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WASTE-TO-ENERGY POTENTIAL IN TRIPOLI CITY-LIBYA

Monaem Elmnifi[1*], Moneer Amhamed[2], Naji Abdelwanis[3], Otman Imrayed[4]

[1]Joife Company of oil technology, Benghazi, Libya
[2]Electrecity Company, Elmarj, Libya
[3]Department of Mechanical Engineering, Omar Al-Mukhtar University, Libya
[4]Department of Electrical & Electronics Engineering, Sirte University, Libya
**Corresponding Author Email: monm.hamad@yahoo.com*

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ABSTRACT

Tripoli City, the Capital of the Libya, has experienced far-reaching changes in spatial and socio-economic patterns during the last few decades, supported by crude oil revenue. The changes have produced far-reaching increase in municipal solid waste (MSW) generation and electricity demand. Open landfilling is the dominant method of MSW disposal in the city. This research aims to assess the value of Waste-to-Energy (WTE) facility as a solution to MSW landfill problem and as a renewable source of electricity. two WTE scenarios were developed: complete incineration; incineration with recycling. The results show that Tripoli has the potential to produce about 57 MW of electricity based on incineration scenario; about 32 MW based on incineration with recycling scenario; in 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

Tripoli City has experienced changes in spatial and socio-economic patterns during the last few decades. Based on the economic growth due to oil reserves, there has been a rapid growth in population and urbanization [1]. Populations, urbanization growth, the rise in the standards of living have all dramatically accelerated the MSW generation in City [2,3]. Demographic distribution in Libya is concentrated in Tripoli, the Western Province and the Eastern Province, as they are commercial hubs and businesses tend to proliferate in urban areas.

Tripoli is the capital of Libya and has a current population of around 1,3 million [4, 5]. The long-term average population growth is about 2.2%. MSW management is a challenging chronic problem in Tripoli City [1]. Developing countries were not able to cope with the MSW generation growth and open landfills remains the dominant method of disposal [6]. The current municipal solid waste management system in Tripoli is simple: collect and get rid of it by dumping it in open landfill sites [1]. The substantial quantity generated by MSW and the high energy contents of its composition demonstrate the significant potential for WTE facilities in the City [7].

1.2 WTE technologies

The conventional forms of energy generation either for thermal or electrical use are under continuous pressure due to detrimental environmental impacts and thus the deployment of renewable energy resources in the energy market has become adamant. WTE provides a cost-effective solution to both energy demand and MSW disposal problems. WTE utilizes three main path ways: thermochemical, physicochemical and biochemical processes (Figure 1) [8].

There are primarily five WTE technologies widely used and implemented for MSW management namely: incineration with energy recovery, pyrolysis or gasification, plasma arc gasification, refused derived fuel (RDF) and bio methanation. In this study, tow technologies were considered for analysis: complete incineration; incineration with recycling. Incineration is the production of energy from waste through combustion [9,10]. Incineration has remained to be the most integral part of MSW management in many countries. RDF is a clean and efficient method of producing an eco-friendly and an alternative fuel for power generating industries, which runs on coal fuel [11]. Bio methanation converts the Organic Fraction of Municipal Solid Waste (OFMSW) into useful energy [12].

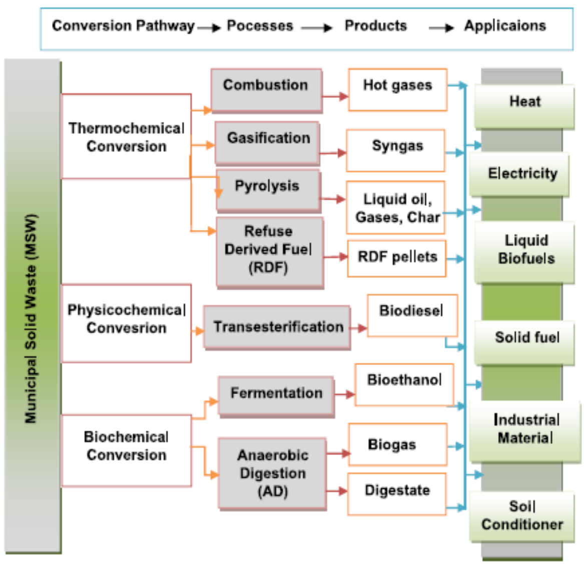


Figure 1: WTE technologies based on their conversion process

2. OBJECTIVE AND METHODOLOGY

This paper aims to assess the value of Waste-to-Energy (WTE) facility as a solution to MSW landfill problem and as a renewable source of electricity in city. two scenarios were considered: complete incineration;

incineration with recycling. The complete incineration scenario implies full utilization of MSW for WTE production. Incineration with recycling assumes removal of all potentially recyclable materials from the waste stream and utilizing the remaining MSW for WTE production.

The year 2012 was chosen as the starting year for forecasting. The MSW production rate was assumed to be 1.3 kg/capita/day [4,5]. The population growth is projected to maintain its historical trend of 2.2% for year up to the year 2030 and MSW total generation for Tripoli city was forecasted accordingly. The calorific energy content of the various types of waste is listed in Table 1 [13]. These measures were used to calculate the total energy content per kilogram of municipal waste. There are a number of developed and emerging technologies that are able to produce energy from waste. The most widely used and proven WTE is the process of producing energy in the form of heat and/or electricity from waste sources via combustion [14]. The research literature has documented a combustion efficiency of 25% to 30% for operated WTE facilities in different places across the globe and around 18% for RDF, Methane conversion to energy is reported to be around 30% [15, 16].

Table 1: Energy content of different components of solid wastes.

Type of waste	Energy content (Btu/lb)
Mixed paper	6800
Mixed food waste	2400
Mixed green yard waste	2700
Mixed plastic	14,000
Rubber	11,200
Leather	8000
Textiles	8100
Demolition softwood	7300
Waste hardwood	6500
Coal	12,300
Fuel, oil	18,300
Natural gas	23,700

2.2 Calculations for heat to power generation potential

In order to evaluate the energy generation potential from MSW, table 1 is used to calculate the lower heating value of the waste by considering the dry solid waste without moisture content. For bulk incineration process the average value of the total waste is considered as a lower heating value while for incineration with recycling, all types of waste that could be recycled are excluded from the calculations. In order to calculate the LHV for this process, the organic waste is excluded from the general stream and the calculations are performed on the remaining waste stream including paper, plastic, glass, wood, textiles and others. The energy recovery potential (GW hr/day), Power generation potential (MW) and Net generation potential (MW) are given by equations (1)-(2)-(3).

$$\text{Energy Recovery Potential (GW hr/day)} = \left(\frac{dry\ wast\left(\frac{tones}{day}\right) * LHV of\ waste\left(\frac{kwhr}{kg}\right)}{1000} \right) \quad (1)$$

$$\text{Power Generation Potential (MW)} = \left(\frac{\text{Dry waste}\left(\frac{kg}{s}\right) * \text{LHVof waste}\left(\frac{kw}{kg}\right)}{1000} \right) \quad (2)$$

Net Power Generation Potential(MW) = η * Power Generation Potential (3)

where η is the efficiency of the process. Efficiency for incineration is taken as 25% [16].

3. RESULTS AND DISCUSSION

3.1 MSW Composition and Quantity Forecast

The waste composition for Libya is tabulated in the table 2 along with the LHV values for each type of waste using the values from table 1. The MSW wastes consists of 56.3% organic materials, 13.5% paper, 10% plastics, 3.7% mineral, 2.6% glass,2. 8% wood, 10.8% textile [17].

Table 2: Libya MSW energy content

Material	Waste composition %	Energy content (Btu/Ib)	KW h/Kg Material	KW h/Kg in Waste HHV
Paper	13.5	6800	4.39	0.58
Plastic	10	14000	9.05	0,905
Glass	2.6	0	0	0
Wood	2.8	7300	4.73	0.132
Textiles	10.8	8100	5.20	0.561
Organic	56.3	2400	1.55	0.872
Others	5.7	5200	3.36	0.191
Total energy for mass Burn with recycling scenario (KW h/kg)				1.443

Total energy contents of mass Burn scenario (KW h/kg)	3.289

The forecasted MSW quantity per year for Tripoli city up to year 2030 is presented in (Figure 2). The figure shows that by the year 2030, about 790 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.

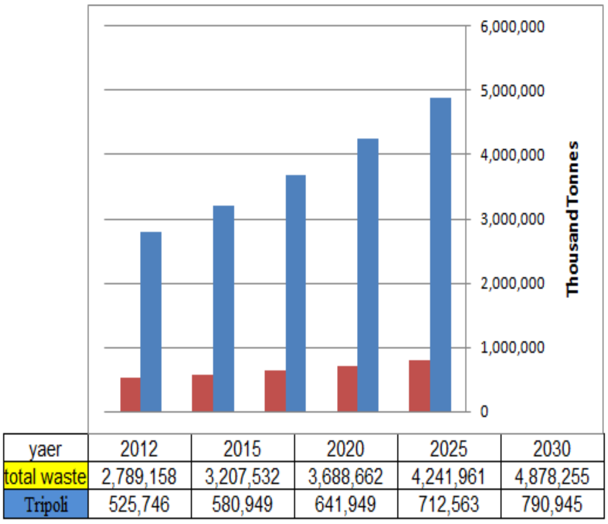
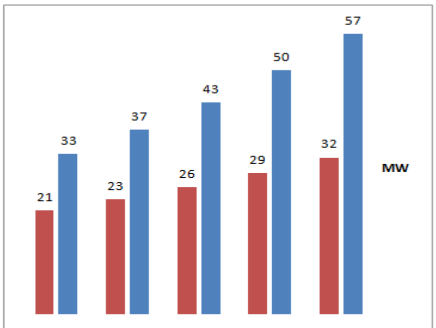


Figure 2: Waste Generation Forecast for Tripoli City up to year 2030

3.2 WTE Scenario results

two scenarios for WTE development were developed and analyzed: complete incineration; incineration with recycling; The forecast results for two scenarios for Tripoli city is presented in (figure 3). The figure shows that for the incineration scenario has a potential to generate about 57 MW in 2030 while incineration with recycling scenario shows a potential to produce about 32 MW in 2030 from Tripoli. The (figure 3) also shows that complete incineration scenario has the highest power generation capacity over the other scenario. Additionally, the two scenarios provide a viable disposal option for MSW and, if implemented, will alleviate the landfills problem in the area. The decision to select among the three scenarios will required further financial, social, technical, and environmental analysis.



yaer	2012	2015	2020	2025	2030
Tripoli	33	37	43	50	57
	21	23	26	29	32

. incineration **. incineration with recycling**

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

4. CONCLUSION

The MSW practices in Tripoli city are simple: collect and dump in the nearest open landfill. This practice has created a chronic MSW disposal problem in City. This research assessed the value of Waste-to-Energy (WTE) facility as a solution to MSW landfill problem and as a renewable source of electricity in Tripoli city. Two scenarios for WTE development were developed and analyzed: incineration, incineration with recycling. The scenarios were forecasted up to year 2030. The research results show that Incineration Scenario has the highest power generation capacity over the other scenario. Additionally, the Two scenarios provide a viable disposal option for MSW and, if implemented, will alleviate the landfills problem in the area.

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