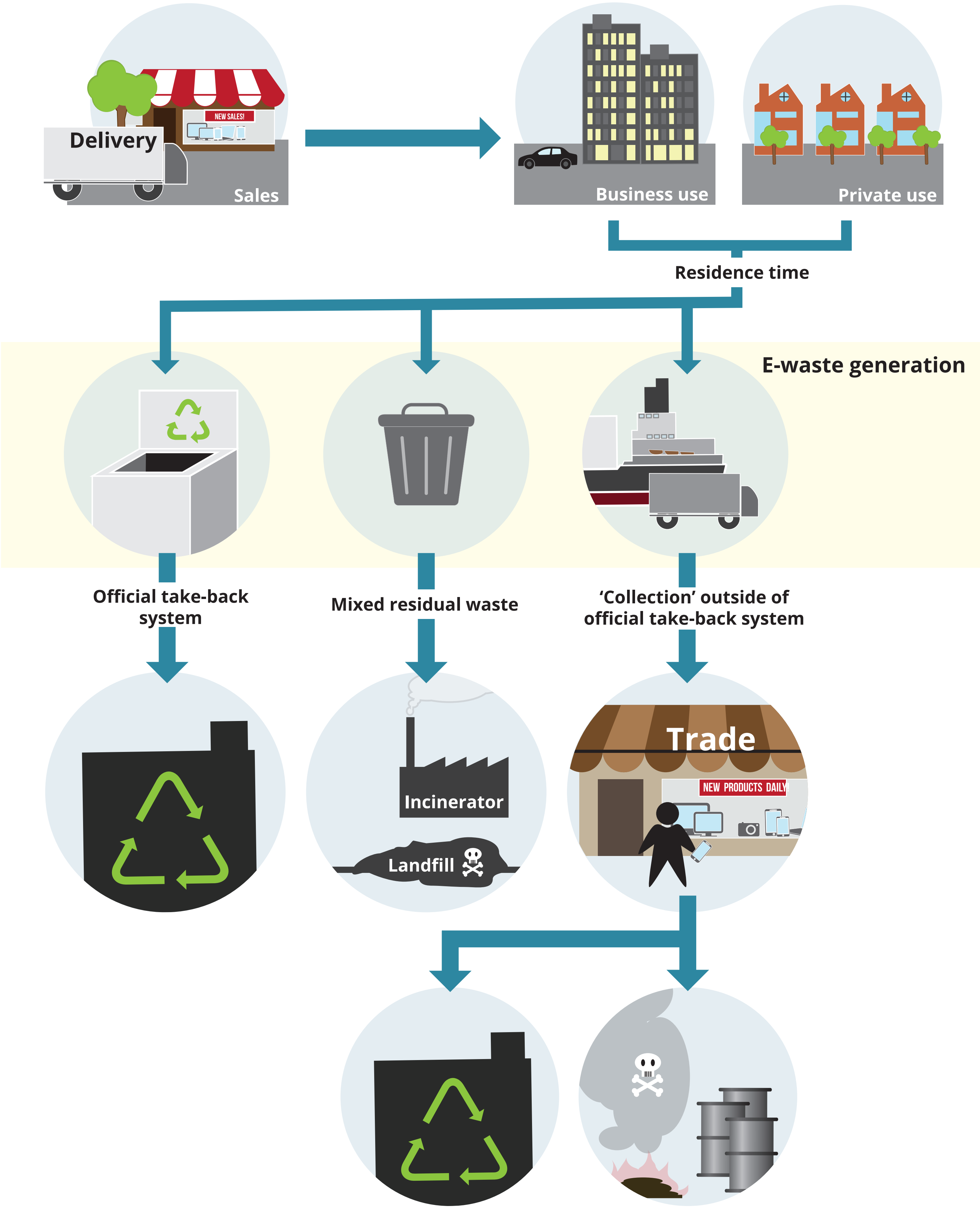
Chapter 5

Standards and Methodologies to Measure E-waste

Illustration 5.1: Life cycle of EEE into e-waste, and the most common e-waste management scenarios



The most common disposal scenarios around the world are measured in a standardized framework developed by the Partnership on Measuring ICT for Development (Baldé et al., 2015a), which captures and measures the most essential features of the e-waste dynamics in a consistent manner. Four indicators have been identified and discussed in this publication:

Indicator 1: Total EEE Put on the Market

Indicator 2: Total E-waste Generated

Indicator 3: E-waste Officially Collected and Recycled

Indicator 4: E-waste Collection Rate

Additional data was gathered for populations that are covered under national e-waste laws, and for e-waste disposed of in waste bins.

In e-waste statistics, definitions and concepts help to classify e-waste, and tracing the flow from consumption to final disposal is central. Both are defined in a statistical measuring framework on e-waste as described by the Partnership of Measuring ICT for Development (Baldé et al., 2015a). The same concepts formed the basis for the first Global E-waste Monitor (Baldé et al., 2015b), and they are also used in the European Union as the common methodology to calculate the collection target of the recast EU-WEEE Directive (European Union, 2012).

5.1 Classifications for E-waste

For each electrical or electronic product, its original function, environmental relevancy, weight, size, and material composition differ considerably. Taking these differences into account, the categorization of EEE, and thus e-waste, can be grouped into roughly 54 homogeneous product types, referred to as the UNU-KEYS (See Annex 1). Each UNU-KEY corresponds to one or more codes in The Harmonized Commodity Description and Coding System (HS). This detailed correspondence table is published in the statistical guidelines from the Partnership on Measuring ICT for Development (Baldé et al., 2015a). The 54 UNU-KEYS can be grouped into six and ten categories of the recast of the WEEE Directive (See Annex 1 for the respective categories and links). The six categories of the WEEE Directive reflect the main groups in which e-waste is managed after collection, and will be used in this publication. Those are:

- Temperature exchange equipment.
- Screens, monitors.
- Lamps.
- Large equipment.
- Small equipment.
- Small IT and telecommunication equipment.

5.2 Measuring Framework of E-waste Statistics

The main lifecycle of EEE into e-waste, and the waste management that generally occurs, can be summarized into four distinct phases. The four phases describe market entry, stock, e-waste generated, and waste management.

Phase 1: Market Entry

The first phase occurs when an EEE product is sold to a consumer or a business and enters the market. Data can come from statistics on sales from a national e-waste registry for compliance with the Extended Producer Responsibility, or if not available, it can be measured with the 'apparent consumption method[6].

Phase 2: Stock

After a product has been sold, it enters a household, enterprise, or institution, called "the stock phase". The stock of EEE can be determined using household or business surveys on a national level. If that data is not available, it can be calculated using the sales information and the time the equipment spends in the stock phase, called the "product's residence time". This residence time includes the dormant time in sheds and exchange of second-hand equipment between households and businesses within the country. When a second-hand functioning product is exported, the 'residence time' in that country also comes to an end, and the product enters the stock phase market again in another country.

Phase 3: E-waste Generated

The third phase is when the product becomes obsolete to its final owner, is disposed of, and turns to waste, referred to as "e-waste generated". It is the annual supply of domestically generated e-waste prior to collection, without imports of externally generated EEE waste. The outcomes of e-waste generated are an important indicator for e-waste statistics.

Phase 4: E-waste Management

The e-waste generated is usually collected in either one of the four following scenarios:

E-waste Collection Scenario 1: The Official Take-Back System

In this scenario, usually under the requirement of national e-waste legislation, e-waste is collected by designated organizations, producers, and/or the government. This happens via retailers, municipal collection points, and/or pick-up services. The final destination for the e-waste that's collected is a state-of-the-art treatment facility, which recovers the valuable materials in an environmentally-sound way. This is the ideal scenario, aimed to reduce the environmental impact.

Typically, data is collected from the treatment facility, and there are laws that enable monitoring with recycling and collection targets. To assess its progress, data on the amount of domestic e-waste collected and recycled was gathered from countries.

E-waste Collection Scenario 2: Mixed Residual Waste

In this scenario, consumers directly dispose of e-waste through normal dustbins with other types of household waste. As a consequence, the disposed of e-waste is then treated with the regular mixed-waste from households. Depending on the region, it can be either sent to a landfill or municipal solid waste incinerator with a low chance of separation prior to its final destination. Neither option is regarded as an appropriate technique to treat e-waste because they lead to resource loss, and have the potential to negatively impact the environment. Landfilling leads to toxins leaching into the environment and incineration leads to emissions into the air. This disposal scenario exists in both developed and developing countries. Products commonly thrown away in dustbins include small equipment, small IT equipment, and lamps.

Scenarios 3+4: The Collection Outside the Official Take-Back System

The collection outside the official take-back system and management of e-waste is very different in countries that have developed waste management practices for their municipal waste recycling versus countries that have not. As a rule of thumb, this is divided into developed and developing countries by the Basel convention. Therefore, two scenarios are described: for countries that have a developed waste management system, and for countries that do not.

Countries with Developed Waste Management

In countries that have developed waste management laws, e-waste is collected by individual waste dealers or companies and then traded through various channels. Possible destinations for e-waste in this scenario include metal recycling, plastic recycling, specialized e-waste recycling, and also exportation.

To avoid double counting, e-waste handled in this scenario is not reported to the official take-back system (Scenario 1). E-waste categories typically handled by informal collection are temperature exchange equipment, large equipment, and IT products.

In this scenario, e-waste is often not treated in a specialized recycling facility for e-waste management, and there is the potential for e-waste to be shipped to developing countries.

Countries With No Developed Waste Management Infrastructure

In most developing countries, there is an enormous number of self-employed people who are engaged in the collection and recycling of e-waste. They usually work door-to-door to buy e-waste from consumers at home, and then sell it to be refurbished and recycled. These types of informal collection activities provide the basic means for many unskilled workers to make a living. Apart from the collection of domestically generated e-waste, the domestic demand for imported, inexpensive second-hand goods and secondary materials leads to the import of used EEE or e-waste from developed countries.

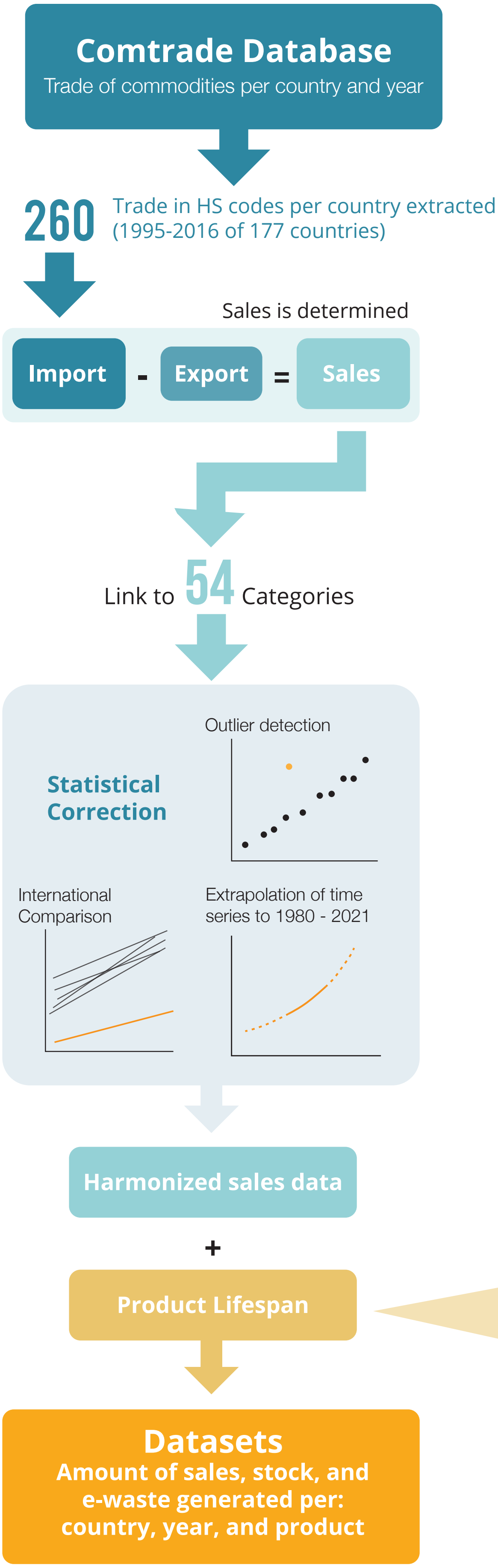
After informal collection, when electronic products do not have any reuse value, they are mostly recycled through "backyard recycling" or substandard methods, which can cause severe damage to the environment and human health. Such substandard treatment techniques include open burning to extract metals, acid leaching for precious metals, unprotected melting of plastics, and direct dumping of hazardous residuals. The lacks of legislation, treatment standards, environmental protection measures, and recycling infrastructure are the main reasons that e-waste is recycled in a crude manner.

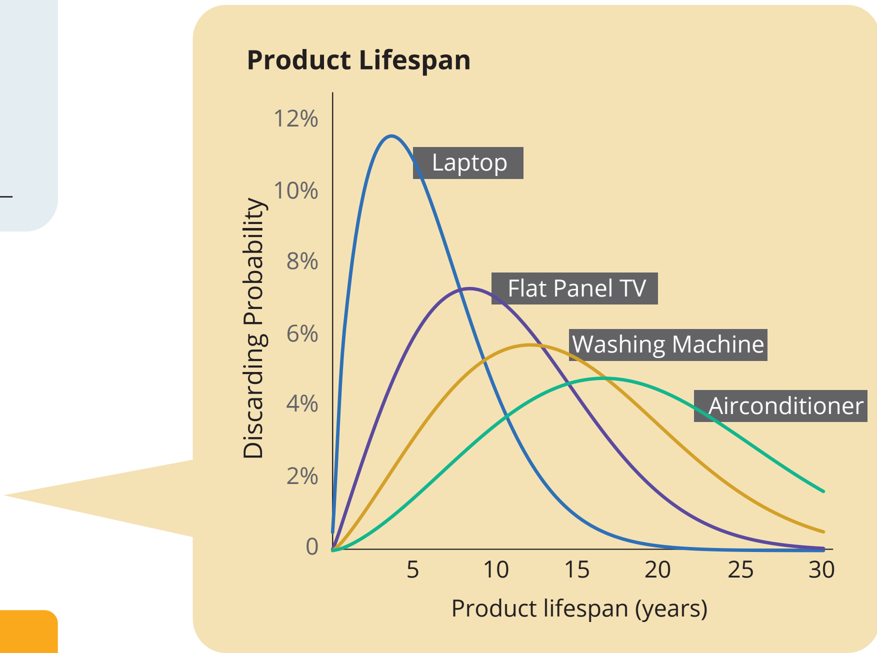
5.3 Data Sources Used for the Data in this Report

Calculation of Sales, E-waste Generated, and Stocks

Nowadays, there are no harmonized datasets available for sales at a global level that cover all countries in the world over a period of more than a decade. Thus, the apparent consumption method has been used in this report to calculate sales, as it provided the highest quality of market entry data currently available. The calculation of e-waste generated is based on empirical data from the apparent consumption method, a sales-lifespan

Illustration 5.2: Methodology for the calculation of sales, e-waste generated, and stocks





model. In this model, lifespan data for each product is subtracted from the sales (using a Weibull function) to calculate the e-waste generated. The input data, modelling steps, and statistical routines are published in the open source script on github (https://github.com/Statistics-Netherlands/wot-world). The data in this report was obtained and treated using the following steps:

1. Selecting the relevant codes that describe EEE in the Harmonized Commodity Description and Coding System (HS)[7]. The product scope is published in the guidelines on e-waste statistics (Baldé et al. 2015a).

2. Extracting the statistical data on imports and exports from the UN Comtrade database. This was done for 177 countries, 260 HS codes for a time series of 1995 to 2016. Countries have then been classified into five groups according to the Purchasing Power Parity[8] (PPP). 1. This procedure has been repeated for each year, since the Country's PPP changes over the years, especially for developing countries. This was useful to make statistics comparable between countries, and to calculate trends between groups. A specific number of countries was used to for each group:

   - Group 1: highest PPP (higher than 34000 USD/inh in 2016): 40 countries

- Group 2: high PPP (34000 – 15280 USD/inh in 2016): 43 countries
- Group 3: mid PPP (15280 – 6740 USD/inh in 2016): 43 countries
- Group 4: low PPP (6740 – 1700 USD/inh in 2016): 46 countries
- Group 5: lowest PPP (lower than 1700 USD/inh in 2016): 13 countries

3. For the European Union, the international trade statistical data was extracted from Eurostat in the eight-digit combined nomenclature (CN) codes. Domestic production data was also extracted from Eurostat.

4. Converting the units to weight using the average weight data per appliance type. The average weights are published in the previously mentioned github publication.

5. Calculating the weight of sales for 54 grouped product categories (UNU-KEYs, see Annex 1) by using the apparent consumption approach: Sales = Import – Export. For 28 EU Member States: Sales = Domestic Production + Import – Export was used (European Commission, 2017). In this report, outcomes for countries other than EU-28 are not available for UNU-Keys 0002 (Photovoltaic Panels), 0502 (Compact Fluorescent Lamps) and 0505 (Led Lamps) because data was not available in UN Comtrade database.

6. Performing automatic corrections for outliers on the sales data. This is needed to detect values that were too low (due to the lack of domestic production data in some countries where domestic production is relatively large) or too high (due to misreporting of codes or units). Those detected entries are replaced with more realistic sales values either from the time series of the origin country or from comparable countries. These statistical routines lead to a harmonized dataset with a similar scope and consistent sales for a country based on their own trade statistics. The steps are published in the previously mentioned github publication.

7. Performing manual corrections resulting from the analysis of the automatic corrections. This is needed to correct unreliable data using knowledge of the market. For instance, CRT TVs have not been sold in recent years.

8. Extending the time series of sales. Past sales are calculated back to 1980 based on the trends of the available data and the market entry of the appliance. Future sales are predicted until 2021 using sophisticated extrapolation methods, the principle takes into account the ratio between the sales and the PPP per county, and uses that ratio to estimate the sales with the forecast of the PPP from the World Economic Outlook from the IMF (IMF, 2017).

9. Determining the e-waste generated by country by using the sales and lifespan distributions. Lifespan data is obtained from the 28 EU Member States using the Weibull distribution (Magalini et al. 2014; Baldé et al. 2015a). The residence times of each product is ideally determined empirically per product per type of country. At this stage, only harmonized European residence times of EEE were available from extensive studies performed for the EU, and were found to be quite homogeneous across Europe, leading to a ±10% deviation in final outcomes (Magalini et al. 2014). Due to the absence of data, it was assumed that the higher residence times per product in the EU were approximately applicable for non-EU countries as well. In some cases, this would lead to an overestimation, since a product could last longer in developing countries than in developed countries because people repair products more often. However, it can also lead to an underestimation, since the quality of products is often lower in developing countries because reused equipment or more cheaply produced versions that don't last as long might enter the domestic market. Deviations in final outcomes for some countries may be also caused by inaccuracies in the sales data or by the shortening or extension of the life span of products. In the latter case, the actual life span might be longer than what is estimated because products are stored at home for a longer period, or because items are sold as second-hand goods in other countries. But in general, it is assumed that this process leads to estimates that are relatively accurate.

10. Determining the stock quantities as the difference between the historical sales and the e-waste generated over the years.

The full overview of the methodology is published for the EU in R programming language. The whole methodology is stored in the scripts, which ensures transparency of the calculations performed (Van Straalen, Roskam and Baldé, 2016). For the global calculations, the methodology is also published on github (Van Straalen, Forti and Baldé, 2017). The method differed slightly from the previous Global E-waste Monitor (Baldé et al., 2015b). In here, both the methodology and the statistical calculations have been improved and updated data sources have been used; therefore the presented results are slightly different than in the previous Global E-waste Monitor.

E-waste in Waste Bins

The source data for the calculations of the e-waste in waste bins was based on studies of residual waste that's available in the literature for various countries. The content of e-waste was determined from the sorting analysis studies. This data was the sample of that part of the analysis. In the sample group, 600 kilotons (kt) of e-waste was found in the residual waste (the sorting analysis studies taken into account are all referenced in the references section). This was on average 5.8% compared to the total e-waste generated. This average was then multiplied with the e-waste generated from the countries with a purchasing power higher than 15260 US$/inh (in 2016) that were not present in the sample.

Officially Collected Amounts of E-waste

For the EU, data on the collected and recycled e-waste was extracted from the Eurostat database for 30 countries. For 77 other countries in the world, data was collected from a pilot questionnaire that UNU conducted with UNECE, OECD, and UNSD. From those countries, only 11 countries could provide data, sometimes only partial data. If data was not available, relevant information was searched for in pre-existing literature. Data was collected from 58 countries in total, but the datasets were far from complete and harmonized. The publicly available data is summarized in Annex 2. Missing collection and recycling amounts from the countries that did not respond to the questionnaire, or did not receive a questionnaire, were left zero in the published totals on e-waste that was collected through the official take-back systems. The collection rates were calculated as the percentage of the e-waste collected (Annex 2) over the total e-waste generated in the reference country (Annex 3).

Unknown Flows

By subtracting the e-waste quantities officially collected and the e-waste found in waste bins from the total amount of e-waste generated, the quantities for which the treatment method is unknown were derived.

Population Exposure with National E-waste Legislation

The development of national e-waste policies was evaluated in this report to assess whether a country has had national e-waste management regulations in effect, until the end of 2016. Population data was obtained from the World Economic Outlook (IMF, 2017). The e-waste legislation status in countries were derived from a database that was kindly provided by C2P database[9]. The results are published in Annex 3.