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Generation of Electricity Using Solid Waste in Chittagong Municipality

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ABSTRACT- *In this paper a new approach to the conversion of solid waste to electrical energy using Thermal Plasma Gasification method for Chittagong Municipality is proposed. Plasma power plant can utilize existing landfill contents as a feedback, thus cleaning up previously toxic sites and enabling them to be sold for other uses such as development. For those conscious of the need to cut their Carbon footprint, its contribution to the Environment is virtually nil. Analysis of the Plasma Gasification process has been shown to have a negative carbon footprint in comparison to other forms of energy generation, produce virtually zero emission and has the highest landfill diversion rate of any available technology. While Plasma technology has been in use for many years it has only recently developed as a waste management solution. This was partly because the conventional landfill approach was considerably less expensive, even with transportation costs and gate fees, and there was no regulated requirement for low-carbon energy. However, which increasing landfills diversion targets and renewable energy targets, the relative cost of the technology has been transformed.*

KEYWORDS: *Solid Waste Materials, Waste Sources, Energy Scenario, Conversion Technology, Conversion Efficiency. Plasma Gasification Waste to Energy Technology.*

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I. INTRODUCTION:

Bangladesh is one of the fastest developing countries with lots of opportunities due to its rich natural resources and human power. With the Government's vision of digital Bangladesh the usage of Electrical and Electronic equipment are increasing day by day. Not only that due to huge population in the capital City Chittagong the wastage is increasing day by day. According to various sources the current population of Chittagong city is around 14.7 million. The total amount of waste developed in Chittagong City per day is around 4,634.52 tons. The contributions of different sectors to the total generation of Chittagong Municipality, where nearly 76% of generated waste came from the residential sector, 22% came from the commercial sector, 1% from the institutional sector and rest from other sectors. The per capita waste generation rate is computed as 0.56 kg/capita/day. And it will increase more day by day. It is estimated that around 2030 the per capita waste will be around 0.78 kg per day. There are many ways to produce energy from waste. For example direct combustion, gasification, pyrolysis, composting, plasma arc, refused derived fuel etc. The feasible methods for Chittagong Municipality would composting that is Biogas.[1] As a part of developing the rural human being, the authorities have planned to electrify the whole country through the year 2020[2]. The intention of this plan might be achieved through quick, medium and longtime technology for growing the through power use of natural plant and additionally waste to electricity resources.

MSW Generation scenario in urban areas of Chittagong				
Year	Urban Population	% of Total Population	Waste Generation rate	Total Waste Generation (tons/day)
1991	20,872,204	20.15	0.49	9,873.5
2001	28,808,477	23.39	0.5	11,695
2004	32,765,152	25.08	0.5	16,382
2015	54,983,919	34.20	0.5	27,492
	78,440,000	40.00	0.6	47,064

Table 1: MSW Generation Scenario in Urban areas of Bangladesh [28]

Figure-1 (a): Waste Collection

Additionally, increases in our population and change in uptake patterns have influenced waste composition and generation rate. To assess the total waste generation and physical compositions, particle action, Bangladesh was engaged by Swiss contact. This value for waste work aims to improve the using solid waste situation at the source, in the logic of 3R (Reduce, Reuse, Recycle) for this purpose.

Separate collection takes places in an efficient and safe way. The value of waste needs precise baseline data on the physical composition of mixed waste discarded by household in Jamal Khan Ward. Before the households start segregating waste into the four categories which are organic compostable, inorganic recyclable, hazardous waste and remaining mixed waste. This will allow us to have precise and reliable knowledge about waste composition and to monitor whether households and building staffs are segregating the different materials. The green house gas emission potential from urban solid waste in Chittagong city is 1,548.09 ton/day and GHG emission potential million ton CO2e/year is (0.25).[3]

II. MATERIALS AND METHODS:

For this study, the waste generated area particularly Chittagong Municipality in Chittagong district was selected. This survey consists of practical field observation and field-based data collection of solid waste generation, collection, transportation of solid waste management situation through questionnaire and formal and non-formal interviews. The overall work to be done is described schematically by the flow chart is showing[4].

And waste materials were collected from each institution on 7 days (Friday to Thursday) for each month. The waste materials of a particular institution were collected and brought to the waste container of that institution on the specified day. The total waste from a particular institution was weighed and recorded. The target types of MSW were then segregated weighed and recorded. A similar procedure was followed for all institution of the study area on each day throughout the whole 6 month. During segregation, collected wastes from each bag were spread on clean plastic sheets and the wastes sorted by hand, following the methodology. The target of types of MSW was:

Paper= paper/book/printed materials
Pack= packaging materials
Can= can/jar/tin/metals
Plastic= plastic/polythene/rubber
Textile= textile/rags/jute
Glass= broken glass/ceramic

Vegetable= vegetable/food waste
Rock= rock/dirt/miscellaneous
Wood= wood/grass/leaves
Hazardous= hazardous medical substances [5]

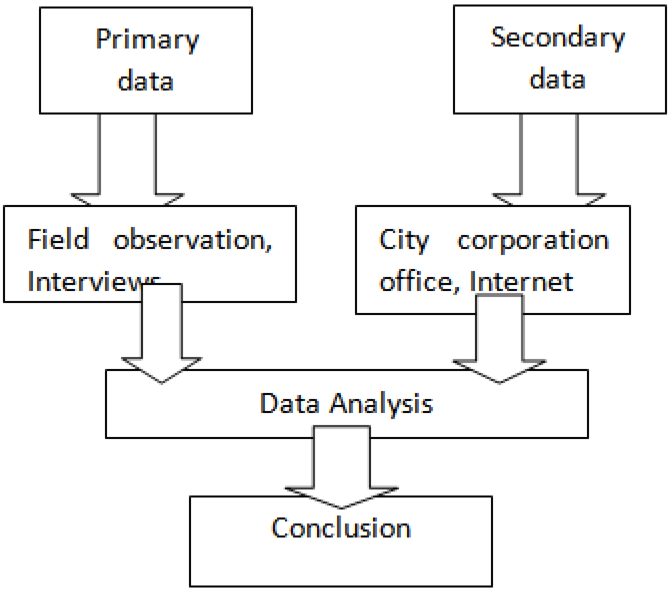


Chart of research methodology [4]

III. PROCESS DESCRIPTION:

The process developed by Natural State Research, Inc. (NSR) involves heating the plastic to form liquid slurry (thermal liquefaction in the range 370-420 °C), partial cooling of the slurry, distilling the slurry in the presence of a cracking catalyst, condensing the distillate to recover the liquid hydrocarbon fuel, and routing the remaining slurry residue back into fresh slurry to undergo another catalyzed distillation and condensation process. No additional chemicals are used in the thermal liquefaction phase, and a commercially available cracking catalyst is used in the distillation and condensation phases. The fuel is filtered using a commercial fuel filter (RCI fuel purifier) that operates using coalescence and centrifugal force.

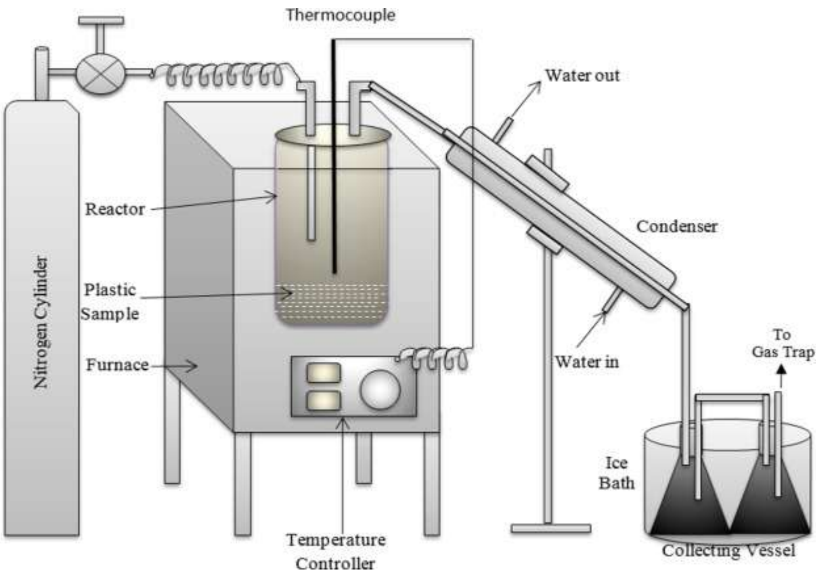


Figure- 2: Schematic diagram of the production of waste plastics to liquid fuel using the NSR direct process [6]

Small-scale conversion tests have been performed with the simplified direct process shown in Figure 1 using various types of waste plastics: polyethylene terephthalate (PET, code 1), high density polyethylene (HDPE, code 2), vinyl/polyvinyl chloride (PVC, code 3), low density polyethylene (LDPE, code 4), polypropylene (PP, code 5), polystyrene (PS, code 6), and other types (code 7). These plastic types were investigated singly and in combination with other plastic types. In the laboratory scale tests, the weight of a single batch of input plastic for the fuel production process ranges from 300 gm to 3 kg. The plastics are collected, optionally sorted, cleaned of contaminants, and cut into small pieces prior to the thermal liquefaction. It should be noted here that NSR process does not exclude the use of random mixtures of different plastic types; however, conversion processes with PET and PVC require further optimization.

NSR filtered fuel (1st distillation) went through the second distillation. The early 40% of the of the distillate (2nd distillation) was collected in the 1st collection flask which is termed as the ‘NSR double condensed fuel 1st collection’ or ‘NSR-1’ and the remaining and final 60% . The total process time for the production of the NSR double condensed fuels is cut by a factor of 2 by placing an intermediate collection flask (for single condensed NSR fuel) in series in the process setup. This new process setup is defined as the NSR modified process (not shown). The final collection flask is used to collect double distilled 1st and 2nd [6].

Generation of electricity from NSR fuel and commercial gasoline-87 was tested under similar conditions. For this experiment, a Jiang Dong gasoline generator was used with 1 liter of NSR Fuel and 1 liter of commercial gasoline-87 separately. The electrical energy output from the generator was monitored with an EML 2020 energy monitoring logger. Three electrical appliances (225-watt fan, 65-watt laptop, and 1500-watt heater) were connected in order to record the amount of electricity that was consumed by the appliances[6].

IV. RESULTS AND DISCUSSIONS:

4.1. Institutional Solid Waste (ISW) Generation:

The study area comprises a total of 72% institution under different categories Table 1 show the estimation of Solid waste generated by an average institution per day in the study area. The analysis of the 72 sample observations in the study area indicated that an average institution of Jamal Khan ward generated 10.42 kg of wastes per day. It also reveals that the rate of waste generation varies in the different institutional categories studied. From the study we were found the average ISW generation of Jamal khan ward is maximum 21.7 kg for the government office and minimum 4.04 kg for the privet institution Table 2 reveals that the institutional waste generation rate by a person in the study area 0.14 kg/day. The waste generation rate by a person was found to be 0.02 kg/day minimum by the educational institution and 0.32 kg/day maximum by the healthcare institution. The study area comprises a total of 72 institutions under different categories. Table 3 reveals that the institutional waste generation rate by each institutional category in the area was (maximum) 32% by the educational institution followed by 21.5% by the government institution and (minimum) 14.5% in privet institution. It also reveals that 604.43 kg of the solid waste was generated per day in the study area. However via Chittagong, Chittagong, Rajshahi, Khulna, Sylhet and Barisal was 0.56kg, 0.48 kg, 0.27 kg, 0.30 kg and 0.25 kg [7]

Table 2: Solid waste generated by an institution per day

Category of Institution	Number of IU* studied	IWGR** (kg/IU/day)
Education Institution	19	10.20
Health Institution	10	10.22
Religious Institution	15	5.96
Government Institution	06	21.70
Privet Institution	22	4.04
Total	72	10.42 (average)

* IU=Institution Unit, **IWGR=Institution Waste Generation Rate

Table 3: Solid waste generation per person per day

Category of Institution	Number of person studied	IWGR* (kg/person/day)
Education Institution	12,239	0.02
Health Institution	329	0.32
Religious Institution	3347	0.03
Government Institution	680	0.19
Privet Institution	547	0.16
Total	17,142	0.14 (Average)

*IWGR= Institutional Waste Generation Rate

Table 4: Total Institution Solid waste generation per day

Category of Institution	Waste generated by each category (kg/day)	Percentage (%)
Education Institution	193.75	32
Health Institution	102.15	17
Religious Institution	89.45	15
Government Institution	130.25	21.5
Privet Institution	88.83	14.5
Total	604.43	100

[5]

4.2. Physical composition of institutional solid waste

Composition of solid waste depends upon a number of facts such as food habits, cultural traditions, socioeconomic status and climatic condition [7] **Table no-4**_indicates the physical composition of Solid waste varying with different institutional categories. All of the ten different items of waste (via paper, packing, material, plastic, and textile, gas, vegetable, wood and hazardous) segregate during the study varied considerably among the institutional categories. Paper/Printed material was found the highest 57% in privet institution followed by 49% in government institution and lowest 3% in religious institution. Packing material was found height 13% in educational institution followed by 12% in religious institution and lowest 6% in privet institution. Plastic/polythene was found highest 24%in healthcare institution. Followed by 14% in Government institution and lowest 2% in religious institution. Vegetable/food waste found maximum 46% in religious institution followed by 33% in health care institution and 26% in educational institution and lowest 8% in government institution. Rock /dirt/miscellaneous was found maximum 27% religious institution and minimum healthcare institution. Medical hazardous waste was found 23% from the healthcare institution. Table no-4 also reveals that the physical composition of ISW where paper was maximum 27% followed by 25% of vegetables/food waste and broken glass/ceramic was minimum 1% hazardous medical waste was found 5% of total ISW but it should be consider as the most injuries and infectious part of institutional solid waste traits. [7] also found that food and vegetables were dominant 66.65% among all sorts of wastes in Bangladesh. Glass/ceramic 2% was recorded as highest in private institution and wood/glass/leaves were recorded as highest 11% in educational institution. The highest percentage of textile/rags/jute 4% was found both in religious and private institution table 4. The above discussion reveals that huge portion of the solid waste was recyclable in the study area. The recyclable portion of ISW includes paper, packaging materials, plastic and can. [7] Equal percentage 50% in each segment of ISW was recorded both from recyclable and non-recyclable waste **table no-4**. The amount of recyclable waste in institutional solid waste indicates the good potential for recycling of waste.[8]

Table 4: physical composition of ISW generated by different institutional categories. The waste of category (%) recyclable.

Categories of institution	Waste category (%)				
	Recyclable				
	Paper	Pack	Plastic	Can	Vegetables
Education	19	13	9	6	26
Healthcare	9	11	24	0	33
Religious	3	12	2	1	46
Government	49	7	14	0	8
Privet	57	6	7	1	12
Composition of ISW	27	10	11	2	25

Table 4 (Cont): physical composition of ISW generated by different institutional categories. The waste of category (%) Non-Recyclable.

Categories of institution	Waste category (%)				
	Non-Recyclable				
	Textile	Rock	Hazardous	Glass	Wood
Educational	2	14	0	0	11
Healthcare	0	0	23	0	0
Religious	4	27	0	1	4
Government	2	17	0	0	3
Privet	4	11	0	2	0
Composition of ISW	2	14	5	1	3

[5]

4.3. Quantity of recyclable and non-recyclable waste:

The quantity of recyclable and Non-Recyclable waste of ISW generated in Jamal Khan Ward is shown in **table no-5**. From the study we were found the average recyclable waste of MSW generation per institution maximum (15.19 kg/day) for government office and minimum (1.07kg/day) for religious institution and average non-recyclable waste of ISW generation per institution maximum (8.17 kg/day) for healthcare institution and minimum (1.17 kg/day) for private institution. Table also reveals that the recycling waste of ISW generation by a person in the study area maximum (0.134 kg/day) for religious institution and average non-recyclable waste of ISW generated by a person maximum (0.25 kg/day) for healthcare institution and minimum (0.008 kg/day) for educational institution.

Table 5: Quantity of recyclable and non-recyclable waste generated by different institutional categories.

Categories of institution	Recyclable		Non-Recyclable	
	Iu/day (kg/day)	Person/day (kg/day)	Iu/day (kg/day)	Person/day (kg/day)
Educational	4.79	0.007	5.41	0.008
Healthcare	2.04	0.06	8.17	0.25
Religious	1.07	0.005	4.89	0.02
Government	15.19	0.134	6.51	0.06
Privet	2.87	0.12	1.17	0.05

*in= institution unit [5]

V. WASTE MANAGEMENT TECHNIQUES:

Following are some general techniques of waste management.

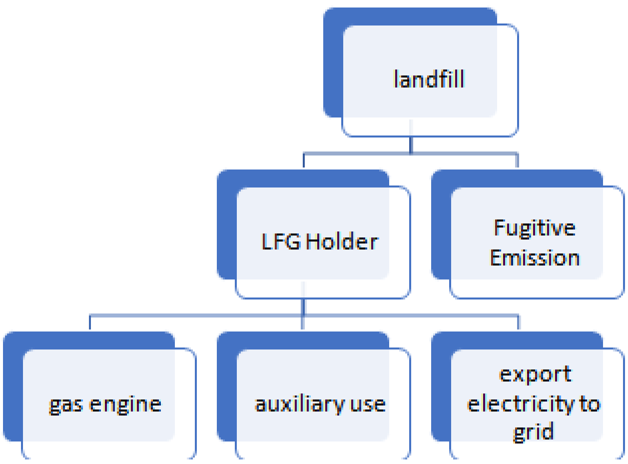
5.1 Incineration method of waste management:

Incineration as a disposal method involves burning the trash. Sometimes this is simply referred to as thermal treatment, as a general category of high temperature treatment of trash material. This method can be used to transform waste into heat, gas, steam and ash. One of the advantages of incineration is that with this method, refuse volume can be reduced by half or more and it requires little usage of land.

5.2 Sanitary landfills as waste disposal:

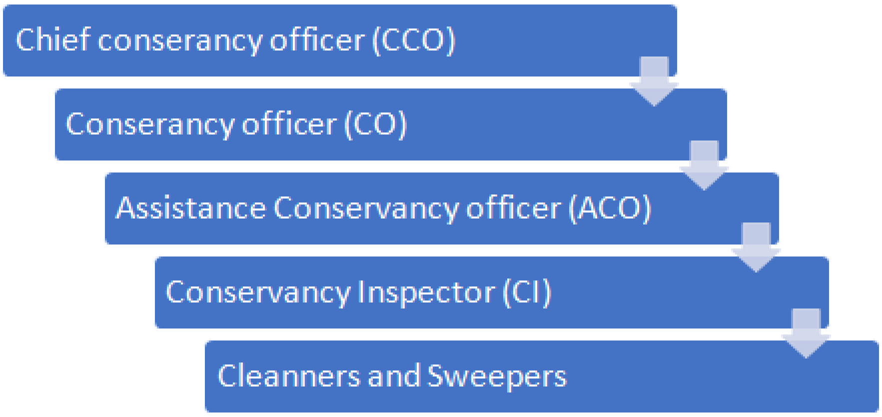
Landfill is probably the most practiced in more areas of the world than any other method. Landfills are often old and abandoned quarries and mining areas. Considered the most cost-effective way of waste disposal, about 75% of the cost of implementation is attributable to the collection and transportation of waste from residential and business to landfills. The waste is layered in thin spreads and then compacted, with a layer of clean earth covering the waste material before more layers are added over time. [9]

Landfill gas (LFG)) to electricity is a process that captures gas and utilizes to generate electricity in the gas engine generators in figure no 1[10]



VI. PRESENT MANAGEMENT PRACTICES:

Chittagong City Corporation have separate department for solid waste measurement. Solid waste management is organized and run by conservancy section, whose prime responsibility is maintenance of the sanitation system. The organizational structure of conservancy section is shown in below.



Organization structure of conservancy section of (CCC)

Waste generated at households is generally accumulated in small containers (often plastic buckets). This waste is not disposed of into community bin until sufficient quantity of waste is accumulated. Containers used for household storage of solid waste are of many shapes and sizes, and are fabricated from a variety of materials. The type of the container generally reflects the economic status of its user (i.e., the waste generator). Waste segregation at source is not practiced. The community storage system is the usually practiced in Bangladesh. Individuals deposit their waste in bins located at street corners at specific intervals. The containers generally are constructed of metal, concrete, or a combination of the two. Community storage may reduce the cost of waste collection, and can minimize problems associated with lack of onsite storage space. However, unless these community storage arrangements are conveniently located, partly as the result of scavenging of the wastes by rag-pickers and stray animals. In a country like Bangladesh, where cheap labor is available, the collection methods are labor intensive and cheaper compared to mechanized collection. Due to the absence of adequate storage capacity for the refuse generated and poor discipline among the generators, the wastes are continually dumped on the road. Existing solid waste management system of CCC is given next figure. [11]

VII. WASTE TO ELECTRICITY:

7.1.1. Waste to electricity overview:

Around 2500 WTE plants are active all over the world and the disposal capacity has been 300 million tons per year. Moreover, around 280 thermal plants with a capacity of almost 75 million annual tons were constructed between 2011 and 2015. Again, there are various ways of waste to energy conversion technologies and among more traditional approach is direct incineration of solid wastes. Considering that 70s [12]

Advanced thermo-chemical process which include physics gasification and plasma arc gasification are quits evolved and experimentally-

experimentally carried out to choose waste streams on a minimal extent in a particularly designed closed chamber with temperatures and pressures used to control the parameters. Moreover, every generation makes use of various kind of requirements for the input operating in particularly designed system configurations in special modes to generate extensive variable products on different particular scales. towards the WtE facilities. China has developed new CFB technology incineration method to burn waste to produce energy which is better than the old incineration method. There are currently 28 CFB power plants in china and there research for suitable waste to power plant energy is ongoing. Not only the WtE is beneficial for the environment but also economically beneficial for the countries. The global WtE market was valued at US$25.32 billion in 2013, a growth of 5.5% on the previous year. WtE technologies based on thermal energy conversion lead the market, and accounted for 88.2% of total market revenue in 2013. [13]

The sections stated below state the thermo-chemical transformation technologies for calorific waste treatment and a brief passage of situations mentioned in the table 3.1.

Incineration: Incineration is all about full oxidative combustion. Also similar process like coal combustion.

Gasification: Gasification is mainly partial oxidation

Pyrolysis: Pyrolysis is related to thermal degration of natural material in situations where oxygen isn't present.

Plasma are Gasification is a combination of the organic fraction and vitrification of the inorganic fraction of the waste feed and it is applicable to both pyrolysis and gasifition. About vitrification it can be said that it is responsible for impermeability of water.

Table 6: Reaction conditions and products from various thermos-chemical approaches (based on Kolb and Seifert).

	Pyrolysis	Gasification	Combustion	Plasma Treatment
Temperature [0*C]	250-900	500-1800	800-1450	1200-2000
Pressure bar	1	1-45	1	1
Atmosphere	Inert/Nitrogen	Gasification Agent: O2, H2O	Air	Gasification Agent: O2, H2O Plasma Agent: O2,N2,Ar
Stoichiometric Ratio	0	<1	<1	<1
Production from the process				
Gas phase	H2, CO, H2o, N2 hydrocarbon	H2, CO, CO2, CH4,H2O,N2	CO2, H2O, O2, N2	H2, CO, CO2, CH4,H2O,N2
Solid phase	Ash, Coke	Slag.Ash	Slag.Ash	Slag.Ash
Liquid phase	Pyrolysis/Water	N/A	N/A	N/A

7.1.1 Pyrolysis:

7.1.1.1 Records of Thermal Plasma Gasification system:

Gasification has turned out to be one of the first industrial thermo chemical methods. Towards the termination of the 19th century all through the industrialization of Europe gasification process was discovered, in general for producing oil and gas from coal, which consists of mostly carbon. Using gasifiers decreased for petroleum was now simply more available soon after WWII ended. Between mid 70s and 80s, using gasification for generating alternative fuels started out. Even today, this utility has been the biggest use of gasification. In the 80s, United States, Europe and Japan has centered at the improvement of gasification for the elimination of rock-hard wastes. Today, there are around 150 industrial gasifiers all over the world. Those are specifically used to deal with coal and biomass. Using gasification for MSW has been often implemented in Japan, in which their shortage of area compelled them to discover options to landfill. Additionally, Japan has the only business plasma are facility that treats municipal solid wastes, in Utashinai where Hitachi metals is one of the operators. The thermo-select is a procedure made by the Germans but due to few technical problems it was shut down later on. Siemens faced similar problems with waste gasification at their Furth plant which bought a critical twist of fate, ensuring in plug of waste shaped in the pyrolysis chamber which created an overpressure and get away of pyrolysis gas. Reputedly, this problem was the result of processing mattresses that aren't shredded at the problem instantly faded away in later versions of the gasifier. But Germany is not thinking about the use of it. Other than Germany, gasification is usually considered as a better opportunity compared to grate combustion because it isn't related to the old and polluting incinerators. Therefore, there may be a market for gasification in competition to grate combustion. Gasification is the breakdown of the natural a part of the waste into synthesis fuel or syngas, which is a combination of CO and H2, through carefully control and screen of the amount of oxygen gift. The important thing difference from combustion is that the overshoot will be useful, partly oxidized and the Sub-Stoichiometric quantity of oxidant permits preserving CO and H2 as very last products instead of the completely oxidized CO2 and H2O. [14]

7.1.1.2 An Introduction of Plasma Are Gasification Operation and basic concepts:

Plasma Arc gasification is an upgraded version of pyrolysis that requires high-temperature where the organics of waste solid are converted into syngas and organic materials and minerals of the waste solid yields a rock alike glass referred to as vitrified slag. The syngas is typically composed of H_2 and CO and it is not hydro-carbon product. The process containing a reactor with a plasma torch processing organics of waste solid is called plasma arc gasification. Commercially, the process is operated using using an infusion of a carbonaceous material like coil or similar materials made of coil into the gasification reactor. This material rapidly reacts with oxygen to create heat for the pyrolysis responses in an oxygen-insufficient surrounding. Equation (3.6) demonstrates the carbonaceous materials as C that can reacts with oxygen to create controlled burning yet with the sufficient warmth required for the syngas reactions (Equations [3.1, 3.2, 3.3, 3.4 and 3.5]). Likewise, steam is added to the plasma arc gasification reactor to advance syngas responses. The ignition responses (exothermic responses) supply warm with extra warmth from the plasma circular segment lights for the pyrolysis responses (endothermic responses), yielding a temperature normally within 4000*C and 7000*C. the inorganic minerals of the waste solid create rock-like offshoots.

Since working conditions are high these minerals are changed over into a vitrified slag regularly involving metals and silica glass. This vitrified slag is essentially non-filtering and surpasses Environmental Protection Agency scales, shortly, known as EPA scales. Metals can be recuperated from the slag can be utilized to deliver other offshoots, for example, shake fleece, floor tiles, rooftop tiles, protection and arranging pieces and beside that, vitrified slag, being naturally adequate as a recyclable result, is one of the more positive qualities of plasma arc gasification process for the administration of MSW contrasted with others. Another affirmative way of the gasification process is that advancement in the outline of the reactor/chamber have enhanced tremendously and diminished the requirement for pretreatment/ preprocessing. [15]

$C_nH_m + nH_2O \leftrightarrow nCO + (n+ 1/2m)\ H_2$; -205kj/mol (exothermic) 8.1
$C + 2H_2 \leftrightarrow CH_4$; +172kj/mol (endothermic) 8.2
$C + H_2O \leftrightarrow CO + H_2$; +131kj/mol (endothermic) 8.3
$C + O_2 \rightarrow CO_2$; -393kj/mol (exothermic) 8.4
$C + CO_2 \leftrightarrow 2CO$; -74kj/mol (exothermic) 8.5
$CO + H_2O \leftrightarrow CO_2 + H_2$; -41kj/mol (exothermic) 8.6

7.1.1.3 An example of pyrolysis which can be implemented in Bangladesh
Alter NRG (Westinghouse) Plasma Corporation:
The accompanying matter talks a about foundation of Alter NRG and the diverse phases of their task of plasma gasification and determination of the reactor.

7.1.1.3.1 Backround:
Westinghouse plasma Corporation’s Plasma innovation was created over a period more prior to 20 years and investing more then hundred million dollars in Westinghouse research and development financing. In 80’s decade, Westinghouse and the Electric Power Research Institute built up a reactor utilizing plasma for recovering divided pieces of metal. Moreover, Westinghouse expanded the plasma vault innovation for the treatment of unsafe- solid wastes including sullied landfill objects, PCB-defiled equipment transformers and capacitors and steel industries till late 1990.

A progression of tests were executed at the WPC plasma Centre in Madison utilizing an assortment of sustain materials and the different dampness substance.

WPC and Hitachi Metals have joined endeavors finished in the exhibition to the Japanese Government that the Yoshii WTE Institute was equipped for utilizing Plasma vitality to dependably and financially gasify remains for vitality generation. In September 2000, The Westinghouse Plasma gasgfier was conceived right after when the Japanese Waste Research Foundation granted a procedure confirmation of the innovation.

Full scale Office in Mihama-Mikata and Utashinai Japan were connected to the lessons lamed at Yoshii, which both started business task in 2002 and 2003 and keep working till now. In 2007 Westinghouse Plasma Corporation was procured by Alter. NRG different undertaking were embraced by the Organization to manage waste administration which were at first illustrated, enhanced and in the end popularized in various parts of over the world. That office treats unsafe wastes from less then 50 distinct enterprises.

Today air Products obtained a plasma gasification reactor from Westinghouse for air products thousand tons for every day plant to be worked in England [29]. The accompanying figure 3.3 denoted the business history of Plasma crop Technology.

As indicated by them the Plasma gasification process not Westinghouse power can likewise create Ethanol, Gas, Diesel fuel and is the best option accessible to fight shy of landfill. These provide many crucial features that include:

- Government are embracing this Plasma arrangement because of energy independence.
- Exclusive IP, specialized mechanism and dynamic licenses around the world.
- Pilot tests are performed over a hundred times on various feedstock at their reality class Plasma core with a normal of 48 tons for every limit.
- Scale-30 to 1000TPD for every gasifier [29]. They have designed quite a few product line of models depending upon demand and supports distinct market verticals described in the figure 4.

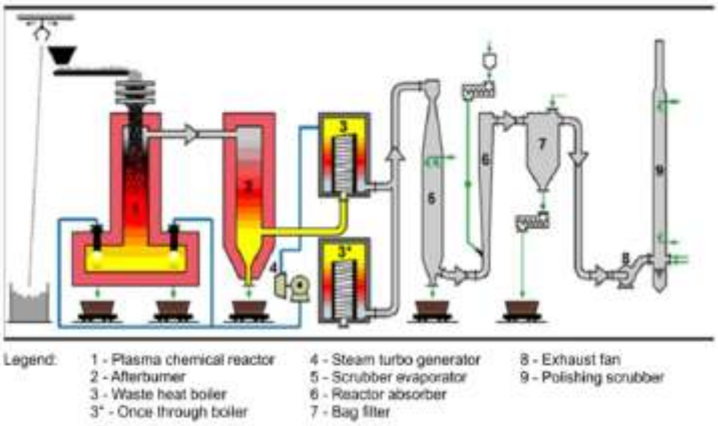


Figure- 4: Gasifier reactor models[16]

Point to be noted:
- Ground level to syngas exit flange. Ductwork height excluded as it is project specific.
- MSW calorific value (C.V) range -14 MJ/kg (4000-6000 Btu/lb) HHV basis.
- Hazardous waste (C.V) range -14.0-23.3 MJ/kg (6000-10,000 Btu/lb) HHV basis.

Point to be noted:

The real results from a WPC gasification space will rely upon the amount of particular feedstock being utilized and the real design of the plant. Gasifiers can be introduced in parallel to make a plant with the ability to suit any requirements. The above Table 3.5 records the amount of syngas, gross and net power age from various models.

7.1.1.3.2 Mechanism:

Inside the gasification chamber the unchanged plasma burn comprises of chilled water run through a pair of copper tubes. The working gas is infused through the little spaces between the terminals. Pressurized air through the electric bend will change over the air stream into a plasma crest which will be known as ionized gas with a temperature around 5800 ℃. These lights are utilized to make massive heat inside the gasifier. These lights help temperatures as

As well as they give critical capacities in devastating dangerous waste and verification of WTE slag.

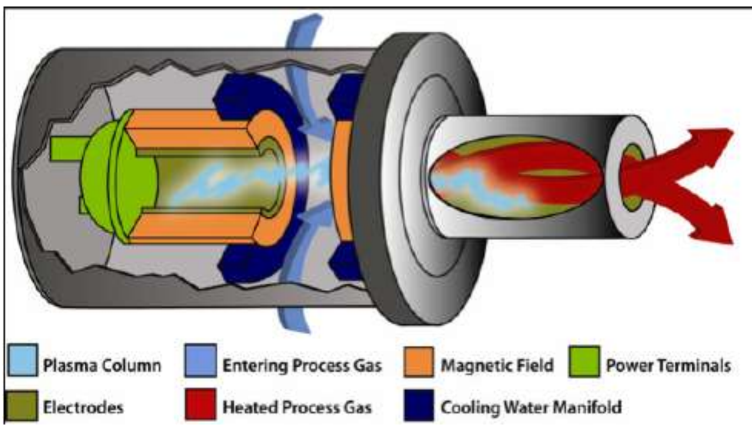


Figure- 5: WPC plasma torch [15]

WPC has built up a gasifier based on plasma where the plasma planes are situated at the base of the gasifier. Six plasma lights at their peak are utilized at the base to give adequate warmth to the gasification to occur. A streamlined chart demonstrating the internals of a plasma burn is being appeared in figure 3 that is stated above. Inside the dome a bed coke is made utilizing metallurgical coke (met coke) to assimilate and hold the warmth vitality from the plasma burns and give a "structure" that backings the MSW bolster as it slides through the gasification reactor and is changed over to gas and fluid slag, this activity is like the marvels happening in an impact heater. The met coke is sustained at the same time as the MSW and is vital for the activity of the gasifier. The real speed of the plasma fly leaving the lights is about Mach2, so we better put restriction towards the gas speed and permits appropriation of warmth equally. A decent basic trustworthiness has been earned by the met coke and can bolster the heaviness of the waste on its own. This procedure can deal with any dampness content in the MSW since it fades away alongside the syngas. The waste coming in ought to be around 10” in terms of dimension.WPC accommodates the gasification island, which incorporates the gasifier and the plasma burn framework and the rest units are accessible

Independently, The procedure is totally controlled by the observing of the temperature of the gases that come out eventually. The last ought to be between 982^{0}C to 1093^{0}C, keeping in mind the end goal to keep the tar arrangement and that little particles blend into those gases. Consequently, the keys for the procedure control are the plasma lights. Pretty much warmth will be included through them depending whether we need to turn up or down the syngas temperature. As the blend of waste and met coke is going down through the gasifier,

the waste will begin gasifying while the met coke will stay strong. The bed coke will gradually gasify yet will

stay at the base. The bed waste will lie over it. The main materials that will get away from the bed coke are the

slag and liquefied metals. They will be recovered toward the end. Metals are isolated from the slag through an extreme rapid method. After the procedure is unfaltering, lights are running consistently, and the power supply can be adjusted. Each power burn is alimented independently, subsequently one light can be closed down and adjusted without the need to close down the entire procedure. As it is conceivable to entirely evacuated one of the plasma burn while the framework is running, a few valves are particularly outlined with the goal that within vessel gases don't escape while this procedure. The gasifier is working at marginally negative strain to stay away from vaporous holes. The accompanying figure 4 gives a delineation of the diverse phases of working temperatures inside a gasifier chamber.

The vessel into which the plasma burn is embedded is really the exclusive plan of WPC appeared in figure 5, and it is the component permitting the great activity of the gasifier. Some air needs to circumvent the plasma burn since it is vital that the plasma stream does not touch the dividers, else they would liquefy [29].

Figure- 6: Internal structure and operating temperatures inside a gasifier [15]

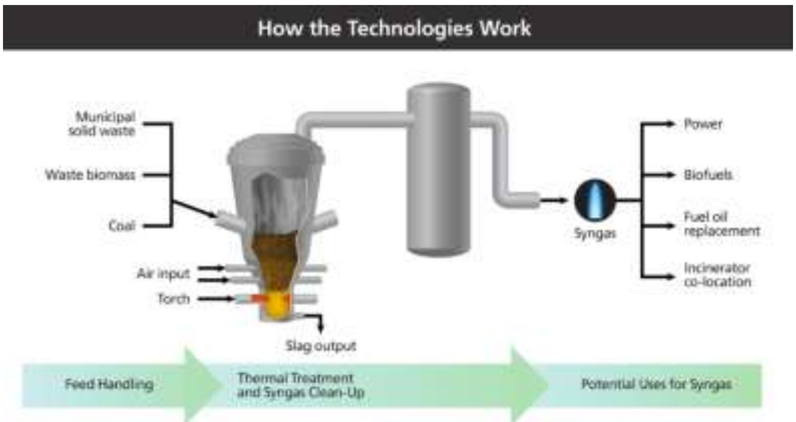


Figure- 7: Input & output of a typical gasifier [14]

Within the vessel is walled with recalcitrant which is a rigid material and can give some sort of insulation at the base. The width and stature are figured relying upon the residency time, the stream rates, satisfactory temperature, and warmth misfortunes.

The syngas will have, best case scenario 33% of the power substance of gas. Consequently, the turbine utilized must be perfect with a lower power gas or gaseous petrol must be added to influence it to work suitably. WPC right now has an organization with Solar Turbines to examine the utilization of their turbine that is good with the low vitality substance of the WPC syngas means can a shot at 100% syngas can be taken conveniently and the main reason for existing is to pitch to customers both the gasifier and the turbine of sun powered turbine at the same time. Nonetheless, if the customer rather includes petroleum gas, WPC will work with them to pick another mechanism. In this survey, an approach can be taken on the Integrated Plasma Gasification Combined Cycle, shortly known as IPGCC, where MSW is gasified with expanding metallurgical coke which needs to be 4% w/w to create syngas and followed by power production by means of a gas turbine. Met coke is added to the heterogeneous stream keeping in mind the end goal to raise the calorific estimation of the sustainability. This IPGCC configuration is a definitive objective of Alter NRG, alongside an entire sustain of MSW. The fundamental distinction between the traditional steam cycle and the consolidated cycle is the nearness of turbines that pack the syngas as opposed to combusting everything in a steam heater and in the end, combustion is undeniably worthier than the other process to recover more power.

The Air Product Tees Valley Renewable Energy Facility is a venture arranged as an IPGCC. Plasma gasification can be utilized to create syngas which can be molded and afterward changed over to a particular type of gasoline or energy through innovation stages like energy units and moreover, for those practical implementations, most of the plant, the segment which is devoted to preparing waste and making clean syngas, will be relatively comparative [29].

7.1.2 Conclusion:

Despite people who are concerned about waste to energy conversion and views plasma arc gasification as one of the traditional combustion processes, plasma arc gasification has the potential to convert the increasing quantity of waste into some serious quantity of energy that can help us to deal with our power outage problem and alleviation of unwanted waste as well. Burning fuel is not a healthy as well as beneficial way to ensure high temperature and pressure unlike plasma arc gasification. Utilizing a controlled air and creating a moderately minimum quantity of gas accelerates the gas cleaning mechanism. Besides, controlling the measure of heat contribution can tweak the structure of syngas and H-CO ratio according to the operator's convenience. [14] The process has been well received by many countries because of the viability but it is a matter of regret that the process is not economically beneficial due to the immense variation of the expense of post-waste management program, which is known as the treatment. In any case, unmistakably the reuse of vitrified slag and vitality generation from syngas will enhance the business practicality of this procedure, and there have been proceeded with progresses towards facilitate advancement. [17] The upcoming ten or twenty years should perceive how this process will develop. Hopefully the chance is good as many plants are being constructed and will be operational within a matter of time.

7.1.3 Anaerobic digestion:

Anaerobic digestion (AD) is a biological process of the break-down of organic matter by naturally occurring bacteria in the absence of air, and this produces biogas and a solid digestate. Biogas comprises of mostly methane and carbon dioxide with a small amount of hydrogen sulphide and hydrogen. Depending on the type of input material, the residual solid matter or dig estate can be a nutrient-rich bio-fertilizer [18] .According to a report by the Bangladesh Centre for Advance Studies [19], the 8.44 million households of Bangladesh have 22.29 million cattle and buffalo, and there are 116,000 poultry farms which produce 22,139 t of litter per day. Traditional use of dung and litter has a big impact on the environment and cultivable land in

Bangladesh because when it is dumped on low ground adjoining dwelling areas it causes them to be affected by smell, dust and surface water pollution [20] Bangladesh already has nearly 40,000 domestic biogas plants using cow dung or poultry litter, but the full potential has been estimated at 3 million plants [21]. The traditional use of biomass for cooking or the burning of renewably harvested fuel wood has often been assumed to be greenhouse gas neutral as eventually all the CO2 will be recycled and taken up by vegetation in the next growing season.

Bangladesh has a suitable climate for biogas production. The ideal temperature for biogas is around 35°C. The temperature in Bangladesh usually varies from 6°C to 40°C, but the internal temperature of a biogas digester in Bangladesh usually remains at 22°C to 30°C, which is very near to the optimum requirement [18]. Suitable raw feed stocks for biogas such as cow dung and poultry litter are easily and cheaply available throughout the country.

The potential for mass deployment of domestic AD plants is very promising. Government and micro-finance companies already support such schemes [22]. The use of AD could supply a much-needed energy resource for domestic consumption for cooking, as well as bio fertilizer to enrich the farm land [23-25].
It would also reduce deforestation by displacing wood fuel, and improve air quality in rural homes by avoiding contributions caused by incomplete combustion of solid fuels. These AD plants would be situated in rural farm areas where there is no realistic option for extending natural gas supply, on smallholdings where the energy would be directly used.

The common use of AD biogas in Bangladesh would also make a significant contribution to the reduction of greenhouse gases, which could provide some income via the Clean Development Mechanism (CDM). However, this approach would require appropriate calculation of baseline carbon emissions. The focus of this study is the determination of the potential energy contribution and energy patterns of small and medium AD systems in Bangladesh from common feed stocks and common scenarios.[22-26]

Figure- 8: Anaerobic Digestion Method to produce Electricity

7.1.4 Incineration method to produce energy:

Incineration is an alternate method of landfill of the waste. From incineration technique the combustion technique came in to produce energy. Such WtE plant burns the waste in control condition to generate steam that is used to run the turbine and generate electricity. Around 500MWh to 700MWh energy is generated by per ton of waste by MSW combusted[27]. The method is simple but the complication occurs while maintain and controlling the harmful materials, compounds produced. The below diagram is an example of a WtE mass burner.

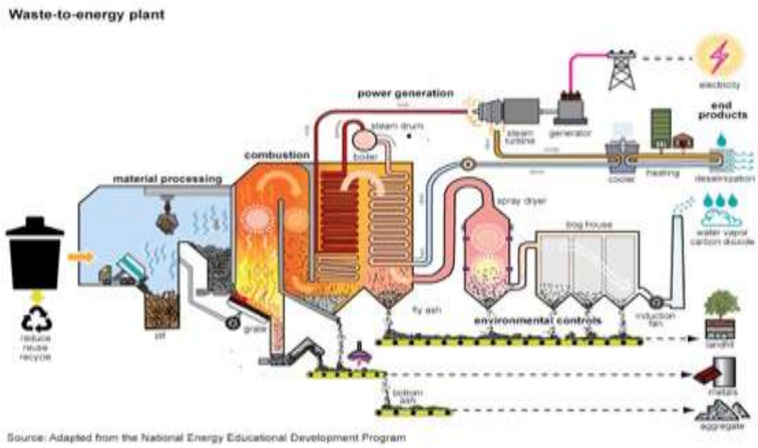


Figure- 9: Waste to Energy Plant Diagram

It works by burning waste that cannot be recycled. In the above figure it is shown that the trash is stored in a bunker and later it is burned and the steam is used to generate electricity and this electricity can be fed into the national grid or supplied to the local community and the flue gases are sent for treatment. And the ash produced from the burning of the waste is collected. The ashes can be used to for constructions. The plants can also produce high pressure hot water or steam that can be used by industry or domestic heating. These plants are highly efficient and are encouraged by UK Government policy [30].

The electricity produced by the mass burner can be used for the plan itself. More advanced technologies are being implemented to control the flue gases. In UK, Germany strict rules and regulations are followed and maintained for the combustion method. Not just that the combustion system provides heat service in many countries. 30% of Denmark's district heating comes from the 28WtE facilities[27]. The below image shows average emission of ten WtE facilities, it is said that WtE has lower carbon emission equivalent to landfill and coal.

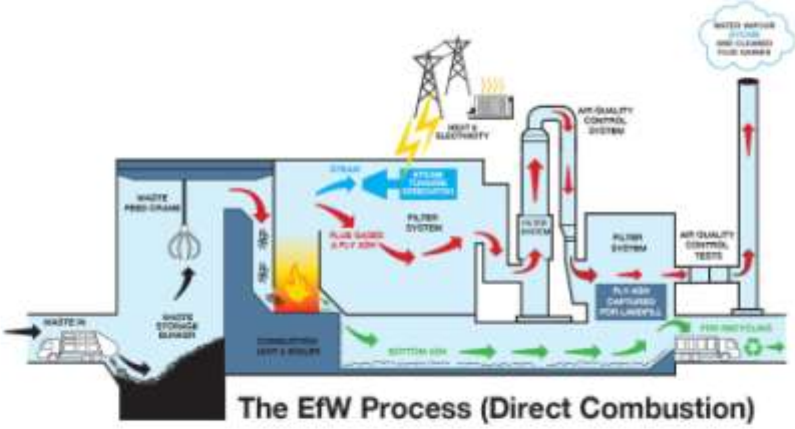


Figure- 10: Direct combustion Plant

VIII. CONCLUSION AND RECOMMENDATION:

Before talking about waste to energy conversion, the theme of waste to energy better be kept in mind as it will create the opportunity of improving the idea of waste to energy conversion which will be used for the betterment of the community right after. Managing wastes put a significant impact on the environment, usable lands as well as our health so it is a must to observe waste management as frequently as possible. There has been a crying need for the sanitary landfills in Bangladesh despite the boost in technological as well as economical fields for many years. Developing countries tend to dispose solid wastes in outside dumping fields and such fields need to handle gas present in the landfill hence environment pollution occurs with respect to the greenhouse gases which has been formed. It is estimated that the quantity of waste that will be produced will increase by .2 times on a yearly basis. Chittagong, the capital of Bangladesh alone produces around 7 kilo tons of solid waste, 4 kilo tons of construction and demolition waste on a daily basis. Such wastes need to be processed via taking to the dumping fields in this case both of the Chittagong. have acquired many ways to improve the situation of waste management for the betterment of the mass as the managed wastes will be used to generate power later on.

Speaking of waste to energy generation, thermal plasma gasification can be proven superior to landfill in a technological manner as it is undoubtedly way better considering energy production and as this process requires short area of land, less amount of greenhouse gases can emit. So there are possibilities for this process, just a bit more commercialization and investment of the enthusiasts are necessary.

The motto that the report is based on is to mark the plus points of waste to energy conversion in Bangladesh's aspect and with the increasing rate of gross domestic product of the country the waste is being generated in a neck to neck rate and so the government has come forward to fund the processes like anaerobic digestion and combustion as well despite many environmental threats. Considering that the processes are being made more and more environment friendly and this report has a firm contribution in that case for sure. Previously which used to end up in landfills are now being processed and used as source of energy, thanks to the invention and restless development of processes like combustion, anaerobic digestion and plasma arc gasification. Moreover, by selling electricity and by forming greenhouse reduction mechanism waste to energy has been a medium that has no competitors other than the solar solution in the power generation sector.

Waste to energy conversion processes need to be introduced in the competitive power generation field in a commercial manner by the advertisement of the practical success they are capable of bringing to the mass. Frequent research works are a must to figure out the unknown capabilities and possibilities that the processes can achieve. Statistics like waste sources that pollute the environment, price of the remains that can be recycled and quantity of waste that are being produced on both industrial and surface level consumerisms' bases need to be pointed out in order to draw the attention of the enthusiasts and well-wishers who are willing to fund. People who are unaware of such technologies need to be drawn attention so that more and more enthusiasts along with environmentalists can come forward and embrace the ideas to build a better future. Starting up open conversations among the researchers and the people who are keen to know the possible potentials of waste to energy conversion processes can surely reduce the gap of ignorance and increase the awareness in a natural manner, which will be proven helpful in terms of flourishing a legitimate clean development mechanism and it can be a helpful way to promote incineration mechanism as incineration is quite viable process for the investors to invest in.

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