Name of Report	Technical Support Document – MSW Plasma Gasification Combined Cycle Power Technology
Author	ENSR/AECOM
Date of Completion	April 2008

Note: All information included below in quotations is precisely what ENSR/AECOM wrote in its report.

Summary

In April 2008, ENSR, a leading independent environmental services firm, reviewed an Alter NRG-designed 750 tonne-per-day (tpd) waste-to-energy (WTE) facility design. The ENRR review document "may be used as an environmental design basis document for environmental evaluation of the technology and as a basis document for applying for necessary air permits to construct such a facility in the US."

Executive Summary from ENSR Report

"Alter NRG Corp. (Alter NRG) is developing the application of plasma gasification technology to convert consumer waste materials such as municipal solid waste (MSW), used tires and construction and demolition debris into clean electricity. In the proposed project, plasma gasification technology will be used to convert about 750 tons per day of these organic feed stocks into clean synthesis gas ("syngas") that will then be combined with natural gas and combusted in a highly efficient 66 MW (gross) combustion turbine combined cycle power plant.

The project will result in substantial renewable energy production from post consumer waste streams that would normally have to be land filled, while providing state-of-the-art emission control of sulfur dioxide (SO_2), acid gases such as hydrogen chloride (HCl) and hydrogen flouride (HF), oxides of nitrogen (NO_x), mercury (Hg), particulates (PM, PM_{10} and $PM_{2.5}$) including non-mercury heavy metals, volatile organic compounds (VOC) including dioxins, furans and poly-aromatic hydrocarbons. These emissions will be substantially lower than traditional mass burn or refuse derived fuel processes commonly used in the waste to energy industry. Diversion of MSW from solid waste landfills (where the potent greenhouse gas methane is formed) will result in substantial net decreases in greenhouse gas emissions as CO_2 equivalent. Since the proposed organic feed stocks are post consumer waste streams, the project represents a renewable and sustainable clean energy resource.

This Technical Support Document may be used as an environmental design basis document for environmental evaluation of the technology and as a basis document for applying for necessary air permits to construct

such a facility in the US. Since environmental permitting requirements in the US vary depending on state-specific regulations that may be more stringent than the Federal Clean Air Act, and since many US Counties are designated non-attainment for ozone (and therefore subject to more stringent permitting standards for NO_x and VOC), the top level of Best Available Control Technology has been applied for each criteria air pollutant in this TSD. For purposes of this TSD, selective catalytic reduction and oxidation catalyst have been assumed to be technically feasible and cost effective for application to the combined cycle combustion turbine, even though those control technologies were not included in the original PGCC Design Basis Memorandum. The technical and economic feasibility of these technologies with the particular syngas to be produced should be verified prior to permitting."

Description of the Technology

Plasma gasification Combined Cycle (PGCC)

"Plasma gasification combined cycle is an innovative application of proven technologies. The commercial application of plasma gasification to produce cleaned syngas to subsequently fuel a combined cycle turbine generator is the collaboration of industrial applications including the metal foundry industry for the design, application and operation of steel melting cupolas; the plasma torch industry for the design, development and application of continuous operating high temperature plasma gas torches; plasma gasification MSW processes constructed and operating in Japan, contaminant removal systems already in use (i.e. particulate removal by venturi scrubbers and wet electrostatic precipitators, mercury removal in the chemical industry with activated carbon bed filters, sulfur removal in the natural gas processing industry) and combined cycle combustion turbines, heat recovery steam generators and Rankine cycle steam turbine generators used in the utility power generation industry.

"The gasification and cleanup train being proposed is analogous to the gasification and cleanup technology being discussed in clean coal technology proposals across the U.S. to fuel new integrated gasification combined cycle (IGCC) plants; the main difference being that instead of gasifying coal, the PGCC process will gasify post consumer organic feed stocks such as MSW, used tires and C&D debris."

Emissions

- Combustion of syngas and natural gas "in the combustion turbine, which may be equipped with its own add-on air pollution control systems, will result in air pollutant emissions on a lb/kW basis lower than most fossil fuel power plants."

Some of the main sources of emissions from the facility (but not limited to) are:

Feedstock Delivery, Storage and Processing

- "The tipping building will be a large enclosed structure, accessed by overhead style doors. The tipping building will be maintained under a slight negative pressure to minimize the escape of odors and fugitive volatile organic emissions, either for use as combustion air to the combustion turbine or other oxidizer or exhausted through carbon filters. The tipping building will also be equipped with fire suppression and fogging systems to control dust."

- "The waste delivery, receiving, storage and processing facilities represent a potential source of fugitive and controlled point emissions of dust (particulate) and volatile organic compounds (VOC) including odor. Best Available Control Technologies will be employed such as the use of paved roadways, truck and periodic road washing and tipping building ventilation capture and control to minimize these potential air emissions. Waste water collection, oil/water separation and waste water treatment (either on-site or off-site via transfer to publically owned treatment works (POTW)) will be employed in all areas where waste materials are placed."

Plasma Gasification System

- "The plasma gasification system and associated syngas clean up train will produce syngas fuel for the combustion turbine, but are not in themselves a source of air emissions. The syngas production system does not contain any intermediate process vents or bypass stacks."

Emergency Syngas Flare

- "A fully enclosed emergency syngas flare is proposed to safely combust vented syngas during an emergency turbine trip as well as during combustion turbine start up and shutdown. The flare is expected to operate infrequently (estimated about 500 hours per year once the system enters commercial operation), and then only for testing, start up, shutdown or in response to an emergency turbine trip. In the event of such a trip, feed to the gasifier will be halted, and syngas production will decrease rapidly, approaching zero within several hours (the flare is expected to operate approximately three to four hours per system shutdown event). The syngas combusted in the emergency flare will be identical to the syngas being combusted in the combustion turbine, and will have very similar combustion products and emissions."

Wastewater Treatment

- "Process water streams from blow-down of the various operations will be collected and sent to one or more wastewater collection tanks. From these tanks, the collected wastewater will be transferred to an on-site or off-site wastewater treatment system to remove suspended solids, floating organics, heavy metals and

toxic components for municipal disposal. The wastewater treatment process will include a flash mix/flocculation tank, a Lamella clarifier/thickener, chemical feed systems, a treated water storage tank and a filter press to dewater the slurry. Most water demands of the facility (with the exception of potable service, water supply during facility start up and potentially RO water for boiler makeup) will be provided from recycling of the treated wastewater."

Combined Cycle Stack Emissions

- "Fueling the proposed combustion turbine with cleaned syngas supplemented with pipeline natural gas will result in very low emissions of criteria air pollutants. The limits proposed for NO_x, NH_3, Hg and CO are assumed to be after the application of Best Available Control Technology and continuously monitored using EPA Part 60 and Part 75 approved continuous emissions monitors (these standards are assumed to be applicable given the ability of the turbine to operate on 100% natural gas if syngas is not available). Emission limits for other pollutants are based on the application of Best Available Control technology as 1-hr limits based on 40 CFR 60 Appendix A stack test methods (the average of three one-hour tests). Table 1 presents proposed maximum composite 1-hr and annual average emission limits from the combined cycle stack firing syngas based on 100% load and "worst case" (maximum emission potential) operation. The emission rate in lb/hr is based on the 1-hr lb/MMBtu emission rates and a peak heat input of 500 MMBtu/hr (which includes syngas plus natural gas with a safety margin over the design basis nominal maximum). Emission rates in ton/year are based on worst-case (maximum) annual heat input (100% Capacity Factor)."

Table 1 Maximum Combined Cycle Stack Emissions (500 MMBtu/hr)

Pollutant	lb/MMBtu 1-hr	ppmvd @ 15% O_2 1-hr	lb/hr	tpy
NO_x[(a)]	0.0071	2	3.6	15.6
CO[(a)]	0.0108	5	5.4	23.7
VOC[(b) (c)]	0.0025	2	1.2	5.4
SO_2[(a)]	0.007	-	3.4	15.0
TSP[(c)]	0.015	N/A	7.4	32.6
PM_{10}[(c)]	0.015	N/A	7.4	32.6
$PM_{2.5}$[(c)]	0.015	N/A	7.4	32.6
Pb[(c)]	1.09 E-4	N/A	0.05	0.24
CO_2 [(a,d)]	219	N/A	67,861	297,231
Hg[(c,e)]	4.42 E-6	N/A	0.002	0.01
Cd	5.09 E-6	N/A	0.0023	0.011
HCl	0.019	N/A	5.23	22.9

Overall Facility Emissions

- "The project will result in substantial renewable energy production from post consumer waste streams that would normally have to be land filled, while providing state-of-the-art emission control of sulfur dioxide (SO_2), acid gases such as hydrogen chloride (HCl) and hydrogen flouride (HF), oxides of nitrogen (NO_x), mercury (Hg), particulates (PM, PM_{10} and $PM_{2.5}$) including non-mercury heavy metals, volatile organic compounds (VOC) including dioxins, furans and poly-aromatic hydrocarbons. These emissions will be substantially lower than traditional mass burn or refuse derived fuel processes commonly used in the waste to energy industry. Diversion of MSW from solid waste landfills (where the potent greenhouse gas methane is formed) will result in substantial net decreases in greenhouse gas emissions as CO_2 equivalent. Since the proposed organic feed stocks are post consumer waste streams, the project represents a renewable and sustainable clean energy resource."

Regulatory Review

"The US-EPA has issued air quality regulations and guidelines that impose very stringent design constraints on sources of air pollution emissions. The project may also be subject to state-specific requirements, which in some cases are more stringent than federal standards. Potentially applicable and/or relevant air permitting standards for a new waste to energy facility or a new waste fueled plasma gasification combined cycle facility in the US may include:

Federal Level

- National and State Ambient Air Quality Standards (NAAQS) (40 CFR Part 50);
- Federal Prevention of Significant Deterioration (PSD) regulations (40 CFR Section 52.21) for areas that meet the applicable NAAQS;
- Federal Emissions Standards 40 CFR Part 60 (New Source Performance Standards [NSPS]) for a new municipal waste combustion (MWC) unit - Subpart Eb (Large Municipal Waste Combustors). While technically not an MWC, these regulations are broadly written to include gasification;
- Air pollution control regulations requiring a permit to construct and the federal Title V operating permit program;
- Compliance Assurance Monitoring requirements (40 CFR Part 64); and
- Risk Management Plan Requirements (40 CFR Part 68; Section 112(r) of the Clean Air Act).

Potential State Level

- State level BACT review with lower thresholds and for additional pollutants
- State air pollution control regulations for new source review in areas that do not meet applicable NAAQS, referred to as "nonattainment areas" (Nonattainment New Source Review [NSR] Regulations);

- State Implementation Plan (SIP) for Municipal Solid Waste Incineration Facilities;
- State specific facility siting regulations including comprehensive Environmental Impacts Review;
- Noise Standards and regulations;
- State energy facility siting approvals; and
- Air Toxic Emission Standards or Guidelines."

The ENSR report goes on to discuss specific requirements applicable to air quality related licensing and permitting of a generic new waste to energy facility in the US.

Comment from Alter NRG

The ENSR Technical Support Document confirms the environmental design basis document for environmental evaluation of the technology and as a basis document for applying for necessary air permits to construct such a facility in the US.