CRITICAL NATIONAL NEED IDEA:

Municipal Waste to Energy Through Improved Plasma Gasification Technology

Submission to the

Technology Innovation Program
National Institute of Standards and Technology
U.S. Department of Commerce

Submitted By:

Applied Plasma Technologies, Contact name – Dr. Igor Matveev, President

1729 Court Petit, McLean, VA 22101

Telephone: (703) 560-9569, Fax: (703) 849-8417, E-mail: i.matveev@att.net

Contributing Organizations:

- Applied Plasma Technologies, Contact name – Dr. Igor Matveev, President, 1729 Court Petit, McLean, VA 22101, Telephone: (703) 560-9569, Fax: (703) 849-8417, E-mail: i.matveev@att.net
- Allied Crude Purchasing, Inc., Contact name – Mr. Gordon Gray, President, 3900 West Hwy 180, P.O. Box 192, Snyder, TX 79550, Telephone: (325) 207-2692, Fax: (325) 573-5550, E-mail: a_l_l_i_e_d@sbcglobal.net
- Thermatool Corp, Inc., Contact name – Mr. Kris Livermore, Director, 31 Commerce Street, East Haven, CT 06512, Telephone: (203) 468-4158, Fax: (203) 468-4281, E-mail: krisl@ttool.com
- PyroGenesis Canada Inc., Contact name – Mr. Peirre Carabin, Chief Engineer, 2000 William Street, Montreal (Quebec), CANADA, Telephone: (514) 937-0002, Fax: (514) 937-5757, E-mail: pcarabin@pyrogenesis.com

Keywords: Plasma, Waste to Energy, Recycling, Renewable Energy, Municipal Waste Management, Climate Change, Global Warming

January 15, 2009

ABSTRACT

This white paper discusses the subject of waste-into-energy through improved plasma gasification ("PGWTE"), a subject that could provide a solution to the problem of shrinking national landfill capacity, particularly in densely populated areas, providing a clean and renewable fuel source to meet the growing national demand for electricity and industrial heat and simultaneously reducing the country's reliance on finite supplies of dirty fossil fuels.

While the general concept of using municipal solid waste (MSW) as an energy source is not a new or novel idea. Current incineration and integrated gasification technologies leave hazardous ash and other byproducts behind, the disposal of which adds expense to the process and makes it economically unfeasible on a large scale. In theory, the use of a plasma medium in the gasification process can eliminate this waste and convert the end product into a usable synthesis gas (syngas) and a solid inert material safe for civil and industrial use. However, current plasma gasification technology is still expensive and is currently constrained by physical factors that limit the useful life of the system and produce a subpar and low quality syngas that is unreliable for large-scale and widespread application.

Technological advances are being made today that promise to improve the usefulness of plasma gasification systems while at the same time reducing costs sufficiently, making PGWTE systems a viable option for waste disposal and energy supplies. These technologies are still nascent and experimental, however, and would benefit greatly from governmental support and attention.

MAPS TO ADMINISTRATION GUIDANCE

1. Municipal Solid Waste Management

In 2002, the United States Environmental Protection Agency (EPA) launched the Resource Conservation Challenge (RCC)[1]. The RCC serves as the EPA's most recent response to the Resource Conservation and Recovery Act (RCRA)[2] and the Pollution Prevention Act[3], passed by Congress in 1976 and 1990, respectively, as a way of addressing the growing nationwide problem of waste disposal and landfill capacity. Through the RCC, the EPA aims to encourage the reducing, reusing, and recycling of materials that are regularly discarded by American industry and the general public, and links the importance of these activities to energy conservation and greenhouse gas (GHG) reductions.

A key, but often overlooked, element of the EPA's response to RCRA is the use of MSW as a source of renewable energy[4].

2. Renewable Energy

The United States is struggling with expanding demand for electric power that threatens to overwhelm its existing generation capacity and transmission infrastructure while simultaneously

[1] http://www.epa.gov/osw/rcc/basic.htm
[2] http://www.epa.gov/lawsregs/laws/rcra.html
[3] http://www.epa.gov/p2/pubs/p2policy/act1990.htm
[4] http://www.wte.org/docs/EEREletter.pdf

reducing the use of finite supplies of dirty fossil fuels[5]. In response to these challenges, domestic demand is increasing both for renewable energy resources[6] and for more distributed and granular sources of electric power generation that lessen the operating and capital costs of long-distance electricity transmission and distribution[7].

In 2006, the President issued his Advanced Energy Initiative[8], stating:

"We can address high costs of natural gas and electricity by generating more electricity from clean coal, advanced nuclear power, and renewable resources"

More recently, President-elect Barack Obama has also stated his own support for renewable energy programs and has announced a plan to raise the share of domestic electricity from renewable sources to 10% by 2012 and 25% by 2025[9], and the Department of Energy projects total domestic energy consumption from renewable sources as a percentage of total energy consumption to grow by 16% from 2007 to 2010[10].

JUSTIFICATION FOR GOVERNMENT ATTENTION

3. Environmental Costs of Expanding Landfills

Waste disposal has long been a problem throughout world history for societies and their governments. With 2.02 billion metric tons generated in 2006, the world's landfills now contain well over a trillion tons of municipal solid waste (MSW)[11].

The United States produced 230 million metric tons of MSW in 2006[12], and on average, each resident of the United States produces just over 2 kilograms of household waste per day[13], an amount that is the highest per capita in the industrialized world[14]. Only 33% of this MSW is recycled and most of the remaining 67%, or about 124 million metric tons, is dumped in landfills[15]. Currently in the United States there are 1,754 active landfill facilities, plus approximately 10,000 old and inactive facilities[16]. The environmental impact of landfills is quite high: in addition to being a major source of methane emissions into the atmosphere (which has 21 times the global warming impact of CO2), leachate from landfills is a constant threat to groundwater supplies. Most facilities also contain unknown quantities of many toxic and hazardous substances in spite of extensive environmental regulation[17].

---

[5] http://www.energy.gov/energysources/electricpower.htm
[6] http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/rentrends.html
[7] http://www.osti.gov/bridge/servlets/purl/861261-MQCG8e/861261.PDF
[8] http://www.whitehouse.gov/stateoftheunion/2006/energy/
[9] http://change.gov/agenda/energy_and_environment_agenda/
[10] http://www.eia.doe.gov/oiaf/aeo/pdf/appa.pdf
[11] www.epa.gov/msw
[12] http://www.epa.gov/epawaste/nonhaz/municipal/pubs/msw07-rpt.pdf
[13] http://www.epa.gov/epawaste/nonhaz/municipal/pubs/msw07-rpt.pdf
[14] www.epa.gov/msw
[15] http://www.epa.gov/epawaste/nonhaz/municipal/pubs/msw07-rpt.pdf
[16] www.epa.gov/msw/facts
[17] http://www.ncbi.nlm.nih.gov/pubmed/15626384

4. Lagging Renewable Energy Accomplishments

The laudable goals and projections for renewable energy use that have been announced by American leaders have thus far not matched up well with reality and the obvious national need for the increased availability of renewable energy sources. Actual energy consumption from renewable sources from 2002 to 2007 grew only 7% as a percentage of total energy consumption. Annual federal spending on renewable energy research was virtually unchanged from 2002 when adjusted for inflation, and as of early 2009 the Federal Government had yet to implement a long expected national renewable energy standard for utilities and industrial users[18].

5. Thesis

` By focusing research and attention on the use of MSW as a viable source of renewable energy, the United States would have at its disposal a way to greatly reduce, or even eliminate, the large quantities of MSW that go into landfills each year, while at the same time increasing the amount of renewable energy available for use by its citizens and its industry. An additional benefit from this research would be a reduction of the environmental impact generated by landfills and waste incinerators.

6. State of the Existing Waste to Energy Industry

An overview of the existing global Waste-to-Energy (WTE) industry (as of 2004)[19] reveals that worldwide, only about 130 million metric tons of MSW are consumed annually in over 600 WTE electric generating and heat production facilities. These facilities are primarily focused on providing heat and steam to municipal districts and for the recovery and recycling of metals and plastics but provide very little electric power for general consumption. The facilities are located in 35 countries, primarily in Europe, and for the most part utilize relatively old and inefficient incineration technologies that provide an estimated 650 kWh of electricity per ton of MSW combusted. The most common is a moving grate technology developed by Martin GmbH (Munich, Germany) with installed worldwide capacity of about 59 million metric tons combined across all facilities; the Martin grate at the Brescia (Italy) plant is one of the newest WTE facilities in Europe. The second most common technology is the Von Roll (Zurich, Switzerland) mass-burning process with 32 million tons combusted worldwide. All other mass-burning and refuse-derived-fuel (RDF) processes together have a total estimated processing capacity of perhaps 40 million tons.

In the United States, only a very small portion of the unrecycled portion of annual MSW production is burned in 89 MSW-fired power generation plants scattered around the country[20], representing approximately 2,500 megawatts (MW) of capacity, or only 0.3% of total American electric power generation capacity[21]. Exploitation of MSW as a legitimate renewable fuel source has been slow for the following reasons[22] [23]:

---

[18] http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2009/01/08/MN041558UP.DTL

[19] Nickolas J. Themelis, "An overview of the global waste-to-energy industry", Waste Management World (www.iswa.org), 2003-2004 Review Issue, July-August 2003, p. 40-47.

[20] http://www.epa.gov/cleanenergy/energy-and-you/affect/municipal-sw.html

[21] http://www.epa.gov/cleanenergy/energy-and-you/affect/municipal-sw.html

[22] http://en.wikipedia.org/wiki/Incineration#Incineration_in_North_America

- Environmental fears of hazardous combustion byproducts (and added treatment costs) that are common in current incineration technology

- Concerns over low energy efficiency and high operating costs when compared to landfilling alternatives

- High capital and installation costs

- Perceived lack of tax incentives and government support

With the recent rapid increases in traditional fossil fuel prices, domestic interest in WTE was recently rekindled as an alternative fuel source to coal, natural gas, and fuel oil for electricity generation. This interest has been strengthened thanks to new and improved plasma gasification waste to energy (PGWTE) technologies that have promised a hotter (~2,500ºC), and therefore cleaner combustion process, which in turn eliminates hazardous waste and improves efficiency compared to older incineration technologies (~1,400ºC). These much higher temperatures convert the waste into an inert (and harmless) slag and higher quality syngas while also totally destroying all organic chemical constituents and hazardous persistent organic pollutants (POPs), such as dioxins and furans. Subsequently, the syngas can then be used for power generation through combustion in IC engines, power boilers, or gas turbines. The remaining uncombusted quantities of inert slag can be used as a raw material in a variety of industrial and civil manufacturing uses. Furthermore, a more complete gasification of organic materials results in lighter and weaker greenhouse gasses, which in turn could prove beneficial under a cap and trade or other carbon regulation regime.

Although PGWTE has been effectively demonstrated on a small scale, several parties have been unable to meet their stated intentions to scale up their respective PGWTE technologies from demonstration projects of 1-2 tons of waste per day (t/d) to a practical operational scale of 100 t/d or more. These firms have apparently encountered significant technical problems and obstacles during their attempts to scale up their small-scale demonstration units Also, high operation and maintenance costs and syngas production with an overly inconsistent composition and low caloric value, which in turn causes correspondingly unreliable combustion and conversion into electrical power has led to results of relatively low operating efficiencies (total power generation 0.8-1.1MW per ton of MSW), high internal power consumption (about 500 kW per ton + auxiliary systems), and high facility operation costs (approximately $70-80 per ton of waste consumed), which ultimately make these processes uneconomical for wide implementation as a national, or global, waste management strategy.

Nonetheless, researchers are developing improvements to existing PGWTE technologies that should correct these defects. Improvements like advanced plasma torch designs that use less external power and have longer operational lives, more efficient and cheaper oxygen separation processes providing a more conducive plasma medium, and improved syngas processing methods that result in a better quality feedstock for combustion later in the energy process.

---

[23] http://www.wte.org/energy/renewable_energy.html

6. Transformational Vision

We believe that the widespread use of improved PGWTE technology would have a major transformational effect on the United States as a whole. With a network of PGWTE systems in place in cities and towns across the country, new landfills would not be needed and existing landfills would very soon quit expanding. They could even begin to shrink as new MSW is diverted for use as energy and old landfills are mined for their contents. Furthermore, placing power generation sources closer to areas of electrical load would lessen the strain on our country's aging and overused electrical transmission system and would greatly reduce the transmission losses that are inherent in long distance electricity distribution. Because a system of small individual power stations would be more robust and controllable than one that relied on a network of only 3-4 large generators, a PGWTE system would have the potential to greatly improve the reliability of our country's electric power grid.

The costs to the consumers of electric power would also be lower using a PGWTE system..Most electricity customers are also waste disposal customers, the current fees being paid for waste collection and landfilling could instead be diverted to the construction and operation of a PGWTE system that in turn would be able to generate electricity for "free" from MSW derived fuel instead of paying for fossil fuels to generate power. Customers would no longer pay for both electricity and waste disposal and instead would pay one fee for both.

Properly designed, a PGWTE system would also prove beneficial to the environment when compared to current fossil fuel usage. Not only would the risk from hazardous landfill contents and their effect on the environment be eliminated, PGWTE would create a cleaner energy source than current fossil fuel combustion or incineration. Harmful air emissions would be reduced as well. Electric customers would not have to pay for expensive post combustion emissions controls or for air emissions allowances to remain in compliance with air quality standards.

7. Collateral Benefits From Improved PGWTE Technologies

By sponsoring PGWTE research and increasing government attention on the industry, the United States will take a large step towards reducing the quantity of waste going into the country's landfills each year while at the same time enhancing and increasing electricity and heat available for future use by its citizens and its industries. Furthermore, individual improvements made to the separate components of the PGWTE process could "stimulate the Nation's scientific frontiers" elsewhere in the chemical and energy industry.

- New and improved plasma torches have shown promise in improving the combustion of traditional fossil fuels like coal and fuel oil when retrofitted to burners in existing energy facilities and could lower emissions of nitrous oxides, sulfur, and mercury into the atmosphere.

- The more energy efficient power supplies developed for an improved plasma torch would have industrial applications like silicon production, coal gasification.

- Improvements in oxygen separation technologies would lower the cost of literally thousands of existing industrial chemical processes.

8. Funding and Education

Although research is ongoing in the field, almost all of it is being done at the University level or by small and underfunded niche firms with very little access to resources that would allow improved PGWTE to gain a wider national exposure. With the current state of the economy and a shrinking national pool of available investment capital, it is unlikely that large-scale capital injections will occur anytime in the near future[24]. Furthermore, with their tax bases shrinking and their demand for services increasing[25], many of the municipalities and local governments who would be the most obvious and likely customers for PGWTE systems are in no position at the moment to be able to consider a shift to such a transformational technology without funding and a mandate from the Federal Government.

Furthermore, the pool of potential customers for PGWTE systems will need to be educated on the benefits of the technology. Since most classical WTE systems are based on dirty incineration technology, many decision makers are unaware of alternatives and are likely to think of all WTE proposals as being unacceptable due to environmental concerns or efficiency limitations.

9. Conclusion

PGWTE has the potential to be a transformative technology in the Unites States by providing a clean and renewable source of energy while at the same time reducing the millions of tons of waste that are disposed in American landfills each year. Technological improvements to the individual components of PGWTE would also simultaneously prove beneficial to other industrial processes in other sectors. Unfortunately, the PGWTE concept presently faces a number of challenges: from the perception of potential customers and stakeholders of all PGWTE systems as dirty and insufficient technologies to a lack of available funding in the current economic climate. This transformative technology would benefit greatly from increased government attention and funding in the future.

[24] http://blogs.wsj.com/independentstreet/2009/01/05/venture-capital-climate-looking-even-bleaker-in-2009/
[25] http://www.post-gazette.com/pg/08353/935838-56.stm