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ECONOMIC FEASIBILITY OF A PLASMA ARC GASIFICATION PLANT, CITY OF MARION, IOWA

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INTRODUCTION

The City of Marion ("City") and *wastenotIowa, Inc.* (WNI), along with other interested parties, has been considering the use of a plasma arc gasification plant ("Plant") as a technology that could reduce their future dependency on landfill disposal. As currently envisioned, the Plant would serve Linn County, including the City and the University of Iowa ("UI") Oakdale research campus, located in Johnson County. In the next step of their evaluations, the City along with the Iowa Department of Natural Resources (DNR) has commissioned SCS Engineers (SCS) to perform a formal economic feasibility study of the Plant. The feasibility study included:

- Assessing potential for other waste material other than municipal solid waste in the region as supplemental plant feedstock.
- Assessing potential markets for the plasma plant by-products.
- Determining the feasibility, requirements and costs related to an interconnect with the power utility grid.
- Assessing the option that the UI could potentially be the exclusive power customer for the Plant.
- Developing a pro-forma model so that various options can be evaluated for the Plant capacity and material and energy output configurations over an assumed initial 20-year contract operating phase, including;
    - Production of syngas for conversion to electrical power
    - Production of syngas for direct use and conversion to fuel products
    - Production of insulation from slag to enhance project revenues.
- Determining the potential economic impact of the Plant on the region.

ECONOMIC EVALUATIONS OF THE PROPOSED CITY PROJECT

Introduction

The economic evaluation will consider a range of waste processing capacities for the plasma plant in order to be responsive to the potential waste flow of the region, as well as providing different output configurations for uses of the plant's main by-products. The assumptions used in the pro-forma analysis will be consistent across all configurations of the plant so that useful and valid comparisons of the economic benefits can be made.

Design Capacity – Assumptions for Plasma Plant

The design capacity of the Plant was varied by SCS to cover three different capacities as follows:

Small: The facility would be sized primarily to process only the municipal solid waste (MSW) generated by the City and nearby cities (i.e., Cedar Rapids, etc.) (150 tons per day design capacity).

Medium: This assumes that the facility would be sized to process MSW generated in the City and other communities and private haulers within the Linn County area, but not all of the MSW generated within the Linn County area (300 tons per day design capacity).

Large: This assumes that the facility would be sized to process all of the MSW generated within the Linn County area (600 tons per day design capacity).

Assumptions for Plasma Plant Output Configurations

For the economic analysis, three main plant by-product output and market configurations were analyzed as follows:

TABLE 1 PLANT BY-PRODUCT OUTPUT AND OTHER MARKET CONFIGURATIONS

Plant Capacity (tons per day – TPD)	Plant By-Products / Outputs	Projected Use of By-Product
150	Syngas	Syngas combusted for electrical power to utility grid
150	Syngas	Direct use of syngas as substitute fuel
150	Syngas and slag	Direct use of syngas as substitute fuel Production of rock wool from slag (i.e., slag wool).
300	Syngas	Syngas combusted for electrical power to utility grid
300	Syngas	Direct use of syngas as substitute fuel
300	Syngas and slag	Direct use of syngas as substitute fuel Production of rock wool from slag (i.e., slag wool).
300	Syngas	Conversion of syngas to ethanol fuel additive
600	Syngas	Syngas combusted for electrical power to utility grid
600	Syngas	Direct use of syngas as substitute fuel
600	Syngas and slag	Direct use of syngas as substitute fuel Production of rock wool from slag (i.e., slag wool)
600	Syngas	Conversion of syngas to ethanol fuel additive

BASIC ASSUMPTIONS AND ELEMENTS OF THE PRO FORMA MODEL

SCS initially developed capital and operating and maintenance costs for the "basic" plasma plant at a design capacity of 300 TPD. For other size plants and different configurations, SCS applied reasonable adjustment factors to these costs to account for the major differences in the plant equipment and function. These assessments are described in the following sections below.

Economic analysis variables were established by SCS, including prices escalators, interest rates and other cost factors. These assumptions are applied consistently throughout the pro-forma modeling and can be adjusted relatively easily for sensitivity analysis. Key economic variables are summarized in Table 2 and discussed further on in the following section.

SCS contacted vendors and operators of plasma arc facilities to obtain cost data and information for capital and operating costs for the proposed facility. SCS is of the opinion that these data provide a reliable basis for projecting the costs of a new facility, absent preparing bid specifications and detailed cost estimates for this facility, which is beyond the scope of this study.

TABLE 2 ASSUMED ECONOMIC VARIABLES

Model Parameters	Assumption	Comment
Base Year	2014	Assumed
Planning Period	2014 – 2034	Assumed
Waste Flow Growth	2% Per Year	Assumed
Consumer Price Index	2.0%	Assumed
Interest Earnings (Of System Revenues)	2.0%	Assumed
Debt Financing Rate	8.0%	Assumed
Debt Service Coverage	125%	Assumed
Length of Bond Issue	20 years	Assumed
Treasury Grant Program	30 % of Capital Costs	U.S. Department of the Treasury
Landfill Tipping Fee (2009)	$35.00 per ton	Cedar Rapids, Linn County Landfill Tipping Fee
Availability of New Unit	75% Years 1 and 2 85% Years 3- 20	SCS Estimate
Slag to Aggregate Revenues	350 pounds per ton of waste processed; $0.52 per ton	SCS Estimate
Recovered Metals Revenues MRF Operations Plasma Arc Facility	3% of incoming waste (2.4% scrap ferrous, 0.6% aluminum cans) $300/ton for scrap ferrous, $0.82 per	SCS Estimate

Model Parameters	Assumption	Comment
	pound for aluminum cans 1.2 pounds per ton processed; $0.12 per ton	
Renewable Energy Credit (REC)	$1.00 per megawatt hour (MWh)	SCS Estimate
Carbon Credit	2.2 tons of CO_2 per ton of processed waste; $7 per ton of CO_2	SCS Estimate, when comparing plasma arc against current landfill disposal method

Configuration No. 1 (Basic Plant)

Cost Assumptions

Capital Costs. In essence, the data and information provided by the potential plant vendors was limited for the purposes of our preliminary economic analysis. Consequently, to assist the City's decision-making process for the Plant, SCS used a combination of two pricing approaches to develop baseline capital and operating costs. This approach is summarized in Table 3.

First, SCS used a widely accepted unit cost of $220,000 per ton of capacity for a conventional mass-burn WTE plant and extrapolated an estimate of capital costs for the Plant based on a 300 TPD initial Plant processing capacity. This results in a base capital cost of $66 million (Table 3). The "basic" plant is configured for all electric power production from combustion of the syngas in engine generators.

Costs were added or deducted from the mass burn base cost for major systems or pieces of equipment specific to the plasma arc process. These were based on certain costs estimated by SCS for the Plasco Ottawa plant and extrapolated to account for the capacity difference in the proposed City and Plasco plants. The added equipment resulted in a net additional cost of $23.5 million and an adjusted base capital cost of $89.5 million for a 300 TPD plant (Table 3).

An estimated cost of $1.5 million was included for the utility interconnect fee and transmission line extension based on local utility contacts.

Operations and Maintenance (O&M) Expenses. The O&M expenses assume costs for labor, administration, operator profit, parts and supplies, typical renewable and replacements, electricity, fuel (propane and natural gas), and normal pass-throughs such as chemicals, insurance, testing and utilities (potable and reclaimed water, wastewater).

SCS also estimated costs based on knowledge of costs for similar items at traditional WTE plants. These were adjusted to account for plant size and technology differences (i.e., torches, ash/slag handling, etc.). A breakdown is provided at the bottom of Table 3.

TABLE 3 DEVELOPMENT OF CAPITAL AND O&M COST FOR 300 TPD PLASMA ARC PLANT (ELECTRIC POWER CONFIGURATION)

Facility Capacity, TPD		300
Plant availability		85%
Plant annual throughput, TPY		**93,075**
Capital Cost		
Unit cost of mass burn plant, $/TPD	$	220,000
Cost of mass burn plant	$	66,000,000
Ratio cost of stoker and boiler		25%
Cost of stoker and boiler	$	<16,500,000>
Cost of exhaust stack	$	<1,200,000>
Cost of plant without stoker/boiler/stack	$	48,300,000
Cost of Scalehouse	$	500,000
Cost of Utility Interconnect	$	1,500,000
Cost of waste pre-processing	$	5,000,000
Cost of plasma arc	$	27,400,000
Cost of heat exchanger	$	6,800,000
O_2 injection	$	-
Gas scrubbing	$	-
Cost of Plasma Arc Facility	**$**	**89,500,000**
Investment to be financed		
Capital Cost	$	89,500,000
Treasury Grant 30%	$	(26,850,000)
Total to Finance	**$**	**62,650,000**
O&M Cost		
Labor		$2,475,000
Maintenance (Plasma Island)		$1,559,500
Maintenance (Balance of plant)		$1,558,000
Consumables		$822,071
Other Cost		$1,200,000
Ash Hauling & Disposal		$574,875
Ash Disposal		0
Management Fee		$777,899
Total O&M Cost		**$8,967,345**

TPD=Tons per day
TPY=Tons per year

Debt Service Coverage. Typical of most similar project financings, operating revenues were assumed to be maintained at a level equal to a minimum of 125% of the annual debt service.

Siting Considerations. For initial projection purposes, SCS assumed that the proposed facility would be located where there is available acreage and nearby electric transmission tie-in, water and wastewater utility, and a high capacity road network to handle increased waste truck traffic. The sites being annexed by the City, or property adjacent to the UI Oakdale Campus, appear to meet these requirements.

Power sales to the Oakdale campus from the Marion industrial park location will require going through the Midwest Independent System Operator (MISO), with all the added costs and complexity that it will generate. Also in the short term, the Oakdale campus appears not to be able to utilize100% of the plant power production in the medium and large capacity plant scenario.

Schedule. For projection purposes, SCS assumed the following implementation schedule:

Two years to obtain permits, conduct procurement process, and obtain financing.
Two years to construct and one year of start-up, shakedown, and final acceptance.

Management and Financing Structure. For initial projection purposes, we have assumed that neither the City nor a private developer of the Project would solely finance the construction of the Project. There appear to be continuing issues at the current time with the investment appetite of financial markets involving private alternative waste disposal projects throughout the United States, especially technologies not considered commercially proven. Our preliminary discussions with financial advisors[1] suggest that the most logical path for the Project would be for local governments and the Private developer of this Project to jointly establish a special purpose corporation ("Special Powers Corporation"), which would manage the Project and also enable the Project to receive access to funds available to such projects from the U.S Department of the Treasury under the American Recovery and Reinvestment Act of 2009 ("ARRA"), and loan guarantee programs by the federal government.

Plant Availability of Processing Capacity. Annual plant availability, tons per year (TPY), is assumed to be 85%, which is comparable with normal waste-to-energy operations.

Slag. For revenue estimating purposes, SCS assumed that the facility would generate 350 pounds of slag per ton of waste processed. Based on market surveys, SCS estimated that revenues would appear to be in the range of approximately $0.52 per ton processed for use as aggregate replacement in road base construction. This revenue is not counted in the analysis cases where the slag is instead processed into synthetic rock wool (slag wool) and sold.

Recovered Metals. For revenue estimating purposes, SCS assumed that the facility would generate 1.2 pounds of metals per ton of waste processed. Revenues are estimated at $0.12 per ton processed. At the upfront materials recovery facility ("MRF") it has been assumed that the incoming waste stream would yield only about 3% metals (2.4% scrap ferrous and 0.6 aluminum cans) because of the extensive removal afforded by the curbside recycling program in existence in the County.

Other Potential Revenue Sources

[1] Personal communications with John May and Lester Krone of Stern Brothers & Co, August 16, 2009.

Steam Production

SCS' plant configuration is based on net electric power output. We acknowledge that other energy configurations are possible, such as steam sale to adjacent industry; however, our equivalent rate of $37 per ton is reasonable and includes cost of cleaning syngas to raise its Btu value for industrial use.

Carbon Credits

No carbon trading market currently exists for emissions for WTE plants; however, SCS has included a revenue item assuming that some form of cap and trade legislation will be passed that creates a national market. The credit assumption is based on the plasma technology offering CO_2 reduction over the current landfill disposal method.

Assumptions for Electric Power Production

Electrical Energy Production. The plant would provide net generation of electric power of approximately 533 kWh per ton (kWh/ton) of waste processed. Given the current state of the plasma arc gasification industry at the present time, this level of net energy production seems achievable. The net kWh/ton ratio is very dependent on the chosen oxidant (air, O_2, H_2). Each oxidant requires different equipment/capital cost, and will produce different by-product. Air operation has been chosen. For air operation, the net kWh/ton ratio is typically lower than 533 (680 gross kWh/ton, i.e., between 350 and 450 net kWh/ton depending on in-house consumption levels). SCS used the higher value with the assumption that a next generation plant can realize this improvement.

Plasco Energy indicated to SCS a value as high as approximately 1,000 kWh/ton for its Ottawa plant; however, we do not have any formal data from them to document this. Plasco's process is fundamentally different than the other companies, separating the basic gasification of raw waste and applying the plasma atmosphere only to raw syngas; thus, this may be a valid factor in a relatively high claim for net power production. However, with no other North American plasma arc plants online, we have chosen to use a conservative value close to what we calculated (550 kWh/ton) from data presented in a University of California Study.[2]
It is worth noting that depending on the plasma technology and plant configuration, independent third party sources have determined that net power outputs for plasma can be significantly lower.

Electrical Revenues. SCS' basic plant configuration assumes syngas is combusted for power and some waste heat captured to produce steam to drive a turbine and produce additional power.

For estimates of energy revenues, SCS used an initial revenue of $70 per megawatt hour (MWh) obtained from local sources, escalated annually by the CPI assumed inflation rate. Because this price includes transmission, distribution and taxes (if any),

[2] Appendices, Evaluation of Conversion Technology Processes and Products. University of California, 2004.

the retail price for the Marion plant would potentially be lower. SCS will use the more optimistic value, unless the local utility provides a price that is significantly different. The utility CIPCO provided SCS a power purchase price of $46/MWh.

SCS also is optimistic that the assumed value for a renewable energy credit (REC) of $1 per MWh is conservative and could be adjusted upward to compensate for a reduced power price. Coupled with the net power output of 533 kWh/ton and including the estimated cost of syngas cleaning to raise Btu values, this represents a revenue rate of $37/ton of waste processed.

Configurations No. 2 and No. 3 — Direct Syngas Use and Syngas-to-Ethanol Conversion Cost Assumptions

The base cost development for the syngas-only configuration is summarized in Table 4 (following text). The plant is assumed to send the syngas through a short, ¼-mile long pipeline to an industrial customer. A small percentage of the syngas is assumed to be combusted on-site in engines to provide power to the plasma plant.

A summary of the economic data input for the pro forma case of direct sale of syngas and on-site production and sale of ethanol is provided in Table 5.

TABLE 5 SYNGAS PRODUCTION AND SYNGAS-TO-ETHANOL PRODUCTION

Item or Variable	Value or Cost	Remarks
Energy conversion (waste to syngas)	3,394 MBtu / day 11,310,000 Btu / ton	Average of values provided by Plasco Energy and InEnTec plasma arc vendors[(1)]
Capital Cost: Syngas compressor station & energy pipeline	$1,100,000	Assume station at $1 million and pipeline at $450,000 / mile. Pipeline is 4-inch diameter and ¼ mile in length
Syngas to ethanol conversion efficiency	60 gallons / ton of waste[(2)]	Biofuels from Municipal Waste – CIWMB 2007
Ethanol plant availability	90%	
Capital Cost Factor: Ethanol plant	$3.00 / gallon	USDA 2002 Ethanol Cost-of-Production Study, July 2005, ranging from $1.05 to $3.00 per gallon.
Capital cost: Ethanol Plant for 300 TPD Plasma Plant	$19,739,000	Based on 60 gals/ton waste x 300 tons x $3.00 per gal. x 365 days x 0.9 = $17,739,000 Add Plant Building = $2 million
O&M cost Ethanol plant	$0.38 / gallon	USDA 2002 Ethanol Cost-of-Production Study, July 2005
Ethanol selling price	$1.50 / gallon	Industry trend is $1 less than price of gasoline - American Coalition for Ethanol 2008 report
Syngas price (start year 2014)	$4.77 per million BTU (MBTU)	U.S. DOE 30-year Projections for Natural Gas prices / Henry Hub Spot Price (reduced by 30%)

(1) InEntec tests report a value as high as 21,000,000 Btu/ton.\
(2) Ethanol plant process vendors (BRI Energy and Enerkem) have reported laboratory results of up to 75 and 87 gallons per ton of sorted waste, respectively. SCS will use the more conservative rate of 60.

Thus, the additional cost to the 300 TPD syngas only plant for the ethanol production plant is $19,739,000 (Table 5 – row 6).

Syngas Pricing Assumption

SCS has chosen to assume a selling price for the use of syngas as a substitute for natural gas that is approximately 30% less than that of natural gas (i.e., the Henry Hub spot price). SCS acknowledges that if syngas purity is *assumed equivalent* to natural gas, then the price should be similar, the difference being that much more syngas would have to be consumed because natural gas has a much higher BTU content than syngas. However, SCS believes there are some valid considerations of extra costs associated with plasma syngas sale, some quantifiable, others less objective but entirely possible, that the effective net result is a price potentially lower than natural gas. These include the following. A calculation summary is provided in Attachment D.

Capital Costs

There would be one-time capital cost for a larger pipeline and ancillary features to handle the higher syngas flow requirement. Based on BTU content, the flow would be 4 times higher for syngas. In addition, the boiler gas piping and related features at the user end would have to be modified to accept the higher syngas flow. We estimated these costs at $750,000 based on 600 TPD waste conversion.

Energy Cost

There will be an annual energy cost extra for larger gas compressor/pumping equipment and related facilities necessary to provide the higher syngas flow. Annually we estimated this difference to be approximately $608,000 per year, and for a 20 year contract, about $12 million total over the contract life.

When the total extra costs are divided into the total energy value, the extra costs equate to about $0.76 per MMBTU. So, for example, if the price of natural gas were $3.80 / MMBTU, then the "effective" syngas price would effectively be $3.04/MMBTU. This is a "reduction" of about 20%.

Syngas Quality and Reliability

SCS believes that because plasma syngas is not yet a commercial commodity, and the process itself is not commercialized in the United States, there would potentially be other aspects of the syngas delivery that would effectively result in the gas having less value. These include the reliability of the plant to produce syngas, a consistent quality syngas and a syngas quantity that would consistently meet the users requirements. We assumed that collectively these would represent another 10% "reduction" in value. Overall, the 30% total reduction in syngas selling price is the sum of all of these factors and for this study has been represented as a "reduction" in the selling price.

Thermal energy of syngas for direct use is 11,310,000 Btu/ton of waste. This is higher than the value used for electric power, and is based on other data from two vendors.

Assumptions for Synthetic Rock Wool (Slag Wool) Production

A summary of the economic data input for the Pro Forma Model of production and sale of synthetic rock wool (slag wool) is provided in Table 6.

TABLE 6 PRODUCTION AND SALE OF SLAG WOOL

Item or Variable	Value or Cost	Remarks
Slag Wool Production Rate	0.105 tons per ton plasma plant capacity, for example; Plasma at 150 TPD = 15 TPD wool Plasma at 300 TPD = 31 TPD wool Plasma at 600 TPD = 62 TPD wool	Per Dr. Circeo reference (150 TPD slag for 1,000 TPD plasma plant) reduced by 30%
Slag Wool Pricing	$190 per ton	Per Dr. Circeo reference ($400/ton) and MEANS catalog, reduced by approximately 50%
Slag Wool "Spinning Plant"	31 TPD wool plant = $3 million 62 TPD wool plant = $6 million	Alibaba, small plant (1 ton/hour, assume 16 tons/day) = $1.5 million
Slag Wool Plant Building	31 TPD wool plant = $1 million 62 TPD wool plant = $2 million	Floor plan for 31 TPD plant assumed at 13,000 sf at $75 / sf installed

Thus, the cost for the for the slag wool production unit is the initial construction of the spinning plant and the building, estimated to total $4 million for the 300 TPD plasma plant and $8 million for the 600 TPD plasma plant.

CAPITAL COST SUMMARY – ALL PLANT CONFIGURATIONS

A summary of the capital costs and annual debt service cost for all plant configurations is provided in Table 7. To account for the price differential of the basic plants due strictly to the design capacity and economy of scale, the 150 TPD plant has a capital cost that is ½ of the capital cost of the 300 TPD plant times a factor of 1.1 (i.e., an increase of 10%). The 600 TPD plant has a capital cost that is twice the capital cost of the 300 TPD plant times a factor of 0.9 (i.e., a reduction of 10%). The Total Capital Cost (column 5 from left) is the cost that was used in the pro-forma model spreadsheet. Annual debt service was based on a 20-year bond issue at a debt service interest rate of 8%.

TABLE 7 SUMMARY OF CAPITAL AND ANNUAL DEBT SERVICE COSTS FOR ALL PLANT CONFIGURATIONS

Plant Capacity (tons per day)	Configuration	Basic Plant Capital Cost ($)	Added Capital Cost ($)	Total Capital Cost (30% ITC applied)[1] ($)	Annual Debt Service ($)
150	Syngas-to-Electric power only	NA	NA	34,457,500	3,509,572
	Syngas direct use only	NA	NA	25,795,000	2,627,278
	Syngas direct use and slag wool	NA	NA	27,335,000	2,784,130
300	Syngas-to-Electric power only	89,500,000	NA	62,650,000	6,381,041
	Syngas direct use only	67,000,000	NA	46,900,000	4,776,869
	Syngas direct use and slag wool	67,000,000	4,000,000	49,700,000	5,062,055
	Syngas-to-Ethanol	67,000,000	4,000,000	63,517,300	6,469,377

Plant Capacity (tons per day)	Configuration	Basic Plant Capital Cost ($)	Added Capital Cost ($)	Total Capital Cost (30% ITC applied)[1] ($)	Annual Debt Service ($)
	and slag wool		19,739,000		
600	Syngas-to-Electric power only	NA	NA	112,770,000	11,485,874
	Syngas direct-use only	NA	NA	84,420,000	8,598,363
	Syngas direct use and slag wool	NA	NA	89,460,000	9,111,699
	Syngas-to-Ethanol and slag wool	NA	NA	114,331,140	11,644,879

(1) ITC = Investment Tax Credit

PRO FORMA ANALYSIS RESULTS

Projected System Disposal Fee

A spreadsheet output model is provided for each of the 11 sensitivity cases presented in Table 7. The spreadsheets illustrate projected operating revenues, operating expenses, estimated debt service, and the projected "system disposal fee", over an expected 20-year operating period. The projected "system disposal fee" for this study is defined as the tipping fee charged by the plant operator for disposal of municipal waste at the plant. SCS estimates the equivalent system rate at the County Landfill is approximately $35 per ton. This was anticipated to escalate to approximately $37 per ton in 2010. SCS assumed that $37 per ton would be valid in 2014. Various landfill rate increases were estimated from 2014 to 2034 applying just an inflation rate of 1%, 1.5% or 2%.

Based on our Pro Forma financial modeling results, it appears that the system disposal fee for the project test cases declined significantly as the processing capacity of the project increased ("economies of scale"). Thus, a 600 TPD-sized project offers a reduced system rate as compared to a 150 or 300 TPD-sized project. This projected operating result is similar to that of facilities in the conventional WTE industry because the larger facility offers economies of scale in terms of operating costs and revenues. The larger unit oftentimes enables the project's owner and/or operator to recoup increased revenues from the sale of energy, and thus, utilize these revenues to pay debt service and maintain the required minimum debt service coverage often required in bond covenants.

The project system disposal fees over the 20 year economic life, for all 11 test cases, are summarized in Figure 1

Findings – Projected Disposal Fees; Plasma Plant and Landfill

Figure 1 indicates that the lowest system disposal fee is achieved for the case of the 600 TPD plasma plant configured for direct-use and sale of syngas to nearby industry. In year 2033, the projected fee was estimated to be approximately $73 per ton. For the other test cases at 600 TPD, the fee was approximately $77 per ton (with addition of slag wool sale) and $98 per ton (with addition of slag wool sale and production and sale of ethanol). For a 300 TPD plasma plant, the lowest projected disposal fee in year 2033 was approximately $81 per ton for the syngas direct-use sale only configuration. For a 150 TPD plasma plant, the lowest projected disposal fee in year 2033 was approximately $89 per ton for a syngas direct-use sale only configuration.

In comparison, the projected landfill disposal fee in year 2033 varied from approximately $44 per ton to $56 per ton, depending on inflation rate. Thus, the difference in the lowest landfill disposal fee of $44 per ton and the best case disposal fee at $73 per ton for the plasma plant is $29 per ton ($73 - $44).

Projected Disposal Fee Change

SCS has prepared a preliminary estimate of the disposal fee change for the first plant operating year (2014), based on the best case 600 TPD plant configuration (syngas direct-use and sale), as presented in the prior section. The estimated disposal fee for that year was $88.25 per ton (Figure 1).

The City should not count on significant revenue streams from slag or metal residuals making a substantial positive impact on the plant operating cost. There may likely be no revenue stream and more likely a cost for managing these by-products from the process until the plant is operating consistently and the by-product is stable. Instead, we recommend that the plant operations include a budget for disposal of slag and metals in the landfill until such time that all necessary approvals are secured, reliable markets are developed and actual contracts for reuse of these materials can be presented by the plant operator.

The calculated system rate in the first year of the Plant operation (2014) varies from approximately $143 per ton, for the 150 TPD plant scenario, to $118 per ton, for a 600 TPD plant scenario. The estimated equivalent system rate for the Cedar Rapids Linn County Landfill is $37 per ton. The pro forma model assumes plant operating and capital costs conditions that appear relatively reasonable to achieve at this time. Increased operating history for these types of plants are expected to result in lowered capital and operating costs over the near term anticipated for the Marion project.

Our analysis indicated that a Plant configuration where the syngas is sold for direct-use to a local industrial facility, potentially as substitute fuel, offered the best economic outcome as far as lowest tipping fee. For a 600 TPD plant capacity, this was calculated to be approximately $88 per ton in 2014 dropping to approximately $73 per ton in 2034. These results would change depending on the actual market price of natural gas and a specific agreed-to price and contract conditions for the plasma syngas by an end user. For example, assuming syngas price *was equal* to the natural gas price, for the 600 TPD pro-forma example, the tipping fee would drop from $88 per ton to approximately $85 per ton (in 2014).

SCS believes the Plant is economically feasible under the broad assumptions applied in the analysis with the most important assumptions being the following:

- The Plant operates at its design capacity at an acceptable annual uptime and produces consistent, high quality syngas and non-hazardous slag.

- A long term commitment to supply at least 600 tons per day of municipal waste to the plant initially and upwards of 1,000 tons per day in the future.

- The slag receives necessary approval for essentially unlimited use in building products.

- Finding/developing robust, sustainable markets and favorable pricing for beneficial use of the syngas and slag produced by the Plant. Plasma arc gasification is not commercially proven in the United States, and thus, the market for the products from this technology has yet to be proven as far as demand and cost.

- The ability of the plant owner to secure favorable Plant financing.

- Winning grants could help to offset a significant part (upwards of 30%) of the Plant’s capital cost.

- The disposal fee for landfilling continues to increase due to regulatory pressures designed to encourage municipalities to incorporate technologies that are less impactful than landfilling on the environment.

TABLE 4 DEVELOPMENT OF CAPITAL AND O&M COST FOR 300 TPD PLASMA ARC PLANT (SYNGAS ONLY CONFIGURATION)

Facility Capacity, TPD	300
Plant availability	85%
Plant annual throughput, TPY	**93,075**
Capital Cost	
Unit cost of mass burn plant, $/TPD	$ 220,000
Cost of mass burn plant	$ 66,000,000
Ratio cost of stoker and boiler	25%
Cost of stoker and boiler	$<16,500,000>
Cost of exhaust stack	$ <1,200,000>
Cost of plant without stoker/boiler/stack	$ 48,300,000
Cost of Scalehouse	$ 500,000
Cost of Syngas Compressor & Treatment & Pipeline to user	1,100,000
Ratio Cost of turbine, steam auxiliary	25%
Cost of turbine, steam auxiliary	$ <16,500,000>
Cost of waste pre-processing	$ 5,000,000
Cost of plasma arc	$ 27,400,000
Cost of heat exchanger	
Cost of engine generators	$ 1,200,000
O_2 injection	$ -
Gas scrubbing	$ -
Cost of Plasma Arc Facility	**$ 67,000,000**
Investment to be Financed	
Capital Cost	$ 67,000,000
Treasury Grant 30%	$ (20,100,000)
Total to Finance	**$ 46, 900,000**
O&M Cost	
Labor	$2,475,000
Maintenance (Plasma Island)	$1,559,500
Maintenance (Balance of plant)	$1,558,000
Consumables	$822,071
Other Cost	$1,200,000
Ash Hauling & Disposal	$574,875
Ash Disposal	0
Management Fee	$777,899
Total O&M Cost	**$8,967,345**

TPD=Tons per day
TPY=Tons per year

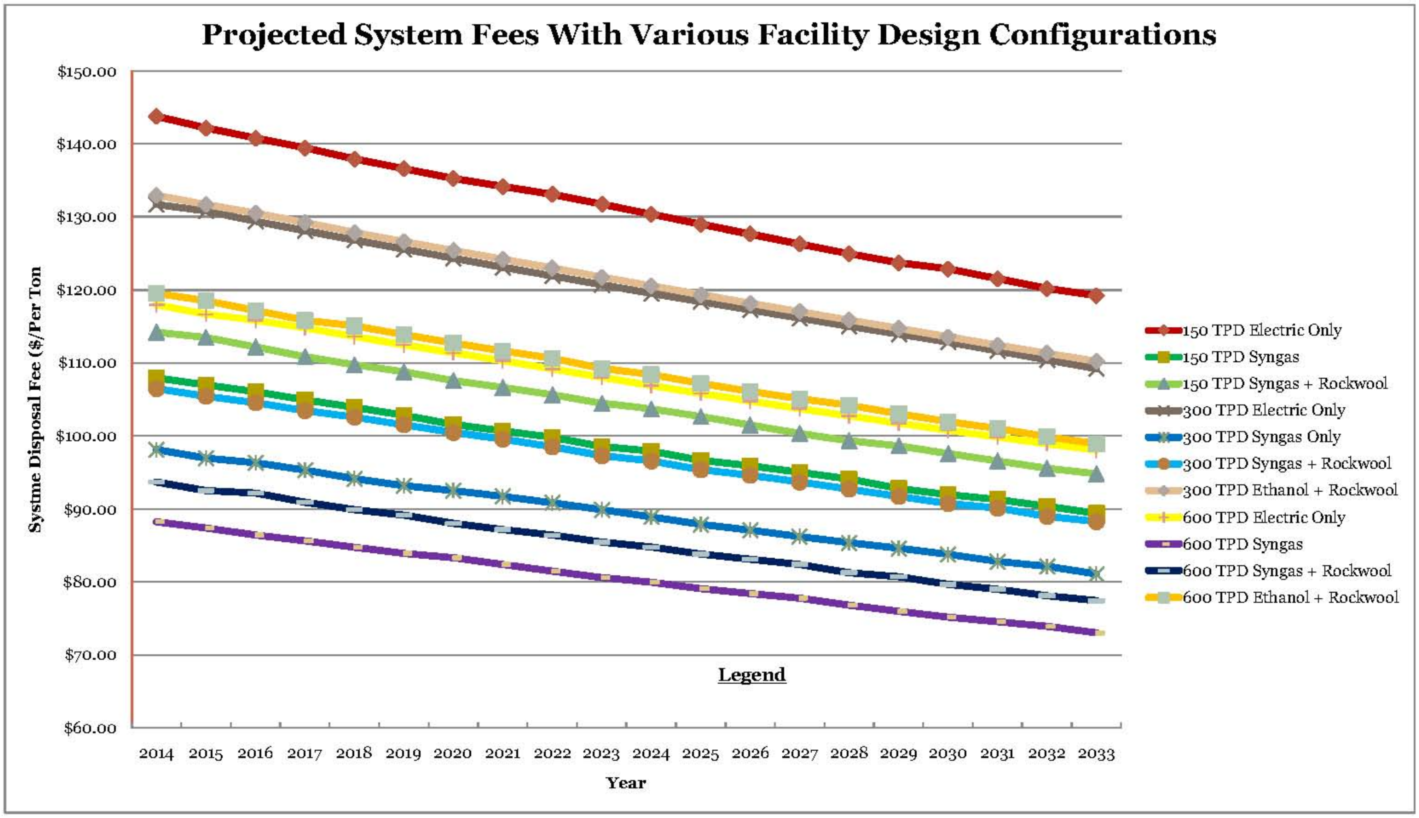

FIGURE 1 PROJECTED SYSTEM DISPOSAL FEES OVER 20 YEARS