The Global E-waste Monitor 2020

Quantities, flows, and the circular economy potential

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Chapter 7

The Potential of E-waste in a Circular Economy


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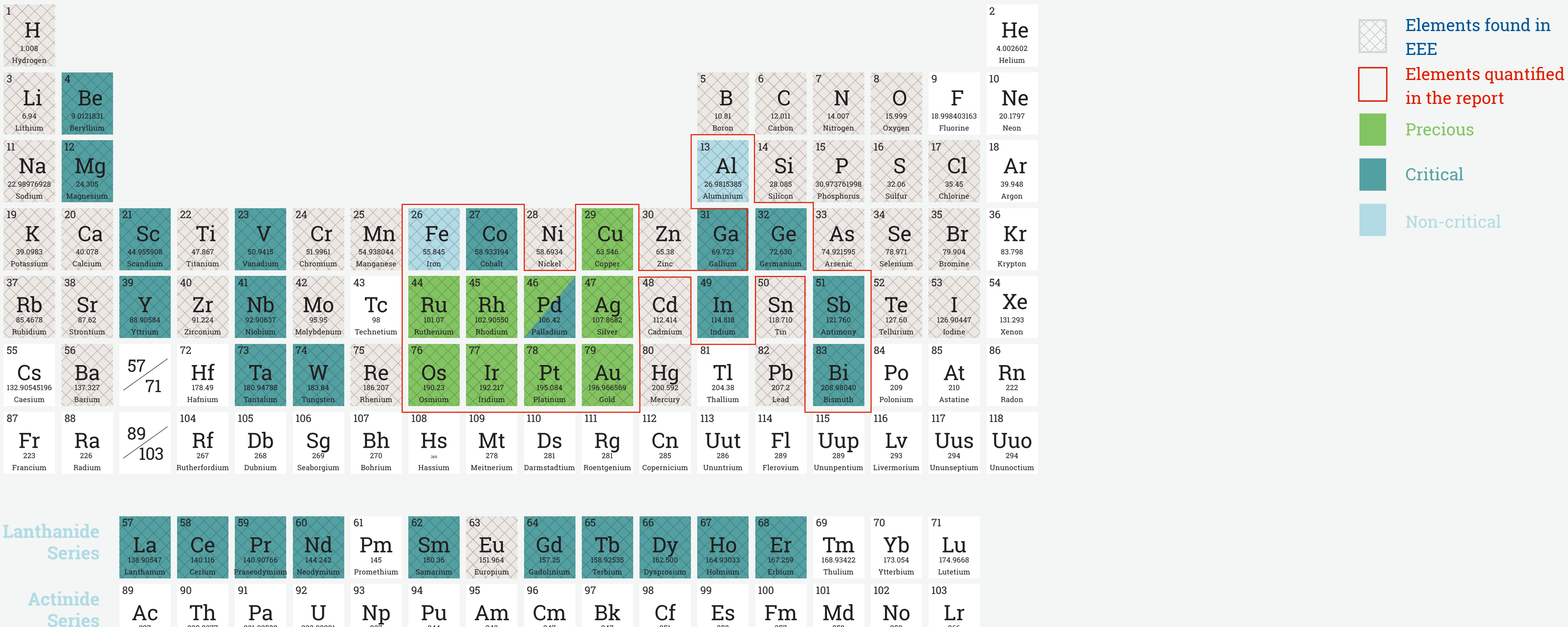
From a material design perspective, EEE is very complex. Up to 69 elements from the periodic table can be found in EEE, including precious metals (e.g. gold, silver, copper, platinum, palladium, ruthenium, rhodium, iridium, and osmium), Critical Raw Materials (CRM)[7] (e.g. cobalt, palladium, indium, germanium, bismuth, and antimony), and non-critical metals, such as aluminium and iron.

Within the paradigm of a circular economy, the mine of e-waste should be considered an important source of secondary raw materials. Due to issues relating to primary mining, market price fluctuations, material scarcity, availability, and access to resources, it has become necessary to improve the mining of secondary resources and reduce the pressure on virgin materials. By recycling e-waste, countries could at least mitigate their material demand in a secure and sustainable way.

This report shows that, globally, only 17.4% of e-waste is documented to be formally collected and recycled. Collection and recycling rates need to be improved worldwide.

On the other hand, the recycling sector is often confronted with high costs of recycling and challenges in recycling the materials. For instance, the recovery of some materials such as germanium and indium is challenging because of their dispersed use in products, and the products are neither designed nor assembled with recycling principles having been taken into account.

On the other hand, base metals (e.g. gold) used in certain devices, such as mobile phones and PCs, have a relatively high level of concentration: 280 grams per ton of e-waste. Methods employed to separate and recycle e-waste can be economically viable, especially if carried out manually, where the material losses are less than 5% (Deubzer 2007). Separate collection and recycling of e-waste can thus be economically viable for products containing high concentrations and contents of precious metals. Nevertheless, the recycling rate of most CRMs is still very low and can be improved for precious metals by better collection and pre-treatment of e-waste.



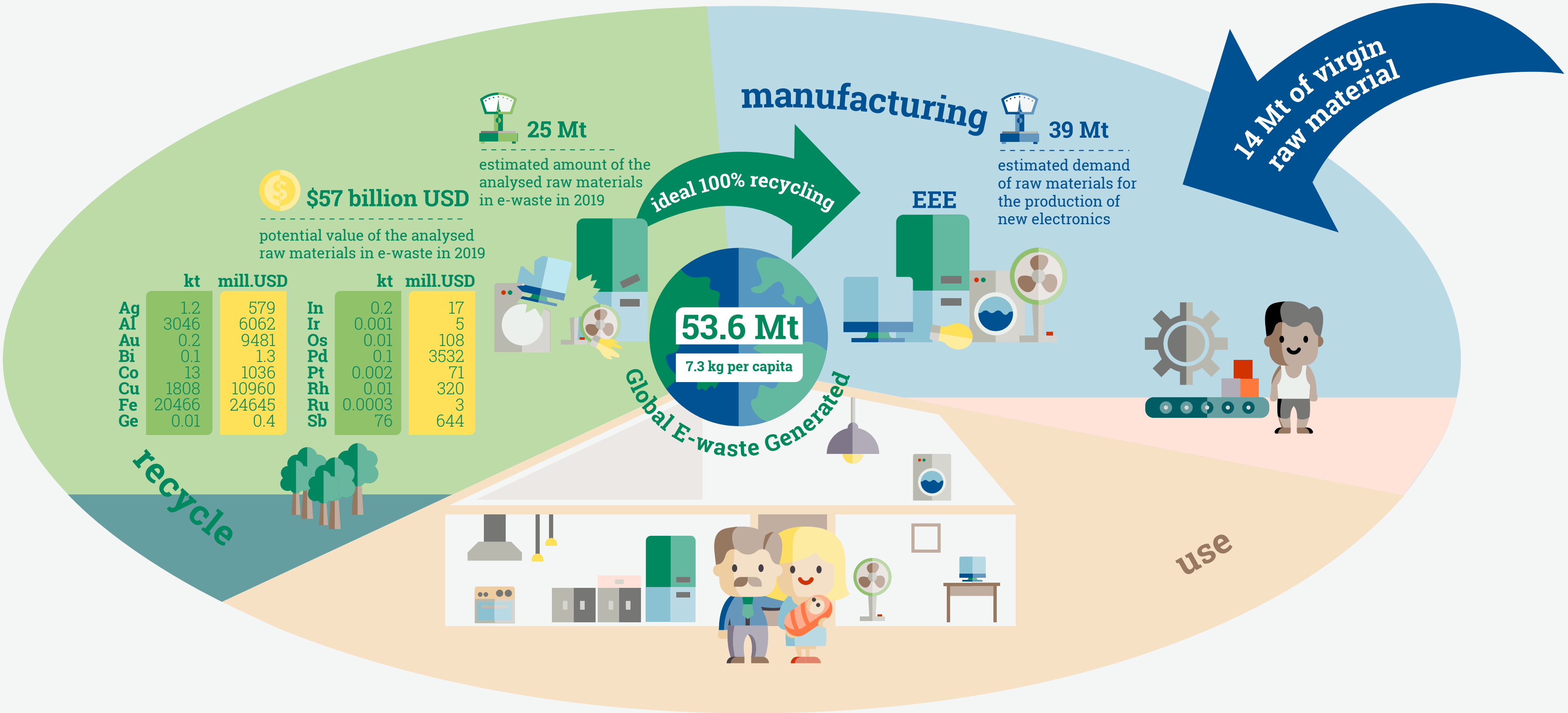
Source: Deubzer et al. 2019

Overall, the value of selected raw materials[8] contained in e-waste in 2019 was equal to approximately $57 billion USD[9], corresponding to a total of 25 Mt.

Iron, aluminium, and copper represent the majority of the total weight of raw waste materials that can be found in e-waste in 2019. These quantities and the material value could be recovered only in an ideal scenario in which all e-waste generated globally is recycled and the recycling of all selected raw materials is economically viable or even feasible with the recycling technologies currently available.

By improving e-waste collection and recycling practises worldwide, a considerable amount of secondary raw materials – precious, critical, and non-critical – could be made readily available to re-enter the manufacturing process while reducing the continuous extraction of new materials.

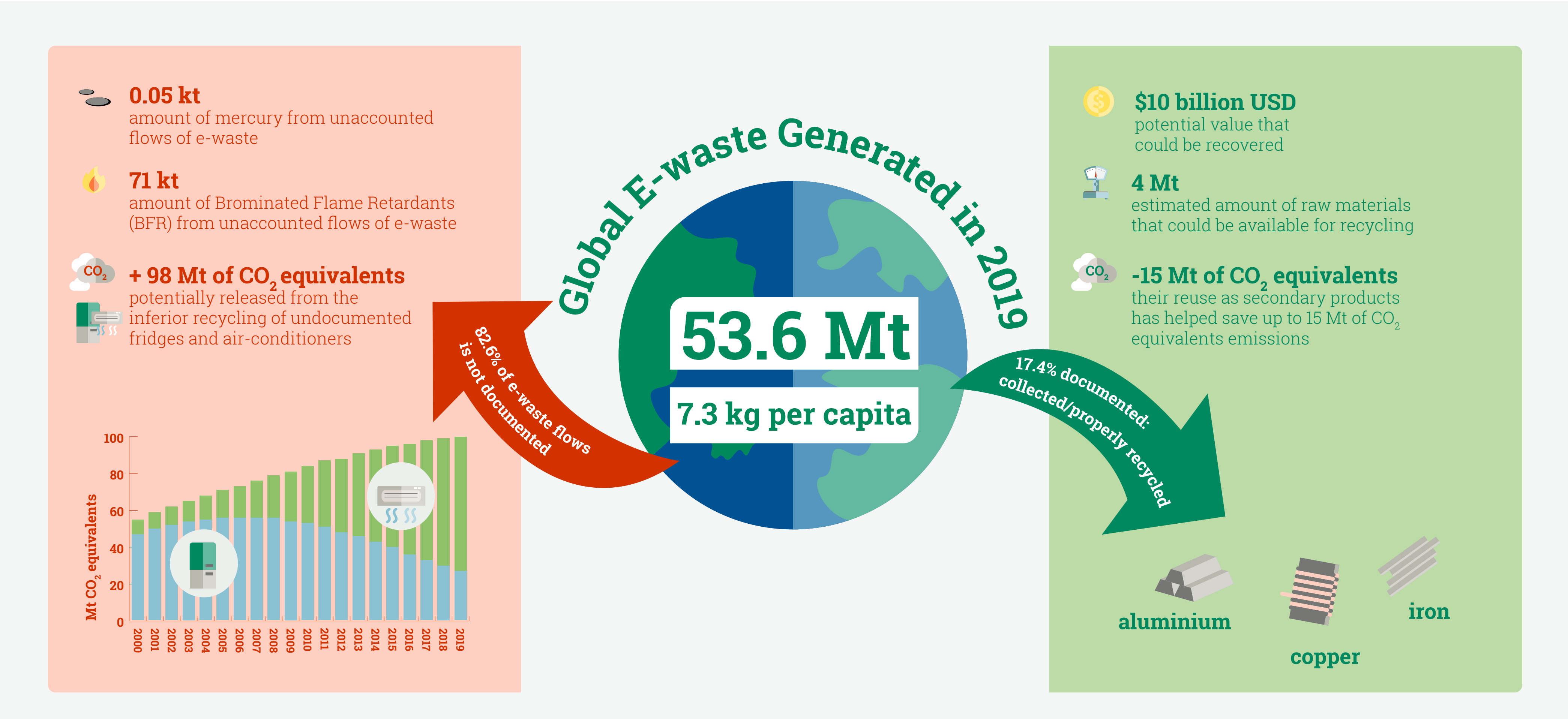
The demand of iron, aluminium, and copper for the production of new electronics in 2019 was approximately 39 Mt. Even in an ideal scenario in which all the iron, copper and aluminium resulting from e-waste (25 Mt) is recycled, the world would still require approximately 14 Mt of iron, aluminium and copper from primary resources to manufacture new electronics (11.6 Mt, 1.4 Mt, and 0.8 Mt, respectively).[10] This indicates that the gap between the secondary iron, aluminium and copper found in e-waste and their demand for the production of new EEE is quite large. This is a consequence of the continuous growth of sales of EEE.



	kt	mill.USD		kt	mill.USD
Ag	1.2	579	In	0.2	17
Al	3046	6062	Ir	0.001	5
Au	0.2	9481	Os	0.01	108
Bi	0.1	1.3	Pd	0.1	3532
Co	13	1036	Pt	0.002	71
Cu	1808	10960	Rh	0.01	320
Fe	20466	24645	Ru	0.0003	3
Ge	0.01	0.4	Sb	76	644

With the current documented formal collection and recycling rate of 17.4%, a potential raw material value of $10 billion USD can be recovered from e-waste, and 4 Mt of secondary raw materials would become available for recycling. Focusing only on iron, aluminium, and copper and comparing emissions resulting from their use as virgin raw materials or secondary raw materials, their recycling has helped save up to 15 Mt of CO_2 equivalent emissions in 2019 (see Annex 2 for details on the methodology).

EEE also contains hazardous substances, usually heavy metalssuch as mercury, cadmium, or lead and chemicals such as chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and flame retardants. Approximately 71 kt of plastic containing BFR (Brominated Flame Retardants) arise from the unaccounted flows of e-waste generated in 2019 (see Annex 2 for details on the methodology). In particular, BFR are used in appliances to reduce the product's flammability, appearing, for example, in outer casings of computers, printed wiring boards, connectors, relays, wires, and cables (McPherson, Thorpe, and Blake 2004 & Herat 2008). The recycling of plastic containing BFR represents a major challenge for e-waste recycling because of the costs related to the separation of plastic containing PBDEs and PBBs from other plastic. Recycled plastic with PBDE and PBB content higher than 0.1% cannot be used for manufacturing of any products, including EEEs. In most cases, compliant recyclers incinereate plastic containing PBDEs and PBBs under controlled conditions to avoid the release of dioxins and furans. On the other end, if incineration is not carried out in an environmentally sound manner, those substances are likely to pose risks to health or the environment. The use of PBDEs and PBBs have been banned in Europe (European Parliament 2011). Some of these contaminants have been banned in Europe, as risk assessment studies have shown that they are persistent, bioaccumulative, and toxic, and can be responsible for kidney damage, several skin disorders, and nervous and immune systems and effects to the nervous and immune systems.

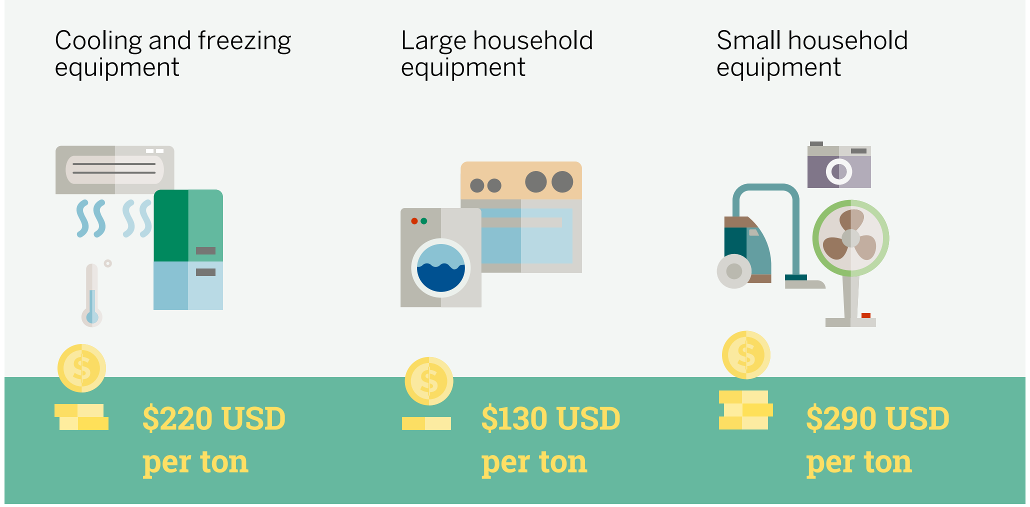


Mercury is used in fluorescent light sources, e.g. in background lights of older flat panel displays and TVs, in compact fluorescent lamps ("energy-saving lamps"), fluorescent lamps, in measure and control equipment, and in old switches. (Baldé et al. 2018). If these appliances are abandoned in open dumpsites as opposed to being properly recycled, mercury can enter the food chain and accumulate in living organisms while bringing damage to the central nervous system, thyroid, kidneys, lungs, immune system, etc (Baldé et al. 2018). A total of 50 t of mercury can be found in the unaccounted flows of e-waste generated in 2019 worldwide.

Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs) are present in refrigerant circuits and insulating foams of older generations of cooling and freezing equipment, such as refrigerators, freezers, and air-conditioning systems. These molecules have a long lfespan in the atmosphere. They react with ozone molecules (O_3), generating molecular oxygen that thins the stratospheric ozone layer (ozone hole). This process leads to an increment of the UV radiation that can pass the stratosphere, likely causing skin cancers, eye-related diseases, and a weakening of the immune system. The Montreal Protocol (adopted in 1987) regulates the production and consumption of manmade chemicals known as ozone-depleting substances, which includes the phasing out of CFCs and HCFCs. These gases have high global warming potential (GWP). If EEE containing these gases is not managed in an environmentally sound manner, refrigerants could be emitted into the atmosphere. Estimations show that a total of 98 Mt of CO_2 equivalents[11] were released from the inferior recycling of undocumented fridges and air conditioners (40% in Europe and 82.6% in the rest of the world). Greenhouse gas (GHG) emissions from the improperly managed refrigerants estimated to be found in air conditioners overtook the emissions from fridges in 2013. In 2019, of the total CO_2 equivalents estimated to be released into the atmosphere, 73% were from air conditioners and 27% were from fridges. This is explained by the fact that refrigerants with high global warming potential were used before 1994 (e.g. R-11 and R-12) and until 2017 (R-134a and R-22). Since then, the refrigerants have been substituted by others with a substantially lower GWP (e.g. R-152a and R-124yf). The decrease of CO_2 equivalent emissions, reflecting the recent obligations for replacing the refrigerants, will be observed only in the next decades, when the new products placed on the market will become waste (see Annex 2 for details on the methodology).

The presence of hazardous substances and scarce or valuable materials in e-waste makes it necessary to recycle and treat the e-waste in an environmentally sound manner; doing so helps avoid the release of such substances into the environment and the losses of ecologically and economically valuable materials. Although several pieces of legislation have banned the use of some substances and are pushing for them to be replaced by safer materials, appliances that were produced in the past and still contain those substances must, once discarded, be treated adequately in order to contain the risks that they can pose to the environment and health. In addition, new equipment may also still contain smaller amounts of those banned substances, due to the fact that they technically cannot yet be substituted or eliminated.

It can be assumed that at least most e-waste collection, treatment, and disposal in the formal sector is legally compliant, thus taking care of the environmental, health, and safety aspects. This assumption may not be applicable for treatment and disposal outside the formal sector. Non-compliant recycling proves to be a cheaper option than the compliant recycling. A recent study by the European Electronics Recyclers Association (EERA) and the United Nations University (Magalini and Huisman 2018) shows that a European compliant recycler incurs substantially higher costs than a non-compliant recycler. In detail, the compliant recyclers based in Europe normally incur technical costs such as costs related to treatment, de-pollution, disposal of hazardous fractions, and disposal of non-hazardous fractions, as well as the proof of legal compliance, quality, and service level.



Source: Magalini and Huisman 2018

The study concludes that the potential cost reductions that can be realised by non-compliant treatment exceed the normal economic margins of legitimate recyclers, applying best available technology and ensuring full compliance, which leads to unfair competition.

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