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Economic and Environmental Value for Electrical and Electronic Waste Recycling in North African Countries

Monaem Elmnifi[1]
Department of Mechanical Engineering, Bright Star University, Libya

Hazim Moria[2]
Department of Mechanical Engineering Technology, Yanbu Industrial College, Yanbu Al-Sinaiyah 41912, Kingdom of Saudi Arabia

Alzaroog Emhamed[3]
Department of Electrical Engineering,
Bright Star University, Libya

Mohammed Alsaker[4]
[5]Department of Chemical Engineering,
Bright Star University, Libya

Moneer Amhamed[5]
[4]Electrecity Company,
Elmarj, Libya

***Abstract* — Population and urbanization in the region of North African Countries (NAC) have increased quickly, with significant improvements in living standards in the last four decades. The Electronic Waste (EW) increases significantly in this fortune. This paper reviews the current NAC drill of EW product management including quantities of EW generation, disposal, and reuse/recycling practices; EW generation forecasts up to 2035, based on two scenarios: low and high; and discusses the long-run potential for EW in the NAC region. The assessment demonstrates that the entire low, high EW generation will be around 1982 and 3568 in 2035. The findings showed that to tackle future environmental concerns and optimize the economic opportunity inherent in EW the EW management laws in the NAC field need to be thoroughly assessed.**

Keywords — Economic Value; Environmental Value; Electronic Waste; Electrical Waste; North African Countries

I. INTRODUCTION

North African Countries (NAC) has experienced a growth in population along with urbanization and living touchstone. This leads to a substantial increase in waste products of all types, including but not limited to, electronic waste [1]. The developments in engineering science combined with throw-away and annual upgrading of electronic device result in shorter life-spans of electronic waste. Appropriate electronic waste management and recycling is a real challenge for both development and development [2]. However, the issues regarding electronic waste in developing countries are significant due to the lack of regularization and adroitness. Electronic waste includes all electrical and electronic equipment discarded by end users, and are not meant to reuse [3,4]. Electronic waste is categorized into different classifications, and its percentages include tiny IT and telecommunications systems 8.72%, small electrical appliances 37.58%, screens and monitors 14.76%, big electrical appliances 36%, lights 1.57%, and heating and freezing equipment 17% [2]. These devices as electronic waste contain a range of materials such as plastic, wood and plywood, spyglass, ferrous and non-ferrous metals, ceramics and rubber, and printed circuit boards. The iron sword has a 50% of electronic waste, 21% of electronic waste contains plastic, and 13% contains non-ferrous metals including aluminum, pig and valuable metals including gold, platinum, silver, palladium, and others [5]. Electronic waste also includes hazardous materials such as mercury, arsenic, lead, selenium, hexavalent chromium, cadmium, and flame retardants that sometimes exceed acceptable rates of room access [6,7]. The global electronic waste material yield in 2016 was calculated to be about 44.7 million metric tons, and around 20% of this sum of money was recycled through proper and regulated recycling outline [2]. The global electronic waste in 2017 was estimated to be around 46 million metric tons and projected to exceed 52.2 million metric tons by 2021. This production of electronic waste worldwide is divided as follows; 40.7% generated by Asia, 27.52% was produced by Europe, 25.28% generated in U.S. (South America 6.71%, Central America 2.68%, and Magnetic north America 15.67%, 4.92% generated in Africa, and 1.57% generated in Oceania [2]. The world population is estimated to surpass 9.6 one thousand million persons by 2050 [8]. This population increase will upsurge waste and electronic waste and thus complicate the situations for all country to regulate and monitor the efficient execution of electric waste recycling. Previous studies have indicated that higher waste per capita exists in countries with higher income as compared with low-income body politic [9]. The correlation between revenue degree and urbanization with the quantity of waste, including electronic waste, is obvious and documented [10]. Have anticipated global per capita electronic waste manufacturing, including fellow NAC member states. This paper reappraisal the current EW management practices in NAC including EW generation measure, disposal, and reuse/recycle methods; prognosis EW generation up to the year 2035 based on two scenarios: low, and high. Also, it describes the environmental and financial values of EW in the NAC Region as regards its long-term potential.

II. NAC ELECTRICAL WASTE

The United Nations University (UN) estimates that national EW generation in Africa was roughly 2.2 Mt in 2017, with contributions from Egypt (0.5 Mt), South Africa and Algeria (0.3 Mt each) ranking highest. The top three African nations with the largest generation of e-waste per inhabitant are

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Seychelles (11.5 kg /in), Libya (11 kg /in), and Mauritius (8.6 kg /in). As illustrated in Figure 1, there is currently little information on the amount of e-waste documented that is collected [2]. Waste generated in Egypt by electrical and electronic equipment (WEEE) is managed by waste traders and waste collectors. A success full WEEE management system such as Switzerland’s is in most cases market driven and self-organized. Among the key limitations in such a comparison is that although the bulk of E-waste is growing in Egypt and the rest of the Arab countries, it is still not high enough to attract huge investments. Instead, the current system consists of private-private relationships among recycling enterprises, wholesalers, dealers, itinerant buyers, and waste pickers. These relationships are driven by financial profit and not social or environmental awareness [11]. The 2006 EW and recycling assessment by Algeria disclosed that the waste amounts that are accessible and the capability of current installations are not linked. Egypt may be the WEEE leadership precursor in the region. Egypt's E-Recycling Co. (EERC) is the country's first WEEE recycling plant and, while still low inability, is the increasing e-waste prominent in environmental protection. A new business, spear ink, developed environmentally friendly toner and inkjet replenishment equipment that are regarded as industrial models [11].

Morocco conducted its first EW and EW leadership programs evaluation nationwide in 2007. It has further facilitated the set-up, in comparison to the other people in high-income economies, of EW managed and CMPP processing plants. The EW Collection project called' Green CHIP for digital equipment used, is run by Managem, Al-Jisr, and CMPP as well. Tunisia holds an annual ability of 1000 tones, of EW, obtained and transported to recycling installations, such as the ones managed by the National Waste Management Agency ANGED [11].

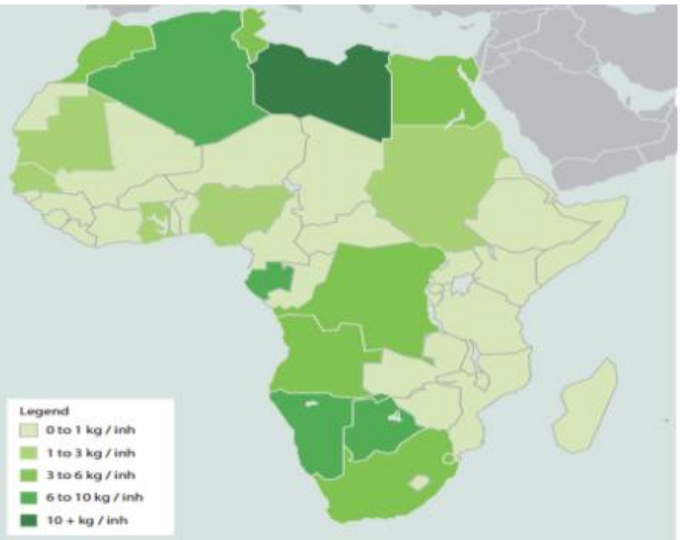


Fig. 1. : Electrical waste generation in Africa [2]

III. EW PRODUCT GENERATION FORECAST

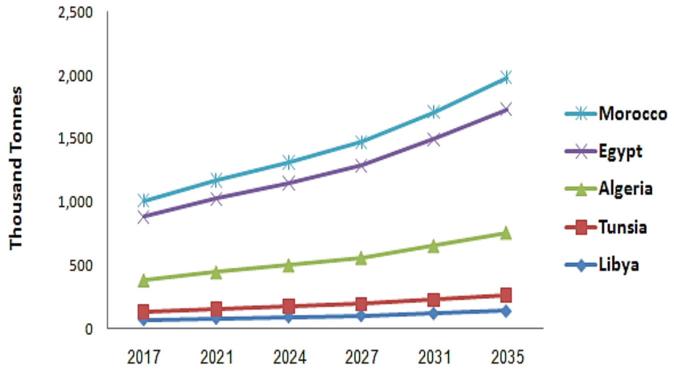
The United State Environmental safeguard agency has estimated a yearly increase image from 5% to 10% in EW generation to occur worldwide due to increasing in-universe and touchstone of living, and advances in technology. NAC neighborhood will be no exception and is expected to be in the higher range of maturation. Two scenarios for a generation were created to know the magnitude and importance of wastefulness: low and high. The scenarios are based on 4% and 8% development in a waste generation for both low and high. Based on EW generation data for the year 2017, as shown in table1, the EW generation rate for each country up to the year 2035 was forecasted.

TABLE I. NACEW GENERATION IN 2017 [2]

Country	Population Million	E-waste per capita, kg	Total, tons × 103
Libya	6.375	11	70
Tunisia	11.53	5.6	63
Algeria	41.32	6.2	252
Egypt	97.55	5.5	497
Morocco	35.74	3.7	127
Total E-waste in NAC			1009

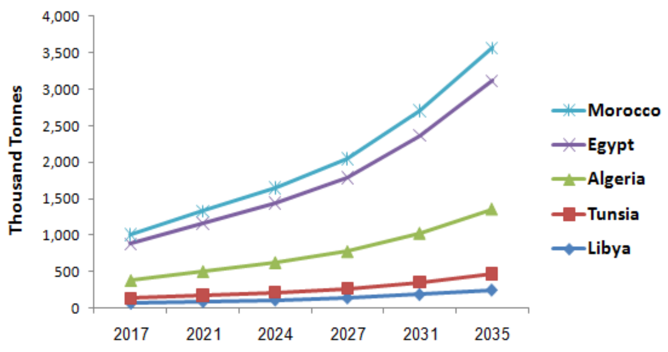
IV. RESULTS AND RESULTS

The following formats illustrate the expected results based on the proposed scenarios. The expected outcomes of the scenes reflect the size of the EW problem in North African countries, but at the same time, highlight their potential economic values. The total generation of EW for low and high scenarios by 2035 will be around 1982 and 3568 thousand tons, respectively. These are significant amounts, and if any of the proposed situations occur, they can either lead to significant economic value, if well managed, or environmental impacts on the operators and population of the region.



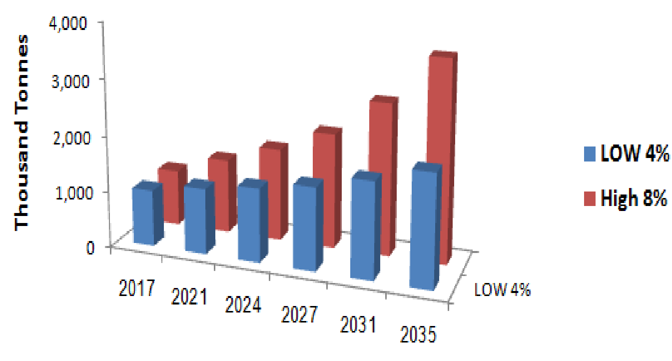
cuntry / yaer	2017	2021	2024	2027	2031	2035
Libya	70	82	93	104	121	140
Tunsia	63	73	82	92	107	124
Algeria	252	292	327	366	425	493
Egypt	497	577	646	724	840	974
Morocco	127	147	166	186	216	251
LOW 4%	1,009	1,171	1,314	1,472	1,709	1,982

Fig. 2. Low Scenario Results



cuntry / yaer	2017	2021	2024	2027	2031	2035
Libya	70	92	114	141	186	246
Tunsia	63	83	103	128	169	223
Algeria	252	333	413	512	676	892
Egypt	497	656	813	1,008	1,331	1757
Morocco	127	168	208	258	341	450
High 8%	1,009	1,332	1,651	2,047	2,703	3,568

Fig. 3. High Scenario Results



yaer	2017	2021	2024	2027	2031	2035
LOW 4%	1,009	1,171	1,314	1,472	1,709	1,982
High 8%	1,009	1,332	1,651	2,047	2,703	3,568

Fig. 4. Total EW Generation

The above results show that North African countries are expected to produce large amounts of waste, even with a 4% annual increase, which is considered low. The increase in per capita income from the North African countries indicates that the yearly increase in EW generation will likely be at an annual level of 8%. This is a significant problem and will put the responsibility of the governments of the region to take immediate action to combat the issue of EW now when the issue remains manageable.

The material in electronic EW product globally was estimated at quintuplet 5 billion Euro s in 2016, and the global electronic waste production was 44 Mt [2]. The NAC portion based on the determined output of 1009 Kt would be 1.651% of which is 1207.6 million Euros. This is equivalent to 1,199. 86 Euro per long ton of electronic waste. This number will be a pivotal value used in the economic appraisal of electronic waste in NAC countries. Using this number as a base of calculation, the potential economic value of electronic waste up to the year 2035 as shown in table 2 and 3 for the low and high scenario, respectively.

Based on the fact that the EWs in the NAC countries are not quantified and segregated, the economic value of e-waste cannot be correctly estimated. This study showed enormous economic value in e-waste in NAC, given the presumptions connected with Scenario's e-waste forecasting. The total estimated economic value of e-waste in the North African countries during 2017 for the low scenario is 1177 million Euros (see table 2). The highest economic value was obtained in 2017 in Egypt, worth EUR 580 million. The overall Economic cost in North Africa is projected to amount to EUR 2309 million by 2035, of which Egypt (EUR 1134 million), Algeria (EUR 575 million), Morocco (EUR 293 million) and Libya (EUR 163 million) will include Tunisia (EUR 144 million), as illustrated in Table 2 and 3.

TABLE II. EXPECTED ECONOMIC VALUES OF EW TO 2035 IN NORTH AFRICAN COUNTRIES FOR LOW SCENARIO

Years	Libya	Tunisia	Algeria	Egypt	Morocco
2017	82	74	293	580	148
2021	96	85	340	672	171
2024	109	96	381	752	193
2027	122	107	426	843	216
2031	141	125	495	978	252
2035	163	144	575	1134	293
Total	713	631	2510	4959	1273

TABLE III. EXPECTED ECONOMIC VALUES OF EW TO 2035 IN NORTH AFRICAN COUNTRIES FOR HIGH SCENARIO

Years	Libya	Tunisia	Algeria	Egypt	Morocco
2017	83	76	298	590	150
2021	97	86	345	683	174
2024	111	97	387	764	196
2027	124	108	433	856	219
2031	143	127	501	994	256
2035	165	146	584	1152	297
Total	723	640	2548	5039	1292

EW poses significant health and environmental risks that are not directly impacted by the presence of heavy metals, persistent organic pollutants, flame retardants, and other hazardous substances. However, some EW also contains high-value materials such as gold, silver, copper, platinum, iron, aluminum, indium, gallium, and other precious metals. One ton of mobile phones contains 3.5 kg of silver, 0.34 kg of gold, 0.14kg of palladium, and 130 kg of copper valued at the US $ 15,000 [12]. The value of the recycled desktop is estimated at 8.61 EUR, according to the market price of the materials [13]. The study showed that not much had been done by North African countries to address the issue of EW so far.

V. ENVIRONMENTAL IMPACT OF ELECTRONIC WASTE

In informal and unregulated African nations, nearly all e-wastes are processed, and in unregulated land, dangerous substances arising from disassembly are disposed of straight into the soil. Tables 4 shows the average material composition of four electric appliances. In addition to burning wires and copper cables, screen and television covers, which mainly contain polychlorinated compounds containing Chlorofluorocarbons (CFCs) or old tires, are fuel for fire, contributing to acute chemical hazards, long-term contamination at sites of combustion, and emission of ozone-depleting substances Ozone and greenhouse gases, as well as health risks. Although electronics and telecommunications businesses are responsible for a significant quantity of the continent's electronic waste, they have no plans (present or future) to securely dispose of it after its expiration. It is located in the city of Accra, Ghana, the world's most massive e-waste dump, which emits thick columns of burning smoke, aimed at extracting copper and aluminum, with large amounts of toxic dioxins. However, most of the burning and recycling work is carried out by young people Children [13]. Greenpeace revealed high levels of heavy metals in soil samples in discharge areas, especially lead, at concentrations 100 times higher than normal levels, exacerbating the crisis by raising cattle, goats, and chickens on plants that grow in these soils [14]. A survey conducted in Sudan revealed that (72%) of the workers in the field of communications are unaware of the dangers of e-waste, some (29%) do not care about the damage, and (84%) do not know who is responsible for protecting people from them [15,16].

TABLE IV. AVERAGE MATERIAL COMPOSITION OF FOUR ELECTRIC APPLIANCES

Materials	TV Set	Refrigerator	Washing Machine	Air Conditioner
Iron (plus alloy)	7.9	49	55.7	45.9
Copper (plus alloy)	1.5	3.4	2.9	18.5
Aluminum (plus alloy)	0.3	1.1	1.4	8.6
Other alloy	1.4	1.1	0.5	1.5
Plastics	16.1	43.3	34.7	17.5
Glass	62.4	0	0	0
Gas (cfc/others)	0	1.1	0	2
Circuit Boards	8.1	0	1.5	3.1
Others	0.5	1	3.3	2.9
Total	100	100	100	100
Breakdown of plastics (mass ratio %)				
Polypropylene (PP)	8.9	24.7	76.5	21.2
Polystyrene (PS)	84.5	26.3	6.2	31.9
Acrylonitrile Butadiene Styrene (ABS)	1.7	16.3	3	10.8
Polyvinyl chloride (PVC)	3.2	7.9	5.7	10.6
Others	1.7	24.8	8.6	25.5

VI. ENVIRONMENTAL IMPACT OF ELECTRONIC WASTE

EW management in North African countries needs to be thoroughly modified to minimize their environmental impacts and increase their economic value. The amendment should begin with new regulations with useful tools for implementing best practices for EW management, such as government incentives to promote EW recycling. In addition to the implementation of initial programs such as recovery programs and other programs that provide incentives to users to provide their end-of-life electronic waste to the companies or government institutions that will ensure them are placed through the appropriate recycling process. The study of EW in North African countries is emerging area of study requires Conduct research on obtaining reliable data on the amount of EW produced in individual North African countries and the possibility of companies entering the market in the region. Waste Recycling. The potential of modern recycling plants depends on the data that can be generated to determine the amount of e-waste produced. The findings of the study highlight the need for a comprehensive research program to assess EW in North African countries.

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