Solid waste déjà vu: waste-to-energy plant technologies break new ground

Marc J. Rogoff, Ph.D., Project Director, SCS Engineers, Tampa, Florida, and member, APWA Solid Waste Management Committee; **Bruce Clark**, P.E., Project Director, and **Amanda Moore**, Staff Professional, SCS Engineers, Tampa, Florida

Introduction

With the cost of energy from fossil fuel continuing to climb relative to historic prices, there again is a renewed interest in development of waste-to-energy (WTE) plants globally. However, there is a twist—some non-incineration technologies that made their debut during the U.S. energy crisis in the 1970s are reemerging as possible alternatives to conventional WTE plants. This article discusses the current experience of conventional WTE plants, what the various issues are surrounding the new WTE technologies, and issues to consider if you are thinking that an alternative technology WTE plant may be in your future.

Existing Experience with Waste-to-Energy

Modern waste-to-energy facilities produce clean, renewable energy (typically heat and/or electrical) through the combustion of municipal solid waste (MSW) in specially designed power plants equipped with advanced air pollution control equipment. Solid waste generally is considered a renewable energy source. Trash volume can typically be reduced by 90% and the remaining residue is then treated and subjected to frequent chemical analyses to ensure conformance to strict environmental standards. This enables its use as a substitute for certain materials in road base construction, building materials and concrete. Where these uses are not available, residue is typically co-disposed with other solid waste in municipal sanitary landfills or dedicated ash monofills.

Currently, there are more than 650 WTE plants operating around the world, mainly in Europe, Southeast Asia, Japan, and the United States. In the U.S., 98 WTE plants currently generate about 2,500 megawatts of electricity to meet the power needs of nearly two million homes, and the facilities serve the trash disposal needs of more than 36 million people. The $10 billion WTE industry employs more than 6,000 American workers with annual wages in excess of $400 million.

WTE technology has benefited from almost 50 years of continuous refinement of basic incineration and power producing technology in Europe and the U.S. As such, waste-to-energy facilities meet some of the most stringent environmental standards in the world and employ the most advanced emissions control equipment available. New and/or updated plants are expected to also see meaningful increases in power efficiency over plants currently operating in the U.S., the latest having gone online in the 1980s.

In a 2003 letter to the Integrated Waste Services Association, the U.S. Environmental Protection Agency (EPA) noted that America's WTE plants produce "dramatic decreases" in air emissions, and produce electricity "with less environmental impact than almost any other source of electricity" compared to earlier generations of incineration technologies. The "outstanding performance" of pollution control equipment used by the WTE industry in the U.S. exceeded the requirements of the Clean Air Act Section 129 Standards and has produced "dramatic decreases" in emissions. EPA data demonstrate that dioxin emissions have decreased by more than 99% in the past ten years, and represent less than one-half of one percent of the national dioxin inventory. Additionally, EPA estimates that WTE technology annually avoids the emission of 33 million metric tons of carbon dioxide, a greenhouse gas that would otherwise be released into the atmosphere.

The European Union (EU) has issued a legally binding requirement for its Member States to limit if not outright curtail the landfilling of biodegradable waste, thus encouraging the development of waste processing and combustion technologies such as WTE plants. The Confederation of European Waste-to-Energy Plants (CEWEP) notes that Europe currently treats 50 million tons of wastes annually at WTE plants, generating power for 27 million people or heat for 13 million people. Upcoming changes to EU legislation will have a profound impact on how much further the technology will help achieve environmental protection goals.

Current Issues

The conventional WTE plant industry is addressing several key issues related to the overall cost and environmental impact of the plants including:

- Ash Reduction and Beneficial Reuse (i.e., other than as landfill cover)
- Advanced Thermal Processes (i.e., gasification and combustion)
- Increased Overall Thermal Efficiency (i.e., more electricity per ton of waste processed)
- Public Perception (i.e., aesthetic effects and/or environmental impacts of emissions from the exhaust stack)

Some potential solutions are emerging as the industry moves ahead. For example, several companies have developed a technology processing ash into masonry building blocks. Other plants convert the ash into an inert slag. Plants that have employed a gasification stage ahead of the combustion stage power a turbine directly and realize an appreciable increase in efficiency. A plant in France was recently constructed underground with no prominent exhaust stack to preserve the visual aesthetics of the nearby Eiffel Tower. With the growth in water desalination plants there is a renewed interest in co-locating WTE plants with them to provide power for potable water production processes. Also, the Japanese have co-located several WTE plants with steelmaking facilities. The WTE industry is well positioned as many more examples worldwide of commercial-scale WTE plants emerge that combine pleasing architectural design, high reliability, low emissions, and beneficial reuse of by-products.

Emerging Alternative Thermal WTE Technologies

The incineration-based WTE plants operating today are based on technology that was introduced in the early 70's when the first "energy crisis" swept the U.S. At the time, alternative sources of energy were in demand and many of the basic solid waste incinerators of the day were considered obsolete, polluting dinosaurs. This spawned interest in a wave of new solid waste processing plants that relied on pyrolysis, an alternative thermal technology, despite the generally high construction and operating costs compared to conventional (and improving) mass burn WTE technologies. Pyrolysis plants held the promise of clean energy production and generation of potentially useful by-products, in addition to electricity. Eventually all of the alternative thermal plants were closed because they were unreliable at full capacity and prevailing energy economics changed. And, as basic incinerators were overhauled into full-fledged WTE plants with more sophisticated air pollution controls and the era of cheap landfills flourished, this effectively killed all of the commercial alternative WTE technology plants.

The primary reasons for the renewed U.S. interest in alternative WTE technologies are for basically the same reasons as in the 70's. Some regions of the country are looking for technologies that potentially have a reduced environmental impact, can provide alternative sources of energy at a competitive cost and have potentially useful by-products. Alternative thermal technologies are based on taking the solid waste and processing it under moderate to very high temperatures in a closed reactor vessel, sometimes under pressure and with or without the introduction of air or steam. Depending on the particular process, traditional recyclables (in particular inorganics) may be removed at the front end of the process or during the process stages. The current predominant process includes variations of *pyrolysis* and *gasification*.

Pyrolysis - Gasification. Gasification processes have attracted much interest because the process is theoretically more efficient than a combustion-based process, thus inherently producing lower emissions. The syngas produced from the waste destruction reaction is a relatively clean energy source and the plant may generate lower volumes and less troublesome air emissions overall. In a typical *pyrolysis* process a relatively low volume of air is introduced into the reactor vessel, resulting in the waste decomposing into certain gases (methane, carbon dioxide and carbon monoxide), liquids (oils/tar) and solid materials (char). The proportions are determined by operating temperature, pressure, oxygen content and other conditions. Because there is little to no air or oxygen available, the waste does not combust as it breaks down (there are no flames).

When the amount of air in the process is less than that required to support combustion, but greater than in a *pyrolysis* process, the process is termed *gasification* (Figure 1). This process is typically used to achieve a different balance of the gaseous by-products, mainly the production of a hydrogen (H)-rich gas with smaller quantities of carbon monoxide (CO), methane (CH4) and carbon dioxide (CO_2).

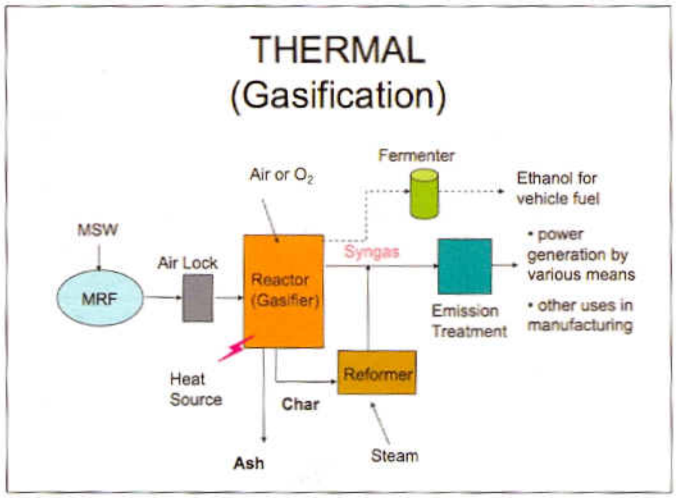

Figure 1 – Typical Gasification Process

The refined gas, primarily H and CO, is termed *syngas* and has many direct applications such as powering a turbine to produce electricity and potentially for use as a feedstock to produce alternative vehicular fuel (ethanol), or other chemical compounds. Most of these processes require an external heat source under normal operating conditions. This is usually hot, clean air from the heat exchangers downstream from the syngas production unit.

Plasma Arc. A relatively recent development proposed for solid waste gasification is the *plasma arc* converter. Although there are many variations, a typical *plasma arc* converter uses an array of plasma torches to generate temperatures in the reactor of more than 5,000 degrees centigrade (Figure 2).

This extremely high temperature, coupled with a gasification environment in a closed system, has shown potential in small laboratory test units to achieve a very high efficiency in decomposing the organic fraction of the waste to *syngas*, while generating a slag material from the inorganic and inert fraction. The slag has potential for use as a substitute ingredient in many building materials, including concrete structural elements (wall panels and blocks, etc.) and asphalt.

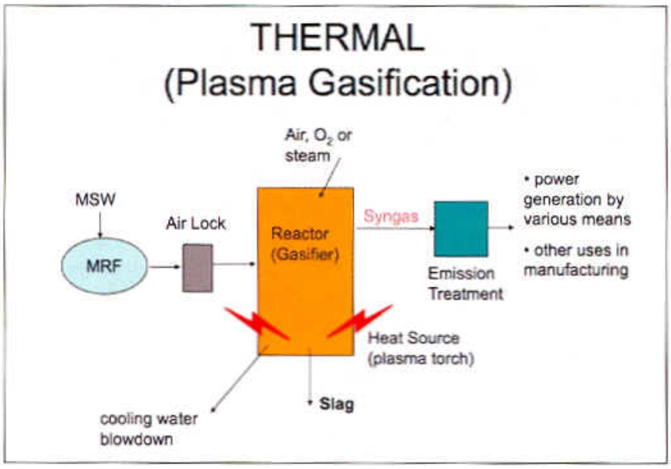

Figure 2 – Typical Plasma Arc Gasification Process

To date there have been no commercial-scale applications of the plasma arc technology in the U.S.

Table 1 is a sampling of some of the thermal conversion WTE projects being planned or operating across the U.S. and Canada, as reported in the literature.

Variables and Possible Unknowns

The possible variables and unknowns of the alternative technologies are similar to issues that would be common to any complex and/or innovative waste processing and/or power plant. Keep in mind that there have already been some plant failures abroad based on new thermal technology in the last 10 years that were attributed to some of these factors:

- Permitting issues
- Syngas Quality/Power Production
- Emissions
- Waste Preparation/Waste Feed
- By-products quality/quantity/markets
- Operator Experience/Financial Strength
- Safety Systems
- Downtime/Reliability
- Warranty
- Construction costs and financing
- Operating Costs

Some of the questions that flow from these variables include:

- How would a conversion plant fit into your system?
  - Where does the waste go presently?
  - Who will be impacted (budgets, staff, etc.)?
  - Can existing disposal contracts be restructured?
  - Do you have adequate flow control?

Location	Technology / Material	Status
Plasco Energy Group / Ottawa, Canada	Plasma Arc / MSW	Operational / 85 TPD 400 TPD Expansion Planned
City of Tallahassee, FL	Plasma Arc / MSW	Negotiation w/vendor
Logite International, Bingham County, ID	Gasification / MSW	Groundbreaking / 100 TPD – estimated 2010 completion
Gainesville Regional Utility, FL	Incineration of Biomass, MSW, wood wastes, tires	Planning & Construction – estimated 2013 completion
St. Lucie County, FL	Plasma Arc / MSW	Financing / Delayed ?
Los Angeles County, CA	Anaerobic digestion, Gasification / MSW	RFP for Pilot Plant "competition"
BRI Energy, Fayetteville, AR	Gasification / MSW	Operational (?) / 1.3 TPD
IES, Romoland,CA	Pyrolysis / MSW	Operational (?) / 50 TPD
Koochiching Economic Development Authority, MN	Plasma Arc / MSW	Planning Grant/ Feasibility Study
Sun Energy Group, LLC, New Orleans	Plasma Arc / MSW	Planning
Aitkin County, MN	Plasma Arc / MSW	Planning Grant/Feasibility Study
Pyrogenisis, Eglin Air Force Base, Okaloosa County, FL	Plasma Arc / MSW	Permitting
StarTech, Puerto Rico	Plasma Arc / MSW	Planning
Plasco Energy, Red Deer, Canada	Plasma Arc / MSW	Planning – 400 TPD
Sunbay Energy, Ontario, Canada	Gasification / MSW & Tires	400 TPD – Broke ground 2008
City of Marion, IA	Plasma Arc / MSW	Economic Analysis

Table 1 – Status of Current Alternative Thermal WTE Technology Projects

- What will be the tipping fee at the plant and is it competitive?
- Can the facility obtain a permit?
- Who will provide land for the plant?
- What other facilities are needed (MRF, transmission line, etc.)?
- Who will own and operate the plant?
- Where will the waste go when the plant is down for scheduled and unscheduled maintenance?
- Are there safeguards if the revenue from power and by-product sales are lower than expected?

For municipalities with larger, more complex systems and facilities, the parties involved in launching a WTE project would be familiar. However, some smaller jurisdictions may be unfamiliar with all of the possible players and arrangements. Every technology application and proposed plant is a little different and there is no "cookie cutter" one-size-fits-all structure. An example arrangement is shown in Figure 3.

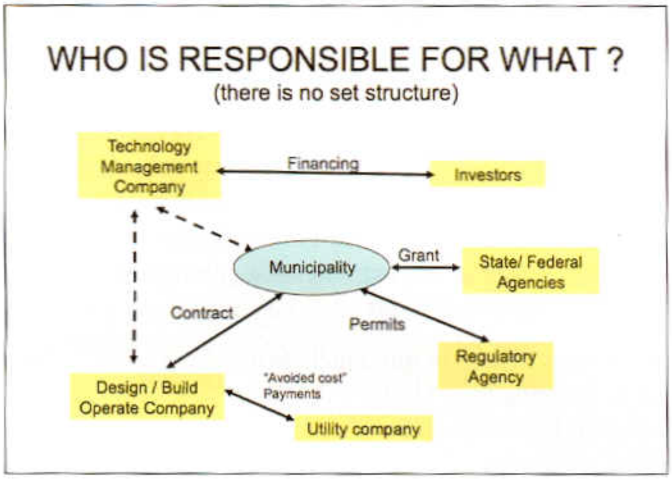

Figure 3 – Various Parties in a WTE Project

Considerations

Before plunging too far into serious talks with vendors of the alternative technologies, consider addressing, initially, some of the basics that should be a part of the overall planning development effort as follows:

- Do your homework:
  - Update your long-term Solid Waste Management Master Plan
  - Update your waste composition data and generation forecasts
  - Assess realistically how alternative technology may fit in for your community and how you would deal with technology and economic risk
- If you move forward, consider an "open" competition; however, set some minimum criteria for qualifications, for example:
  - Quantifying the waste flow available
  - Facility design which would enable it to operate for 20 years
  - Capital cost for appropriately-sized facility
  - Markets for end products
  - Full-scale operating facilities using the technology that could be toured
  - Intellectual properties covered by technology
  - Labor requirements
  - Five-year Pro Forma analysis
- Documentation of the financial strength of companies involved

The current alternative conversion technologies still need to accumulate a track record at a commercial scale before they can be considered a viable alternative to traditional landfilling and mass burn WTE plants in the U.S. Keep in mind that there are very few success stories in any heavy industry where new technologies transitioned, without successful pilot testing, directly from the laboratory stage to full-scale commercial operation. Apparently because of attractive offers by some plant vendors to build these plants "at no cost" to a municipality, some municipalities are considering the development (with a technology vendor) of large-scale plants (i.e., 1,000 TPD or greater) without any significant smaller-scale pilot plant operational history.

Operational Facilities

As for North America, there is one pilot-scale plasma arc plant rated at 85 TPD, located in Ottawa, Canada. This is operated by Plasco Energy Group and the plant reportedly has been processing MSW and selling power to the utility grid since early 2008. The plant design is based on the company's operation of a similar laboratory-scale unit and is part of a two-year monitoring program to prove the technology. According to Plasco's website, plans have been approved by the Canadian government to expand the capacity to more than 400 TPD. Abroad, probably the best examples of operating plants are in Japan where several cities rely on alternative WTE plants with one or more processing modules in the 60 to 185 TPD range.

Closing

Alternative WTE plant technologies are emerging in the U.S. market at an accelerating pace, and the source, relevancy and amount of detailed information provided on the technologies vary considerably. Many appear to be promising and may well find a permanent place in the industry. However, municipal officials should resist relying for their MSW processing primarily on a technology that has yet to be consistently proven on a commercial scale; this could result in placing the overall operation of a regional solid waste management system at significant risk.

Marc Rogoff can be reached at (813) 621-0080 or mrogoff@scsengineers.com; Bruce Clark can be reached at (813) 621-0080 or bclark@scsengineers.com; and Amanda Moore can be reached at (813) 621-0080 or amoore@scsengineers.com.