**Plasma Gasification based 'Green Hydrogen' generation from MSW-RDF / Agri-waste (in Brief)**

**Process Description (in Brief)**

### 5.1 Introduction

MSW-RDF is a value-added material with a high calorific value, low moisture content, high volatile and carbon content. RDF gasification is very attractive technology as it increases energy recovery efficiency, reduces the dimension of the section of post-treatment for pollutants emissions control, prevent dioxins and furans formation (due to reducing conditions).

The high temperature in the plasma converter breaks down tar and char enhancing the quality of the syngas, and vitrifies the ashes generated from the gasifier, which would otherwise pose both operational and disposal problems for most other gasification or combustion processes. The ash vitrification yields an environmentally stable and non-leachable product namely slag with a variety of uses.

In this domain, NTPC intends to use MSW-RDF/Agri-Waste through plasma enhanced gasification process to generate H2.

### 5.2. Process Description

The Gasification block comprises of the multi-stage plasma enhanced gasifier that converts the MSW-RDF/Agri-Waste (25 TPD) into synthesis gas (Syngas) using O2.

#### 5.2.1. Block 1- Feed Preparation

In Block 1 of plasma gasification process, MSW-RDF/Agri-Waste is prepared as per the specification (Table 1). In order to produce MSW-RDF/Agri-Waste, waste may first be screened and shredded and then carefully sorted to remove all non-combustible materials such as glass, metal and stone via a series of mechanical operations i.e. vibrating screen, magnetic separator, shredder etc.

Table 1. Physico-chemical characteristics of MSW-RDF/Agri-Waste

| Parameters | Units | MSW-RDF ( Grade III) / Agri-Waste | Design Basis Avg | Design Basis Min/Max |
|---|---|---|---|---|
| Moisture | Wt % (ar) | < 20% | 20% | 25% |
| Ash | Wt % (d) | < 15% | 15% | 20% |
| Chlorine | Wt % (d) | < 1.0% | 0.5% Cl | 1.0% Cl<br>1.2% Cl+F+Br |
| Sulfur | Wt % (d) | < 1.5 % | 1.0% | 1.5% |
| Net Calorific Value (NCV) | Kcal/kg (ar) | >3000 | 3000 | 2800 (Min) |
| Size | mm | < 50 or < 20 | | <50 |
| PVC | | None | Allowed | Allowed |
| Mercury | mg/kg (d) | | 0.25 | 0.5 |

| | | | | |
|---|---|---|---|---|
| Radioactives | | | None | None |
| Arsenic | mg/kg (d) | | | 10 |
| Cadmium | mg/kg (d) | | | 10 |
| Cobalt | mg/kg (d) | | | 25 |
| Chromium | mg/kg (d) | | | 100 |
| Copper | mg/kg (d) | | | 200 |
| Nickel | mg/kg (d) | | | 50 |
| Lead | mg/kg (d) | | | 50 |
| Antimony | mg/kg (d) | | | 50 |
| Vanadium | mg/kg (d) | | | 50 |

**5.2.2. Block 2 - Gasifier Block**

The main process equipment may include gasifier chamber, plasma torch, product gas cleaning system, slag vitrification subsystem, in-process analyser and control system.

MSW-RDF/Agri-Waste will be fed to a multi-stage gasification reactor by a waste feed system. PNG is to be provided to the gasifier's preheat burners only at the start-up to raise the gasifier chamber to operating temperature before beginning to feed waste.

Raw synthesis gas obtained from MSW-RDF/Agri-Waste gasification will pass through a series of chambers designed to provide turbulent mixing and adequate residence time for the gasification reactions. The final chamber (Activator) incorporates a plasma torch (or any alternate high heat element) which provides intense heat to ensure that tars and particulates in the syngas are removed, and syngas quality is maximized.

The inorganic MSW-RDF/Agri-Waste content which is not gasified is referred to as ash. The ash exits the gasifier is then transferred to a vitrification chamber to be melted using the intense heat generated by a plasma torch. Molten slag is drained from the vitrification chamber into a water-filled slag discharge dredge conveyor. The slag solidifies as it cools in the water bath. The solidified slag forms a glassy, non-leaching solid residue similar to glass or obsidian.

Further, in the syngas cleaning system, an evaporative cooler rapidly lowers the gas temperature, from approximately 1000 °C to around 200 °C. The rapid cooling is achieved by the injection of a liquid stream in the form of fine droplets. The liquid stream consists mainly of water and some dissolved sodium chloride. The stream is injected through an atomizing nozzle, where an atomizing medium is used to produce the fine droplets. Because the syngas is both hot and flammable the use of an inert atomizing medium, in this case steam, is required. The flowrate of the injection stream is controlled so that the flow is sufficient to cool the gas (to 200oC) without bringing the gas close to saturation point. The sodium chloride in the liquid stream forms solid particles which are removed by the fabric filter.

In the next step of the Gasification system, lime (as CaO or Ca(OH)2) and activated carbon are injected into the syngas stream before it enters a fabric-filter baghouse. This process is known as Dry Sorbent Injection (DSI). The lime reacts with, and captures into the solid phase, acid gases present in the product gas stream (primarily Hydrogen Chloride (HCl) and Hydrogen Fluoride (HF)). The activated carbon particles adsorb gaseous mercury (Hg) and other volatile metals, capturing them in the solid

phase also. The baghouse removes the particulates by a filtration process. As most of the acid gases (e.g., HCl), and volatile/semi-volatile metals have been moved into the solid phase as a result of the sorbent injection, they are now particulates which are captured along with any residual ash or other solids on the surface of filter bags within the fabric filter housing. (Typical acid gas removal is ~ 85%. Typical solids removal is > 99%.)

Following the fabric filter solids removal stage of the gasification cleaning system, the syngas next enters a polishing wet scrubber where an aqueous solution removes residual acid gases (HCl and HF) with a high (typical residual HCl removal of 99%) efficiency as well as further cooling the syngas. The solution that circulates and removes the acid gases is neutralized with caustic injection into the scrubber sump. The wet scrubber is operated at close to neutral pH in order to selectively remove all but traces of the acid gases (HCl and HF) from the syngas while removing minimal, if any, Carbon Dioxide (CO2) and Hydrogen Sulphide (H2S). The syngas exiting the wet scrubber is saturated with water vapor and is at a temperature of approximately 50oC. The gasifier, as well as the entirety of the syngas cleaning system from the inlet of the evaporative cooler to the exit of the wet scrubber, is maintained under a slight vacuum.

Nitrogen (99.9% purity) is primarily used for purging and inerting purposes in the gasification process to ensure safe operations. Significant uses include inerting of the MSW-RDF/Agri-Waste feed airlock and back-pulsing of the Baghouse filter media. During start-up and system inerting, the Plasma Torches may be operated on Nitrogen rather than Instrument Air.

**5.2.3. Block 3: Syngas Conditioning**

The syngas from the gasifier may further cleaned in the 2 stage scrubber system to remove impurities, producing very clean syngas consisting primarily of H2 and CO.

**5.2.4. Block 4 - Block 7: H2 Recovery from Syngas**

This block may consist of membrane unit/ VPSA/PSA unit to recover H2 from syngas. Further cascade vessels based system may be used to store H2 at 200 bar.

**5.2.5 Hydrogen compression, storage and dispenser Block**: Hydrogen storage at 200 bar

**5.2.6 Power Block**: To generate electricity from remaining syngas (mainly CO, H2 etc) available after H2 separation from syngas using technologies like gas engines etc.

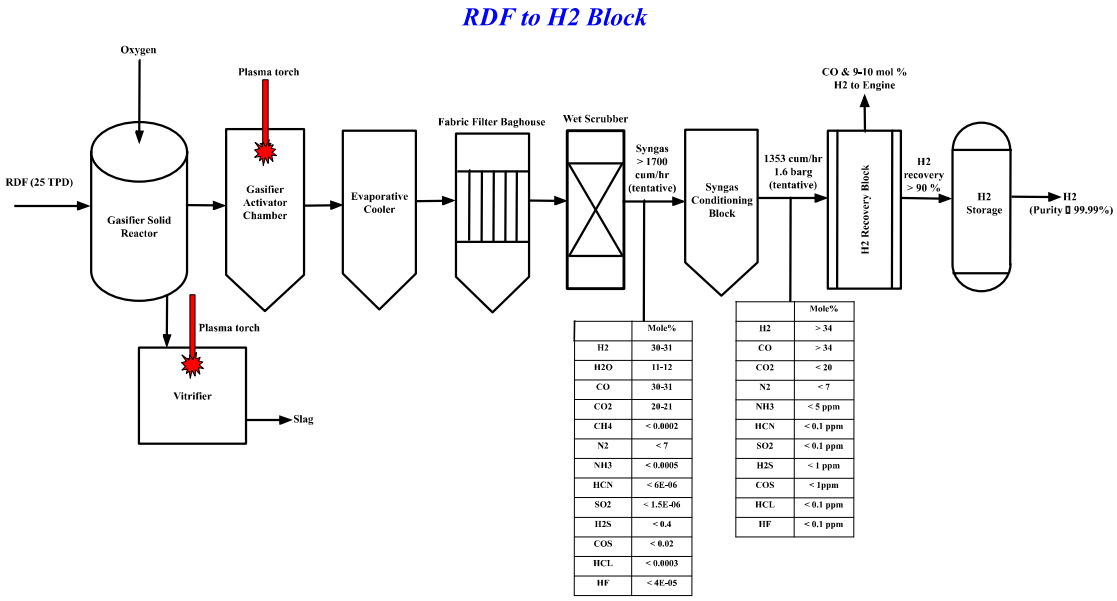


**Figure 2.** Process Flow Diagram of Plasma Enhanced Gasification Process for Green Hydrogen Production (Indicative for tender purpose only)

**List of BOQ Items (Indicative for tender purpose only)**

| Sr. No. | Description | Equipment/Systems (BOQ Items) |
|---|---|---|
| I | Direct Cost | |
| 1 | Conveyor & Elevator | |
| | 1 | Solid Waste Feed Conveyor |
| | 2 | Solid Waste Feed Elevator |
| 2 | Plasma Gasification Block (Enersol) | |
| | | Supply & Design |
| | 1 | PEGS Gasification |
| | 2 | Utilities Subsystems Block |
| | 3 | Vitrifier |
| | 4 | BULK MATERIALS |
| | 5 | SPARES |
| | 6 | Relief Header Water Seal |
| | 7 | DETAILED ENGINEERING & DESIGN |
| | | Installation |
| | 8 | Installation, Assembly and Integration Supervision |
| | 9 | Installation subcontractor |
| | | Startup & commissioning |
| | 10 | Startup, commisioning, Training & acceptance testing |
| | 11 | Natural Gas (240 hrs/yr) - 750,000 Kcal/hr |

| | | |
|---|---|---|
| | | SubTotal |
| 3 | Syngas Cleaning Block Block | |
| | 1 | Syngas cleaning block (upto wet scrubber) |
| | 2 | Syngas compressor (Pkg with HE ant KO drum) |
| | 3 | COS removal Unit |
| | 4 | HCL romoval unit |
| | 5 | Sulfur removal unit |
| | 6 | Mercury Removal unit |
| | 7 | Syngas sampling/analyzer |
| 4 | Hydrogen Separation Block | |
| | 1 | Syngas compressor |
| | 2 | Membrane Unit |
| | 3 | VPSA Hydrogen Unit |
| 5 | **Hydrogen compression, storage and dispenser Block** | |
| | **1** | Hydrogen Compressor (4 units) |
| | **2** | Storage Cascade |
| | **3** | Dispenser Unit |
| | **4** | Buffer Vassel |
| | | **Installation Cost** |
| | **5** | Cost of Installation, Commissioning & Testing Engineer will be. (During Installation & commissioning, Client will arrange necessary gate pass to our engineers & manpower's at Plant site.) (VPSA & Hydrogen compression, storage and dispenser Block) |
| 6 | **Power Block** | |
| | | Gas Engine |
| | | Producer Gas Generator |
| 7 | Utilities and Offsites | |
| | 1 | Oxygen System |
| | 2 | Nitrogen System |
| | 3 | Compressed Instrument Air |
| | 4 | Cooling Water System |
| | 5 | LP Steam System |
| | 6 | DM Plant |
| | 7 | Effluent Treatment Plant |
| 8 | Bulk Materials | |
| | 1 | Piping(Pipes & Fittings as per design pressure temperature & fluid ) |

| | | |
|---|---|---|
| | 2 | Electrical(Cable, Motor, MCC Pannal, Earthing system etc) |
| | 3 | Control & Instrumentation (Cable,Trasmitters,gauges,PLC System and etc) |
| | 4 | Mandatory Spares |
| 9 | Other Neccessary Req. | |
| | 1 | Buidling |
| 10 | Erection | |
| | 1 | Mechanical/ Electrical / Instrumentation/Equipment installation & Insulation and Painting |
| | 2 | Civil & Structural works |
| II | Indirect Cost | |
| 1 | Licensor Fee & BDEP | |
| 2 | Freight & Insurance | |
| 3 | EPC charges | |
| III | GST | |
| 1 | GST | |
| IV | Markup | |
| 1 | Escalation During Construction | |
| V | O&M for 2 Year | |
| 1 | OPEX for two year | |
| | 1 | O&M of Plant |
| | 2 | Supply of RDF and other inputs |