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A Proposed Indigenous Municipal Waste Based RE Generation Plant Design for South Asian Coastal Mega Cities

Sabir Ali Kalhoro, Dr. Ghous Bakhsh,
NED University of Engineering & Technology
Corresponding author e-mail: sabir13es66@gmail.com

Abstract: The urbanisation in developing countries has resulted in growth of big cities. There are emerging engineering challenges inviting out of box solutions. The paper proposes the Indigenous solution to municipal waste in Karachi, Pakistan. The model proposed here can be replicated in any of the coastal cities with climate conditions and waste types resembling that of Karachi.

Keywords: Municipal Waste-to-Energy; Energy**;** Electricity;

1. Introduction

Waste holds an adequate amount of energy to serve as a viable renewable energy source. Moreover, it is poised to create healthy revenue and handsome economy for country as waste mayserve as energy, wealth and gold. We are converting our waste into wealth. By transforming it into useful resource, Sindh solid waste management board (SSWMB) estimates that Karachi will generate 16,000 tons of garbage daily by 2020. Currently, Karachi metropolis produces approximately 12,000 tons of garbage every day. Through proper management of the solid waste, the existing huge garbage may well be converted into an efficient source of income as well as energy generation [1]. By doing so, Karachi may be relatively safe, disease free and environmentally clean city. Solid waste management in metropolis has emerged as a 21st century challenge. The Solid waste is increasing problem day by day. It is creating environmental hazards and social problems due to increase in waste, health Issues and lack of management [2]. So it is high time to convert this problem in to a viable mechanism coupled with the solution by applying the instruments of proper management for the solid waste. The Solid waste ejection is the most

common problem in third world countries [3]. The municipal solid waste management has completely failed to overcome these waste issues leading to insufficient collection and inappropriate disposal [4]. The existing solutions advocate the waste disposable through dumping underneath, ocean dumping and incinerations of some sort. Unfortunately, these all are not long term solutions. These way will generate global environmental issues, hazardous issues, generation of dirty gases issues [5] and harmful for all living things either in ocean living things or earth living things. Solid waste shall create the excessive waste water, the land and air pollutions that are harmful for human health and environment [6]. Therefore, it is high time to overcome these issues through proper management of solid waste by applying ways of "waste to energy" [7].
We have different types of wastes such as bio-degradable, non-bio degradable, e-waste, industrial waste, nuclear waste, organic waste, paper/card waste ceramics, tins [8], metal waste and glass waste. These all types of waste need to be recycled and converted into energy by adding some appropriate management rule [9].

1.1 Existing Condition of Waste Management in Karachi

Solid waste management is one of the major concerns to the environmentalists as it is creating many problems to life [10]. This is true to the urban areas where population as well as waste is rapidly increasing [11]. Sindh Solid Waste Management Board (SSWMB) opines that every year the Karachi waste is increasing at the rate of 2% as compared with the previous year. So it will require proper management otherwise this city will be converted into garbage [12]. Karachi sanitation mechanism and SSWMB has totally failed to accommodate such huge garbage. Last year, SSWMB have signed an agreement with Hangzhor Jinjiang Group Environment sanitation service Company, China covering two districts of Karachi, namely south and east districts for the span of seven years. The expenditure to dispose the waste requires an amount of Rs.2 billion and huge staff who collect the garbage from door to door [13]. They have to handle it by proper management. Unfortunately, SSWMB has failed to convince the company. Karachi is generating unstoppable garbage. Due to unappropriated management, 60-70% is collected from the available waste. Out of all the collected waste, only 25 % of the garbage is dumped at **Surjani Town, Jam Chakhro** and **Deh Gondal Pass** near **Northern Bypass.** These two landfill sites are unable to fill the requirement gap that's why government approve another third landfill site most probable **Dhabeji**. That manages different sources of waste generated in Karachi Metropolis [14].
Karachi has been divided in to the eighteen towns with eleven landfill sites. The identified landfill sites are Jam Chakro, Gond Pass, Saba Cinema (North Karachi), Korangi 5, Lalabad (Landhi), Korangi 3.5 (Ibrahim Haidry Police Station) and Korangi 1.5 by one hundred quarters. Whereas the main waste dumps are categories as 1600 tons/day at Gondal Pass and 1200 tons/day at Jam Chakro. Moreover, the Sindh Solid Waste Management Board (SSWMB) has sanctioned the lands of Karachi Development Authority (KDA) to develop the Garbage Transfer Station (GTS). However, building the GTS in all District of the Karachi is probably going to prove the easily collection from the every town [15]. The location wise GTS in the Karachi metropolis is

1. Korangi Causeway Malir River
2. Sector-26, Korangi Industrial Area
3. Sector 52, Korangi Township
4. Shariffi Goth Cemetery Landhi

5. Sufoora Goth near Race Course
6. Nazarat Ground Gulshan-e-Iqbal
7. Mewa Shah near Graveyard, District West, Karachi
8. Sharafi Goth near Graveyard, Altaf Hussain Road, Landhi
9. Sohrab Goth near Lyari Expressway, 5.6 Gulshan-e-Iqbal, District East
10. DMC South, West & Central, Karachi to landfill sites (Gond Pass and Jam Chakro)
11. DMC East, DMC Korangi & DMC Malir

In addition, these GTS create a lot of social as well as dangerous problem for the city. The private, public sector, schools, shopping malls, and homes within the closer space concern to stop their working operations due to the near site of GTS in the city. The GTS contain the decomposed organic matter, it emits a pungent smell and dangerous gases. Whereas the so many organization especially the civil aviation authorities complain that the GTS can attract birds which will effect on the flights operations [16]. They iterate that airport is a sensitive place, the bird can collide the airplane which damage the engines and flight operation. There may be severe health problems for the residents of those near the GTS areas if SSWMB increases the number of GTS then the social and environmental problem will be increased [17-18]. The transportation of Garbage from GTS to Landfill Sites is the lifting, shipping and disposal of all sorts of garbage solid waste (excluding hazardous waste) and includes the domestic/industrial garbage, rubbish, shrub, tree cutting of any condition (dry, semi dry or wet) aswell as debris mixed with garbage, from GTS (whether formal or informal, temporary or permanent) placed involved DMC to the landfill site. Currently, the land is a depot wherever foreign machinery from china is being housed. The manual force & machinery by suggests that of dumpers, loaders, excavators etc. The GTS inside the jurisdictions of DMC to landfill sites (Jam Chakro & Gond Pass) as all charges, taxes and the price of weightage of the Solid waste, complete service as directed by the approved officers according to work set up for the assignment [19]. The maximum weight of garbage that will be loaded to transport the garbage through a 10-wheeler truck having an approximate capacity of 500 cft is estimated to equal 14 tons based on the respective density of garbage. The maximum weight of garbagethat can be loaded in and transported through dump trucks having capacity of 1000 cft approximately comes to 28 tons. Any weight higher than and over the capacity worked out by the density of garbage as noted above shall not be considered for payment and shall be at contractor’s own risk and cost [20].

The SSWMB has did not manufacture desired results for creating town clean. The SSWMB meeting, Sindh Chief Minister Syed Murad Ali monarch asked all the involved establishments to increase their support to so they might perform to the simplest of their capability strictly on trendy and scientific lines within the interest of metropolis and Karachiites [21].

The city is concerning 12,000 tons per day, out of that 9,000 plenty of waste is generated in municipal areas as well as DMCs and District Council of city. The remaining 3,000 plenty of waste is generated in areas of different civic administrative like six Cantonment boards, SITE, KPT, Railways, CAA etc. He aforementioned the SSWMB has three basic parts like front end assortment, middle-end Garbage Transfer Stations (GTS), back-end SWM Services i.e. Landfill.

Currently, transportation price relating to solid waste management services is extremely high as a result of the lowland sites square measure thirty five kilometer distant from the town center meaning seventy kilometer up and down whereas this distance is over fifty kilometer (+100 kilometer up-down) from several areas of Karachi [22-23]. The SSWMB projected that two lowland sites (LFS) of five hundred acres, Jam Chakro and Gondal Pass square measure merely marketing grounds and do not meet international standards of 'Sanitary lowland Sites'.

Figure1: Map Indicate Karachi metropolis. Picture Source: Google

2. Different available Garbage Sources of the Karachi Metropolis

Karachi is one of the world's 29 mega-cities along with London, New York, Paris and Tokyo. The Karachi is the Pakistan's gateway to the world. The Karachi is the largest city of the country with a 22 million of population. Karachi is the center of immigration with no ethnic group predominate the city, all cultural and social activities essentially revolve around the city. The Karachi is the 3rd largest city in the world by population and the 7th largest urban accumulation in the world. It is the largest city in the Muslim world and the capital city of Sindh province [24-26]. It has so many domestic, public and industrial sector these all sector are interlinked with their respective sub branches. Karachi is the city where there is increasing urbanization as well as industrialization that will directly increases the garbage in the metropolis

2.1 Domestic waste

Domestically composition of waste is heterogeneous that causes mix-up of biodegradable and non-biodegradable waste material such as e-waste, organic waste, paper waste, metal and glass waste.

2.2 Industrial waste

The waste such as e-waste, polythene waste, rubber waste, plastic, glass, can waste and bottle waste are the industrial waste. It is highly dangerous for the living as well as non-living things. It will create toxic gases, environmental hazardous and social problem.

The sugar cane industry produces large volumes of bagasse each year. Bagasse is potentially a major source of biomass energy as it can be used as boiler feedstock to generate steam for process heat and electricity production. Most sugar cane mills utilize bagasse to produce electricity for their own needs but some sugar mills are able to export substantial amounts of electricity to the grid.

The food business produces an oversized variety of residues and by-products which will be used as biomass energy sources. These waste materials are generated from all sectors of the food business with everything from meat production to confectionery manufacturing waste which will be used as an energy source. Solid wastes embrace peelings and scraps from fruit and vegetables, food that doesn't meet internal control standards, pulp and fiber from sugar and starch extraction, filter sludges and occasional grounds. These wastes are sometimes disposed of in lowland dumps [26-27].

The extremely polluting industries are consumes great deal of energy and water in numerous units of operations. The waste product discharged by this business is extremely heterogeneous because it contains compounds from wood or alternative raw materials, processed chemicals additionally as compounds fashioned throughout process. The industrial waste judiciously utilized the production of biogas exploitation of the anaerobic through the advance technology [28].

Liquid wastes are generated by laundry meat, fruit and vegetables, blanching fruit and vegetables, pre-cooking meats, poultry and fish, cleanup and process operations furthermore as wine creating. These waste waters contain sugars, starches and different dissolved and solid organic matter. The potential exists for these industrial wastes to be anaerobically digestible to supply biogas, or hard to supply fermentation alcohol, and a number of other business samples of waste-to-energy conversion exist already [28-30].

2.3 Hospital waste

Many hospitals in Karachi Indicate the increasing level of garbage. Karachi’s hospital such as civil hospital, Jinnah hospital, agha khan hospitals, liaqat medical hospital, Indus hospital, and Al-Ibrahim hospital produce large amount of hospital waste that will simultaneously increases the solid waste and management issue.

2.4 Animal Waste

The animal wastes is the big sources of biomass energy. The foremost animal and poultry is the recovered and sold as a fertilizer or just unfold onto agricultural land, however the introduction of tighter environmental controls on odor and pollution implies that some type of waste management system is currently needed, that provides the incentives for waste-to-energy conversion. The foremost enticing technique of changing these waste materials to helpful type is anaerobic digestion which provides biogas that may be used as a fuel for combustion engines, toget electricity from little gas turbines, burnt directly for change of state, or for house and water heating. Food process and edifice wastes are a possible anaerobic digestion feedstock [31].

2.5 Forestry Waste

Forestry residues area unit generated by operations like dilution of plantations, clearingfor work roads, extracting stem-wood for pulp and timber, and natural attrition. Wood process conjointly generates vital volumes of residues typically within the variety of wood. The waste matter is usually not utilised and sometimes left to rot on web site. But it will be collected and utilized in a biomass gasifier to provide hot gases for generating steam.

2.6 Solid Waste

Millions of tonnes of domestic waste are collected every year with the irresistible majority disposed of in dumps. The biomass resource in MSW contains the paper and plastic. The averages 80% of the overall MSW is collected. Municipal solid waste is born-again into energy by direct combustion, or by natural anaerobic digestion within the lowland. At the lowland sites the gas made by the natural decomposition of MSW is collected fromthe hold on material and clean and cleansed before feeding into combustion engines or gas turbines to get heat and power. The organic fraction of MSW is anaerobically stabilized in a very high-rate sterilizer to get biogas for electricity or steam generation [32].

2.7 Sewage

Sewage may be a supply of biomass energy that's terribly like the opposite animal wastes. Energy may be extracted from waste victimization anaerobic digestion to supply biogas. The waste sludge that continues to be incinerated or endure transmutation to supply a lot of biogas.

2.8 Agricultural Waste

Large quantities of crop residues square measure created annually worldwide, and square measure immensely underutilized. The foremost common agricultural residue is that the rice husk, that makes up twenty fifth of rice by mass. Alternative residues embody sugar cane fibre (known as bagasse), coconut husks and shells, groundnut shells, cereal straw etc. Current farming follow is sometimes to plough these residues into the soil, or they're burnt, left to decompose, or touched by the variety of agricultural and biomass studies, however, have ended that it should be acceptable to get rid of and utilize some of crop residue for energy production, providing giant volumes of low value material [33]. These residues may be processed into liquid fuels or combusted/gasified to supply electricity and warmth.

3. Existing Waste Management Condition of the Karachi with its side effect.

The whole existing solution are not long term solution. These are baseless solution. In future it will create a lot of social as well as environmental problem.

3.1. Dumping

The Karachi metropolis dump the waste into the selected dumping sites that landfill sites over tuned from their capacity. The dumping waste create a lot of serious issue for under water and environment.

3.2. Ocean Dumping

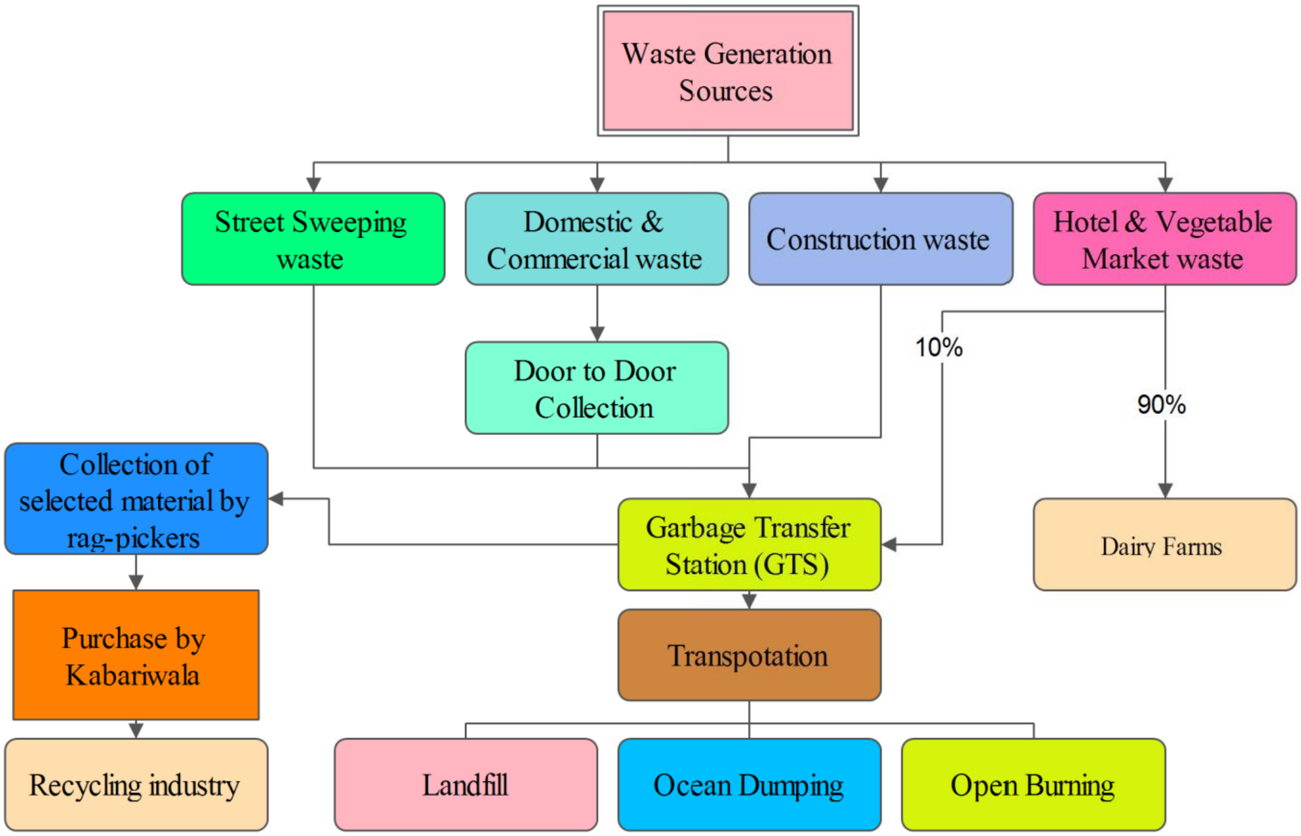
Dumping untreated sewage has caused 40% drop in marine population, in a report by Director General Pakistan Maritime Security Agency (MSA) revealed that untreated sewage being dumped into the Arabian Sea has had an adverse impact on the quality and population of marine life off the coast of Pakistan?

On a daily basis about 500 million gallons of untreated sewage is being dumped into the sea along with 12 tons of garbage which in result produces a forty percent drop in marine life populations. Unfortunately, there are no designated landfill sites in Karachi, therefore the sewage and solid waste, which includes plastic, is thrown directly into the sea or dumped in rainwater steams or nullahs and ultimately are washed into the sea after monsoon floods [34].

3.3. Open Burning

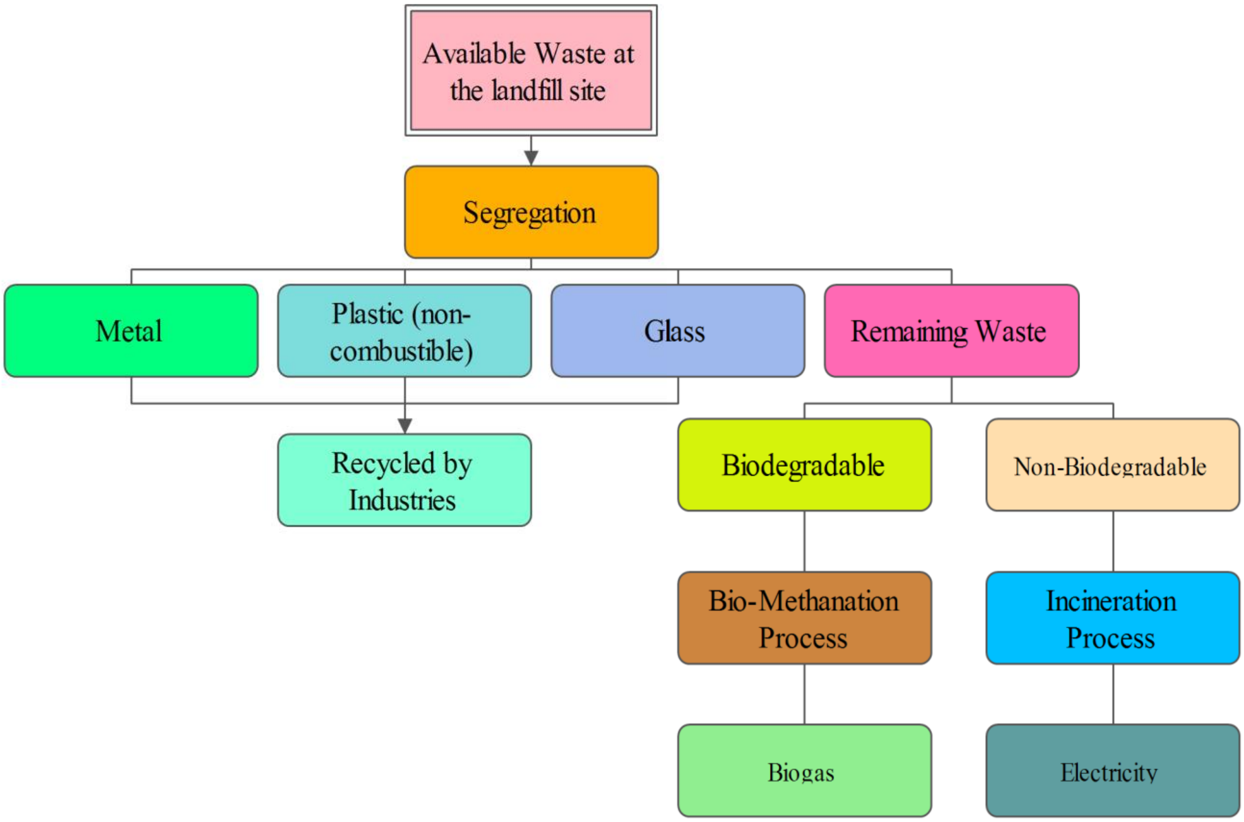
The burning of municipal garbage in the port city is posing serious environmental threats to the country's economic hub. The garbage can been seen piling up everywhere in the city at empty plots, public parks, public and private schools, shopping malls, open spaces, slums, policestations, government offices, and even on the city's beach. According to official data of KMC, the city produces 12,000 tonnes of municipal waste every day and there is not a single functional scientific dumping site anywhere in the city.

Environmentalists are worried about this new situation and they warned that if burning ofgarbage is not stopped in the city, it would harbinger another disaster in the metropolis in near future. Health experts also expressed grave concerns over inappropriate disposal of garbage across Karachi and burning effluent at public places. Dr. Seemin Jamali, joint executive director, Jinnah Postgraduate Medical Center (JPMC), said that burning of garbage has carcinogenic impacts, which can cause cancer [35-36].



4. Proposed Solution to Mitigate the Solid Waste

The propose technics will play a vital role in mitigation of municipal solid waste that is waste to energy plant. The waste-to-energy (WtE) plants have the vital advantages, environmentally safe waste management and disposal, moreover the generation of electrical power. The WtE facilities turn out clean, renewable energy through thermochemical and organic strategies. The growing use of WtE as a technique to dispose of solid and liquid wastes to generate power that greatly reduced environmental impacts of municipal solid waste, as well as emissions of greenhouse gases. The WtE conversion is effective in two ways. One the Electricity is generated that reduces the dependence on the national grid. Other the greenhouse emission emissions considerably reduced by preventing emissions of hazardous gasses. Moreover, the WtE plants are extremely economical in harnessing the unexploited sources of energy. The WtE plants manufacture a lot of power than all other existing renewable resources. The WtE plants in the Europe offer electricity to the 27 million citizens. Japan's incinerating plants making energy comparable to the existing atomic power plant. The Egypt produce 120,000 tons of fertilizer annually from the waste. The Europe aim to produce the domestic energy consumption from the waste. Correspondingly the USA aims to generate 5% of its power, 20% of its transport fuel, and 25% of its chemicals from biomass from farm and municipal waste. The proposed solution is the environmentally viable methodology to treat waste. The proposed method is the extremely crucial for the contemporary way to mitigate the existing waste. The proposed system is support the existing energy systems byadding the renewable energy in the form of WtE plants. The plant is critical to fulfill the ever- increasing demand of energy as well as handle environmental considerations.



The waste-to-energy plants is the environmental solution as well as the performance ofthe trade is on the far side reproach. Studies have shown that communities which use waste- to-energy technology have higher reprocessing rates than communities that don't utilize waste-to-energy. The waste-to-energy plants really cut back the quantity of greenhouse gases that enter the atmosphere. Nowadays, waste-to-energy plants support combustion technologies that is extremely economic to utilize municipal solid waste as a fuel insteadof coal, oil or gas. The waste-to-energy plants recover the thermal energy contained within the trash in the extremely economical way. The boilers generate steam which will then be sold-out on to industrial process on-the-scene to drive turbines for electricity production. WtE plants are extremely economical in harnessing the untapped energy potential of organic waste by changing the perishable fraction of the waste into high hot price gases.

4.1 Segregation

The container tipping floor contain plastic, glass, metal and cans waste. The container line remove all the non-recyclable streams also the container line goes through differentmachines to separate different materials type. The steel container is used to rotate the belt magnet for the separation of the metal as well as the steel containers pull up and rotate the belt as it goes around to carries the magnet. when the steel reach at the end point of rotatingbelt, the belt is demagnetized and steel cans drop down to a conveyer that leads to steel cage bunker.

In the air classifier the heavy weight material like glass drops down and light weight material, plastic, aluminum can foil. The milk cottons, shopper bags, water bottles and juice boxes are blown up by an air stream and travel through the perforator that makes sorting materials easier.

The optical sorter is used for the arranging different types of plastic. It is programmed to differentiate the different types of plastic based material by chemical compositions. The optical sorter known by its ability of infrared light that identify the each type of plastic waste. The waste is travels under the light eye that send out the electronic signal to turn ON the air jet. By this way the useful plastic is separated for the process.

The separation of aluminum cans is done by “Aluminum separate”. it induces an electric current as the aluminum cans pass through magnetic field. They are repelled in one direction while remaining non-aluminum items move to other directions.

The Paper line separate the all non-paper recyclable items and transfer them into the container line by using the screening process [37-38].

4.2 Biomass Plant

Biogas process produce the biogas from the micro-organisms which digest cellulose and other organic content by animal. The biomass plant process the bio-waste at the suitable temperature of 28c to 35c. The biomass process involves mixing the methane producing bacteria in modern digester and then collecting the raw biogas in biogas balloon. This raw gas will be sent to burners through pipes to the furnace to Waste to Energy Plant. Biogas contains roughly 50 to 70% $CH4$ and 30 to 45% $C02$. The digestible portion of the waste is very wealthy in nutrients and is wide used as bio fertilizer in several components of the globe. The biomass plant have another two process to generate the energy as

4.2.1 Biochemical Conversion

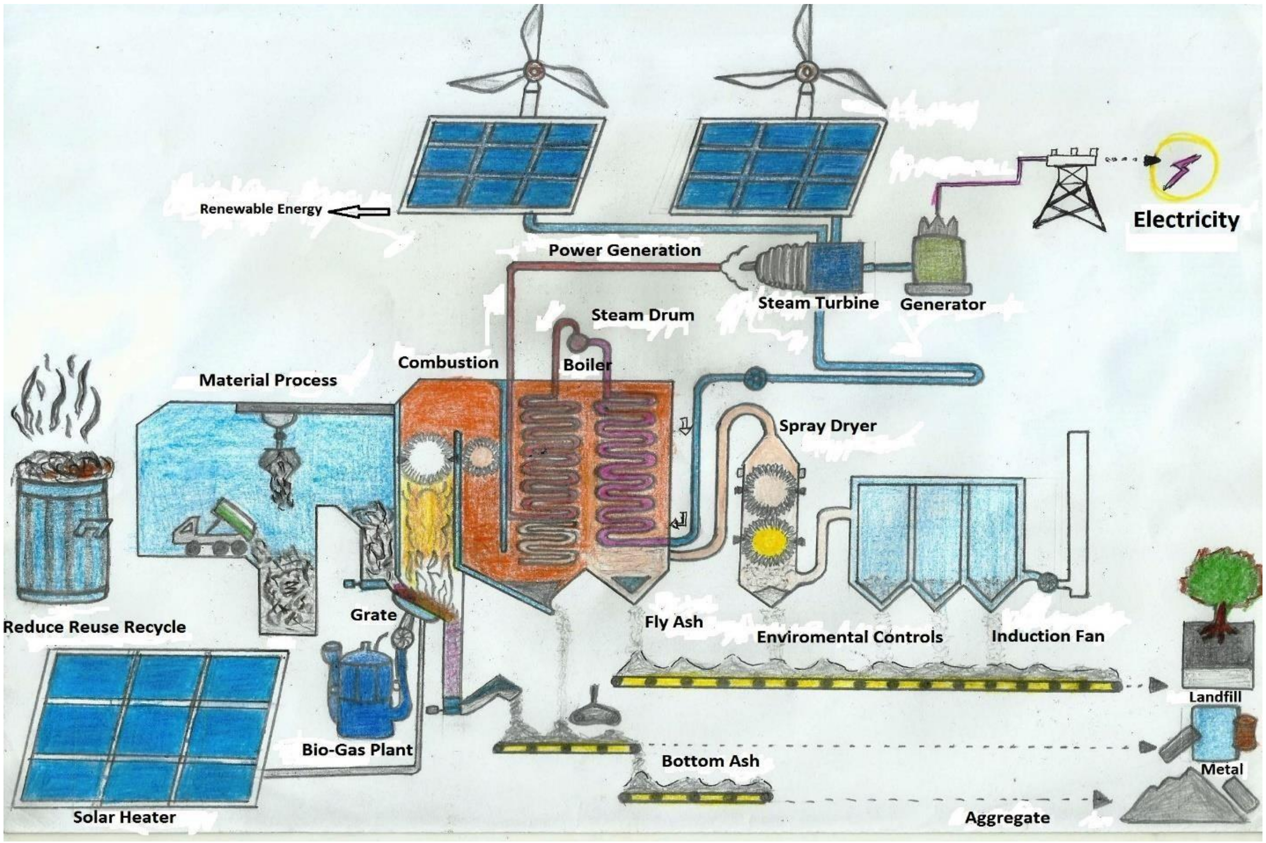
The bio-chemical conversion processes is the anaerobic digestion and fermentation that is most popular for wastes having high proportion of organic putrescible matter and high wet content. Anaerobic digestion could be a reliable technology for the treatment of wet, organic waste. Organic waste from varied sources is composted in extremely controlled. The oxygen-free conditions circumstances leading to the assembly of biogas which manufacture each electricity. The anaerobic digestion conjointly ends up in adry residue referred to as digest which might be used as a soil conditioner. The alcohol fermentation is that the transformation of organic fraction of biomass. It finds haggle of application within the transformation of woody biomass into plastic ethyl alcohol.

4.2.2 Physico-chemical Conversion

The physico-chemical technology involves numerous processes to boost physical and chemical properties of solid waste. The flammable fraction of the waste is born-again into extraordinary energy fuel employed for the steam generation [39].

4.3 Implement Proposed Waste-to-Energy Plant at the Landfill Site

The waste to energy plant converts the rubbish into electricity. The widest technology takes the waste and burns it, the heat created is used to make steam which in turns drive the turbine and it generates the electricity. The technique we look here is widely used around the world, it is noticed that all the plants are very big, this is the process that works the best on a large scale.



The incinerating waste creates emission and residues and part of the process is focused on dealing with this. Achieving a high rate of efficiency with a low volume of product is our aim. There are many systems of varying complexity but they all work on the same principles.
To set up this kind of a waste to energy plant we need:

1. Waste
2. Furnace
3. A boiler with heat exchanger
4. A water supply system
5. A turbine
6. A generator
7. Renewable sources
8. A biogas digester

The waste is collected and delivered to the plant where it is stored in large bunkers. After the process of segregation that is discussed earlier the uniform type of waste is allowed for the further process. This waste is transferred to the furnace below the plant's boiler.
The temperature in the furnace should be very high, the gas inheritor should be heated over 850'C to 1200'C, to make sure that all the waste burns completely to form stable end products. The source of heat for the furnace is taken from the biogas plant where all the organic waste has to be treated. The organic waste after the segregation is delivered to the biogas plant. This process is done by the Bio-methanation process. Firstly, the organic waste has to go through the food grade crusher where it is cut into small pieces and mixing with water makes a slurry, then this slurry is transferred to biogas plant through a pumping unit.
After the burning of waste, the residues remain called bottom ash and is non-hazardous that should be sent for recycling and is usually used by the construction industries. About the 20% byweight of the waste ends with the bottom ash.
The intense heat from the furnace rises into the series of chambers in the boiler. The idea is to

capture the thermal energy as efficiently as possible. In the boiler, the heat exchangers a series of pipes filled with water a bit like a household radiator, the heat vaporizes the water to form super-heated high-pressure steam. This is sent to the turbine where it encounters the series of turbine's blades. The high-pressure steam forces the blades to rotate at high speed, driving the generator to make electricity. Then the electricity is fed to the power grid for use by industries and localities of Karachi.
Water travels in the system in closed loop cycle after passing through the turbine the steam is allowed to condense and then returns to heat exchangers to be heated again.
The gas emitted by the boiler is known as flue gas that must be treated for being released from the plant's chimney stack. This process contains a series of parts called "Absorption, Scrubbing, and Filtering system".

5. Waste-to-Energy around the World

The waste-to-energy has thrived in Europe and Asia because the leading methodology of waste disposal. The WtE will cut back the degree of waste associate in tending the environment and generate the valuable energy. The WtE process mitigate the greenhouse emissions and provide sufficient energy system. The European nations accept WtE because the most popular methodology of waste disposal has issueda wrongfully binding demand for its member States to limit the landfilling of unpreserved waste. According to the Confederation of European WtE Plants treats 50 million ton of wastes every year and generate the associate quantity of energy which may provide electricity for twenty seven million individuals. The coming changes in EU legislation can have a profound impact on what proportion at thetechnology can facilitate reach environmental protection goals.
The technologies are out there for realizing the potential of waste as energy supply, starting from terribly straight forward systems for doing away with the dry waste with help of advanced technologies which is capable of managing massive amounts of commercial waste [35-38].

6. Existing Government Policy

The Sindh government has goal to promote the establishment of renewable energy projects and create conducive conditions and clean environment for such projects with respect to government finances. The scope of this government financing includes mainly subsidy and grants funding for the projects, various power generation projects, promotional efforts, research and development, resources assessments, technology upgrades, and performance evaluations .

The funding selection process is typically judged on the basis of the potential amount of WtE proposed technology, and capacity. The amount of funding itself is limited by the capacity of a given plant, its location, and other such important circumstances. The government, for example, heavily subsidizes a typical waste-to-energy project in Karachi. This funding is typically transferred to project leads through banks and financial services mediation. The government also set structured procedures for monitoring the progress of such WtE projects. This structureincludes periodic monitoring by the federal and state governments and frequent progress reports from the project lead by the government [37-38]..

7. Proposed Future Solutions

The Karachi is the financial hub of the Pakistan and has the highest potential for energygeneration from the solid wastes in the country. The Karachi has the major problem to overcome the increasing waste. It is the hope of Sindh government in Karachi to finance the WtE in the cityas a beacon that improves living conditions of the citizen which is dependent on the import of fossil fuels.

The first step of WtE in the Karachi is capital and operation costs, revenues, land requirements and the benefits of a WtE in the city. Also need of proposed model to optimize the inconsistency between benefits and costs. In this research we build a mathematical model and calculation that optimal the real time solution for the investor to generate the revenue.
The proposed research study develop a linear model to integrate the different options and investor that involve in the MSW in the Karachi. The various economic and environmental costs associated with MSW management were taken into consideration while developing the model. The objective function includes the minimization of net cost of an integrated solid waste management system. The waste is processed at the available landfill site known as jam chakro near the bypass. The proposed compost plants become viable option for the community based collection and segregation of the waste from the households which recycle the material and sale out the wholesalers.
The proposed model develop a sheds light on the cost profit analysis of a MSW in the Karachi. Also the model largely focuses existing selected landfill to run the similar mathematical model on real time WtE incineration process. The model has the cost benefit analysis to develop an original potential of an incineration plant in the metropolis. The MSW expresses doubt about future investment in WtE plant the importance of investments in pyrolysis techniques over incineration techniques.

8. Model and Methodology

The proposed research plan to build a WtE plant at the jam chakro dumping site having 2000 tons-per-day capacity. The jam chakro is government-owned landfill site. We will expand the study to include a detailed analysis studying the expensive and profits associated with building a plant in the Karachi and compare these figures to the costs and benefits of the available plant near the landfill site. Additionally, we will reference some figures of the available plant. Using this analysis, we will evaluate the feasibility of building and operating waste to energy facility in Karachi, Pakistan. The same model is valid for Mumbai because of the same nature of the waste.
The proposed plant comparison evaluate from the existing running plant of the Asian and European countries continuing the current WtE. For each method, we want to evaluate plant expensive and the profit of the proposed plant [36, 37]. The expensive is the associated expenses of the plant. The Profit is the total benefits associated with the plant.
Available Waste (A_W) at the landfill site is process to convert the proposed plant for the waste mitigation in the form of Waste to Energy. The available max waste form at the jam shakro landfill is electronic waste (E_w), glass waste (G_W), biodegradable-waste (B_W), non-biodegradable waste (N_{BW}) and other waste (O_w) is shown in the Eq.1.

$$A_W = [\sum_{i=1}^{n} E_w + G_W + B_W + N_{BW} + O_w] \ldots\ldots\ldots\ldots\ldots \text{Eq.1.}$$

$$A_W = [\sum_{i=1}^{n} B_W + N_{BW}] - [\sum_{i=1}^{n} E_w + G_W + O_w] \ldots\ldots\ldots\ldots \text{Eq.2.}$$

The proposed plant will process the only biodegradable and the non-biodegradable waste as in the Eq.2. The other waste $\sum_{i=1}^{n} E_w + G_W + O_w$ will be send to the industries for another process. The remaining waste for the proposed plant will be as below in Eq.3.

$$A_W = [\sum_{1}^{n} B_W + \sum_{2}^{n} N_{BW}] \ldots\ldots\ldots\ldots\ldots\ldots \text{Eq.3.}$$

The now the available waste has the biodegradable and the non-biodegradable waste. The biodegradable waste is including vegetable waste (Vg_W), fruit waste (F_W), market waste (Mk_W), animal waste (A_W), slaughter house waste (Sh_W) and human waste (H_W) as mention in the Eq.4. After the segregation the biodegradable waste is send in the Bio-Methanation Process ($BM_{Process}$) for the biogas generation as happen in the Eq.5.

$$B_W = \sum_{i=1}^{n} B_W = [\sum_{1}^{n} Vg_W + \sum_{2}^{n} F_W + \sum_{3}^{n} Mk_W + \sum_{4}^{n} A_W + \sum_{5}^{n} Sh_W + \sum_{6}^{n} H_W + \ldots] \ldots\ldots \text{Eq.4.}$$

$$BM_{Process} = \sum_{i=1}^{n} B_W \left(Req_{Temperature} + Req_{Pressure}\right) + K_o \text{........ Eq.5.}$$

The non-biodegradable waste is containing as in the kilogram plastic waste (Pw_{Kg}), rubber waste (Rw_{Kg}), cigarette waste (Cw_{Kg}), leather waste (Lw_{Kg}), diapers waste (D_W), and other waste (Ow_{Kg}) as in the Eq.6.

$$N_{BW} = \sum_{i=2}^{n} N_{BW} = \left[\sum_1^n Pw_{Kg} + \sum_2^n Rw_{Kg} + \sum_3^n Cw_{Kg} + \sum_4^n Lw_{Kg} + \sum_5^n D_W + \sum_6^n Ow_{Kg} \ldots\right].$$

..........Eq.6.

The non-biodegradable waste is process for the incineration for the generation of the reliable electricity in the megawatt. The plant require all the dependable process the generation of the power so the incineration process of the plant

$$W_{Incenerartion}\, Process = N_{BW} = \sum_{i=2}^{n} N_{BW} \left[Req_{BT} + Req_{BP} + P_{Temperature} + K_o\right] \text{...... Eq.7.}$$

8.1 Cost Model of the Proposed Plant

The cost model describe the require expenses and the profit of the proposed plant as bio-methanation and the incineration process respectively as follows as the total expensive for the proposed bio-methanation plant is shown in the Eq.8.

The total expensive for the bio-methanation proposed plant ($\sum_{i=1,2,..}^{n} E_{PP}$) describe as the cost of the construction, labor, land, fuel, collection, transportation, environmental and operation as in the Eq.8.

$$\left(\sum_{i=1,2,..}^{n} E_{PP}\right) = \sum_1^n E_{pp}Construcion + \sum_2^n E_{pp}Labor + \sum_3^n E_{pp}Land + \sum_4^n CE_{pp}Fuel + \sum_5^n E_{pp}Collection + \sum_6^n CE_{pp}Transportation + \sum_7^n CE_{pp}Enviromental + \sum_8^n CE_{pp}\text{Operation}\text{..Eq.8.}$$

Similarly the model of the expensive for the incineration plant is describe in the Eq.9. The total expensive for the incineration plant refer the expensive of the plant construction, labor, land, fuel, collection, transportation, environment and the plant operation as in the Eq.9.

$$\left(\sum_{i=1,2,..}^{n} E_{PP}\right) = \sum_1^n E_{pp}Construcion + \sum_2^n E_{pp}Labor + \sum_3^n E_{pp}Land + \sum_4^n CE_{pp}Fuel + \sum_5^n E_{pp}Collection + \sum_6^n CE_{pp}Transportation + \sum_7^n CE_{pp}Enviromental + \sum_8^n CE_{pp}\text{Operation}\text{..Eq.9.}$$

8.2 Profit Model of the Proposed Plant

There is huge benefit of proposed plant as the energy gain and clean environment that profits by the proposed plant as$\left(\sum_{i=1,2,..}^{n} P_{PP}\right)$. The plant give the biogas and the huge amount of the electricity gain with the zero effect of the environmental disturbance. The model of the profit describe the energy gain and the environment as shown in the Eq.10.

$$\left(\sum_{i=1,2,..}^{n} P_{PP}\right) = \sum_1^n P_{pp}Energy + \sum_2^n P_{pp}Enviromental \text{......................................Eq.10.}$$

Also the profit from the proposed plant of the bio-methanation as$\left(\sum_{i=1,2,..}^{n} P_{PP}\right)$. The plant gives the output in the form of biogas energy, bio-fertilizer and the transportation fuel as shown in the Eq.11.

$$\left(\sum_{i=1,2,..}^{n} P_{PP}\right) = \sum_{1}^{n} P_{pp}Energy + \sum_{2}^{n} P_{pp}Biofertilizer + \sum_{2}^{n} P_{pp}Transportation\ Fuel$$

………..Eq11.

The deep study of the proposed plant in comparison with the existing running plant of the Asian and European countries. The current running WtE plant of the Asian countries that located at the coastal area studies for the proposed plant of WtE at the south Asian coastal region. Each proposed model is based upon the research study and mathematical model of the currently running WtE plant. The basic evaluation of the proposed plant is its construction expenses and profit. The plant expenses and the output gain is associated with the plant is described as the $50 on the construction of the plant.

$$\left(\sum_{i=1,2,..}^{n} E_{PP}\right) = \sum_{1}^{n} \$50 + \sum_{2}^{n} \$0 + \sum_{3}^{n} \$0 + \sum_{4}^{n} \$0 + \sum_{5}^{n} \$0 + \sum_{6}^{n} \$0 + \sum_{7}^{n} \$15 + \sum_{8}^{n} \$37.9$$

……..Eq.8.

$$= \$50 + \$2{,}800 + \$0 + \$0 + \$0 + \$0 + \$15 + \$37.9$$

$$= \$102.9\ million$$

$$\left(\sum_{i=1,2,..}^{n} E_{PP}\right) = \sum_{1}^{n} \$15 + \sum_{2}^{n} \$0 + \sum_{3}^{n} \$0 + \sum_{4}^{n} \$0 + \sum_{5}^{n} \$0 + \sum_{6}^{n} \$0 + \sum_{7}^{n} \$6 + \sum_{8}^{n} \$3$$

….Eq.8.

$$= \$15 + \$0 + \$0 + \$0 + \$0 + \$0 + \$6 + \$3$$

$$= \$24\ million$$

$$\text{Total Plant Expensive} = \sum_{t=1}^{50} \frac{\$102.9(1+3\%)^t}{(1+12\%)^t} + \sum_{t=1}^{50} \frac{\$24(1+3\%)^t}{(1+12\%)^t} + \sum_{t=1}^{50} \frac{\$0.0336(1+3\%)^t}{(1+12\%)^t}$$

$$= \$126.9336\ million$$

Position	Monthly Salary($)	Total Annual Salary($) for each	Number
Project Manager	900	10,800	1
Assistant Manager	800	9600	2
Foreman	700	8400	3
Assistants Executive	250	3000	3
Worker	150	1800	35
Total	2,800	33,600	44

The Profit is the total benefits associated with the plant.

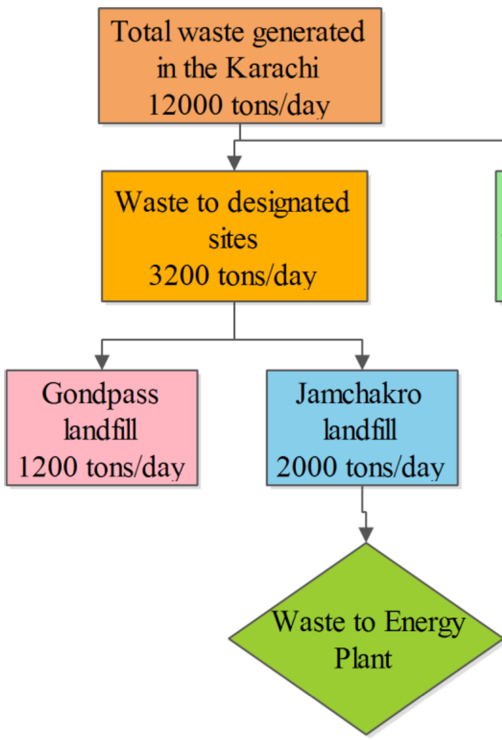
$$Profit_{pp} = P_{pp}Energy + P_{pp}\ Enviroment$$

$$Profit_{pp} = \$63.9 + \$4.01 = \$67.91\ million$$

$$\textbf{Total Profit of Plant} = \sum_{t=1}^{50} \frac{\$63.9(1+3\%)^t}{(1+12\%)^t} + \sum_{t=1}^{50} \frac{\$4.01\ (1+3\%)^t}{(1+12\%)^t} = \$\mathbf{67.91}\ \boldsymbol{million}$$

9. Analysis

The proposed plant has the input capacity to process 2000 ton/day and it is located at the jam shakro landfill. The proposed estimated lifetime for the plant is 50 years based on data from Asian and European Waste to Energy plants. Hence, the calculated time frame of the proposed plant 50 years. The proposed plant have 2000 ton/day capacity to process at the landfill site for WtE generation. The plant is allocated at the available jam shakro landfill site that is used for waste disposal. The cost of the transportation, collection, land, fuel and landfill is eliminated zerodue to plant is proposed at the available landfill site. The plant will effectively build at the available landfill site where there is daily collection of the 2000 ton of garbage is happened. The construction cost of the proposed incinerator part of plant is $2926.9 million and the bio- methanation part of the plant is$24 million. The whole data is estimated from the Asian and European running WtE plant. The selected site for the plant is government owned and has already been allocated by the Sindh government for the landfill. So the land cost for the proposedplant is eliminated zero. The labor which are working at the plant will be accumulated by the commendable salary as shown in table. So the estimated costs for the labor is $33,600 per year, increasing with the 3% per year.



The assumption for the plant staff is based on the requirement as 44-person needed for the plant process. The Fuel Costs for the proposed plant is negligible due the plant will complete its electricity requirement from the renewable resources. The heat generated from the plant will be able to continue the combustion processes. The waste collection expensive are negligible due to proposed plant is built on the available landfill site where there is already collected waste is present to process the system. Hence the proposed plant will be operated at the jam chakro landfill site where there is collected garbage is present for the process of plant. The plant working expensive including salaries of the labor and other maintenance is estimated as the only
$3 million per year, growing with the 1% per year. The research study is for the 50-year duration based on the existing running WtE plant. The cost will accumulate total cost of the plant. The plant generate the revenue of $67.91 million. The generated revenue is based on existing Asian and European WtE plant. The generated electricity can be seal to the K-Electric or other Karachi leading industries. The efficiency of the proposed plant can be increased by the increasing the

amount of waste [37-38].

Item	Amount
Capacity per day	2000 tons/day
Capacity per line	1000 tons/day
Number of lines	2
Total capacity	730,500 tons/year
Net electricity generation	0.6 MWh/ton
Total electricity generated	12MW
Ash generation	0.20 tons ash/ton waste
Non-ferrous metal	0.0002 tons metal/ton waste
Ferrous metal	0.0065 tons metal/ton waste

Table: Proposed Plant characteristics and materials generation

10. Discussion

The WtE plant will reduce the waste management option by generating the renewable power from the available waste. This poses a real environmental cost by generation of the energy. Thereare many benefits of the WtE plant that are dispersed to a wide range of beneficiaries. All residents of Karachi would benefit from the waste reduction in landfills and the increased the energy generation.

The minimum uses of landfills will not only alleviate the environmental problems of the Karachi, but it will also help to alleviate health risks. Additionally, the reduction in waste will improve the beauty of Karachi. The additional support to the national grid productivity. The usage of the WtE plant increase the level of the electricity generation, also the decrease the usage of non- renewable resources.

The WtE plant becomes successful for the municipal organizations of the Karachi. The city will take the advantage from the proposed plant to reduce the increasing amount of the solid waste. Additionally, the reduction will be happened in the usage of GTS. The available landfills would pertinent for the growth proposed plant that is affordable for the government as well as common investor.

The WtE plant will require high expert labor, which increases the employment rate in the Karachi. The proposed WtE plant facilitate the private companies who wish to enter the WtE space which currently cannot participate due high capital costs. The proposed plant provide the radical solution in waste management and environment. The collection and transportation of the MSW will be able to save the costs associated with landfill site. The clean environmental changes will not only benefit the residents of the Karachi, but also the residents of the entire country. The Karachi is able to lead the path of the whole country towards emissions of the greenhouse gasses and alleviate global warming issues of the country.

The proposed plant has the high segregation technique due to the extra efficiency of the WtE plant. Currently the municipal corporation will require more money to ensure the waste properly

segregate. The proposed plant could also lead an enlarged opportunity of the municipal corporation that decide import this project to other landfill sites.
The WtE plant are not negligible without proper safety standards and protocols in existinglandfill site, the environmental pollution of a WtE plant can be very high so filter are require to clean the air. The generated ash from the incineration plant will be disposed in the jam chakro landfill site.

The Sindh government gives a subsidy to private companies that build WtE plants. By reallocating funds, the subsidy results in an opportunity cost for the government.

11. Conclusion

The rapid growth in the population in the developing countries has resulted in growth of cities. In this way, the capacity of garbage will be increase at high rate. The proposed study reflect the best solution for the existing garbage problem. There are emerging engineering challenges inviting out of box solutions. The paper proposes the Indigenous solution to municipal waste in Karachi, Pakistan. The model proposed here can be replicated in any of the coastal cities with climate conditions and waste types resembling that of Karachi.

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