Electrical and Electronic Equipment: E-Waste Collected Tool Manual

Institution's Name	**UNITAR SCYCLE**
Current tool version	**V9, 31 March 2023**
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Abbreviations

E-Waste	:	Waste of electrical and electronic equipment
WG	:	Waste generated
WC	:	Waste collected
EEE	:	Electrical and electronic equipment
GHG	:	Greenhouse gases
GWP		Global warming potential
EU	:	European Union
CIS	:	Commonwealth of Independent States
PV	:	Photovoltaic (solar panels)
EU6PV	:	Six distinct categories of e-waste differentiated according to treatment requirements, plus solar PV panels; this classification was adopted by the EU
POM	:	Put on the market (electronic and electrical products that eventually become e-waste)
WoT	:	Waste Over Time (model that calculates generated e-waste using POM and product lifespan distributions)
SSP	:	Shared socio-economic pathway
BaU	:	Business-as-usual
CE	:	Circular economy

1. Introduction

The "E-Waste Collected Tool" is an 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 socio-economic impacts due to release of hazardous substances and loss of valuable materials.

The tool builds on the methodologies developed by the task group of the E-waste statistics Partnership for Measuring ICT for Development (Balde, 2015), and introduces new functionalities to allow for both near-term and long-term planning to increase e-waste collection rates. The current version of the tool is pre-configured for the 12 countries in the CIS+ region.

The user can utilize the tool as follows:

- In the main user interface sheet (Inputs), specify the country to analyse, set a base year for e-waste management planning, and the duration of e-waste management cycles to ratchet-up collection targets

- In the main user interface sheet (Inputs), set exploratory e-waste collection targets in the end of each management cycle to aid the planning
- In the main user interface sheet (Inputs), enter the actual e-waste collected data as it becomes available to compare against the set near-term targets
- In the Outputs sheets, obtain both annual and cumulative results for the estimated amounts of future managed and unmanaged waste under the specified collection targets, and compare them with the scenario when there are no collection increases
- In the Outputs sheets, obtain the corresponding annual quantities of recovered and lost materials, their value and the associated compliant recycling costs
- In the Outputs sheets, obtain the corresponding environmental and socio-economic impacts due to release of hazardous substances and loss of valuable materials
- In the Outputs sheets, track progress against the set targets when new e-wasted collected data becomes available

The purpose of this manual is to assist the user in applying the new interactive tool for e-waste management planning in the country under investigation.

2. Overview of the E-Waste Collected Tool

The E-Waste Collected Tool is programmed in Excel 2019 as a macro-enabled (".xlsm") workbook. It uses long-term projections for e-waste generated in the CIS+ region under a full range of SSP scenarios for county-level population, economy and renewable technologies (solar PV panels), which are provided by the Waste over Time (WoT) model developed by UNITAR. The scenarios also include both Business as Usual (BaU) and Circular Economy (CE) alternatives for consumer behaviour and technology in the context of the EEE sector, which are based on the framework presented in the UNITAR report "2050 Electrical & Electronic Waste Outlook in West Asia."

The E-Waste Collected Tool workbook contains 20 sheets. **All the sheets are required for the proper functioning of the tool and their names should not be changed. Likewise, none of the formulae or constant model parameter entries should be changed.** The description of all the sheets is given in Table 1.

The tool is interactive, allowing the user to provide values for multiple data entries in the "Inputs" sheet, as well as to choose the required data to show in the "Output" sheets. The user can specify future e-waste collection targets for selected future years and estimate the associated future quantities of managed and unmanaged e-waste, including hazardous substances and valuable materials. The analysis is performed for a single country at a time. The tool is preconfigured for all 12 countries in the CIS+ region.

In addition to the quantities of managed and unmanaged e-waste broken down into the EU6PV categories, the tool estimates the quantities of the most common refrigerants, plastics, glass, mercury, and lead. These substances can have detrimental environmental and socio-economic impacts if not managed properly.

The tool also estimates the managed and unmanaged quantities of valuable metals: iron, aluminium, copper, silver, gold, platinum, and palladium. If recovered from the e-waste, these materials could have considerable value and reduce environmental impacts by replacing primary materials.

All the estimates are based on UNITAR's databases and peer-reviewed publications.

Table 1: Overview of the sheets of the E-Waste Collected Tool

Sheet Name	Description/Purpose
Inputs	Main User Interface
Outputs_Annual	Time series plots showing annual quantities of managed and unmanaged e-waste between 2020 and 2050, either with no change or with targeted change in collection rates. The user can choose to output either total e-waste or each of the EU6PV categories. Tables with the underpinning data are provided below the plots
Outputs_Hazardous_Emissions	Time series plots showing total annual quantities of avoided and emitted GHGs (both direct and indirect) between 2020 and 2050, either with no change or with targeted change in collection rates. Additional time series plots show managed and unmanaged quantities of multiple harmful substances between 2020 and 2050, either with no change or with targeted change in collection rates. In these plots, the user can choose to output the required harmful substance. Tables with the underpinning data are provided below the plots
Outputs_Valuable_Metals	Time series plots showing managed and unmanaged quantities of multiple valuable metals between 2020 and 2050, either with no change or with targeted change in collection rates. The user can choose to output the required valuable metal. Tables with the underpinning data are provided below the plots
Outputs_Value_And_Costs	Time series plots showing annual recovered value and treatment costs of managed e-waste, and monetised environmental and socio-economic impacts of unmanaged e-waste between 2020 and 2050, either with no change or with targeted change in collection rates. The plots also show the overall economic impact of e-waste, either with no change or targeted change in collection rates. The overall economic impact represents the difference between the recovered value and the total cost, which includes the cost of treatment of managed

	waste plus monetised environmental and socio-economic impacts of unmanaged waste). Additional time series plots show the total environmental and social costs of e-waste between 2020 and 2050, either with no change or with targeted change in collection rates, broken down into sources of the negative impacts. Tables with the underpinning data are provided below the plots
Outputs_EU6PV_Breakdown	Pie charts showing breakdown of annual managed e-waste into the EU6PV categories in 2020, and in two user-defined future years (e.g. 2030 and 2050) under the specified collection targets. Tables with the underpinning data are provided below the plots
Outputs_Cumulative	Bar graphs showing cumulative quantities of managed and unmanaged e-waste between 2020 and two user-defined future years (e.g. 2030 and 2050), either with no change or with targeted change in collection rates. Tables with the underpinning data are provided below the plots. The corresponding cumulative quantities of valuable materials and hazardous substances are also provided
Outputs_Monitoring	Time series plots comparing near-term annual e-waste collection targets with collection data (as it becomes available). The user can choose to output either total e-waste or each of the EU6PV categories. Tables with the underpinning data are provided below the plots
Outputs_Full_Data	Table providing time-series outputs for managed and unmanaged e-waste between 2000 and 2050, either with no change or with targeted change in collection rates. The corresponding annual quantities of valuable resources and hazardous substances, direct and indirect GHG emissions, and recovered value, treatment costs, and environmental and socio-economic impacts, are also provided
The following sheets are hidden, but can be made visible by clicking on the "show sheets" button in the Inputs sheet	
Generic_Parameters	Definitions of the countries, e-waste categories, material compositions, costs, scenarios and other relevant model parameters
Post_Processing	Calculations to convert results into the required output format
WC_Monitoring	Calculations to compare targeted collection increase with the actual data when it becomes available

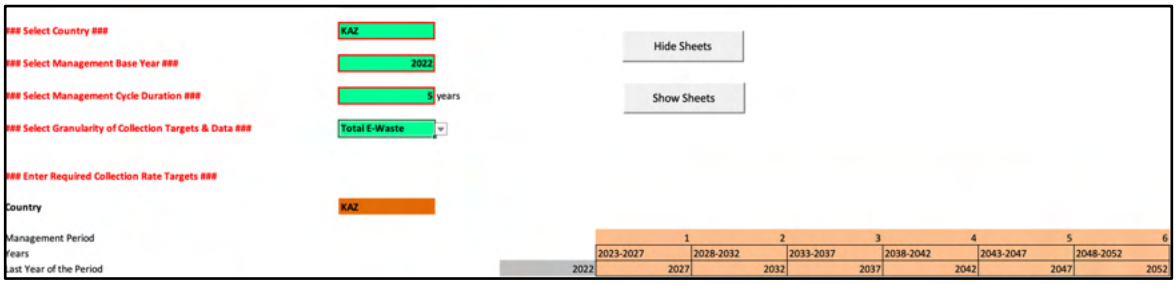
Costs_Projections	Calculations to estimate projected costs of recycling, value of the materials extracted, and environmental and socio-economic impacts of unmanaged e-waste
GHG_Projections	Calculations to estimate projected direct and indirect GHG emissions
Material_Projections	Calculations to estimate projected managed and unmanaged quantities of hazardous materials and valuable resources in e-waste
Material_Trends	Calculations to estimate time-varying trends in material composition of the EU6PV categories
WC_Projections	Calculations to estimate projected managed and unmanaged quantities of e-waste for each of the EU6PV categories
WC_Baseline	Calculations to estimate collected e-waste tonnages and their breakdown into the EU6PV categories based on the collection rates provided for the relevant base year (default = 2021) and estimates for e-waste generated from the WoT model. The sheet also estimates the corresponding e-waste collection rate in the chosen management base year (default = 2022)
WG_Country_Summary	Calculations to extract WoT model data for the country under investigation and work out the required statistics across multiple scenarios analysed by the WoT model
WG_Historic_And_Scenarios_WoT	Data frame with long-term projections for e-waste generated in the CIS+ region under a range of scenarios. Imported from the relevant version of the WoT model

3. Using the E-Waste Collected Tool

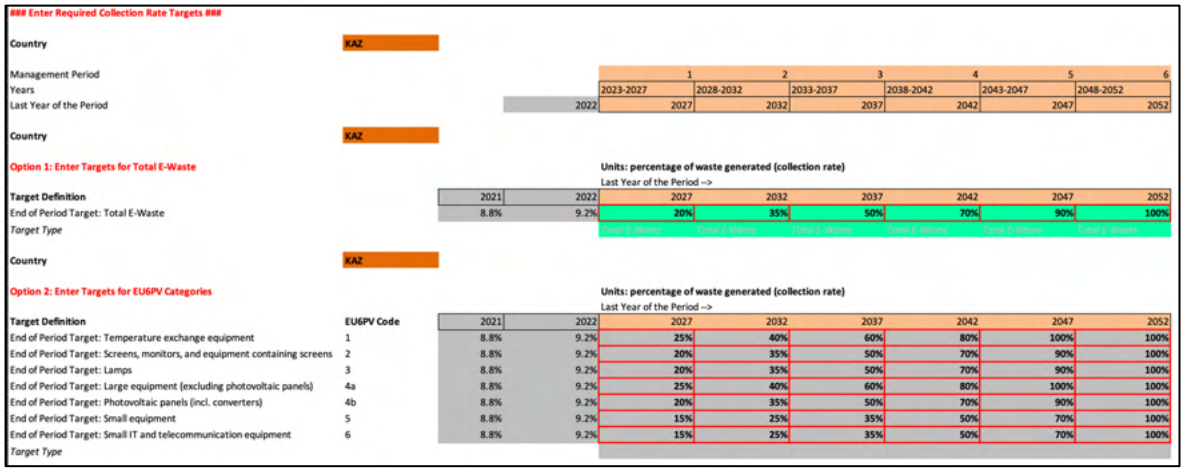
The "Inputs" sheet allows the user to specify key parameters in order to set e-waste collection targets. The parameters are:

- Focus country in the CIS+ region
- Base year for setting management cycles and targets (e.g. 2022)
- Duration of the management cycle (e.g. five years)
- Granularity for setting the targets and entering collected e-waste data (either total e-waste or EU6PV categories
- Collection targets in the end of each of the specified e-waste management periods, either for total e-waste or EU6PV categories
- Collected e-waste data as it becomes available, either for total e-waste or EU6PV categories

All the user entries are highlighted in green and outlined in red, and most of them are implemented as drop-down menus:

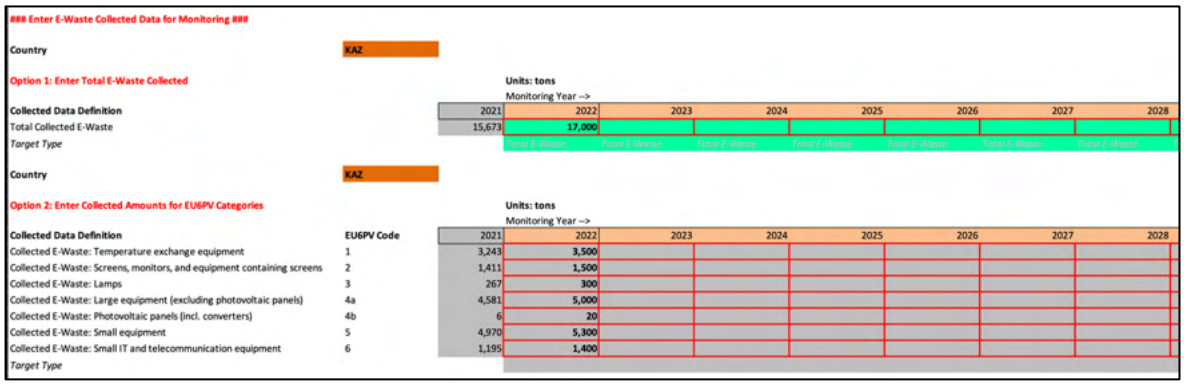


Depending on the choice of granularity for setting the targets and entering the data, the relevant entry fields are highlighted in green while the inactive fields are grey:



Enter Required Collection Rate Targets

Country	KAZ								
Management Period			1	2	3	4	5	6	
Years			2023-2027	2028-2032	2033-2037	2038-2042	2043-2047	2048-2052	
Last Year of the Period		2022	2027	2032	2037	2042	2047	2052	
Country	KAZ								
Option 1: Enter Targets for Total E-Waste			Units: percentage of waste generated (collection rate)						
			Last Year of the Period -->						
Target Definition		2021	2022	2027	2032	2037	2042	2047	2052
End of Period Target: Total E-Waste		8.8%	9.2%	20%	35%	50%	70%	90%	100%
Target Type				Total E-Waste	Total E-Waste	Total E-Waste	Total E-Waste	Total E-Waste	Total E-Waste
Country	KAZ								
Option 2: Enter Targets for EU6PV Categories			Units: percentage of waste generated (collection rate)						
			Last Year of the Period -->						
Target Definition	EU6PV Code	2021	2022	2027	2032	2037	2042	2047	2052
End of Period Target: Temperature exchange equipment	1	8.8%	9.2%	25%	40%	60%	80%	100%	100%
End of Period Target: Screens, monitors, and equipment containing screens	2	8.8%	9.2%	20%	35%	50%	70%	90%	100%
End of Period Target: Lamps	3	8.8%	9.2%	20%	35%	50%	70%	90%	100%
End of Period Target: Large equipment (excluding photovoltaic panels)	4a	8.8%	9.2%	25%	40%	60%	80%	100%	100%
End of Period Target: Photovoltaic panels (incl. converters)	4b	8.8%	9.2%	20%	35%	50%	70%	90%	100%
End of Period Target: Small equipment	5	8.8%	9.2%	15%	25%	35%	50%	70%	100%
End of Period Target: Small IT and telecommunication equipment	6	8.8%	9.2%	15%	25%	35%	50%	70%	100%
Target Type									



### Enter E-Waste Collected Data for Monitoring ###									
Country	KAZ								
Option 1: Enter Total E-Waste Collected		Units: tons							
		Monitoring Year -->							
Collected Data Definition		2021	2022	2023	2024	2025	2026	2027	2028
Total Collected E-Waste		15,673	17,000						
Target Type			*Total E-Waste*	*Total E-Waste*	*Total E-Waste*	*Total E-Waste*	*Total E-Waste*	*Total E-Waste*	*Total E-Waste*
Country	KAZ								
Option 2: Enter Collected Amounts for EU6PV Categories		Units: tons							
		Monitoring Year -->							
Collected Data Definition	EU6PV Code	2021	2022	2023	2024	2025	2026	2027	2028
Collected E-Waste: Temperature exchange equipment	1	3,243	3,500						
Collected E-Waste: Screens, monitors, and equipment containing screens	2	1,411	1,500						
Collected E-Waste: Lamps	3	267	300						
Collected E-Waste: Large equipment (excluding photovoltaic panels)	4a	4,581	5,000						
Collected E-Waste: Photovoltaic panels (incl. converters)	4b	6	20						
Collected E-Waste: Small equipment	5	4,970	5,300						
Collected E-Waste: Small IT and telecommunication equipment	6	1,195	1,400						
Target Type									

The main purpose of the tool is for the user to explore the effects of setting higher future targets for e-waste collection rates (defined as the percentage of collected and recycled e-waste relative to the total e-waste generated). The collection rates range from 0% to 100%. The most recent historic collection rates data (for 2021) and its extrapolation to the chosen base year of the assessment (e.g. 2022) is provided for reference in grey next to the input field for the future collection targets.

The user can also enter the quantities of collected e-waste (in tons) in the base year and future years as the data becomes available, to be used to monitor progress against the set targets.

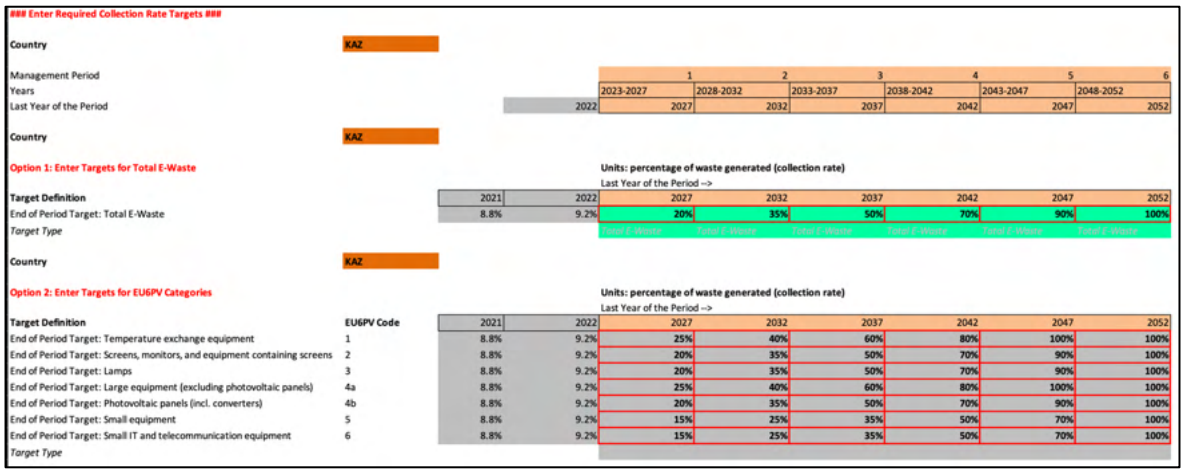
3.1 Hide/Show Sheets Button

There are a total of 20 sheets in the tool among which 11 are hidden. These 11 sheets can be made visible by clicking on the "Show Sheets" button. Clicking on the "Hide Sheets" button will hide the sheets again and only 9 of the 20 sheets will be unhidden.

3.2 E-Waste Collected Tool: Input functionalities

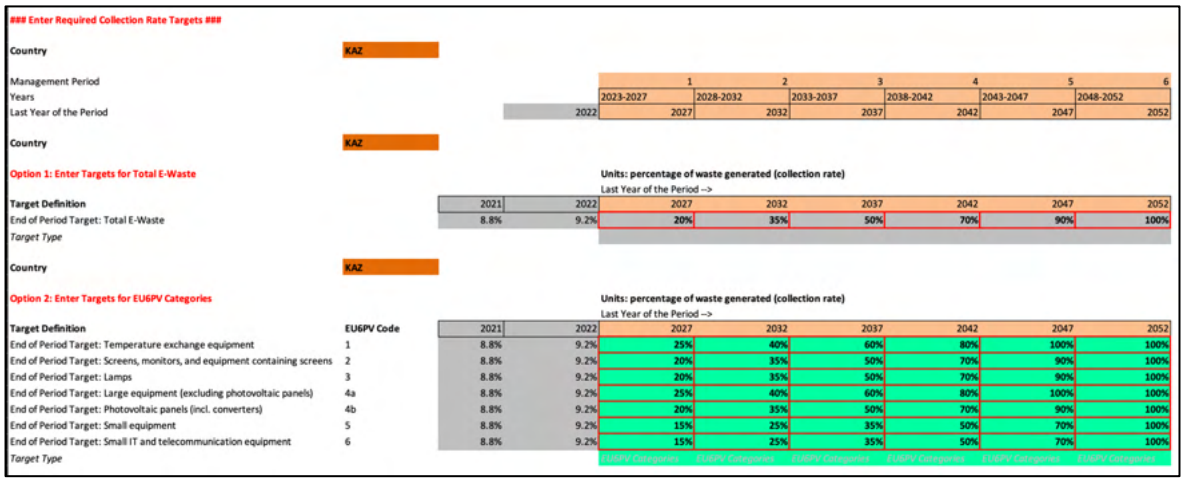
3.2.1 Enter Collection Targets

For total e-waste:



### Enter Required Collection Rate Targets ###									
Country	KAZ								
Management Period			1	2	3	4	5	6	
Years			2023-2027	2028-2032	2033-2037	2038-2042	2043-2047	2048-2052	
Last Year of the Period		2022	2027	2032	2037	2042	2047	2052	
Country	KAZ								
Option 1: Enter Targets for Total E-Waste			Units: percentage of waste generated (collection rate)						
			Last Year of the Period -->						
Target Definition		2021	2022	2027	2032	2037	2042	2047	2052
End of Period Target: Total E-Waste		8.8%	9.2%	20%	35%	50%	70%	90%	100%
Target Type				*Total E-Waste*	*Total E-Waste*	*Total E-Waste*	*Total E-Waste*	*Total E-Waste*	*Total E-Waste*
Country	KAZ								
Option 2: Enter Targets for EU6PV Categories				Units: percentage of waste generated (collection rate)					
				Last Year of the Period -->					
Target Definition	EU6PV Code	2021	2022	2027	2032	2037	2042	2047	2052
End of Period Target: Temperature exchange equipment	1	8.8%	9.2%	25%	40%	60%	80%	100%	100%
End of Period Target: Screens, monitors, and equipment containing screens	2	8.8%	9.2%	20%	35%	50%	70%	90%	100%
End of Period Target: Lamps	3	8.8%	9.2%	20%	35%	50%	70%	90%	100%
End of Period Target: Large equipment (excluding photovoltaic panels)	4a	8.8%	9.2%	25%	40%	60%	80%	100%	100%
End of Period Target: Photovoltaic panels (incl. converters)	4b	8.8%	9.2%	20%	35%	50%	70%	90%	100%
End of Period Target: Small equipment	5	8.8%	9.2%	15%	25%	35%	50%	70%	100%
End of Period Target: Small IT and telecommunication equipment	6	8.8%	9.2%	15%	25%	35%	50%	70%	100%
Target Type									

Individually for EU6PV categories:



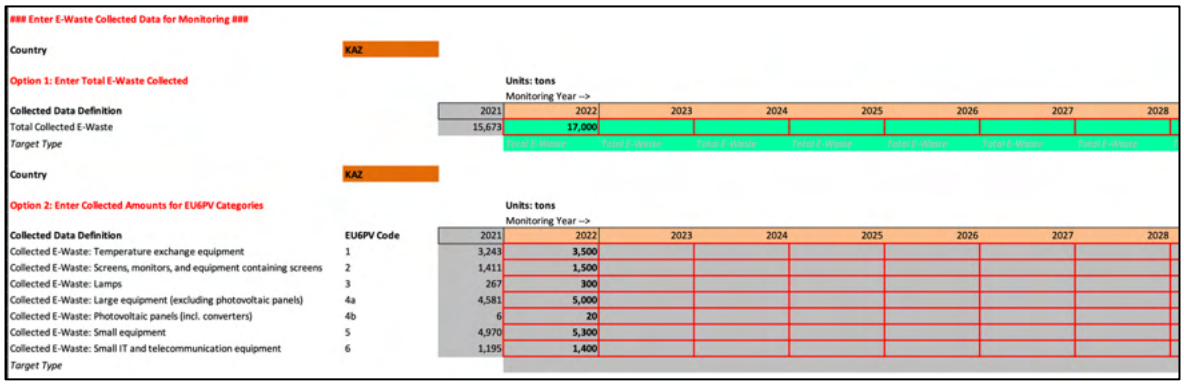
### Enter Required Collection Rate Targets ###										
Country	KAZ									
Management Period				1	2	3	4	5	6	
Years				2023-2027	2028-2032	2033-2037	2038-2042	2043-2047	2048-2052	
Last Year of the Period			2022	2027	2032	2037	2042	2047	2052	
Country	KAZ									
Option 1: Enter Targets for Total E-Waste				Units: percentage of waste generated (collection rate)						
				Last Year of the Period -->						
Target Definition		2021	2022	2027	2032	2037	2042	2047	2052	
End of Period Target: Total E-Waste		8.8%	9.2%	20%	35%	50%	70%	90%	100%	
Target Type										
Country	KAZ									
Option 2: Enter Targets for EU6PV Categories				Units: percentage of waste generated (collection rate)						
				Last Year of the Period -->						
Target Definition	EU6PV Code	2021	2022	2027	2032	2037	2042	2047	2052	
End of Period Target: Temperature exchange equipment	1	8.8%	9.2%	25%	40%	60%	80%	100%	100%	
End of Period Target: Screens, monitors, and equipment containing screens	2	8.8%	9.2%	20%	35%	50%	70%	90%	100%	
End of Period Target: Lamps	3	8.8%	9.2%	20%	35%	50%	70%	90%	100%	
End of Period Target: Large equipment (excluding photovoltaic panels)	4a	8.8%	9.2%	25%	40%	60%	80%	100%	100%	
End of Period Target: Photovoltaic panels (incl. converters)	4b	8.8%	9.2%	20%	35%	50%	70%	90%	100%	
End of Period Target: Small equipment	5	8.8%	9.2%	15%	25%	35%	50%	70%	100%	
End of Period Target: Small IT and telecommunication equipment	6	8.8%	9.2%	15%	25%	35%	50%	70%	100%	
Target Type				EU6PV Categories	EU6PV Categories	EU6PV Categories	EU6PV Categories	EU6PV Categories	EU6PV Categories	

The currently entered dummy values are for Kazakhstan and are provided for illustration. For countries other than Kazakhstan, the users are advised to modify the collection rates according to the most recent e-waste collection data in their country in 2021; the rates vary considerably between the countries. The 2021 data is pre-programmed in the tool and is outputted in grey for the chosen country next to the main data entry blocks to guide the user.

As a general rule, it is desirable for collection rates to increase with time, which is one of the guiding principles for setting future targets. However, the tool does not protect the user against setting lower collection targets in future years, even though such a scenario will likely lead to undesirable environmental and socio-economic consequences.

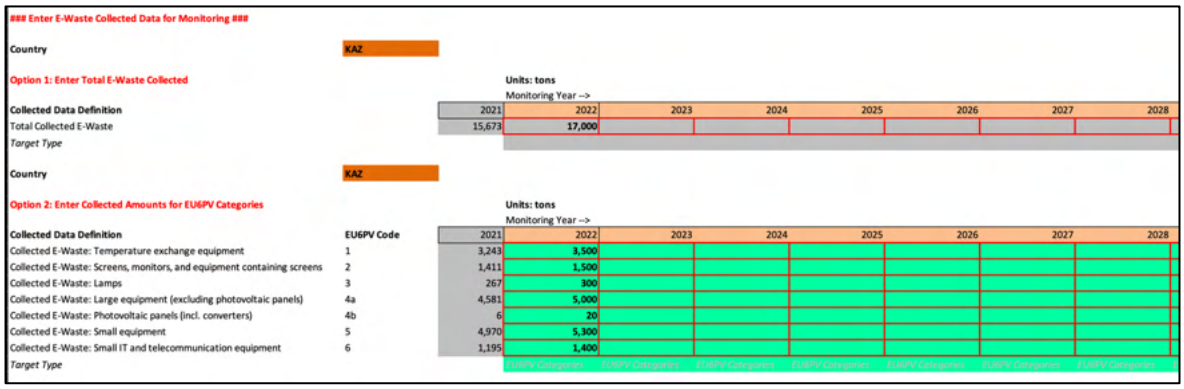
3.2.2 Enter Collected E-Waste Data

For total e-waste:



### Enter E-Waste Collected Data for Monitoring ###									
Country	KAZ								
Option 1: Enter Total E-Waste Collected			Units: tons						
			Monitoring Year -->						
Collected Data Definition		2021	2022	2023	2024	2025	2026	2027	2028
Total Collected E-Waste		15,673	17,000						
Target Type			Total E-Waste	Total E-Waste	Total E-Waste	Total E-Waste	Total E-Waste	Total E-Waste	Total E-Waste
Country	KAZ								
Option 2: Enter Collected Amounts for EU6PV Categories			Units: tons						
			Monitoring Year -->						
Collected Data Definition	EU6PV Code	2021	2022	2023	2024	2025	2026	2027	2028
Collected E-Waste: Temperature exchange equipment	1	3,243	3,500						
Collected E-Waste: Screens, monitors, and equipment containing screens	2	1,411	1,500						
Collected E-Waste: Lamps	3	267	300						
Collected E-Waste: Large equipment (excluding photovoltaic panels)	4a	4,581	5,000						
Collected E-Waste: Photovoltaic panels (incl. converters)	4b	6	20						
Collected E-Waste: Small equipment	5	4,970	5,300						
Collected E-Waste: Small IT and telecommunication equipment	6	1,195	1,400						
Target Type									

Individually for EU6PV categories:



### Enter E-Waste Collected Data for Monitoring ###									
Country	KAZ								
Option 1: Enter Total E-Waste Collected		Units: tons							
		Monitoring Year -->							
Collected Data Definition		2021	2022	2023	2024	2025	2026	2027	2028
Total Collected E-Waste		15,673	17,000						
Target Type									
Country	KAZ								
Option 2: Enter Collected Amounts for EU6PV Categories		Units: tons							
		Monitoring Year -->							
Collected Data Definition	EU6PV Code	2021	2022	2023	2024	2025	2026	2027	2028
Collected E-Waste: Temperature exchange equipment	1	3,243	3,500						
Collected E-Waste: Screens, monitors, and equipment containing screens	2	1,411	1,500						
Collected E-Waste: Lamps	3	267	300						
Collected E-Waste: Large equipment (excluding photovoltaic panels)	4a	4,581	5,000						
Collected E-Waste: Photovoltaic panels (incl. converters)	4b	6	20						
Collected E-Waste: Small equipment	5	4,970	5,300						
Collected E-Waste: Small IT and telecommunication equipment	6	1,195	1,400						
Target Type			EU6PV Categories	EU6PV Categories	EU6PV Categories	EU6PV Categories	EU6PV Categories	EU6PV Categories	E

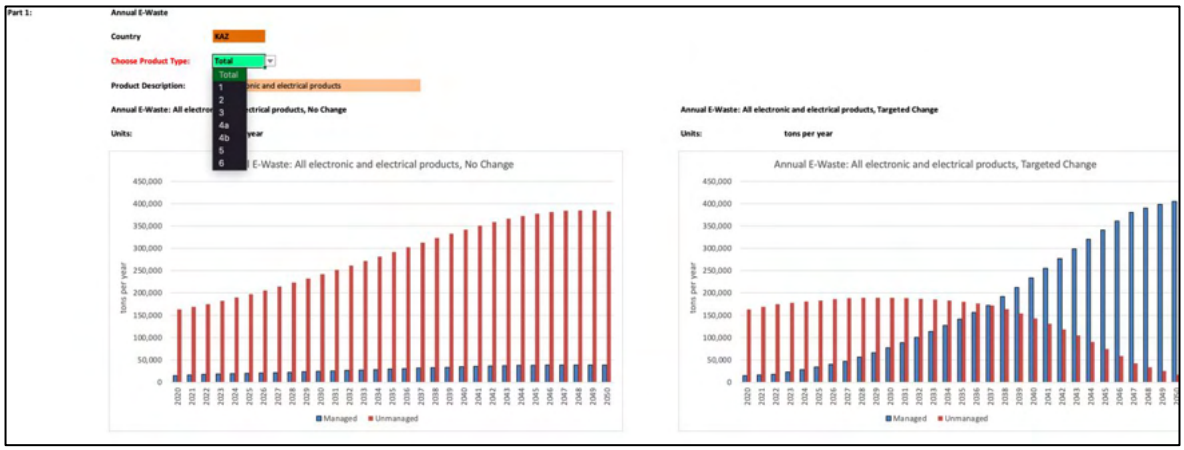
The currently entered dummy values are for Kazakhstan and are provided for illustration. The users will need to enter the latest e-waste collection data for their country as it becomes available.

3.3 E-Waste Collected Tool: Output functionalities

3.3.1 Annual managed and unmanaged e-waste

This sheet provides time series plots showing annual quantities of managed and unmanaged e-waste between 2020 and 2050, either with no change or with targeted change in collection rates.

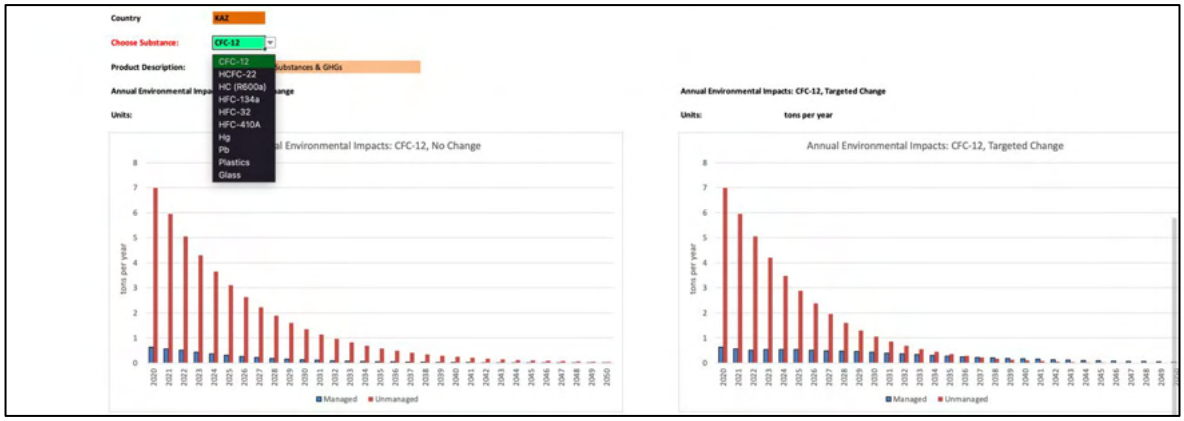
The user can choose to output either total e-waste or each of the EU6PV categories:



3.3.2 Annual emissions of hazardous substances

This sheet provides time series plots showing total annual quantities of avoided and emitted GHGs (both direct and indirect) between 2020 and 2050, either with no change or with targeted change in collection rates:

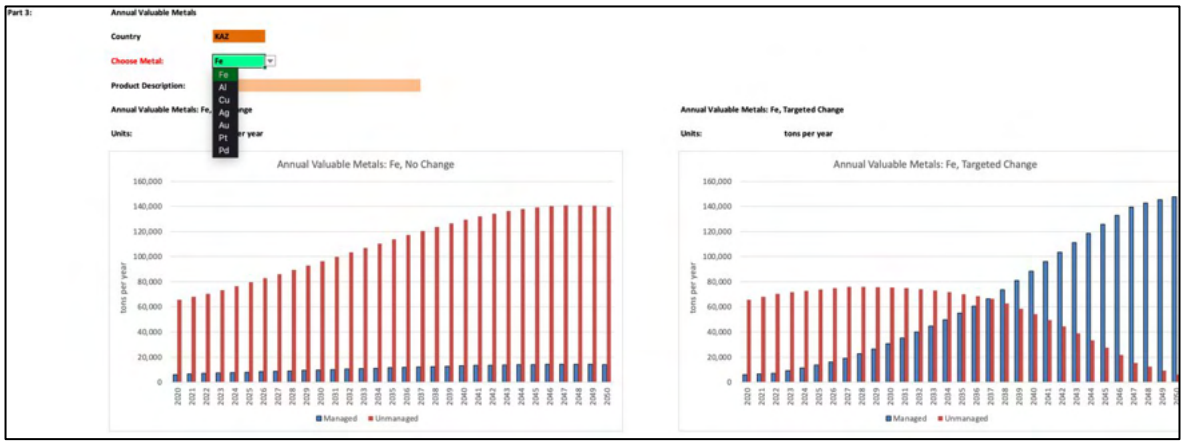
Additional time series plots show managed and unmanaged quantities of multiple harmful substances between 2020 and 2050, either with no change or with targeted change in collection rates. In these plots, the user can choose to output the required harmful substance:



3.3.3 Annual quantities of valuable metals

This sheet provides time series plots showing managed and unmanaged quantities of multiple valuable metals between 2020 and 2050, either with no change or with targeted change in collection rates.

The user can choose to output the required valuable metal:

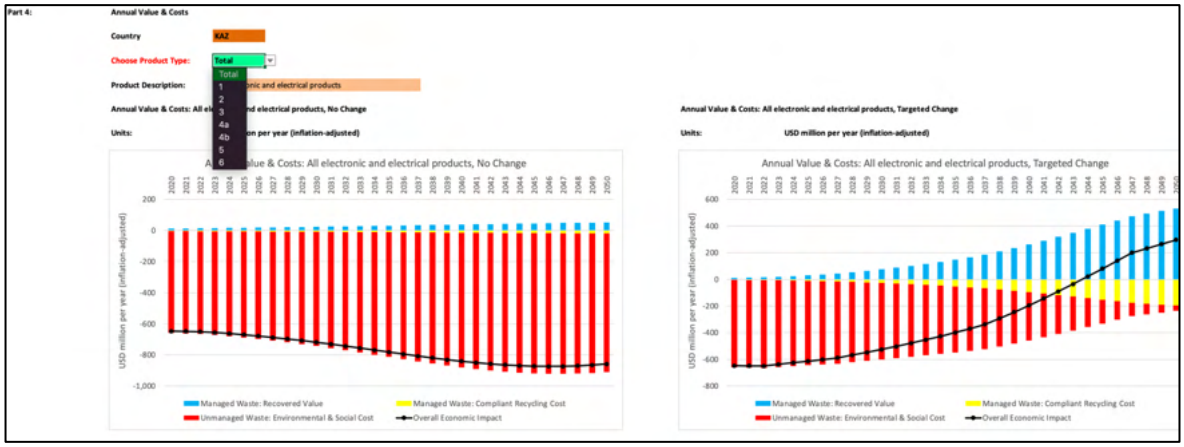


3.3.4 Annual value of recovered materials, compliant recycling cost, and environmental and socio-economic costs of unmanaged waste

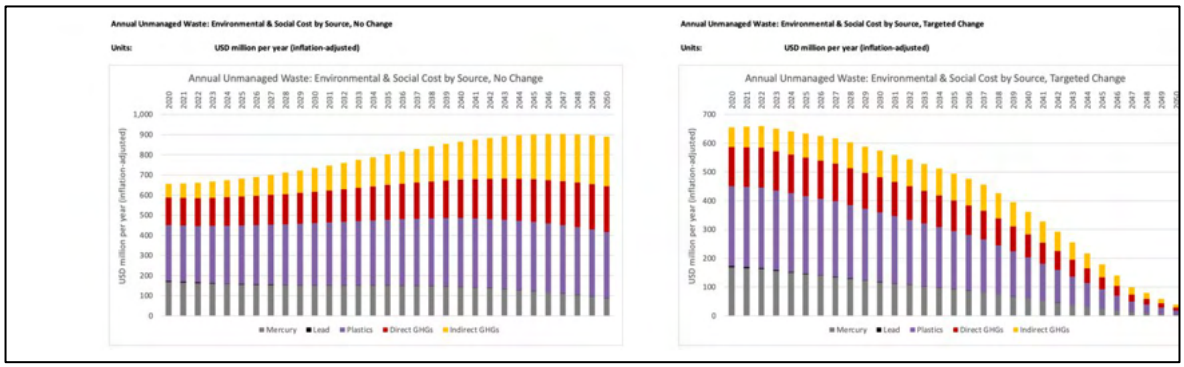
This sheet provides time series plots showing annual recovered value and compliant recycling costs of managed e-waste, and monetised environmental and socio-economic impacts of unmanaged e-waste between 2020 and 2050, either with no change or with targeted change in collection rates.

The plots also show the overall economic impact of e-waste, either with no change or targeted change in collection rates. The overall economic impact represents the difference between the recovered value and the total cost, which includes the cost of treatment of managed waste plus monetised environmental and socio-economic impacts of unmanaged waste.

The user can choose to output either total e-waste or each of the EU6PV categories:



Additional time series plots show the total environmental and social costs of e-waste between 2020 and 2050, either with no change or with targeted change in collection rates, broken down into sources of the negative impacts (mercury, lead, plastics, direct GHGs and indirect GHGs):



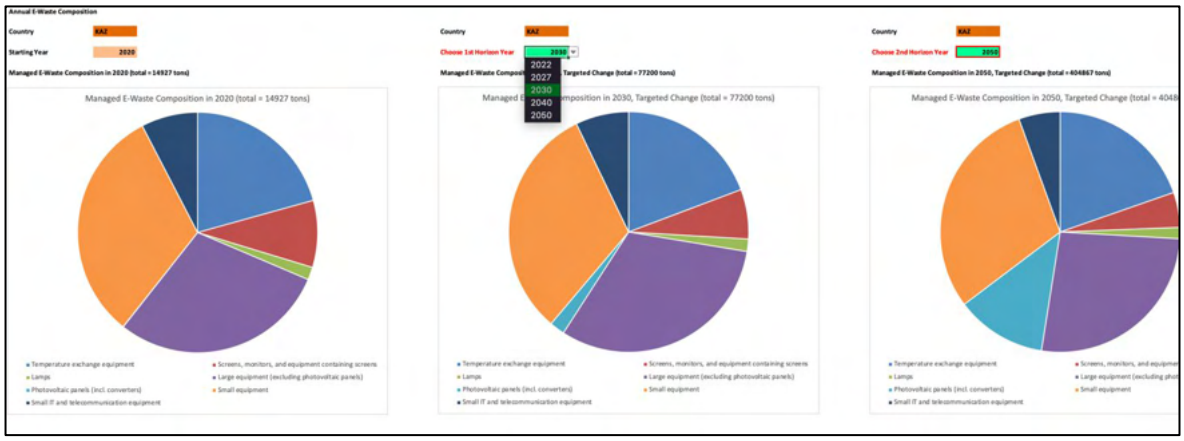
The monetisation of the environmental and socio-economic impacts of harmful studies is based on peer-reviewed studies in the US, EU and globally.

The estimates for the value of the recovered materials and compliant recycling costs are based on UNITAR's databases and global commodity prices (as of summer 2022).

The tool does not account for potential environmental and socio-economic impacts of the informal recycling industry.

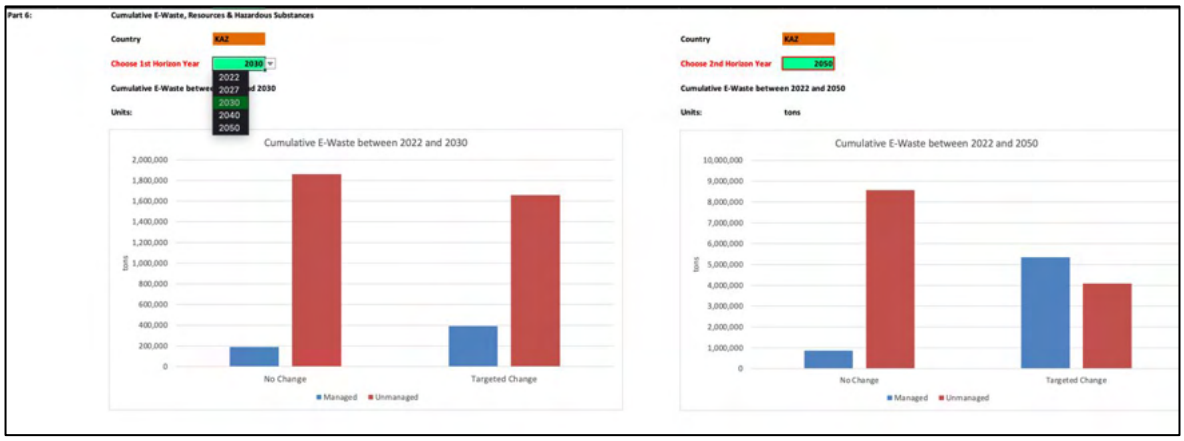
3.3.5 Annual e-waste composition

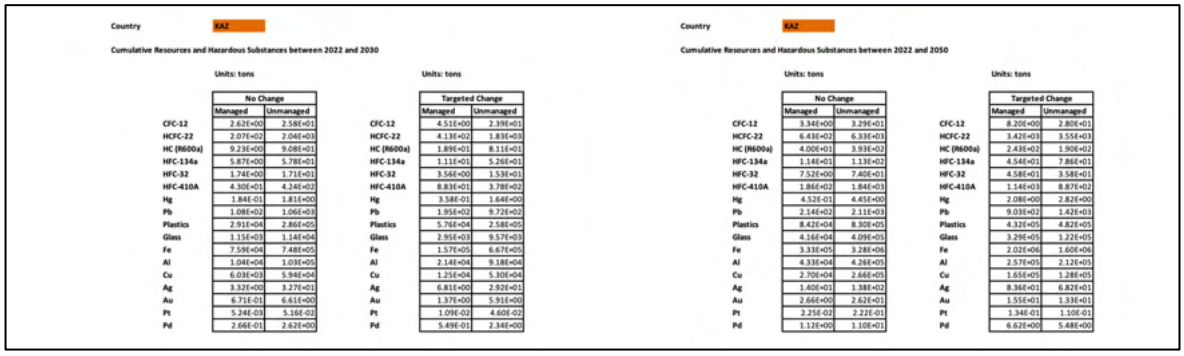
This sheet provides pie charts showing breakdown of annual managed e-waste into EU6PV categories in 2020, and in two user-defined future years (e.g. 2030 and 2050) under the specified collection targets:



3.3.6 Cumulative quantities of e-waste, hazardous substances and valuable materials

This sheet provides bar graphs showing cumulative quantities of managed and unmanaged e-waste between 2020 and two user-defined future years (e.g. 2030 and 2050), either with no change or with targeted change in collection rates. The corresponding cumulative quantities of valuable resources and hazardous substances are also provided:

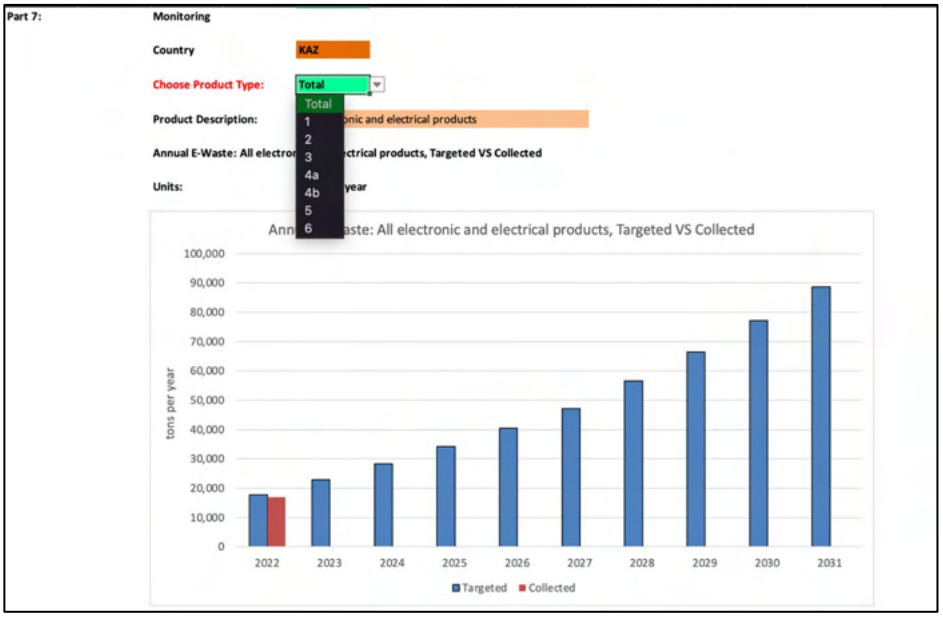




3.3.7 Monitoring collected amounts against specified targets

This sheet provides time series plots comparing near-term annual e-waste collection targets with the actual collection data (as it becomes available).

The user can choose to output either total e-waste or each of the EU6PV categories:



3.3.8 Full output

This sheet provides time-series outputs for managed and unmanaged e-waste between 2000 and 2050, either with no change or with targeted change in collection rates. The corresponding annual quantities of valuable resources and hazardous substances, and recovered material value, compliant recycling costs, and environmental and socio-economic impacts of unmanaged e-waste, are also provided.

Annex: Technical Notes

Data Sources

NOTE: WG = waste generated; WC = waste collected; WoT = Waste over time (model)

Data source for WG projections in the Tool:	WoT model (CIS version) with SSP and CE scenario extensions
WoT output file	"tbl_WEEE_Excel_Tool_Output_03i.xlsx"
WoT output sheet	"Historic_And_Scenarios"
Sheet in the Tool imported to	"WG_Historic_And_Scenarios_WoT"
Data imported on	31/03/2023
WC baseline data	Regional E-Waste Monitor CIS + Georgia, 2021
Material composition excl. PV	2018 Eastern European WG data (BGR, BLR, CZE, HUN, MDA, POL, ROU, RUS, SVK, UKR); 2020-2030 average from HazMat version of the LBN e-waste generated tool (SSP2 pathway)
Material composition PV	2015-2020 EU data for Ag and Glass composition of solar PVs (no distinction between POM and WG)
Metal prices	London Metal Exchange, https://www.lme.com; https://www.dailymetalprice.com
Plastic & glass prices	2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf"
Recycling costs	2018 UNU VIE-SCYCLE report “WEEE Recycling Economics: The shortcomings of the current business model"; 2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf"
GWP values	IPCC AR5 via US EPA and CA GOV

Countries, E-Waste Categories & Scenarios

Source: WoT model, CIS region

Countries

The Tool is configured for the former Soviet Union countries except for the Baltic states which are now part of the European Union. Most of these countries have been part of the Commonwealth of Independent States (CIS) since 1991

Country	Description
ARM	Armenia
AZE	Azerbaijan
BLR	Belarus
GEO	Georgia
KAZ	Kazakhstan
KGZ	Kyrgyz Republic
MDA	Moldova
RUS	Russian Federation
TJK	Tajikistan
TKM	Turkmenistan
UKR	Ukraine
UZB	Uzbekistan

E-Waste categories

The Tool is configured for the seven e-waste categories known as EU6PV

EU6PV	Full name
1	Temperature exchange equipment
2	Screens, monitors, and equipment containing screens
3	Lamps
4a	Large equipment (excluding photovoltaic panels)
4b	Photovoltaic panels (incl. converters)
5	Small equipment
6	Small IT and telecommunication equipment

Scenarios

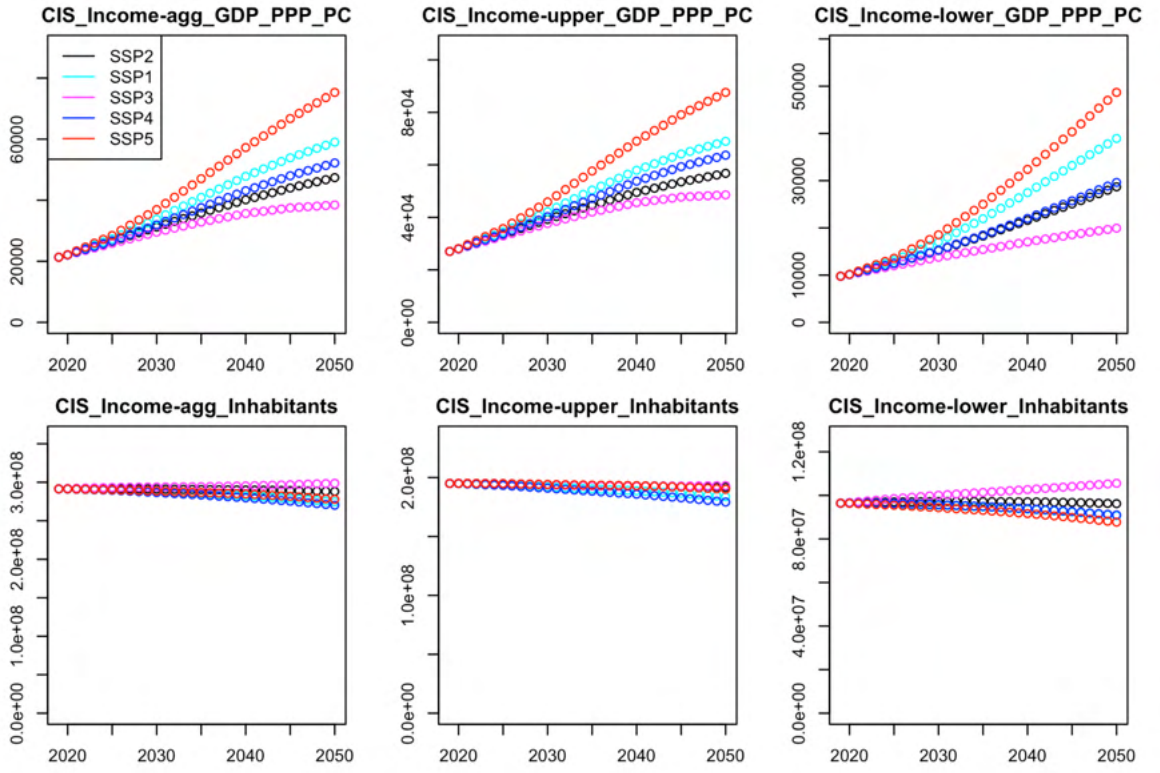
GDP and population

The methodology follows the one adopted in the earlier study "2050 Electronic and Electrical Waste Outlook in West Asia". URI: https://wedocs.unep.org/20.500.11822/42147

SSP pathways	Underpinning narratives
SSP1	Sustainability – Taking the Green Road (Low Challenges to Mitigation and Adaptation)
SSP2	Middle of the Road (Medium Challenges to Mitigation and Adaptation)
SSP3	Regional Rivalry – A Rocky Road (Significant Challenges to Mitigation and Adaptation)
SSP4	Inequality – A Road Divided (Low Challenges to Mitigation, High Challenges to Adaptation)

SSP5	Fossil-fuelled Development – Taking the Highway (High Challenges to Mitigation, Low Challenges to Adaptation)
Historic	Historic data reconstructed back to 1980 and used as a basis for the projections

The corresponding GDP purchasing power parity (PPP) per capita (PC) projections and population (inhabitants) projections are plotted below for the CIS region as a whole, as well as separately form the upper- and lower-income countries in the region



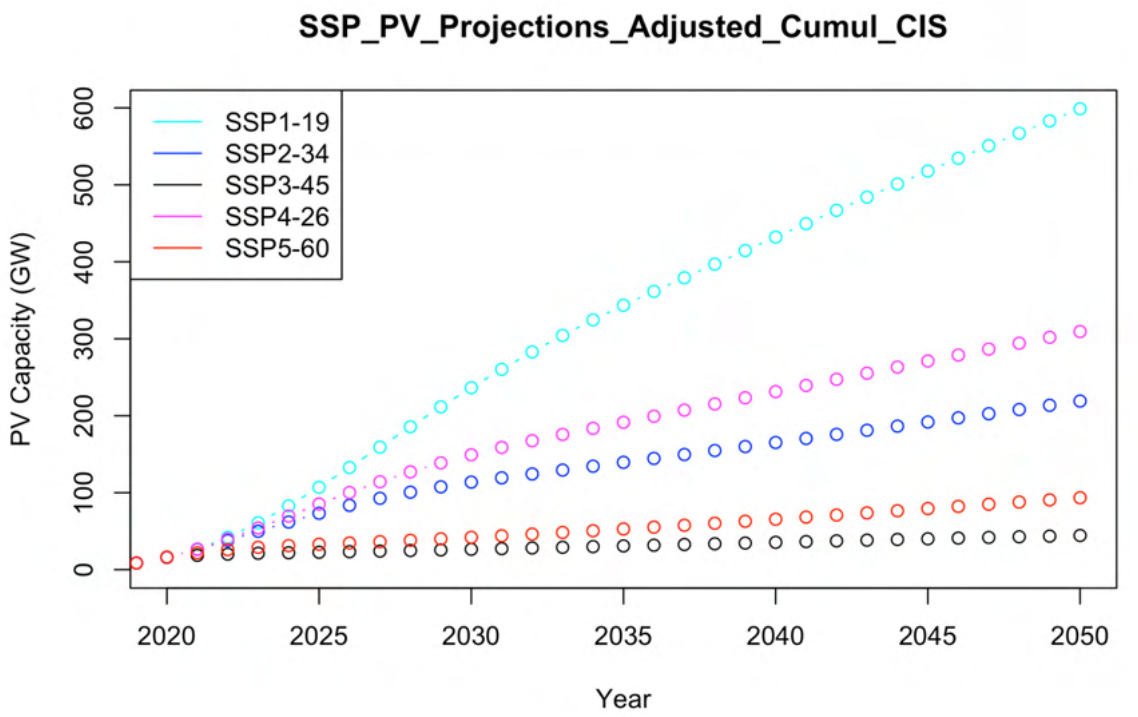
Solar PV projections

The methodology follows the one adopted in the earlier study "2050 Electronic and Electrical Waste Outlook in West Asia". URI: https://wedocs.unep.org/20.500.11822/42147

We used SSP projections for solar PV installations in the following region in the SSP database:

"R5.2REF = Countries from the Reforming Economies of Eastern Europe and the Former Soviet Union"

These projections were adjusted according to historic country-level PV installation trends in the region between 2000 and 2020 available from the IRENA database. The resulting adjusted cumulative PV projections for the CIS region as whole, separately for each SSP pathway, are plotted below



Circular economy assumptions for e-waste

The methodology follows the one adopted in the earlier study "2050 Electronic and Electrical Waste Outlook in West Asia". URI: https://wedocs.unep.org/20.500.11822/42147

Circular economy pathways	Underpinning assumptions
CE ("Circular Economy")	• Full or partial obsolescence for certain products • Saturation in stock per capita • Increased durability • Less hoarding • More sharing
BaU ("Business as Usual")	Current consumption and disposal behaviours for electronic and electrical goods persists

Compared to the West Asia study, we made further adjustments to the BaU projections for each granular product category (referred to as UNU key) to reflect on the likely consumption constrains. These adjustments are summarised in the table below. The adjustments focus on the likely obsolescence and saturation for a number of UNU keys, and translate into the corresponding constraints for the CE pathway

"POM Target Relative" (full or partial obsolescence) = fraction of the present-day POM projected to remain by 2050

"Stock ppi Target Absolute" (saturation) = projected maximum number of pieces of equipment per inhabitant (ppi) to be reached in household stocks at some point between present and 2050

UNU Key	UNU Key Description	BaU Obsolescence POM Target Relative	BaU Saturation Stock ppi Target Absolute
1	Central Heating (household installed)†		0.1
2	Photovoltaic Panels (incl. inverters)†		
101	Professional Heating & Ventilation (excl. cooling equipment)†		0.0015
102	Dish washers†		0.4
103	Kitchen equipment (e.g. large furnaces, ovens, cooking equipment)†		0.6
104	Washing Machines (incl. combined dryers)†		0.4
105	Dryers (wash dryers, centrifuges)†		0.15
106	Household Heating & Ventilation (e.g. hoods, ventilators, space heaters)†		0.8
108	Fridges (incl. combi-fridges)†		0.7
109	Freezers†		0.15
111	Air Conditioners (household installed and portable)†		0.6
112	Other Cooling equipment (e.g. dehumidifiers, heat pump dryers)†		0.06
113	Professional Cooling equipment (e.g. large air conditioners, cooling displays)†		0.5
114	Microwaves (incl. combined, excl. grills)†		0.4
201	Other small household equipment (e.g. small ventilators, irons, clocks, adapters)†		
202	Equipment for food preparation (e.g. toaster, grills, food processing, frying pans)†		6
203	Small household equipment for hot water preparation (e.g. coffee, tea, water cookers)†		
204	Vacuum Cleaners (excl. professional)†		0.7
205	Personal Care equipment (e.g. tooth brushes, hair dryers, razors)†		2
301	Small IT equipment (e.g. routers, mice, keyboards, external drives & accessories)†		2
302	Desktop PCs (excl. monitors, accessoires)†	0.1	
303	Laptops (incl. tablets)†		1.5
304	Printers (e.g. scanners, multi functionals, faxes)†		0.4
305	Telecommunication equipment (e.g. (cordless) phones, answering machines)†	0	
306	Mobile Phones (incl. smartphones, pagers)†		2
307	Professional IT equipment (e.g. servers, routers, data storage, copiers)†		0.05
308	Cathode Ray Tube Monitors†	0	

309	Flat Display Panel Monitors (LCD, LED)†		0.2
401	Small Consumer Electronics (e.g. headphones, remote controls)†		4
402	Portable Audio & Video (e.g. MP3, e-readers, car navigation)†	0	
403	Music Instruments, Radio, Hi-Fi (incl. audio sets)†	0.2	
404	Video (e.g. Video recorders, DVD, Blue Ray, set-top boxes) and projectors†	0.1	
405	Speakers†		1.25
406	Cameras (e.g. camcorders, photo & digital still cameras)†	0	
407	Cathode Ray Tube TVs†	0	
408	Flat Display Panel TVs (LCD, LED, Plasma)†		1
501	Small lighting equipment (excl. LED & incandescent)†		
502	Compact Fluorescent Lamps (incl. retrofit & non-retrofit)†	0	
503	Straight Tube Fluorescent Lamps†	0.5	
504	Special Lamps (e.g. professional mercury, high & low pressure sodium)†		1
505	LED Lamps (incl. retrofit LED lamps)†		
506	Household Luminaires (incl. household incandescent fittings & household LED luminaires)†		60
507	Professional Luminaires (offices, public space, industry)†		6
601	Household Tools (e.g. drills, saws, high pressure cleaners, lawn mowers)†		3
602	Professional Tools (e.g. for welding, soldering, milling)†		0.05
701	Toys (e.g. car racing sets, electric trains, music toys, biking computers, drones)†		10
702	Game Consoles†		0.4
703	Leisure equipment (e.g. sports equipment, electric bikes, juke boxes)†		
801	Household Medical equipment (e.g. thermometers, blood pressure meters)†		
802	Professional Medical equipment (e.g. hospital, dentist, diagnostics)†		
901	Household Monitoring & Control equipment (alarm, heat, smoke, excl. screens)†		
902	Professional Monitoring & Control equipment (e.g. laboratory, control panels)†		
1001	Non- cooled Dispensers (e.g. for vending, hot drinks, tickets, money)†		0.0015

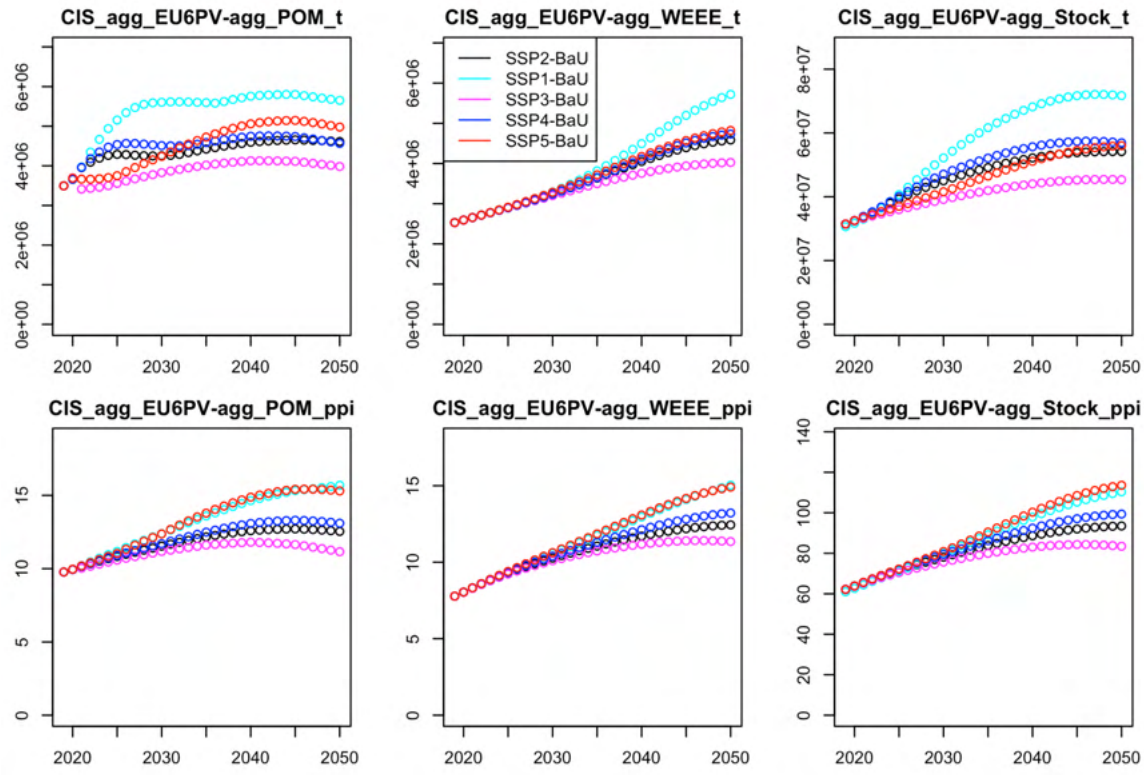
1002	Cooled Dispensers (e.g. for vending, cold drinks)†		0.005

Combined pathway used in the Tool

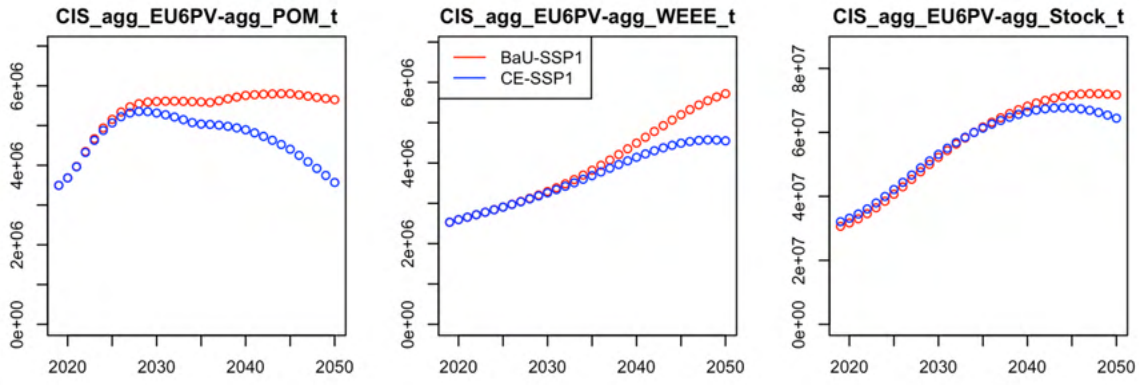
The Tool uses mean of the 10 pathways formed by combinations of the five SSPs with the CE and BaU scenarios:

Combined pathway = mean(SSP1-CE, SSP2-CE, SSP3-CE, SSP4-CE, SSP5-CE, SSP1-BaU, SSP2-BaU, SSP3-BaU, SSP4-BaU, SSP5-BaU)

The differences between the SSP projections for POM, WEEE and Stock, either for tonnes (t) or pieces per inhabitant (ppi), are illustrated below for the BaU pathway describing the consumer behaviour in the CIS region. NOTE that the SSP1 pathway is characterised by a large acceleration in the uptake of solar PV panels between present and mid-2030s (see above), which leads to increases in the overall POM compared to other SSPs



The differences between the BaU and CE consumer behaviour projections for POM, WEEE and Stock, measured in tonnes (t), are illustrated below for the SSP1 pathway ("sustainable development") for the underpinning GDP and population projections in the CIS region



Granularity of targets for collected E-Waste

Target Type	Description
Total E-Waste	Set targets for total WC across all categories
EU6PV Categories	Set targets for WC separately for each EU6PV category

Base Year, Management Period & Output Settings

Base year options

2022
2023
2024

NOTE: The first option is the year immediately after the year for which the WC data is provided

Management period options

Units: years

3
5
10

Collection rate percentage options for targets

5%
10%
15%
20%

25%
30%
35%
40%
45%
50%
60%
70%
80%
90%
100%

Product types to plot for annual time series

Label	Description
Total	All electronic and electrical products
1	Temperature exchange equipment
2	Screens, monitors, and equipment containing screens
3	Lamps
4a	Large equipment (excluding photovoltaic panels)
4b	Photovoltaic panels (incl. converters)
5	Small equipment
6	Small IT and telecommunication equipment

First Analysis Year	2000

NOTE: Ensure it includes sufficient historic period (2000-2020); DO NOT change (the arrays are hardcoded for the 2000-2050 time range)

First Annual Outputs Year	2020

NOTE: Fix it to ensure the time series plots don't give errors when the base year for management changes

Cumulative outputs year options

2022	Chosen Base Year
2027	Chosen Base Year + One Chosen Management Period
2030	Common Horizon of Interest
2040	Common Horizon of Interest
2050	Common Horizon of Interest

Collection Rates

WC data baseline year	2021

NOTE: This is a recent year for which the WC data is provided; must be the same as the year for the data in the table below

Country	E-waste collection rate (% of WG, by weight)
ARM	0.1%
AZE	0.01%
BLR	33.6%
GEO	NA
KAZ	8.8%
KGZ	NA
MDA	0.8%
RUS	2.5%
TJK	0.8%
TKM	NA
UKR	NA
UZB	NA

Source: Regional E-Waste Monitor CIS + Georgia, 2021

NOTE: Enter "NA" if the country has not collected e-waste on a large scale, or could not provide the data. To fill in the gaps in the data, we introduce the following empirical WC rate in the base year:

Value to replace NAs	0.1%

Material Composition

EU6PV Composition (% of total weight per EU6PV category)

Units: ton substance per ton e-waste
Source: 2018 Eastern European WG data (BGR, BLR, CZE, HUN, MDA, POL, ROU, RUS, SVK, UKR); 2020-2030 average from HazMat version of the LBN e-waste generated tool (SSP2 pathway)

Substance	Description	EU6PV 1	EU6PV 2	EU6PV 3	EU6PV 4a	EU6PV 4b	EU6PV 5	EU6PV 6
CFC-12	Ozone Depleting Substances & GHGs	0.055%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
HCFC-22	Ozone Depleting Substances & GHGs	0.772%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
HC (R600a)	GHG Substances	0.024%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
HFC-134a	GHG Substances	0.042%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
HFC-32	GHG Substances	0.005%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
HFC-410A	GHG Substances	0.114%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Hg	Mercury	0.000%	0.000%	0.012%	0.000%	0.000%	0.000%	0.000%
Pb	Lead	0.003%	3.619%	0.031%	0.005%	0.000%	0.020%	0.085%
Plastics	Plastics	21.674%	21.312%	2.708%	8.506%	0.000%	48.407%	36.756%
Glass	Glass	0.000%	0.000%	0.000%	0.000%	68.403%	0.000%	0.000%
Fe	Metals	42.496%	27.962%	14.033%	52.470%	10.000%	34.745%	31.976%
Al	Metals	4.943%	7.202%	8.483%	2.417%	0.000%	9.777%	3.313%
Cu	Metals	2.815%	2.946%	10.992%	1.378%	1.500%	5.092%	2.284%
Ag	Metals	0.0000%	0.0087%	0.0003%	0.0000%	0.0012%	0.0013%	0.0094%
Au	Metals	0.00000%	0.00199%	0.00001%	0.00001%	0.00000%	0.00017%	0.00213%
Pt	Metals	0.000000%	0.000000%	0.000000%	0.000005%	0.000000%	0.000001%	0.000015%
Pd	Metals	0.00000%	0.00037%	0.00000%	0.00019%	0.00000%	0.00006%	0.00050%

Exponential Decay Rates for Selected Components (e.g. CFCs, Hg and Pb being phased out)

Units: 1 per year
Source: 2018 Eastern European WG data (BGR, BLR, CZE, HUN, MDA, POL, ROU, RUS, SVK, UKR); 2020-2030 average from HazMat version of the LBN e-waste generated tool (SSP2 pathway)

Substance	EU6PV 1	EU6PV 2	EU6PV 3	EU6PV 4a	EU6PV 4b	EU6PV 5	EU6PV 6
CFC-12	-0.197	0.000	0.000	0.000	0.000	0.000	0.000
HCFC-22	-0.031	0.000	0.000	0.000	0.000	0.000	0.000
HC (R600a)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HFC-134a	-0.090	0.000	0.000	0.000	0.000	0.000	0.000
HFC-32	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HFC-410A	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hg	0.000	-0.044	-0.071	0.000	0.000	0.000	0.000
Pb	-0.005	-0.173	0.000	-0.009	0.000	-0.012	0.000
Plastics	-0.031	-0.134	0.000	0.000	0.000	-0.059	-0.073
Glass	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fe	0.000	0.000	0.000	0.000	0.000	0.000	-0.014
Al	0.000	0.000	0.000	-0.003	0.000	-0.005	-0.016
Cu	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ag	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Au	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pt	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pd	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Global Warming Potential of Gases

Substance	Description	GWP100	Source
CFC-12	Ozone Depleting Substances & GHGs	10,900.0	IPCC AR4 values, https://www.epa.gov/sites/default/files/2016-12/documents/transitioning_to_low-gwp_alternatives_in_domestic_refrigeration.pdf
HCFC-22	Ozone Depleting Substances & GHGs	1,810.0	IPCC AR4 values, https://www.epa.gov/sites/default/files/2016-12/documents/transitioning_to_low-gwp_alternatives_in_domestic_refrigeration.pdf
HC (R600a)	GHG Substances	3.0	IPCC AR4 values, https://www.epa.gov/sites/default/files/2016-12/documents/transitioning_to_low-gwp_alternatives_in_domestic_refrigeration.pdf
HFC-134a	GHG Substances	1,300.0	IPCC AR5 values, https://ww2.arb.ca.gov/resources/documents/high-gwp-refrigerants
HFC-32	GHG Substances	677.0	IPCC AR5 values, https://ww2.arb.ca.gov/resources/documents/high-gwp-refrigerants
HFC-410A	GHG Substances	1,923.5	IPCC AR5 values, https://ww2.arb.ca.gov/resources/documents/high-gwp-refrigerants

GHG Savings from Using Recycled Materials

Units: ton CO2e per ton
Source: UNITAR; Nuss P, Eckelman MJ. Life cycle assessment of metals: a scientific synthesis. PLoS One. 2014 Jul 7;9(7): e101298; Figure 2; Secondary footprint data not readily available

Material	GHG Savings of using Secondary instead of Primary	Primary Footprint	Secondary Footprint	Source
Fe	1.95	2.25	0.3	UNITAR
Al	13.3	14	0.7	UNITAR
Cu	4	6	2	UNITAR
Ag	196	196	0	Nuss & Eckelman (2014)
Au	12500	12,500	0	Nuss & Eckelman (2014)
Pt	12500	12,500	0	Nuss & Eckelman (2014)
Pd	3880	3,880	0	Nuss & Eckelman (2014)

GHG Reporting Categories	Description
Direct GHG CO2e	CO2 equivalent of refrigerants

Indirect GHG CO2e	CO2 equivalent of GHG savings from recycled materials

Recycling Costs & Material Values

Basic parameters

KAZ recycling cost year	2020

Source: 2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf", page 91, table 57

EU recycling cost year	2022

Source: "Memo on Treatment Costs v26.08.2022_for CSD" by Kees Balde + follow-up correspondence

Commodity prices year	2022

Assumed rate of inflation	2.0%	% per year

NOTE: This is long-term inflation post 2010 in developed economies (excluding latest post-Covid spike)

Exchange rates to USD in the years for which the cost estimates are provided

USD per KZT (Tenge)	0.0024	USD/KZT

Source: 2020 exchange rate; https://www.xe.com/currencyconverter/convert/?Amount=1&From=KZT&To=USD, accessed on 05/08/2022

USD per EUR	1.1	USD/EUR

Source: 2016 exchange rate, https://www.exchangerates.org.uk/USD-EUR-spot-exchange-rates-history-2016.html, accessed on 10/08/2022

Cost of recycling of 1 ton of e-waste in KAZ

Recycling cost in KZT	149,000	KZT/ton

Source: 2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf", page 91, table 57

NOTE: This cost is not split into EU6PV

Cost of compliant recycling of 1 ton of e-waste in EU, separately for each EU6PV category

Units: EUR per ton

EU6PV Category	Recycling Cost Part 1: Collection & Transportation	Notes
1	NA	NOTE: No data currently; set to "NA" and UPDATE in due course
2	NA	
3	NA	
4a	NA	
4b	NA	
5	NA	
6	NA	

Units: EUR per ton

EU6PV Category	Recycling Cost Part 2: Treatment	Notes
1	320	Source: "Memo on Treatment Costs v26.08.2022_for CSD" by Kees Balde
2	260	
3	1,800	
4a	140	
4b	70	
5	346	
6	150	

EU6PV Category	Recycling Cost Total (Part 1 + Part 2)	Units
1	320	EUR/ton
2	260	EUR/ton
3	1,800	EUR/ton
4a	140	EUR/ton
4b	70	EUR/ton
5	346	EUR/ton
6	150	EUR/ton

NOTE: The formula recognises NAs in the data entry blocks above and replaces them with zeros

Value of selected recovered materials in KAZ

Material	Value	Units	Source
Plastics	44,800	KZT/ton	2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf", page 91, table 58
Glass	86,000	KZT/ton	2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf", page 93, table 62

Fe	35,000	KZT/ton	2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf", page 91, table 58
Al	114,000	KZT/ton	2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf", page 91, table 58
Cu	625,000	KZT/ton	2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf", page 91, table 58

Recycling costs converted to USD and adjusted to commodity base year

Recycling cost in USD	372.04704	USD/ton

Source: 2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf", page 91, table 58

NOTE: This cost is not split into EU6PV

EU6PV breakdown of the recycling costs

Category	Recycling Cost Total	Units
1	352	USD/ton
2	286	USD/ton
3	1980	USD/ton
4a	154	USD/ton
4b	77	USD/ton
5	380.6	USD/ton
6	165	USD/ton

NOTE: These values are used in the calculations

Value of selected recycled materials converted to USD and adjusted to commodity base year

Material	Recycled Value	
Plastics	111.863808	USD/ton
Glass	214.73856	USD/ton
Fe	87.3936	USD/ton
Al	284.65344	USD/ton
Cu	1560.6	USD/ton

Source: 2020 KAZ report "200928 Отчет по шинам, маслам, аккумуляторам, ЭЭО Заказчику.pdf", page 91, table 58; page 93, table 62

Global metal commodity values in August 2022

Fe	400	USD/ton
Al	1,850	USD/ton
Cu	7,700	USD/ton
Ag	604,755	USD/ton
Au	56,000,000	USD/ton
Pt	28,000,000	USD/ton
Pd	65,000,000	USD/ton

Sources: Approximate 3-month value of Steel Scrap, London Metal Exchange, https://www.lme.com, accessed on 05/08/2022; Approximate 1-month value, https://www.dailymetalprice.com/metalprices.php?c=ag&u=mt&d=1, accessed on 05/08/2022

Global to KAZ price ratio for selected metals

Fe	4.576994196	fraction
Al	6.499131013	fraction
Cu	4.933999744	fraction

Chosen material values based on the available options

Fe	400	USD/ton
Al	1,850	USD/ton
Cu	7,700	USD/ton
Ag	604,755	USD/ton
Au	56,000,000	USD/ton
Pt	28,000,000	USD/ton
Pd	65,000,000	USD/ton
Plastics	112	USD/ton
Glass	215	USD/ton

NOTE: Use global commodity values for scrap metals and KAZ values for other recovered materials

Material value per EU6PV category based on current material composition

NOTE: Material composition is assumed to be constant for valuable metals, unlike the shares of CFC, Hg and Pb which are dropping

Category	Value per ton of e-waste in a given category	
1	504.5105762	USD/ton
2	1903.057041	USD/ton
3	1067.271672	USD/ton
4a	500.262533	USD/ton
4b	309.8592241	USD/ton
5	903.5829443	USD/ton
6	1981.236432	USD/ton

Material value breakdown within each EU6PV category based on current material composition

NOTE: Material composition is assumed to be constant for valuable metals, unlike the shares of CFC, Hg and Pb which are dropping

Units: USD per ton

		EU6PV Composition: Material Value, USD per ton of e-waste for each commodity in each EU6PV category						
Substance	**Description**	1	2	3	4a	4b	5	6
CFC-12	Ozone Depleting Substances & GHGs	0	0	0	0	0	0	0
HCFC-22	Ozone Depleting Substances & GHGs	0	0	0	0	0	0	0
HC (R600a)	GHG Substances	0	0	0	0	0	0	0
HFC-134a	GHG Substances	0	0	0	0	0	0	0
HFC-32	GHG Substances	0	0	0	0	0	0	0
HFC-410A	GHG Substances	0	0	0	0	0	0	0
Hg	Mercury	0	0	0	0	0	0	0
Pb	Lead	0	0	0	0	0	0	0
Plastics	Plastics	24.2	23.8	3.0	9.5	0.0	54.2	41.1
Glass	Glass	0.0	0.0	0.0	0.0	146.9	0.0	0.0
Fe	Metals	170.0	111.8	56.1	209.9	40.0	139.0	127.9
Al	Metals	91.4	133.2	156.9	44.7	0.0	180.9	61.3
Cu	Metals	216.7	226.8	846.4	106.1	115.5	392.1	175.8
Ag	Metals	0.0	52.9	1.5	0.3	7.5	7.7	56.7
Au	Metals	2.0	1113.4	2.9	3.1	0.0	93.0	1192.3
Pt	Metals	0.0	0.0	0.0	1.3	0.0	0.1	4.3
Pd	Metals	0.1	241.0	0.4	125.3	0.0	36.6	321.8

Environmental & Social Costs

Social cost of mercury pollution

	EW	LT	
Benefits in the US from reducing US mercury emissions (MATS regulation)	324,000,000	1,100,000,000	USD / ton Hg

Benefits in the US from reducing global mercury emissions (Minamata Convention)	46,000,000	150,000,000	USD / ton Hg

Definitions: EW stands for economy-wide benefits (based on human capital assessment of productivity and wages); LT stands for lifetime benefits (based on cost of illness and value of statistical life)

Source: Giang, A., & Selin, N.E. Benefits of mercury controls for the United States. PNAS, 113 (2) 286-291, 2015

NOTE: The US benefits of implementing global restrictions on mercury emissions are given for reference only and are not used in the calculations since we focus on the effects of preventing country-level emissions from e-waste

Average socio-economic cost of emitting 1 ton of unmanaged mercury	712,000,000	USD / ton Hg

NOTE: Average of the two estimates for the US-based emissions above (since we focus on the effects of preventing country-level emissions from e-waste). A more country-specific estimate requires country-level data on mercury emissions and deposition

Social cost of lead pollution

	MIN	MAX	
Annual environmental and social cost of lead pollution from hunting and sports bullets in the EU	383,000,000	960,000,000	EUR per year in the EU
Annual lead pollution from hunting and sports bullets in the EU	31,000	41,000	ton Pb per year in the EU

Source: Pain, D.J., Dickie, I., Green, R.E. et al. Wildlife, human and environmental costs of using lead ammunition: An economic review and analysis. Ambio 48, 969–988 (2019)

NOTE: This combines estimates for hunting and sports bullets

Average socio-economic and environmental cost of 1 ton of unmanaged lead, EUR	18,653	EUR / ton Pb
Average socio-economic and environmental cost of 1 ton of unmanaged lead, USD	20,518	USD / ton Pb

NOTE: Use this value in the calculations

Environmental and social cost of plastic pollution

Total env. & socio-econ. losses from unmanaged waste to be created by new plastic produced in 2019	3.142E+12	USD
Global total amount of plastic produced in 2019	368,000,000	ton plastic

Source: “Plastics: The Costs to Society, the Environment & the Economy”. WWF Report, 2021 (https://wwfint.awsassets.panda.org/downloads/wwf_pctsee_report_english.pdf); Fig 4 value for ecosystem costs due to unmanaged waste;

Global plastics tonnage: https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/

Average environmental & socio-economic cost of 1 ton of unmanaged plastic	8,538	USD / ton plastic

Social and environmental cost of GHG emissions

Social cost of CO2 (SCCO2) definition: Discounted present value of long-term socio-economic & environmental impacts of emitting 1 ton of CO2e, driven by the effects of climate change

SCCO2 (long-term socio-economic & environmental impacts of emitting 1 ton of CO2e)	250	USD / ton CO2e

NOTE: This is an approximate global average value based on the following sources:

Pindyck, R.S. The Social Cost of Carbon Revisited. National Bureau of Economic Research, 2016

Ricke, K., et al. Country-level social cost of carbon. Nature Clim Change 8, 895–900 (2018)

Kikstra, J.S., et al. The social cost of carbon dioxide under climate-economy feedbacks and temperature variability. Environmental Research Letters, 2021, 16(9):094037.

Rennert, K., Errickson, F., Prest, B.C. et al. Comprehensive Evidence Implies a Higher Social Cost of CO2. Nature (2022). https://doi.org/10.1038/s41586-022-05224-9

NOTE: The uncertainties in the SCCO2 estimates are currently high, but the chosen average value is representative of a wide range of recent assessments

NOTE: In this model, SCCO2 is assumed to change with time according to the main inflation rate specified for all other costs; this is a simplification

NOTE: In this model, we do not consider variations in SCCO2 between countries

Summary: Environmental & social costs

Substance	Environmental & Social Cost	
Hg	712,000,000	USD / ton Hg
Pb	20,518	USD / ton Pb
Plastics	8,538	USD / ton plastic
Total GHG	250	USD / ton CO2e