hazardous substances, pollutants or contamination. The property for the new WtE facility is one of three plots that were the site of a

munitions factory run by Remington Arms until they were abandoned in 1988 (See Photo 1). The plot lies within a "light industrial" zone that extends between Helen St. on the west side, Seaview Ave. on the east side, Crescent Ave. on the south side, and Boston Ave. on the north side. We decided on this location because its large size allows for a buffer zone between the facility and the surrounding community. Additionally, the location has good access to key transportation infrastructure, including Interstate 91, Interstate 95 and a rail line, which will facilitate the delivery of MSW to the facility. In the subsequent sections, we examine how FCC would operate and execute the project of building this new thermal gasification WtE facility.

Photo 1. The site of the former Remington Arms factory, as it looks today.



Map 1. Bridgeport, CT and the location of the coalition's proposed waste-to-energy facility.

Organization, Contracting & Staffing

This section defines organizational structure of the Fairfield County Coalition (FCC) of municipalities and the entities it will collaborate with to build and operate a new WtE facility in Bridgeport. The management structure is a public-private partnership between the coalition that will make executive decisions and manage contracts, and private contractors that will handle day-to-day operation of the plant.

The Fairfield County Coalition

The FCC consists of all of the 24 towns and cities in Fairfield County, Connecticut. The coalition consists of an Executive Board that meets to make decisions quarterly and a CEO who handles day-to-day affairs, as explained below.

The Executive Board

There are 24 towns and cities within Fairfield County and each municipality will submit one representative to the Executive Board (hereon referred to as "the board").[xlv] The board will consist of mayors, first selectmen, or locally appointed members from the respective municipalities of Fairfield County, at each municipality's discretion.[xlvi] [xlvii] [xlviii] Collectively, the board will make significant decisions on behalf of the new WtE facility and its investors. It will also manage the contracts for energy production and waste transportation. The members approve an annual budget and they will be also responsible for policy matters, such as nominating the Chairman of the Board and achieving compliance with the provisions of the Connecticut General Statutes. This board will meet each quarter and members may appeal to the board chairman and convene a special session. Extraordinary sessions are limited to two per quarter.

The Chief Executive Officer (CEO)

The CEO will oversee the daily operations of the construction and the operation of the facility. The CEO will report to the Executive Board during the quarterly session meetings and extraordinary sessions when required by the board.

The Directors

Overseen by the CEO, there will be four directors: the Director of Administration, the Director of Finance, the Director of Legal and Environmental Affairs, and the Director of Public Relations.

Director of Administration

The Director of Administration will issue salary to all staff members, distribute information to the staff, develop the schedules of FCC employees, and maintain efficient operations within the organization.

Director of Finance

The Director of Finance will provide comptrollership functions in order to ensure finances are managed according to legislation, policies, and generally accepted accounting principles.

Director of Legal & Environmental Affairs

The Director of Legal and Environmental Affairs will manage legal matters related to business issues and company

strategies, and will represent the FCC in all legal proceedings. He or she will work with colleagues in drafting and editing agreements and ensuring the coalition operates in compliance with applicable laws and regulations at the local, state, and federal levels. In addition, he or she will prepare briefs, complaints, motions, and other documents necessary in court during the commencement of the WtE plant construction. The Legal Advisor will lead the FCC effort on permit procedures.

Director of Public Relations

The Director of Public Relations is responsible for maintaining positive community relations and earning beneficial media coverage for the coalition. He or she will conduct outreach to the media and will manage the development, implementation, and coordination of internal and external public relations strategies. He or she will collate and analyze media coverage, produce external communications and publicity, and plan community-relations events.

Permitting Procedures

The Executive Board will work with the appointed CEO to acquire all permits that are required before the beginning of plant construction. Permitting procedures can take more than a year to complete and all agreements and contracts will be made under Connecticut State laws and regulations. One particular consideration will be meeting the state's regulatory requirements for brownfield sites, since the plant will be built on a brownfield plot in Bridgeport.

Below are the minimum permits Fairfield County Coalition requires to initiate the project:

- Environmental compatibility and public need
- Municipal consultation
- Application to municipal agencies
- Land use and zoning
- Air navigation
- Sound
- Water runoff evaluation
- Subsurface environmental conditions

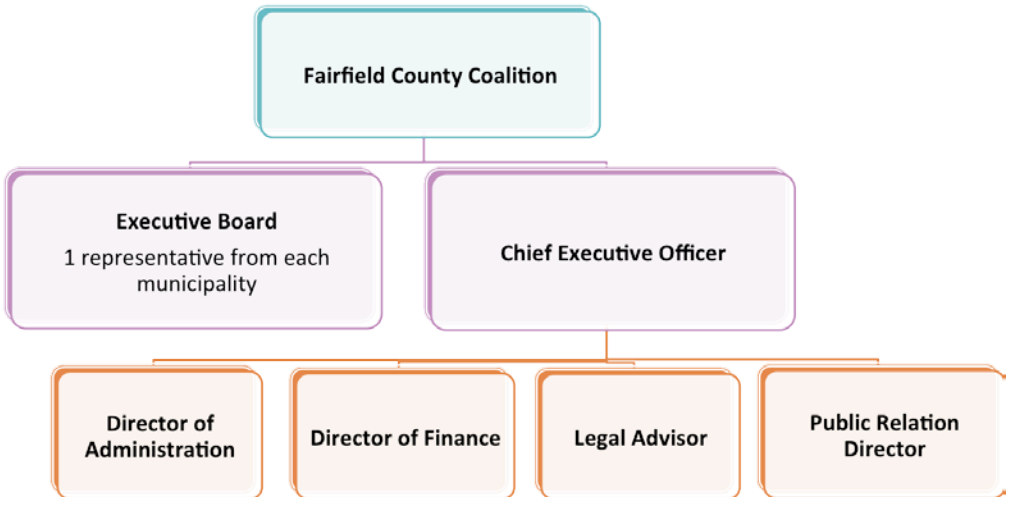


Chart 1. The Fairfield County Coalition structure

Contracting

Since the Fairfield County Coalition of municipalities lacks the appropriate resources and expertise to directly run all aspects of the plant, the coalition will contract with various entities. The five primary contracts are for: the construction of the facility, the operation of the plant, waste delivery, power purchasing, and secondary waste disposal.

Construction

Covanta Energy, one of the world's largest owners and operators of WtE plants, will be in charge of building the facility on time and within budget, as well as the daily operations of the facility once it is built.[xlix]

Covanta will lead the construction of the new waste-to-energy facility in Bridgeport, which will employ engineering and construction project managers from engineering firms and general contractors. Covanta will have a construction project manager and site manager at the facility during construction in order to oversee the engineering and construction project managers from engineering firms as well as the contractors and subcontractors.[l] In addition, Covanta's construction project manager will also oversee all of the skilled workers and professionals involved in building the plant. The types of positions include: carpenters, electricians, architects, engineers, and safety inspectors. Lastly, Covanta will be responsible for the mechanical completion, start-up, testing, and commissioning of the plant.[li]

Using numbers from Covanta's experience building a WtE plant in Florida, we estimated that building the new Bridgeport plant would create a total of 70 permanent construction jobs and 116 indirect jobs. The Florida plant has a capacity of 1,500 tons per day, significantly larger than the FCC plant's proposed capacity, and employed 250 people during construction. We scaled down these numbers proportionally to fit a plant processing 350 tons per day, and then we added additional employees to account for the fact that the Bridgeport plant will be equipped with a new technology.[lii]

Operation

Covanta Energy will also run the operation of the facility, through the Regional Vice President of Operations.[liii] Covanta will then assign workers in different operational levels of the facility. See Figure 3 for a flow chart of the waste-to-energy plant operations process. Descriptions of some of the positions at a waste-to-energy plant include[liv]:

- *Facility Managers*: are responsible for overseeing and managing the operations, maintenance, and support workers.
- *Engineers*: oversee the daily operation of the plant, provide technical support, and maintain thorough records of plant operations.
- *Business Manager*: oversees any business management issues that the plant may face including facility contracts as well as local government and community affairs.
- *Shift Supervisors*: are responsible for monitoring and managing the day-to-day operations of the plant

including both safety and environmental compliance.
- *Control Room Operators*: are responsible for monitoring and operating high-pressure boilers and auxiliaries from the control room.
- *Equipment Operators*: are responsible for operating assigned equipment in a safe manner.
- *Instrumentation and Controls Technicians*: are responsible for repairing, both on a routine and emergency basis, plant instrumentation, control systems computers, and plant electrical systems.
- *Maintenance Mechanics*: are responsible for repairing the plant's operating systems including pumps, compressors, and pipes.

The Fairfield County Coalition's waste-to-energy plant will use the Covanta Low Emission Energy Recovery Gasification (CLEERGAS) technology, which transforms unprocessed municipal solid waste into a synthetic gas, which is then processed through an energy recovery system. [lv] This new, state-of-the-art technology will require a total of 25 employees at the plant for successful operation. A study on plasma-assisted WtE plants found that a similar facility processing 750 tons per day requires a team of 50 employees[lvi]. Scaling these figures to our plant, which is half the capacity, we conclude it will require 25 people to operate.

The division of the employees will be as follows:
- 1 staff director
- 1 assistant manager
- 2 foremen
- 2 administrative staffs
- 19 skilled laborers

Waste Delivery

The municipalities in Fairfield County will contract with the coalition to ensure delivery of municipal solid waste to the facility. Fairfield County cities and towns currently utilize multiple sanitation contractors. The most common contractors include BIG Little Sanitation, JM Candee Sanitation, Santaguida Sanitation, and Winters Bros Company.[lvii,lviii,lix,lx] In addition, many of the towns have hired private trash hauling. To this extent, the municipalities will be ultimately responsible for arranging and executing contracts with their own hauler to transport trash to the plant. The hauler must be one of the four choices provided above and FCC will approve these memorandums of agreements. If there is no trash hauling organized by the municipality, FCC will designate centers where residents may drop off refuse and recyclables.

Since the new WtE facility will be located in Bridgeport, the Bridgeport Sanitation Division (BSD) will oversee the waste disposal operations for all the incoming trash from the different municipalities by organizing the routes, the collection dates and regulating the incoming municipal solid waste.


Wheelabrator

Power Purchasing Agreement (PPA)

The FCC will contract with the United Illuminating Company (UI) to distribute the electricity generated by the plant to the electrical grid. Currently, UI is involved with the purchase, transmission, distribution, and sale of electricity in the greater New Haven and Bridgeport areas.[lxi] The coalition's Finance Director and the Director of Legal and Environmental Affairs will work with UI to discuss and negotiate the terms of the power purchasing agreement. The terms will specify the price of the energy sold to UI and the contract term will be in effect for five years.

Secondary Waste Disposal

Finally, the coalition will contract with Winters Bros waste-transportation company to dispose of secondary waste created by the facility. This will be overseen by the BSD who will work to comply with state and city ordinances of waste disposal. The BSD will work closely with Connecticut's Resource and Recovery Authority and provide information to either or both the Director of Operations and Environmental Affairs and Director of Recycling and Enforcement.[lxii] Bridgeport's Manager of Sanitation will be the primary contact person with the Board and Covanta Operating Manager. [lxiii]

Budget and Revenue

In order to create a feasible financial plan for the construction and operation of the new thermal gasification plant, it is necessary to put together a thorough budget forecast. The following pages provide detailed revenue projections, estimations for construction and operating costs, and the assumptions and forecast methods used.

Budget Summary

Initial budget and revenue projections show facility profitability by the end of the first year of operation. By issuing 20-year municipal bond certificates, the Fairfield County Coalition (FCC) will be able to fund the $107 million upfront capital costs. Our projected waste disposal fees, Class I Renewable Energy Certificates (RECs), metals recovery, and electricity production will provide the necessary revenue to ensure both loan repayment and profitability. Our budget forecast does contain a substantial amount of risk. Community opposition, environmental organizations, and changing political attitudes all harbor possible cost concerns in our financial model. To lower our risk profile and gain local acceptance, a public relations team will be employed to administer outreach programs in Fairfield County.

Project Finance

Our budget allocates $98 million for the Engineering, Procurement of Materials, and Construction (EPC contract) of the facility. This approximation was garnered from scientific literature, interviews with selected industry leaders, and past WtE projects. [lxiv,lxv,lxvi,lxvii,lxviii] Along with land acquisition, planning, permitting, and financing costs, the Bridgeport project requires an initial capital investment of approximately $107 million.

To finance our WtE plant, we will issue municipal bonds. Since Connecticut is unusual in that it does not utilize county governance, we would have to create our own regional authority – in our case, the Fairfield County Coalition. Each town within the coalition would sign a "full faith and pledge" agreement. Essentially, this is an agreement wherein each town promises to tax its constituents to pay for the principal and interest of the bond if the revenue from the WtE facility is insufficient. The towns will hire an investment banker to package bonds and sell them on the market.

An alternative to forming a regional authority is to ask the Connecticut Resources Recovery Authority (CRRA) to issue the bonds. In this way, CRRA would act as a conduit issuer and have its name on the bonds. However, we would still go through all the other steps above, such as hiring an investment banker. We are assuming that all the towns agree to issue bonds and promise to pay their fair percentage.

Projected revenues from long-term power purchasing agreement and waste delivery agreements will further back bonds. The revenue agreements will increase the stability of the bonds, helping us attract additional investors. The town

commitments will match the term of the bonds, and, ideally, the electricity contracts will also run for the term of the bonds. We have decided to issue 20-year bonds to match the lifecycle of a CLEERGAS facility. This is a conservative time-period estimate since most WtE plants have a longer effective lifespan. [lxix]

The interest rate of the bonds is dependent on our towns' credit ratings. Within Fairfield County, the town with the lowest credit rating will determine this interest rate. There are two major rating agencies: Moody's and Standard & Poor's. The better the rating, the lower the interest rate at which we can sell our bonds because the market labels the investment as secure. Bridgeport has the lowest rating of all the towns in Fairfield. With the 20-year bond, Bridgeport's A1 (Moody's) or A+ (S&P) rating corresponds with 3.15% general obligation yield.[lxx,lxxi] We will issue fixed-rate bonds, meaning that the stated coupon on the bonds remains fixed until the maturity of the bonds.

Our $107 million loan will be repaid with annual payments that gradually increase over the 20-year lifespan of the bonds. The yearly interest payment on the municipal bonds is fixed at $3,370,500 and our first year principal expenditure is $4,100,000. Our interest payments are fixed but the bond principal costs will increase by $125,000 in each subsequent year for a total payout of $159,521,500 over the 20 years. See the Appendix for full budget numbers.

Assumptions

In Planning and Construction

Several assumptions were made concerning the allocation of funds for a two-year planning phase and two-year construction phase. The site acquisition, site development (permitting, public relations fund, project design), and municipal bond financing fees are the three expenditures during the planning phase. The actual facility construction budget also plans for grid connection, legal fees, project insurance, and $2 million of extra capital, among other considerations. Since Fairfield County Coalition will need to pay interest payments beginning three years from the start of any plant operations, our much larger facility in Bridgeport will use its newly generated Class I REC revenue to cover this expense.

In the Operating Budget

There were numerous assumptions made for the operating budget. All rates, fees, and labor costs were based on current WtE operations in Connecticut and newly constructed plants in Florida and Iowa.[lxxii,lxxiii] The plant will be run by a workforce of 25 full-time staff (a mixture of operators, technicians, administrative assistants, and managers) and a governing board consisting of a CEO, and directors of administration, finance, legal and environmental affairs, and public relations. The electricity needed to run the plant is calculated as zero because it has already been deducted from our revenue budget. The proposed budget was calculated from an inflation rate of two percent until 2021.

In Revenue

Finally, several major assumptions were made in calculating our revenue. These estimations were garnered from current WtE facility budget reports in Connecticut and across the United States.

Revenue Source	**Rate**
Tons MSW Processed/day	350
Operation Days/year	330[lxxiv]
Ferrous Metals Price/ton	$300[lxxv]
Ferrous Metals Recovery Rate/ton MSW (incoming)	1%[lxxvi]
Electricity Generation/ton MSW	685 kWh (net = 533kWh)[lxxvii]
Class I REC Rate/MWh	$30[lxxviii]
Service Charge Contract/ton MSW	$70[lxxix]
Service Charge Spot/ton MSW	$90[lxxx]
Percentage Non-Contract MSW	3%[lxxxi]
Electricity Generation Rate/kWh	$0.07[lxxxii]
Bulky Materials – Price/Unit	$40[lxxxiii]
Annual Inflation Rate	2%

Our proposed budget plan for a new CLEERGAS WtE facility in Bridgeport, Connecticut, indicates that a revenue surplus could be achieved immediately, generating over $1.4 million in revenue for Fairfield County in the first year of operation. The potential for a larger surplus is attainable if electricity rates continue to rebound, REC prices stay afloat, and the plant is run at full capacity. Project-cost overruns are a risk, along with unforeseen legal fees and litigation, community denigration, difficulties obtaining permits, and, most importantly, unexpected problems from our contracts. However, every assumption made in our budget analysis is conservative and based on current industry research.

Master Calendar

The first year of the waste-to-energy project will involve completing several pre-construction tasks and applying for environmental permits. The specific sequencing of these tasks and permits as well as who is in charge of execution (see Tables 4 and 5) will be critical to successfully completing the project on time. Some of the tasks and permits will be dependent on each other so the sequencing of them will be important. The timeline for applying for these permits, as shown in Table 5, is front-loaded because some of the permits will take up to six months to complete, so these will need to be started during the first half of the year. The Fairfield County Coalition's four directors and their staff will be in charge of executing the tasks and pre-construction environmental permits. Each task and permit that needs to be completed within the first year is described below.

Tasks for the First Year

There are six main tasks that the Fairfield County Coalition will need to undertake in the first year (see Table 4). First, the Coalition will need to issue municipal bonds totaling $107 million dollars.[lxxxiv] Second, once the municipal bonds have been processed, this money will be used to purchase the Remington site, which consists of three parcels of land from Remgrit Reality Inc. and the City of Bridgeport.[lxxxv] Third, the Coalition will need to sign a power purchase agreement with the United Illuminating Company, as well as a waste-disposal contract with the municipalities in Fairfield County.[lxxxvi] [lxxxvii] Lastly, the Fairfield County Coalition will need to host two community outreach events to enhance understanding of and local support for the waste-to-energy project.

Task	Execution	J	F	M	A	M	J	J	A	S	O	N	D
Issue municipal bonds	State's Treasury Office, Director of Finance, outside investment bank												
Purchase Remington Site	Director of Finance												
Sign power purchase agreement	Legal Advisor & Director of Finance												
Sign waste disposal contract	Legal Advisor & Director of Finance												
Host 1st community outreach event	Director of Administration												
Host 2nd community outreach event	Director of Administration												

Table 4. The logistical tasks that will be undertaken during the first year of the project.

Permits Required

There are 13 pre-construction environmental permits that need to be completed in the first year (see Table 5). First, the Fairfield County Coalition will need to apply for its first of three zoning permits by submitting an application to the Zoning Board of Appeals, which approves variances and waivers.[lxxxviii] Second, the Coalition will need to apply for a permit for all discharges of storm water and dewatering wastewater from construction activities, which may result in the disturbance of the site.[lxxxix] Third, the Coalition will need to apply for the Permit to Construct, but before the permit will be approved, the Commissioner of the Connecticut Department of Environmental Protection will need to grant a 30-day public comment period.[xc] [xci] [xcii] Fourth, they will need to apply for the second out of three zoning permits by submitting an application to the Planning and Zoning Commission Board, which approves special permits for zoning use as well as site plan reviews.[xciii] Fifth, the Coalition will need to complete an environmental justice plan detailing how the facility will reach out to the community on environmental justice issues.[xciv] Sixth, the Coalition will need to apply for its last zoning permit, a Certificate of Zoning Compliance and Building Permit, which ensures that the land, the building and the use of each, will conform with the provisions of light industrial regulations.[xcv]

Next, the Coalition will apply for the Permit to Operate, now that the Permit to Construct has been issued. Then, the Coalition will apply for the Certificate of Environmental Compatibility and Public Need, which ensures the preparation of the site for construction, and the construction activity itself, will not have a significant negative environmental effect. Next, the Coalition will need to submit two general discharge permits, one for the discharge of sewage from subsurface sewage disposal systems and one for the discharge of cooling and heat pump water.[xcvi] Lastly, the Coalition will need to apply for air, sound, and light permits. The air navigation permit involves the amount of emissions of smoke, ash, or particulates the facility anticipates on producing.[xcvii] The sound permit involves the decibels of the machinery and how much of a disturbance it will cause the community.[xcviii] The light permit has to do with whether the facility will obstruct the view of the surrounding neighbors and whether it will block sunlight.[xcix]

By the end of the first year, the Fairfield County Coalition will have:

- Issued municipal bonds
- Obtained control of the land
- Signed power purchase and waste disposal contracts
- Obtained necessary zoning permits
- Received permit to construct and applied for permit to operate
- Completed an environmental justice plan
- Held 2 public outreach events
- Obtained necessary pre-construction environmental permits

Once all these tasks and permits have been applied for and completed, it will take another two to three years before construction of the new waste-to-energy plant is finished and the plant is operational.

Permit	Execution	J	F	M	A	M	J	J	A	S	O	N	D
Submit application to Zoning Board of Appeals	Legal Advisor												
Apply for storm water and wastewater discharge permit	Legal Advisor												
Apply for Permit to Construct	Legal Advisor												
Submit application to Planning and Zoning Commission Board	Legal Advisor												
Submit environmental justice plan	Legal Advisor												
Apply for Certificate of Zoning Compliance and Building Permit	Legal Advisor												
Apply for Permit to Operate	Legal Advisor												
Apply for Certificate of Environmental Compatabiity and Public Need	Legal Advisor												
Apply for sewage discharge permit	Legal Advisor												
Apply for discharge of cooling and heat pump water permit	Legal Advisor												
Apply for air navigation permit	Legal Advisor												
Apply for sound permit	Legal Advisor												
Apply for light permit	Legal Advisor												

Table 5. The numerous permits that will be applied for in the first year of the project, as well as how long it takes to be granted a given permit.

Performance Management

Through the use of a performance management system, the FCC can assess the new WtE facility to ensure it achieves the following desired outcomes: minimize environmental problems, maximize safety, efficiency and quality, and maintain positive community relations. We propose such a system for both the construction phase and the operation phase of a new WtE facility.

Outcome 1: Minimize Environmental Problems

A new waste-to-energy facility will abate existing environmental problems, but it will also cause new ones. The construction phase will involve the use of toxic chemicals and produce large volumes of waste, and the operation phase will emit pollutants such as particulate matter and greenhouse gases. In order to comply with federal regulations, to meet the environmental goals of Connecticut H.B. 5118, and to minimize harm to the surrounding community, the new facility should assess its environmental impact by adopting the following system.

In the construction phase, we will track three important measurements to meet these goals. First, we want to minimize waste and will therefore track the amount of construction debris being discarded. Second, to address the goal of reducing greenhouse gas emissions, we will track energy usage, both for liquid fuels in trucks and machinery as well as electricity usage. Third, we will track the levels of particulate matter in the air because construction may cause emissions that negatively affect nearby residents and animal life.[c]


Scientific American

In the operation phase, we will track the emissions of carbon dioxide (CO_2), carbon monoxide (CO), particulate matter (PM), nitrogen oxides (NO_x), and sulfur dioxides (SO_x) in mg/nm.[ci] These are the main pollutants produced from waste-to-energy plants and the leading contributors to climate change and air pollution.[cii] Our plant will use continuous emissions monitoring to track the pollutants emitted from our smoke stacks, and we will review and report these findings to the EPA on a quarterly basis.[ciii, civ] Additionally, our plant will track emissions through the entire process, which includes those associated with trucking municipal solid waste (MSW) to the plant and disposing of the byproducts. We will require that mileage is recorded daily and sent to our facility for review on a monthly basis.

We will ensure that emissions from the new plant not only meet EPA's standards but also are well below the emissions from the current mass-burn Wheelabrator Bridgeport facility in order to encourage Wheelabrator to reduce its own emissions. With the trucking emissions data, we will perform calculations to ensure that the trucking of MSW and disposing of byproducts creates fewer emissions than if the same amount of waste had gone to a landfill. We will use this information to identify more efficient trucking routes and to reduce NO_x and SO_x emissions in compliance with the Clean Air Interstate Rule (CAIR).[cv]

If we find that our plant is producing levels of emissions higher than the EPA standards, we will need to make upgrades to the facility. If the emissions from trucking MSW are higher than if the waste had gone to a landfill, or if they are contributing significantly to NO_x and SO_x levels in our county, we will need to evaluate new trucking routes or change the types of trucks we use.

Environmental Performance

Indicator	Outcome
Construction	
Non-recyclable waste (tons/week)	Efficient and sustainable use of resources
Recyclable waste (tons/week)	Efficient and sustainable use of resources
Gasoline consumption (gallons/week)	Reduce fuel costs, air pollution, and GHG emissions
Electricity consumption (kWh/week)	Reduce electricity costs and GHG emissions
Air dust suspension density (mg/L)	Reduce air pollution
Operation	
CO_2, PM, NO_x, SO_x emissions (mg/$Nm^{3)}$	Reduce air pollution and GHG emissions from plant
Trucking mileage (miles/day)	Reduce air pollution and GHG emissions from transport
Amount of MSW and byproducts (tons)	Reduce volume of waste sent to landfills

Table 6. The FCC's environmental performance management system.

Outcome 2: Maximize Safety, Efficiency and Quality

A successful performance management system will identify and address areas of the WtE facility operations that need improvement in order to comply with government regulation, develop better business procedures, and meet expectations from stakeholders. The WtE facility will collect data for both physical measures, like the volume of incoming waste, and financial measures, like revenue generated per unit of electricity sold to the utilities. These measures provide valuable quantitative and qualitative information for the Fairfield County Coalition and its contractors to operate efficiently, safely, and cost-effectively.

Physical indicators

The WtE facility will track the difference between the amount of waste received and the amount of waste processed at the facility. This measurement indicates whether equipment has worn down and

requires maintenance. If the amount of waste received does not equal the amount of waste that is processed, equipment may be malfunctioning. To avoid this issue, the WtE facility will have regularly scheduled maintenance audits. The WtE facility will also track the composition of trash in order to evaluate how the new plant impacts the county's recycling efforts. If the amount of recyclable material in received waste decreases, it indicates that Connecticut residents are fulfilling the state's Solid Waste Management Plan and WtE has not hindered this goal.

Managerial Indicators

Managers of the WtE facility need to assess employee performance and other related activities such as training. These measures are important because the WtE facility needs qualified and reliable staff members to operate and manage the facility. This information will help in evaluating the staff and in making hiring and termination decisions.

The WtE facility should measure accidents at the facility because it is mandated under the Occupational Health and Safety Act[cvi] and this evaluation can help prevent physical accidents and unnecessary expenses. Work-related accidents can result in legal fees, medical bills, and missed work. The pieces of information that should be collected are the date and time of the accident, the type of injury, the cause of the accident, and an evaluation of whether it could be prevented. The human resource department will evaluate the accidents on a bi-annual basis and report these statistics to the senior management. This evaluation will help determine whether accidents are prevalent enough to justify implementing a new policy or revising the standard operating procedures.[cvii]

Financial Indicators

Sources of revenue, such as power sales to the utility company United Illuminating and sales of collected metals, are important to measure because they indicate the financial status of the WtE facility. The accountants in the WtE Finance Department will collect the information monthly via payments from United Illuminating Company and other companies that the department invoices. The accountants will utilize an online accounting system to document the transactions and present the information to the Covanta Regional Vice President of Operations, who then reports the information to the Director of Finance of FCC. [cviii] Tracking the costs of the operation is equally important as tracking the revenue. The costs, such as hiring labor and purchasing capital, are important factors to measure because if the plant does not adhere to its budget then the FCC may not be able to make debt payments on the municipal bonds that financed the project. Accountants will collect this information on a daily basis using an online accounting system, which is the recording mechanism for the expenditures. [cix] The accountants will report the aggregate data on weekly basis to the Regional Vice President of Operations, who then reports the information to the Director of Finance of FCC bi-monthly. Both the Regional Vice President and Director of Finance will meet to discuss the progress and stability of the facility and also to determine projected annual costs. [cx]

Operations Performance (maximizing efficiency, safety and quality)	
Indicator	**Outcome**
Physical	
MSW received (tons/day)	Increase efficiency of operations
MSW processed (tons/day)	Increase efficiency of operations
Recyclable material received (tons/day)	Adhere to Connecticut Solid Waste Management Plan recycling goals
Ash residue (tons/day)	Minimize costs of ash disposal
Recovered metals (tons/day)	Calculate revenues from recovered metals
Electricity produced (kWh/day)	Increase efficiency of operations
Electricity delivered to grid (kWh/day)	Increase efficiency of operations
Operating time (hours/day)	Increase efficiency and reduce costs of operations
Downtime (idle hours/day)	Provide a stable and predictable supply of electricity
Managerial	
Employee performance evaluations (bi-annually)	Maintain a competent work force
Employee satisfaction survey (annually)	Maintain a satisfied work force
Turnover rate (%)	Maintain a competent work force
Costs for continued education and training of employees	Maintain a competent work force
Financial	
Price per ton of landfilled ash residue	Minimize costs of ash disposal
Operation costs per day	Minimize costs of operations
The price of tipping fees per ton	Track revenues of waste reception
The price of Class 1 REC (1 MWh)	Track revenues of the environmental benefits
The price of metals per ton	Track revenues from recovered metals

Table 7. The performance management system for plant operations.

Outcome 3: Maintain Positive Public Relations

The WtE facility should track its interactions with the community because this evaluation can improve the relationship between the industry and local community stakeholders, especially stakeholders who oppose the new WtE facility. Waste-to-energy has been politically controversial in Connecticut, so it will be vital for the WtE facility to operate transparently and to communicate with the public in order to gain support.

To improve public perception of the WtE facility, the FCC will record and collect data on the number of complaints received from neighboring residents or businesses. These records will include the date and time of disturbance, the type of complaint (debris, odor, noise, etc.), if this disturbance could be alleviated, and, if so, whether the remedy can be provided in the short term or long term. Addressing the complaints of the community demonstrates corporate responsibility and creates a positive image to the public. Another important measure we will track is the number of community events sponsored by the WtE facility. Additionally, the FCC will record data on the number of positive and negative reviews the facility receives in the media, the number of FCC press releases picked up by media publications, and the types of media covering the facility. The communications department will collect the information and then report to the human resource department for legal and record keeping purposes. The information will be used to measure the wellbeing of the community and the community's perception of the facility, helping encourage understanding and collaboration between stakeholders in Fairfield County.

Community Relations Performance (media, community, and other stakeholders)	
Indicator	**Outcome**
Number of complaints/month	Reduce community discontent
Types of complaints	Address the specific area of discontent
Number of events hosted in local community	Increase public knowledge and acceptance of WtE
Number of tours given in WtE	Increase public knowledge and acceptance of WtE
Number of positive and negative reviews in media publications	Monitor public perception of plant
Number of press releases picked up by the media	Influence public perception of plant
Type of media covering the WtE facility	Monitor public perception of plant

Table 8. The FCC's public relations tracking system.

Conclusion

In conclusion, Connecticut H.B. 5118 proposes to reclassify WtE from a Class II to a Class I renewable energy source. This would provide a subsidy to WtE facilities in the form of RECs that can be bought and sold by Connecticut power retailers in order to meet the requirements of Connecticut's RPS. The bill would send revenue from the sale of RECs derived from WtE to the municipalities that utilize the WtE facilities. Connecticut H.B. 5118 provides discretion to these municipalities as to how to utilize the new revenue.

Our analysis found that replacing fossil fuel power generation with WtE would reduce emissions of greenhouse gases, NO_x, and PM relative to Connecticut's status quo. The reduction comes from eliminating emissions from landfilling and from trucking waste. In this way, WtE presents a solution to the environmental problems of climate change and air pollution. Climate change threatens Connecticut by increasing the intensities of storms and raising sea levels. Air pollution threatens Connecticut residents by increasing ground-level ozone, which can exacerbate asthma, among other health concerns.

To analyze the effects of Connecticut H.B. 5118 would have if it passed, we took the perspective of a newly formed hypothetical coalition of municipalities in Fairfield County, Connecticut, called the FCC. Fairfield currently houses a WtE facility in the city of Bridgeport, and we assumed this coalition would utilize the new revenue from REC sales to address environmental problems and to create a cost-effective waste-management solution by increasing WtE production.

After considering an option of using the new revenue to subsidize the existing plant and another option of retrofitting that facility with emission-reducing technology, our coalition of municipalities developed a program to instead build a new, efficient waste-to-energy plant in Bridgeport. We determined this was the most cost-effective way to meet the goals of reducing greenhouse gas emissions and air pollution and providing a cost-effective waste-management solution.

The new facility would process 350 tons of waste per day using Covanta Energy's CLEERGAS thermal gasification technology. We sited the plant at a brownfield plot on the east side of Bridgeport. Using conservative assumptions based on data from current WtE facilities in Connecticut and across the United States, we determined this gasification facility would employ 25 full time people, create a revenue surplus and take three to four years to complete. Our budget allocates funding to address environmental justice issues through community outreach and monitoring of environmental impacts, operational efficiency, and impact on the community.

Ultimately, our program has the potential to address the environmental problems of air pollution and climate change, and to provide a cost-effective waste management strategy for Connecticut.

Appendix

Greenhouse Gas Changes From Status Quo	
	CO_2e (tons)
New WtE emissions	168,170
Replaced fossil fuel emissions	-88,360
Eliminated trucking emissions	-64,922
Eliminated landfill emissions	-204,707
Net emissions	**-189,818**
(Source – See section A)	

Figure 1. Changes in greenhouse gas emissions from the status quo under analysis assumptions.

Construction Budget:										
Budget:	**Total**	**1/1/12 - 12/31/13**	**3/31/14**	**6/30/14**	**9/31/14**	**12/31/14**	**3/31/15**	**6/30/15**	**9/31/15**	**12/31/15**
EPC Contracting	98,000,000		12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000	12,250,000
Site Development	1,000,000	1,000,000	0	0	0	0	0	0	0	0
Municipal Bond Interest	10,111,500	3,370,500	842,625	842,625	842,625	842,625	842,625	842,625	842,625	842,625
Site Acquisition	4,347,915	4,347,915	0	0	0	0	0	0	0	0
Start-up Commissioning	400,000	0	10,000	20,000	40,000	60,000	60,000	60,000	60,000	90,000
Grid Interconnection	500,000	0	100,000	0	0	0	0	0	200,000	200,000
Controlled Insurance Plan (CIP)	240,000	0	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Working Capital	1,000,000	0	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000
Debt Reserve	1,000,000	0	125,000	125,000	125,000	125,000	125,000	125,000	125,000	125,000
Environmental Services	225,000	0	120,000	50,000	10,000	10,000	10,000	10,000	10,000	5,000
Legal Fees	200,000	0	150,000	20,000	20,000	10,000	0	0	0	0
Tax Credits	0	0	0	0	0	0	0	0	0	0
Financing Costs	100,000	50,000	6,250	6,250	6,250	6,250	6,250	6,250	6,250	6,250
Total										
	117,124,415	8,768,415		13,468,875	13,448,875	13,458,875	13,448,875	13,448,875	13,648,875	13,673,875
Assumptions										
Construction Length	2yrs									
Covanta agrees to EPC	$98 million covers all necessary Engineering, Materials Procurement and Construction									
Tax Credits/Subsidies	Connecticut state subsidy for energy development expires in 2013									
Municipal Bond Interest	Payments start 1/1/12 at 3.15% interest									

Figure 2. New WtE plant construction and development costs.

Operating Costs	1/1/16-12/31/16	1/1/17-12/31/17	1/1/18-12/31/18	1/1/19-12/31/19	1/1/20-12/31/20	1/1/21-12/31/21
Fixed (O&M)						
Loan Repayment	7,470,500	7,595,500	7,720,500	7,845,500	7,970,500	8,095,500
Municipal Bond Interest	3,370,500	3,370,500	3,370,500	3,370,500	3,370,500	3,370,500
Municipal Bond Principal	4,100,000	4,225,000	4,350,000	4,475,000	4,600,000	4,725,000
Maintenance	200,000	204,000	208,080	212,241	216,485	220,814
Variable (O&M)						
Labor Costs/Benefits	2,670,000	2,723,400	2,777,868	2,833,422	2,890,087	2,947,884
Contract Covanta - Operations/Systems	900,000	918,000	936,360	955,087	974,188	993,671
Contract Covanta - Engineers/Technicians	400,000	408,000	416,160	424,483	432,972	441,631
Contract Covanta - Administrative	180,000	183,600	187,272	191,017	194,837	198,733
Contract Covanta - Management	240,000	244,800	249,696	254,689	259,782	264,977
CFO/CEO/Chief Council	500,000	510,000	520,200	530,604	541,216	552,040
Public Relations Team	250,000	255,000	260,100	265,302	270,608	276,020
Legal Fees	100,000	102,000	104,040	106,120	108,242	110,406
Consulting Services	100,000	102,000	104,040	106,120	108,242	110,406
Insurance	250,000	255,000	260,100	265,302	270,608	276,020
Debt Reserve	250,000	250,000	250,000	250,000	250,000	250,000
Community Relations Fund	250,000	255,000	260,100	265,302	270,608	276,020
Ash Removal Contract	1,310,809	1,337,025	1,363,765	1,391,040	1,418,860	1,447,237
Urea and Lime Pebbles	165,838	169,154	172,537	175,987	179,506	183,096
Emissions Monitoring	150,000	153,000	156,060	159,181	162,364	165,611
Environmental Testing/Repermitting	150,000	153,000	156,060	159,181	162,364	165,611
Office Supplies	10,000	10,200	10,404	10,612	10,824	11,040
Odor Control Systems/Supplies	100,000	102,000	104,040	106,120	108,242	110,406
Electricity for Gasification Operation	0	0	0	0	0	0
Other Utilities	20,000	20,400	20,808	21,224	21,648	22,080
Postage Fees	5,000	5,100	5,202	5,306	5,412	5,520
Miscellaneous	10,000	153,000	156,060	159,181	162,364	165,611
Total						
	13,012,147	13,385,779	13,621,584	13,859,599	14,099,872	14,342,450

Figure 3. New WtE plant operating costs.

Revenue						
	1/1/16-12/31/16	**1/1/17-12/31/17**	**1/1/18 - 12/31/18**	**1/1/19 - 12/31/19**	**1/1/20 - 12/31/20**	**1/1/21 - 12/31/21**
Description						
Service Charges Solid Waste - Contract	7,842,450	7,999,299	8,159,284	8,322,469	8,488,918	8,658,696
Service Charges Solid Waste - Spot	311,850	318,087	324,448	330,936	337,554	344,305
DEP Certified Soils/Cover Material	--					
Metals Recovery	336,000	342,720	349,574	356,565	363,696	370,969
Municipal Bulky Waste/Matresses	40,000	40,800	41,616	42,448	43,296	44,161
Net Electricity Production	$4,180,025	4,263,625	4,348,897	4,435,874	4,524,591	4,615,082
Class I Renewable Energy Credits	$1,791,439	1,827,267	1,863,812	1,901,088	1,939,109	1,977,891
Debt Service Reserve Fund	--					
Total Revenues	**14,501,764**	**14,791,798**	**15,087,631**	**15,389,380**	**15,697,164**	**16,011,104**
Total Costs	**13,012,147**	**13,385,779**	**13,621,584**	**13,859,599**	**14,099,872**	**14,342,450**
Projected Annual Profit	**1,489,617**	**1,406,019**	**1,466,047**	**1,529,781**	**1,597,292**	**1,668,654**

Assumptions		
Tons MSW Processed/day	350	
Operation Days/yr	330	
Ferrous Metals Price/Ton	$300	
Ferrous Metals Recovery Rate/Ton MSW (Incoming)	1.00%	
Electricity Generation/Ton MSW	685 kWh	(Net Electricity = 533 kWh)
Class I REC Rate/MWh	$30	
Service Charge Contract/Ton MSW	$70	
Service Charge Spot/Ton MSW	$90	
Percentage NonContract MSW	3%	
Electricity Generation Rate/kWh	0.07¢	
Bulky Materials - Price/Unit	$40	
Inflation	2%	

Figure 4. New WtE plant revenue.

Figure 5. New WtE plant performance management system overview.

Measurement	
Outcome	Maintain positive community relations
Output	Respond to complainant within 24 hours
Input	Complaint response time
Collection	
How	Telephone or web form
Where	FCC or City of Bridgeport
Details	When, type, where, etc.
Who	Communications department
When	Daily
Store	Database
Reporting	
Short term	How: mail
	To whom: line manager
	Frequency: daily
Long term	How: report
	To whom: management, public
	Frequency: semi-annually
Feedback	
Short term	Line manager responds to complainant
	Manager assesses/implements short-term changes
Long term	Management identifies significant areas of improvement
	Management assesses/implements long-term solutions

Figure 6. The detailed performance management system when receiving complaints.

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