

THE COMMERCIAL VIABILITY OF PLASMA ARC TECHNOLOGY

A White Paper



Prepared by

SOLENA GROUP

Project Developer and Technology Licensor

I. **Introduction:**

Plasma arc technology was developed and employed in the metal industry during the late 1800s to provide extremely high heat. During the early 1900s, plasma heaters were used in the chemical industry to manufacture acetylene fuel from natural gas. This application remains the largest (150 megawatt) plasma heated industrial plant in the world, located in the Chemische Were Huls plant, Marl, Germany.

Plasma Arch heaters received renewed attention when the United States NASA Space program, during the early 1960s, evaluated and selected Plasma Arc Heating technology for simulating and recreating the extreme high heat of reentry into the earth's dense atmosphere encountered by spacecraft from orbit. Using a water-cooled copper electrode, a 50 Mega Watt plasma arc heater was used to convert electricity into heat in order to test the reentry heat shield material at NASA.

Subsequently, small-scale prototype plasma heated processes were built and tested during the decade of the 1970s. Large-scale industrial plants were built and commissioned during the decade of the 1980s. Today, plasma technology is being used successfully in industrial plants worldwide for different applications ranging from chemical industry, metallurgical industry to the waste/environment industry.

Utilizing the same plasma technology, scientists who previously worked for NASA, have refined and improved the plasma arc technology in both efficiency, cost, and wider user applications; the lead NASA scientist, Dr. S.L. Camacho and his colleagues have joined Solena Group (SG), while others have joined SG's affiliated companies such as Westinghouse Plasma Corp. Solena Group, WPC, and Stone & Webster have formed a strategic teaming alliance and are jointly developing and promoting the plasma arc technology for the safe disposal of waste in projects worldwide.

II. **The Commercial Viability of Plasma Technology**

Solena Group's current team of companies has participated, either wholly or partially, in every commercial plasma systems in use today. Dr. S. L. Camacho and Dr. G. Leatherman of Solena Group and Dr. Shyam Dighe of Westinghouse are the top plasma and waste experts in the world today; collectively, they have several hundreds of patents filed worldwide in plasma heating technology, plasma processes, plasma torches, and plasma equipment.

Our experts, either individually or collectively, participated either in the design, the engineering, the testing, the construction, and/or the operation of the following plasma commercial installations:

<u>Project/Client Name</u>	<u>Description</u>
1. Kawasaki Steel Company - TEPCO	Disposal of toxic ash
2. Ebara - Infilco (1993)	Disposal of toxic ash
3. Ebara - Infilco (1994)	Disposal of toxic ash
4. Inertam - Bordeaux/EDF	Disposal of Asbestos containing Material
5. Port Clinton, Ohio - Defense Logistics Agency	Disposal of Asbestos fibers



6. Ravenswood - ALCOA	Disposal/recovery of Aluminum waste
7. Love Canal, Niagara Falls	Disposal of toxic sludge
8. BNL/EPA/COE	Sediment decontamination
9. Geneva Steel	Plasma fired cupola - steel scrap
10. Westinghouse Hanford	Low Level Radioactive waste vitrification
11. Philip Environmental	Zinc recovery from EAF dust
12. ESSAR steel (India)	Plasma ironmaking
13. NIST	Diamond film production
14. ALCAN (Canada)	Aluminum waste/dross recovery
11. IHI (Japan)	MSW Ash disposal
12. Westinghouse Hanford	High level radioactive Waste Calcination
13. USTDP	Sponge iron melting
14. Private	Nanophase Material production
15. Sandia Natl Laboratory	Plasma-halide Nuclear Reprocessing
16. General Motors	Iron Melting plasma cupola
17. Rockwell International	Alkali Nitrate Decomposition
18. Babcock and Wilcox	Boiler ignition
19. Westinghouse/PSI	Contaminated landfill disposal
20. Plasma Mesabi Metals	Plasma ironmaking
21. EPRI	Plasma fired cupola development
22. Studsvik Energy (Sweden)	Reactor Metal Vaporization
23. NKK Steel (Japan)	Pilot Blast furnace
24. SKF (Sweden)	Plasma ironmaking
25. Cockerill Steel	Blast furnace firing
26. SKF Steel (Sweden)	Plasma ferromanganese
27. Jet Propulsion Laboratory	High purity silicon Processing
28. International Minerals & Chemicals	Phosphate Defluorination
29. Dow Chemical	Hydrocarbon Cracking
30. DOE (OTD), (at Ukiah)	Plasma disposal of radioactive waste
31. British Nuclear Fuels (at Ukiah)	Plasma destruction of radioactive waste
32. DOE/Argonne Natl. Laboratory, INEL	Radioactive waste testing, disposal
33. US Naval Surface Warfare Center, Carderock	Design plasma shipboard waste system
34. DOE/USN/Private clients (at Idaho Falls)	Various Waste disposal, testing
35. DOE/Private (at Pittsburgh plasma center)	Various Waste disposal, testing
36. New York city harbor (at Pittsburgh center)	New York harbor sludge disposal
38. Canadian Environment Agency (at Raleigh)	MSW disposal and demo
39. Bordeaux city council (at Raleigh)	Toxic ash disposal and demo
40. Numerous private clients (at Raleigh)	Various waste disposal, testing

The above list is a partial list of the commercial projects, clients and services performed by Solena Group's and Westinghouse's personnel over the last several years. The majority of these plants continue to utilize the different plasma torches and plasma heating systems which have been developed and engineered by the SOLENA GROUP' team and which will be employed in our plasma waste projects worldwide; these systems have been in use typically 24 hrs a day year round (except for routine maintenance) at industrial capacity and have a life expectancy/guarantee for over 15 years (depending on size and applications, of course).



For example, the GM plant in Defiance, Ohio employs six (6) Marc II 2.5 megawatt Torches simultaneously handling over forty tons per hour of scrap metals, while the Geneva Plant in Utah utilizes nine (9) Marc II 2.5 MWh torches simultaneously to treat over 60 tons per hour. The Alcan plant treat Aluminum waste 24 hrs a day with exceptional equipment longevity (the longest torch electrode life ever demonstrated in plasma industrial plants) despite the caustic nature of the waste material. The Marc II plasma torch and heating system is the main piece of equipment for all of SOLENA GROUP's projects worldwide.

The impressive list of clients and projects above clearly demonstrate that :

- A. **The plasma arc technology is a well-proven, well-demonstrated commercially viable technology which is currently utilized in industrial plants worldwide.**
- B. **The consortium of Global Plasma Systems Group, Westinghouse Plasma Corp. and Stone & Webster has a clear and well proven track record in the commercial plasma arc heating industry**

The experience and data generated from the above projects and from our testing facilities collectively provide the SOLENA GROUP team with the most extensive data base, experience, expertise and proven track record than any other company or group of companies worldwide in the field of plasma arc technology, plasma waste treatment and environmental technology.

III. ***Plasma Waste Disposal Experience of SOLENA GROUP' team:***

As noted by the last six items in the above list, SOLENA GROUP (at its North Carolina pilot testing facility with 2 tons per hour capacity over a three year period) and Westinghouse (at its Pittsburgh Plasma Center with 2 tons per hour capacity since 1987) have tested, treated and analyzed hundreds of waste streams at industrial capacity (from several hundred kilos to over two metric tons per hour) over many years. These tests and/or treatment periods are at times performed on behalf of certain clients (public or private) and at other times as part of our R & D efforts which have resulted in hundreds of patents for our companies.

The waste streams that were successfully treated and disposed of by our plasma arc technologies at these three facilities include (but are not limited to):

1. Municipal Solid waste
2. Automobile tires
3. Waste coal
4. Coal
5. Sludges
6. Hazardous fly ash
7. Incinerator ash
8. Steel scrap
9. Car Fluff



10. Hospital Medical waste
11. Pyrolysis of PCB oil
12. Ferrous Chromium containing waste
13. Portland Cement Manufacture waste
14. Pathological wastes
15. Ferro-manganese reduction
16. Electric Arc Furnace dust
17. Titanium scrap melt
18. Asbestos containing material
19. Asbestos fibers
20. Niobium recovery
21. Glass waste
22. Ceramic waste
23. Harbor sludges
24. Natural gas for acetylene production
25. Solvents
26. Paints
27. Low level radioactive waste
28. Contaminated landfill material
29. Mixed source waste (combination of different waste source with MSW, ash, coal, tires, etc..)
30. Contaminated soils and fines

Based on the treatment of the above waste, our team has generated a significant database with specific information on the treatment and disposal of each and every waste stream; these data include

- a. The SER (Specific Energy Requirement) for each waste stream, i.e. the amount of energy required within the plasma system to completely gasify and vitrify a ton of the specific waste stream.
- b. The cost of operation per ton of waste,
- c. The behavior of each waste stream within a plasma reactor
- d. The optimum capacity of the plant for each waste stream,
- e. The heat and material balance for each waste stream,
- f. The characteristics and composition of the synthesis gas generated by the waste stream under plasma PPV conditions
- g. The energy content of the fuel gas and the energy recovered from the gas either in the form of electricity or liquid methanol fuel, etc..
- h. The characteristics and safety of the vitrified slag, its TCLP limits, etc..
- i. The environment impact of our system
- j. The air pollution control/gas scrubbing system required for each waste stream
- k. The optimum waste condition/composition to generate the maximum energy/material recovery.

These data are voluminous and are considered proprietary and confidential business information. It is based on these data that our experts (individually, in partnership or as the corporation) have filed over several hundreds patents as well as thousands of publications. A large part of these data are not yet patented or in the process of undergoing patent protection and considered as proprietary in



nature. Our extensive experience, database and expertise are the basis of our companies' strength and advantages over all other plasma companies in the world and in essence, established the SOLENA GROUP team as the world leader in plasma waste technology.

For our European projects, Solena Group's Architect & Engineering partner, Stone & Webster will serve as the prime EPC contractor providing basic engineering, procurement, construction, assembly and start up services with full performance, pricing and delivery schedule. Stone & Webster has over twenty years of experience in the waste management industry and has built waste disposal and waste to energy plant worldwide and will bring forth their expertise, resources and practical waste management experience to the SOLENA GROUP projects.

IV. Economic viability of a plasma arc waste disposal facility:

The financial and economic viability of each and every waste disposal or waste to energy project will depend on the:

- (i) Waste streams to be treated (composition, calorific contents, etc..)
- (ii) The commercial competitive tipping fees for each waste stream
- (iii) The capacity of the reactor and the plant,
- (iv) The organic contents of the waste vs. the inorganic contents of the waste,
- (v) The local labor costs,
- (vi) The local equipment costs,
- (vii) The local tax implications,
- (viii) The local environmental regulations that will dictate the requirements for the allowable waste treatment processing systems and the associated requirements for residuals disposal, the air emission control, and the wastewater disposal.
- (ix) The local utilities sale and purchase rate, and, most importantly,
- (x) The design basis of the plant (whether the project is a strict waste disposal facility or waste resource recovery /energy production facility).

Taking all the above variables into consideration, it is standard practice for the SOLENA GROUP team to perform a technical and economic feasibility study on the project for the client. We have completed two feasibility studies, one for our client, Kualiti Alam Sdn.Bhd. for their industrial waste facility in Bukit Nanas, Malaysia, and another one for our client GP Valencia S.A., in Spain for their tannery waste projects in Canals, Spain. .

Therefore, the economic and technical viability of a project can only be determined after extensive evaluation of the waste streams, our technical team's final design recommendations, and our team's detailed analysis of the financial and economic factors for the project.

Note: Our systems have been operating without electric generation due to the low electric rate in the US industrial market; however for our foreign clients in Europe and Asia, we recommend converting the generated synthesis gas from the waste into electric energy, which will supply the torches and the plant and also generate additional revenues for the project from the sale of the net electric production to the local utilities.

