Generation of electricity and waste management by using plasma

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Abstract. Using a plasma torch can intervene practically all types of solid urban waste, residential as well as industrial waste, and obtain electrical energy in the process. The process behind plasma waste treatment is known as plasma gasification, where enough energy is transferred to a solid or liquid substance such that it is transformed into partly in gas, more precisely in synthesis gas (syngas), and another partly in molten lava. The molten lava cools to become an inert vitreous sub product, leaving potentially hazardous products trapped in a crystalline net, such as some heavy metals. Hot gases can be used for electricity production and this can be used both to energize the same treatment plant and to deliver electricity to the external power grid. This is a brief report dedicated to study the viability of implementing the treatment of urban residues by the use of plasma.

1. Introduction
A theme present today in all countries is the amount of garbage per capita produced daily. This amount has reached unmanageable levels that explains the need to implement new and sustainable technologies for the management and treatment of waste. This is a brief report that is part of a more larger study dedicated to assessing the feasibility of implementing the treatment of urban residues by the use of plasma in a small OECD country. Urban solid waste, both from households and industries, can be roughly classified as hazardous and non-hazardous [1], both harmful to the environment or to humans. Among the hazardous ones can be mentioned toxic, combustible, explosive and radioactive waste. Among the non-hazardous are organic, metallic, glass and plastic waste. Due to the increasing amount of waste generated by the population and industry in recent years the waste management is a crucial issue that complies with environmentally responsible standards. The technologies involved in waste management should focus on maximizing material recovery, improving processes that allow us to obtain usable energy from the same waste and above all minimizing environmental impact. By using a plasma torch you can handle all types of waste and get electrical power in the process. Three different types of plasma torches are: the transpiration stabilized arc [2, 3], the arc with stabilized coaxial flow [4] and the stabilized jet with axial symmetry [5]. The process behind plasma waste treatment is known as plasma gasification, where enough energy is transferred to the waste such that it is transformed into partly in gas, more precisely syngas which is basically composed of H$_2$ and CO, and another partly in molten lava, known as slag. The plasma gasification is a technologically advanced process that in recent years has been reused due to the lack of implementing environmentally friendly techniques to remove wastes and convert them into other usable products and this is a non-incineration thermal process that uses extremely high temperatures. Due to high temperatures, any another more complex molecule is separated into its basic constituents. The molten lava cools to become an inert vitreous sub product, leaving potentially hazardous products, such as some heavy metals, trapped in a crystalline net. Hot gases can be used in conjunction with a turbine system to generate electricity and this electric power can be used both to energize the same treatment plant and to deliver electricity to the external power grid mean an integrated plasma gasification combined cycle system.
2. Electricity Generation mean a Plasma Torch and Financial viability

A plasma is created by applying energy to a gas to rearrange the electronic structure of atoms and molecules. This energy can be of thermal origin or be transported by an electric current or by electromagnetic radiation [6]. Depending on the amount of energy transferred, the properties of the plasma change, that is it changes its electronic density or its temperature [7]. One can distinguish between two classes of laboratory plasmas. The first are high temperature or fusion plasmas, where the electrons, ions and neutral species are in a thermodynamic equilibrium. The second is low temperature plasmas or gas discharges. For the latter, a further distinction can be made between thermal plasmas in which a state of quasi-equilibrium and cold plasmas where a non-equilibrium state occurs [6].

![Diagram of a plant](image)

Figure 1. A schematics diagram of a plant. The plasma gasification reactor (PG) is supported by the net power and a by a self-generated power. The gasification resultants sub products are the slag and the syngas. After of a heat recovery (HR) process the syngas is cleaned and sent to the combined cycle (CC) system dedicated to power generation, this power can be used for the different subsystems.

An integrated plasma gasification combined cycle system plant combines the process of plasma gasification with a combined cycle power generation system. Said cycle consists of one or more gas turbines and a steam turbine. The syngas is burned in highly efficient gas turbines to produce electricity. Excess heat from the turbines is used to generate steam which is sent to a steam turbine to produce additional electricity and in this case also using heat from the gasification reaction. The synthesis gas from the plasma gasification must be cooled down before it can be used for the generation of electricity. Besides the gas must be cleaned to comply with the technical specifications of the fuel used by the gas turbine chosen for the treatment plant. In order to drastically reduce air
pollution, the cleaning system must achieve the efficient removal of any particulate matter, mercury, sulphur compound, chlorides and other volatile elements. These gas turbines used in such a plant are similar to jet engines and also very similar to natural gas combined cycle gas turbines but specially adapted for use with syngas. In particular, these gas turbines are adapted to operate with highly hydrogen-rich synthesis gas and this system must include a carbon dioxide capture device.

The Figure 1 shown a schematic diagram of a system of this kind. The plasma gasification reactor (PG) is supported by net power and also can be supported by self-generated power at the same plant. If the self-generated power at the plant is greater than the total net power used net power can be generated. The gasification resultants sub-products are hot slag and the syngas. The slag is cooled down and stored properly. After of a heat recovery (HR) process the syngas is cleaned and sent to one the turbines of the combined cycle (CC) system of two turbines dedicated to the power generation at the same plant, water is converted in steam at the HR system and used by the other turbine. If the self-generated power is greater than the total net power used for the plant net power can be generated. This power also can be used for the different subsystems of the plant: the PG, HR and the clean-up stage.

The amount of electricity that can be generated in this way is directly proportional to the amount of waste that the plant can treat daily, the financial viability of a plant of this type also depends on this amount. The number of tons of waste produced annually by a given urban area is proportional to the number of inhabitants in it [1]. An estimated price of a plant of this type is MUSD $ 68 [8], the latter is assumed an estimated government contribution of 30% over the total plant cost. A conservative amount of energy that a plant of this type can generate is 0.55 MWh/ton [8], and can be up to 1 MWh/ton [8]. An estimated price in a OECD country (Chile in this example) in the early November of 2016 is USD $ 60 per MWh [9].

3. Conclusions
In areas of very low density of population, such as small islands and rural areas, the financial viability of a plant of this type is questioned, but not the technical viability. In any case, it is concluded that the current form in which the treatment of waste is made must be changed [1], optimized and modernized both in large areas of the population and in areas where it is reduced. As a solution to this dilemma, the following hypothesis is proposed: the creation of sister waste treatment plants, the largest one built in a large urban area and the smallest in an area of few habitants, both financially linked, can make waste treatment viable through the use of plasma in both areas, especially in the area of few population. All this associated to technologies of minimum emission to the atmosphere [10] and extreme care of the environment [10].

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