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ENERGY RECOVERY FROM MUNICIPAL SOLID WASTE INCINERATION _BENGHAZI LIBYA _CASE STUDY

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ABSTRACT

Waste-to-Energy (WTE) is a viable option for Municipal Solid Waste (MSW) management and a renewable energy source. MSW is a chronic problem in Libya and more specifically in Libya Urban areas. The MSW practices in Libya are simply done by collecting the waste and dumping it in open landfill sites. Libya is considering WTE as a potential renewable energy source that can contribute to electricity demand. This research aims to assess potential contribution of WTE facility to meet electricity demand in the Benghazi city and to provide an alternative solution to landfills. Scenario for WTE utilization was developed: Mass Burn the analyses were completed for Benghazi city; with current total population. The results show that Benghazi has the potential to produce about 19 MW of electricity based on incineration scenario the year 2030. These values are based on theoretical ideals and help in identifying the optimal WTE techniques for each city.

KEYWORDS

Waste-to-Energy, Municipal Solid Waste, Renewable Energy, Incineration.

1. INTRODUCTION

The municipal solid waste (MSW) is generated from household, commercial, and institutional activities. MSW refers to a common waste such as food scraps, paper, plastics, clothing, glass, metals, wood, street sweepings, landscape and tree trimmings and general wastes from recreational areas [1]. It does not include industrial, hazardous, and construction wastes. In 2012, about 1.3 billion tons of solid waste was generated worldwide, which is expected to double in 2025. Therefore, the solid waste management (SWM) costs will increase from today's annual US $205.4 billion to about US $375.5 billion in 2025. In cities of developing world, SWM is the city's single largest budgetary item, where poor SWM system is adversary affecting the health, environment, and economy [2].

Municipal solid waste (MSW) management system aims to handle health, environment, aesthetic, land-use resources, and economic concerns related to improper disposal of waste [3-5]. Population, urbanization growth and the rise of standards of living have all dramatically accelerated the MSW generation in developing countries [6,7]. Developing countries are not able to cope with the MSW generation growth and open landfills remain the dominant method of disposal [8, 9].

The population growth of an average 2.2% over the last four decades coupled with an increase in the urbanization level from about 50% of the total population at present; has resulted in substantial growth of MSW generation in the country [10]. The current municipal solid waste management system in the Libya is simple: collect and dispose of by dumping it in open landfill sites. Most of the landfills are mature and are expected to reach their capacities within a few years. The substantial quantity generated by MSW and the high energy contents of its composition demonstrates the significant potential for WTE facilities in Libya. Even though several ways are widely used to treat waste in the World, Libyan waste management has not applied any of the basic techniques at any waste treatment level. In this paper, incineration treatments model has been studied to apply it in Benghazi city. The results show that the rate of waste in the city (kg/capita/ day) has been increased from in 2012 to 2030. In addition, our calculations show can be generating energy from MSW.

2. MSW THERMAL TREATMENT

2.1 MSW thermal treatment processes

Incineration is used as a treatment for a very wide range of wastes. Incineration itself is commonly only one part of a complex waste treatment system that altogether, provides for the overall management of the broad range of wastes that arise in society. Basically, waste incineration is the oxidation of the combustible materials contained in the waste. Waste is generally a highly heterogeneous material, consisting essentially of organic substances, minerals, metals and water. Temperature range of oxidation process is generally between 600 and 1450 °C.

The most common thermal treatment process for MSW is incineration by mass-burn technology with temperature range between 600 and 800°C [11]. Fluidized bed incineration and refuse derived fuel systems are less common in municipal solid waste treatment. Aside from combustion, other thermal processes exist, including paralysis, gasification, sintering, verification and melting [11,12]. The incineration process itself requires energy for its operations e.g. pumps and fans. The demand varies greatly depending on the on the constructions of the plant. In some cases, the demands can be met partially or entirely through heat exchange with the hot incinerations gases [11,13].

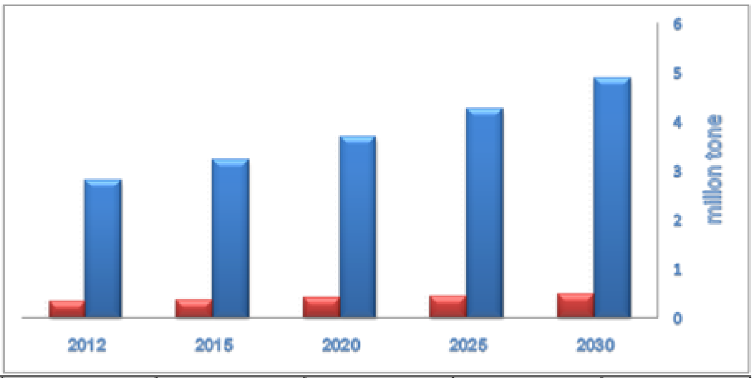
2.2 Benghazi MSW input data

MSW data are collected from Benghazi city during the period of (2012 – 2030). In 2006, the percentage of MSW per capita was about 0.915 kg / day, while in 2012 the proportion of the individual production of MSW was 0.98 kg per day [14]. The Municipal Solid Waste (MSW) generation in the Middle East and North Africa is estimated about 0.16 to 5.7 kg /person/day, with an average of 1.1 kg/capita/day [15]. Based on the previous researches and our calculations the rate of 1.1-1.3 is used in this study. The technical data for MSWI potential for Benghazi is shown in table 1.

Table 1: Technical data for MSWI potential of BENGHAZI

Year	Citizens [pears]	Waste indicators [kg/pres/ day]	Waste quantity [kg/pres/ day]	Waste quantity [ton/year]	The cumulative amount of waste
2012	691,700	1.1	899,210	328,212	328,212
2015	760,870	1.1	989,131	361,033	689,245
2020	836,957	1.2	1,088044	397,136	1,086381
2025	920,652	1.3	1,196847	436,849	1,523230
2030	1,012,717	1.3	1,316532	480,534	2,003764

The forecasted MSW quantity per year for Benghazi city up to year 2030 is presented in Figure 1. The figure shows that by the year 2030, about 480 thousand tons of MSW. This is a huge quantity and should be managed properly otherwise a severe environmental consequence can be anticipated in the long-term. The Benghazi MSW composition includes 56.3% organic materials, 10.3% plastics, 13.5% paper, 10.8% textile, 2.6% glass, 3.7% metals, 2.8% wood, and 3.7% other [10].



yaer	2012	2015	2020	2025	2030
total waste	2,789,158	3,207,532	3,688,662	4,241,961	4,878,255
Benghazi	328,212	361,033	397,136	436,849	480,534

Figure 1: Waste Generation Forecast for Benghazi City up to year 2030

3. PROPOSED SOLUTION FOR MSW THERMAL TREATMENT OF BENGHAZI

Considering the fact that the significant quantity of MSW produced in Benghazi are generated by the householders, the proper solution feasible for this kind of waste are grate incinerators. Grate incinerators are widely applied for the incineration of mixed municipal wastes. In Europe approximately 90 % of installations treating MSW use grates. Other wastes commonly treated in grate incinerators, often as additions with MSW, include: commercial and industrial non-hazardous wastes, sewage sludge and certain clinical wastes [11]. Grate incinerators usually have the following components:

- Waste bunker
- Firing system: fluidized bed reactor
- Waste heat boiler
- Flue-gas cleaning devices consisting of: Electrostatic precipitator, three-stage wet scrubber,
- Catalyst for NOX removal and dioxin destruction
- Multistage waste water treatment plant
- Steam turbine, generator and heat decoupling system.

Below figure 2 illustrates an example of a great incinerator with a heat recovery boiler:

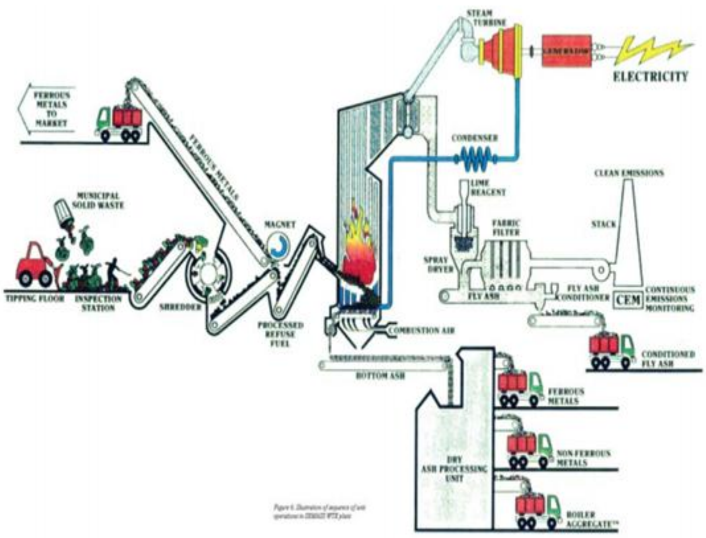


Figure 2: Shows the general structure of the power station of waste incineration

The energy outputs from this kind of waste incinerators are: electricity can be easily calculated; the incineration process itself may use some of the produced electricity. The heat released in the combustion process can be recovered to feed industrial or domestic users. To electrical energy recover from the steam produced by the boiler is mandatory to provide a steam turbine (generator group). In situations where economic incentives are provided to support the production of electrical energy from incineration (a renewable source) there may be a price differential between purchased and exported electricity. Plants may then choose (for economic reasons) to export all of the electricity generated by the incinerator, and import from the grid, that which is required to run the incineration process itself. Where this is the case, the incineration plant will often have distinct electricity flows for input and output [11]. Considering this fact and the Benghazi potential background, a suitable solution for thermal treatment of MSW is the implementation of a great incinerator with an energetic group that used a condensation steam turbine.

4. RESULTS AND DISCUSSIONS

The possible efficiency of a waste incineration process is influenced to a large extent by the output options for the energy produced. The highest waste energy utilization efficiency can usually be obtained where the heat recovered from the incineration process can be supplied continuously as district heat, process steam etc., or in combination with electricity generation the adoption of such systems is very dependent on plant location. After a technical-economical study work is concluded that to fulfil Benghazi MSW integrated management suitable for economical point of view is needed: system of a great incinerator with a heat recovery boiler of 64 t/h (55 bar, 400°C); power generation group of 19 MW, in condensation with adjustable steam glad to 2 bars [4]. the figure 3 shows that complete incineration scenario has the power generation capacity. Additionally, the scenario provides a viable disposal option for MSW and if implemented will alleviate the landfills problem in the area.

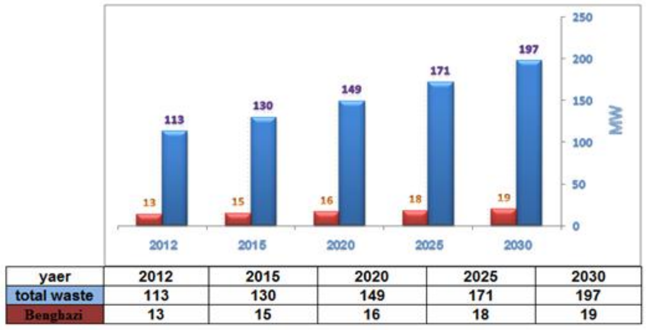


Figure 3: Power Generation Potential (MW) for Benghazi City for the years 2012-2030.

5. ECONOMICS AND COST

In this section, the costs of the energy system with the different scenarios are presented. In the table 2, the costs used for the analysis are illustrated [16, 17].

Table 2: Comparison of selected WTE technologies with respect to capital cost, operational cost, and power generation.

processes	Type of waste	Capital cost, ton/y ($)	Net operational cost/ton ($)	Daily power generation (MW/ton)	Complexity of technology	Labor skill level	Geographic location	η%
Incineration	General waste stream	14.5–22	1.5–2.5	0.01–0.02	Low	Low	Urban	25
Refused derived fuel	General waste stream without high protein	7.5–11.3	0.30–0.55	0.01–0.014	Intermediate	High	Urban and industrial	18
Anaerobic digestion	Organic	0.1–0.14	Minimal	0.015–0.02	Low	Low	Rural	25

6. ENVIRONMENTAL VALUES

Landfills are major source of greenhouse gases, which contribute about 3.4% to 3.9% of global greenhouse gases emissions. During decomposition, large quantities of methane and carbon dioxide are produced, and released into the atmosphere. Methane is 21 times more detrimental as greenhouse gases than is carbon dioxide figure 4 [18]. The potential reduction in greenhouse gasses for processing of waste using the Mass Burn with recycling and Mass Burn scenarios in comparison to landfilling were calculated. The calculations were completed under the consideration of the net greenhouse gases reduction potential for the various components of MSW as presented in table 3 and the Benghazi MSW composition. Table 4 presents the greenhouse gases reduction per ton of Benghazi MSW. Two values of the greenhouse gases reductions per ton of SW were calculated for the Mass Burn with Recycling scenario and Mass Burn scenario. The results show the potential to reduce greenhouse gases emissions based on Mass Burn with recycling scenario of about 0.49 metric tons carbon equivalent MTCE per ton of MSW material and about 0.2 MTCE per ton of MSW materials based on Mass Burn scenario.

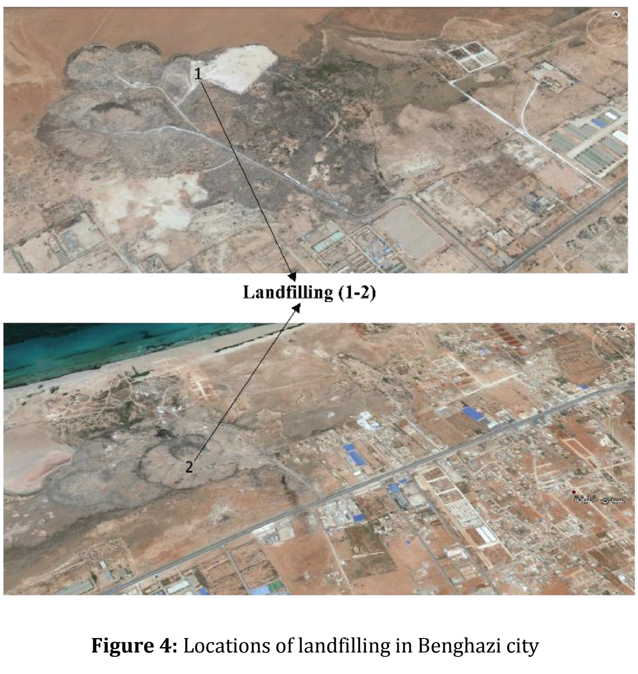


Figure 4: Locations of landfilling in Benghazi city

Table 3: Net greenhouse emission reduction in MTCE per ton of material [18].

Materials	Recycling versus Landfilling	Combustion versus Landfilling
Paper	1.01	0.34
Plastic	0.41	-0.26
Glass	0.50	0.43
Wood	0.54	0.08
Textiles	1.97	0.10
Organic	0.12	0.12
Others (Mixed MSW)	0.60	0.18

Table 4: Net greenhouse gases reduction in MTCE per ton of MSW material for the Two scenarios.

Materials	Waste Composition %	Mass Burn with Recycling MTCE/ton of MSW	Mass Burn MTCE/ton of MSW
Paper	13.5	0.13	0.04
Plastic	10.3	0.04	-0.02
Glass	2.6	0.01	0.01
Wood	2.8	0.01	0.00
Textiles	10.8	0.21	0.10
Organic	56.3	0.07	0.07
Others (Mixed MSW)	3.7	0.02	0.00
TOTAL (MTCE/ton of MSW)		0.49	0.2

The potential land saving in comparison to landfilling for Mass Burn with Recycling and Mass Burn scenarios was calculated up to the year 2030 and presented in Figure 5. The figure shows a need for about 9.6 hectare (ha) per year of landfill area for complete landfilling of MSW in 2030. This will add a tremendous pressure on Benghazi land resources. The implementation of Mass Burn scenario will reduce the landfill area requirement to about 0.96 ha while the Mass Burn with Recycling scenario will reduce landfill area requirement to about 0.57 ha in 2030.

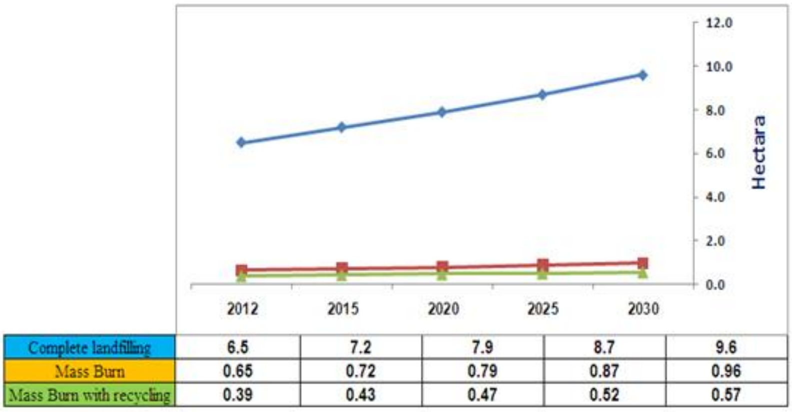


Figure 5: Landfill area requirements complete landfilling and for the two scenarios.

7. CONCLUSION

The MSW practices in Libya are simply done by collecting waste and disposing it off by dumping it in open landfill sites. This practice has created a chronic MSW disposal problem in the Libya. WTE as a potential renewable energy source that can contribute to electricity demand in the Libya and alleviate the MSW disposal problem. This research has assessed the potential contribution of WTE facility to meet electricity needs in the Benghazi city and provided a solution to landfills sites problem. Scenario for WTE were developed and analysed: Mass Burn. The scenarios were forecasted up to year 2030. The research results show that Mass Burn Scenario has the power generation capacity. Additionally, provide a viable disposal option for MSW and, if implemented, will alleviate the landfills problem in the area.

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