

Challenges and Proposed Solutions toward Successful Dealing with E-Waste in Kuwait

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Abstract—Kuwait, like many parts of the world, has started facing the dangerous growth of electrical and electronic waste. This growth has been noted in last two decades, emerging with the development of mobile phones, computers, TVs, as well as other electronic devices and electrical equipment. Kuwait is already among the highest global producers of electronic waste (e-waste) in kg per capita. Furthermore, Kuwait is among the global countries that set high-level future targets in renewable energy projects. Accumulation of this electronic waste, as well as accelerated renewable energy projects, will lead to the increase of future threats to the country. In this research, factors that lead to the increase the e-waste in Kuwait are presented. Also, the current situations of dealing with e-waste in the country as well as the associated challenges are examined. The impact of renewable energy projects on future e-waste accumulation is considered. Moreover, this research proposes the best strategies and practices toward successfully dealing with the waste of electronic devices and renewable energy technologies.

Keywords—E-waste, landfill, environmental management, valuable metals, hazardous materials.

I. INTRODUCTION

ELECTRONIC waste, or e-waste, as other types of waste, has harmful consequences to the environment if it is handled randomly. E-waste is considered one of the fastest growing waste products in the world due to the development of mobile technologies and other types of electronic device production.

Kuwait, as in many parts of the world, has started facing the growth of electrical and electronic waste. This growth has been noted over the last two decades arising with the development of mobile phones, computers, TVs as well as other electronic devices and electrical equipment.

There are many factors that lead to the increase of the solid waste in general and specifically the e-waste in Kuwait. One of the main factors is the type of people's lifestyle in the country. Kuwait is considered one of the highest countries in GDP in terms of Power Purchase Parity per capita, 7th top country in the world according to International Monetary Fund 2017 [1]. This indicator highlights the high consumption ability of the Kuwaiti people, and therefore, the increased rate of producing used product waste.

This research starts with the overview of the waste in Kuwait showing some facts regarding general types of waste generated in the country. The main governmental sectors that are responsible for waste management in Kuwait are described.

Then, the current situation of e-waste in Kuwait is presented as well as the cons and challenges facing it. Furthermore, this study presents proposed solutions that improve dealing with the accumulation of e-waste by establishing a solid infrastructure for e-waste management processes that shows and proposes other stakeholders who should be engaged toward a successful process of dealing with e-waste. Future expectations and next required steps are also discussed here.

II. OVERVIEW OF WASTE IN KUWAIT

Kuwait is the second Gulf country in terms of the level of solid waste production per capita per day after the United Arab Emirates as stated in World Bank Group report [2]. This report stated that solid waste in Kuwait is generated at a rate of more than 1.5 kilograms per person per day. This rate is considered very high compared to the general average per capita production of waste in the world, which is 0.75 kilograms per capita. Solid waste in Kuwait reaches approximately 1.7 million tons per year, according to the data report received from the Kuwait Central Statistics Office in 2018 [3]. The report also showed the types of waste produced in Kuwait in 2016 and 2017. They are classified into seven types of waste as shown in Table I.

TABLE I
TYPES OF WASTE IN KUWAIT [3]

Waste Type	2016	2017	Calculated Yearly Change Rate
Household Solid Waste (ton)	1567965	1696923	+ 8.2%
Construction Waste (ton)	11810325	15851493	+ 34.2%
Commercial Waste (ton)	353808	437832	+ 23.7%
Agricultural Waste (ton)	403431	437832	+ 8.5%
Liquid Waste (gallon)	406409000	422955437	+ 4.1%
Medical Dangerous Waste (kg)	3890370	4955389	+ 27.4%
Tire Waste	3691191	19365789	+424%

From Table I, it is noted that e-waste is not specifically classified solely among other waste types in Kuwait. That means the country deals with e-waste as part of solid waste that can be considered among the household solid waste and commercial waste even though Kuwait announced the signing of the Basel Convention on April 7, 2006 [4]. In 2002, the Basel Convention included provisions related to electronic and electrical waste within the agreement that concern the control of the transboundary movement of hazardous waste and its disposal, since electronic waste is a hazardous waste [5]. It is

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also noted from Table I that household solid waste and commercial waste has increased from 2016 to 2017 by the rate of 8.2% and 23.7% respectively.

In Kuwait, there is three main sectors that deal and take actions toward waste in general. These sectors are as Fig. 1.



Fig. 1 Main sectors that deal with waste in Kuwait

A. Kuwait Municipality

Kuwait Municipality (KM) was established in 1930 [6]. Its role toward waste is very vital. KM is concerned with solid, semi-solid and liquid waste, which result from residential and commercial waste, in addition to animal and agricultural waste. Some types of industrial waste (non-hazardous) can be taken care of by the municipality through an arrangement with the Public Authority of Industry. The main actions that the municipality takes are specifying landfills, collecting waste, transporting and dumping them in public landfills. So far, 13 public landfills have been closed since they have reached capacity or because of the emergence of serious environmental and health problems while currently, there are three active landfills [7]. Unfortunately, these landfills do not meet the criteria of sanitary landfills since they generally bury the waste in certain areas in the desert [7].

B. Public Authority for Industry

The Public Authority for Industry (PAI) was established in 1997 to be an independent body supervised by the Minister of Trade and Industry [8]. One of its important roles is focused on monitoring factories in cooperation with the Environment Public Authority in terms of the limits of the percentage of produced gases and carbon emissions as well as monitoring how to dispose of their waste resulting from manufacturing processes.

The PAI obliges factories to estimate their annual industrial waste at specific weights. Therefore, these wastes must be delivered at specific locations determined by the KM and whose specifications are determined by the Environment Public Authority. These wastes are supervised and monitored by the PAI, which also has the authority to approve private recycling

plant licenses. Currently, Kuwait has only a small number of waste management companies and recycling plants.

C. Kuwait Environment Public Authority

The Environment Public Authority (EPA) is a governmental body established to achieve Kuwait's vision in environmental affairs; especially after the terrible pollution that Kuwait was subjected to during the brutal Iraqi invasion in 1990, in which mainly crimes were committed by burning oil wells [9]. The role of the EPA is to set and implement the general policy of the state regarding the protection of the environment, as well as to develop strategies and action plans for the protection of the environment. Furthermore, it has the role toward preservation of natural resources and the achievement of sustainable development goals. Also, it prepares studies and specifies actions to face environmental disasters and to develop a comprehensive environmental database for the country.

D. Waste in Kuwait

As noted from Table I, e-waste has been dealt with as part of solid waste in Kuwait. This means that e-waste is mixed and dumped in landfills with other organic and solid waste. This action allows for the negative chemical reactions of the different waste materials that cause harmful environmental consequences.

Main concerns of the danger of electronic waste are their negative effects in the health and environmental aspects since they contain more than a thousand of materials. Many of these materials have toxic components, from plastics and heavy metals such as lead, cadmium, and mercury. These components and metals can cause serious health complications to humans' body and pose a danger to the environment due to their

accumulations in plants and animals in general [10]. Our concern about e-waste is not limited to its environmental and health dangers, but also to the other concerns that should make us deal seriously with e-waste. These concerns are outlined as follows:

- E-waste comprises of many different materials. Some of these consist of precious metals as well as ferrous and non-ferrous metals; thus, high revenue can be earned from recycled e-waste.
- Most of this e-waste contains confidential information whether individual information or institutional secret information.

Globally, growth rates of e-waste accumulation are increasing annually at a rate of approximately 4% [11]. E-waste was approximately 44.7 million tons in 2016, and it is expected to reach 52.2 million tons in 2021 [12]. We believe that the rapid growth of e-waste is due to the different cases when dealing with electronic devices. An electronic device can be considered waste when it fits one of following cases:

- When it becomes broken and damaged.
- When it reaches the end of its lifetime and does not work properly.
- When a consumer buys a new electronic device but keeps the old one in the storage or just throws it away even though it is still functioning.

Kuwait is the top country among Gulf Council Countries (GCC) with the highest amount of annual production per capita of electronic waste at a rate of 17.2 kg, equal to that of the United Arab Emirates [13]. In 2016, e-waste production had been estimated to be 66.8 kilo tons in Kuwait. This amount of e-waste is very high however Kuwait does not have any established and systematic procedures to overcome this growing issue. Currently, Kuwait does not have government- or private sector-run e-waste recycling plants. While Kuwait has some private waste management companies, they do not recycle waste and instead they collect certain types of e-waste and export it overseas to recycling plants. The current case for dealing with e-waste in Kuwait is represented in Fig. 2.

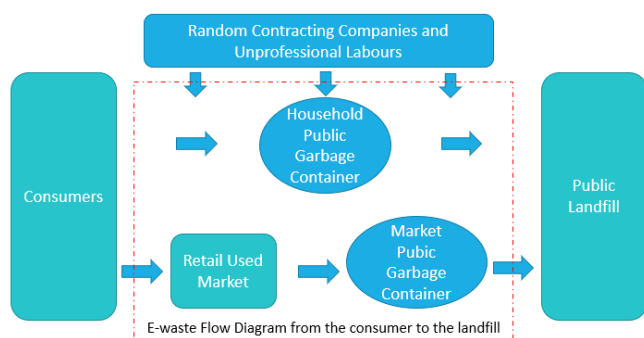


Fig. 2 Current case of dealing with e-waste in Kuwait

It is noted in Fig. 2 that the destination of any e-waste in Kuwait is the public landfill where it is mixed with other different waste. Fig. 2 shows that consumers consist of both individuals who are dealing with e-waste at home, as well as private and public institutions.

It can be seen in Fig. 2 that some waste created by electronic devices in Kuwait is sent to the retail used market. This market usually takes some small functioning electronic parts of electronic devices waste while the remainder is sent to the market public garbage. E-waste that are mixed with other types of waste are transported from household garbage and market garbage into a mixed public landfill.

Here in Kuwait, there are no government recycling plants. Furthermore, there are no organized schemes that can control the pathways of electronic devices' life cycles that are started from the selling agent until reaching the phase of unwanted product and became a waste. There are unfortunately no electrical and electronic devices factories and manufacturers in the country that produce electronic devices. When a country has many electronic device manufactures, these manufacturers can provide effective schemes to encourage consumers to return and exchange their old electronic devices.

There are some local contracting companies who focus on collection of some parts of the e-waste from the retail used markets and household garbage containers to export overseas to specialist e-waste recycling plants. While this practice can generate some profits for these companies, it is not productive in terms of the recycling of e-waste for the country for two main reasons. First, most of these companies are dismantling certain types of electrical appliances waste manually and randomly. Furthermore, they do not have professional recycling facilities in dealing with the risk of leakage of hazardous materials into the soil as well as the emission of toxic gases.

Second, exporting valuable e-waste parts overseas will deprive the country from benefiting from the production of raw materials, whether they are precious metals or base metals. That may result in depriving the country of the opportunity of improving the local economy as well as providing job opportunities.

III. PROPOSED PROCESS SOLUTION OF THE E-WASTE CYCLE IN KUWAIT

The main objective for improving the ways of dealing with e-waste is to achieve the following main goals:

1. E-waste treatment contributes to improving the local economy through the extraction of raw metals and thus enables the establishment of local factories for the formation of metals. Thus, it contributes to reducing the quantities of metals imports from abroad.
2. Specifying a certain collection area for e-waste will lead to a reduction in the amount of total waste that is taken to the public landfill. It will also lead to a reduction in the effects of toxins and greenhouse gases that would exist with mixing e-waste with other types of waste.
3. Creating a systematic process for e-waste recycling will lead to opportunities of establishing official recycling plants by the government and private sector that would provide professionalism of dealing with confidential information that is usually saved in electronic devices, mainly mobiles and computers. The authorities in Kuwait need to establish systematic processes toward managing and dealing with e-waste. These processes include the

following procedures:

- Applying the 4Rs principle [14]. This principle contributes to **R**educing the volume amount of waste, **R**eselling the functioning parts in this waste, **R**ecycling suitable and valuable materials, and then using the appropriate remaining parts into energy **R**ecovery processes.
- Imposing some laws and strategies to control the growth of e-waste. The required laws need to engage other vital sectors to contribute to the waste management systematic process, which will be explained next.



Fig. 3 4Rs waste management steps [15]

IV. PROPOSED GOVERNMENT'S ROLE TOWARD E-WASTE

As noted from Fig. 2, the controlling role of government is almost absent. In Kuwait, the government's role in dealing with solid waste is mainly limited to the process of collecting and transporting waste, and which is then buried in public landfills. These processes are carried out by the government contracting private companies through agreements worth millions of dinars.

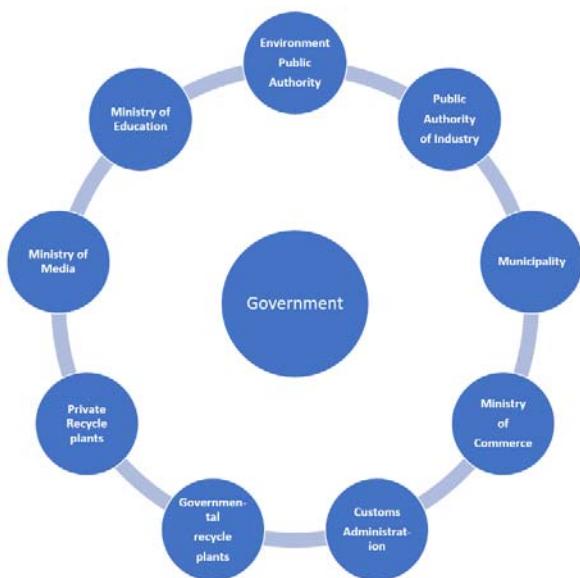


Fig. 4 Vital sectors should be involved in Kuwait IMSW

The Kuwaiti government should impose some laws and strategies to control the growth of e-waste as well as apply professional steps to reduce, reuse, recycle, and recover before reaching the sanitary landfill. It is noted from Fig. 1 that only three governmental sectors are dealing with waste. These

sectors are not enough to satisfy the government's ambitions to apply integrated management of solid waste (IMSW) which e-waste is part of it. The Kuwait government should engage other vital sectors, which are summarized in Fig. 4. Each sector has a vital role in the waste systematic processes as explained next.

Below description shows each sector's proposed responsibilities.

- **EPA:** This Authority has the main responsibility to deliver a clear description of e-waste as described in the Basel Convention. The current situation in Kuwait is that all ministries and sectors are dealing with e-waste as a general solid waste. That means ministries currently send their e-waste to the general garbage container which ends up to the public landfill. When the EPA imposes a clear description of e-waste, and circulates it to all state institutions, it will contribute to controlling not only the e-waste in state ministries but also gradually in all private sectors as well.
- **KM:** This government sector has two proposed main responsibilities toward e-waste. First, it is required to deal with e-waste separately from solid waste. E-waste is classified as hazardous waste according to the Basel Convention [10]; however, the KM currently is not dealing with e-waste as hazardous waste, but as general solid household waste. Secondly, the KM's supposed responsibility is to stop mixing different types of waste and to send them to a common landfill. The KM should specify a certain separate land to be used as a collection area for e-waste. Once the KM establishes the process of collecting e-waste in certain lands, the e-waste recycle companies will grow in the market.
- **PAI, Public Authority of Industry:** This authority has the main role of organizing and setting out the roadmaps for establishing governmental and private waste recycling plants based on the guidance of the EPA and KM.
- **Ministry of Commerce (MOC):** This ministry should be involved in two ways. First, it should propose the idea of extended producers' responsibility (EPR) and push the manufactures, local agents, and retailers of electronic devices and electrical equipment to take responsibility for the disposal of the electronic devices. Second, the MOC should apply specifications for products that have high recycle efficiency materials so that in future that will lead to a reduction in the amount of harmful waste dumped in landfills.
- **Custom Administration (CA):** This administration can play a vital role in dealing with electronic devices that are imported overseas. The CA should follow and apply the specifications that would be proposed by the MOC in order to allow in the country the suitable electronic devices that have reasonable recycle efficiency materials.
- **Recycling Plants:** Currently, Kuwait markets are not attractive for recycling plant businesses since the dealing with waste in general is random as well as lacks in regulations. Once the five sectors mentioned earlier, EPA, KM, PAI, MOC and CA, increase their responsibilities and apply new and suitable regulations, the recycling companies will be encouraged to contribute to Kuwait

markets to collect, treat and recycle the waste of electronic devices as well as other types of waste.

- Ministry of Information (MOI) and Ministry of Education (MOE): These government entities have the main role of building community awareness as well as market awareness regarding the government regulations and

processes of waste management systems.

V. RECOMMENDED E-WASTE PATHWAY PROCEDURES IN KUWAIT

As outlined earlier, it is important to increase the contributions and integrated responsibilities of nine sectors in the Kuwait government. The integration of the responsibilities of these nine sectors will lead to improvements in the current e-waste pathway in Kuwait to develop into the well-organized proposed pathway shown in Fig. 5.

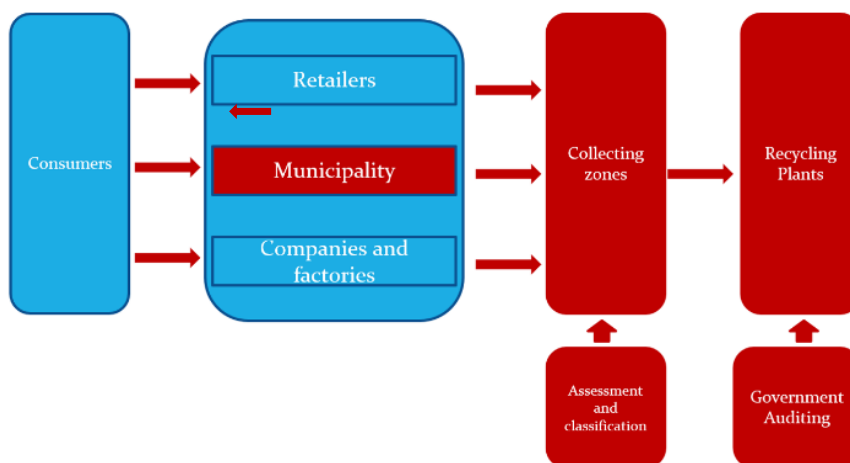


Fig. 5 Recommended e-waste pathway procedures in Kuwait

When this proposed systematic procedure in Fig. 5 is applied, e-waste can be moved to the municipality's e-waste garbage container where it is then taken to designated e-waste collecting zones. Also, e-waste can be moved to both retailer's market and electronic factories market to be replaced or handed in according to EPR agreements. These markets would try to get advantage of some of parts of this waste and then they must, according to the EPR regulation, take it to the specified e-waste collection zones. At this step, government and private recycling plants would be involved largely once the e-waste is deposited in the designated collection points. This systematic proposed pathway of e-waste in Fig. 5 would not succeed if the government did not apply two mechanisms. The first involves the assessment and classification mechanisms which are essential to evaluate and measure the efficiency of collecting processes. The second one is related to the recycling operations auditing mechanism. This mechanism is essential to ensure that the recycling processes is followed according to the anticipated outcomes of producing raw materials and maintaining professionalism and safety during the entire recycling operation.

VI. FUTURE E-WASTE CHALLENGES AND EXPECTATIONS IN KUWAIT

The main concern in the future is the fact that e-waste, which is hazardous, is the fastest growing solid waste worldwide [16]. The rate of annual increase of e-waste can reach 4% [11]. Taking no action for e-waste in Kuwait leads to have the accumulation of e-waste every year. It is expected that the

annual production of e-waste in Kuwait could reach 81.3 kilo tons by 2021 as calculated in Table II.

TABLE II
 ANNUAL ESTIMATED AMOUNT OF E-WASTE IN KUWAIT

Year	Amount of E-waste produced in Kuwait (kilo ton)
2016	66.8 [13].
2017	69.5*
2018	72.3*
2019	75.1*
2020	78.2*
2021	81.3*

(*) These values are estimated based on the annual increase of e-waste in Kuwait by 4% [11].

Kuwait, as with most of other countries, started with plans to install many of renewable energy projects in 2012, with the Kuwait RE vision announcement. This vision stated that the Kuwait will install renewable energy projects to meet 15% of the country's electricity demand by 2030 [16]. It is expected, according to the vision, that the size of renewable energy projects in Kuwait would reach 5 GW by 2030. One of the largest projects in Kuwait is the 3500 MW Alsheqaya Solar Photovoltaic (PV) plant [16]. The average size of PV panels that are used in PV solar power plants is 350 W. That means, a 1 kW solar system consists of 3 solar panels. For Alsheqaya solar project in Kuwait, which is 3500 MW, it is expected to use 10 million PV panels, assuming the size of each panel is 350 W. These panels have a lifetime operating period of 30 years. Most of panels can be replaced before that to improve energy production performance. The Waste Electrical and Electronic

Equipment (WEEE) Directive is a European Community directive, which introduced PV solar panels as an e-waste in a directive revision in 2012 [18]. Since PV panel waste is considered an e-waste, this means that Kuwait will have accumulate more than 10 million waste panels in 30 years from now. Accumulation of such quantities are too many for a small country like Kuwait. Thus, it is vital to pay serious consideration to the correct handling of waste PV panels following the well-organized processes of an e-waste

management system as shown in Fig. 5.

PV panel technologies and factories are moving gradually toward producing panels that can be mostly recycled after decommissioning. Therefore, the waste parts generated by PV panels can consist of e-waste that is useful for local recycling companies [17], [18].

Fig. 6 shows the main compositions of different types of PV solar panels. It is shown that glass is the main component at more than 75% as well as some parts of aluminum, copper, sealants, polymers, and semiconductor materials [18].

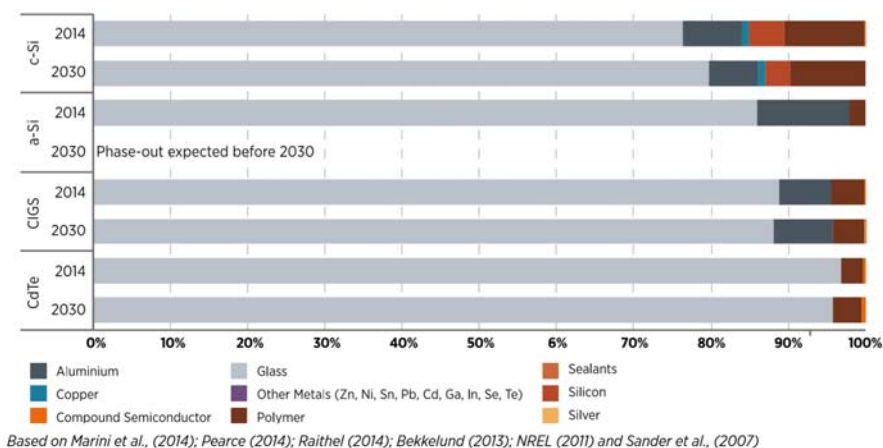


Fig. 6 Main Compositions of different types of solar PV panels [19]

Solar PV plants projects do not only contain PV panels but also have many other components such as, AC cables, DC cables, junction boxes, circuit breakers, transformers, inverters, SCADA monitoring systems, communication systems and so on. Therefore, the future challenge of increasing of e-waste accumulation in Kuwait is remarkably high so that the serious action of establishing systematic procedures for e-waste is highly recommended and needed.

VII. CONCLUSION

E-waste has become one of the main issues for many countries since it was included as part of the Basel Convention. Many countries have taken the issue of e-waste very seriously. E-waste has many harmful consequences if it is not handled and disposed of correctly. Furthermore, e-waste consists of a number of valuable and other base metals. These metals and other useful materials in e-waste can be recycled and be beneficial to local economies.

Kuwait, a decade ago, and since then, has not taken any serious actions to control, treat and recycle the important waste materials or avoid the effects of any hazardous materials.

The proposed systematic procedures shown in this study can be a useful part of the solutions to control the waste of electronic devices starting from the consumers through to the recycle plants as well as suitable landfills. Delay on taking serious action by the state will result in the problems of e-waste becoming even more difficult and complicated especially as the country moves towards a giga watt of renewable energy projects.

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