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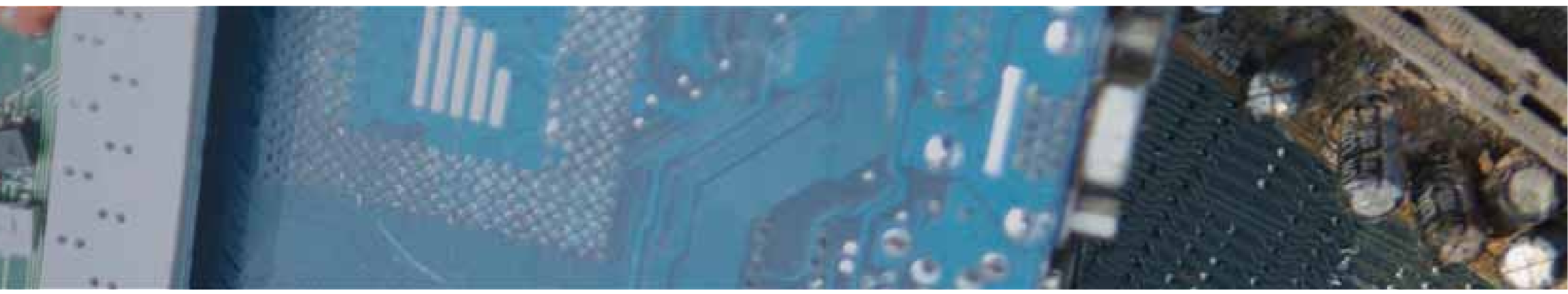
THE GLOBAL E-WASTE MONITOR 2014

Quantities, flows and resources



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The Global E-waste Monitor 2014

Quantities, flows and resources

Authored by:
Baldé, C.P., Wang, F., Kuehr, R., Huisman, J.

FOREWORD

E-waste, or waste electrical and electronic equipment, is an emerging and fast-growing waste stream with complex characteristics. The growing amount of e-waste has posed a significant challenge to waste management in both developed and developing countries. Rapid technology innovation and ever-shortening product lifespans are among the factors contributing to the growing amount of e-waste.

Over the past two decades, policymakers, producers and recyclers in various countries have created specialized "take-back and treatment systems" to collect e-waste from final owners and process it in professional treatment facilities. Unfortunately, despite these efforts, the collection and state-of-the-art treatment of e-waste is limited, and most nations are still without such e-waste management systems. There is a large portion of e-waste that is not being collected and treated in an environmentally-sound manner. Further, some of the world's e-waste is shipped great distances to developing countries where crude and inefficient techniques are often used to extract materials and components. These "backyard" techniques pose dangers to poorly protected workers and the local natural environment. Global trading of electronics and substandard recycling in developing countries has led to environmental catastrophes in places like Guiyu, China and Agbogbloshie, Ghana, to name two examples.

Many studies have touched multiple aspects of e-waste, such as pollution and toxicity, recycling technologies and best policies for the collection and treatment of this waste stream. However, as of yet there is no study that monitors the global quantity of e-waste by applying a harmonised measurement method for all countries. Many estimated quantities of e-waste streams are either out-dated, based on varying e-waste definitions and methodologies making them impossible to compare, or concerning a specific region only.

As a worldwide leading institute in e-waste research, the United Nations University (UNU), through its Institute for the Advanced Study of Sustainability, will now publish the first monitor of quantities of global e-waste using a harmonised methodology. The results are based on empirical data and provide an unprecedented level of detail. This information gives a more accurate overview of the magnitude of the e-waste problem in different regions. The e-waste volumes are indicative of the recycling industries' potential to recover secondary resources, as well as setting environmental targets for detoxification. This information is also necessary for policymakers to identify the need for action. By tracking the destinations of the waste stream, this monitor can also provide useful baseline information for establishing the necessary infrastructure to collect, finance and treat e-waste. It also helps to identify additional interventions, such as raising consumer awareness, to appropriately dispose of equipment.

Based on the global quantity of e-waste, the resource potential of recyclable materials, commonly called the "urban mine", is presented. Similarly, the content of hazardous materials, commonly called the "toxic mine", is also presented. These figures are useful for policymakers and recycling industry to plan the location, capacity and technologies for recycling infrastructures.

As a whole, this monitor illustrates the size of the e-waste challenge, the management progress for establishing the specialized e-waste collection and treatment systems and the future outlook. The data and information can provide a baseline for national policymakers, such as governments, producers and the recycling industry, to plan for take-back systems. It can also facilitate cooperation around controlling illegal trade, supporting necessary technology development and transfer, and assisting international organizations, governments and research institutes in their efforts as they develop appropriate countermeasures. This will eventually lead to improvement of resource efficiency while reducing the environmental and health impacts of e-waste.

As a global think tank and postgraduate teaching organization, the UNU has a role to play in paving paths towards solutions of the e-waste problem, because it is one of the pressing problems of humankind. UNU-IAS through its Operating Unit SCYCLE plans to regularly publish this e-waste monitor and outlook, and also to contribute through further networking, research and training with our sister UN organizations, governments, industry, academia and non-governmental organizations.

Kazuhiko Takemoto

Director, United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS)

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EXECUTIVE SUMMARY

"E-waste is a term used to cover all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of reuse" (Step Initiative 2014). E-waste, or waste electrical and electronic equipment (WEEE), is a complex and fast-growing waste stream that covers a large variety of products. The composition of this waste stream, that is, its constituents including toxics and its resource potential, varies significantly by product. This makes e-waste very difficult to manage. Rapid product innovation, miniaturization and replacement, especially for information and communication technology (ICT) products and consumer equipment are fuelling the increase of e-waste. Moreover, more and more products contain a battery or plug, categorising it as EEE, such as intelligent clothes, smart toys and tools, dispensers and ubiquitous medical equipment. From past assessments, it is still unclear precisely how much e-waste is generated and collected in each country and region. Available estimates are either out-dated or impossible to compare across regions due to different product scopes, e-waste definitions and evaluation methods.

This monitor aims to present the first comprehensive assessment of e-waste volumes, their corresponding impacts and management status on a global scale. This is measured using an internationally-adopted measuring framework that has been developed by the Partnership on Measuring ICT for Development (Baldé et al., 2015). The methodology calculates the amount of e-waste generated from harmonised modelling steps and data sources. The outcomes show an unprecedented level of accuracy and harmonisation across countries and are very useful for international benchmarking. It is estimated that the total amount e-waste generated in 2014 was 41.8 million metric tonnes (Mt). It is forecasted to increase to 50 Mt of e-waste in 2018. This e-waste is comprised of 1.0 Mt of lamps, 6.3 Mt of screens, 3.0 Mt of small IT (such as mobile phones, pocket calculators, personal computers, printers, etc.), 12.8 Mt of small equipment (such as vacuum cleaners, microwaves, toasters, electric shavers, video cameras, etc.), 11.8 Mt of large equipment (such as washing machines, clothes dryers, dishwashers, electric stoves, photovoltaic panels, etc.) and 7.0 Mt of cooling and freezing equipment (temperature exchange equipment).

The official take-back legislation is organized only in a limited number of countries. Because of the large population in both India and China (both of which have national e-waste regulation in place), official take-back legislation covers around 4 billion people. However, the existence of legislation does not necessarily imply successful enforcement of this legislation and the existence of a sufficient e-waste management system. Most national take-back legislation does not cover all e-waste categories as measured in this publication. In some countries, legislation exists for only one type of appliance, or the collection amount is low. Driven by these national laws, at least 6.5 Mt of e-waste was reported as formally treated by national take-back programs and schemes at the global scale (around 15.5 per cent of the e-waste generated in 2014). Through these programs, the highest quality of recycling and safe disposal of e-waste takes place.

Besides national take-back systems, e-waste is also disposed of with mixed residual waste (the waste bin), where it is treated together with other municipal wastes. Disposal of e-waste in mixed residual household waste accounts for 1 to 2 kg per inhabitant in the EU. This fraction is mainly comprised of small equipment, such as mobile phones, lamps, electrical toothbrushes, toys, etc. In the 28 EU Member States, it is estimated to be 0.7 Mt of e-waste annually. This statistic is unknown for other countries.

For the collection outside the take-back systems, no harmonized data with good regional coverage could be gathered in this edition of the monitor. In addition, the transboundary movement of e-waste is not recorded by official sources. In some developing countries, the collection outside the take-back systems probably equals of the whole e-waste market. In other developed countries, it can be as large as one third of the e-waste market. The impact of collection and recycling outside the official take-back systems on the society and the environment varies significantly as this sector is less regulated than the official take-back scenario.

The intrinsic material value of global e-waste is estimated to be 48 billion euro in 2014. The material value is dominated by gold, copper and plastics contents. The annual supply of toxins from e-waste is comprised of 2.2 Mt of lead glass, 0.3 Mt of batteries and 4 kilo tonnes (kt) of ozone-depleting substances (CFCs). Other toxic substances are not quantified in this report. Whether the raw materials are recycled or the toxins lead to actual harmful emissions largely depends on their collection and treatment manners. As mentioned before, only 6.5 Mt of the 41.8 Mt of e-waste are documented and recycled with the highest standards. Thus, the full potential of e-waste collection and treatment has not been explored. These figures are useful for policymakers, like those in international regimes, governments and recycling industries, to document e-waste collected and to plan the location, capacity and technologies for creating the necessary recycling infrastructure.

Photo Credit: Lowette

1. What is e-waste?

E-waste is a term used to cover all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of re-use.

WHAT IS E-WASTE?

E-waste is a term used to cover all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of re-use (Step Initiative 2014). It is also referred to as WEEE (Waste Electrical and Electronic Equipment), electronic waste or e-scrap in different regions. E-waste includes a wide range of products, – almost any household or business item with circuitry or electrical components with power or battery supply.

Basically, EEE can be classified into the following six categories and therefore also e-waste:

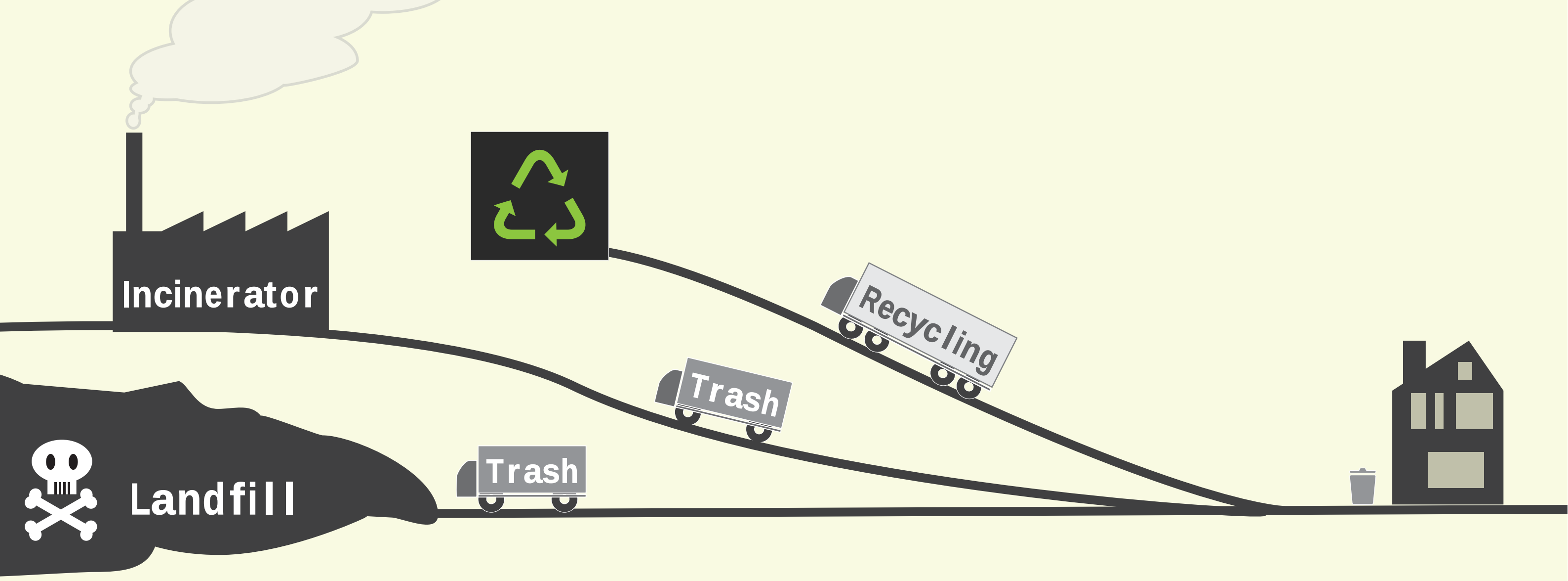
• Temperature exchange equipment. Also more commonly referred to as, cooling and freezing equipment. Typical equipment is refrigerators, freezers, air conditioners, heat pumps.

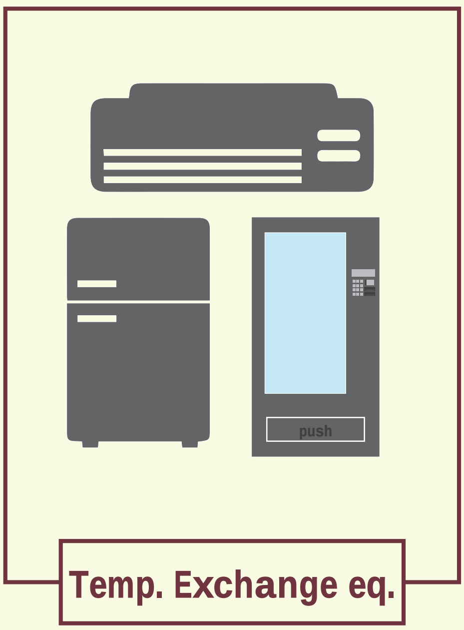
• Screens, monitors. Typical equipment comprises televisions, monitors, laptops, notebooks, and tablets.

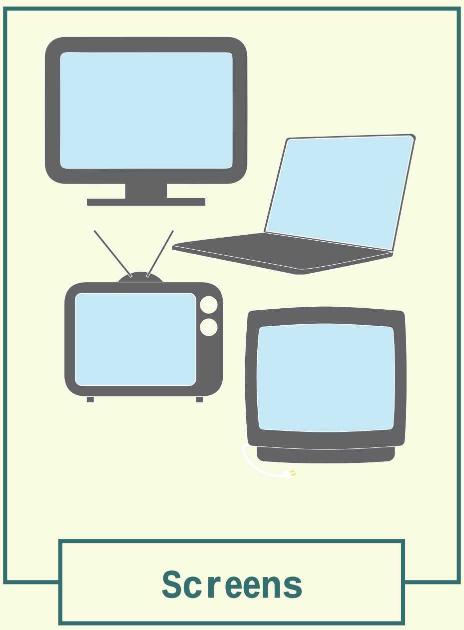
• Lamps. Typical equipment comprises straight fluorescent lamps, compact fluorescent lamps, fluorescent lamps, high intensity discharge lamps and LED lamps).

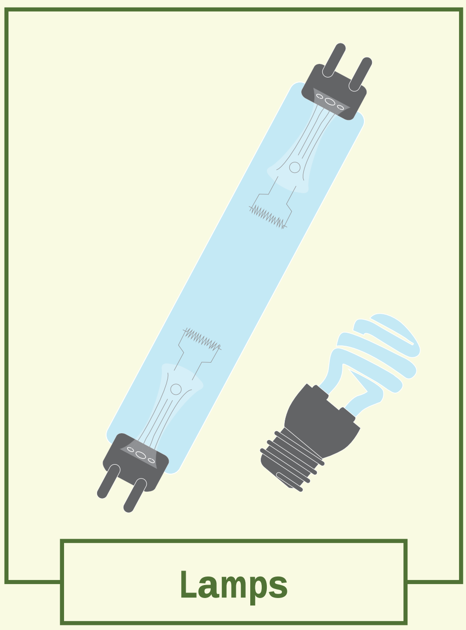
• Large equipment. Typical equipment comprises washing machines, clothes dryers, dish washing machines, electric stoves, large printing machines, copying equipment and photovoltaic panels.

• Small equipment. Typical equipment comprises vacuum cleaners, microwaves, ventilation equipment, toasters, electric kettles, electric shavers, scales, calculators, radio sets,







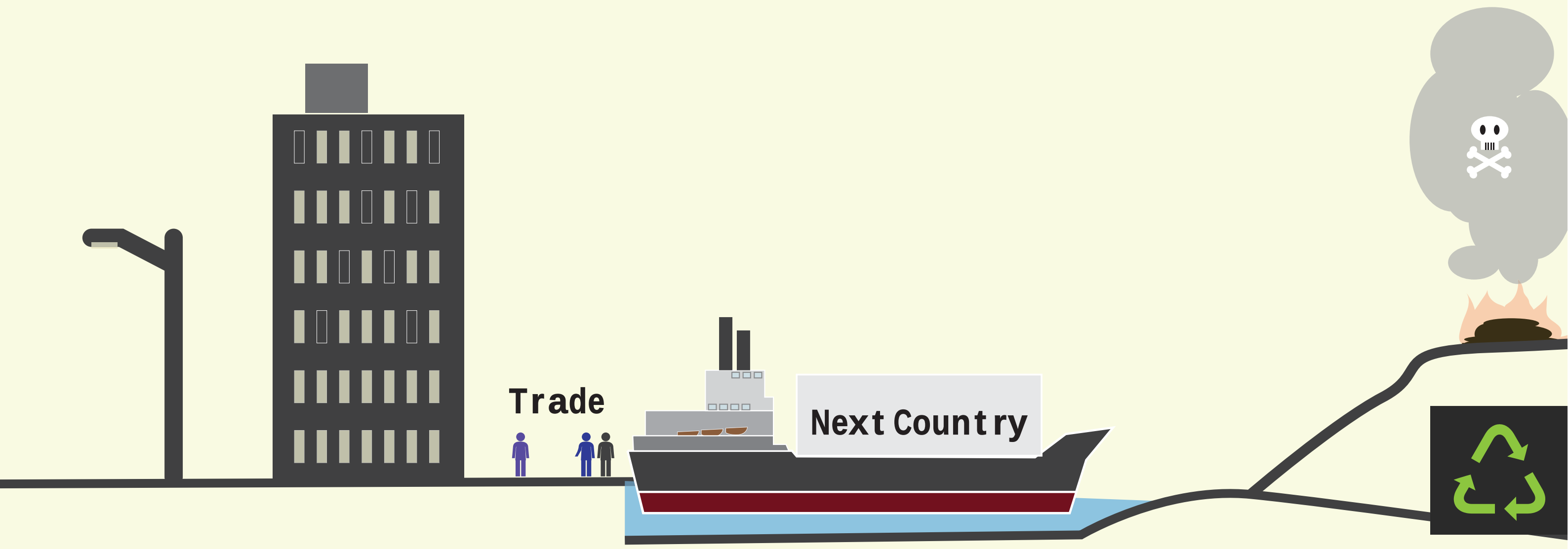


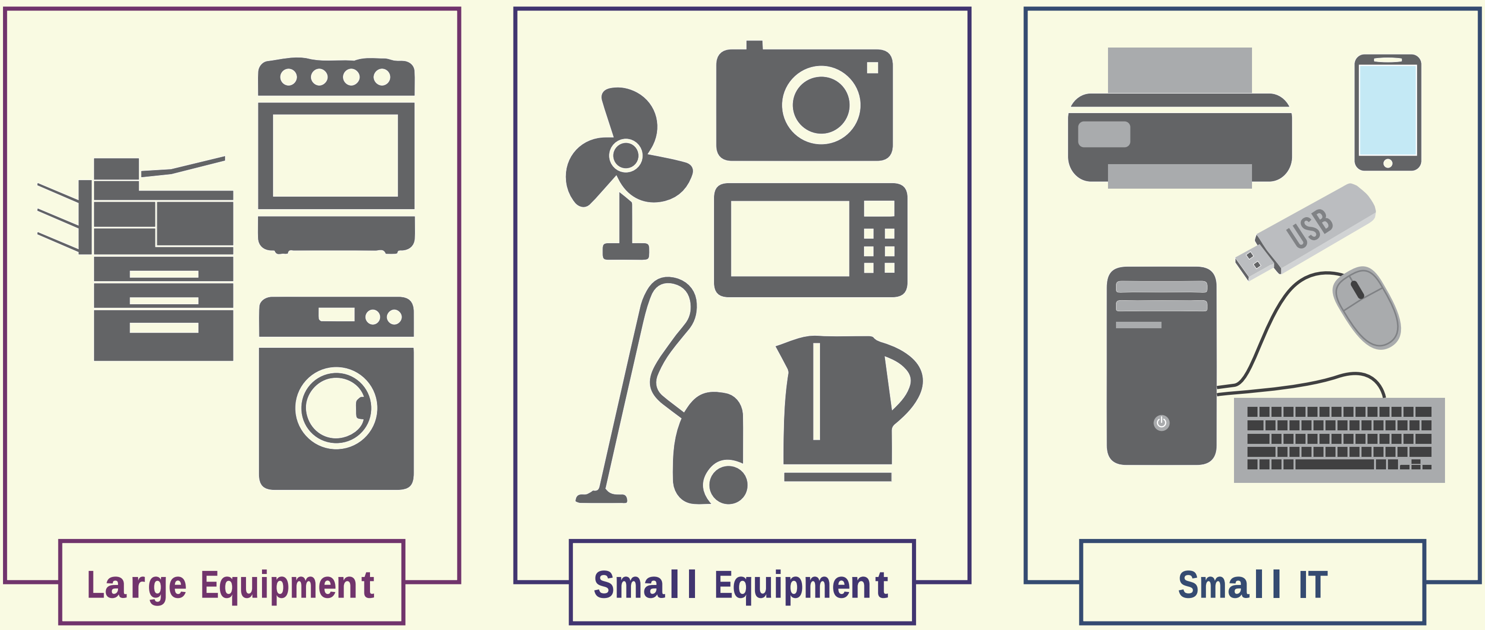
video cameras, electrical and electronic toys, small electrical and electronic tools, small medical devices, small monitoring and control instruments).

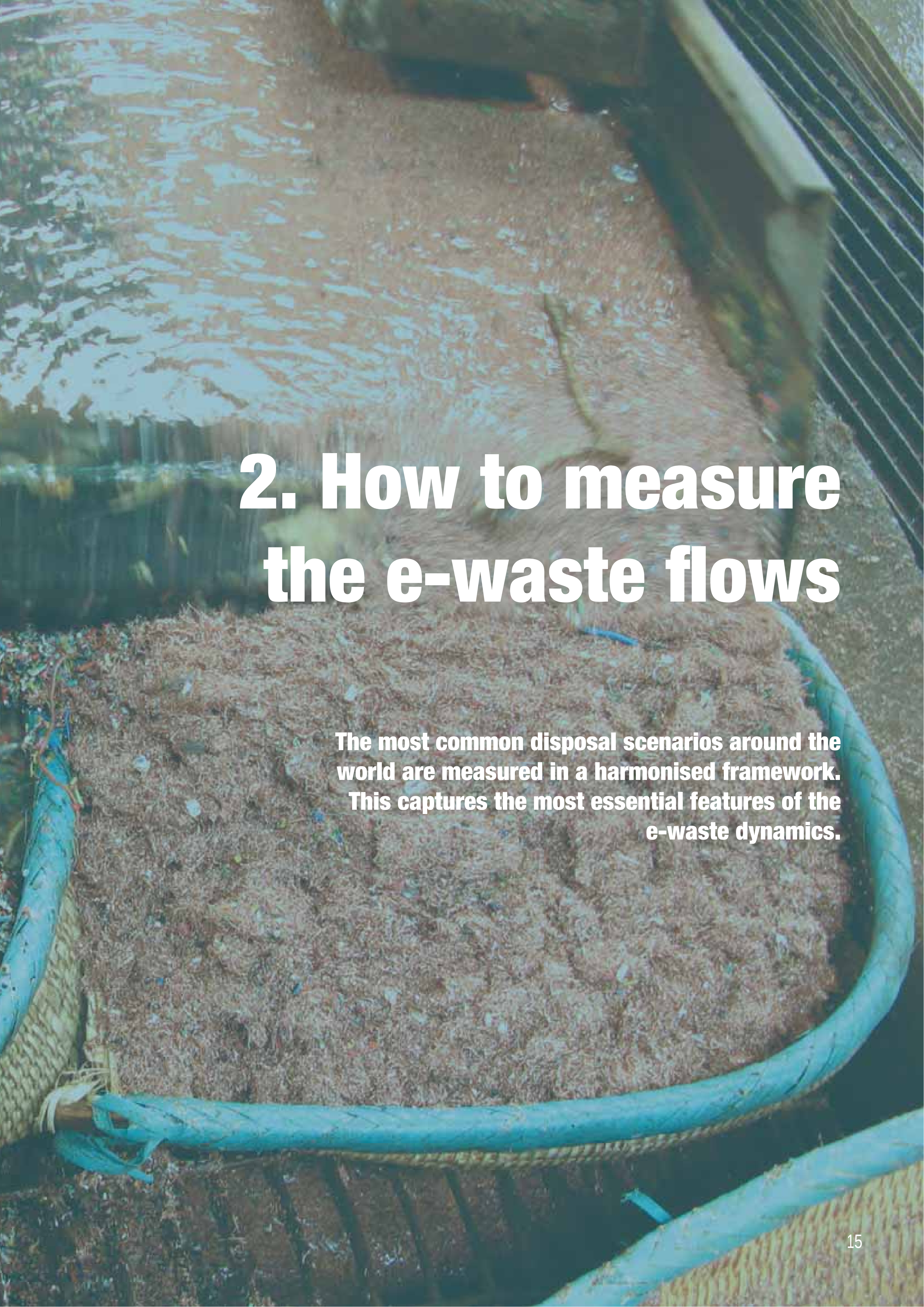
• Small IT and telecommunication equipment. Typical equipment comprises mobile phones, GPS, pocket calculators, routers, personal computers, printers, telephones).

For each category, its original function, weight, size, material composition differ. These end-of-life attributes determine that each category has different waste quantities, economic values, as well as potential environmental and health impacts through inappropriate recycling. Consequently, the collection and logistic means and recycling technology are different for each category in the same way as the consumers' attitude in disposing of the electrical and electronic equipment.

The environmental issues associated with e-waste arise from the low collection rates, because the final owner either stores equipment in drawers, cabinets, cellars, attics etc. or disposes those off through the normal household bins, finally ending up in incineration or land-filling. Another dimension of improper disposal is where waste ends up in the undesirable channels and destinations, such as substandard treatment in developing countries. In an ideal case, optimum resource efficiency and low environmental impacts can be reached when e-waste is collected and treated in the state-of-the-art facilities. However, imperfect disposal scenarios existed and still exist, and cause the e-waste problems nowadays.





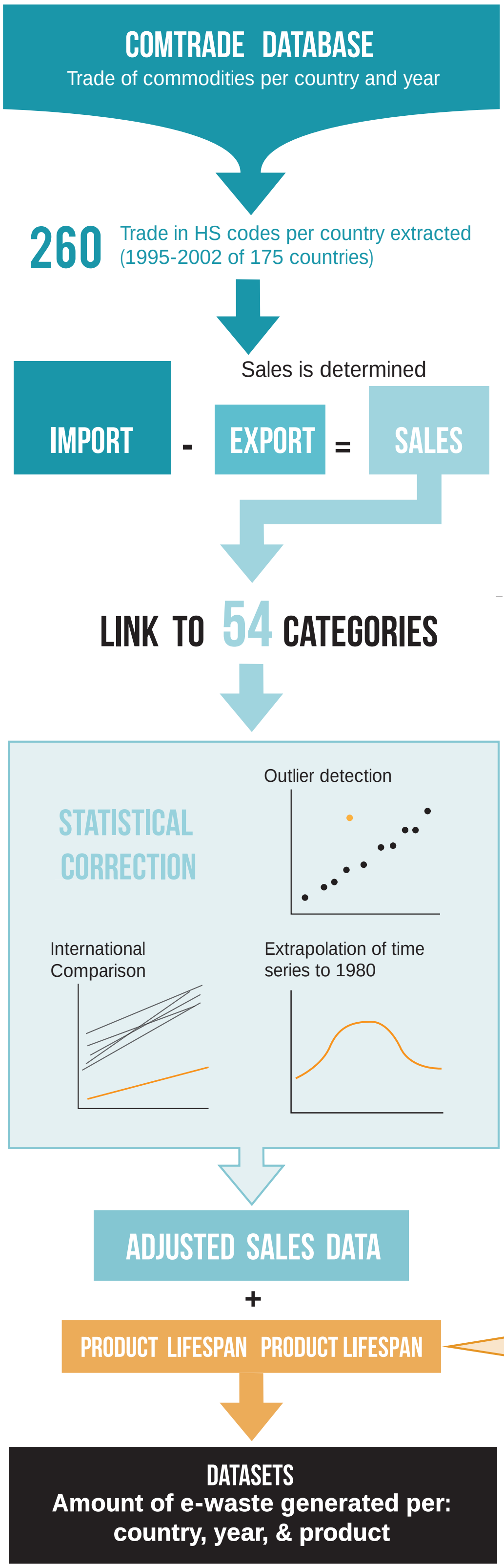


2. How to measure the e-waste flows

The most common disposal scenarios around the world are measured in a harmonised framework. This captures the most essential features of the e-waste dynamics.

2.1 CALCULATION OF SALES AND E-WASTE GENERATED

METHODOLOGY



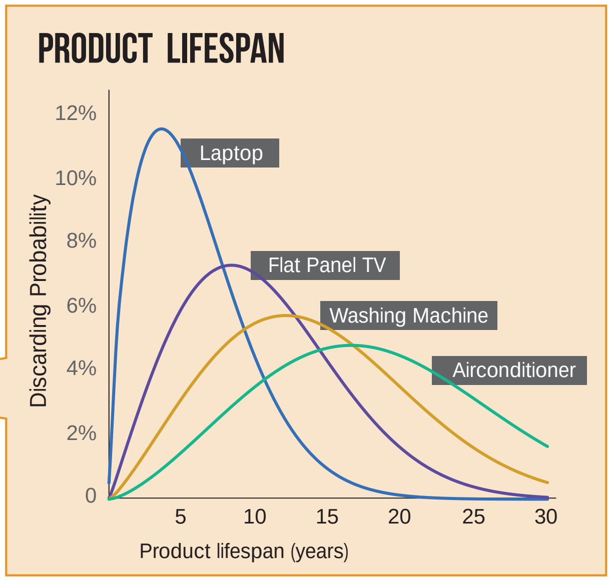
The calculation of e-waste generated is based on empirical data, a model and statistical routines. The data in this report was obtained and treated using the following steps:

1. Selecting the relevant codes that describe EEE in the Harmonized Commodity Description and Coding System (HS). The product scope is shown in Annex 4.

2. Extracting the statistical data from the UN Comtrade database. This was done for 175 countries, 260 HS codes for a time series of 1995 to 2012.

3. For the European Union, the international trade statistical data was extracted from Eurostat in the eight-digit combined nomenclature (CN) codes. The CN is the more detailed European version of the six-digit HS codes. Domestic production data was also extracted from Eurostat.

4. Converting the units to weight using the average weight data per appliance type.



5. Calculating the weight of sales for 54 grouped product categories (UNU-KEYs, see Annex 4) by using the apparent consumption approach: Sales = Import – Export. For 28 EU Member States: Sales = Domestic Production + Import – Export was used.

6. Performing series of automated outlier analysis 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 were 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 harmonised dataset with a similar scope and consistent sales for a country based on their own trade statistics.

7. Determining the e-waste generated by country by applying the "Sales – Lifespan Distribution" method with empirical lifespan data. Lifespan data is obtained from the 28 EU Member States using the Weibull distribution (Magalini et al. 2014; Baldé et al. 2015).

The lifetime assumes, mathematically, the form of the Weibull function, with parameters of scale and shape. The scale parameter, which is associated to the average life of EEE, was fitted to real data in EU in order to get the closest real life characteristics. The average age of household EEE stocks and the average age of discarded e-waste enabled the construction of lifetime profiles for each product. This included the dormant time of electronic equipment on storage.

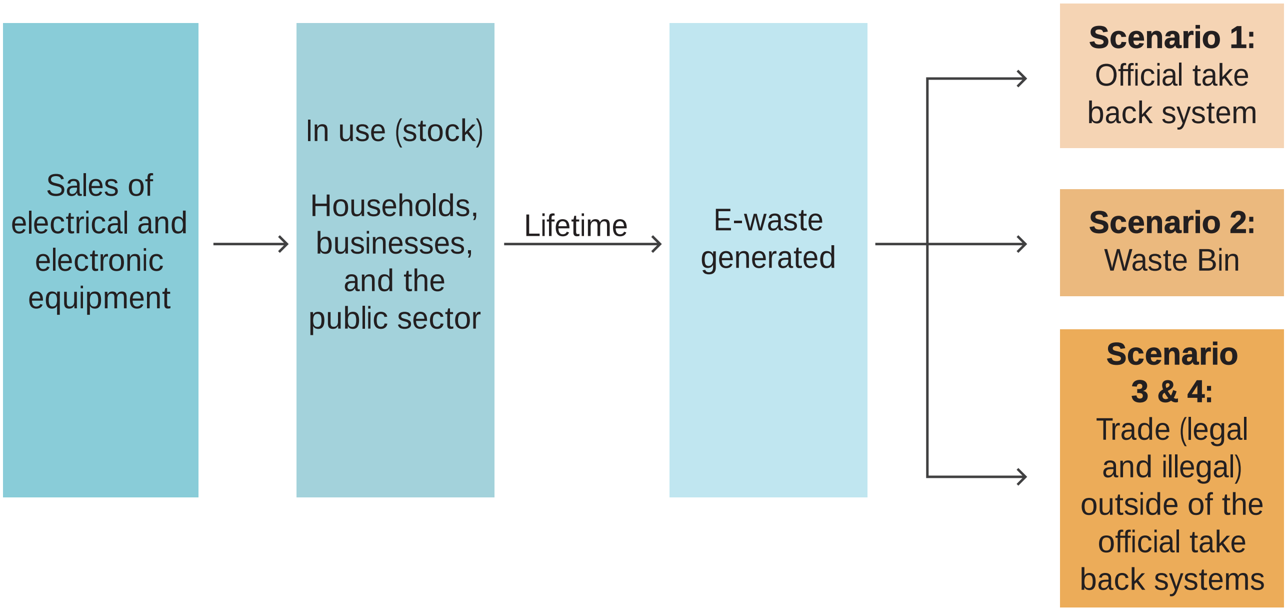
The e-waste generated results for each country are presented in Annex 1.

A full overview of the methodology can be found in the guidelines on e-waste statistics from the Partnership on Measuring ICT for development and the report on the common methodology that was developed for the European Commission (Magalini et al. 2014; Baldé et al. 2015).

Date Quality for Measuring E-waste generated

The outcomes of the e-waste generated bear some limitations. First of all, the domestic production was not considered for countries outside the European Union. This is then corrected with the statistical routines that detect and replace outliers. This accuracy is estimated to be ± 10 per cent. Thus, the presented e-waste generated data is expected to have the same accuracy. The lifetimes were also only known in the countries of the European Union (Magalini et al. 2014), and these were used for the other countries. This was also an assumption that inevitably leads to some uncertainty. This uncertainty is expected to be also ± 5 to 10 per cent of the e-waste generated.

2.2 FRAMEWORK MEASURING E-WASTE FLOWS



The internationally-adopted measurement framework for e-waste statistics has been developed in the context of the Partnership Measuring ICT for Development (Baldé et al., 2015). The framework captures the most important elements of the e-waste disposal scenarios around the world so as to measure the dynamics of e-waste in a consistent manner.

The measurement framework starts with sales of EEE. After the equipment has been sold, it remains in households or offices for some time. The time the equipment spends at households, offices and the public sector is called the product's "lifetime" or "residence time". This includes the exchange of second-hand equipment between households and businesses. The residence times of each product should ideally be determined empirically per product. After a certain residence time, the product is disposed of (becomes waste). This is referred to as "e-waste generated". It is the annual supply of domestically generated e-waste prior to collection and without imports. The e-waste generated can be collected one of in four scenarios, which will be described in more detail in chapters 4.1 to 4.4 respectively:

- Scenario 1: The "official take-back system"

- Scenario 2: The e-waste can also end up in non-separately collected household waste (waste bin).

- Scenario 3: The "collection outside formal take-back systems" in developed countries

- Scenario 4: The ''collection outside formal take-back systems" in developing countries

In practice, transboundary movement of e-waste takes place from developed to developing countries, most commonly between Scenarios 3 and 4.

2.3 OTHER INFORMATION USED IN THIS REPORT

Other information and data sources used in this report include:

- The quantity of e-waste generated is shown in Annex 1

- Officially reported collected and treated amount of e-waste under national legislation or compliance scheme per country (Annex 2)

- Data of e-waste in waste bins from sorting analysis (Annex 3)

- Indicator on the world population covered by e-waste legislation is derived from the data in Annex 1, for the countries that are indicated by having national e-waste legislation.

- Material composition per product category (Wang 2014)

- Commodity price for selected materials

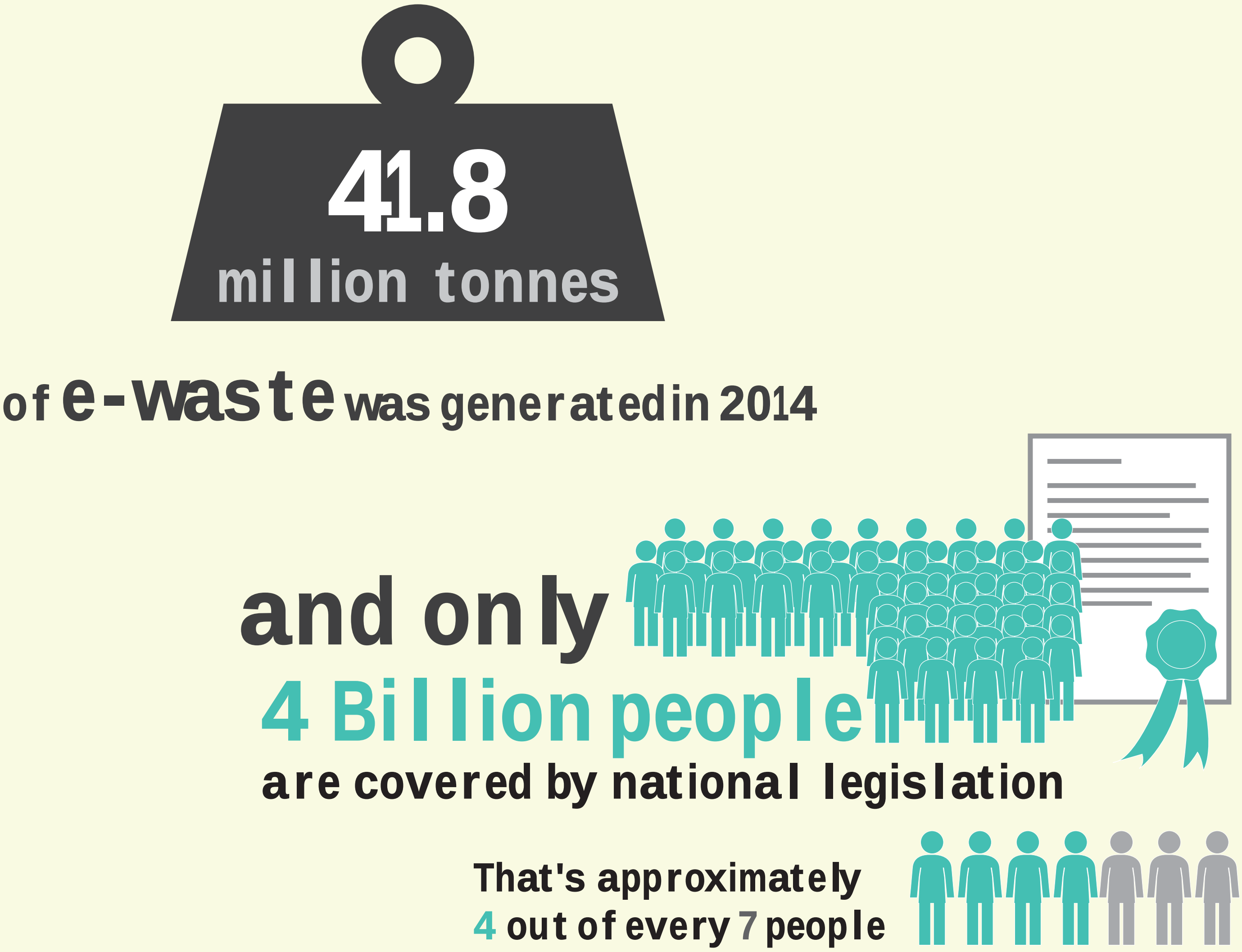
- Socio-economic data per country (population and Purchasing Power Parity)

3. The quantity of e-waste worldwide

This chapter presents the main overview about the global e-waste generation and collection.

OVERVIEW

The global quantity of e-waste generation in 2014 was around 41.8 Mt. In 2014, approximately 4 billion people were covered by national e-waste legislation, though legislation does not necessarily come together with enforcement. Driven by these national laws, around 6.5 Mt of e-waste was reported as formally treated by national take-back systems (Scenario 1). Not all e-waste laws have the same scope as the comprehensive scope in this report. In total, 0.7 Mt of e-waste is thrown into the waste bin in the 28 EU Member States (Scenario 2). The amount of e-waste that is disposed of in waste bins is unknown for other regions. The quantities of the collection outside formal take-back systems (Scenarios 3 and 4) are not documented systematically. However, they are likely to be the gap between e-waste generated, official collected and the e-waste in the waste bin. Official data for the transboundary movement of e-waste (mostly from developed to developing countries) are unknown.



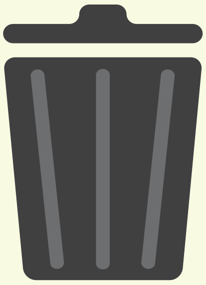
at least

6.5 million tonnes

are collected by official take-back systems

*for more information see scenario 1

in the European Union 0.7 million tonnes



will end up in waste bins

In the EU-28, 0.7 million tonnes end up in waste bins.
This is 8% of the total e-waste in EU-28.
Quantities for the rest of the world are unknown.

*for more information see scenario 2

? Outside official take-back systems

*for more information see scenarios 3 & 4

1. Collection outside official take-back systems in developed countries is still unknown

2. Transboundary movement is still unknown

3. Informal collection systems in developing countries are still unkown

WORLDWIDE DISPOSAL OF E-WASTE

OVERVIEW

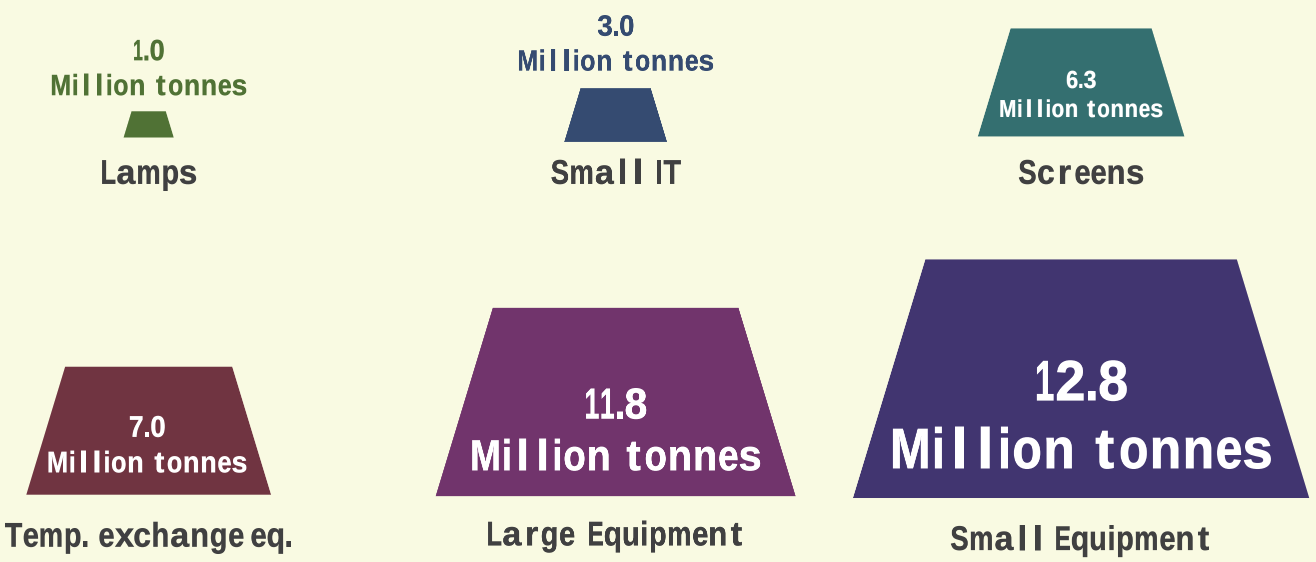
The global quantity of e-waste in 2014 is comprised of 1.0 Mt lamps, 3.0 Mt of Small IT, 6.3 Mt of screens and monitors, 7.0 Mt of temperature exchange equipment (cooling and freezing equipment), 11.8 Mt large equipment, and 12.8 Mt of small equipment. The amount of e-waste is expected to grow to 49.8 Mt in 2018, with an annual growth rate of 4 to 5 per cent.

GLOBAL QUANTITY OF E-WASTE GENERATED

Year	E-waste generated (Mt)	Population (billion)	E-waste generated (kg/inh.)
2010	33.8	6.8	5.0
2011	35.8	6.9	5.2
2012	37.8	6.9	5.4
2013	39.8	7.0	5.7
2014	41.8	7.1	5.9
2015	*43.8*	*7.2*	*6.1*
2016	*45.7*	*7.3*	*6.3*
2017	*47.8*	*7.4*	*6.5*
2018	*49.8*	*7.4*	*6.7*

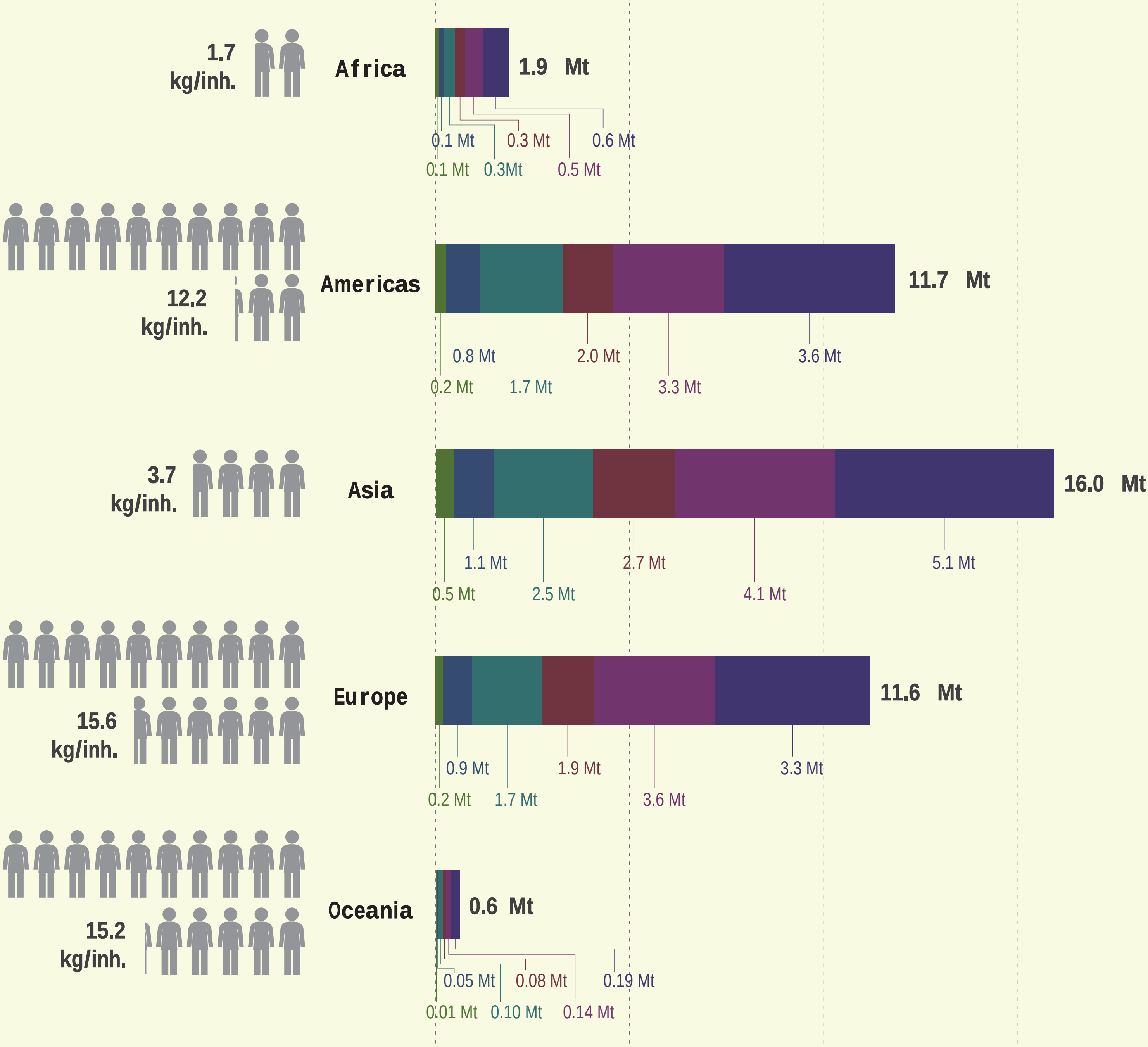
Data 2015 onwards are forecasts

TOTAL E-WASTE PER CATEGORY IN 2014



E-WASTE GENERATION PER CATEGORY, CONTINENT AND PER INHABITANT

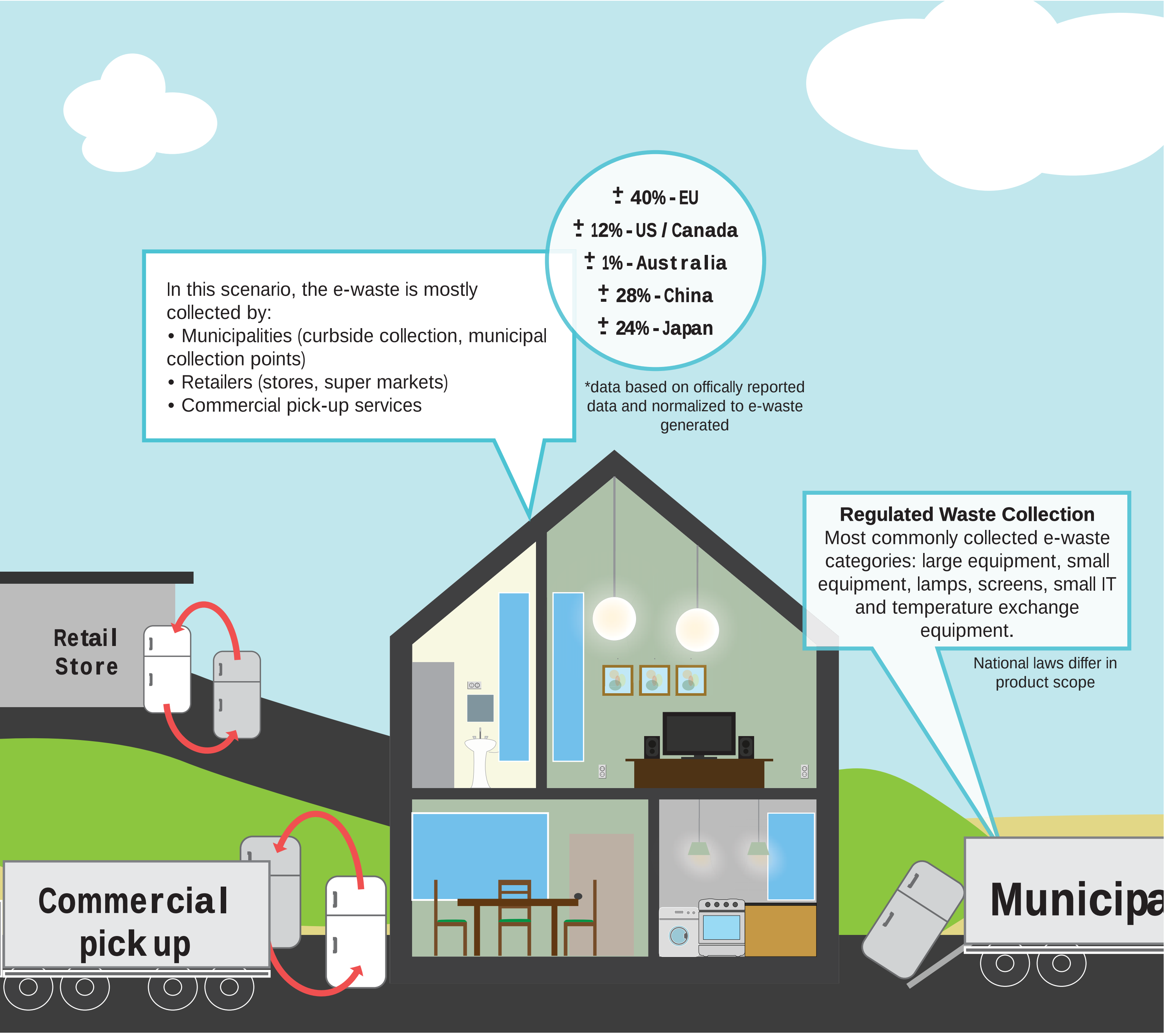
Most of the e-waste was generated in Asia: 16 Mt in 2014. This was 3.7 kg for each inhabitant. The highest per inhabitant e-waste quantity (15.6 kg/inh.) was generated in Europe. The whole region (including Russia) generated 11.6 Mt. The lowest quantity of e-waste was generated in Oceania, and was 0.6 Mt. However, the per inhabitant amount was nearly as high as Europe's (15.2 kg/inh.). The lowest amount of e-waste per inhabitant was generated in Africa, where only 1.7 kg/inh. was generated in 2014. The whole continent generated 1.9 Mt of e-waste. The Americas generated 11.7 Mt of e-waste (7.9 Mt for North America, 1.1 Mt for Central America, and 2.7 Mt for South America), which represented 12.2 kg/inh.



4. How are electronic products disposed of around the world?

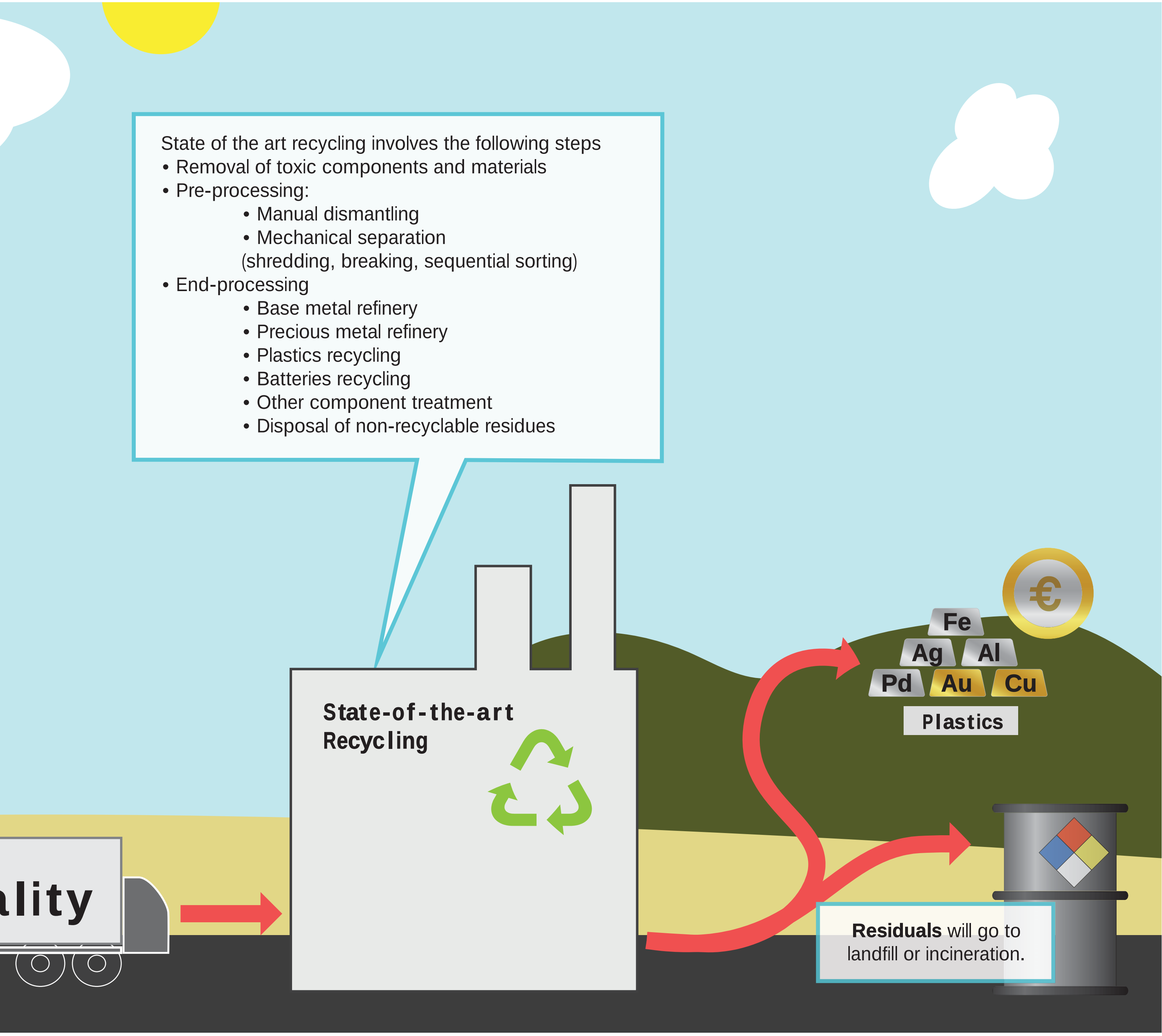
Most environmental damage and health impacts related to e-waste arise from improper collection and treatment approaches. Four typical disposal scenarios for the collection, trade and treatment of e-waste are summarized.

4.1. SCENARIO 1: OFFICIAL TAKE-BACK SYSTEMS



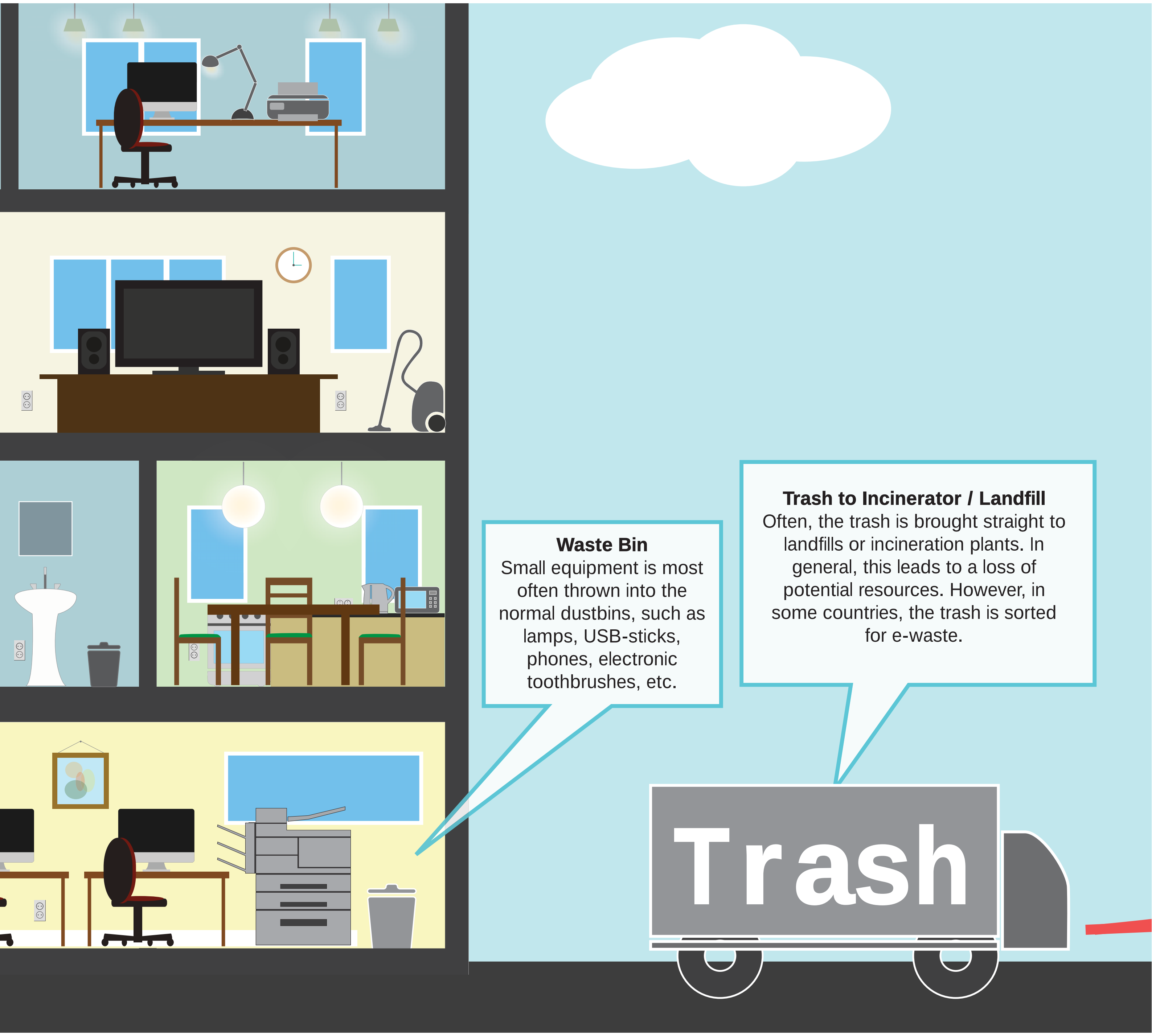
In this scenario, usually under the requirement of national e-waste legislation, e-waste is collected by designated organizations, producers and/or by the government. This happens via retailers, municipal collection points and/or pick-up services. The final destination of the collected e-waste is state-of-the-art treatment facilities, which recover the valuable materials in an environmentally-sound way and reduce the negative impacts.

In the European Union, roughly 40 per cent of the annually generated e-waste is officially reportedly treated in this manner; in the United States and Canada, the level is around 12 per cent;

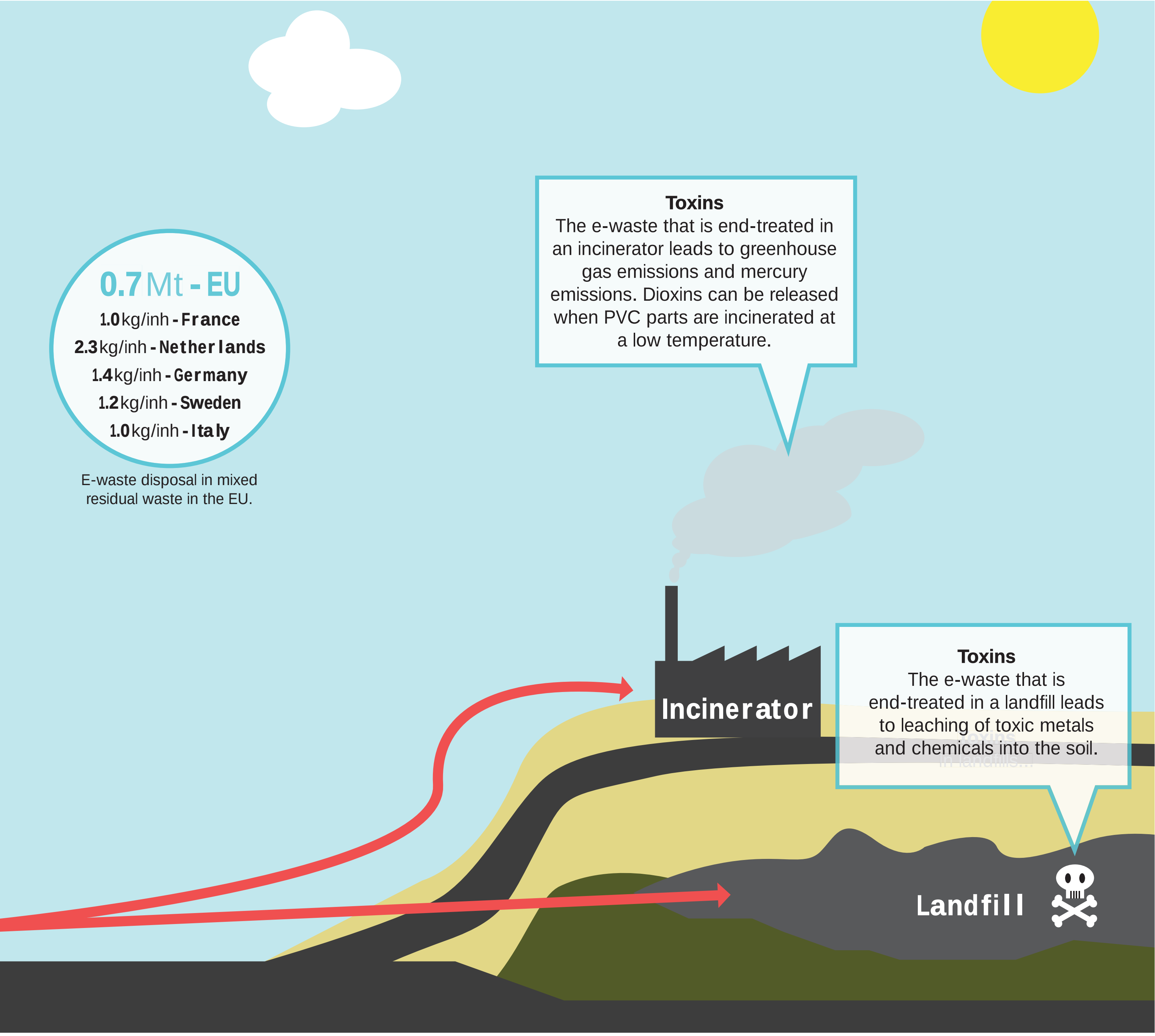


for China and Japan, it is around 24 to 30 per cent and in Australia, is around 1 per cent. That said, the scope of collected products differs among the countries, depending on the priority setting at the national level. Usually, product categories with significant potential for resource recovery or those containing a significant amount of toxic elements are collected, such as temperature exchange equipment (cooling and freezing equipment), screens and monitors, lamps, large equipment and small IT and telecommunication equipment. This disposal scenario exists in both developed and developing countries.

4.2. SCENARIO 2: DISPOSAL OF E-WASTE IN MIXED RESIDUAL WASTE



In this scenario, consumers directly dispose of e-waste through the normal dustbins together 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 either be sent to landfill or municipal solid waste incineration with a low chance of separation prior to these final destinations. Neither of these two destinations is regarded as an appropriate technique to treat e-waste, because it leads to resource loss and has the potential to negatively impact the environment. The e-waste in a landfill can lead to toxin leaching, and if e-waste is incinerated, emissions into air occur. This disposal scenario exists in both



E-waste disposal in mixed residual waste in the EU.

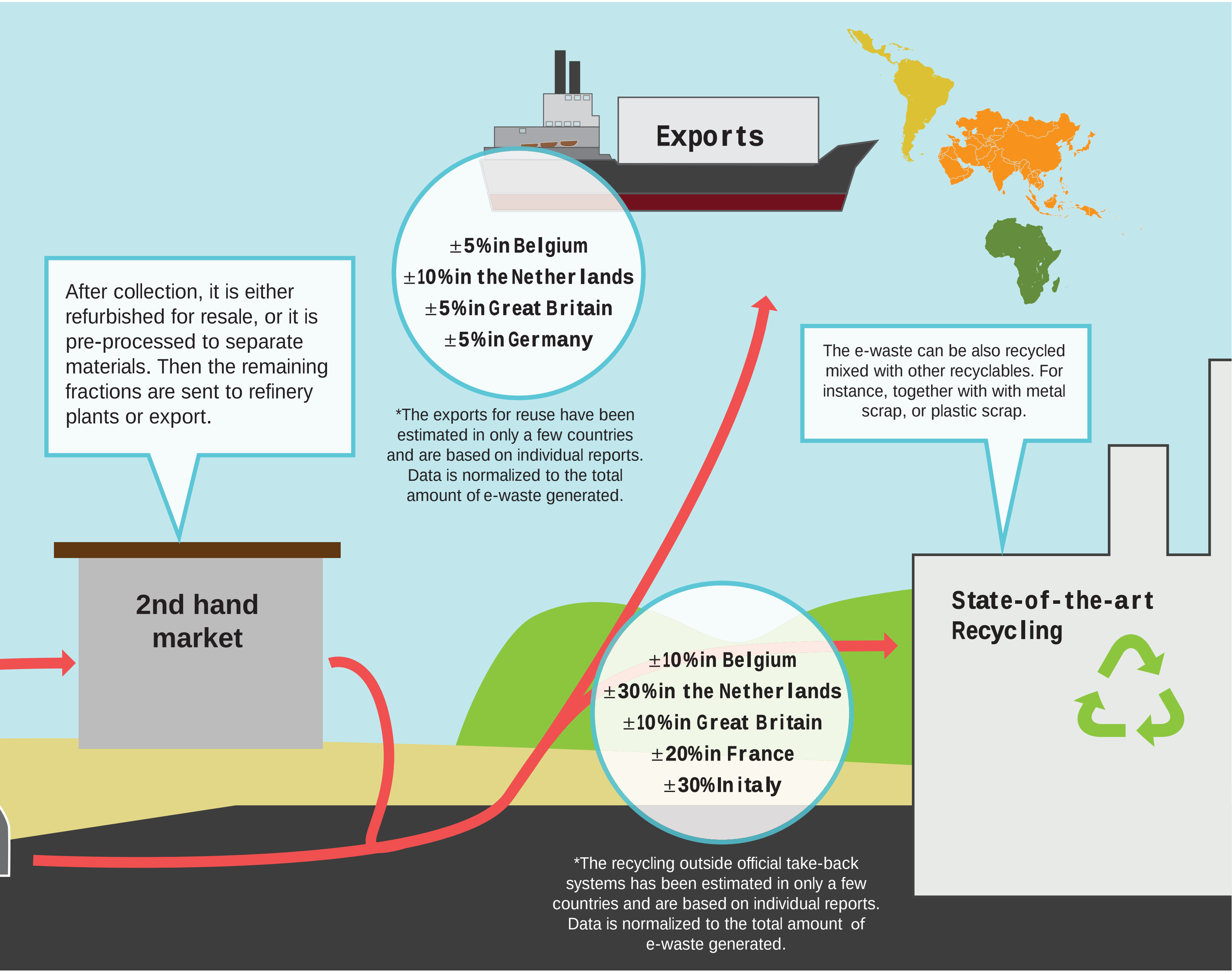
developed and developing countries. Products commonly thrown away in dustbins include small equipment, small IT equipment and lamps.

In most developing countries, valuable e-waste is hardly seen in dustbins, but invaluable e-waste like lamps and small products can be easily disposed of in dustbins and then sent to landfill or incinerator. There are no official statistics in countries about the quantity of e-waste that is disposed with mixed waste in dustbins. For all data that was found, about 1 to 2 kg per inhabitant was disposed in the waste bin in Europe. This represents roughly 8 per cent of the total European e-waste generation. Please refer to Annex 3 to find country-specific data.

4.3. SCENARIO 3: COLLECTION OF E-WASTE OUTSIDE OFFICIAL TAKE-BACK SYSTEMS IN DEVELOPED COUNTRIES

In developed countries, e-waste is also 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 export. Usually, e-waste handled in this scenario is not reported as part of the official treatment amount by the established take-back systems (Scenario 1). E-waste categories that are typically handled by the informal collection are temperature exchange equipment, large equipment, screens and IT products.

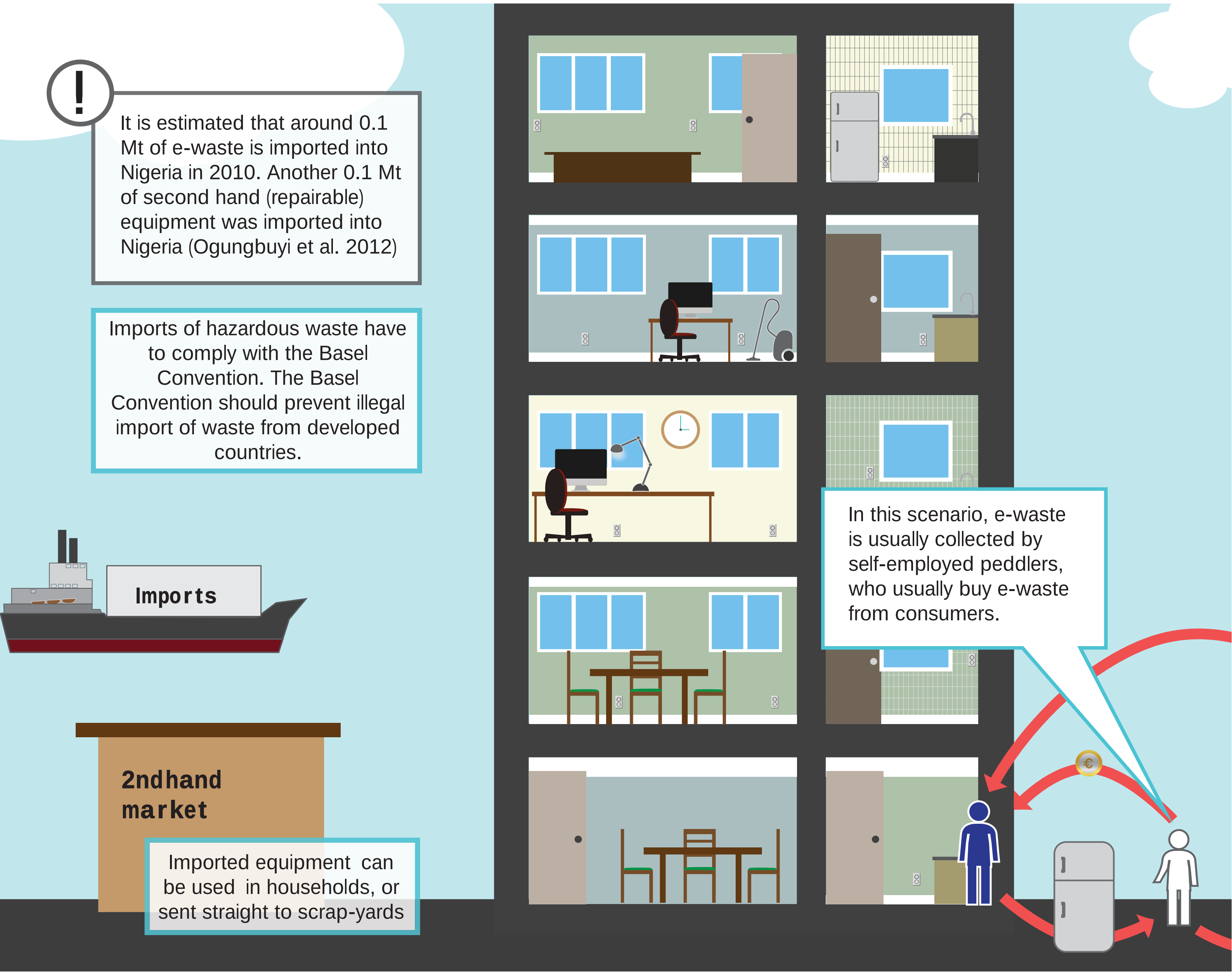
The main feature of this scenario is that e-waste is traded freely, and usually, its quantity is not systematically documented or reported to authorities, due to lack of specific reporting framework or requirements. In this scenario, e-waste is often not treated in the state-of-the-art facilities, and there is a potential that e-waste is shipped off to developing countries. There is a



substantial amount of e-waste being collected in developed countries and then traded to developing countries for further treatment. The demand for inexpensive second-hand equipment and raw materials in less-developed regions is the biggest driver for the interregional and global trade of e-waste.

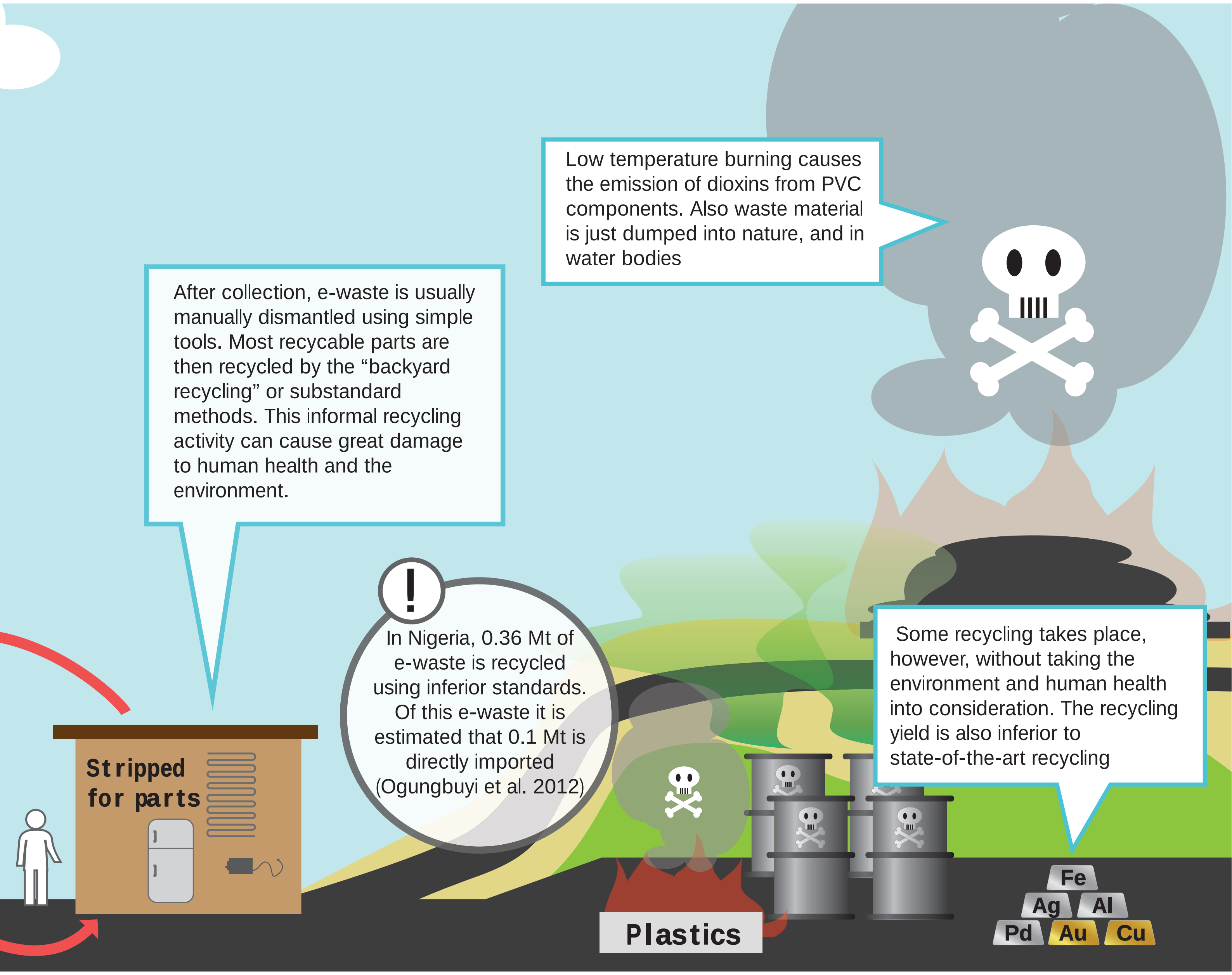
Trading of second hand equipment is legal only if it is allowed by both sending and receiving countries. However, the dumping of waste occurs exists in practice, is illegal. If the exporting country has ratified the Basel Convention, exports of hazardous waste must comply with the Basel Convention. The Basel Convention is meant to prevent developed countries from illegally dumping waste in developing countries, where recycling infrastructure is typically absent.

4.4. SCENARIO 4: INFORMAL COLLECTION AND RECYCLING IN DEVELOPING COUNTRIES



In most developing countries, there are an enormous number of self-employed people engaged in the collection and recycling of e-waste. They usually work on a door-to-door basis to buy e-waste from consumers at home, and then they sell it to refurbishers and recyclers. These types of informal collection activities provide the basic means necessary for many unskilled workers to pay for their living. Apart from domestic collection, the demand for inexpensive second-hand goods and secondary materials is an incentive of to import e-waste from developed countries (as explained in Scenario 3).

After informal collection, when electronic products do not have any reuse value, they are mostly recycled by 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. Lacking legislation, treatment standards, environmental protection measures and recycling infrastructure, are the main reasons that e-waste is recycled in a crude manner. Typical e-waste categories handled by the informal collection include temperature exchange equipment, large equipment, screens and IT products.

 Photo Credit: NASA

5. Regional details of e-waste management

This chapter presents the details in each region, on national e-waste quantities and management status.

5.1 AFRICA

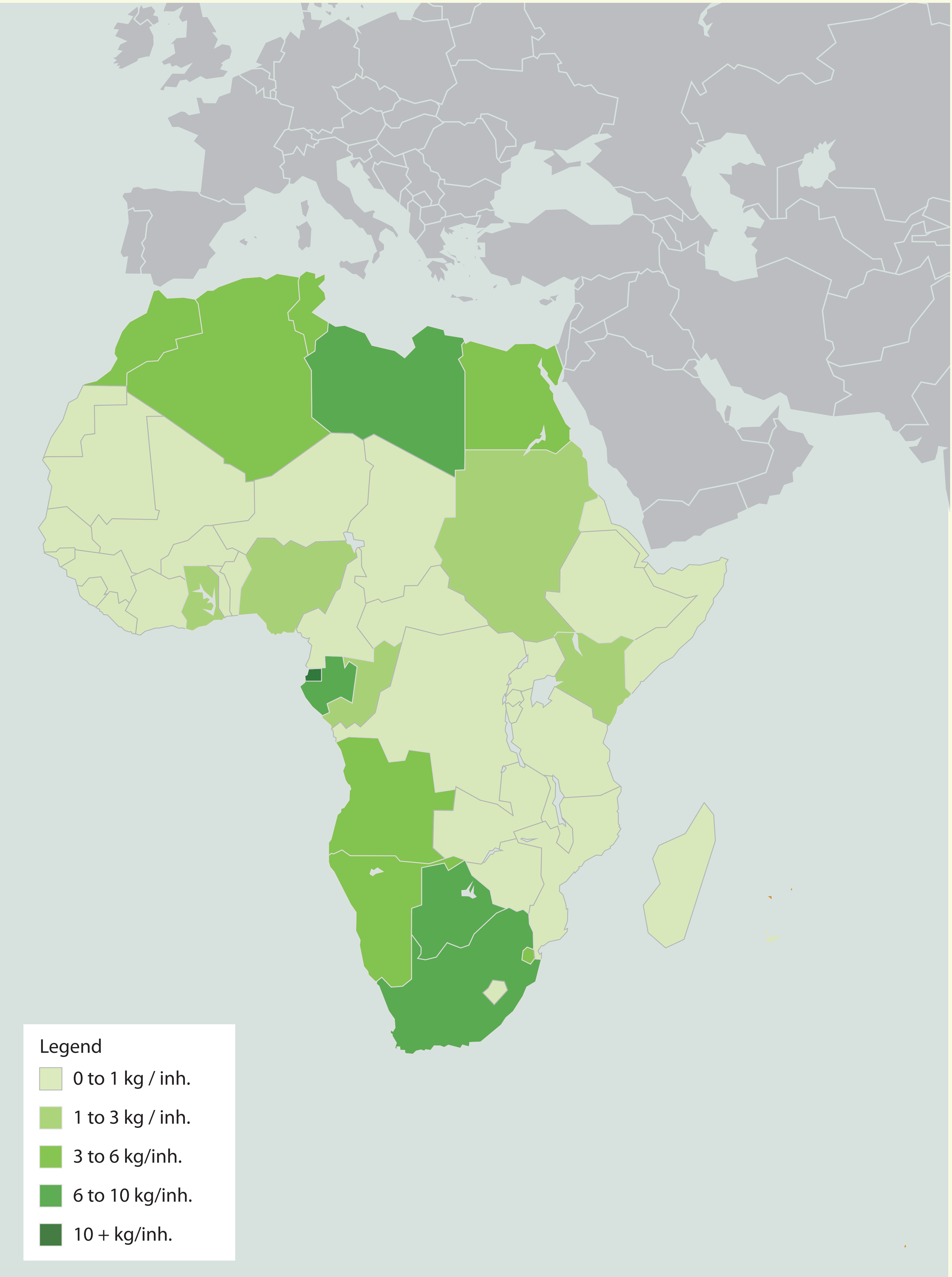
In Africa, the total e-waste generation was 1.9 Mt in 2014. Only Cameroon and Nigeria have enforced national e-waste related legislation, while Ghana, Ethiopia and Kenya still have legislation pending approval. The top three African countries with the highest e-waste generation in absolute quantities are Egypt (0.37 Mt), South Africa (0.35 Mt) and Nigeria (0.22 Mt). The top three African countries with the highest e-waste generation in relative quantities are Equatorial Guinea (10.8 kg/inh.), Seychelles (10.9 kg/inh.) and Mauritius (9.3 kg/inh.). In contrast with these relatively wealthy countries, the whole continent only generates 1.7 kg/inh. of e-waste domestically (excluding imports) annually. Very few official government reports are available on e-waste management in Africa. On the continent, the e-waste challenge is on the political agenda the past couple of years, but there is generally a lack of e-waste management infrastructure, which is reflected by the absence of e-waste management laws. Here most of the generated e-waste is either stored in households, treated or dumped, according to the informal treatment sector described in Disposal Scenario 4 in Section 4.4.

Africa, particularly the western Africa, becomes the dumping destination for e-waste from various regions of the world. This is because the East and Southern African regions have gradually put measures to prevent the dumping of e-waste, and it started to take effect. Illegal import of e-waste or used electronics from all over the world is a major source of e-waste in countries like Ghana and Nigeria. This is driven by the demand of inexpensive EEE and secondary materials, as well as cheap dumping prices compared to the treatment with stricter standards in the export countries. The recycling activities of e-waste in Africa are usually carried out on an informal basis, often involving open burning in unmonitored dumpsites or landfills. This rudimentary recycling has caused substantial damage to the health of scavengers and local environment. If properly regulated and managed, recycling of e-waste can help to develop local economies and reduce poverty. However, it demands the strong cooperation in both the developing and developed world, in order to make sure that waste legislation and stringent compliance are adopted and enforced.

In Mauritius, which is a small, relatively wealthy island, it was estimated that 9.3 kg/inh. of e-waste was generated in 2014. In 2011, it was found that 1.5 kg/inh. of e-waste was transferred at waste transfer stations mixed with the other wastes. Mauritius does not have a regular separate collection system for e-waste. Due to absence of this, most households store the e-waste in their homes. It was found in a consumer survey that 42 kg of e-waste per household was stored waiting to be disposed or collected (Africa Institute 2012). There have been many ad hoc e-waste collection campaigns, where the items are sent to dismantlers who recover materials that can recycled locally (mainly metals and plastics) and export the hazardous components for treatment abroad.

In Ethiopia, the use of many types of EEE is mostly restricted to urban centres, as the lack of electricity and purchasing power in rural communities often hampers the prevalence of devices such as TVs, refrigerators and computers. Nevertheless, these rural communities do make use of battery-powered devices such as torchlights and radios. Thus, e-waste generation in Ethiopia reflects the existing rural-urban disparities with small e-waste volumes in rural areas (predominantly waste batteries, radios and torch lights) and a much broader e-waste mix in urban communities. E-waste is not yet a major source of environmental pollution, and has not caused major health effects in Ethiopia. Compared to other African countries, such as Ghana and Nigeria, the volume of e-waste is still quite moderate. There are no indications that unsound recycling and disposal are practiced systematically. Although there are some hints that e-waste is disposed of in an uncontrolled manner, the majority of obsolete EEE is currently stored within government buildings, offices, international organizations and households or awaiting future solutions (Manhart et al. 2013). While there is no fully functional e-waste management system in place yet, some promising efforts serve as starting points for the creation of environmentally-sound e-waste management systems.

Domestic E-waste generated in africa



5.2 AMERICAS

In the Americas, the total e-waste generation was 11.7 Mt in 2014. The top three countries in the region with the highest e-waste generation in absolute quantities are: the United States (7.1 Mt), Brazil (1.4 Mt) and Mexico (1.0 Mt). The top three countries in the Americas having the highest e-waste generation in relative quantities are: the United States (22.1 kg/inh.), Canada (20.4 kg/inh.) and the Bahamas (19.1 kg/inh.).

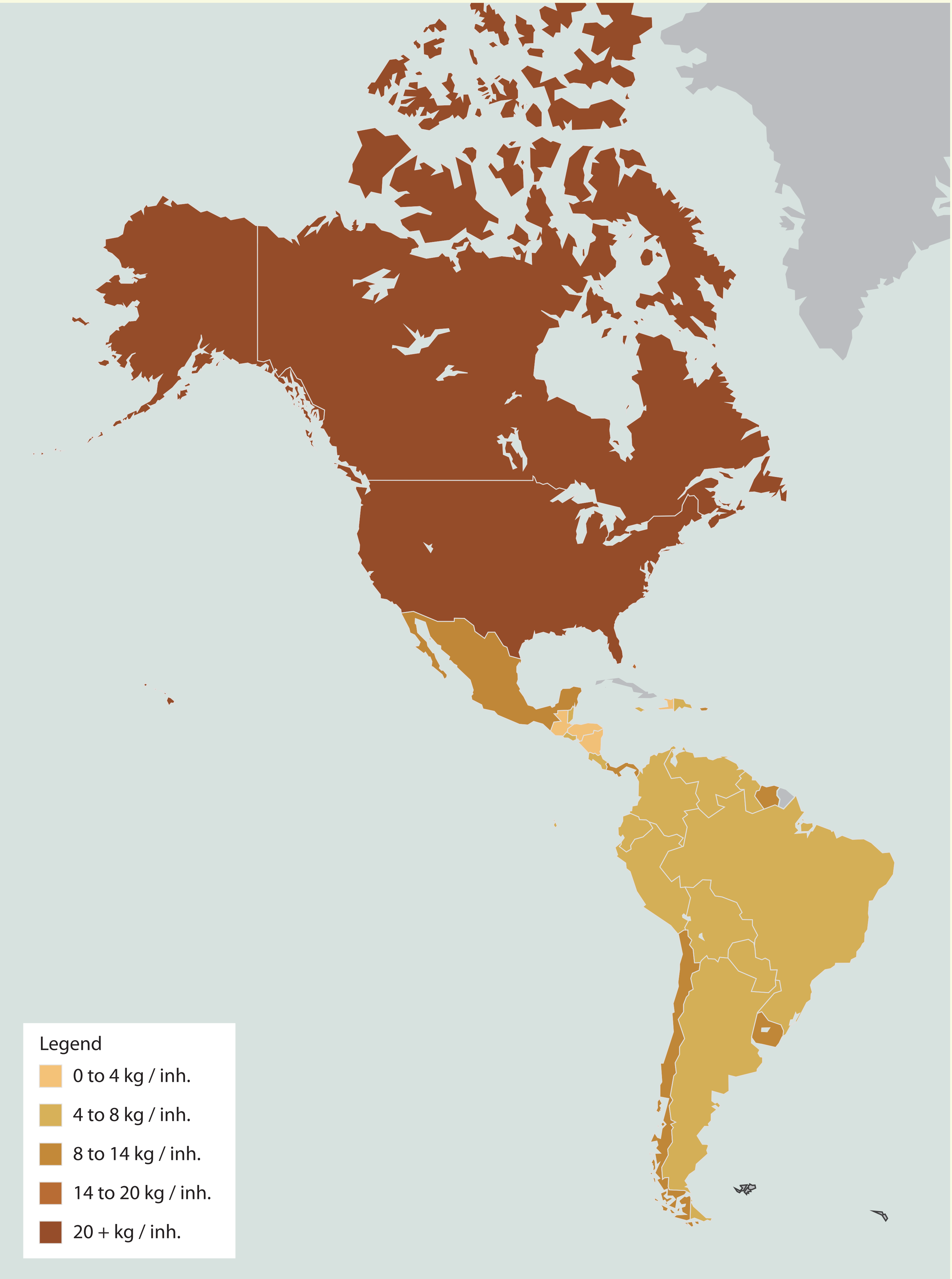
In Central America, only Costa Rica has implemented national legislation to take back and recycle e-waste. In South America, Peru, Bolivia and Ecuador already have national e-waste legislation, while Brazil and Chile have national laws pending approval. In North America, there are no federal mandates, but there are state-level e-waste laws in the United States, and 65 per cent of the U.S. population was covered by a state e-waste recycling law in 2013 (Electronics TakeBack Coalition 2014). Nine out of 14 provinces in Canada also have e-waste related legislation (covering 94 per cent of the population).

In the United States, the 1 million tonnes of officially reported collected e-waste only represents 15 per cent of the total e-waste generated in 2012 (US EPA 2014). The low collection rate could be partly a scope issue, as not all categories of e-waste have been documented in governmental statistics. Nevertheless, there is also a lot of room to improve the official collection rates through formal take-back systems (Disposal Scenario 1 in Section 4.1). It is very important to track the e-waste being collected and treated outside the official take-back and treatment systems (Disposal Scenario 3 in Section 4.3), as it is likely that part of the e-waste collected by this approach is exported, as the United States did not ratify the Basel Convention that restricts the transboundary movement of international hazardous waste. In 2010, it was estimated that 8.5 per cent of the collected units of computers, TV's, monitors, and mobile phones were exported as whole units (Duan et al, 2013). This was 26.5 kt in weight. Most larger electronic items, especially TVs and monitors, were exported overland or by sea to destinations such as Mexico, Venezuela, Paraguay and China, while used computers, especially laptops, were more likely to go to Asian countries. The main destinations for mobile phones were Hong Kong and countries in Latin America and the Caribbean.

In the United States, there are two domestic third-party certification systems for e-waste recyclers: R2 and E-Stewards. The electronics recycling industry is increasingly embracing these programs to improve their environmental performances and reduce human health impacts from improper recycling.

Out of the 21 countries in Latin America, e-waste regulations are in place only in Mexico, Costa Rica, Colombia, Peru, Argentina, and Ecuador. But in the absence of national strategies, most of them only operate at the local level. Such local laws stipulate that e-waste must be sent to an environmentally-responsible destination when disposed of, and specific funding might be used to finance selective waste collection projects. Only Brazil, Mexico and Costa Rica have R2-certified recycling facilities, which is an internationally recognized standard. The certification of recyclers has been limited due to lack of incentives from legal frameworks, awareness of pollution control during recycling as well as the lack of training opportunities for certification.

Domestic E-waste generated in Americas



5.3 ASIA

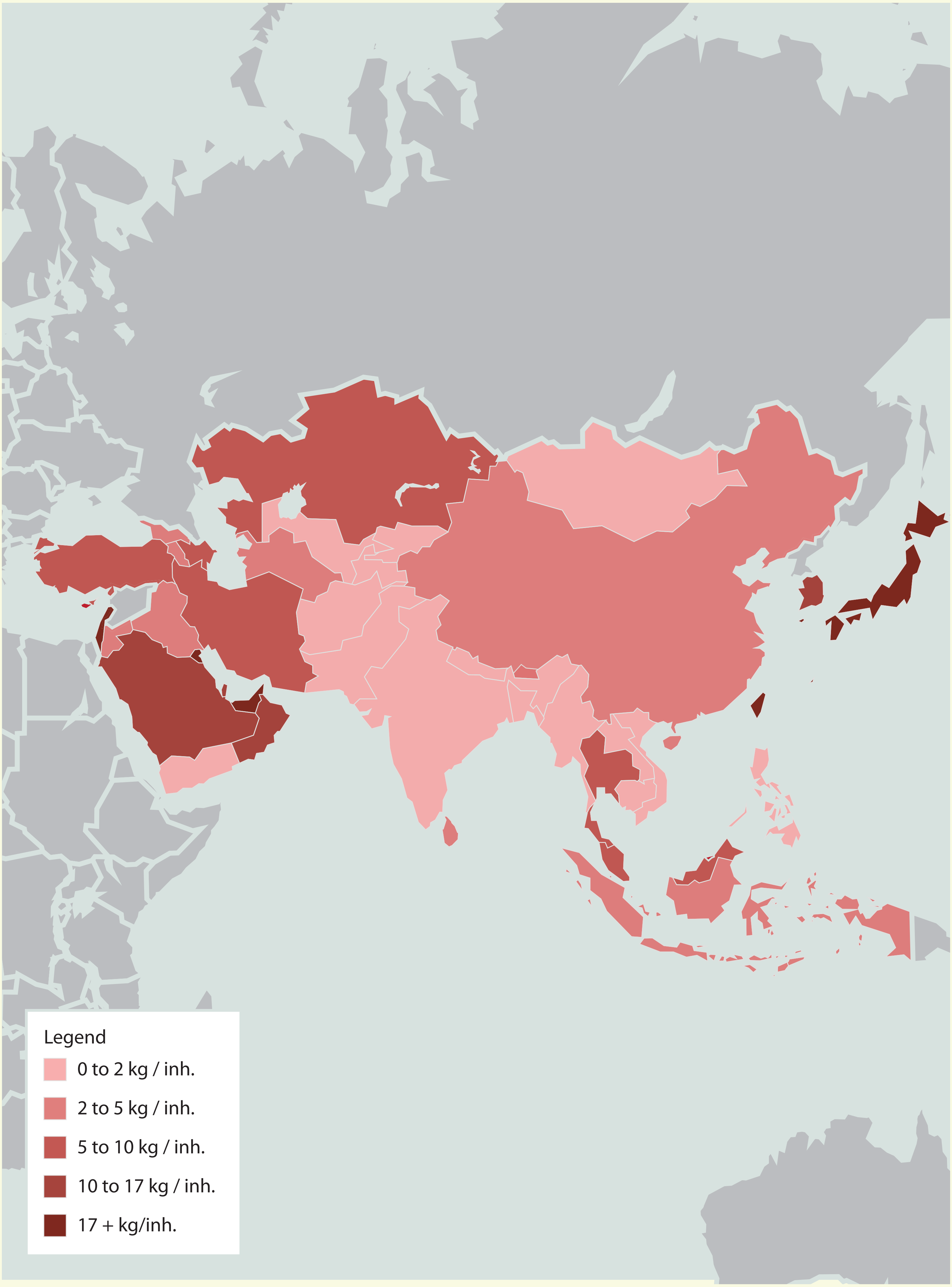
In Asia, the total e-waste generation was 16.0 Mt in 2014. China, India, Japan, Hong Kong, South Korea, Viet Nam, Bhutan, Cyprus and Turkey have national e-waste related laws. The Philippines and Jordan have regulations pending approval.

The top three Asian countries with the highest e-waste generation in absolute quantities are China (6.0 Mt), Japan (2.2 Mt) and India (1.7 Mt). The top three Asian regions or countries having the highest e-waste generation in relative quantities are: Hong Kong (21.5 kg/inh.), Singapore (19.6 kg/inh.) and Brunei (18.1 kg/inh.).

China plays a key role in the global EEE industry, including the manufacturing, refurbishment, and reuse of EEE and recycling of e-waste. Under the progressive development of pilot projects and domestic e-waste legislation over the past five years, the formal e-waste recycling industry in China has shown considerable growth in both treatment capacity and quality. However, due to a range of social and economic factors, the informal sector continues to play a major role in the collection and recycling of e-waste, and informal recycling often leads to detrimental effects on the environment and the health and safety of workers and local communities (Scenario 4 in Section 4.4). The growth of the formal sector is important for lessening the environmental and health impacts of e-waste treatment. In the coming years, the formal and informal sectors will both continue to operate. In China, national e-waste legislation manages the collection and treatment of TVs, refrigerators, washing machines, air conditioners and computers (desktop and laptops). In 2013, China officially collected and treated around 1.3 Mt of these five types of e-waste, which was 28 per cent of the total e-waste generated for all categories (Wang et al. 2013).

For Japan, six products, namely air conditioners, TVs, personal computers, washing machines, refrigerators and mobile phones, are regulated. This is nearly 40 per cent of the e-waste generated for all categories investigated in this report. Japan is an early adopter in the development and enforcement of a legal mechanism for e-waste. Japan was one of the first counties worldwide to implement an EPR (Extended Producer Responsibility) based system for e-waste, largely building on the strong existing framework for solid waste management. As a result, not only is there a strong legal framework, it is also backed by an advanced collection and take-back system and processing infrastructure. The country has different laws for different products, some with compulsory recycling targets, with other products falling under voluntary initiatives. It is reported that 556 kt of e-waste was officially collected and treated in Japan in 2013 (AEHA 2013), which is roughly 24 per cent of the total e-waste generated that year.

Domestic E-waste generated in Asia



5.4 EUROPE

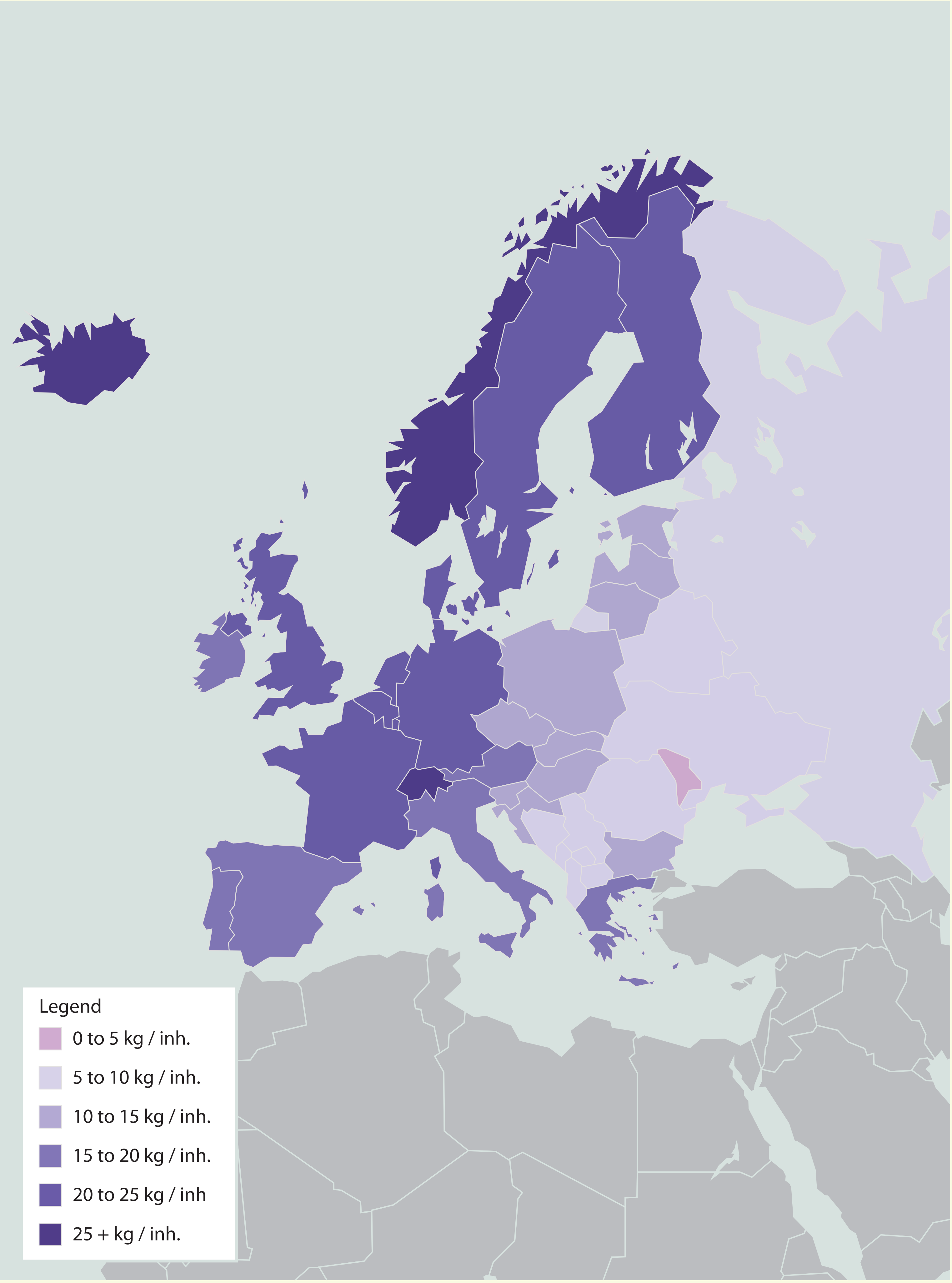
In Europe, the total e-waste generation was 11.6 Mt in 2014. The European countries with the highest e-waste generation in absolute quantities are Germany (1.8 Mt), the United Kingdom (1.5 Mt), France (1.4 Mt) and Russia (1.2 Mt). The top three regions or countries with the highest e-waste generation in relative quantities are Norway (28.3 kg/inh.), Switzerland (26.3 kg/inh.) and Iceland (26.0 kg/inh.).

In 2012, only 3.2 Mt of e-waste was officially collected in the 28 Member States of the European Union, whereas 9 Mt of e-waste was generated in 2012 in this region. The European Union is one of the few regions in the world where there is uniform legislation regarding the collection and processing of e-waste. This is formulated in the WEEE Directive. The successor of the WEEE Directive will come into force in 2019 (European Union 2012). In here, one of the targets is to collect 85 per cent of generated e-waste. In practice, most Member States do not reach that collection level yet. Only Sweden, Denmark and Bulgaria currently collect more than 60 per cent of their e-waste generated. In practice, around 8 per cent of e-waste is discarded in the waste bin (see Scenario 2 in Section 4.2, and data in Annex 3), and part of the e-waste stream is mixed and recycled together with metal scrap, thus recycled outside the official take-back systems (Scenario 3 in Section 4.3). This is estimated to account for about 20 per cent of the e-waste generated in France (Monier et al. 2013), about 30 per cent of the e-waste generated in Italy (Magalini et al. 2012), the Netherlands (Huisman et al. 2012) and Great Britain and about 10 per cent of the e-waste generated in Belgium (WRAP 2012) and (Wielenga et al. 2013). Finally, the e-waste can be exported for reuse. Although this has a higher priority in the waste treatment hierarchy, these exports can lead to improper recycling in the destination countries. This is estimated to be about 10 per cent of the e-waste generated in Austria and the Netherlands and about 5 per cent of the e-waste generated in Great Britain, Belgium and Germany (Baldé et al. 2014).

The Balkan region is often regarded as the destination for e-waste disposal from the developed world (Anthouli et al. 2013). The practices for dealing with locally-generated WEEE are unsatisfactory, which lead to a loss of secondary resources and damages the environment. National legislation on e-waste management has been put in force in five countries of this region: Montenegro, Macedonia, Serbia, Bosnia and Herzegovina. There is no national legislation tackling e-waste in Kosovo. However, the western Balkans region has not implemented an effective e-waste take-back system like the EU Member States. Further development in collection schemes and recycling infrastructure is needed in this region.

The situation in Russia and Belarus, Kazakhstan, Armenia, Kirgizstan is not quite clear. So far, they do not have any e-waste legislation or management system in place. However, in late December of 2014, the Russian Duma (the parliament) held a second discussion over the bill concerning the production and consumption waste. During this disucssion, EPR (Extended Producer Responsibility) was introduced, and although this does not cover e-waste specifically, the potential new law is considered a first step in the right direction. Different inter-agency working groups on regulations are now working towards an implementation of the law.

Domestic E-waste generated in Europe



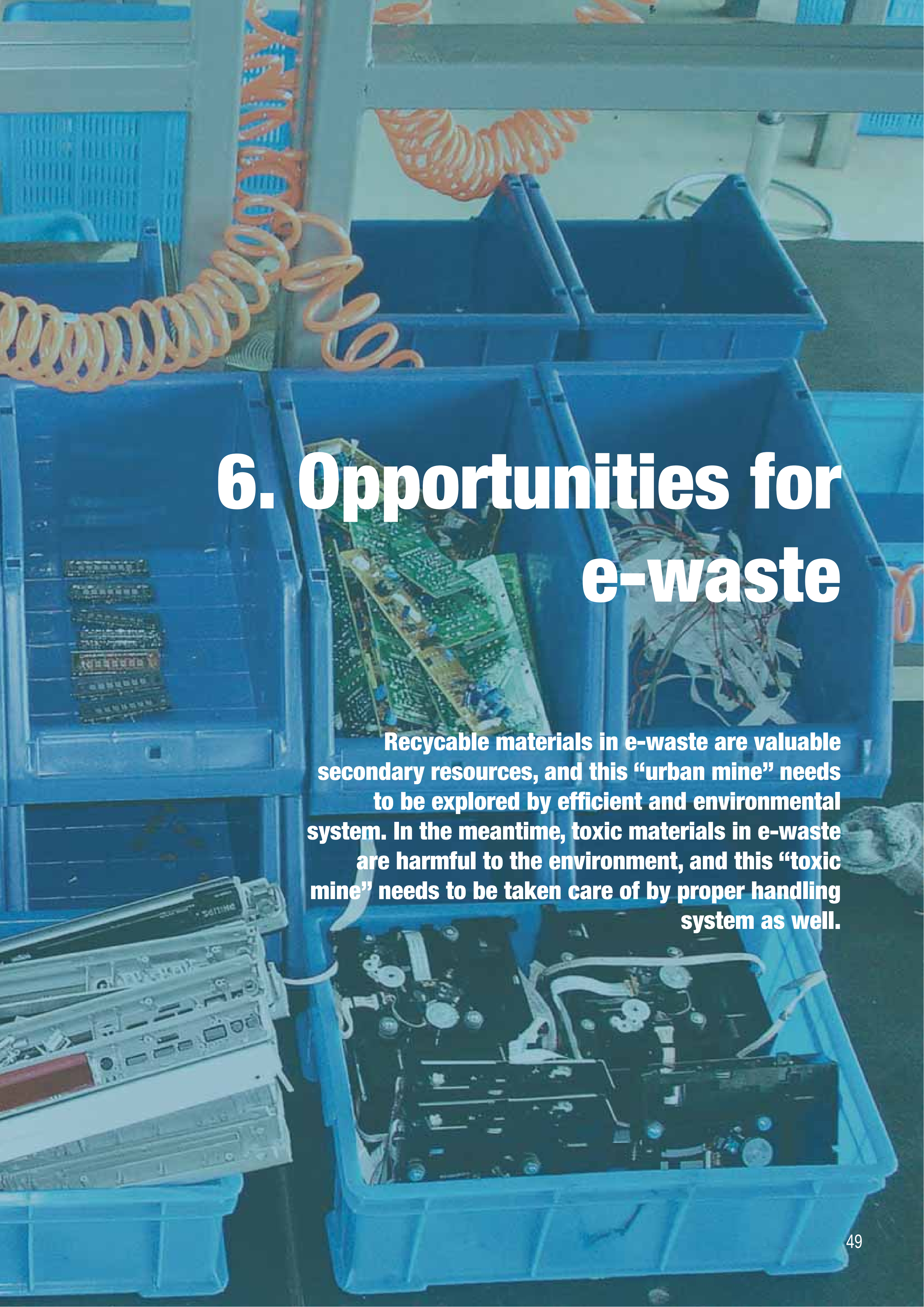
5.5 OCEANIA

In Oceania, the total e-waste generation was 0.6 Mt in 2014. The top three countries with the highest e-waste generation in absolute quantities are Australia (0.47 Mt), New Zealand (0.09 Mt) and Papua New Guinea (0.0008 Mt). The top three regions or countries with the highest e-waste generation in relative quantities are Australia (20.0 kg/inh.), New Zealand (19.0 kg/inh.) and the Marshall Islands (5.5 kg/inh.).

Only Australia has a national regulation regarding the disposal of end-of-life computers and television units. In Australia, waste management is primarily the responsibility of state and territorial governments and, through them, local governments. "The Product Stewardship Act 2011" was enacted in 2011, which provides a legislative framework for national product stewardship schemes. The Product Stewardship (televisions and computers) Regulations were made in 2011, establishing the National Television and Computer Recycling Scheme. The regulations require all importers and manufacturers of above threshold volume of televisions and computers to join and fund an approved co-regulatory arrangement. The regulations require the industry to fund collection and recycling activities to meet progressively increasing annual recycling targets, set as a proportion of the estimated total television and computer waste generation in Australia. These targets started at 30 per cent in 2012–13 and will increase to 80 per cent by 2021–22 (Australian government, 2014). Disposing of mercury-containing lamps is primarily a state and local government responsibility in Australia; there is no national legislation on collecting and recycling lamps. Landfill disposal of large amounts of mercury-containing lamps is forbidden in some states. There is a national voluntary scheme for recycling mercury-containing lamps from the commercial and public lighting sectors (Australian government 2014). During 2012 and 2013, 40,813 tonnes of waste televisions and computers were recycled in Australia, which was equivalent to 98.8 per cent of the predefined national recycling target (41,327 tonnes for two types of waste products) (Australian government 2014). However, this collected amount is only 8.7 per cent the total amount of e-waste generated for all product categories.

In New Zealand, most e-waste is still going to landfill. E-waste is still classified as a non-priority waste stream in New Zealand. Therefore, there is no restriction on e-waste sent to landfill, and there is no national legislation to regulate the collection and recycling of e-waste (Government of New Zealand 2013).

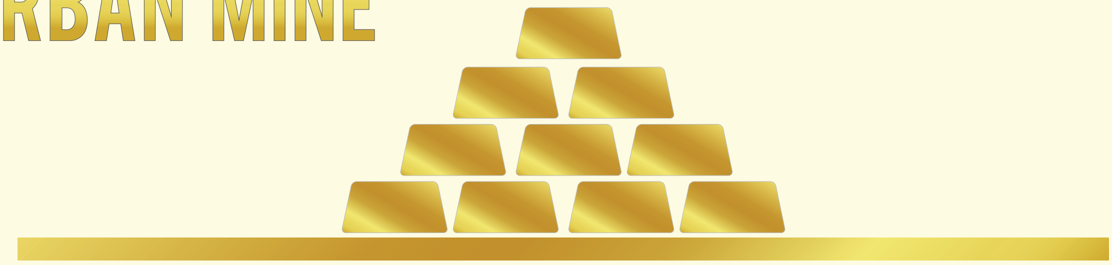
Domestic E-waste generated in Oceania

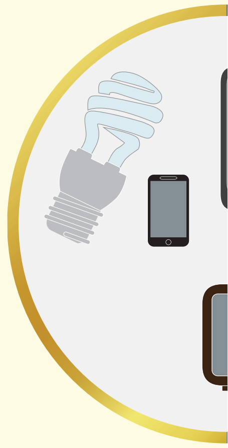


6. Opportunities for e-waste

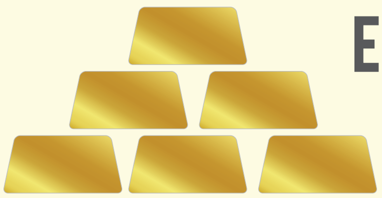
Recycable materials in e-waste are valuable secondary resources, and this "urban mine" needs to be explored by efficient and environmental system. In the meantime, toxic materials in e-waste are harmful to the environment, and this "toxic mine" needs to be taken care of by proper handling system as well.

URBAN MINE





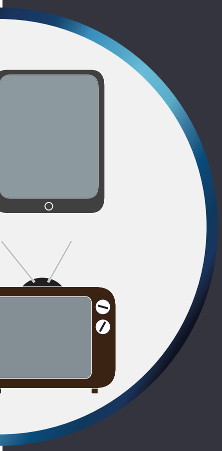
Material	Kilotons	Million Euros
METAL		
Iron, Steel (Fe)	16,500	9,000
Copper (Cu)	1,900	10,600
Aluminum (Al)	220	3,200
Precious Metals		
Gold (Au)	0.3	10,400
Silver (Ag)	1.0	580
Palladium (Pd)	0.1	1,800
PLASTICS		
PP, ABS, PC, PS	8,600	12,300



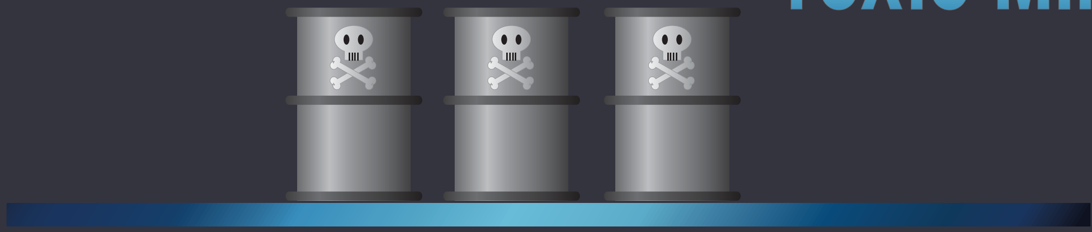
ESTIMATED 48,000,000,000 EUROS

EEE contains various materials including hazardous, valuable and scarce metals. Common hazardous materials found in e-waste are: heavy metals (such as mercury, lead, cadmium etc.) and chemicals (such as CFCs/chlorofluorocarbon or various flame retardants). In addition to hazardous materials, e-waste also contains many valuable materials (such as iron, copper, aluminium and plastics) and precious metals (like gold, silver, platinum and palladium) that can be recycled. In fact, up to 60 elements from the periodic table can be found in complex electronics, and many of them are recoverable, though it is not always economic to do so presently.

From the resource perspective, e-waste is a potential "urban mine" that could provide a great amount of secondary resources for remanufacture, refurbishment and recycling. For instance, the gold content from e-waste in 2014 is roughly 300 tonnes, which represents 11 per cent of the global gold production from mines in 2013 (2770 tonnes) (USGS 2014). Recovery of such valuable materials requires both high collection rate and recycling efficiency



TOXIC MINE



METALS

Mercury, Cadmium, Chromium

Lead

Lead glass - 2,200 kilotons

COMPONENTS

Batteries - 300 kilotons

CHEMICALS

Poly- / Brominated Flame Retardants in Plastics

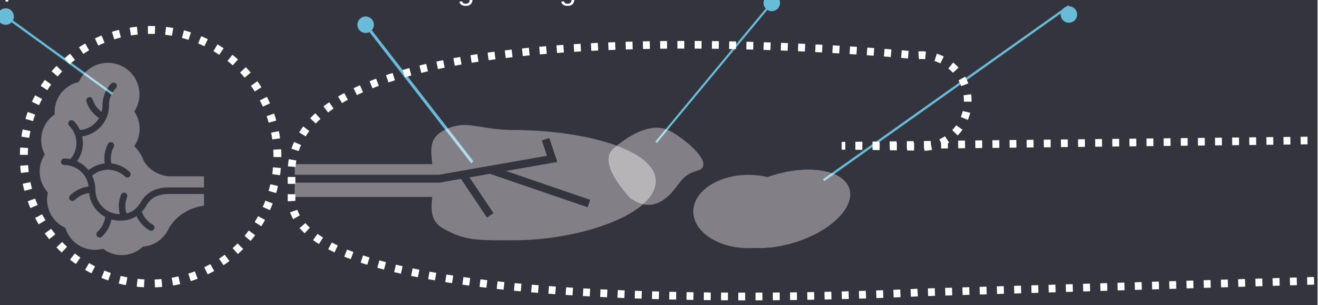
Phosphors

PCBs/A Polychlorinated biphenyl (old capacitors)

Hexavalent chromium (PVV)

Ozone depleting substances (CFCs, HCFC, HFC, HCs) - 4.4 kilotons

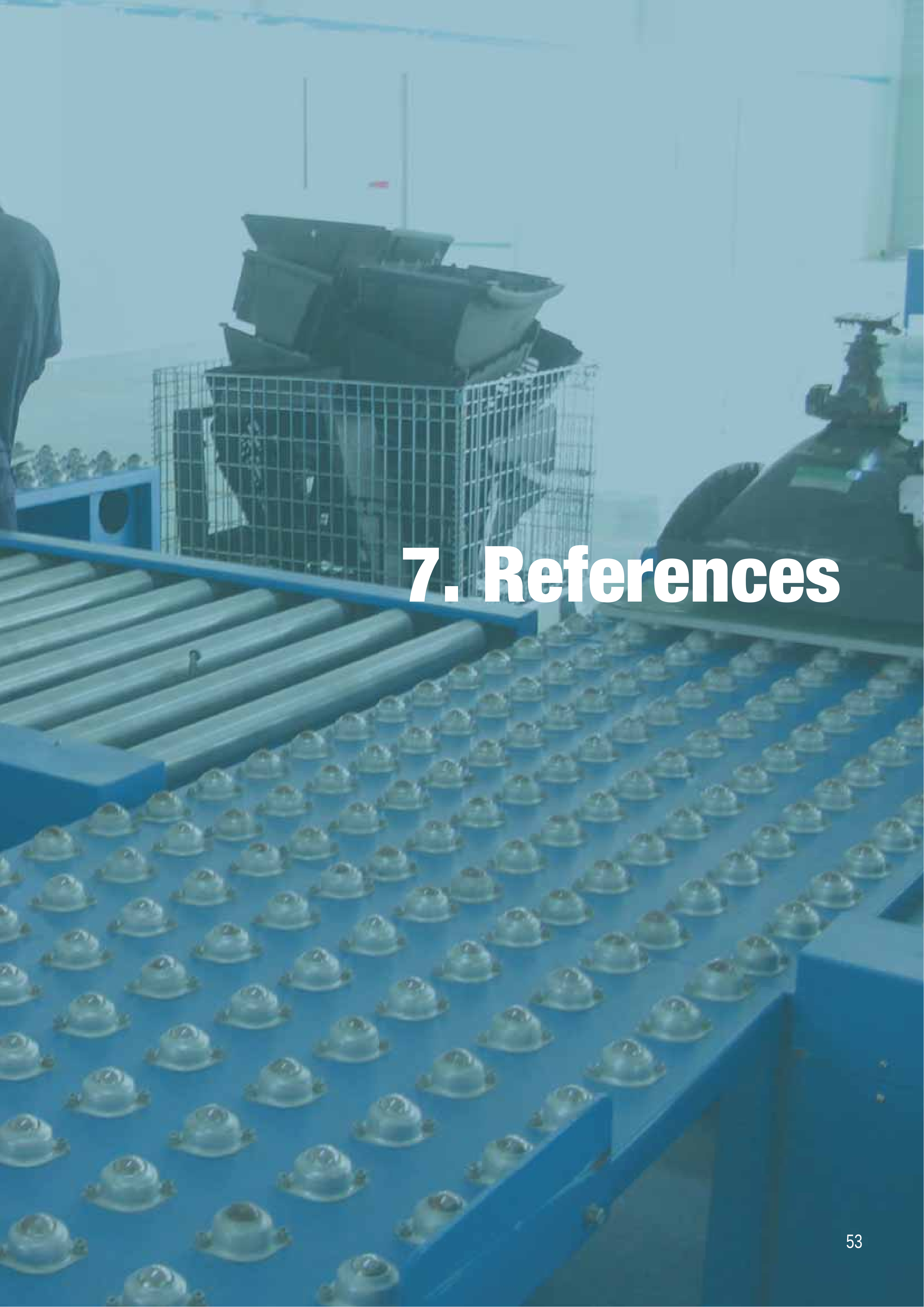
Potential Health Effects



for the fractions. In order to efficiently harvest resources through this “urban mine”, the e-waste stream needs to be diverted to the formal take-back systems (Disposal Scenario 1, Section 4.1) and avoid entering other channels such as dustbins (Disposal Scenario 2, Section 4.2) or substandard recycling (particularly, Disposal Scenario 4, Section 4.4), because valuable materials are easily lost due to imperfect separation and treatment practices.

In order to exploit the opportunities and simultaneously mitigate pollution, good policies are needed that facilitate the creation of an infrastructure, ensure that all collected e-waste is treated using state-of-the-art technologies and that green employment opportunities are created.


东江环保



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8. About the authors

ABOUT THE AUTHORS

KEES BALDÉ

Since 2012 Kees Baldé has served as a consultant to the United Nations University's Institute for the Advanced Study of Sustainability. He is also head of waste statistics as part of the environmental statistics team at Statistics Netherlands where he represents the Netherlands at international meetings. Kees initiated and was a key contributor to the 2011 report on Green Growth in the Netherlands. His work has led to the development of a common methodology for the recast of the European Union's Waste Electrical and Electronic Equipment (WEEE) Directive, a detailed assessment of the fate of e-waste in various European countries and setting guidelines to measure e-waste statistics in the context of the UN Partnership of measuring ICT for Development. Kees Holds a PhD in chemistry from Utrecht University.

FENG WANG

Feng Wang joined UNU in 2009 to work on a variety of waste-related research projects, capacity building activities and international cooperation. Feng led the "Best of the 2 Worlds" project, which aimed to develop eco-efficient treatment infrastructure for e-waste in developing countries. He has also involved in a series of country studies on mapping e-waste flows (the Netherlands, Italy, Belgium and China). His recent work involves research projects to provide policy suggestions to the European Commission on the Recast of WEEE Directive, as well as quantifying the global e-waste generation. Feng Wang holds a PhD in e-waste management from Delft University of Technology.

JACO HUISMAN

Jaco Huisman is Scientific Advisor to the United Nations University and leads the IAS SCYCLE Electronics Recycling Group. He steers various international projects to quantify the e-waste amounts and problems worldwide in cooperation with key research institutes and universities. In the past, he has served as the lead author of the UNU study supporting the European Commission's 2008 Review of the EU WEEE Directive and the advanced e-waste country study for various European countries. He is also the scientific coordinator of the FP7 project CWIT: "Countering WEEE Illegal Trade" and the H2020 project ProSUM: Prospecting Secondary raw materials in the Urban Mine. He holds a PhD from Delft University of Technology on eco-efficiency of take-back and recycling systems for electronics. Besides his UNU responsibilities, he is an associate professor at Delft University of Technology.

RUEDIGER KUEHR

Ruediger Kuehr heads UNU-IAS Operating Unit SCYCLE, which is focusing its work and activities on sustainable production, consumption and disposal ever since the establishment of the Institute for the Advanced Study of Sustainability (UNU-IAS). Since 2007 Ruediger has also functioned as the Executive Secretary of the Solving the E-Waste Problem (Step) Initiative, which aims to initiate and develop just and environmentally-safe solutions to the e-waste problem.

He served as Senior R&D Specialist with The Natural Step in Sweden and as a freelance policy-consultant to various national governments, international organizations and companies. He was a visiting fellow to the Free University of Berlin (Germany) and the Hitotsubashi University (Japan), a Research Associate to the Japan Research Centre of the University of Osnabrück (Germany), and a freelance writer for some large weekly and daily newspapers. Ruediger Kuehr is a member of a number of national and international Steering and Expert Committees and a regular reviewer for several scientific journals.

Kuehr is political and social scientist by education with a PhD (Dr. rer. pol.) from the University of Osnabrück (Germany) and an MA (Magister Artium) from the University of Münster, (Germany), as well as additional post-graduate studies in Tokyo (Japan).

JENNIFER WONG (DESIGNER)

Jennifer Wong is a recently graduated design researcher from Delft University of Technology with a background in architecture and communication design. Jennifer now runs her own research and design consultancy focusing on designing for an environmentally, economically, and socially sustainable urban future. Her most recent project was the design of a children's game to stimulate awarenes of air quality and pollution levels in the Rijnmond area. Her work focuses on the development of designs, strategies, and communication tools that stem from deep rooted research through a variety of mediums. Although the company is still young and growing in the Netherlands, she hopes to expand her work on an international scale to cross boundaries and bring more holistic solutions in the near future.

9. Appendix

ANNEX 1 : DOMESTIC E-WASTE GENERATED PER COUNTRY IN 2014

Continent	Region	Name	kg/inh.	kt	National Regulation in force till 2013	population (1000)
Africa	Eastern Africa	Burundi	0.2	2	no	9201
Africa	Eastern Africa	Comoros	0.7	1	no	724
Africa	Eastern Africa	Djibouti	1.2	1	no	939
Africa	Eastern Africa	Eritrea	0.3	2	no	6000
Africa	Eastern Africa	Ethiopia	0.5	43	no	90982
Africa	Eastern Africa	Kenya	1.0	44	no	44572
Africa	Eastern Africa	Madagascar	0.3	6	no	23537
Africa	Eastern Africa	Malawi	0.2	4	no	17604
Africa	Eastern Africa	Mauritius	9.3	12	no	1309
Africa	Eastern Africa	Mozambique	0.7	16	no	23365
Africa	Eastern Africa	Rwanda	0.6	6	Wno	10865
Africa	Eastern Africa	Seychelles	10.9	1	no	94
Africa	Eastern Africa	Uganda	0.9	33	yes	38040
Africa	Eastern Africa	United Republic of Tanzania	0.5	26	no	49047
Africa	Eastern Africa	Zambia	0.9	13	no	14617
Africa	Eastern Africa	Zimbabwe	0.3	4	no	13260
Africa	Middle Africa	Angola	3.0	65	no	21444
Africa	Middle Africa	Cameroon	0.9	21	yes	22544
Africa	Middle Africa	Central African Republic	0.3	1	no	5109
Africa	Middle Africa	Chad	0.8	9	no	11284
Africa	Middle Africa	Congo	2.5	11	no	4274
Africa	Middle Africa	Democratic Republic of the Congo	0.2	17	no	79301
Africa	Middle Africa	Equatorial Guinea	10.8	8	no	785
Africa	Middle Africa	Gabon	7.6	12	no	1586
Africa	Middle Africa	Sao Tome and Principe	1.2	0	no	179
Africa	Northern Africa	Algeria	4.9	183	no	37597
Africa	Northern Africa	Egypt	4.3	373	no	85833
Africa	Northern Africa	Libya	8.3	55	no	6649
Africa	Northern Africa	Morocco	3.7	121	no	33179
Africa	Northern Africa	Sudan	1.2	43	no	35276
Africa	Northern Africa	Tunisia	5.0	56	no	11060

Africa	Southern Africa	Botswana	8.3	16	no	1920
Africa	Southern Africa	Lesotho	0.9	2	no	1911
Africa	Southern Africa	Namibia	5.0	11	no	2192
Africa	Southern Africa	South Africa	6.6	346	no	52433
Africa	Southern Africa	Swaziland	4.0	4	no	1106
Africa	Western Africa	Benin	0.9	8	no	9858
Africa	Western Africa	Burkina Faso	0.6	11	no	18166
Africa	Western Africa	Cape Verde	2.0	1	no	542
Africa	Western Africa	Côte d'Ivoire	0.8	20	no	24791
Africa	Western Africa	Gambia	1.2	2	no	1927
Africa	Western Africa	Ghana	1.4	38	no	26216
Africa	Western Africa	Guinea	0.8	9	no	11403
Africa	Western Africa	Guinea-Bissau	0.5	1	no	1646
Africa	Western Africa	Liberia	0.2	1	no	4187
Africa	Western Africa	Mali	0.6	10	no	17379
Africa	Western Africa	Mauritania	0.9	4	no	3804
Africa	Western Africa	Niger	0.2	4	no	17116
Africa	Western Africa	Nigeria	1.3	219	yes	173938
Africa	Western Africa	Senegal	0.9	12	no	13830
Africa	Western Africa	Sierra Leone	0.4	2	no	6481
Africa	Western Africa	Togo	0.8	5	no	6587
Americas	Caribbean	Antigua and Barbuda	11.6	1	no	88
Americas	Caribbean	Bahamas	19.1	7	no	360
Americas	Caribbean	Barbados	13.2	4	no	279
Americas	Caribbean	Dominica	9.7	1	no	71
Americas	Caribbean	Dominican Republic	5.4	58	no	10610
Americas	Caribbean	Grenada	10.0	1	no	106
Americas	Caribbean	Haiti	0.6	6	no	10470
Americas	Caribbean	Jamaica	5.8	16	no	2774
Americas	Caribbean	Saint Kitts and Nevis	10.1	1	no	60
Americas	Caribbean	Saint Lucia	9.9	2	no	170
Americas	Caribbean	Saint Vincent and the Grenadines	9.7	1	no	110
Americas	Caribbean	Trinidad and Tobago	9.0	12	no	1341
Americas	Central America	Belize	6.5	2	no	355
Americas	Central America	Costa Rica	7.5	36	yes	4770

Americas	Central America	El Salvador	4.8	30	no	6282
Americas	Central America	Guatemala	3.5	55	no	15870
Americas	Central America	Honduras	1.8	16	no	8546
Americas	Central America	Mexico	8.2	958	no	117181
Americas	Central America	Nicaragua	1.7	11	no	6165
Americas	Central America	Panama	8.2	31	no	3788
Americas	Northern America	Canada	20.4	725	no	35538
Americas	Northern America	United States of America	22.1	7072	no	319701
Americas	South America	Argentina	7.0	292	no	41961
Americas	South America	Bolivia (Plurinational State of)	4.0	45	yes	11246
Americas	South America	Brazil	7.0	1412	no	201413
Americas	South America	Chile	9.9	176	no	17711
Americas	South America	Colombia	5.3	252	yes	47711
Americas	South America	Ecuador	4.6	73	yes	15699
Americas	South America	Guyana	6.1	5	no	780
Americas	South America	Paraguay	4.9	34	no	6930
Americas	South America	Peru	4.7	148	yes	31424
Americas	South America	Suriname	8.5	5	no	560
Americas	South America	Uruguay	9.5	32	no	3404
Americas	South America	Venezuela (Bolivarian Republic of)	7.6	233	no	30457
Asia	Central Asia	Kazakhstan	7.7	131	no	17019
Asia	Central Asia	Kyrgyzstan	1.2	7	no	5700
Asia	Central Asia	Tajikistan	0.8	7	no	8302
Asia	Central Asia	Turkmenistan	3.9	22	no	5796
Asia	Central Asia	Uzbekistan	1.5	45	no	30160
Asia	Eastern Asia	China	4.4	6033	yes	1367520
Asia	Eastern Asia	China, Hong Kong Special Administrative Region [1]	21.5	157	yes	7296
Asia	Eastern Asia	Japan	17.3	2200	yes	127061
Asia	Eastern Asia	Mongolia	1.8	5	no	2914
Asia	Eastern Asia	Republic of Korea	15.9	804	yes	50475
Asia	Eastern Asia	Taiwan [2]	18.6	438	-	23499

1. Due to the different characteristics of Hong Kong and data availability, this region has been investigated separately
2. Due to the different characteristics of Taiwan and data availability, this region has been investigated separately

Asia	South-Eastern Asia	Brunei Darus-salam	18.1	7	no	411
Asia	South-Eastern Asia	Cambodia	1.0	16	no	15561
Asia	South-Eastern Asia	Indonesia	3.0	745	no	251490
Asia	South-Eastern Asia	Lao People's Democratic Republic	1.2	8	no	6557
Asia	South-Eastern Asia	Malaysia	7.6	232	no	30467
Asia	South-Eastern Asia	Myanmar	0.4	29	no	66257
Asia	South-Eastern Asia	Philippines	1.3	127	no	99434
Asia	South-Eastern Asia	Singapore	19.6	110	no	5595
Asia	South-Eastern Asia	Thailand	6.4	419	no	64945
Asia	South-Eastern Asia	Timor-Leste	4.1	5	no	1172
Asia	South-Eastern Asia	Viet Nam	1.3	116	yes	92571
Asia	Southern Asia	Afghanistan	0.3	9	no	33967
Asia	Southern Asia	Bangladesh	0.8	126	no	153257
Asia	Southern Asia	Bhutan	3.7	3	yes	746
Asia	Southern Asia	India	1.3	1641	no	1255565
Asia	Southern Asia	Iran (Islamic Republic of)	7.4	581	no	78089
Asia	Southern Asia	Maldives	6.1	2	no	342
Asia	Southern Asia	Nepal	0.5	15	no	32010
Asia	Southern Asia	Pakistan	1.4	266	no	186279
Asia	Southern Asia	Sri Lanka	4.2	87	no	20964
Asia	Western Asia	Armenia	4.6	16	no	3433
Asia	Western Asia	Azerbaijan	5.1	48	no	9383
Asia	Western Asia	Bahrain	12.9	16	no	1198
Asia	Western Asia	Cyprus	16.3	14	yes	876
Asia	Western Asia	Georgia	4.6	21	no	4531
Asia	Western Asia	Iraq	3.1	112	yes	35871
Asia	Western Asia	Israel	17.2	138	no	8040
Asia	Western Asia	Jordan	4.5	30	no	6694
Asia	Western Asia	Kuwait	17.2	69	no	3999

Asia	Western Asia	Lebanon	9.4	39	no	4115
Asia	Western Asia	Oman	14.0	46	no	3288
Asia	Western Asia	Qatar	16.3	33	no	1989
Asia	Western Asia	Saudi Arabia	12.5	379	no	30254
Asia	Western Asia	Syrian Arab Republic			no	
Asia	Western Asia	Turkey	6.5	503	yes	76707
Asia	Western Asia	United Arab Emirates	17.2	101	no	5873
Asia	Western Asia	Yemen	1.2	34	no	27460
Europe	Eastern Europe	Belarus	7.7	72	no	9293
Europe	Eastern Europe	Bulgaria	10.7	77	yes	7146
Europe	Eastern Europe	Czech Republic	14.8	157	yes	10594
Europe	Eastern Europe	Hungary	12.6	125	yes	9922
Europe	Eastern Europe	Poland	10.0	397	yes	39638
Europe	Eastern Europe	Republic of Moldova	1.8	6	no	3553
Europe	Eastern Europe	Romania	9.2	197	yes	21266
Europe	Eastern Europe	Russian Federation	8.7	1231	no	140955
Europe	Eastern Europe	Slovakia	11.4	62	yes	5447
Europe	Eastern Europe	Ukraine	5.7	258	no	45000
Europe	Northern Europe	Denmark	24.0	135	yes	5610
Europe	Northern Europe	Estonia	14.0	19	yes	1340
Europe	Northern Europe	Finland	21.4	118	yes	5476
Europe	Northern Europe	Iceland	26.0	9	yes	331
Europe	Northern Europe	Ireland	19.8	92	yes	4641
Europe	Northern Europe	Latvia	10.7	22	yes	2030
Europe	Northern Europe	Lithuania	11.4	34	yes	2970
Europe	Northern Europe	Norway	28.3	146	yes	5150
Europe	Northern Europe	Sweden	22.2	215	yes	9655
Europe	Northern Europe	United Kingdom of Great Britain and Northern Ireland	23.5	1511	yes	64271
Europe	Southern Europe	Albania	6.1	20	no	3275
Europe	Southern Europe	Bosnia and Herzegovina	5.3	21	yes	3871
Europe	Southern Europe	Croatia	10.8	48	yes	4402
Europe	Southern Europe	Greece	15.1	171	yes	11242

Europe	Southern Europe	Italy	17.6	1077	yes	61156
Europe	Southern Europe	Malta	14.6	6	yes	418
Europe	Southern Europe	Montenegro	7.1	4	yes	626
Europe	Southern Europe	Portugal	16.1	171	yes	10569
Europe	Southern Europe	Serbia	7.3	56	yes	7566
Europe	Southern Europe	Slovenia	15.0	31	yes	2066
Europe	Southern Europe	Spain	17.7	817	yes	45995
Europe	Southern Europe	The former Yugoslav Republic of Macedonia	6.1	13	yes	2076
Europe	Western Europe	Austria	22.0	188	yes	8520
Europe	Western Europe	Belgium	21.4	242	yes	11260
Europe	Western Europe	France	22.1	1419	yes	63996
Europe	Western Europe	Germany	21.6	1769	yes	81589
Europe	Western Europe	Luxembourg	21.0	12	yes	550
Europe	Western Europe	Netherlands	23.3	394	yes	16861
Europe	Western Europe	Switzerland	26.3	213	yes	8098
Oceania	Australia and New Zealand	Australia	20.0	468	yes	23339
Oceania	Australia and New Zealand	New Zealand	19.0	86	no	4510
Oceania	Melanesia	Fiji	3.3	3	no	908
Oceania	Melanesia	Papua New Guinea	1.1	8	no	7172
Oceania	Melanesia	Solomon Islands	1.6	0.95	no	592
Oceania	Melanesia	Vanuatu	2.9	0.78	no	262
Oceania	Micronesia	Kiribati	3.9	0.43	no	108
Oceania	Micronesia	Marshall Islands	5.5	0.32	no	58
Oceania	Micronesia	Micronesia (Federated States of)	5.4	0.56	no	103
Oceania	Polynesia	Samoa	4.0	0.76	no	185
Oceania	Polynesia	Tongata	5.4	0.58	no	105
Oceania	Polynesia	Tuvalu	1.7	0.02	no	11

ANNEX 2 : E-WASTE COLLECTION DATA FROM OFFICIAL TAKE-BACK SYSTEMS

Continent	Country/region	Collection (kt)	Year	Source
Europe	Belgium	116	2012	Eurostat
	Bulgaria	38	2012	Eurostat
	Czech Republic	54	2012	Eurostat
	Denmark	76	2012	Eurostat
	Germany	691	2012	Eurostat
	Estonia	5.5	2012	Eurostat
	Ireland	41	2012	Eurostat
	Greece	47	2010	Eurostat
	Spain	158	2010	Eurostat
	France	434	2010	Eurostat
	Croatia	16	2012	Eurostat
	Italy	231	2012	Eurostat
	Cyprus	2.6	2010	Eurostat
	Latvia	4.7	2012	Eurostat
	Lithuania	14	2012	Eurostat
	Luxembourg	5.0	2012	Eurostat
	Hungary	44	2012	Eurostat
	Malta	1.5	2012	Eurostat
	Netherlands	128	2010	Eurostat
	Austria	77	2012	Eurostat
	Poland	175	2012	Eurostat
	Portugal	40	2012	Eurostat
	Romania	26	2010	Eurostat
	Slovenia	9	2012	Eurostat
	Slovakia	23	2012	Eurostat
	Finland	53	2012	Eurostat
	Sweden	169	2012	Eurostat
	United Kingdom	504	2012	Eurostat
	Iceland	1.6	2010	Eurostat
	Liechtenstein	0.1	2012	Eurostat
	Norway	105	2012	Eurostat
	Switzerland	129	2012	EMPA
America	Canada	122	2013	Electronic Products Recycling Association; Ontario Electronic Stewardship
	United States	1000	2012	US EPA

Continent	Country/region	Collection (kt)	Year	Source
Asia	China	1290	2013	China Ministry of Environment
	Hong Kong	55.8	2013	Hong Kong EPD
	Japan	511	2011	Japan AEHA
Oceania	Australia	41	2012	Australian Ministry of Environment
Africa	Mauritius	2	2011	Africa Institute 2012

ANNEX 3 : DATA OF E-WASTE DISPOSAL IN MIXED RESIDUAL WASTE

Country	Year	kg/inh.	kt	Source
Belgium	2010	1.53	17	(Wielenga et al. 2013)
Bulgaria	2010	0.00	0	(Dvoršak et al. 2011)
Czech Republic	2010	2.32	24	PhD thesis M. Polak, to be published
Denmark	2010	0.63	3	(Bigum et al. 2013)
Estonia	2011	3.76	5	(Moora 2013)
France	2007	1.00	62	(Monier et al. 2013)
Germany	2012	1.40	114	(LfU 2012), (UEC 2013)
Great Britain	2010	6.33	394	(WRAP 2012)
Italy	2012	1.01	61	(Magalini et al. 2012)
Luxemburg	2012	1.15	0.6	Personal communication to B. Mottet, CEO from Ecotrel.
Netherlands	2010	2.30	38	(Huisman et al. 2012)
Portugal	2007	1.51	16	Personal communication via FP-7 Project Countering –Waste Illegal Trade Project
Romania	2009	0.39	8	(Dvoršak et al. 2011)
Spain	2010	0.98	45	(Reuter et al. 2013)
Sweden	2010	1.23	12	(Avfall Sverige AB 2013)
Switzerland	2012	1.25	10	(Steiger 2012)

ANNEX 4 : CLASSIFICATION OF ELECTRICAL AND ELECTRONIC EQUIPMENT AND E-WASTE (UNU-KEYS)

UNU KEY	Description	Collection category
0001	Central Heating (household installed)	Large equipment
0002	Photovoltaic Panels (incl. converters)	Large equipment
0101	Professional Heating & Ventilation (excl. cooling equipment)	Large equipment
0102	Dishwashers	Large equipment
0103	Kitchen (f.i. large furnaces, ovens, cooking equipment)	Large equipment
0104	Washing Machines (incl. combined dryers)	Large equipment
0105	Dryers (wash dryers, centrifuges)	Large equipment
0106	Household Heating & Ventilation (f.i. hoods, ventilators, space heaters)	Large equipment
0108	Fridges (incl. combi-fridges)	Cooling and Freezing
0109	Freezers	Cooling and Freezing
0111	Air Conditioners (household installed and portable)	Cooling and Freezing
0112	Other Cooling (f.i. dehumidifiers, heat pump dryers)	Cooling and Freezing
0113	Professional Cooling (f.i. large air conditioners, cooling displays)	Cooling and Freezing
0114	Microwaves (incl. combined, excl. grills)	Small equipment
0201	Other Small Household (f.i. small ventilators, irons, clocks, adapters)	Small equipment
0202	Food (f.i. toaster, grills, food processing, frying pans)	Small equipment
0203	Hot Water (f.i. coffee, tea, water cookers)	Small equipment
0204	Vacuum Cleaners (excl. professional)	Small equipment
0205	Personal Care (f.i. tooth brushes, hair dryers, razors)	Small equipment
0301	Small IT (f.i. routers, mice, keyboards, external drives & accessories)	Small IT
0302	Desktop PCs (excl. monitors, accessoires)	Small IT
0303	Laptops (incl. tablets)	Screens
0304	Printers (f.i. scanners, multi-functionals, faxes)	Small IT
0305	Telecom (f.i. (cordless) phones, answering machines)	Small IT
0306	Mobile Phones (incl. smartphones, pagers)	Small IT
0307	Professional IT (f.i. servers, routers, data storage, copiers)	Large equipment
0308	Cathode Ray Tube Monitors	Screens
0309	Flat Display Panel Monitors (LCD, LED)	Screens
0401	Small Consumer Electronics (f.i. headphones, remote controls)	Small equipment
0402	Portable Audio & Video (f.i. MP3, e-readers, car navigation)	Small equipment
0403	Music Instruments, Radio, Hi-Fi (incl. audio sets)	Small equipment
0404	Video (f.i. Video recorders, DVD, Blue Ray, set-top boxes)	Small equipment
0405	Speakers	Small equipment
0406	Cameras (f.i. camcorders, photo & digital still cameras)	Small equipment

UNU KEY	Description	Collection category
0407	Cathode Ray Tube TVs	Screens
0408	Flat Display Panel TVs (LCD, LED, Plasma)	Screens
0501	Lamps (f.i. pocket, Christmas, excl. LED & incandescent)	Lamps
0502	Compact Fluorescent Lamps (incl. retrofit & non-retrofit)	Lamps
0503	Straight Tube Fluorescent Lamps	Lamps
0504	Special Lamps (f.i. professional mercury, high & low pressure sodium)	Lamps
0505	LED Lamps (incl. retrofit LED lamps & household LED luminaires)	Lamps
0506	Household Luminaires (incl. household incandescent fittings)	Small equipment
0507	Professional Luminaires (offices, public space, industry)	Small equipment
0601	Household Tools (f.i. drills, saws, high pressure cleaners, lawn mowers)	Small equipment
0602	Professional Tools (f.i. for welding, soldering, milling)	Large equipment
0701	Toys (f.i. car racing sets, electric trains, music toys, biking computers)	Small equipment
0702	Game Consoles	Small IT
0703	Leisure (f.i. large exercise, sports equipment)	Large equipment
0801	Household Medical (f.i. thermometers, blood pressure meters)	Small equipment
0802	Professional Medical (f.i. hospital, dentist, diagnostics)	Large equipment
0901	Household Monitoring & Control (alarm, heat, smoke, excl. screens)	Small equipment
0902	Professional Monitoring & Control (f.i. laboratory, control panels)	Large equipment
1001	Non Cooled Dispensers (f.i. for vending, hot drinks, tickets, money)	Large equipment
1002	Cooled Dispensers (f.i. for vending, cold drinks)	Cooling and Freezing

 Photo Credit: HPP GmbH

10. About UNU-IAS-SCYCLE

Image of E-waste Academy - Science Edition 2009
(Photo credit: Gerad van Bree)

ABOUT UNU-IAS-SCYCLE

UNITED NATIONS UNIVERSITY
UNU-IAS
Institute for the Advanced Study of Sustainability

United Nations University (UNU)

The United Nations University is an international community of scholars engaged in research, postgraduate training and the dissemination of knowledge in furtherance of the purposes and principles of the United Nations, its Peoples and Member States. The University functions as a think tank for the United Nations system, contributes to capacity building, particularly in developing countries, and serves as a platform for new and innovative ideas and dialogue.

UNU Institute for the Advanced Study of Sustainability (UNU-IAS)

UNU-IAS is a new UNU institute, created in January 2014 by consolidating the former UNU Institute of Advanced Studies and UNU Institute for Sustainability and Peace (UNU-ISP). It is based at UNU Headquarters in Tokyo. The mission of UNU-IAS is to serve the international community through policy-relevant research and capacity development focused on sustainability, including its social, economic and environmental dimensions.

UNU-IAS applies advanced research methodologies and innovative approaches to challenge conventional thinking and develop creative solutions to emerging issues of global concern in these areas. The institute's research, education and training combine expertise from a wide range of areas related to sustainability, and engage a global network of scholars and partner institutions. Through postgraduate teaching UNU-IAS develops international leaders with the interdisciplinary understanding and technical skills needed to advance creative solutions to problems of sustainability.

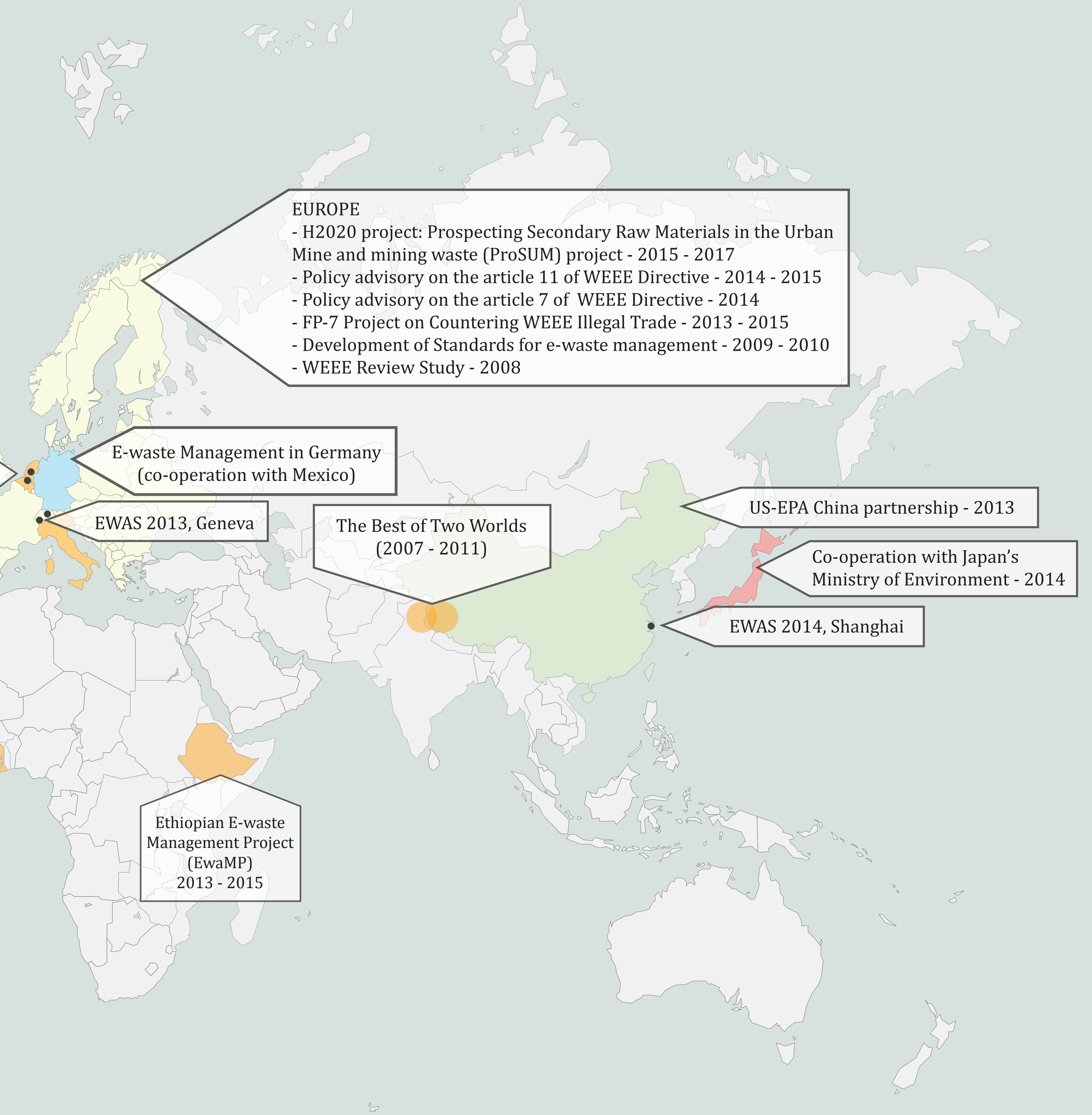
UNU-IAS Operating Unit Sustainable Cycles (UNU-IAS-SCYCLE)

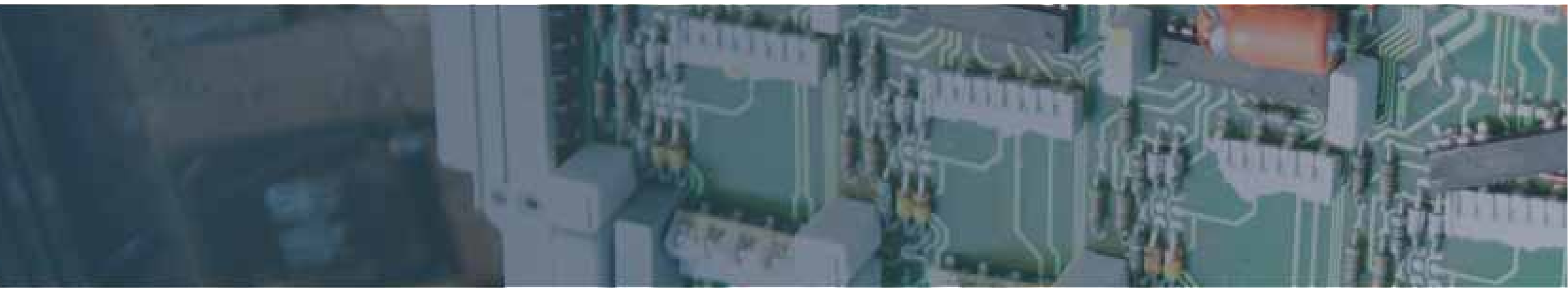
UNU-IAS-SCYCLE is an operating unit of UNU-IAS based in Bonn, Germany. Its activities are focused on the development of sustainable production, consumption and disposal scenarios for electrical and electronic equipment, as well as other ubiquitous goods. SCYCLE leads the global e-waste discussion and advances sustainable e-waste management strategies based on life-cycle thinking.

Within this context UNU-IAS-SCYCLE:

- conducts research on eco-structuring towards sustainable societies;
- develops interdisciplinary and multi-stakeholder public-private partnerships;
- assists governments in developing e-waste legislation and standards, meeting a growing need for such support;
- undertakes education, training and capacity development; and
- facilitates and disseminates practical, science-based recommendations to the United Nations and its agencies, governments, scholars, industry and the public.

E-WASTE WORK OF UNU-IAS-SCYCLE


EUROPE
- H2020 project: Prospecting Secondary Raw Materials in the Urban Mine and mining waste (ProSUM) project - 2015 - 2017
- Policy advisory on the article 11 of WEEE Directive - 2014 - 2015
- Policy advisory on the article 7 of WEEE Directive - 2014
- FP-7 Project on Countering WEEE Illegal Trade - 2013 - 2015
- Development of Standards for e-waste management - 2009 - 2010
- WEEE Review Study - 2008
E-waste Management in Germany (co-operation with Mexico)
EWAS 2013, Geneva
The Best of Two Worlds (2007 - 2011)
US-EPA China partnership - 2013
Co-operation with Japan's Ministry of Environment - 2014
EWAS 2014, Shanghai
Ethiopian E-waste Management Project (EwaMP) 2013 - 2015



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