ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ЭКОЛОГИЯ ЖӘНЕ ТАБИҒИ
РЕСУРСТАР МИНИСТРЛІГІ

National E-waste Monitor 2023

KAZAKHSTAN

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Funded and supervised by:

Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection

Umwelt Bundesamt

National E-waste Monitor 2023

KAZAKHSTAN

Colophon

This report was prepared through a collaborative effort involving the United Nations Institute for Training and Research, the Ministry of Ecology and Natural Resources of Kazakhstan, and the Center Cooperation for Sustainable Development.

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Please cite this publication as:
United Nations Institute for Training and Research / Ministry of Ecology and Natural Resources of the Republic of Kazakhstan / Center Cooperation for Sustainable Development. National E-waste Monitor 2023 - Kazakhstan, 2023, Bonn/Astana/ Almaty.

ACKNOWLEDGEMENTS
The authors would like to thank the contributors of the national consultations, the national forum in Kazakhstan, and the validation process. Specifically, the following persons are acknowledged:

Republic of Kazakhstan:
Sabit Tokmurzayev, Dinara Sadvakasova, Sungat Gabdurashit, Pavel Mukhin, Roman Mukhin, Igor Zaitsev, Murat Mukhambetov, Yerlan Kazankapov, Vladimir Olechshenko, and Egor Filimonov.

German Environment Agency:
Xenia Lewandowski, Regina Kohlmeyer, and Hendrik Freitag.

ITU:
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UNEP:
Tomas Marques, Olzhas Atymtayev, and Aidai Kurmanova.

This project is funded by the German Federal Environment Ministry's Advisory Assistance Programme (AAP) for environmental protection in the countries of Central and Eastern Europe, the Caucasus, and Central Asia and other countries neighbouring the European Union (Project number N°167903). It is supervised by the German Environment Agency (UBA). The responsibility for the content of this publication lies with the authors.

The National Forum in Astana held on 22-23 November 2022 was co-funded by the International Telecommunication Union (ITU).

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Funded by:

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

Supported by:

ITU

In cooperation with:

UN environment programme

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ABBREVIATIONS	
CIS	Commonwealth of Independent States
CSD Center	Center 'Cooperation for Sustainable Development'
EAEU/EEU	Eurasian Economic Union
EEE	Electrical and electronic equipment
EEE POM	Electrical and electronic equipment placed on the market
EPR	Extended producer responsibility
ESM	Environmentally Sound Management
EU	European Union
e-waste / WEEE	Waste electrical and electronic equipment
GDP	Gross domestic product
GEM	*Global E-waste Monitor* (latest edition, 2020)
Inh	Inhabitant
kt	(Metric) kiloton, or 1,000,000 kg
MSW	Municipal solid waste
Mt	Million metric tons
NGO	Non-governmental organisation
PPP	Purchasing power parity
SDG	Sustainable Development Goals
SSP	Shared Socioeconomic Pathways
UNECE	United Nations Economic Commission for Europe
UNITAR	United Nations Institute for Training and Research

Executive summary

With a global generation of 53.6 million metric tons (Mt) in 2019 [1], e-waste is one of the fastest growing waste streams globally. E-waste contains both harmful substances and rare and valuable materials and can lead to environmental, health, and economic issues if it is not managed in an environmentally sound manner.

According to the *Regional E-Waste Monitor for the CIS + Georgia - 2021*, in 2019, the volume of e-waste generation in Kazakhstan was 7.3 kg per capita per year or 136.1 kilotons (kt) in total, and the collection and recycling rate of e-waste was 8.8% [9]. Thus, Kazakhstan, like many countries around the world, faces the problem of increasing e-waste generation as well as challenges in collecting and recycling e-waste in an environmentally sound manner.

136.1 kt of e-waste generation in Kazakhstan, in 2019.

The state policy of Kazakhstan in the field of waste management is defined by a number of strategic documents, such as: the Concept for the Transition of Kazakhstan to a Green Economy, the National Project 'Green Kazakhstan', and the Concept for the Development of Housing and Communal Infrastructure. Strategic documents largely determine the improvement of the sector of waste collection, processing, recycling, and reuse as one of the priority objectives.

The main legal act for regulating e-waste management in the country is the Environmental Code of Kazakhstan [17]. The Environmental Code provides for the separate collection of e-waste, mercury-containing waste, waste batteries, and other hazardous components and requires that they are transferred to specialised enterprises. Due to the presence of hazardous substances, it is prohibited to dispose of e-waste in landfills. The Environmental Code of Kazakhstan also regulates issues related to waste classification and hazardous waste management and defines requirements for extended producer responsibility (EPR).

The Environmental Code of Kazakhstan provides for the separate collection of e-waste.

Technical requirements for the management of e-waste are defined by the standard ST RK 3753-2021 [20]. The standard establishes requirements for separate collection of e-waste and its storage and recycling, imposes a ban on disposal at landfills, and makes it possible to ensure the necessary level of safety in handling e-waste at specialised enterprises.

According to the data from the Kazakh Association for Waste Management "Kazwaste", there are approximately 19 specialised enterprises in Kazakhstan that are engaged in the collection and processing of e-waste (Annex 1).

Therefore, some prerequisites for the establishment of the e-waste management system are available in Kazakhstan. However, a number of problems in the collection and recycling of e-waste remain relevant, including a low compliance with legal requirements, a lack of infrastructure for collecting e-waste from the population, a low level of applied e-waste recycling technologies, and a low level of public awareness of the need for separate collection and transfer for recycling.

With a projected population of 24 million people in Kazakhstan and an increased consumption of EEE per person, in 2050 the amount of e-waste generation is expected to be 18 kg per capita, which is comparable with 2019 data on the generation of e-waste per capita in the European Union [1]. This determines the need for decisive measures to improve the e-waste management system in Kazakhstan in order to reduce the negative impact on the environment and use the resource potential of e-waste.

The development of e-waste management in Kazakhstan can follow one of two scenarios: ‘Business as Usual’ or ‘Circular Economy’. Both scenarios demonstrate the challenges and opportunities for the country, which are determined by the environmental and health impacts of hazardous components and the recovery of valuable materials, as well as the overall environmental and socioeconomic impacts.

In the ‘Business as Usual’ scenario, the cumulative amount of unmanaged e-waste from 2020 to 2050 could reach 8.4 Mt over 30 years, but the Circular Economy scenario would halve this figure to 4 Mt. The Circular Economy scenario would recover and recycle 3.2 Mt of valuable materials by 2050 and reduce greenhouse gas emissions by about 95%.

The amount of e-waste is expected to grow by 9 to 10 kt per year.

E-waste management can have a significant economic impact by reducing production costs of primary raw materials, creating income opportunities from recycling valuable materials, reducing disposal costs and fines, avoiding environmental costs, and stimulating economic growth through sustainable resource use. Implementation of the Circular Economy scenario would achieve a positive economic effect of USD $276 million in e-waste management in Kazakhstan until 2050, while the baseline scenario could result in costs of USD $791 million.

Thus, the results of the ‘Business as Usual’ scenario and Circular Economy scenario projections clearly demonstrate the importance of adopting a sustainable e-waste management system and show that implementing measures aimed at improving resource efficiency and proper waste treatment can lead to significant economic, environmental, and social benefits.

To achieve such approaches, Kazakhstan needs to take measures for improving legislation and statistics and for developing infrastructure, technologies, and measures to support e-waste collection and recycling. Important measures to be taken include the development of extended producer responsibility, financial incentives for e-waste recycling, and public awareness-raising. This report provides recommendations and a practical national roadmap for environmentally sound management of future e-waste developed as part of national stakeholder dialogues.

This report provides recommendations and a practical national roadmap for environmentally sound management of future e-waste.

Chapter 1.
Introduction

A. WHAT IS E-WASTE AND WHY DOES E-WASTE NEED ATTENTION?

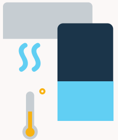
Electrical and electronic equipment (EEE) includes a wide range of products, including nearly all household or business items with circuitry or with electrical components that have a power or battery supply — like basic kitchen appliances, toys, and ICT items, such as mobile phones, laptops, etc. EEE is also increasingly used in transport, health, security systems, generators of energy, and even more traditional products, such as clothes and furniture [1].

EEE becomes e-waste once it has been discarded by its owner as waste without the intent of reuse [2]. E-waste, also commonly referred to as waste electrical and electronic equipment (WEEE), encompasses a wide variety of products that can be categorised in different ways, including by product type or size.

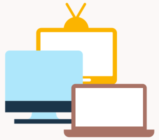
However, for statistical purposes in global practice, EEE is classified by similar function, comparable material composition, average weight, and similar end-of-life attributes. The E-waste Statistics Guidelines on Classification Reporting and Indicators - Second Edition divides EEE into 54 different product-based categories, referred to as the UNU-KEYs (listed in Annex 2) [3].

The 54 EEE product categories are grouped into six general categories that correspond closely to their waste management characteristics. This categorisation is compliant with the European Union WEEE Directive (Figure 1).

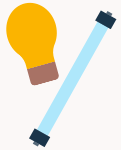
Figure 1. Six categories of EEE that correspond closely to their waste management characteristics



1. Temperature exchange equipment: more commonly referred to as cooling and freezing equipment. Typical equipment includes refrigerators, freezers, air conditioners, and heat pumps.

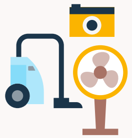


2. Screens and monitors: typical equipment includes televisions, monitors, laptops, notebooks, and tablets.



3. Lamps: typical equipment includes fluorescent lamps, high intensity discharge lamps, and LED lamps.

4. Large equipment: typical equipment includes washing machines, clothes dryers, dishwashing machines, electric stoves, large printing machines, copying equipment, and photovoltaic panels.



5. Small equipment: typical equipment includes vacuum cleaners, microwaves, ventilation equipment, toasters, electric kettles, electric shavers, scales, calculators, radio sets, video cameras, electrical and electronic toys, small electrical and electronic tools, small medical devices, small monitoring, and control instruments.

6. Small IT and Telecommunication equipment: typical equipment includes mobile phones, Global Positioning System (GPS) devices, pocket calculators, routers, personal computers, printers, and telephones.

E-waste is one of the fastest-growing waste streams globally, resulting from the high consumption rate of such equipment, short product lifecycles, and a lack of repair options. This waste stream poses a threat to the environment and human health if not treated properly, as it contains a host of hazardous materials and substances, including heavy metals, chemicals, and flame retardants [1]. See section 5a for further details.

Likewise, e-waste represents an economic and environmental opportunity through the recovery of valuable materials, making it possible to avoid the waste of natural resources and energy, secure the supply of raw materials to the industry, and reduce environmental impacts while providing job opportunities. Specifically, e-waste can contain precious metals such as gold, copper, and nickel, as well as rare materials of strategic value, such as Indium and Palladium [1].

For these reasons, it is essential to improve the environmentally sound management of e-waste at the global level.

B. KAZAKH CONTEXT

Kazakhstan is a state in Central Asia. The area of the territory is 2,724,902 km^2. According to the Bureau of National Statistics of Kazakhstan (Bureau of National Statistics), the country's population was 19,186,015 people as of 2021 [4]. The population density is one of the lowest in the world: lower than 7 people per square kilometer. The country's major cities are Almaty and Shymkent, as well as the capital city of Astana.

Annually, 4.5-5 Mt of municipal solid waste (MSW) are generated in Kazakhstan. According to the Bureau of National Statistics for 2021, the level of MSW generation was 4,214.1 kt, among which 985.3 kt (21.1%) were recycled and reused. Table 1 shows MSW generation, recycling, and reuse rates for 2017-2021. The overall generation of MSW has decreased from 2017 to 2021, while the recycling and reuse rate has progressively increased.

Table 1. MSW generation in Kazakhstan and recycling rates for 2017 - 2021 [5]

YEAR	2017	2018	2019	2020	2021
Generation of MSW, kt/year	4,864.3	4,319.2	4,736.6	4,551.7	4,214.1
Recycling, reuse of MSW, ktyear	440.0	497.1	705.2	868.9	985.3
Percentage of recycling, reuse of MSW, %	9.0	11.5	14.9	18.6	21.1
Generation of MSW per capita, kg	296.7	236.3	255.8	242.7	221.8

In a number of cities, MSW is sorted and recycled in factories, as well as by small and medium-sized businesses. Separate MSW collection is implemented in 94 cities in Kazakhstan and is sorted in 80 settlements. Separate collection and sorting of MSW is implemented both in large cities and in separate districts and settlements. More than a thousand jobs have been created at sorting complexes. However, the main method of MSW handling in the country is still disposal in landfills. There are 3,007 landfills in the country, but only 603 (20%) meet environmental and sanitary standards [5].

In 2021, hazardous waste generation rates decreased markedly. Compared to 2020, there was a 69.5% decrease in generation volumes. It should be noted that this may be due to a change in the approach of classifying waste as hazardous or non-hazardous. According to the Bureau of National Statistics, the level of hazardous waste generation for 2020 is 137,828 kt, and in 2021, 42,090 kt. At the same time, the percentage of recycling and reuse in 2020 and 2021 reached 22.3% and only 11.7%, respectively. Table 2 presents data on hazardous waste generation and recycling for 2017-2021.

Table 2. Hazardous waste generation in Kazakhstan and recycling rates for 2017-2021 [5]

YEAR	2017	2018	2019	2020	2021
Hazardous waste generation, kt/year	126,874	149,962	180,506	137,828	42,090
Recycling, reuse of hazardous waste, kt/year	190,785	29,992	36,645	30,711	4,924
Percentage of recycling, reuse of hazardous waste, %	150.4^	20.0	20.3	22.3	11.7
Hazardous waste generation per unit of GDP, kg/thousand USD in 2017 prices	282.9	321.2	370.0	290.1	85.1
Hazardous waste generation per capita (SDG 12.4.2), kg	7,034	8,205	9,750	7,349	2,215

^ Unrecycled waste is accumulated at facilities and may be recycled the following year or even a year later. ***Recycling in 2017 exceeded the generation figures, which means that the accumulated hazardous waste before 2017 was recycled in 2017***

** from 2020 to 2021: change in the approach of classifying waste into hazardous and non-hazardous*

Thus, the waste management system in Kazakhstan is actively developing. However, there are a number of problems associated with low rates of implementation of separate waste collection in cities, handling of specific types of waste, active operation of landfills, etc.

C. ABOUT THIS REPORT

This report is intended for national stakeholders involved in e-waste management from both public authorities and the economic sector, the (interested) general public, NGOs, academia, and e-waste stakeholders in other countries. The report starts with a brief description of the methodology employed herein in chapter 2. We utilised the existing statistics from the *Regional E-Waste Monitor for the CIS + Georgia* - 2021 [9] on electrical and electronic equipment placed on the market (EEE POM), lifespans, e-waste generated, and e-waste collection and recycling in order to create long-term projections to 2050. The international context of e-waste management is described in chapter 3. Chapter 4 discusses the current situation of e-waste management in Kazakhstan and elaborates in chapter 5 on the challenges and opportunities, and sets out the directions of development of e-waste management system in Kazakhstan to 2050 in two contrasting scenarios, focusing on the associated opportunities to avert environmental and health impacts and recycle valuable materials. Building from one variant of target indicators of the UNITAR tool, two contrasting scenarios have been developed:

1. The ‘Business as Usual’ scenario, which represents present-day consumption, lifespan, and recycling behaviours extrapolated to 2050 with adjustments from economic and demographic drivers
2. The ambitious Circular Economy scenario, in which product lifespans are projected to increase due to more reuse, repair, and remanufacturing, while sharing of certain equipment becomes more common, and e-waste collection and recycling infrastructure is incrementally developed until 100% collection rates are reached in 2050.

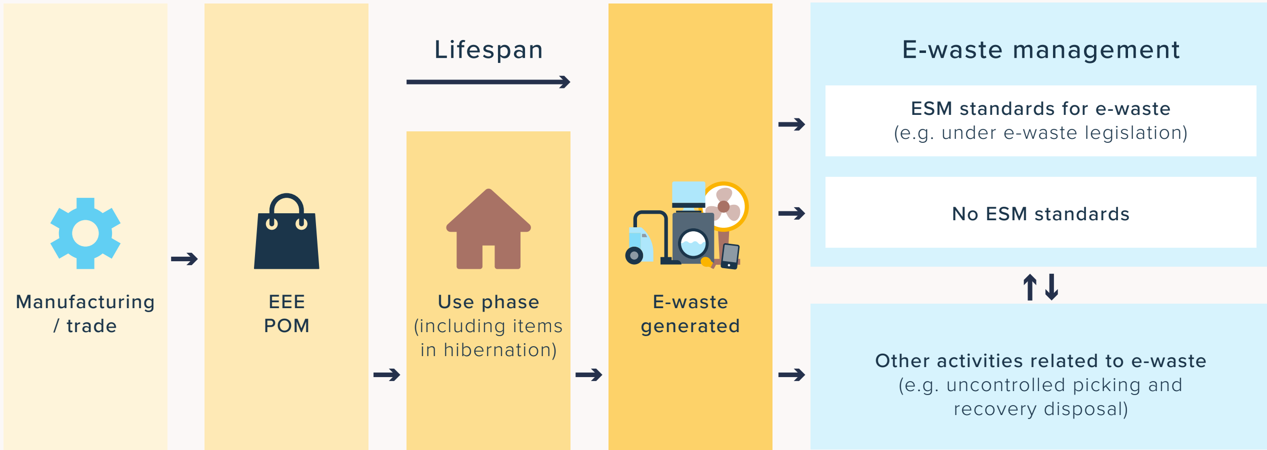
Chapter 6 provides a number of recommendations focusing on improved legislation and statistical data, development of infrastructure, technology, and measures to support e-waste collection and recycling, financing of the system, as well as capacity-building and awareness-raising. The recommendations of chapter 6 are translated into a practical national roadmap in chapter 7 for environmentally sound management of future e-waste developed as part of national stakeholder dialogues.

Chapter 2. Methodology

A. E-WASTE STATISTICS

The measurement framework of e-waste projections follows a mass balance approach over the entire life cycle of EEE. This approach is consistent with the global e-waste statistics guidelines [3] [6]. The approach covers production, imports, exports, placing on the market, e-waste generation, e-waste management, and other e-waste-related activities (Figure 2). It covers any product supplied to the national market for consumption and use by households, businesses, or public authorities. Calculations were made for 54 products - the so-called UNU-KEYs. The UNU-KEYs are a product-based classification in which each UNU-KEY has a homogeneous lifespan, average weight, material composition, and hazardousness profile. The UNU-KEYs can be linked to the six e-waste categories and are used to measure e-waste statistics (see Annex 2).

Figure 2. E-waste Statistics Framework



The EEE POM is obtained by deducting the exports from the EEE imported and domestically produced. The market entry includes EEE placed on the market by households, businesses, and the public sector. A product's lifespan is the period of time from when it is placed on the market until it becomes e-waste (see Figure 2). This includes the hibernation phase — such as the hoarding time of the equipment prior to actually being discarded at the end of its life — as well as the passing on of the equipment from one owner to another (reuse). The lifespan of EEE is expressed as a Weibull function and varies per UNU-KEY, with the shape and scale parameters associated with the average lifespan for each UNU-KEY individually. After a certain lifetime sampled from the Weibull function, the product is disposed of and becomes waste. E-waste generated in a country refers to the total weight of e-waste resulting from EEE that had been POM in that country, prior to any other activity — such as collection, preparation for reuse, treatment, or recovery, including recycling and exporting of e-waste.

In general, e-waste management involves the collection, transportation, storage, treatment, recycling, recovery, and disposal of waste, including aftercare of disposal sites. It can be undertaken by an economic actor within a legal framework, but waste handling carried out by informal economic actors (e.g. informal waste-picking) and illegal waste-handling also exist. In this context, 'waste management' is differentiated from 'other waste-related activities', as proposed by the UNECE's Waste Statistics Framework [7]. The 'other waste-related activities' include waste dumping, waste-picking and scavenging, disposal, etc. and may include the informal sector. It is vitally important that e-waste undergoes depollution, that hazardous parts are disposed of in an environmentally sound manner, and that recyclable components are properly recycled. This is typically, but not exclusively, performed under the requirements of national e-waste legislation. Therefore, in this report and in the e-waste statistics guidelines, the e-waste flow is referred to as 'e-waste formally collected'. This term implies that the e-waste is collected under the specific legislation for e-waste (or in a similar manner) and is also referred to as 'e-waste managed environmentally soundly'.

The UNITAR's E-waste Collected Tool is an interactive tool for setting e-waste collection targets to explore the resulting amounts of managed and unmanaged waste from 2020 to 2050.

B. E-WASTE PROJECTIONS TO 2050

All calculations were done using UNITAR's new 'E-Waste Collected Tool' for Kazakhstan. This is an Excel-based interactive tool for setting e-waste collection targets to explore the resulting amounts of managed and unmanaged waste, the corresponding recovered and lost materials, their value and the associated compliant recycling costs, and the environmental and socioeconomic impacts due to release of hazardous substances and loss of valuable materials. The tool can be used by trained national stakeholders for further assessment and update. For more technical and methodological information, refer to UNITAR's E-waste Collected Tool Manual [24].

The flows of generated e-waste are projected using the same framework as the e-waste statistics described in section 2.a and are split into two scenarios: a 'Business as Usual' scenario and a Circular Economy scenario [8].

EEE POM from 1980 to 2020 was obtained from the readily available country-level data, collected from authorities and e-waste stakeholders as part of the *Regional E-Waste Monitor for the CIS + Georgia - 2021* [9]. The historic solar photovoltaic installation figures for Kazakhstan, which form the fastest-growing part of POM, were downloaded from a global dataset compiled by the International Renewable Energy Agency (IRENA). The EEE POM data has been broken down into relatively detailed product groups (UNU-KEYs; 54 groups in total). It is projected into the future with an empirical relationship between EEE POM and country-level scenarios for Gross Domestic Product (GDP) purchasing power parity (PPP) per capita, established from the global historic EEE POM and GDP data [1]. We use GDP PPP and population scenario projections from the Shared Socioeconomic Pathways (SSPs), which represent a plausible range of regional and global socioeconomic futures with various degrees of cooperation, competition, urbanisation, education, technological development, and other relevant indicators [10]. The SSP scenarios are described in detail in Annex 4.

In the 'Business as Usual' scenario, present-day consumption patterns for EEE goods are projected to 2050 with some adjustments according to the underlying economic conditions, population, consumer behaviour, product lifespans, and e-waste management infrastructure (see Table 3). We also factored in full or partial obsolescence of EEE POM for selected products by 2050 as well as stock saturation constraints (see below).

In the Circular Economy scenario, additional behavioural and/or technological changes are assumed to be taking place until 2050 for selected product groups (UNU-KEYs), capturing the main aspects of Circular Economy transition specific to the EEE sector. These changes (with illustrations for selected UNU-KEYs) include [8]:

1. **Full or partial obsolescence of EEE POM by 2050 (also applicable to 'Business as Usual')**
   A near-complete drop in EEE POM of new video equipment, e.g. video recorders, DVDs, Blu-rays, set-top boxes, and projectors (UNU-KEY 0404), driven by advances in smartphones and internet streaming

2. **Stock saturation constraints per capita (also applicable to 'Business as Usual')**
   Household electrical products such as fridges (UNU-KEY 0108) reaching market saturation in wealthier countries, when it does not make sense for an average household to have more than a certain number of items of a given product, even if they can afford them

3. **Improved durability**
   A gradual increase in both designed and user-driven lifespans across most EEE products, including greater product reuse via second-hand markets (included in the lifespans implicitly)

4. **Less hoarding**
   Products such as laptops (UNU-KEY 0303) and mobile phones (UNU-KEY 0306) either being used for longer periods, reused, or recycled instead of being hoarded, leading to reduced overall stock across households

5. **More sharing**
   Products such as household tools (UNU-KEY 0601) being shared more, leading to higher product utilisation and the associated reduction in lifespan, as well as reduced overall stock across households

Further details on the Circular Economy and 'Business as Usual' scenarios, including a detailed set of assumptions for each UNU-KEY, are provided in the Annex 2 and in Table 3.

The e-waste generated is calculated using the EEE POM and lifespan projections for both the 'Business as Usual' and Circular Economy scenarios. The e-waste recycling rate is calculated by dividing 'e-waste managed in an environmentally sound manner' by 'e-waste generated'. The recycling rate in Kazakhstan for 2020 to 2050 is extrapolated from the present-day (2022) base value of 9.2% from the *Regional E-Waste Monitor for the CIS + Georgia - 2021* [9]. In the 'Business as Usual' scenario, the recycling rate is kept as a constant of 9.2%, while in the Circular Economy scenario, it is incrementally increased, linearly with time, from 9.2% to 100% in 2050.

The amounts of 'unmanaged e-waste' are calculated as 'e-waste generated' minus 'e-waste managed environmentally soundly'. The resulting effects of e-waste management are calculated using the material compositions per UNU-KEY category obtained from the ProSUM [11] for EEE POM in 2018. The environmental impacts of managing e-waste are based on the quantifications of 'e-waste managed environmentally soundly' and 'unmanaged e-waste' from the *Regional E-Waste Monitor for the CIS + Georgia - 2021* [9]. More information about the SSP and photovoltaic forecasts are explained in Annexes 3 and 4.

Table 3. E-waste projections under 'Business as Usual' and Circular Economy scenario [8]

PARAMETER	1980 - 2022	2022 - 2050 BUSINESS AS USUAL SCENARIO	2022 - 2050 CIRCULAR ECONOMY SCENARIO
EEE POM	Country-level and product-level (54 UNU-KEY) data was taken from the *Regional E-waste Monitor for the CIS + Georgia - 2021* [9]. Country-level solar photovoltaic data was downloaded from IRENA.	Country-level SSP projections for GDP PPP and population were downloaded from the IIASA SSP Database. These were adjusted using the World Bank data for historic country-level GDP PPP and Kazakhstan's population. Further details are provided in the References section and in section 2.3. POM projections were derived using country-level empirical correlations between UNU-KEYs and GDP PPP, as described in The Global E-waste Monitor 2020 [1]. We also factored in full or partial obsolescence of EEE POM for selected products by 2050 and stock saturation constraints.	Same as the 'Business as Usual' scenario, except that per UNU-KEYs, additional changes were built in full or partial obsolescence of EEE POM for selected products by 2050, stock saturation constraints, improved durability, less hoarding, and more sharing. The changes result in less EEE POM than in the 'Business as Usual' scenario for most UNU-KEYs. Further details are provided in Annex 2.
Lifespan	UNU-KEY-level data for product lifespans was taken from the *Regional E-waste Monitor for the CIS + Georgia - 2021* [9].	Same as 1980-2022.	Products become more durable (30% longer lifespans) and/or get utilised more (leading to 15% shorter lifespans).
E-waste Generated	Calculated from above datasets.	Calculated from above datasets.	Calculated from above datasets.
E-waste recycling rate	Taken from the *Regional E-waste Monitor for the CIS + Georgia - 2021* [9].	The recycling rate for 2022 (9.2%) remained constant.	Incremental increase from 9.2 to 100% collection and recycling rate.

C. STAKEHOLDER CONSULTATION AND NATIONAL ROADMAP DEVELOPMENT

A stakeholder consultation method was used to collect various stakeholders' inputs, needs, and interests related to e-waste management processes. The stakeholders involved included state agencies, central and local authorities, manufacturers, importers and retailers of EEE, e-waste collectors and recyclers, the environmental community represented by non-governmental organisations, universities, and research institutes.

In order to study the current situation in Kazakhstan, a questionnaire was conducted with all stakeholders involved, as well as individual meetings to obtain more information and clarify data. A total of 29 consultations and meetings were held.

In view of establishing a dialogue between stakeholders, the National Forum 'E-waste Management in Kazakhstan: current situation and next steps' was held in Astana on November 22-23, 2022. The Forum served as a platform to increase capacity and strengthen stakeholder interaction, facilitate the exchange of international and regional best practices, and contribute to the development of e-waste management policy in Kazakhstan. The conclusions and recommendations of the consultations and the National Forum are reflected in this publication.

The national roadmap for the environmentally sound management of e-waste, which is an integral part of this document, is based on the discussion of the working groups organised within the National Forum, as well as the results of questionnaires and meetings with stakeholders. Specific activities and actions, deadlines, forms of completion and executors in the national roadmap are defined, taking into account the priorities set by the public, private, and civil sectors.

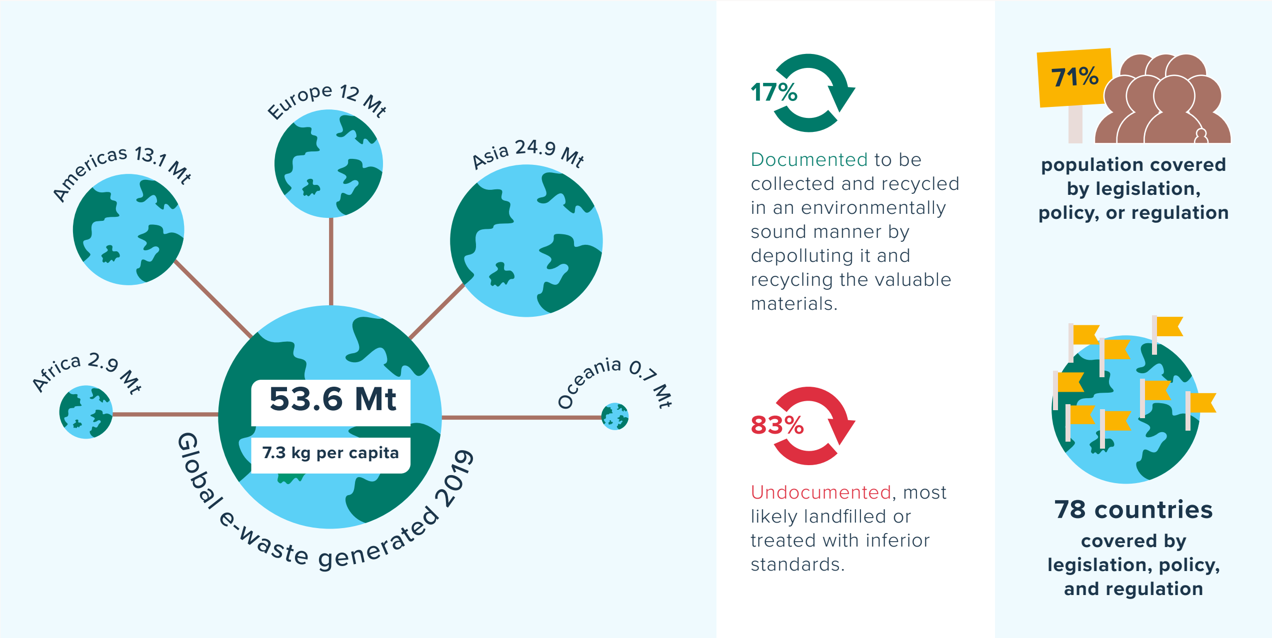
Chapter 3.
International experience of e-waste management

A. GLOBAL E-WASTE STATISTICS

The *Global E-waste Monitor* provides the most comprehensive update of global e-waste statistics.

According to The *Global E-waste Monitor*, the world generated 53.6 million metric tons (Mt) of e-waste in 2019 - an average of 7.3 kg per capita. This amount increased by 21%, from 44.4 Mt in 2014, and is projected to reach 74.7 Mt by 2030 [1] [12]. Asia is the major producer of e-waste in net weight (24.9 Mt), followed by the Americas (13.3 Mt), Europe (12 Mt), Africa (2.9 Mt), and Oceania (0.7 Mt). However, looking at the generation per capita, Europe is ranked first with 16.2 kg, followed very closely by Oceania (16 kg per capita), then the Americas (13.3 kg per capita), Asia (5.6 kg per capita), and Africa (2.5 kg per capita) [1].

Figure 3. Overview of key statistics 2019 as published in *The Global E-waste Monitor 2020*



Building from data reported by countries, *The Global E-waste Monitor 2020* estimated that only 17.4% (9,3 Mt) of the e-waste generated is formally collected and recycled, an increase of 1.8 Mt since 2014. The vast majority of e-waste generated (82.6% or 44.3 Mt) was not formally collected or managed in an environmentally sound manner. This share of undocumented e-waste was most likely sent to landfills, mixed in with other waste streams or incinerated, leading to loss of valuable resources and the release of hazardous substances into the environment. There are very high discrepancies among continents in terms of reporting; Europe has the highest reporting rate, with 42.5% of e-waste documented to be formally collected and recycled, followed by Asia (11.7%), the Americas (9.4%), Oceania (8.8%), and Africa (0.9%) [1].

B. GLOBAL AND REGIONAL POLICY OVERVIEW

In order to cope with the growing amount of e-waste, governments around the world need to introduce or improve specific legislation to enforce environmentally sound management (ESM) of e-waste.

According to *The Global E-waste Monitor 2020*, at of the end of 2019, 78 of 193 countries worldwide had a national e-waste policy and legislation of regulation in place, covering 71% of the world's population*. However, in many countries, policies are not legally binding and not appropriately supported financially, thus hindering their proper implementation. As well, most legal frameworks focus on improving e-waste management, but not on reducing the volume of e-waste generated, e.g. by supporting eco-design and favoring EEE repair and reuse practices [1].

According to the *Regional E-waste Monitor for the CIS + Georgia - 2021* [9], the twelve CIS countries† in the region have well-developed legal and regulatory frameworks in the field of waste management. Georgia, Moldova, and Ukraine have e-waste-specific legislation or regulation, while Belarus, Kazakhstan, and Russia regulate e-waste through bylaws in the national legislation (i.e. by specifically mentioning e-waste in their general waste laws). All other countries have laws for general waste management but do not regulate e-waste specifically. An EPR system for e-waste has been established in five countries (Belarus, Georgia, Kazakhstan, Moldova, and Russia) and is under development in two countries (Armenia and Ukraine).

C. E-WASTE COLLECTION AND RECYCLING TARGETS IN THE EUROPEAN UNION

In the European Union, e-waste is regulated by the Directive 2012/19/EU on waste electrical and electronic equipment. The WEEE Directive set collection, recycling, reuse, and recovery targets for all six categories of e-waste [28], which have been revised over time (the below provide the target as per latest update).

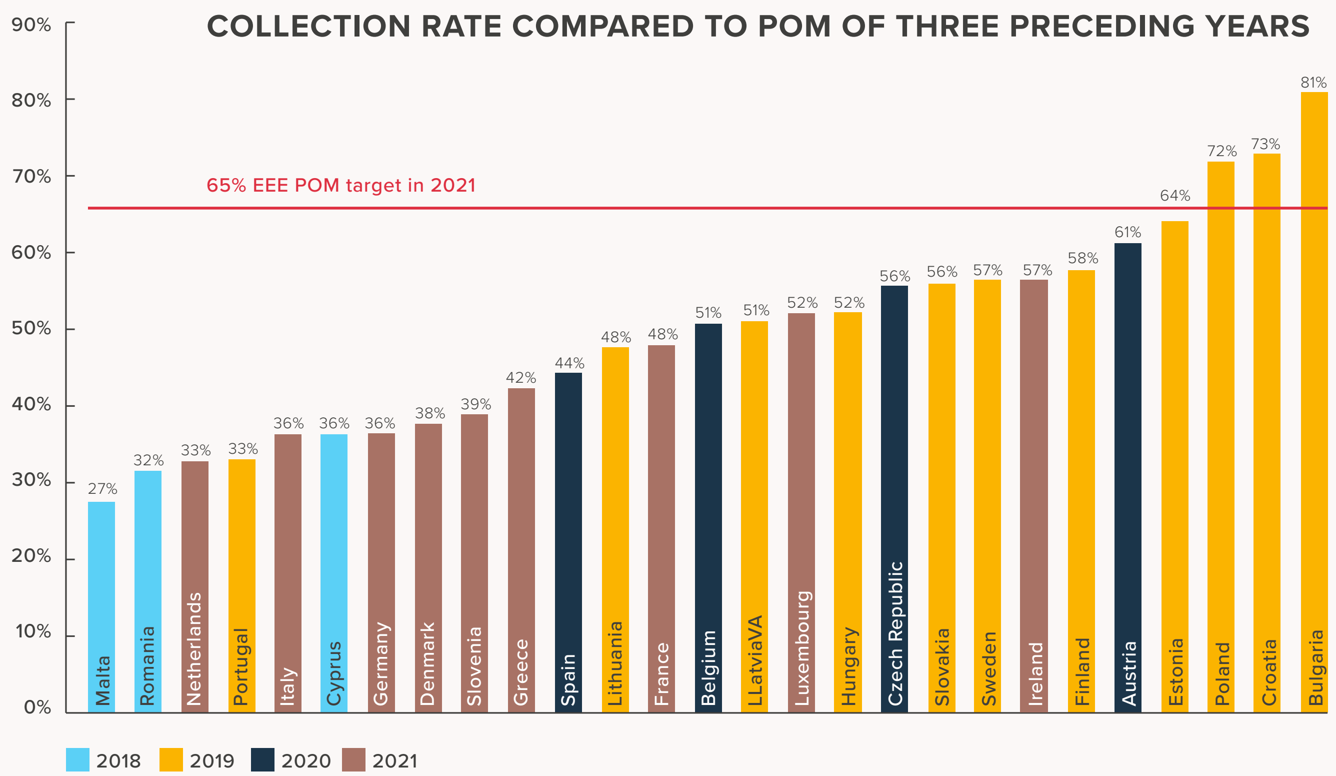
Article 7 of the WEEE Directive states that, starting in 2019, the minimum collection rate to be achieved annually shall be 65% of the average weight of EEE placed on the market in the three preceding years in the Member State concerned, or alternatively 85% of e-waste generated on the territory of that Member State.

As previously mentioned, as of 2019, 42.5% (5.1 Mt) of e-waste was reported to be collected and properly recycled in the EU. A recent study by UNITAR and the WEEE Forum [13] looking at the e-waste generation in the EU, Norway, United Kingdom, Switzerland, and Iceland estimated the formal collection at 5.6 Mt (10.5 kg/inhabitant) in 2021. The study examined the two methods provided in the WEEE Directive to calculate the collection rate.

Using the 'EEE POM method', calculated as the mass of e-waste collected divided by the average amount of EEE POM in the three preceding years, the collection rate in the covered countries was 44%.

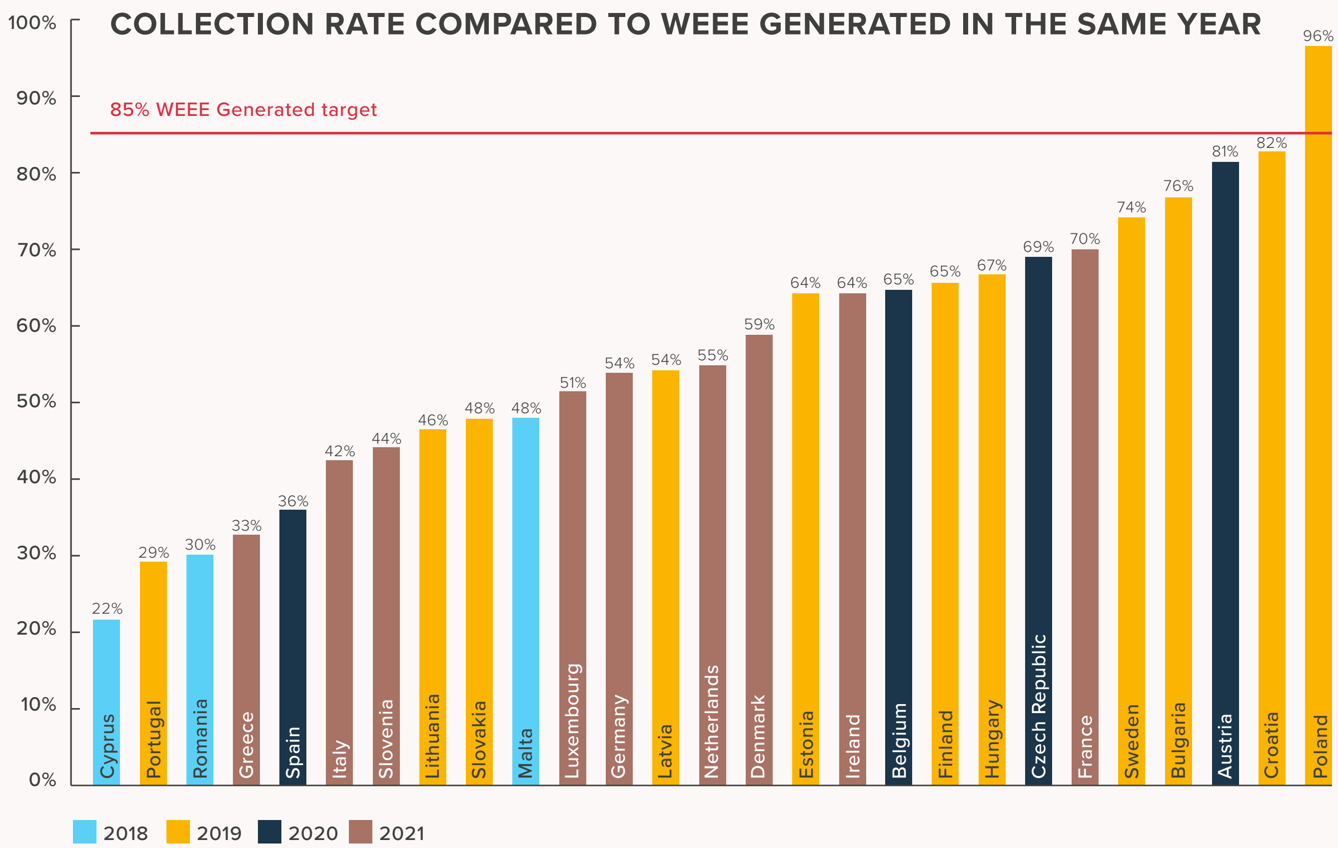
* Note: this apparent wide coverage of population is due to the fact that the most populous countries, such as China and India, have national legal instruments in place.
† CIS countries include: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

Figure 4. Overview of collection rate compared to EEE POM of three preceding years for Member States of the EU-27 [13]



Using the 'WEEE Generated method', calculated by mass of e-waste collected divided by the mass of WEEE Generated in the same year, the collection rate in 2021 was 54%.

Figure 5. Overview of collection rate compared to WEEE Generation for Member States of the EU-27 [13]



These results reveal that the e-waste collection significantly increased over the past year compared to the e-waste generation, but that the increase of EEE put on the market was even bigger. No matter which method is used, the large majority of the EU and other covered countries are not reaching the target set in the WEEE Directive (with the exception of Bulgaria, Croatia, and Poland with the EEE POM method, and Poland with the WEEE Generated method as well).

According to the study, considerable amounts of e-waste are diverted to other undocumented flows, thus preventing EU countries from reaching the collection targets. It was estimated that:

- 1.4 Mt (2.7 kg per capita) was collected with metal scrap and recycled, but not with the same environmental and material efficiency standards as e-waste formally managed would be
- 0.8 Mt (1.5 kg per capita) was disposed of with mixed residual waste and ended up in incinerators and landfills
- 0.5 Mt (1 kg per capita) was illegally exported outside the EU-27 and 0.6 Mt (1.1 kg per capita) was exported for reuse. The exports for reuse and illegal exports are hardly monitored in most countries, also due to the lack of trade codes for used EEE.

Another obstacle in reaching the collection targets is the amount of e-waste stored at home. The study estimated that 3 Mt of EEE is hoarded and broken in the covered countries.

Table 4 presents the minimum targets for e-waste, preparation for reuse, and recycling applicable by category in the European Union provided for in the WEEE Directive, from August 2018:

Table 4. Minimum targets for e-waste recovery, preparation for reuse, and recycling, applicable by category as per the European WEEE Directives

CATEGORY	
1. Temperature exchange equipment 4. Large equipment (any external dimension more than 50 cm)	85% shall be recovered, and 80% shall be prepared for reuse and recycled
2. Screens, monitors, and equipment containing screens having a surface greater than 100 cm^2	80% shall be recovered, and 70% shall be prepared for reuse and recycled
5. Small equipment (no external dimension more than 50 cm) 6. Small IT and telecommunication equipment (no external dimension more than 50 cm)	75% shall be recovered, and 55% shall be prepared for reuse and recycled
3. Lamps	80% shall be recycled

Chapter 4.
Current situation of e-waste management in Kazakhstan

A.CURRENT E-WASTE AND OTHER RELEVANT WASTE POLICIES AND LEGISLATION IN KAZAKHSTAN

i. Kazakh policy and targets for waste management

The development of the waste management system is a priority for Kazakhstan. The state policy of Kazakhstan in the field of waste management is defined by a number of strategic documents.

The 'Concept for the transition of Kazakhstan to a green economy' plan lays the foundation for a systemic transformation to a green economy until 2050. It defines the improvement of the recycling, disposal, and reuse sector as one of the priority objectives [14]. The main target indicators of the Concept by 2030 are:

- MSW recycling rate - 40%
- Population coverage of MSW collection - 100%
- Compliance of landfills with environmental requirements and sanitary rules - 95%

To achieve the target indicators under the transition, the following three measures have been identified: 1) creation of a coordinated system of waste management with the provision of a full range of services, 2) development of a closed-cycle economy with multi-turnover use of materials products both within and outside the value chain, and 3) identification of options for recycling/disposal of hazardous and toxic waste for 100% waste and others. Currently, the 'Concept for the transition of Kazakhstan to a green economy' plan is undergoing a revision procedure.

The national project 'Green Kazakhstan' (2021-2025) is focused on creating a favorable living environment for the population and improving the environmental situation, which, among other things, includes the effective management of production and consumption waste [15]. Waste management indicators by 2025 include the following two points:

- Coverage of separate collection in the cities of Astana and Shymkent and in the regions of Pavlodar and Kyzylorda, including 80% for hazardous types of waste (including electronic and household appliances)
- Percentage of recycling and disposal of MSW - 34%

The concept of development of housing and communal infrastructure (2022-2026) involves the improvement of housing and communal services, including the environment, as one of the main living goods that determine the standard of living of the population. The concept provides for the introduction of technology for separate collection of municipal waste using a two- and three-container system, as well as for the recycling of recoverable materials [16].

ii. E-waste legislation

The main legal act in the field of e-waste is the new Environmental Code of Kazakhstan [17], which went into force on July 1, 2021. The code provides for separate collection of e-waste, mercury-containing waste, batteries, and other hazardous components and stipulates that the waste be transferred to waste recycling companies. Given the presence of hazardous components, it is prohibited to bury e-waste in a landfill. The Environmental Code of Kazakhstan also regulates issues related to waste classification and hazardous waste management, and defines the requirements for extended producer responsibility (EPR).

iii. Extended Producer Responsibility

The EPR has been in effect in Kazakhstan since January 1, 2016 and establishes requirements for eligible importers and producers in the form of either:

1. Applying their own system of collection, transportation, preparation for reuse, sorting, recycling, recovery, depollution, and/or disposal of waste, or
2. Concluding an agreement with the EPR operator to organise the collection, transportation, preparation for reuse, sorting, recycling, recovery, depollution and/or disposal of waste with the payment of the recycling fee

The EPRs were applied to EEE goods (products) at a zero rate from January 23, 2017. The list of relevant goods on producers and importers subject to EPR includes [18]:

- Lamps
- Large-size electrical and electronic equipment
- Electrical and electronic equipment containing coolants
- Electrical and electronic equipment containing screens and monitors
- Small-size electrical and electronic equipment
- Small information electronic and electrical equipment

Since February 2022, manufacturers and importers of EEE pay the recycling fee, according to the Methodology for calculating the recycling fee using certain coefficients‡ for each type of EEE. Previously, no coefficients were applied to EEE.

Table 5 shows the amount of the recycling fee for manufacturers and importers of EEE per 1 ton, according to the above methodology.

To date, the discussions are ongoing to improve the mechanism for implementing the EPR, and the functions of the EPR operator have been transferred to the state organisation in early 2022.

Table 5. Amount of recycling fees for EEE [19]

PRODUCTS GROUP IN KAZAKH LEGISLATION	COEFFICIENT	PAYMENT AMOUNT USD/1 TON	PAYMENT AMOUNT TENGE/1 TON	PRODUCT GROUP ACCORDING TO INTERNATIONAL E-WASTE CATEGORIES
Lamps	47.2	359	162,875	Lamps
Large-size EEE	3.94	30.0	13,593	Large Equipment
EEE containing coolants	7.88	60.0	27,186	Temperature Exchange Equipment
EEE containing screens and monitors	16.3	124	56,235	Screens and Monitors
Small-size EEE	2.00	15.2	6,900	Small Equipment
Small information EEE	24.4	186	84,284	Small IT and Telecommunication Equipment

Note: the US dollar - tenge exchange rate as of May 1, 2023 is USD $1 = 453 tenge

‡ The recycling fee for manufacturers and importers is calculated according to the formula: mass of products (goods) produced (imported) (in tonnes) multiplied by the amount of one monthly calculation indicator (currently in Kazakhstan, this amount is set at 3,450 tenge and it is indexed annually) multiplied by coefficient, which is set by the Methodology for different groups of goods.

iv. Standards for the treatment of hazardous waste

The presence of potentially hazardous components in e-waste establishes special environmental requirements that are regulated by national standards in the management of certain types of waste. In the field of e-waste management, one of the most significant standards is the National Standard ST RK 3753-2021 [20], which aims to ensure sound requirements for handling e-waste at all stages of the life cycle. The national standard establishes requirements for separate collection of e-waste, its storage, and recycling and a ban on disposal at landfills, and it makes it possible to ensure the necessary level of safety in handling e-waste at specialised enterprises.

Qualification requirements for specialised enterprises necessary to obtain licenses for hazardous waste management include the availability of the necessary premises and equipment and the treatment of hazardous waste, environmental emission permit, conclusion of state environmental impact assessment or comprehensive environmental permit, as well as insurance [21].

Specialised enterprises and organisations engaged in the recycling or depollution of hazardous waste, producers of hazardous waste, and business entities engaged in the collection, transportation, and/or depollution of hazardous waste shall keep chronological records of the quantity, type, and origin of waste, destination, frequency of collection, processing method, and method of treatment of hazardous waste and submit this information to the authorised body in the field of environmental protection.

The Hazardous Waste Inventory Report shall be submitted annually as of January 1 and by March 1 of the year following the reporting year in electronic form. The form of the inventory report involves reporting in accordance with the types of waste established by the waste classifier.

v. Restriction of Hazardous Substances (RoHS)

Technical regulation TR EEU 037/2016 applies in the territory of the Eurasian Economic Union (EEU). It establishes mandatory requirements for restricting the use of hazardous substances in electronic and radioelectronic products manufactured in the EEU, as well as permissible concentrations of hazardous substances contained in homogeneous materials [22].

In particular, this Regulation prohibits the use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, and polybrominated diphenylethers in the 12 categories of electrical and electronic products included in the scope of the Regulation. Concentration of hazardous substances in homogeneous materials shall not exceed 0.1% or, for cadmium, 0.01%. Products of EEE can be placed on the market in the territory of the Customs Union, including Kazakhstan, provided that they have passed confirmation of compliance with the requirements of this Regulation in the prescribed manner. The Regulation is currently being updated so that the following substances can be added to the list of controlled hazardous substances: diethylhexylphthalate, butylbenzylphthalate, dibutylphthalate, and diisobutylphthalate.

vi. Enforcement of waste legislation

Control over compliance with the law, including environmental requirements in waste management, is carried out by the authorised body in the field of environmental protection and local executive authorities. They are also responsible for organising a sound system of municipal waste management, which provides for the proper separate collection of e-waste and its transfer to specialised enterprises for recovery. As well, the local executive authorities are responsible for organising the development and enforcement of municipal waste management programs, which focus on reducing waste generation and increasing the share of waste recycling. In a number of regions, there is a low level of development and execution of these programs. In addition to these issues, national stakeholders expressed concerns about illegal importation of e-waste in the country.

Thus, the basic legal norms for the regulation of e-waste have been defined in Kazakhstan. However, there are a number of problems and gaps, both in the legislation itself - in terms of EPR mechanisms and inconsistency of classification of e-waste with international approaches - and in the low level of implementation and enforcement of the legislation.

B. CURRENT NATIONAL INFRASTRUCTURE FOR MANAGING E-WASTE

E-waste management in Kazakhstan involves many stakeholders: state agencies, local executive authorities, manufacturers, importers and retailers of EEE, collectors, recyclers, manufacturers of recycled products, NGOs, and the civil sector.

i. EEE manufacturing industry

The EEE manufacturing industry in Kazakhstan is insufficiently developed and is represented only by the production of transformers, high-voltage and low-voltage equipment, cable products, batteries, and capacitors. In 2020, there were 117 companies producing EEE in Kazakhstan. According to the official statistics, the volume of production of EEE in the total production of industrial products in 2020 amounted to 0.2% (40,888 million tenge). Most EEE that is placed on the market is imported [23].

Manufacturers and importers of EEE in Kazakhstan are only partially involved in the collection of used EEE from the private households. Some manufacturers and importers collect part of the e-waste from the public that has lost its consumer properties from authorised service centers and stores.

Adhering to the principle of 'no compromise on environmental protection', multinational EEE companies have created their own standards for the control of substances in manufactured products, which reflect international standards - such as the EU RoHS (Restriction of Hazardous Substances) Directive and REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) Regulation - and carefully monitor their own activities.

Similarly, it should be noted that not all manufacturers and importers have an established system for collecting and transferring for recycling of e-waste generated during the activities of companies (for example, defective products).

ii. Official e-waste collection and recycling

The infrastructure for e-waste management consists of collection, recycling, and production of secondary raw materials. However, this infrastructure is not yet fully developed. According to the data from the Kazakh Association for Waste Management 'KazWaste,' there are 19 specialised enterprises in Kazakhstan that are engaged in the collection and processing of e-waste (Annex 1). Due to the introduction of licensing requirements, the majority of e-waste management companies undergo licensing procedures. However, some companies continue to operate without obtaining a license, which is permissible when handling non-hazardous waste.

As a rule, e-waste collection and recycling companies work with legal entities and deal with self-collection of e-waste from legal entities. The infrastructure for collecting e-waste from the population is very poorly developed. Containers and collection points for e-waste collection are installed only in some major cities and do not provide coverage of the entire urban population.

The e-waste recycling cycle at specialised enterprises in Kazakhstan includes 2 stages:

1. Pre-processing: disassembly and sorting into hazardous and valuable parts, and
2. Transfer of valuable parts to enterprises to the secondary raw material recovery

Recycling of ferrous and non-ferrous metals occurs in Kazakhstan, while other valuable parts, such as electronic scrap, plastics, and others, are most often exported abroad.

There are no technologies for the printed circuit boards secondary raw material recovery in Kazakhstan. The existing refineries ('Tau-Ken Altyn' LLP, 'Kazzinc' LLP, and 'Kazakhmys Smelting' LLP) do not use technology to extract precious metals from electronic equipment.

The existing specialised enterprises do not operate at full capacity, due to the low collection rates of e-waste. Additionally, there is a weak technical equipment and a lack of technological lines for depollution of hazardous components of electronic waste, including lithium-ion batteries.

There is not much competition in the sphere of e-waste management.

iii. Unofficial collection and recycling

Also, an important factor is the presence of unofficial recyclers, working alongside e-waste collection and recycling companies. Unofficial recyclers are mainly engaged in collection of valuable components from electronic waste and their subsequent resale. Such recyclers may ignore the necessary environmental measures and regulations and/or the health and sound measures and regulations in the e-waste recycling process, including the use of personal protective equipment and best practices for handling hazardous components in an environmentally sound manner.

iv. Non-governmental organisations

The environmental community, represented by non-governmental organisations (NGOs), research institutes, and universities, makes a significant contribution to the development of the e-waste management system in Kazakhstan. Environmental NGOs are involved in projects aimed at outreach and information support, installation of specialised containers to collect certain types of e-waste, and organisation of removal of discarded equipment and its further disposal, as well as conducting various research works on e-waste management and strengthening stakeholder interaction. A number of universities and research institutes have separate waste collection points and collection points for waste batteries and rechargeable batteries that have lost their use value.

Despite the efforts made, a number of problems remain relevant in the sphere of infrastructure. They include insufficient provision of infrastructure for collection of e-waste from private households, the low level of development of applied technologies at specialised enterprises, and the lack of technologies for the e-waste secondary raw material recovery.

C.E-WASTE STATISTICS IN KAZAKHSTAN

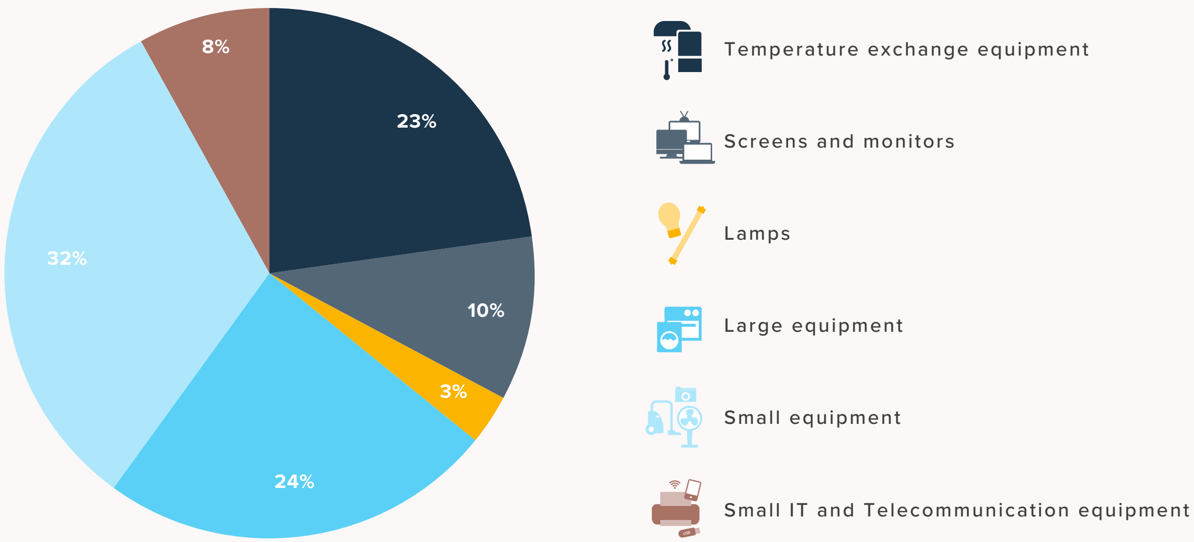
According to UNITAR, the EEE POM in Kazakhstan in 2019 was 221.6 kt (11.8 kilograms per capita). The e-waste generation was 136.1 kt of e-waste (7.3 kg per capita), and the e-waste collection and recycling was 11.9 kt (0.6 kg per capita), amounting to 8.8% of the e-waste generated.

Table 6. Key data on EEE and e-waste in Kazakhstan in 2019 cording to UNITAR [9]

INDICATORS	VALUES
EEE placed on the market	221.6 kt 11.8 kg per capita
E-waste generation	136.1 kt 7.3 kg per capita
E-waste collection and recycling	11.9 kt 0.6 kg per capita
E-waste recycling, %	8.8 %

Figure 6 shows how the e-waste generated in Kazakhstan in 2019 can be broken down into the six e-waste categories. The highest share of e-waste generation in Kazakhstan is for small-sized equipment (Category V) - 32%, or 2.3 kg per capita, and the lowest for lamps (Category III) - 3%, or 0.2 kg per capita.

Figure 6. E-waste generation in Kazakhstan by category of e-waste, 2019 (Baldé et.al, 2021) [9]



On the contrary, according to national statistics based on data provided by companies, the amount of e-waste generated in Kazakhstan in 2019 was 1.3 kt (and was 1.1 kt in 2020 and 4 kt in 2018). In 2021, according to the new classification mentioned above, this amount had decreased to 553 tons (Table 7).

Table 7. E-waste generated in Kazakhstan in 2021 according to the Bureau of National Statistics [5]

16 02 Waste electrical and electronic equipment, total	553 tons
16 02 09* Transformers and capacitors containing polychlorinated biphenyls	1 tons
16 02 10* Discarded equipment containing or contaminated with polychlorinated biphenyls, other than those mentioned in 16 02 09	26 tons
16 02 11* Discarded equipment containing chlorofluorocarbons, HCFCs (hydrochlorofluorocarbons), HFCs (hydrofluorocarbons)	-
16 02 12* Discarded equipment containing respirable, free asbestos	-
16 02 13* Discarded equipment containing hazardous components§, other than those mentioned in 16 02 09-16 02 12	19 tons
16 02 14 Discarded equipment, other than those mentioned in 16 02 09-16 02 13	370 tons
16 02 15* Hazardous component parts, recovered from discarded equipment	8 tons
16 02 16 Components removed from discarded equipment, other than those mentioned in 16 02 15	129 tons

National statistics on e-waste have varied widely in recent years. They differ significantly from UNITAR data, due to the use of different calculation methods, including the use of different degrees of coverage of sources of WEEE generation and e-waste categories.

Additionally, the following problems remain relevant in the field of statistics:

1. Statistics on e-waste generation provided by the Bureau do not account for all sources of e-waste or all categories of e-waste
2. Statistics on e-waste generation in recent years are not comparable and show a significant (more than 500-fold) increase in e-waste generation in companies that provide information to the State Waste Cadastre
3. Lack of detailed division into types of EEE, which results in insufficient and distorted data and which complicates the assessment of environmental impact
4. Insufficient compliance with reporting requirements for supplementing information in the State Waste Cadastre
5. No account is taken of e-waste that goes to the informal e-waste management sector (shadow collection)

Discrepancies and insufficient data complicate the accounting of e-waste and the assessment of its environmental impact and economic consequences, and thus make it difficult to make quality decisions in the management of e-waste.

The Bureau of National Statistics is currently considering changes and additions to municipal waste reporting forms (report 1-waste and 2-waste) to improve e-waste statistics.

§ Pharmaceutical preparations and medical and veterinary components

Chapter 5.
Challenges and opportunities

A. PROJECTIONS OUT TO 2030 AND 2050: ENVIRONMENTAL IMPACT AND RESOURCE POTENTIAL OF E-WASTE

E-waste generated

According to the UNITAR's E-waste Collected Tool, it is expected that the volume of e-waste generated in Kazakhstan will continue to grow. With Kazakhstan's projected population of 24 million in 2050, the amount of e-waste generation is expected to be 18 kg per capita, which is comparable with 2019 data on the generation of e-waste per capita in the European Union [1].

Figure 7 shows the projections of the total cumulative amount of managed and unmanaged e-waste until 2030 and 2050 in the absence of measures to improve the management of e-waste in Kazakhstan (under the 'Business as Usual' scenario).

As seen in figure 7a, unmanaged e-waste could reach 1.9 Mt by 2030 and 8.4 Mt by 2050.

Hazardous substances in e-waste

Hazardous components in e-waste negatively affect human health and pollute the environment, including contributing to climate change. For example, gas discharge lamps and backlighting of older flatscreen displays contain mercury, and monitors and television sets with cathode ray tubes contain lead. EEE may contain polyvinyl chloride (PVC) and polytetrafluoroethylene (PTFE), which negatively affect respiratory mucosa and the central nervous and reproductive systems. Printed circuit boards (and further plastic components) contain brominated flame retardants (BFRs), such as tetrabromobisphenol-A (TBPA) or polybrominated diphenyl ethers (PBDEs). Certain EEE may contain beryllium, mercury, cadmium, and gallium arsenide (GaAs), which are hazardous substances for human health and the environment.

Temperature exchange equipment contains substances that are harmful to the ozone layer, such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), and are greenhouse gases, such as CFCs, HCFCs and hydrofluorocarbons (HFCs), and others.

Figure 7a. Total accumulated e-waste volumes from 2022 to 2030 and 2050, under the 'Business as Usual' scenario [24]

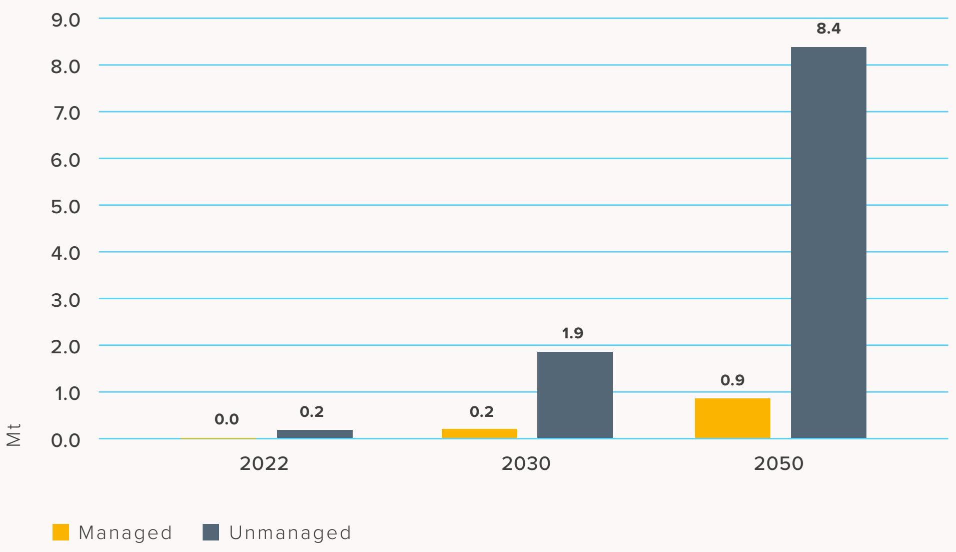


Figure 7b. Generation of managed and unmanaged e-waste 2022, 2030, and 2050, under the 'Business as Usual' scenario

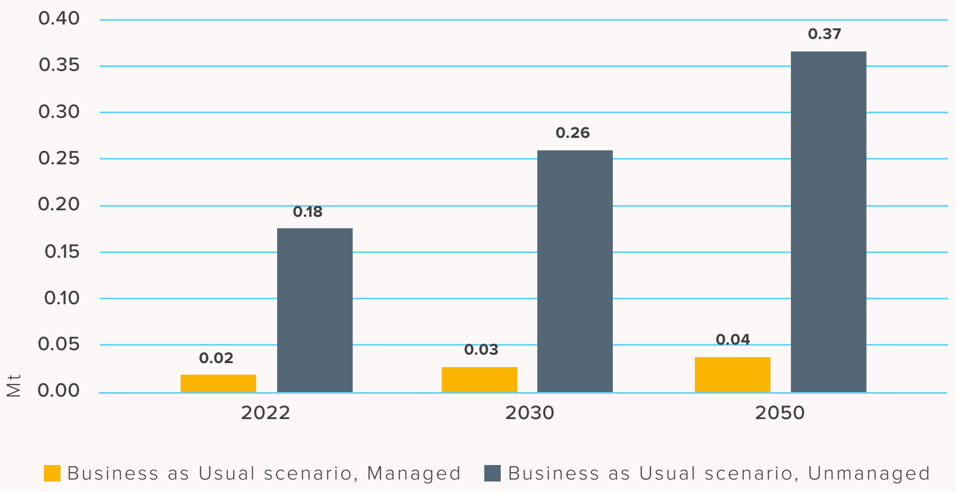


Table 8 shows the projected content of hazardous substances in e-waste for 2022-2030 and 2022-2050 under the 'Business as Usual' scenarios.

Table 8. Projected content of hazardous substances in managed/unmanaged e-waste for 2030 and 2050, under the 'Business as Usual' scenario [24]

HAZARDOUS SUBSTANCES	CUMULATIVE 2022-2030, TONS		CUMULATIVE 2022-2050, TONS	
	Managed	Unmanaged	Managed	Unmanaged
HFC-32	1.73	17.1	7.43	73.2
HC (R600a)	9.22	90.8	39.5	389
HFC-410A	43.0	423	184	1,815
HFC -134a	5.87	57.8	11.4	112
CFC-12	2.62	25.8	3.33	32.8
HCFC-22	207	2,034	637	6,273
Mercury (Hg)	0.17	1.68	0.33	3.29
Lead (Pb)	107	1,057	208	2,050

Valuable materials in e-waste

In addition to hazardous substances and toxic substances, e-waste contains valuable materials such as steel, copper, aluminum, precious metals, and other types of metals. In today's mining practice, the primary extraction of raw materials often causes significant negative environmental impacts. Fluctuating market prices, shortages of materials, and the supply risks of raw materials create the need to implement methods to recover secondary raw materials and reduce the pressure on primary raw materials. In this regard, e-waste is an important source of secondary raw materials [1].

Table 9 shows the projected content of valuable materials in e-waste for 2022-2030 and 2022-2050 in Kazakhstan, under the 'Business as Usual' scenario. Precious metals such as gold, silver, and palladium can be found in, e.g., printed circuit boards.

Table 9. Projected content of valuable materials in managed/unmanaged e-waste for 2022-2030 and 2022-2050, under the 'Business as Usual' scenario [24]

VALUABLE MATERIALS	CUMULATIVE 2022-2030, TONS		CUMULATIVE 2022-2050, TONS	
	Managed	Unmanaged	Managed	Unmanaged
Iron (Fe)	75,842	746,828	328,354	3,233,336
Plastic	29,022	285,782	83,206	819,340
Aluminum (Al)	10,401	102,420	42,031	413,883
Glass	1,154	11,368	41,558	409,226
Copper (Cu)	5,995	59,035	25,949	255,525
Silver (Ag)	3.31	32.6	13.5	133
Gold (Au)	0.67	6.60	2.56	25.2
Palladium (Pd)	0.01	0.05	0.02	0.22
Platinum (Pt)	0.27	2.62	1.09	10.7

As with any country, the availability of valuable materials and the development of an environmentally sound e-waste management system for Kazakhstan can be a platform for creating a sustainable recycling business and jobs.

Environmental costs of pollution by e-waste

UNITAR estimates the current economic damage by the mainly unmanaged e-waste as follows:

- Economic losses in Kazakhstan associated with the environmental and social impacts of unmanaged e-waste are estimated at USD $649 million (288 billion tenge) for 2022 (Table 10). This is mainly due to unmanaged hazardous substances and greenhouse gas emissions. The cost is 0.3% of the 2021 GDP [25].
- Revenues from the recycling of valuable materials will be limited to USD $15 million (6 billion tenge) per year.

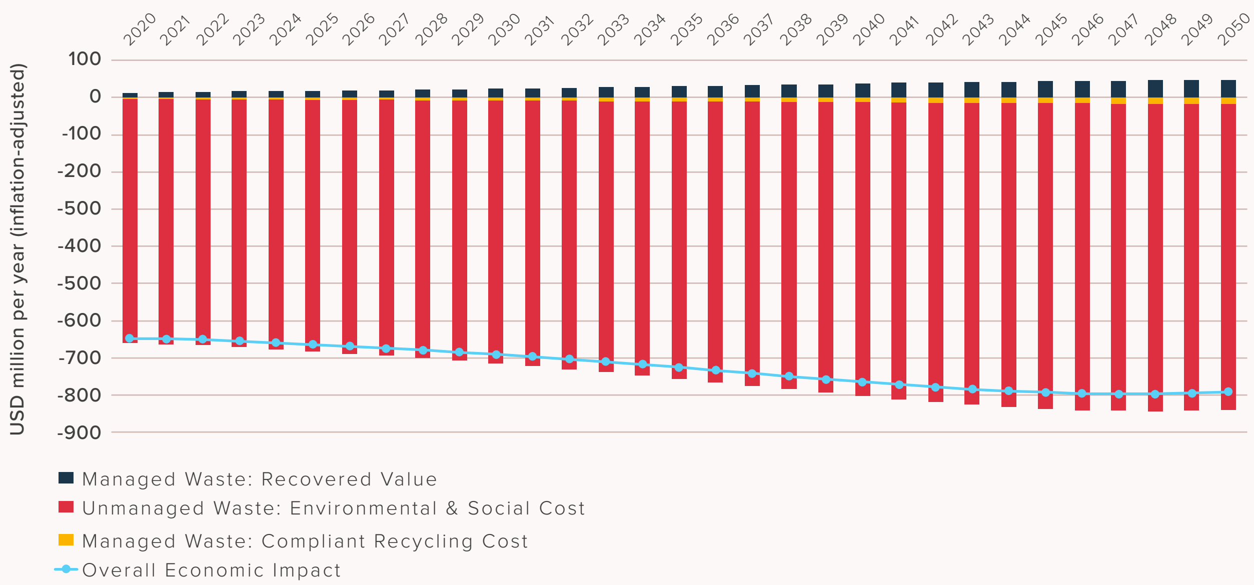
Table 10. Economic losses in 2022, 2030, and 2050 under the 'Business as Usual' scenario

ECONOMIC INDICATORS, MILLION USD PER YEAR			
	2022	2030	2050
Environmental and social costs of unmanaged e-waste	-655	-705	-820
Costs of recycling of managed e-waste	-6	-8	-18
Revenue from the recycling of managed e-waste	15	24	48
Total economic effect	-650	-690	-791

Under the 'Business as Usual' scenario and with no change in the collection and recycling rates of e-waste, and taking into account the corresponding rates of inflation, the following consequences are expected (Figure 8):

- Monetised environmental and social losses will grow and could increase by 22%, which would be minus USD $791 million (352 billion tenge) per year
- Revenues from the recycling of valuable materials would be only USD $48 million (21 billion tenge) per year.

Figure 8. Dynamics of environmental and socio-economic impacts, under the 'Business as Usual' scenario in Kazakhstan



If the e-waste management system develops under the 'Business as Usual' scenario, the loss of valuable materials and the release of hazardous constituents and toxic substances contained in e-waste will have tangible environmental and economically negative consequences for Kazakhstan in 2030; by 2050, the impact will be even more detrimental.

The projected negative effect emphasises the need for consistent measures to improve the e-waste management system in accordance with a clearly defined scenario of system development and specific targets that will help track its growth and development.

B. INTERACTION BETWEEN E-WASTE COLLECTION AND RECYCLING AND THE SUSTAINABLE DEVELOPMENT GOALS

In September 2015, all United Nations Member States adopted the ambitious 2030 Agenda for Sustainable Development and identified 17 Sustainable Development Goals (SDGs) and 169 targets aimed at ending poverty, protecting the planet, ensuring prosperity, and fostering peace through global partnership.

Considering the issues and opportunities associated to e-waste, improving e-waste management would contribute to the achievement of several SDGs related to environmental protection and health, employment, and economic growth, as detailed below.

Environmental protection and health

The hazardousness inherent to e-waste leads to various environmental and health-related issues, including the pollution of air, water, and soil, if the e-waste is mismanaged. SDG 3 on good health and well-being, and more specifically Target 3.9, tackles the reduction of the number of deaths and illnesses caused by hazardous chemicals and air, water, and soil pollution and contamination. Under SDG 6 on clean water and sanitation, Target 6.1 aims to achieve universal and equitable access to safe and affordable drinking water for all, and Target 6.3 is focused on reducing pollution, eliminating dumping, and minimising release of hazardous chemicals and materials. SDG 14 on life below water and Targets 14.1 and 14.2 refer to marine pollution and the protection of the marine ecosystem.

Most e-waste is generated in cities, so it is particularly important to improve collection and recycling rates in urban areas. Under SDG 11 on sustainable cities and communities, target 11.6 seeks to reduce the adverse per capita environmental impact of cities by paying special attention to air quality and to municipal and other waste management.

Under SDG 12 on responsible consumption and production, target 12.4 intends to achieve the environmentally sound management of chemicals and all waste throughout the life cycle, in accordance with agreed international frameworks, and to significantly reduce their release into air, water, and soil in order to minimise their adverse impacts on human health and the environment. Target 12.5 addresses the issue of over-consumption of goods and over-production of waste and aims to substantially reduce waste generation through prevention, reduction, repair, recycling, and reuse.

Figure 9. 17 Sustainable Development Goals (SDGs) [29]

Under SDG 12, more specific sub-indicators have been recognised for monitoring growth in e-waste, i.e. e-waste has been included in the work plan and the documentation around indicator 12.5.1 on the national recycling rate and tons of material recycled, and under indicator 12.4.2 on hazardous waste generated per capita and proportion of hazardous waste treated by type of treatment.

Employment and economic growth

Solid waste management and recycling employs between 19 and 24 million women and men worldwide, of which four million work in the formal waste and recycling sector [26]. For now, e-waste is often processed in the informal sector, which is associated with work safety and security issues. However, due to the presence of valuable materials, the management of e-waste can be an opportunity for entrepreneurs to create sustainable businesses and green jobs and to contribute to economic growth in the recycling and refurbishing sector. Under SDG 8 on decent work and economic growth, Target 8.3 aims to promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity, and innovation, and to encourage the formalisation and growth of micro-, small-, and medium-sized enterprises. Target 8.8 calls for the protection of labour rights and promotes safe and secure working environments for all workers, including migrant workers, particularly women migrants, and those in precarious employment.

C. POSSIBLE WAYS OF DEVELOPING AN E-WASTE MANAGEMENT SYSTEM IN KAZAKHSTAN

Based on Kazakhstan's strategic documents on green economy and carbon neutrality (see chapter 4a), as well as the possible environmental, social, and economic consequences for the environment and economy of Kazakhstan of the lack of a sound e-waste management system in Kazakhstan, it becomes clear that the improvement of e-waste management in Kazakhstan should be carried out in accordance with the principles of circular economy.

The Circular Economy e-waste management scenario (see chapter 2b) can be implemented in different ways. To assess this projection scenario, this publication uses targets demonstrating intensive growth of the share of e-waste collection and recycling in Kazakhstan from 9.2% in 2022 to 100% by 2052 (Table 11).

Table 11. Proposed e-waste collection and recycling targets (managed e-waste) for the Circular Economy scenario

	2022 (CURRENT LEVEL)	2027	2032	2037	2042	2047	2052
Value of the indicator	9.2%	20%	35%	50%	70%	90%	100%

A comparison of the results of the 'Business as Usual' and Circular Economy scenarios projections demonstrates a significant difference in the volume of unmanaged e-waste (Figure 10), which has a serious negative impact on the environment and human health and on the production of secondary raw materials.

In the Circular Economy scenario, the amount of unmanged e-waste is nearly zero by 2050, as shown in Figure 10. It would reduce the cumulative amount from 2020 to 2050 of unmanaged e-waste by half, from 8.4 Mt to 4 Mt, by ensuring that e-waste is managed through collection and recycling (Figure 11).

Figure 10. Projections of unmanage e-waste generation under two scenarios of e-waste management

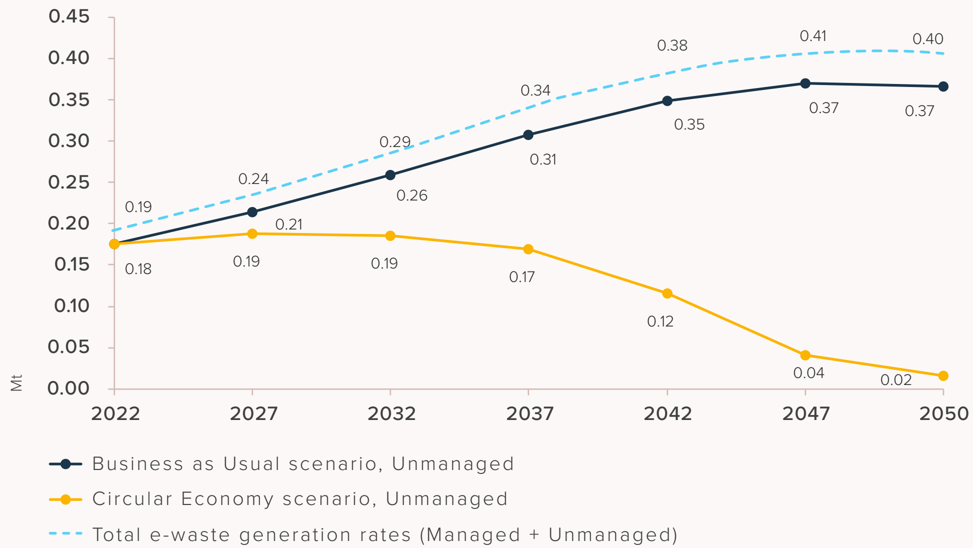


Figure 11. Total volumes of accumulated e-waste under two scenarios of e-waste management

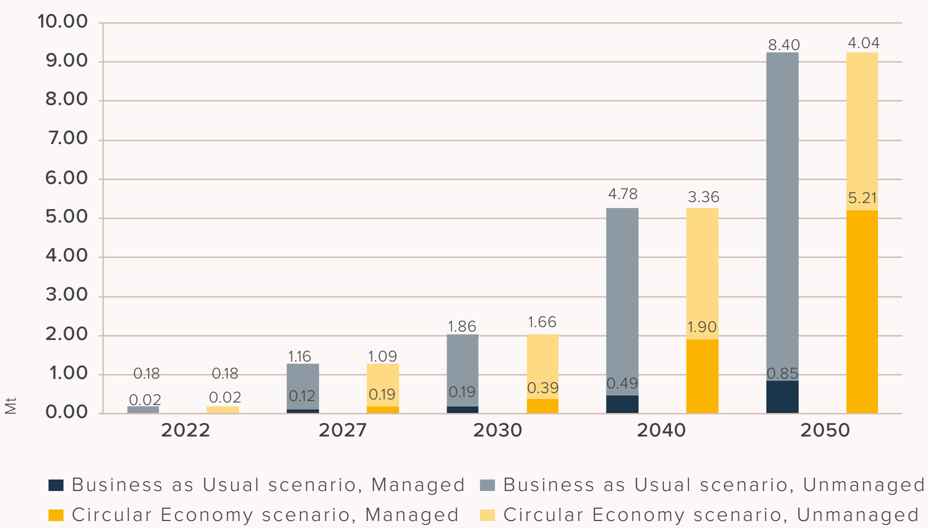


Table 12 presents UNITAR's projections for the cumulative amounts of hazardous substances in e-waste in the absence of progress in e-waste management development ('Business as Usual' scenario) and in the case that Kazakhstan makes significant progress in e-waste management and improves collection rates (Circular Economy scenario).

Table 12. Projected content of hazardous substances in managed/unmanaged e-waste for 2022-2050, under two scenarios of e-waste management [24]

HAZARDOUS SUBSTANCES	BUSINESS AS USUAL SCENARIO 2022-2050, TONS		CIRCULAR ECONOMY SCENARIO 2022-2050, TONS	
	Managed	Unmanaged	Managed	Unmanaged
HFC-32	7.43	73.2	45.0	35.6
HC (R600a)	39.5	389	240	189
HFC-410A	184	1,815	1,117	882
HFC -134a	11.4	112	45.0	78.4
CFC-12	3.33	32.8	8.16	28.0
HCFC-22	637	6,273	3,376	3,534
Mercury (Hg)	0.33	3.29	1.33	2.29
Lead (Pb)	208	2,050	858	1,400

The implementation of the Circular Economy scenario would make it possible to recover and recycle 3.2 Mt of valuable materials (1,974 kt of iron, 247 kt of aluminium, 423 kt of plastic, etc.) from e-waste by 2050. These materials can be reused as secondary resources for the production of EEE, construction materials, vehicles, etc.

Table 13. Projections content of valuable materials in managed/unmanaged e-waste for 2022-2050, under two scenarios of e-waste management [24]

VALUABLE MATERIALS	BUSINESS AS USUAL SCENARIO 2022-2050, TONS		CIRCULAR ECONOMY SCENARIO 2022-2050, TONS	
	Managed	Unmanaged	Managed	Unmanaged
Iron (Fe)	328,354	3,233,336	1,974,526	1,587,164
Plastic	83,206	819,340	423,813	478,733
Aluminum (Al)	42,031	413,883	247,223	208,691
Glass	41,558	409,226	328,743	122,041
Copper (Cu)	25,949	25,5525	156,446	125,028
Silver (Ag)	13.5	133	79.5	67.0
Gold (Au)	2.56	25.2	14.7	13.1
Palladium (Pd)	1.09	10.7	6.41	5.43
Platinum (Pt)	0.02	0.22	0.13	0.11

Recycling e-waste can significantly reduce greenhouse gas emissions by cutting emissions as a direct consequence of e-waste management and indirect when this happens along the lifecycle. Direct avoided emissions happen when temperature exchange equipment is managed in an environmentally sound manner. Some of the refrigerants contained are greenhouse gases, and managing them avoids emissions. Indirect emissions could occur when secondary raw materials are produced, and new ores do not have to be mined. Both direct and indirect greenhouse gas emissions from the e-waste management system in Kazakhstan will increase under the 'Business as Usual' scenario and could reach about 1 Mt by 2050. The development of an e-waste management system under the Circular Economy scenario would prevent approximately 95% of greenhouse gas emissions, which would amount to only 0.05 Mt of CO_2-equivalents (Figure 12).

E-waste management can have a significant economic impact - reducing production costs, creating income opportunities from recycling valuable materials, reducing disposal costs and fines, and stimulating economic growth through sustainable resource use. The implementation of the Circular Economy scenario would achieve a positive economic effect of USD $227 million (101 billion tenge) in e-waste management in Kazakhstan by 2050, while the 'Business as Usual' scenario could result in a cost of USD $791 million (352 billion tenge) by 2050 (Figure 13), which is mainly attributed to hidden environmental and societal costs of unmanaged e-waste. In the Circular Economy scenario, by 2050 the overall management of e-waste could have a net positive impact of USD $227 million (124 billion tenge), mainly due to the revenue of recycling of e-waste through the production of secondary raw materials.

Figure 12. Projections of direct and indirect greenhouse gas emissions from e-waste management in CO_2-equivalents

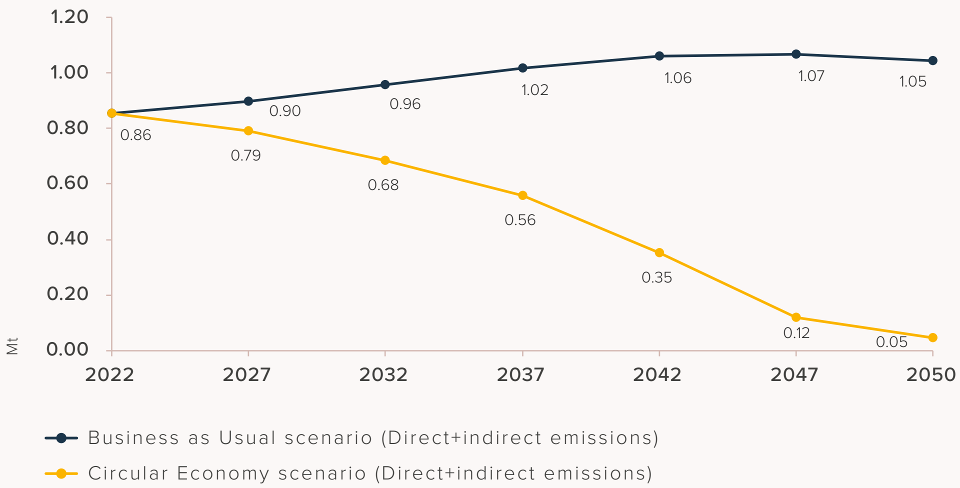


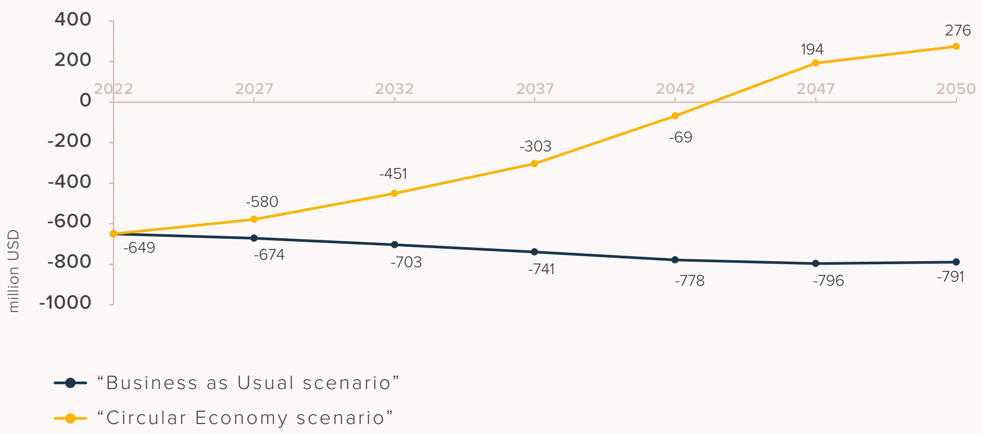
Table 14. Economic revenues and losses in 2022, 2030, and 2050, under two scenarios of e-waste management [24]

ECONOMIC INDICATORS, MLN USD	NOW	BUSINESS AS USUAL SCENARIO	CIRCULAR ECONOMY SCENARIO
	2022	2050	2050
Environmental and social costs of unmanaged e-waste	-659	-821	-72.3
Costs of recycling managed e-waste	-5.5	-17.6	-175
Revenue from the recycling of managed e-waste	15.4	47.5	474
Total economic effect	-649	-791	227

*negative values represent costs / negative impacts on the environment and society.

As shown in Figure 13, the Circular Economy scenario will achieve positive economic effects as early as 2044, which will increase as the volume of recycled waste increases, recycling and reuse technology develops, and the price of valuable materials increases.

Figure 13. Total economic effect of e-waste management system under two e-waste management scenarios, million USD



*negative values represent costs

Thus, the results of the 'Business as Usual' and Circular Economy scenario projections clearly demonstrate the difference in the future development of e-waste management in Kazakhstan. The 'Business as Usual' scenario assumes a continuing upward trend in unmanaged e-waste, resulting in increased negative environmental and health impacts as well as a loss of valuable resources and economic benefits. In contrast, the Circular Economy scenario assumes a reduction in unmanaged waste, a reduction in greenhouse gas emissions and pollution, and an increase in economic benefits through greater resource efficiency. Thus, the results of the 'Business as Usual' and Circular Economy scenario projections clearly demonstrate the importance of moving toward sustainable e-waste management and show that the implementation of resource efficiency and waste reduction measures can lead to significant economic, environmental, and social gains.

Chapter 6.
Further directions for an e-waste management system in Kazakhstan

The results of forecasting the environmental and socio-economic consequences of the current e-waste management system in Kazakhstan, the relationship between the collection and recycling of e-waste and the sustainable development goals, and international and regional agreements that Kazakhstan is bound to all highlight the need for decisive measures to improve the e-waste management system.

The international approach involves ten actions or steps for an effective e-waste collection and recycling system in countries. These steps are proposed by the Solving the E-waste Problem (StEP) Initiative and presented in the 'Guidelines for the Development of E-Waste Management and Legislation' [2]. They can be implemented at various stages of decision-making, and the priority and sequence of each step may differ from country to country.

On the basis of international experience and the results of the national dialogue of stakeholders, necessary measures for the development of the e-waste management system in Kazakhstan were identified.

The implementation of these measures is inextricably linked to the collective efforts of all stakeholders, including government agencies, manufacturers and importers of electronic appliances and equipment (EEE), collectors, e-waste recyclers, and all other stakeholders.

A. IMPROVEMENT OF LEGISLATION EXPLICITLY COVERING E-WASTE

One of the main directions in conjunction with the development of an e-waste management system is the necessary improvement of existing legislations. The needed actions in this direction are to:

- Implement the system of classification of e-waste according to the European Union Directive 2012/19/EU on waste electrical and electronic equipment (WEEE), for uniform application and accounting of categories of e-waste in regional and national monitoring
- Establish national goals and targets for the collection and recycling of e-waste, in order to improve the efficiency of the e-waste management sphere
- Conduct domestic ratification procedures under the agreement of 1 June 2018 'On cooperation of CIS member states in the management of e-waste' to establish a regional e-waste management system
- Strengthen control over the implementation of environmental legislation, as well as to bring to administrative responsibility those who violate the requirements for the handling of e-waste
- Strengthen control over the implementation of municipal waste management programs, as well as accelerate the approval and subsequent implementation of these programs
- Increase the capacity of state agencies in the field of environmental protection on the environmentally safe handling of e-waste

B. IMPROVEMENT OF THE STATISTICAL DATA COLLECTION AND PROCESSING SYSTEM FOR E-WASTE GENERATION, COLLECTION, AND RECYCLING

As part of this direction, the following key measures should be taken:

- Increase the capacity of specialised enterprises, representatives of small and medium-sized businesses to provide reporting, reporting forms and deadlines
- Conduct a study to identify the volume of exports and imports of EEE that is not declared (illegal imports), and strengthen measures to combat it
- Introduce the use of the Electronic Waste Collection Tool developed by UNITAR to monitor e-waste generation volumes and the broader socio-economic and environmental impact of e-waste collection and recycling over a period of time up to 2050
- Establish monitoring of e-waste collection and recycling volumes as part of the EPR mechanism and in enterprises with minimum waste collection and recycling standards

C. DEVELOPMENT OF INFRASTRUCTURE AND IMPROVED TECHNOLOGY FOR E-WASTE COLLECTION AND RECYCLING

The following key measures should be taken within this direction:

- Create a national e-waste management infrastructure suitable for Kazakhstan in terms of logistics, financing, raising public awareness, working with government agencies, communicating with stakeholders and consumers, evaluating the effectiveness of the system, etc
- Stimulate formalisation of the informal sector and facilitate the process of transitioning to formal activities
- Introduce e-waste end-processing technologies, including at national metallurgical plants, or provide access to international/regional end-processing facilities to recover valuable parts of e-waste
- Upgrade the current technical equipment of e-waste recycling facilities and include the implementation of Best Available Techniques (BAT)
- Run processing lines to depollution hazardous components of e-waste, including recycling of lithium-ion batteries
- Consider introducing recycling technologies for different types of plastics contained in e-waste

D. NECESSARY MEASURES TO SUPPORT THE E-WASTE COLLECTION AND RECYCLING SECTOR

The collection and recycling sector is an important part in the development of an e-waste management system and there is a need to support this sector in the following directions:

- Create a direct dialogue between recyclers and public authorities to strengthen the cooperation and transparency of both parties
- Consider providing tax incentives, to specialised enterprises engaged in the collection and recycling of e-waste in order to improve competitiveness and attract investment in the sphere of e-waste
- Increase awareness of the informal sector on the benefits of running a legal recycling business, existing legal requirements and support measures, the impact of e-waste on human health in improper waste management
- Restore the financing of specialised enterprises for the collection and recycling of e-waste, by the current EPR Operator
- Development of financial mechanisms in the EPR system to encourage manufacturers and importers to switch to their own e-waste collection system by attracting local recyclers to perform the EPR
- Consider the possibility of organising a separate EPR operator as a non-profit organisation, while ensuring the gradual transition of functions from the public sector to the non-profit sector
- Development of financial mechanisms to stimulate the transition of manufacturers and importers to their own e-waste collection system by involving local recyclers
- Consider the possibility of organising a separate recycling operator as a non-profit organization, while ensuring the gradual transition of functions from the public sector to the non-profit sector
- Revise the methodology for calculating the recycling fees of manufacturers (importers), and the subsequent monitoring of the intended use of funds
- Improve the reporting on the distribution of recycling fees in order to ensure a transparent system

E. CAPACITY-BUILDING AND STAKEHOLDER AWARENESS ON E-WASTE MANAGEMENT AND COMMUNITY OUTREACH

Capacity-building and informing stakeholders on e-waste management, as well as active awareness-raising with the public, are important tasks on the way to creating an effective e-waste management system. To actively develop this area, the following key measures should be taken:

- Strengthen information outreach to the public and stakeholders about the potential impact of e-waste on the environment and human health, the sound management of e-waste, and the importance of e-waste collection and the importance of e-waste collection
- Increase consumer culture in favor of extending the life of EEE
- Develop mechanisms to encourage consumers to collect and turn in e-waste to e-waste collection and recycling companies
- Conduct guest lectures, on an ongoing basis, from representatives of companies in the field of environmental protection, and conduct training on separate waste collection, on the problems with the formation of e-waste, MSW, plastic, glass, paper, etc.

Chapter 7.

National roadmap for environmentally sound management of future e-waste

N°	ACTIVITIES	DEADLINES	COMPLETION FORM	EXECUTORS
Improvement of legislation explicitly e-waste-centered				
1.	Include goals and targets for the collection and recycling of e-waste in the national development plans and strategic documents of Kazakhstan	2024	Revision of strategic documents of Kazakhstan	Ministry of Ecology and Natural Resources; EPR Operator; International and national experts; Industry business associations.
2.	Amend the bylaws in terms of classification of e-waste	2024-2025	Updated version of the bylaws	Ministry of Ecology and Natural Resources; Bureau of National Statistics; EPR Operator; International and national experts.
3.	Amend the methodology for calculating the recycling fee and other bylaws to improve the EPR system	2023-2024	Updated version of the bylaws	Ministry of Ecology and Natural Resources; EPR Operator; International and national experts; Industry business associations; And other interested state bodies.
4.	Conduct the ratification procedure of the Agreement on cooperation of the CIS member states in the field of e-waste management of June 01, 2018	2023	Adoption of mechanisms for implementing the agreement on the territory of Kazakhstan	Ministry of Ecology and Natural Resources; Ministry of Foreign Affairs; EPR Operator.
5.	Amend the regulatory framework to regulate the assessment of harm/ damage to the workers and population to prevent the consequences of exposure to hazardous substances when treating e-waste	2024	Updated regulatory framework	Ministry of Health; Ministry of Labor and Social Protection; Ministry of Ecology and Natural Resources; Local Executive Bodies.
Improvement of the statistical data collection and processing system for e-waste generation, collection, and recycling				
1.	Implement the 'E-waste Generation Monitoring Tool' developed by UNITAR to forecast in the operation of state bodies, track and monitor the generation, collection and recycling of e-waste, and analyse the socio-economic and environmental impact of e-waste in the country	2023 - 2024	Reports	Ministry of Ecology and Natural Resources; Bureau of National Statistics; EPR Operator.
2.	Conduct information campaigns for business representatives, involved in collection and recycling of e-waste to improve the capacity to provide departmental and statistical reporting forms	2024-2025	Records of events Event reports	Industry Business Associations; Ministry of Ecology and Natural Resources.

N°	ACTIVITIES	DEADLINES	COMPLETION FORM	EXECUTORS
Development of infrastructure and improved technology for e-waste collection and recycling				
1.	Develop an action plan to introduce e-waste recycling technologies with the mandatory implementation of BAT, launching technological lines for the depollution of hazardous components of e-waste, including recycling of lithium-ion batteries	2024/2025	Action plan for the implementation of e-waste recycling technologies	Local Executive Bodies; EPR Operator.
2.	Include the development of infrastructure for collecting e-waste from the population in the local waste management programs developed by local executive bodies	2024-2025	Approved waste management programs of districts and cities	Local Executive Bodies; EPR Operator.
3.	Stimulate formalisation of the informal sector, facilitate the process of transition to formal activities, and include them in the e-waste management system	2025-2027	Company Map/Report	EPR Operator; Local Executive Bodies; Recyclers/collectors of e-waste.
Necessary measures to support the e-waste collection and recycling sector				
1.	Amend the tax legislation of Kazakhstan on tax benefits for specialised enterprises in the field of collection and recycling of e-waste for the duration of the approbation	2025-2026	Updated Tax Code of the RK	Ministry of Ecology and Natural Resources; Ministry of Finance Industry Business Associations.
2.	Improve financial and non-financial reporting for the distribution of recycling fees	2023	Reports to Ministry of Ecology and Natural Resources	EPR Operator.
3.	Train e-waste management companies on how to attract investment and obtain grants and soft loans	2023-2025	Records of events Event reports	Industry business associations; NGOs; Development institutions.
4.	Development of recommendations to encourage manufacturers and importers to switch to their own e-waste collection system	2024	Report	Industry business associations; NGOs.
Capacity-building and stakeholder awareness on e-waste management and community outreach				
1.	Conduct consultative seminars, roundtables for government agencies on environmentally sound handling of e-waste, EPR, familiarisation with international directives and initiatives on e-waste management, etc.	2023-2025	Records of events Event reports	Industry business associations; NGOs; Development institutions.
2.	Conduct training seminars to improve the competence of producers and suppliers of EEE, industry associations, e-waste educators, specialised waste management companies	Annually	Records of events Event reports	Producers/importers; Local executive bodies; All stakeholders.
3.	Conduct information campaigns for the public on the negative impact of e-waste on the environment and human health	Annually	Records of events Event reports	Producers/importers; Local executive bodies; All stakeholders.
4.	Conducting information work on the need to comply with legal requirements for the collection and recycling of electronic waste	2024-2025	Reports on activities	Producers/importers; Local executive bodies; All stakeholders.

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[18] Order of the Minister of Ecology, Geology and Natural Resources of Kazakhstan dated November 9, 2022 N° 689. "On approval of the list of certain types of products (goods) manufactured in Kazakhstan and (or) imported into the territory of Kazakhstan by individuals and legal entities, for which the collection, transportation, preparation for reuse, sorting, processing, recycling, neutralization and (or) disposal of waste generated after the loss of consumer properties of such products (goods)". https://adilet.zan.kz/rus/docs/V2200030484

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Chapter 9.
Annexes

Annex 1. List of companies for the collection and recycling of electronic waste in Kazakhstan

N°	COMPANY	CITY
1.	PromTechnoResource LLP	Almaty
2.	Kyzyl Bel LLP	Almaty
3.	Eco Almaty LLP	Almaty
4.	Technic Destroy LLP	Almaty
5.	New line capital LLP	Almaty
6.	Waste Management Company «PHOENIX» LLP	Almaty
7.	UtilEcoService LLP	Almaty
8.	Scientific-Production Firm Aziagroup LLP	Astana
9.	KazRecycleservice LLP	Astana
10.	ALSEZA COMPUTERS LLP	Astana
11.	Utilization LLP	Astana
12.	NTP KazekotehAstana LLP	Astana
13.	Roof Master LLP	Kokshetau
14.	Tsvetmet-Nord LLP	Petropavlovsk
15.	Promohod Kazakhstan LLP	Karaganda
16.	TemirZhasGroup LLP	Kyzylorda
17.	Aleks-Asu LLP	Aktobe
18.	Eco Prom KZ LLP	Aktobe
19.	ITPROF СЕРВИС LLP	Aktau

Annex 2. UNU-KEYs, link to e-waste categories and “Business as usual” scenario settings

UNU KEY	UNU KEY DESCRIPTION	E-WASTE CATEGORY	BUSINESS AS USUAL OBSOLESCENCE POM TARGET RELATIVE	BUSINESS AS USUAL SATURATION STOCK PPI TARGET ABSOLUTE
0001	Central Heating (household installed)	Large Equipment		0.1
0002	Photovoltaic Panels (incl. inverters)	Large Equipment - PV panels		
0101	Professional Heating & Ventilation (excl. cooling equipment)	Large Equipment		0.0015
0102	Dish washers	Large Equipment		0.4
0103	Kitchen equipment (e.g. large furnaces, ovens, cooking equipment)	Large Equipment		0.6
0104	Washing Machines (incl. combined dryers)	Large Equipment		0.4
0105	Dryers (wash dryers, centrifuges)	Large Equipment		0.15
0106	Household Heating & Ventilation (e.g. hoods, ventilators, space heaters)	Large Equipment		0.8
0108	Fridges (incl. combi-fridges)	Temperature Exchange Equipment		0.7
0109	Freezers	Temperature Exchange Equipment		0.15
0111	Air Conditioners (household installed and portable)	Temperature Exchange Equipment		0.6
0112	Other Cooling equipment (e.g. dehumidifiers, heat pump dryers)	Temperature Exchange Equipment		0.06
0113	Professional Cooling equipment (e.g. large air conditioners, cooling displays)	Temperature Exchange Equipment		0.5
0114	Microwaves (incl. combined, excl. grills)	Small equipment		0.4
0201	Other small household equipment (e.g. small ventilators, irons, clocks, adapters)	Small equipment		
0202	Equipment for food preparation (e.g. toaster, grills, food processing, frying pans)	Small equipment		6
0203	Small household equipment for hot water preparation (e.g. coffee, tea, water cookers)	Small equipment		
0204	Vacuum Cleaners (excl. professional)	Small equipment		0.7
0205	Personal Care equipment (e.g. tooth brushes, hair dryers, razors)	Small equipment		2
0301	Small IT equipment (e.g. routers, mice, keyboards, external drives & accessories)	Small IT		2
0302	Desktop PCs (excl. monitors, accessoires)	Small IT	0.1	
0303	Laptops (incl. tablets)	Screens and monitors		1.5

UNU KEY	UNU KEY DESCRIPTION	E-WASTE CATEGORY	BUSINESS AS USUAL OBSOLESCENCE POM TARGET RELATIVE	BUSINESS AS USUAL SATURATION STOCK PPI TARGET ABSOLUTE
0304	Printers (e.g. scanners, multi functionals, faxes)	Small IT		0.4
0305	Telecommunication equipment (e.g. (cordless) phones, answering machines)	Small IT	0	
0306	Mobile Phones (incl. smartphones, pagers)	Small IT		2
0307	Professional IT equipment (e.g. servers, routers, data storage, copiers)	Large Equipment		0.05
0308	Cathode Ray Tube Monitors	Screens and monitors	0	
0309	Flat Display Panel Monitors (LCD, LED)	Screens and monitors		0.2
0401	Small Consumer Electronics (e.g. headphones, remote controls)	Small equipment		4
0402	Portable Audio & Video (e.g. MP3, e-readers, car navigation)	Small equipment	0	
0403	Music Instruments, Radio, Hi-Fi (incl. audio sets)	Small equipment	0.2	
0404	Video (e.g. Video recorders, DVD, Blue Ray, set-top boxes) and projectors	Small equipment	0.1	
0405	Speakers	Small equipment		1.25
0406	Cameras (e.g. camcorders, photo & digital still cameras)	Small equipment	0	
0407	Cathode Ray Tube TVs	Screens and monitors	0	
0408	Flat Display Panel TVs (LCD, LED, Plasma)	Screens and monitors		1
0501	Small lighting equipment (excl. LED & incandescent)	Small equipment		
0502	Compact Fluorescent Lamps (incl. retrofit & non-retrofit)	Lamps	0	
0503	Straight Tube Fluorescent Lamps	Lamps	0.5	

UNU KEY	UNU KEY DESCRIPTION	E-WASTE CATEGORY	BUSINESS AS USUAL OBSOLESCENCE POM TARGET RELATIVE	BUSINESS AS USUAL SATURATION STOCK PPI TARGET ABSOLUTE
0504	Special Lamps (e.g. professional mercury, high & low pressure sodium)	Lamps		1
0505	LED Lamps (incl. retrofit LED lamps)	Lamps		
0506	Household Luminaires (incl. household incandescent fittings & household LED luminaires)	Small equipment		60
0507	Professional Luminaires (offices, public space, industry)	Large equipment		6
0601	Household Tools (e.g. drills, saws, high pressure cleaners, lawn mowers)	Small equipment		3
0602	Professional Tools (e.g. for welding, soldering, milling)	Large equipment		0.05
0701	Toys (e.g. car racing sets, electric trains, music toys, biking computers, drones)	Small equipment		10
0702	Game Consoles	Small IT		0.4
0703	Leisure equipment (e.g. sports equipment, electric bikes, juke boxes)	Large equipment		
0801	Household Medical equipment (e.g. thermometers, blood pressure meters)	Small equipment		
0802	Professional Medical equipment (e.g. hospital, dentist, diagnostics)	Large equipment		
0901	Household Monitoring & Control equipment (alarm, heat, smoke, excl. screens)	Small equipment		
0902	Professional Monitoring & Control equipment (e.g. laboratory, control panels)	Large equipment		
1001	Non-cooled Dispensers (e.g. for vending, hot drinks, tickets, money)	Large equipment		0.0015
1002	Cooled Dispensers (e.g. for vending, cold drinks)	Temperature Exchange Equipment		0.005

UNU-KEYs, link to e-waste categories and “Circular Economy” scenario settings

UNU KEY	UNU KEY DESCRIPTION	E-WASTE CATEGORY	CIRCULAR ECONOMY OBSOLESCENCE POM TARGET RELATIVE	CIRCULAR ECONOMY SATURATION STOCK PPI TARGET ABSOLUTE	CIRCULAR ECONOMY IMPROVED DURABILITY FLAG	CIRCULAR ECONOMY REDUCED HOARDING FLAG	CIRCULAR ECONOMY INCREASED SHARING FLAG
0001	Central Heating (household installed)	Large Equipment	0		X	X	
0002	Photovoltaic Panels (incl. inverters)	Large Equipment - PV panels			X		
0101	Professional Heating & Ventilation (excl. cooling equipment)	Large Equipment			X		
0102	Dish washers	Large Equipment			X	X	
0103	Kitchen equipment (e.g. large furnaces, ovens, cooking equipment)	Large Equipment			X		
0104	Washing Machines (incl. combined dryers)	Large Equipment			X	X	X
0105	Dryers (wash dryers, centrifuges)	Large Equipment			X	X	X
0106	Household Heating & Ventilation (e.g. hoods, ventilators, space heaters)	Large Equipment			X	X	
0108	Fridges (incl. combi-fridges)	Temperature Exchange Equipment			X	X	
0109	Freezers	Temperature Exchange Equipment			X	X	
0111	Air Conditioners (household installed and portable)	Temperature Exchange Equipment			X	X	
0112	Other Cooling equipment (e.g. dehumidifiers, heat pump dryers)	Temperature Exchange Equipment			X	X	
0113	Professional Cooling equipment (e.g. large air conditioners, cooling displays)	Temperature Exchange Equipment			X		
0114	Microwaves (incl. combined, excl. grills)	Small equipment			X	X	
0201	Other small household equipment (e.g. small ventilators, irons, clocks, adapters)	Small equipment		4	X	X	
0202	Equipment for food preparation (e.g. toaster, grills, food processing, frying pans)	Small equipment		3	X	X	
0203	Small household equipment for hot water preparation (e.g. coffee, tea, water cookers)	Small equipment		1.25	X	X	

UNU KEY	UNU KEY DESCRIPTION	E-WASTE CATEGORY	CIRCULAR ECONOMY OBSOLESCENCE POM TARGET RELATIVE	CIRCULAR ECONOMY SATURATION STOCK PPI TARGET ABSOLUTE	CIRCULAR ECONOMY IMPROVED DURABILITY FLAG	CIRCULAR ECONOMY REDUCED HOARDING FLAG	CIRCULAR ECONOMY INCREASED SHARING FLAG
0204	Vacuum Cleaners (excl. professional)	Small equipment			X	X	
0205	Personal Care equipment (e.g. tooth brushes, hair dryers, razors)	Small equipment			X	X	
0301	Small IT equipment (e.g. routers, mice, keyboards, external drives & accessories)	Small IT			X	X	
0302	Desktop PCs (excl. monitors, accessoires)	Small IT			X	X	
0303	Laptops (incl. tablets)	Screens and monitors			X	X	X
0304	Printers (e.g. scanners, multi functionals, faxes)	Small IT			X	X	X
0305	Telecommunication equipment (e.g. (cordless) phones, answering machines)	Small IT				X	
0306	Mobile Phones (incl. smartphones, pagers)	Small IT			X	X	
0307	Professional IT equipment (e.g. servers, routers, data storage, copiers)	Large Equipment			X		
0308	Cathode Ray Tube Monitors	Screens and monitors				X	
0309	Flat Display Panel Monitors (LCD, LED)	Screens and monitors			X	X	
0401	Small Consumer Electronics (e.g. headphones, remote controls)	Small equipment			X	X	
0402	Portable Audio & Video (e.g. MP3, e-readers, car navigation)	Small equipment				X	
0403	Music Instruments, Radio, Hi-Fi (incl. audio sets)	Small equipment			X	X	
0404	Video (e.g. Video recorders, DVD, Blue Ray, set-top boxes) and projectors	Small equipment			X	X	
0405	Speakers	Small equipment			X	X	
0406	Cameras (e.g. camcorders, photo & digital still cameras)	Small equipment			X	X	
0407	Cathode Ray Tube TVs	Screens and monitors			X	X	
0408	Flat Display Panel TVs (LCD, LED, Plasma)	Screens and monitors			X	X	
0501	Small lighting equipment (excl. LED & incandescent)	Small equipment			X	X	

UNU KEY	UNU KEY DESCRIPTION	E-WASTE CATEGORY	CIRCULAR ECONOMY OBSOLESCENCE POM TARGET RELATIVE	CIRCULAR ECONOMY SATURATION STOCK PPI TARGET ABSOLUTE	CIRCULAR ECONOMY IMPROVED DURABILITY FLAG	CIRCULAR ECONOMY REDUCED HOARDING FLAG	CIRCULAR ECONOMY INCREASED SHARING FLAG
0502	Compact Fluorescent Lamps (incl. retrofit & non-retrofit)	Lamps				X	
0503	Straight Tube Fluorescent Lamps	Lamps			X	X	
0504	Special Lamps (e.g. professional mercury, high & low pressure sodium)	Lamps			X	X	
0505	LED Lamps (incl. retrofit LED lamps)	Lamps			X	X	
0506	Household Luminaires (incl. household incandescent fittings & household LED luminaires)	Small equipment			X	X	
0507	Professional Luminaires (offices, public space, industry)	Large equipment			X		
0601	Household Tools (e.g. drills, saws, high pressure cleaners, lawn mowers)	Small equipment			X	X	X
0602	Professional Tools (e.g. for welding, soldering, milling)	Large equipment			X		X
0701	Toys (e.g. car racing sets, electric trains, music toys, biking computers, drones)	Small equipment			X	X	
0702	Game Consoles	Small IT			X	X	
0703	Leisure equipment (e.g. sports equipment, electric bikes, juke boxes)	Large equipment			X	X	X
0801	Household Medical equipment (e.g. thermometers, blood pressure meters)	Small equipment			X	X	X
0802	Professional Medical equipment (e.g. hospital, dentist, diagnostics)	Large equipment			X		
0901	Household Monitoring & Control equipment (alarm, heat, smoke, excl. screens)	Small equipment			X	X	
0902	Professional Monitoring & Control equipment (e.g. laboratory, control panels)	Large equipment			X		
1001	Non- cooled Dispensers (e.g. for vending, hot drinks, tickets, money)	Large equipment			X		
1002	Cooled Dispensers (e.g. for vending, cold drinks)	Temperature Exchange Equipment			X		

Annex 3. Socioeconomic pathways underpinning the scenarios

The ‘Business as Usual’ and Circular Economy projections for PM and e-waste have been calculated using the Shared Socioeconomic Pathways (SSPs) for GDP PPP, population, technology, energy, land use, and other socioeconomic indicators, which were developed by IPCC to perform climate change and broader sustainability assessments [10]. The SSPs capture a range of plausible world futures and include multiple underlying trends that both characterise and affect the crucial aspects of humanity’s development, including how material goods are being consumed and recycled.

The plausible futures described by the SSPs range according to sub-national and international levels of cooperation, competition, government regulation, wealth distribution, education, urbanisation, technological development, energy use, land use, and so on. We note that gender only features in the modelled age pyramids explicitly, though both the GDP and population projections implicitly depend on the assumed levels of emancipation of women in the underlying OECD macroeconomic models from which these projections have been derived [10].

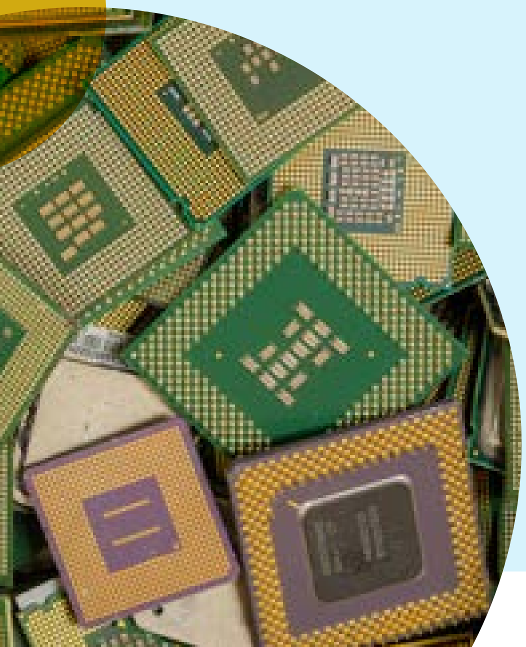
In this report, we use the SSP projections for GDP PPP and population individually in Kazakhstan in order to explore the effects of long-term socioeconomic changes on EEE POM and e-waste generated in the region out to 2050. For both the ‘Business as Usual’ and Circular Economy scenarios, the three most contrasting SSP scenarios (SSP1, SSP3, and SSP5) were calculated and averaged:

- SSP1, which provides medium-level projections for both GDP PPP and population, with the underlying drivers being associated with a broad sustainability and Circular Economy transition across much of the economy and society
- SSP3, which represents a world with high population growth, regional rivalries, material-intensive consumption, and sluggish economic development across the board
- SSP5, which is characterised by rapid economic growth, fast technological progress, high energy and resource consumption, and moderate population increases

Annex 4. Projections for Solar Photovoltaic Panels

Solar photovoltaic panels form a relatively recent but a fast growing stream of EEE, and though they are not yet generating considerable quantities of e-waste, they are currently being placed on the market in large quantities and with accelerating rates [1]. Modelling future growth in photovoltaic panels among EEE POM is difficult due to rapidly evolving economic and geopolitical conditions underpinning climate change mitigation. In this report, we use the solar photovoltaic projections from the energy transition component of the SSP scenarios out to 2050 as a basis, adjusting them according to trends in the CIS+ region from recent history (dataset of the International Renewable Energy Agency). There is a considerably different Circular Economy in the projected photovoltaic capacity under the SSP1-19 pathway compatible with the 1.5C target from the Paris Agreement, and all other SSP pathways, such as SSP2-34, SSP3-34, SSP4-26, and SSP5-60 (the suffixes in the scenario names represent target anthropogenic radiative forcing levels in 2100). Our adjusted photovoltaic projections broadly capture the differences in the underpinning SSP scenarios for solar photovoltaic installations, while also being aligned both with the relevant historic data and the IEA projections for the CIS+ region.

The projected annual installed photovoltaic capacities for each scenario in the CIS+ countries have been converted to EEE POM by calculating the annual changes of the cumulative installed capacity. The changes were converted to EEE POM by using recent global statistics for average output and weight of a single photovoltaic panel [1]. In this report, the latest technical parameters - of approximately 300 W and 20 kg per panel - were extrapolated to 2050, assuming that the bulk of the efficiency gains in photovoltaics had already taken place over the past 20 years. The photovoltaic lifespans were modelled based on the latest e-waste data from the EU [27]. The datasets are allocated to UNU-KEY 0002 Photovoltaic Panels (incl. inverters).



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