APPLICATION OF MSW GASIFICATION PROJECTS IN THE CARIBBEAN BASIN

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Introduction

Islands located in the eastern Caribbean must address, like other parts of the World, the following issues:

- The management of solid waste and hazardous waste.
- The protection of the environment.
- Energy supplies.

These Islands are constrained in addressing these issues by the following:

- Indigenous fuel supplies generally do not exist on the Islands.
- High population densities limiting the quantity of land available for facilities; especially landfills, to manage solid waste and hazardous waste.
- The distance to off island permitted solid waste or hazardous waste management facilities is frequently hundreds of miles.
- Solid waste or hazardous waste must be transported to off island facilities via ship. This mode of shipping entails issues such as delays due to weather and transfer of waste between modes of transportation. Transportation and ultimate disposal costs are expensive.

Projects

The Thermoselect gasification technology is under review by governmental entities in the United States Virgin Islands and Puerto Rico. Both locations have difficult waste disposal challenges.
United States Virgin Islands - The United States Virgin Islands (USVI) are located approximately 1,100 miles southeast of Miami, Florida and include the three main islands - St. Croix, St. Johns and St. Thomas. The population is approximately 110,000 in a total land area of 135 square miles resulting in a population density of 815 people per square mile.

Municipal solid waste is disposed in landfills (dumps) located on St. Thomas and St. Croix, which are not in compliance with applicable laws and regulations. Additionally, hazardous waste is generated by heavy industries.

USVI falls under the United States laws and regulations. One dump is adjacent to a major airport serving the USVI. The poor condition of the dump has prompted the United States Federal Aviation Administration to consider closure of the airport. Significant adverse economic impacts, given the USVI’s dependence on tourism, would result from the closure.

Additionally, the USVI does not have an indigenous source of fuel.

The proposed facility has a design throughput capacity of approximately 660 tons per day.

Caguas, Puerto Rico – Caguas is located in eastern Puerto Rico approximately 20 miles south of the San Juan, Puerto Rico metropolitan area. Puerto Rico is approximately 100 miles east to west and approximately 40 miles north to south (4,000 square miles). The population is approaching 4,000,000 resulting in a population density of 1,000 people per square mile. Puerto Rico does not have indigenous fuel sources. An active manufacturing business sector generates hazardous waste while an active tourism business sector produces significant quantities of waste.

Puerto Rico, located approximately 1,000 miles southeast of Miami, Florida and as a commonwealth of the United States falls under Federal laws and regulations.

Approximately 9,000 tons per day of municipal solid waste and hazardous waste are generated in Puerto Rico. Ten regional landfills, several small landfills and some recycling programs presently manage the municipal solid waste. The regional landfills receive up to 2,500 tons per day each while the small landfills receive 100 or 200 tons per day. Only, three of the regional landfills have a bottom liner. Additionally, a permitted hazardous waste management facility does not exist in Puerto Rico.

The proposed facility will provide regional waste management services and has a design throughput capacity of 3,300 tons per day.
Basis for Consideration

The following characteristics of the Thermoselect technology have resulted in its consideration in the Caribbean Basin:

- The technology recovers the energy content in waste as a synthesis gas. The synthesis gas will be used to generate electricity. In the USVI, a portion of the electricity used in an electric generation or steam generation system or used as material in certain manufacturing processes.

- The limited air emissions.

- The reuse of the byproducts and granulates produced from the processing of the waste.

- Capability for all types of waste, including industrial waste, tires, white goods, medical waste and hazardous waste in addition to typical municipal solid waste.

Prior to delving into these characteristics, a brief history of the development of the Thermoselect technology and its physical and chemical processes is warranted.

Development History

The technology entered the development phase in the later part of the 1980s. A test and demonstration facility operated from 1992 to 1998 at Fondotoce, Italy. This facility had a single process line with a throughput capacity of approximately 110 short tons per day. The data secured from this demonstration facility resulted in the design of a “standard process line” with a design throughput capacity of 330 short tons per day.

The following waste management facilities utilizing the Thermoselect technology are operating on a commercial basis:

- Karlsruhe, Germany with three process lines and a design throughput capacity of 255,000 short tons per year. Operations commenced in 2001.

- Cibe, Japan with two process lines and a design throughput capacity of 115,000 short tons per year. Operations commenced in 1999.

The following facilities utilizing the Thermoselect technology are under construction or entering the construction phase:

- Ansbach, Germany with one process line and a design throughput capacity of 85,000 short tons per year with startup scheduled for 2002.

- Hanau, Germany with two process lines and a design throughput capacity of 100,000 short tons per year with startup scheduled for 2004.
The following facilities are in contract negotiation or the permitting phase:

- Giubiasco, Switzerland with two process lines and a design throughput capacity of 165,000 short tons per year.
- Herten, Germany with three process lines and a design throughput capacity of 250,000 short tons per year.
- Chiba #2, Japan with two process lines and a design throughput capacity of 110,000 short tons per year.
- Mutsu, Japan with two process lines and a design throughput capacity of 55,000 short tons per year.
- Kawagoe City, Japan with two process lines and a design throughput capacity of 110,000 short tons per year.
- Kurashiki City, Japan with three process lines and a design throughput capacity of 200,000 short tons per year.
- Hirado City, Japan with one process line and a design throughput capacity of 26,000 short tons per year.

Thermoselect Inc., the technology developer, has granted Interstate Waste Technologies, Inc., based in the United States, the development rights for North America and other designated areas of the World. Interstate Waste Technologies, Inc. has an affiliated company know as Caribe Waste Technologies, Inc.

**Physical and Chemical Processes**

Figure 1 on the following page shows a schematic of the Thermoselect technology. The major physical and chemical processes incorporated into the technology are as follows:

- Compaction of waste into the degasification chamber to a density of 2,100 pounds per cubic yard (1,250 kg/cu.m).
- Breakdown of waste within the degasification chamber into gases, carbon char and metallic and mineral components by utilization of high temperatures of 1,500 degrees F (800 degrees C).
- Conversion of the gases and char by chemical reaction with steam and pure oxygen in a high temperature reactor with temperatures at approximately 2,200 degrees F (1,200 degrees C). The reactions produce a syngas with approximately 250 BTUs per cubic
foot and the following approximate composition on a dry basis:

- 25 to 42% Carbon monoxide.
- 25 to 42% Hydrogen.
- 10 to 25% Carbon dioxide.
- 3 to 4% Nitrogen.

- Shock cooling of the syngas to significantly minimize the formation of compounds such as dioxins.

- Heating of the metallic and mineral components in a homogenization vessel at temperatures up to 3,600 degrees F (2,000 degrees C). The heating is followed by quenching of the metallic and mineral components to form metal and mineral granules.

- Process water cleanup.

Technology Characteristics

Energy Output

Figure 2 shows a typical energy balance for a facility with the Thermoselect technology located in the Caribbean Basin. The energy balance is based on the following:

- The waste processed has an average energy content of 5,000 BTUs per pound (HHV).

- The electric generation system consists of internal combustion (IC) engines driving generators.

Air Emissions

Figure 3 shows some typical air emission levels relative to the United States New Source Performance Standards from a facility utilizing the Thermoselect technology. The typical air emissions assume the following:

- A typical United States municipal solid waste is processed.

- The syngas is combusted in IC engines, which drive electric generators. The IC engines are equipped with catalytic systems for the control of NOx and CO air emissions.
The low air emission levels for CO, NOx, SO2, Particulates and Dioxins/Furans result from the following characteristics of the technology:

- The syngas consists predominating of H, CO and CO2 and is combusted in IC engines with NOx and CO emission control systems.
- The heavy metals in the solid waste are captured in the mineral granulates and metal granulates.
- The shock cooling essentially eliminates the reformation of dioxins during the processing of the syngas.

**Residues and Granulates**

Figure 4 shows a typical simple mass balance for a facility with the Thermoselect technology. The residues resulting from the processes generally consist of the following:

- Mineral granulates and metal granulates from the waste degasification processes.
- A sulfur compound from the syngas scrubbing processes.
- Metal hydroxides (sludge) from the treatment of process water.
- Mixed salts, predominantly sodium chloride.

The mineral granulate granulate consist largely of the oxides of the following metals [1]:

- Silicon – 42% by weight.
- Iron – 11% by weight.
- Calcium - 13% by weight.
- Aluminum – 20% by weight.
- Sodium – 5% by weight.

The granulates also generally contain 0.4% to 3% by weight of each of the oxides of magnesium, titanium, phosphorous, potassium and sulfur.

The granulates have undergone testing and are not classified as hazardous waste pursuant to the United States laws and regulations.
The metal granulates are an alloy consisting principally of the following metals:

- Iron – 80+% by weight.
- Copper – 10% by weight.
- Nickel – 1% by weight.

Other metals in the alloy in minor amounts include phosphorous, molybdenum, tin, cobalt, zinc, chromium and lead.

The sulfur compound largely contains the following [1]:

- Sulfur – 40% by weight.
- Water – 30% by weight.
- Total carbon – 20% by weight.
- Other – 10% by weight and largely consists of chloride, copper, iron, lead and tin.

The metal hydroxides (sludge) comprised of the following [1]:

- Water – 80% by weight.
- Metal hydroxides – 20% by weight and consisting largely of zinc, calcium and aluminum with minor amounts of cadmium, copper, iron, lead, magnesium, manganese, nickel and zinc.

The mixed salts consist largely of the following [1]:

- Sodium chloride – 80% by weight.
- Water – 10% by weight.
- Carbon or carbonates – approx. 7% by weight.
- Fluorine, metals and salts – approx. 5% by weight.

Markets have been identified for the granulates, the sulfur and the zinc concentrate that would be produced at the proposed facility in the USVI and at Caguas, Puerto Rico. The salts, approximately one percent by weight of the waste processed at the facilities, will be recycled by IWT.
Conclusions

Governmental agencies in the Caribbean are assessing the Thermoselect technology for the management of waste based on the following:

- Limited air emissions.
- Capabilities to process municipal solid waste and hazardous waste.
- Capabilities to produce energy, syngas or electricity.
- Generation of residues most of which have the potential for recycling.

References

SCHEMATIC OF THEMEOSELECT TECHNOLOGY

1. Main bunker
2. Loading tunnel
3. Press
4. Degassing channel
5. High temperature reactor HTR
6. Quench
7. Melt cooling with water lock
8. Homogenizing reactor
9. Acid scrubber
10. Alkaline scrubber
11. Desulphurisation
12. Drying
13. Active charcoal filter
14. Sulphur
15. Water lock
16. Sedimentation water lock
17. Buffer tank
18. Granulate
19. Material discharge
20. Precipitation A
21. Precipitation B
22. R/O evaporation
23. Pure water cooling system
24. Metal Hydroxides
25. Salt
26. Pure syngas
27. Condensate from gascooling
28. Process water
TYPICAL ENERGY BALANCE FOR 
PROPOSED CARIBBEAN FACILITY

1 TON 
WASTE @ 
5,000 BTU's/lb.

1,000,000 
BTU's/TON 
OF WASTE

5,625,000 
BTU's GAS

250,000 BTU's 
RECOVERED HEAT

5,625,000 BTU's 
WASTE HEAT

ELECTRIC 
GENERATOR 
SYSTEM

340 Kwh FOR EXPORT

280 Kwh FOR PROCESS USE

NATURAL GAS 
OR 
PROPANE

WASTE & GAS 
PROCESSING SYSTEMS

100,000 
BTU's
THEMOSELECT AIR EMISSIONS AS PERCENT OF UNITED STATES
NEW SOURCE PERFORMANCE STANDARDS FOR LARGE
MUNICIPALITY WASTE COMBUSTERS
N.T.S.
WASTE 1000 kg

Compression

Gasification

Oxygen (474 kg) and Natural Gas or Propane (20 kg)

Additives (HCl, NaOH, NaS, FeCl, FHM) 20 kg

Compression Gasification

Synthesis Gas Scrubbing

Process Water Treatment

Minerals 230 kg
Metals 29 kg

Sulfur 2 kg
Metal Hydroxides 3 kg
Salt 10 kg
Clean Water 350 kg

TYPICAL MASS BALANCE FOR THEMOSELECT TECHNOLOGY

N.T.S.