

Analysis of Electricity from Munciple Solid Waste of Peshawar City by Utilized plasma Arc Gasification Technique

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Abstract—The utilization of the waste to energy technology was studied for Peshawar city, the data was compiled from the authentic data base of Municipal Corporation Peshawar. It includes the data from twelve different regions of Peshawar city. It is estimated that the flammable share of MSW of Peshawar city in tons will be 544.38 tons. Hence a power of 18.5 MW can be generated from MSW of Peshawar City by utilization of Plasma Arc Gasification Technique. It's suggested that 18.5MW Power Plant will generate electricity @ 9 ¢/ KWh which is less as compare to current national average rate.

Keywords— Municipal Solid waste Fueled Power Plant, Pakistan Power Crises, Waste to Energy, Electric Power Generation.

I. INTRODUCTION

Imagine a process in which we convert the inorganic components of the municipal solid waste in architectural tiles and construction bricks, at the same time we convert all the organic contents of the waste into synthesis gas, that is actually a mixture of hydrogen and carbon mono oxide ($H_2 + CO$), almost a green fuel and in addition we generate electrical power. furthermore, Showing Power generation (Energy mix) of Pakistan in year 2014[3] in summer minimum 3340 and max 6902 ,could we have a system that doesn't generate ashes, and doesn't pollute the air, the water nor the soil, as incineration does? The answer is yes. The first wind turbine was designed and built in 1888 by Charles brush generated a peak power of 12 KW [11] but so it is not better.

The plasma torches that operate at very high temperatures (between 5,000°C and 100,000°C) can process all kinds of waste: municipal solid, toxic, medical, biohazard, industrial and nuclear waste at atmospheric pressure. The inorganic waste is vitrified effectively, in solid-like glass materials that are used to manufacture aggregates for the construction industry (Magmafication process) and the organic materials that includes plastics, paper, oil, bio-materials, etc. are converted into Syngas with caloric value, fuel that is used on the Heavy-duty advanced gas turbines for the generation of electrical power (Gasification process). No ashes are produced because at more than 5,000°C, all the Organic Molecules Are Disintegrated And Only The Mix Of $H_2 + CO$ Remains At High Temperature The per capita

electricity availability is 43W, which is 1/7th of the world average [6].This Paper Is Going To Describe The Emerging Waste-To-Energy (Wtssse) Technology, Called Plasma Gasification. The Technology Will Be Described And Compared To Incineration And Gasification. A Model Will Be Employed To Compare The Energy Content Of The Resulting Gas Products From The Plasma Gasification Process For Various Types Of Waste Feedstock. Plasma Gasification Has Many Advantages And Some Disadvantages Compared To Other Wte Methods Which Will Be Described. Depending On The Objective Of Developing A Particular Wte Plant, The Plasma Gasification Technology Advantages Could Outweigh The Disadvantages The burden on the economy of Pakistan due to heavy oil imports can be revealed from the fact that 40% of the total imports in 2011 were consist of oil with overall trade deficit of 14% [6].

A. Contents of Municipal Waste

Municipal Solid Waste (MSW) is garbage or trash waste which consists of day to day used or discarded item by the public. The main composite of MSW includes our daily life refuses house holes such as fruits refuses, vegetable refuses, remaining of tree trimming. The major types of MSW are Recyclable waste, inert waste and Bio degradable waste. Recyclable waste contain cloths, paper, pin cans, glass bottles and certain plastic etc. Inert waste is type of waste which consists of demolition sites, dirt, rocks, and debris from construction. Bio degradable generally includes the waste of kitchen (vegetable and fruits). The main things among all the conversion technologies are the burring of MSW to generate steam or heat which is then converted to generate power.

B. Technologies used to process Wastes

The four common techniques used for MSW are Pyrolysis, Conventional gasification,

II. PLASMA GASIFICATION AND INCINERATION OR CONVENTIONAL MASS-BURN INCINERATION

A. Pyrolysis

This process involves thermal decomposition of organic substances in the absence of atmosphere or oxygen. This technique is an endothermic process. The organic wastes are

placed in sealed air tight drums known as pyrolysis chamber. If one tone of MSW is used by this process, an average of 571KWH power can be generated.

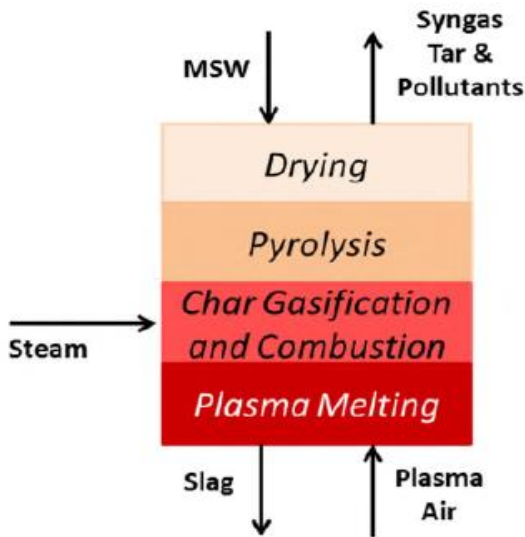


Figure.1

III. INCINERATION OR CONVENTIONAL MASS-BURN INCINERATION

Incineration or mass burn is a technique of the burning of municipal solid waste in the presence of oxygen or air, the technique is known as Incineration. The average power generation in incineration conversion technique is 544KWHper ton ,The end products from the process of conventional methane CH4 and predominantly gases Hydrogen H2 and CO[1] Municipal solid waste in limited availability of oxygen or air. In conventional gasification process one ton of municipal solid waste can produce an average of 685KWh of power.

Plasma gasification: Plasma arc gasification is a conversion technology. It produces electricity from organic compound in which hot ionized gas is used to decompose the organic compound. The main advantage of this technology is to decrease the harmful effects of ash from the incinerator. In this technique the amount of power generated is 816KWH per ton which is the highest among all conversion technologies of MSW. Slag is produce as by-product and can be used in construction of road or other material like flower tiles, roof tiles and insulating material.



Fig No 2: Plasma arc gasification.

B. Municipal Solid Waste Collection in Peshawar

The waste collected by Municipal Corporation can be estimated by the schedule of MSW collection facility computation and capability. The waste collection from Peshawar city is collected by municipal corporation Peshawar. The waste is mainly collected from the old city area of Peshawar. The Cantt board of Peshawar collected MSW from cantonment region. MSW amount is approximately 1331 tons per day. MSW generated by each person can be calculated as

$$MSW = \frac{1331\text{tons}}{3.5\text{millions}} = \frac{0.38Kg}{\text{person per day}}$$

Pakistan is 6th most populated country in the world, with population of around 190 million and is 2.56 % of world total population. However, our energy consumption standing is 37th in the world which is about 0.37 % of worlds total energy consumption. Energy available to per person is 43 watt that is 0.14 times the average utilization of per person in the world.[6] The sun radiates light energy like photons which rush toward the earth with a speed of 670 million miles per hour and reaches to the earth in approximately eight minutes [14]. Photovoltaic material such as silicon absorbs light photons and increases the kinetic energy of the electrons of its own and transfers them into higher energy levels within the material and some of them to conduction band to produce electricity. According to Pakistan Electric Power Company PEPCO, in April 2011, the shortfall in power generation across the country reached up to 5000MW, with demand standing at 14,475MW and supply at 9465 MW[7] In order to increase the portion of hydel energy in energy mix of Pakistan some of medium and small hydel power projects are under construction amongst which the most effective will be Neelum Jehlum Hydro power plant having a capacity of 969 MW and will be available in system till 2016 [13].

Methodology:

Pyrolysis and conventional gasification are less effective than mass burn is low generation. Plasma Arc Gasification is a conversion technology to produce electricity from organic compound in which hot ionized gas is used to decompose the organic compound to generate power. The main advantage of this technology is to decrease the harmful effects of ash from the incinerator. In this process the temperature of the air is kept up to 7000F. The heat is provided using AC or DC electric discharge in Plasma Arc gasification chamber Waste incineration to generate power[19] and new technologies such as Plasma Arc Gasification [5]. Generation of electricity from Waste. The inorganic material is converted into melted form and is later on converted into glassy material which is non-harmful by cooling process. Conventional Gasification and pyrolysis has less efficiency then other two conversion techniques [5] due to slow and sensitive conversion process and hence not desirable. In Arc Plasma gasification technique air is controlled in the chamber. It has better results as compared to conventional mass burn that is 816 KWh/ton with the cost of approximately 9 to 10 C/ KWh which is comparatively less than our national average cost of 14 cents per KWh. Slag produce from Plasma Arc gasification technique is much less harmful as compare to others. It can be

used as insulating material, road construction and making of industry tiles and has almost costs 15\$/ ton [1, 2]. The operational complexities and high capital cost are the hurdles to this technique but with the ongoing research in this field is overcoming these complexities. The cost of power generation through direct incinerations is approximately 5C/ KWh [15] which is comparatively less than other conversion techniques but the main disadvantage of this conversion technique is the harmful effects of hazardous gases produced through this process, less power generation and less power generation per unit mass of MSW as 544KWH. While in plasma arc

gasification process less harmful gases are produced and the unit power generation through this process is much greater than other conversion techniques which is 816KWH/ton and its cost is 9 - 10 C/ KWh which is comparatively less than our national average cost of electricity 14C/ KWh[8]. As there is electricity crisis in Pakistan that's why plasma Arc Gasification technique is most suitable due to its high power generation in future for Peshawar city. Diagram Plasma arc gasification process.

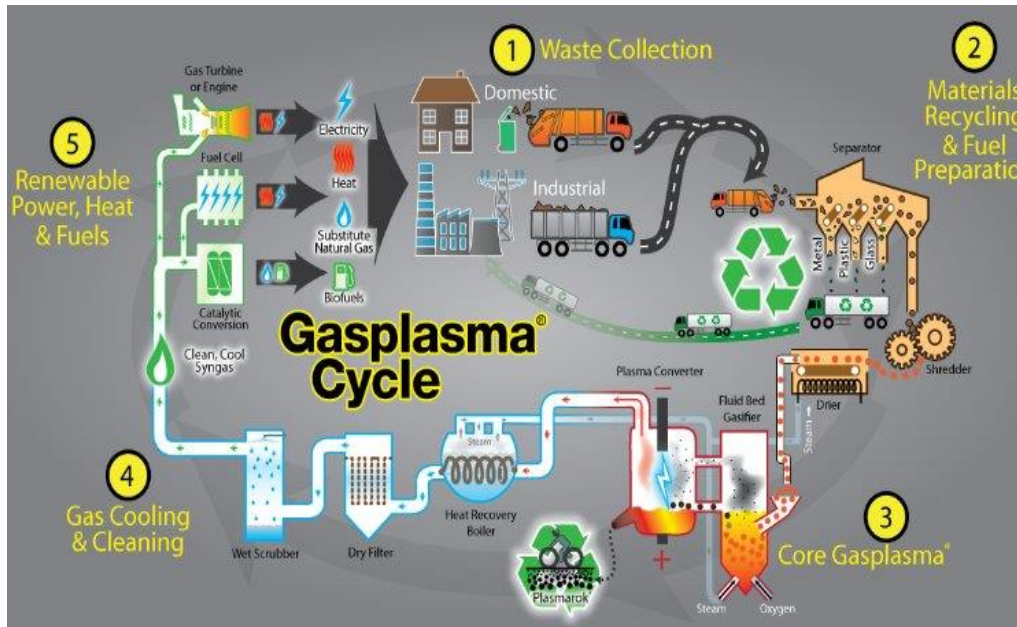


Fig no5:Gas Plasma Cycle

Average msw collected by city Municipal Corporation per day:

TABLE NO1: TOTAL MSW OF PESHAWAR CITY/DAY

vehicle	Number of vehicles	no of trips	waste carrying capacity of each in ton	total in ton
container	130	1	5	650
trucks	24	2	4	192

tractor trolley	30	3	3.5	315
mini tractor trolley	15	3	2	90
pick ups	28	3	1	84
total				1331

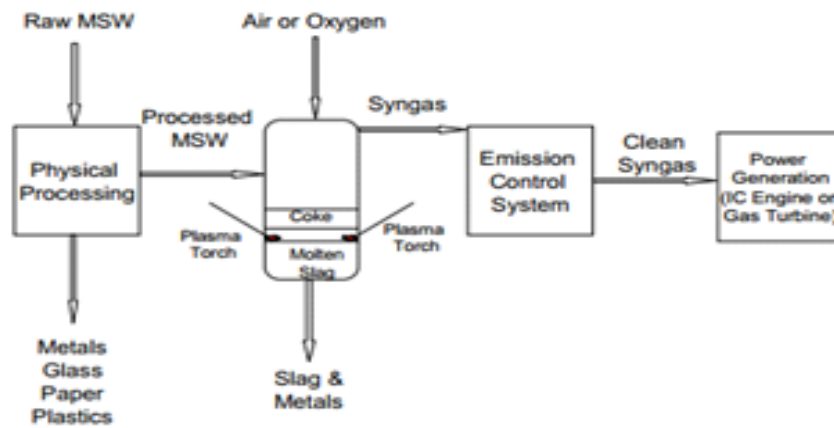


Fig: No3 Plasma Arc gasification chamber

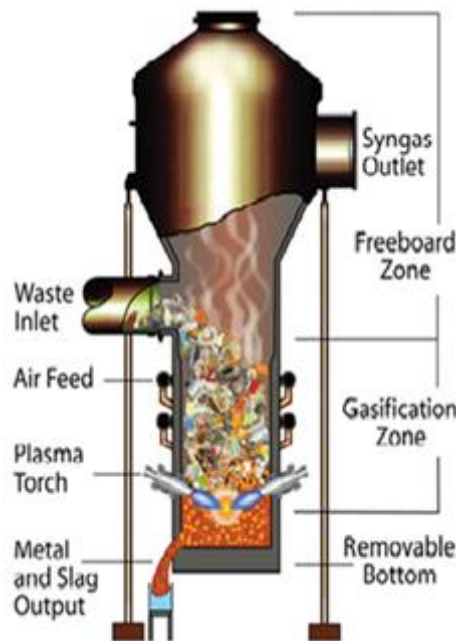


Fig no4: The inside 3D view of Plasma Arc gasification chamber

The Composition of MSW of Peshawar City.

MSW is combination of paper products, textiles products, plastics, cardboard materials wood fragments and Food wastes such as vegetables and fruits. Paper products and plastics can be recycled to manufacture new products but all of them cannot be

separated from one another. The percentage arrangement MSW is described in the figure.

The below figures present the percentage composition of MSW of Peshawar city :

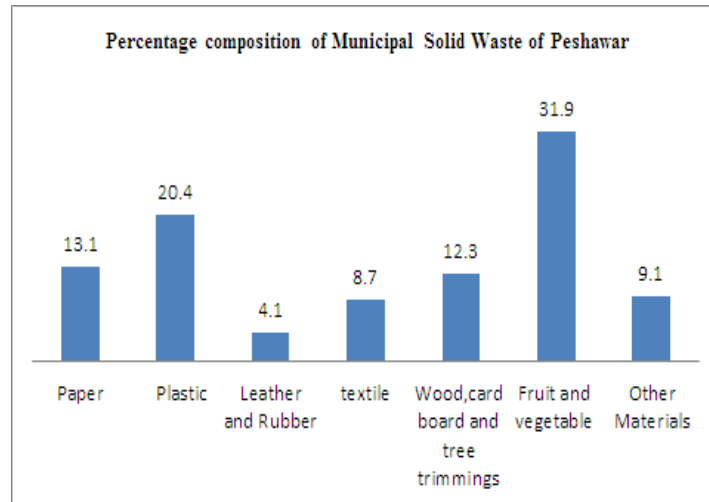


Fig no5 : Percentage Composition Of Municipal Solid waste

The The analyses of composition of the waste sample are collected from 12 different locations of Peshawar city and the composition in percentage is shown above. The result

Shows that main components of MSW are vegetable and fruit wastes which share about 31.9% of total waste. The second component of MSW is plastic which about 20.4% of the total waste is,. The third component of MSW is paper product which has calorific value of 1677.6KJ/kg. The other component of MSW are dry grass, card board, tree trimming and practical of wood which has calorific value of 19305.8KJ/kg which consist 12.3%of the waste of Peshawar city. The non-flammable materials of MSW are metal, clay and ceramics which is 9.1% of the total waste of Peshawar. The below figures present the percentage composition of MSW of Peshawar city. Power generation capacity of different MSW Conversion Technologies [4] Mass burn (Incineration) 544 kWh/ton MSW, Pyrolysis 571 kWh/ton MSW, Conventional Gasification685 kWh/ton MSW, Plasma Arc Gasification 816 kWh/ton MSW the some different other source is also used for power generation tidal energy .

Turbines are used in water passages to convert the potential energy of difference in water levels into the kinetic energy and then to rotational energy to generate power. The openings are designed with specific gates which allow large flow of water with modest differential head [16] Bio-energy is a form of renewable energy derived from materials of biological sources Since 1990 world energy supplies growth is recorded as 1.4 % and the growing contribution of renewable sources is 1.7%. 10.4 % of world total energy is contributed by Bio mass and new renewable sources such as Wind, Solar and tidal contributes only 1 % of total energies. In Sweden biomass provides 16% of total energy produced, in Brazil 27% and in Finland 19% [17]. Bio energy sources are made up of mainly forests, agricultural, and wastes A 23 MW of Tracy in California a plant uses wood straws as a fuel and generated 138,139 MWh in 2010 only by running at an average capacity of 69MW[18].

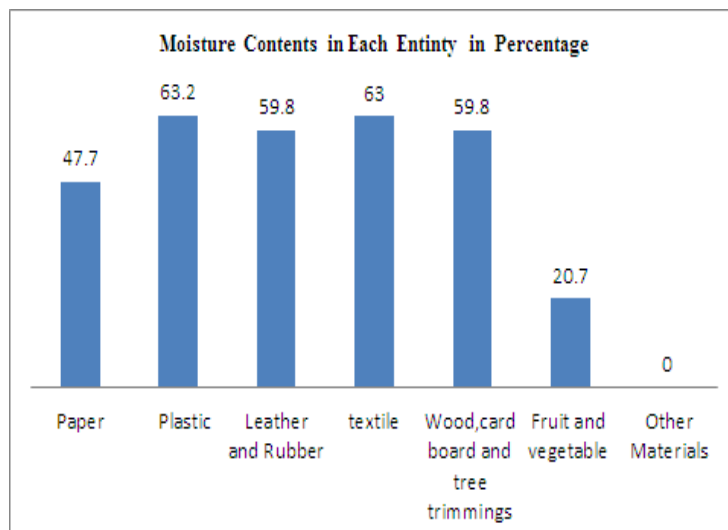


Fig no6: Moisture Contents in Each Entity in Percentage

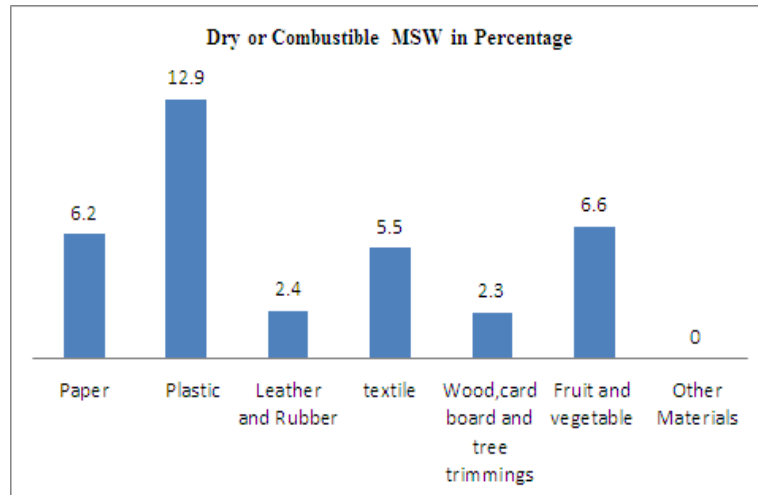


Fig no 7: Dry or Combustible MSW in Percentage

The Heat Generating Estimation: Each component is have a heating value, the below table is showing the heating value of different compound of MSW in BTU/Lb and KJ/Kg [20]. Each component of municipal solid waste have a specific value of water contents. The demographics condition and climate have a deep effect on the moisture intensity in waste. The analysis of MSW shows that dry waste is 40.9% [20] of the total MSW.

The capacity of MSW power plant and its estimation:

The combustible or dry part of Municipal Solid Waste in percent is given as 40.9 % In above Fig

The combustible share of MSW of Peshawar city in tons will be = 544.38 tons

The share of combustible MSW of Peshawar city in tons will be = 544.38 Tons

Converting the value of 9841.1KJ/Kg into MJ/ton

9841.1 MJ/ton

And also 1 joule = 0.000277 Wh So 9841.1MJ/ton can produce 2.7336 MWh/ton

Considering 20 % thermal efficiency [19], the energy generated in KJ per ton will be

$2.7336 \times 0.2 \text{ MWh} = 544 \text{ KWh}$

The equation in fig shows the results much closer to the standard values as mentioned in the above fig Now by taking the value of combustible MSW of Peshawar city as 544.38 and the standard value of 816 KWh/ton through Plasma arc gasification.

$816 \text{ KWh/ton} \times 544.38 \text{ tons} = 444214 \text{ KWh/ day}$
 So $=[444214 \text{ KWh}/24 = 18508.9 \text{ KW}]=18.5 \text{ MW}$

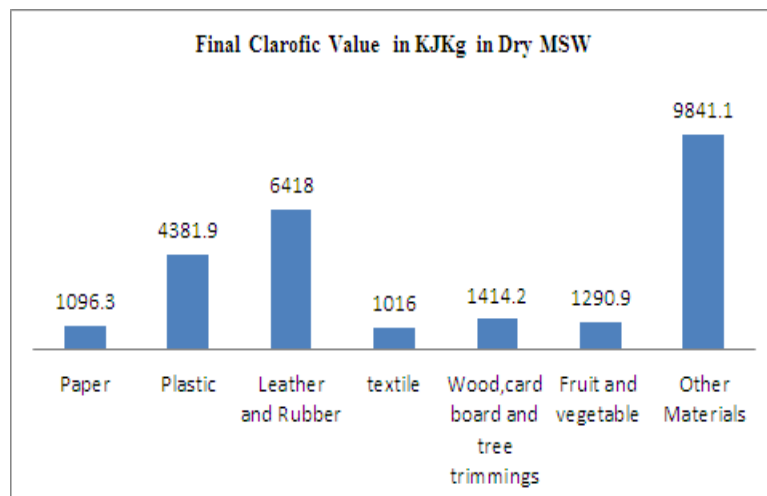


Fig no 8: Final Clarific Value in KJKg in Dry MSW

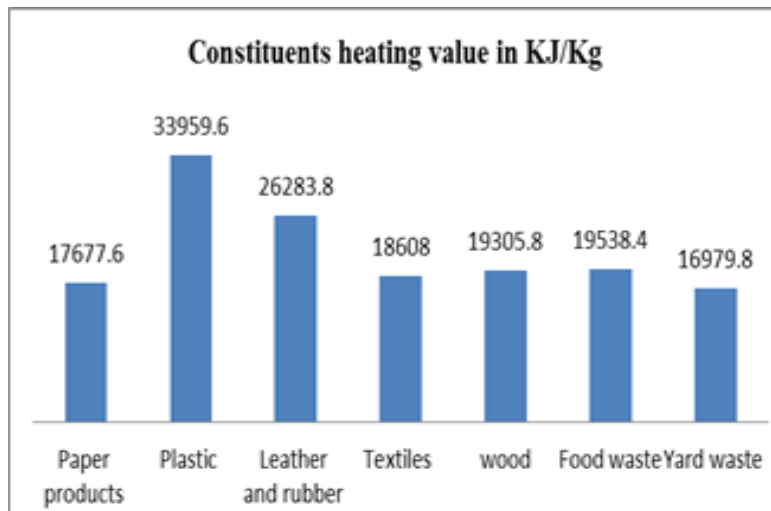


Fig no 9: constant heating value:

Cost Estimation of Proposed MSW Thermal power plant:

From literature survey cost of the proposed scheme is calculated, which is expected to be affected as per change in era.

S.No.	Equipment	Cost (Rs)	References
	Total Cost	214,065,927.50	

TABLE NO2 : COST ESTIMATION OF PROPOSED MSW THERMAL POWER PLANT

S.No.	Equipment	Cost (Rs)	References
1	Steam boiler	76,132,335.1	[37]
2	Steam turbine and generator	3,501,170.7	
3	Feed pumps	35,000.0	
4	Cond. extraction pump	9000.0	
5	Condenser	17,306,123.8	
6	Civil works	57,418,809.8	
7	Electrical works	59,663,488.1	

FUTURE WORK:

The proposed scheme may be extended to get further improvements. Some of the changes are suggested as follow

1. Liquid Waste Utilization in the proposed scheme.
2. Analysis of environmental effect of this plant.
3. How to Improve Power Generation of this scheme.

Other Techniques in addition to the existing with plasma Arc technique.

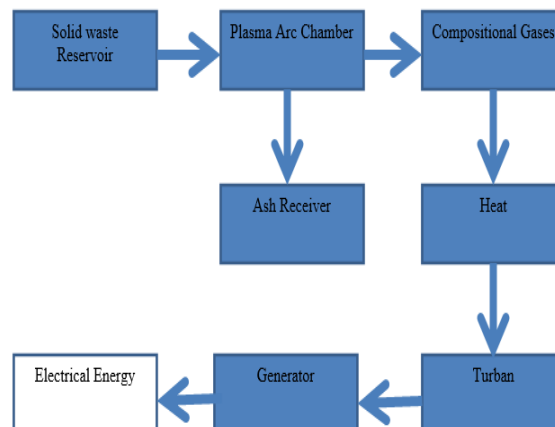


Fig no. 10 Block Diagram of Generalized power plant is suggested for the [1]

proposed scheme, which is Shown in the following figure

THE "LOCATION" OF POWER PLANT

The location for power plant mainly depends upon certain constants such as supply of MSW, distance from power station, Fuel supply of Municipal Solid Waste etc. in below drawing location of power plant selected near Badaber because of fast dumping point in which is 7KM away. Second dumping point is shown 06 kilometer away from power plant. The second dumping points 6KM away from the power hub of the city. The site of plant is 15KM away from the center of city. Currently Two locations have design by MCP, Which have a vast land and

can be used as dumping station of MSW. The first dumping point is shown in fig 1 and the waste of whole city to and its surrounding areas can use it for dumping. The first dumping point is marked On ring road abrader Kalley .The second dumping point is marked on ring road near Shahid Abad shown in fig 4.1. Sheikh Mohammad grid station of 500KV is power control transmission of Peshawar city and its surrounding, which is 20KM away from city center. The collecting and delivering the waste to the site of power plant [9]by optimal rotating technique can be useful and effective by using real genetic algorithm.

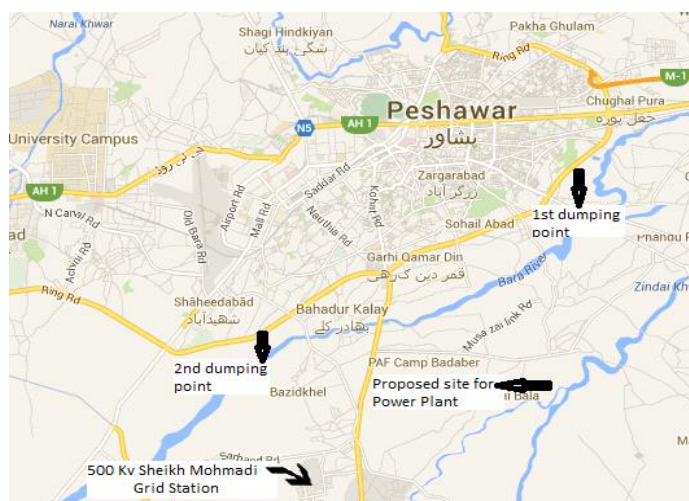


Fig No 10 (Map of Peshawar city showing proposed site of power plant, existing first dumping point, second dumping point and 500 KV Grid Station) [10]

CONCLUSION

In this research work the feasibility analysis of Municipal Solid Waste fueled power plant has been carried out. The estimation of MSW of Peshawar city has been carried out; the ability of generation of power plant is 18.5MW. The power dilemma of our country is higher cost of per unit of electricity due to more dependence on oil based power plants. Plasma Arc Gasification is having better results as compared to conventional mass burn i.e. 816 KWh/ton with the cost of approximately 9 - 10 C/ KWh which is comparatively less than our national average cost of 14 cents per KWh. Slag produce from Plasma arc gasification technique is much less harmful as compare to others, it can be used insulating material, road construction and making of industry tiles and has almost costs 15\$/ ton. The operational complexities and high capital cost are the hurdles to this technique but with the ongoing research in this field is overcoming these complexities.

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