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Assess the Potential Contribution of Municipal Solid Waste Power Generation Facilities in Libya

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Abstract: *The generation of municipal solid waste (MSW) has lately increased as a result of population rapid growth in Libya. However, according to some reported issues, the country's electricity demand and the problem of waste in Libya lies in the lack of good waste management is an important dilemma that needs to solve. As the disposal of all types of waste goes in open dumps, and that negatively affects the environment and increases greenhouse gases. This study gives a brief proposal to use renewable energy, which contains waste-to-energy (WTE) facilities. This paper evaluates the potential contribution of WTE facilities to total maximum energy demand in Libya up to 2030 based on two scenarios: mass incineration and mass incineration with recycling in the whole country of Libya and not just the cities. The analysis shows that a potential of about 197 MW based on the mass combustion scenario and about 57 MW based on the mass incineration scenario with recycling. Moreover, these values are around 0.82% and 0.24% of the expected 2030 peak electricity demand of 24.1 GW. The projected results for each city of the two scenarios can use to design the future WTE facilities in major cities in Libya. Further investigations recommended assessing the two scenarios based on financial, social, technical, and environmental criteria.*

Keywords: *Municipal solid waste, Incineration, Libya, electricity demand, waste to energy*

I. INTRODUCTION

Libya is located in North Africa between latitudes 18 degrees and 33 degrees north and longitudes 9 degrees and 25 degrees east. Libya is one of the oils producing countries in the world, and it has the eighth oil reserves in the world. Oil has contributed extensively both economically and socially over the past four decades to raising the income of the population. This development is accompanied by an increase in population and an increase in living standards for most of the population. Libya's population has increased at an annual rate of 2.2% over the past 35 years. In total, the total population reached 3.2 million in 1984 to about 5.8 million in 2012 [1-2]. This situation has led to the rapid growth of electricity demand in the country from municipal solid waste (MSW) [1-2-3]. This was accompanied by the demographic explosion, also with an increase in the level of urbanization, with the urban population [1-4-5].

Municipal Solid Waste (MSW) is our valuable source of recycled materials and energy. Municipal solid waste has enormous benefits for developing countries like Libya to use to help provide the primary source of energy to reduce oil consumption. [2] Currently, the scope of municipal solid waste practices in Libya is simple. Collect it and dispose of it by burying it in open dumps. In addition, the low cost of landfills makes the implementation of the large MSW recycling program unattainable at present [2]. The only large-scale recycling system that currently exists is waste sorters who collect metal and cardboard from garbage bins. At present, Libya produces about 2.4 million tons of municipal solid waste with an average of 1.3 kg/person/day [6, 7]. In addition, MS waste includes 56.3% organic matter, 13.5% paper, 10% plastic, 3.7% metal, 2.6% glass, 2.8% wood, 10.8% textile [8]. The higher rate of municipal solid waste production is a result of the lack of programs at the community level to promote environmental awareness, encourage the reduction of municipal solid waste generation, and promote recycling. The US Environmental Protection Agency has considered WTE technology as a renewable source of electricity with fewer environmental impacts than almost any other source [9]. WTE reduces the amount of MSW deposited in landfill sites; usually, it reduces the size by 90% and reduces the mass by 80% [10]. Incineration also reduces leachate, methane, and odor emissions. From a global warming perspective, methane is 21 times more harmful than carbon dioxide [11-12]. Many of the landfills in Libya are mature landfills of this large size that are already used by municipal waste deposits. With additional dumping, the number of unwanted by-products such as leachate, municipal waste sludge, methane emissions, and odor reflux, and all the health risks associated with these will continue to increase. There are many studies conducted in Libya for the possibility of evaluating energy production

from waste, and expectations were encouraging and supportive of the waste management process and the electricity production sector [1-2-3]. Six cities were selected for this study in Libya: Tripoli, the capital, 1.108 million, Benghazi 691700, Jabel alkarbi 321400, AL-Marje 195100, Sirte 146300, Gatt 23700.

Electricity Demand

Electricity demand increased on average at an average rate of 8% between 2004 and 2010 [13]. The current peak electricity demand is around 7.7 gigawatts (GW). Peak electricity demand is expected to reach 24 gigawatts by 2030, as shown in Figure 1 [13]. The current demand is usually met by conventional heavy oil, diesel, and gas power plants spread across the country [14]. The Libyan government's vision for future energy resources is to maximize the utilization of science, research, and industries related to renewable energy for peaceful purposes in a way that leads to raising living standards and the quality of life in Libya [13]. In this direction, Libya proposes a brilliant plan to use renewable energy with the addition of a photovoltaic power plant to produce 2 gigawatts in the Ghadames area and the construction of the Derna wind power plant. We propose that this plan include waste-to-energy (WTE) [13].

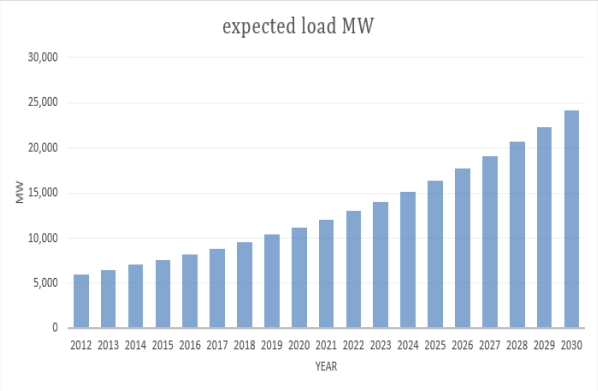


Fig. 1. The peak electrical demand

II. OBJECTIVE AND METHODOLOGY

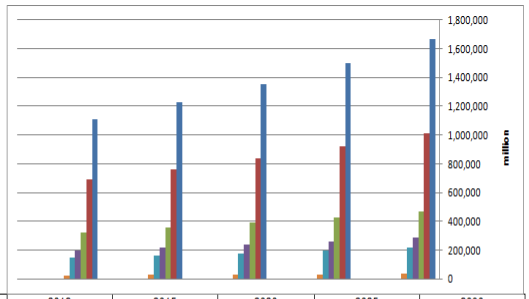
The aim of this research is to assess the potential for waste-to-energy facilities to contribute to reducing the peak energy demand in Libya until 2030. The forecast will be made by conducting an analysis of the potential electricity production in Libya. The analysis will take into account two scenarios for the development of WTE: Mass Burn and Mass Burn with Recycling. The comprehensive incineration scenario involves the full use of MSW to produce solid waste. Mass incineration with recycling assumes the removal of all potentially recyclable materials from the waste. The total amount of electricity generation from municipal solid waste will project for Libya and for the six major cities up to 2030. 2012 chosen as the starting year for the forecast. The caloric energy content of different types of waste listed in Table 1 [15]. These measurements are used to calculate the total energy content per kilogram of Libyan municipal waste. There is a number of promising and recent technologies that are capable of producing 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 by combustion. The research literature has documented combustion efficiencies ranging from 25% to 30% for WTE installations operating in various locations around the world [17]. A combustion efficiency of 25% will be assumed in the WTE account for Libya [18-19].

TABLE 1. ENERGY CONTENT OF DIFFERENT TYPES OF WASTES [12].

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

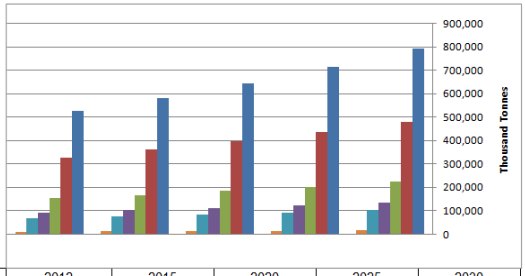
III. RESULTS AND DISCUSSION

According to statistics, the population growth should continue along with the same pattern (2.2% annually) due to the behavior that determines the reproductive nature in Libya and the social and economic customs. There are cities and regions in Libya. The population of these cities and regions varies according to their location in the country. Figure 2. Projections of the Libyan population up to 2030. In 2030, the population of Libya will be twice that of Libya in 2012, of about 10 million. This will also increase and double the amount of solid waste generated. Figure 3 displays the municipal solid waste generated annually for the entire country and for the six cities selected for the study. The amount of municipal solid waste for the year 2012 is estimated to be about 2.7 million tons, and it is estimated that it would reach about 4.8 million tons by the year 2030. A huge amount of MSW must be managed and controlled. Libya's municipal solid waste management system (landfill) will lead to environmental and financial consequences. This confirms that WTE is a futuristic solution and supports recycling as well.



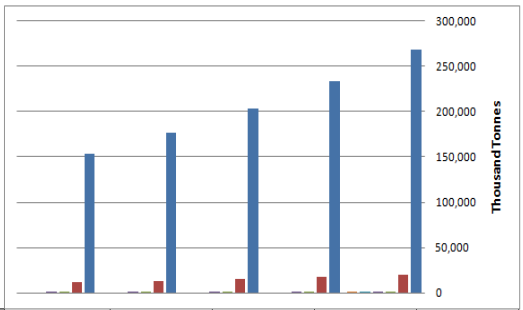
yaer	2012	2015	2020	2025	2030
total population	5,878,100	6,759,815	7,773,787	8,939,855	10,280,833
Tripoli	1,108,000	1,224,340	1,352,895	1,501,714	1,666,902
Benghazi	691,700	760,870	836,957	920,652	1,012,717
Jabel alkarbi	321,400	353,540	388,894	427,783	470,561
ALmarje	195,100	214,610	236,071	259,678	285,645
Sirt	146,300	160,930	177,023	194,725	214,197
Gatt	23,700	26,070	28,677	31,544	34,699

Fig. 2. The Libya population forecast results.



yaer	2012	2015	2020	2025	2030
total waste	2,789,158	3,207,532	3,688,662	4,241,961	4,878,255
Tripoli	525,746	580,949	641,949	712,563	790,945
Benghazi	328,212	361,033	397,136	436,849	480,534
Jabel alkarbi	152,504	167,755	184,530	202,983	223,281
ALmarje	92,575	101,832	112,016	123,217	135,539
Sirt	69,419	76,361	83,997	92,397	101,636
Gatt	8,651	12,370	13,607	14,968	16,465

Fig. 3. MSW generation forecast results.



yaer	2012	2015	2020	2025	2030
total waste	2,789,158	3,207,532	3,688,662	4,241,961	4,878,255
paper	153,404	176,414	202,876	233,308	268,304
plastic	11,505	13,231	15,216	17,498	20,123
glass	380	437	502	577	664
Textiles	5	6	7	8	9

Fig. 4. MSW recycled materials forecast results.

TABLE 2.LIBYA MSW ENERGY CONTENTS

Material	Waste composition %	Energy content (Btu/lb)	KW h/Kg Material	KW h/Kg in Waste HHV
Paper	13.2	6800	4.39	0.58
Plastic	10	14000	9.05	0,905
Glass	2.6	0	0	0
Wood	0.8	7300	4.73	0.38
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)				3.489

A. Recycle Materials

Municipal waste contains many valuable materials that can be recycled at a good price, including plastic, wood, paper, metals, and textiles. To obtain sufficient data on the potential for recycling, the quantity generated from these produced materials predicted and shown in Fig. 4. The values in the figure below illustrate the potential for recycling and material recovery. The option to recycle or burn mass materials will require verification and assurance of financial and environmental impacts.

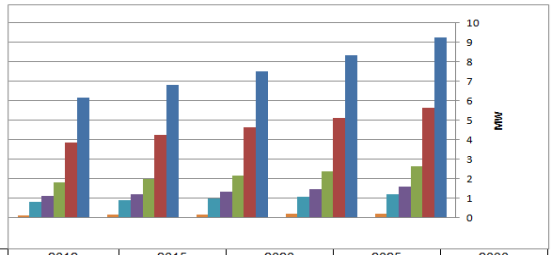
B. MSW Power Contents

The energy level in solid waste was determined based on the caloric content of MSW materials (Table 1) and the MSW composition. Table 2 shows the energy contents in kilowatts per kilogram of solid waste. Two values of energy contents per kilogram of MSW were calculated for the mass combustion scenario and the mass incineration scenario with the recycling scenario. The comprehensive incineration scenario includes the full use of municipal solid waste to produce solid waste without recycling and the energy rate estimated at 3,489 kWh / kg. The total combustion with recycling scenario assumes that all potentially recyclable materials sifted from the waste and the remaining MSW used to produce the solid waste. The energy content for a mass incineration scenario with recycling is estimated to be 1.443 kWh / kg. The significant difference between the energy contents in the two scenarios resulted from the removal of materials with higher energy content (paper, wood, plastic, textiles) from the burning scenario and considering them for recycling purposes.

C. WTE Production Forecast

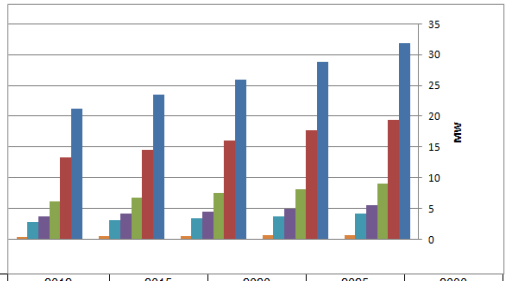
The projected population statistics, as well as the municipal solid waste projections, were relied on to estimate the waste production potential in Libya. The production potential of WTE is calculated for two scenarios. Figure 5 displays the predictions results for mass combustion with recycling scenario. The figure shows the potential to produce about 57 megawatts of electricity from the municipal solid waste by 2030. This value represents about 0.14% of the peak electricity demand of 24.1 gigawatts, in 2030. The city's potential production results show that Tripoli has the greatest potential of 9 MW and that the minimum potential is for Sirte at about 1 MW by 2030. Figure 6 presents the results of the total combustion scenario. The capacity to produce about 197 MW of electricity from municipal waste by 2030. This value constitutes about 1.73% of the peak electricity demand of 24.1 GW for that station. The results of the projections for all cities are consistent with two scenarios for the cities of Libya. There is a clear difference

between the productions of potential energy in the two scenarios.



yaer	2012	2015	2020	2025	2030
total waste	33	37	43	50	57
Tripoli	6	7	8	8	9
Benghazi	4	4	5	5	6
Jabel alkarbi	2	2	2	2	3
ALmarje	1	1	1	1	2
Sirt	1	1	1	1	1
Gatt	0	0	0	0	0

Fig. 5. Mass Burn with recycling scenario results.



yaer	2012	2015	2020	2025	2030
total waste	113	130	149	171	197
Tripoli	21	23	26	29	32
Benghazi	13	15	16	18	19
Jabel alkarbi	6	7	7	8	9
ALmarje	4	4	5	5	5
Sirt	3	3	3	4	4
Gatt	0	0	1	1	1

Fig. 6. Mass Burn scenario results.

IV. CONCLUSION

The research assesses the potential contribution of waste utilities to energy to the total peak energy demand in Libya up to 2030. The potential contributions assessed by conducting a quantitative predictive analysis of WTE electricity production up to 2030. The analysis took into account two scenarios for the development of WTE: Mass Burn and Mass Burn with recycling. The two scenarios considered for the entire country and the six cities. The combustion and recycling scenario results show an expected energy production of around 57 MW of municipal solid waste by 2030. This value constitutes
About 0.24% of the peak electricity demand of 24.1 GW in 2030. The combustion scenario results show a projected production of about 197 MW of WTE energy, which is about 0.82% of the projected electricity demand for 2030. Expected results for each of them, one of the two scenarios can be used to design a future WTE facility in major cities in Libya. Mass Burn scenario could produce 5 times more electricity for WTE than Mass Burn scenario with recycling scenario. Several investigations recommended that would compare the two options in terms of technical, environmental, and financial parameters. Social and economic research must take into account the cost of producing polluted waste, recycling, land, as well as choosing the best way to convert waste into energy to apply in Libya.

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