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AWARE
educating for e-waste recycling

E-waste – trash or treasure?

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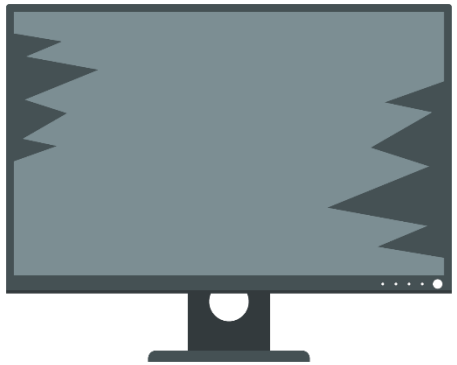
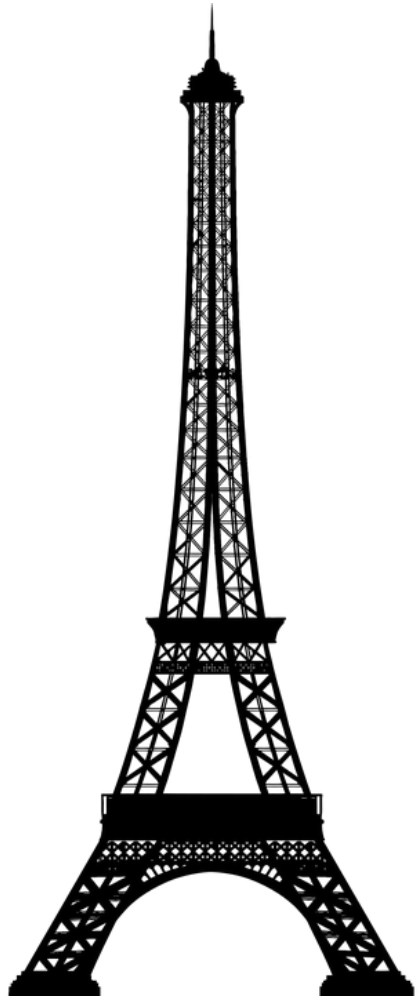
E-waste is one of the fastest growing waste streams



- **E-waste** means electrical and electronic waste. It includes broken or otherwise discarded devices such as mobile phones, laptops, televisions etc.
- Globally over 50 million tonnes of e-waste is generated annually – this equals the amount of over 5000 Eiffel towers!
  - This means 7.3 kg of e-waste per person each year.
- In Europe, 16.2 kg of e-waste per person is generated each year.



More information: http://ewastemonitor.info/

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What happens to e-waste?

- Globally only 20 % of e-waste is collected and recycled properly.

- In Europe slightly less than 50 % is collected and recycled properly.

- Where does the rest of e-waste end up?
  - Municipal waste or metal recycling
  - Stored at households (especially small equipment)
  - Unofficial recycling

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Result: loss of valuable resources

- Electronics contain many materials such as **metals, plastics and ceramics**. Many of these materials are
  - Valuable
  - Scarce
  - Listed as critical raw materials (CRM)

- It is estimated that **23 tonnes of gold, 118 tonnes of silver and 5 tonnes of platinum** in e-waste ends up in unknown destinations in the EU each year.

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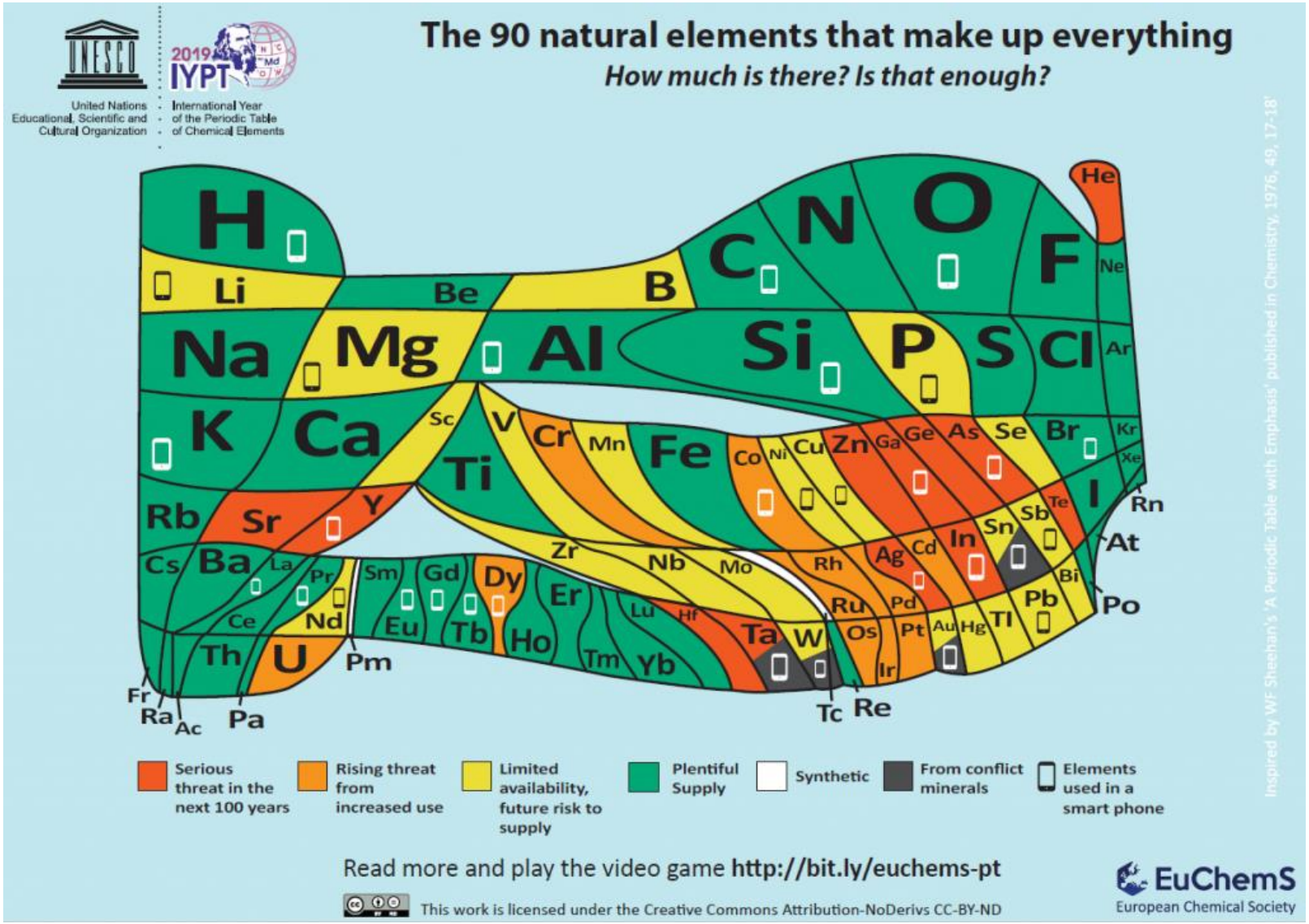
Are there enough resources in the future?



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More information available at: https://www.euchems.eu/euchems-periodic-table/

Urban mining means recovery of materials from different waste streams

- E-waste often contains higher concentrations of precious metals than ores.
  - For example the amount of gold in e-waste can be hundred fold compared to the amount of gold in ores.
  - The gold contained in about 100 mobile phones is enough to produce a ring.

- Even though the amount of valuable materials in one mobile phones is small (about 2€ of value), total amount of mobile phone waste was estimated 435 kilotonnes in 2016. Potential value of these raw materials equals **9.4 billion €**.

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Materials in electronics

Metals

Glass and ceramics

Plastics

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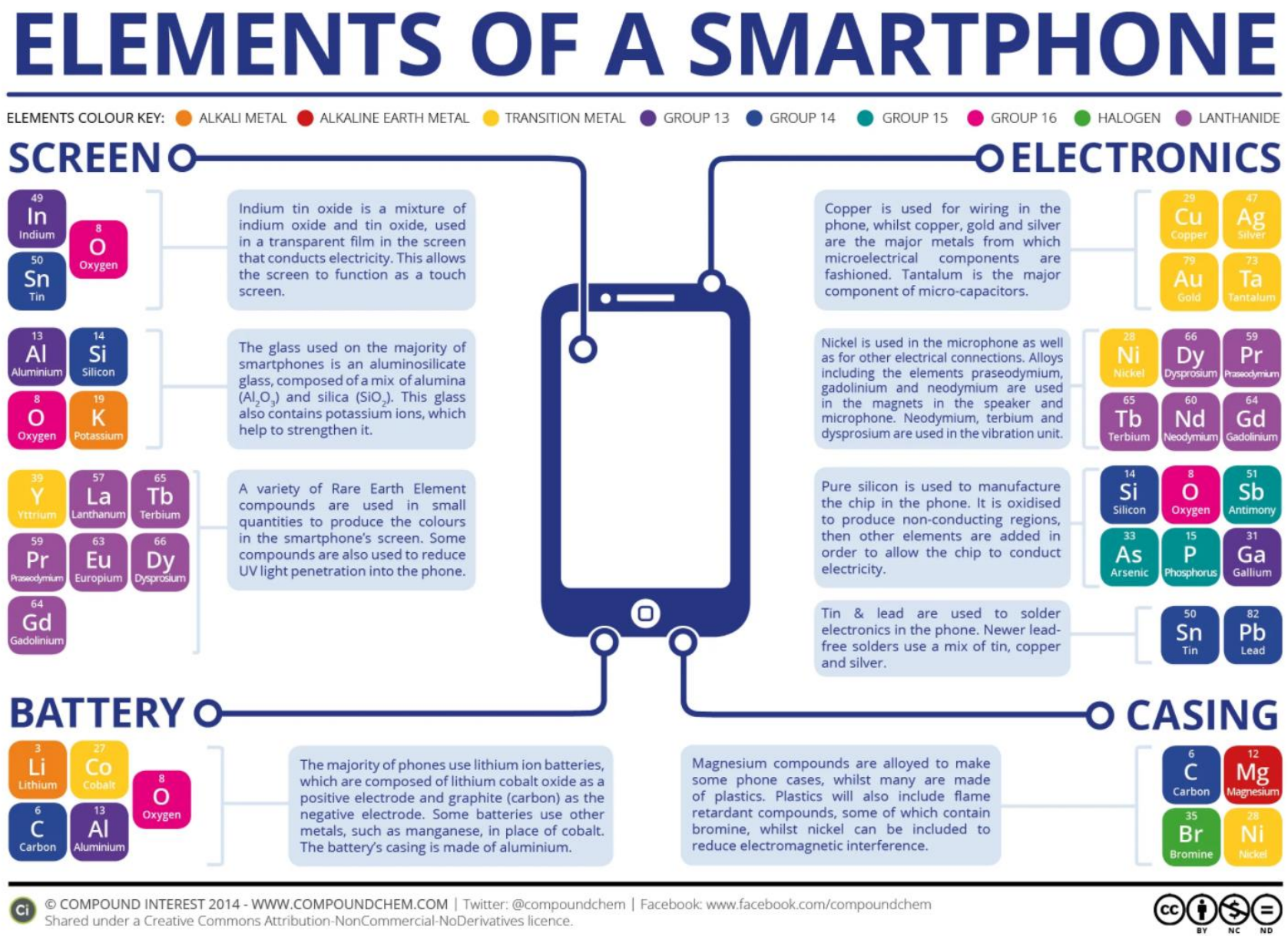
Materials in a smart phone

- Smart phones can contain over 60 different elements from the periodic table!

- Concentrations of scarce and valuable materials in one device is very small, but they are important for many functions (such as light weight batteries, touch screens, and very small circuit boards)



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More information: https://www.compoundchem.com/2014/02/19/the-chemical-elements-of-a-smartphone/

Origin of the metals used in electronic: Mining industry

Picture: Stephen Codrington (under CC BY 2.5)

- Only small fraction of metals used in electronics is secondary materials (from recycling). Most of the materials are primary materials mined from the earth.
- Mining industry is very resource and energy intensive.
  - Recycling of metals saves energy when compared to producing new metals from ores.

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What are critical raw materials (CRM)?

- Critical raw materials are materials that are essential for many important applications, but which are associated with **high risk in their supply**.

2020 critical raw materials (new as compared to 2017 in bold)		
Antimony	Hafnium	Phosphorus
Baryte	Heavy Rare Earth Elements	Scandium
Beryllium	Light Rare Earth Elements	Silicon metal
Bismuth	Indium	Tantalum
Borate	Magnesium	Tungsten
Cobalt	Natural graphite	Vanadium
Coking coal	Natural rubber	**Bauxite**
Fluorspar	Niobium	**Lithium**
Gallium	Platinum Group Metals	**Titanium**
Germanium	Phosphate rock	**Strontium**

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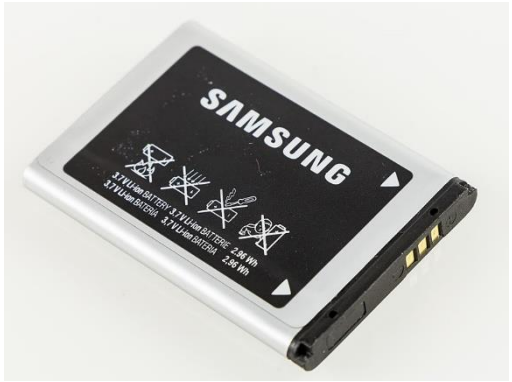
Where are critical raw materials used?

- Examples of electronic components utilizing critical raw materials:
  - Magnets: NdFeB permanent magnets include neodymium and dysprosium. These are the strongest permanent magnets and they are important in electric vehicles and wind power generators.
  - Batteries: cobalt, natural graphite and lithium are important materials in manufacturing lithium ion batteries.
  - Printed circuit boards (PCB): PCB are found in almost all electronic devices. They can include for example palladium, gallium, tantalum and beryllium.



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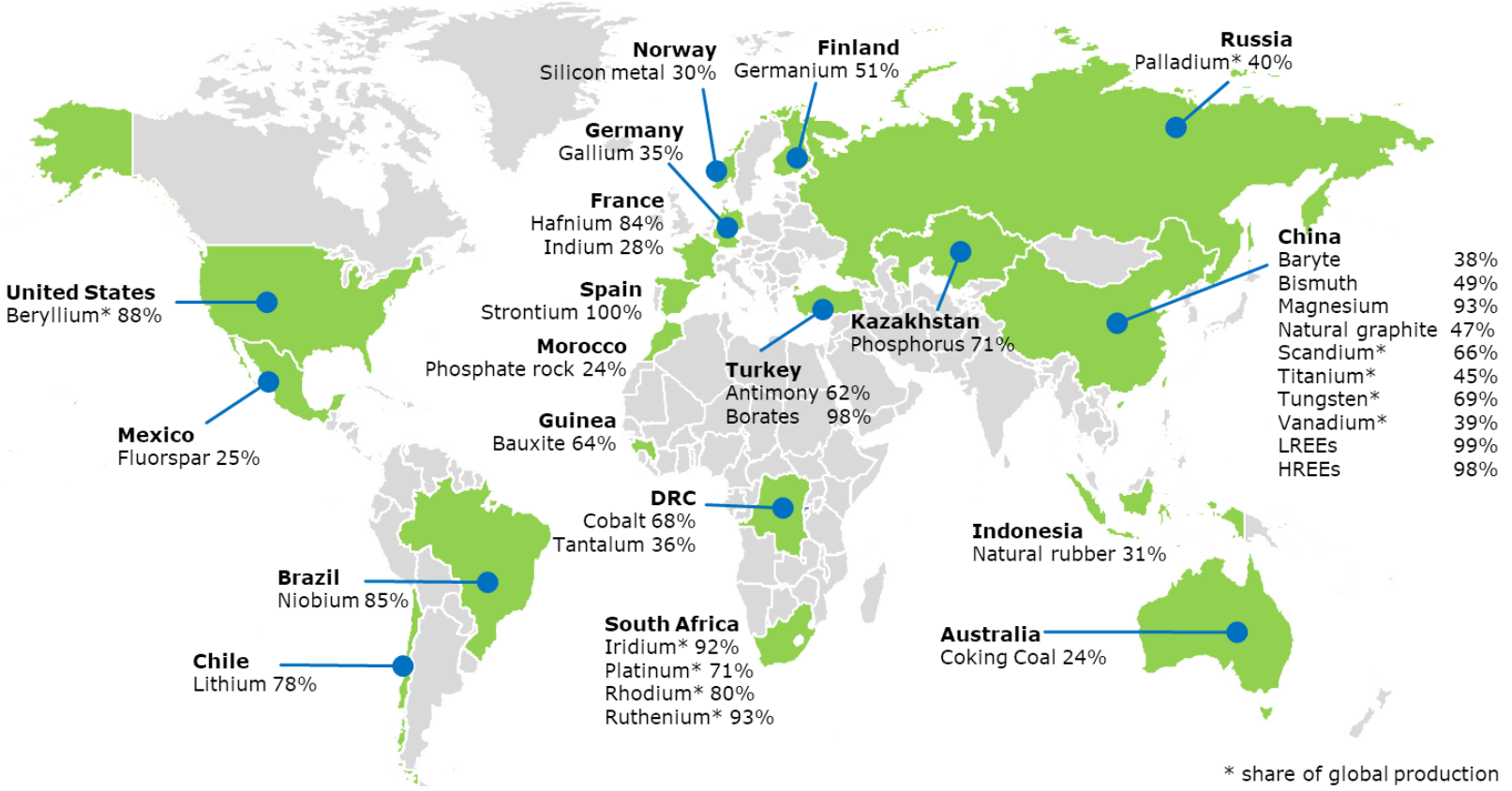
The origin of critical raw materials

- The supply of critical raw materials is highly concentrated.
  - 98-99 % of rare earth elements (REE) supply to EU is from China
  - 68 % of cobalt supply to EU is from Democratic Republic of Congo
  - Major share of platinum group metals is from Russia and South Africa
- Dependency on import is associated with low substitution and low recycling rates

Countries accounting for largest share of EU supply of CRMs



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More information: https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

Conflict minerals

- **Conflict minerals**: *Mineral-rich countries afflicted by conflicts face a vicious circle in which revenue from illegally extracted resources feeds armed revolts. … the Democratic Republic of the Congo and the Great Lakes region are the most obvious examples.*
    - Conflict minerals include tin, tantalum, tungsten and gold which are used in the production of many electronic devices

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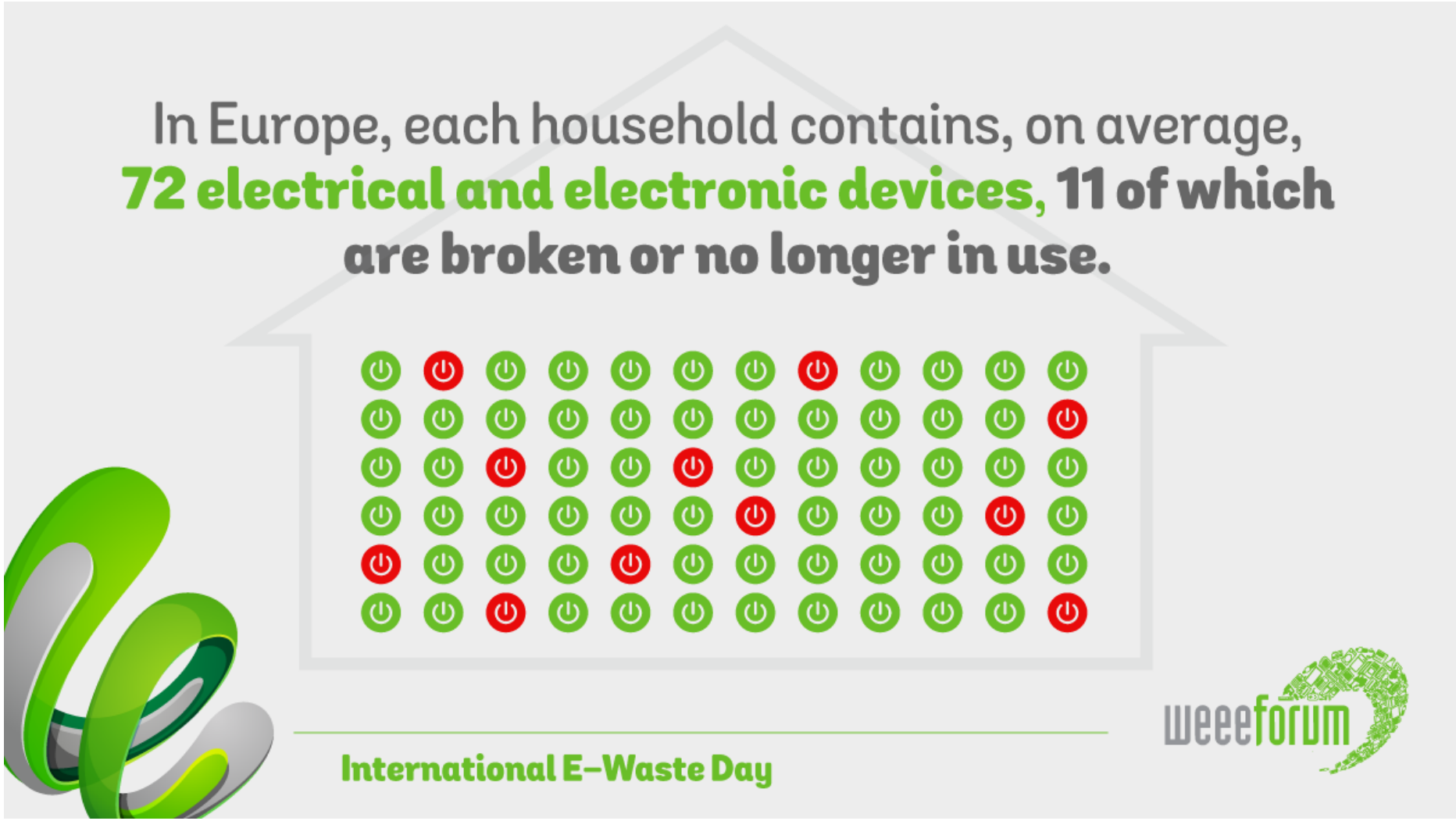
https://www.europarl.europa.eu/news/en/press-room/20170308IPR65672/conflict-minerals-meps-secure-due-diligence-obligations-for-importers

Electronics in everyday life



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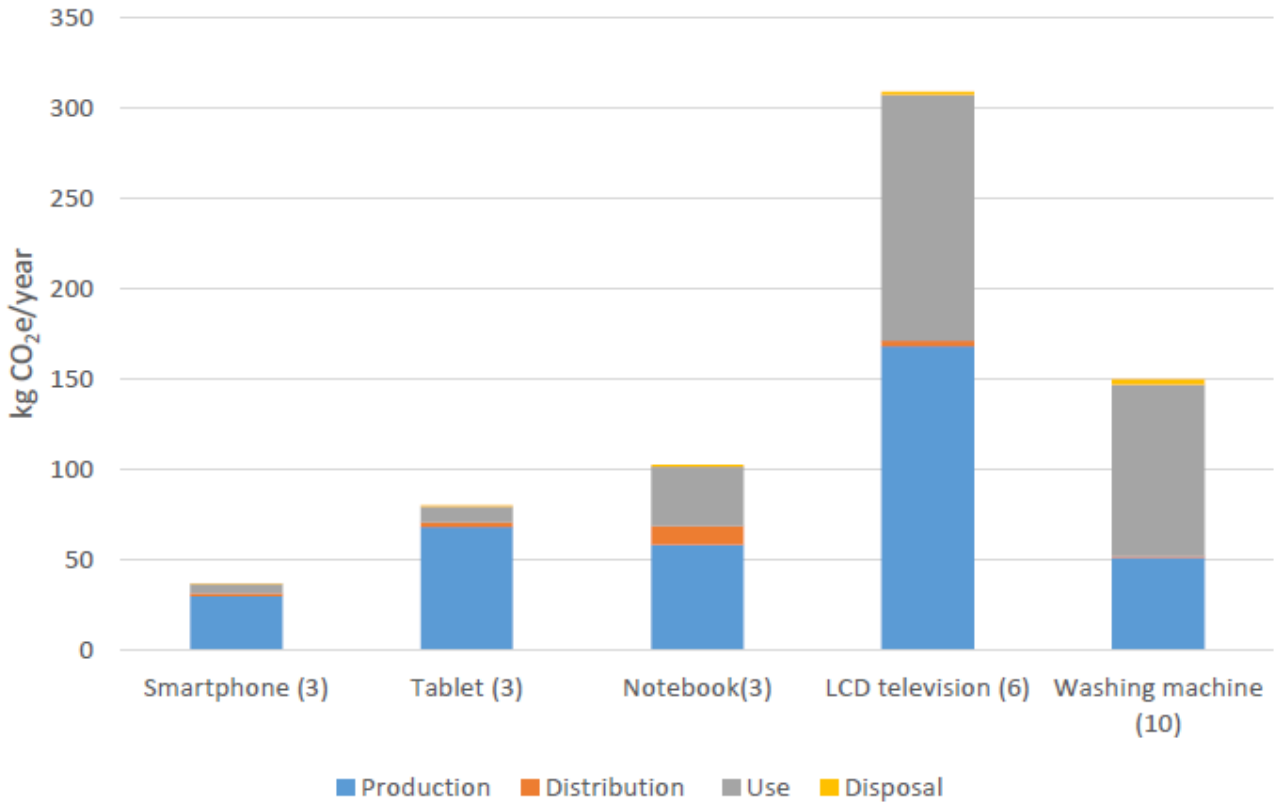
https://weee-forum.org/iewd-gallery/

Environmental impacts of electronics

- Manufacturing and use of electronics have significant impacts on the environment
- The impact of different electronic devices over the life cycle varies significantly.
    - For some devices, such as washing machines and tumble dryers, most emissions are from the use phase, while for mobile phones, most emissions are from resource extraction and production.



Note: The number in brackets refers to the lifespan of the product
LCD = liquid crystal display

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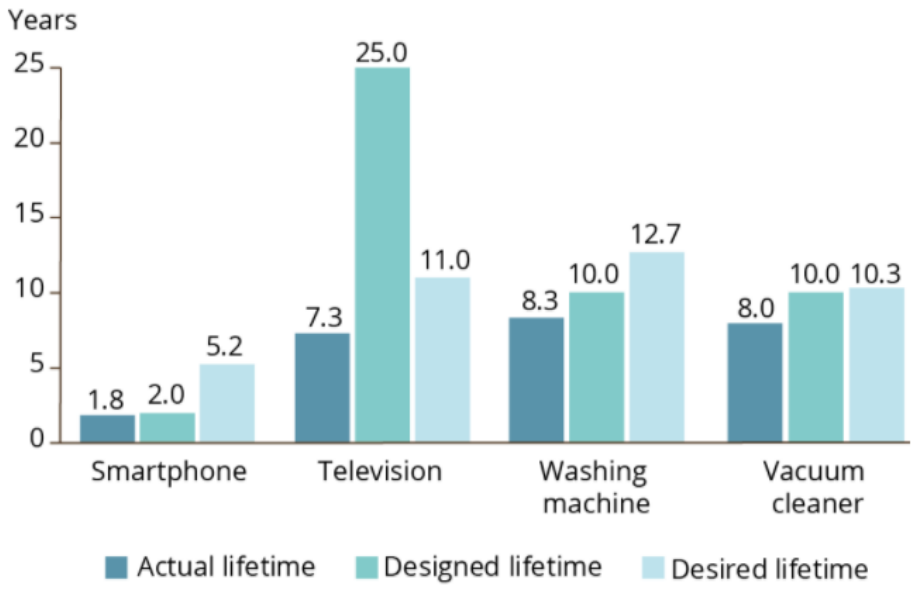
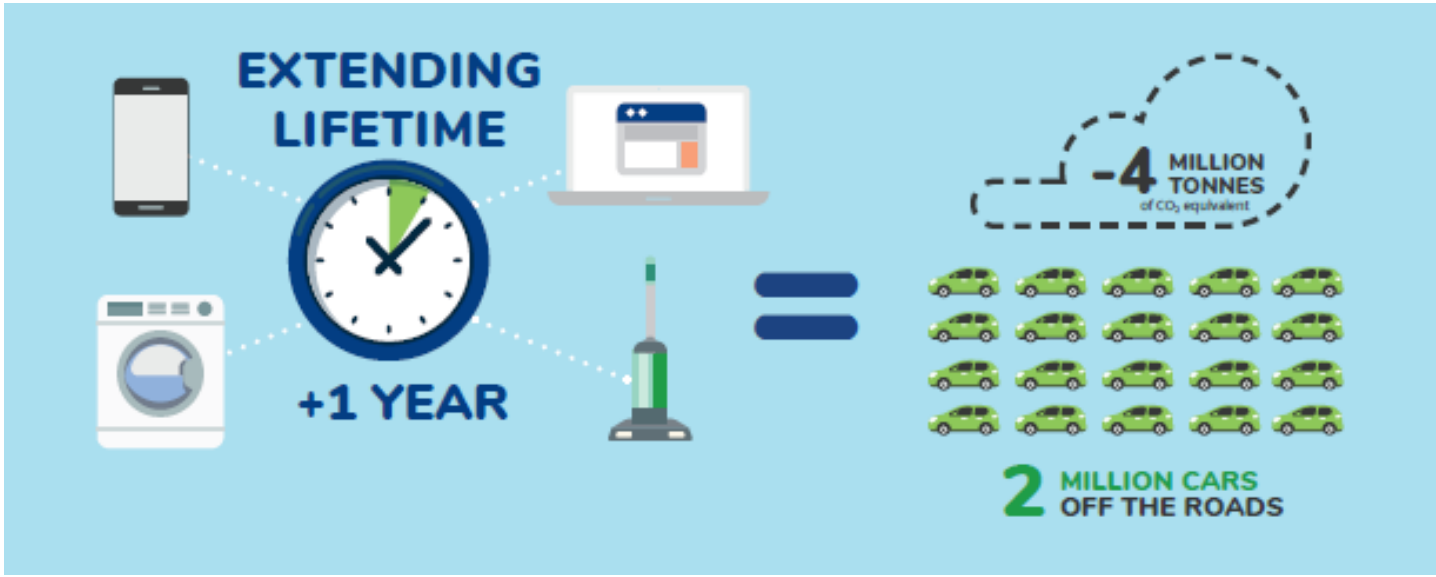
Figure: https://www.eea.europa.eu/themes/waste/resource-efficiency/benefits-of-longer-lasting-electronics

Lifetime of electronics

- Actual lifetimes of many electronic devices are typically shorter than their designed or desired lifetimes that consumers want products to last.
- Extending the lifetime of electronics can significantly reduce their environmental impacts.

Figure 2. Lifetimes for smartphones, televisions, washing machines and vacuum cleaners





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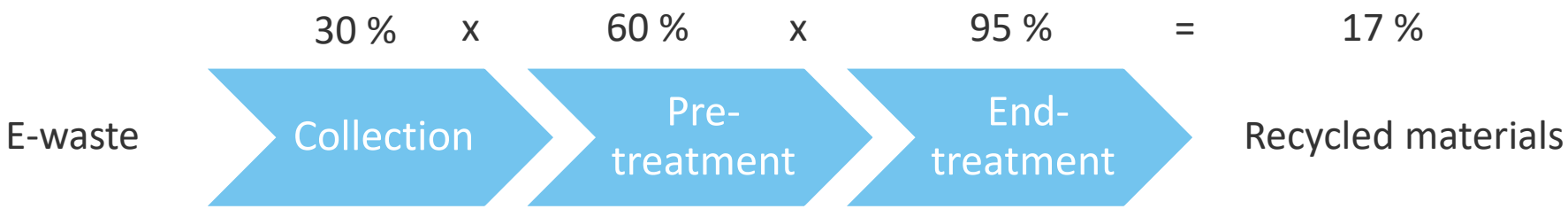
Figures and more information: https://www.eea.europa.eu/themes/waste/resource-efficiency/benefits-of-longer-lasting-electronics & www.eeb.org/coolproducts-report

How valuable resources are recovered from e-waste?
Collection and recycling of e-waste

- Especially small portable electronics pile up in households instead of people bringing them to recycling.
- First step in improving the e-waste recycling rate is to improve the collection of the discarded devices.
    - Role of consumers important.



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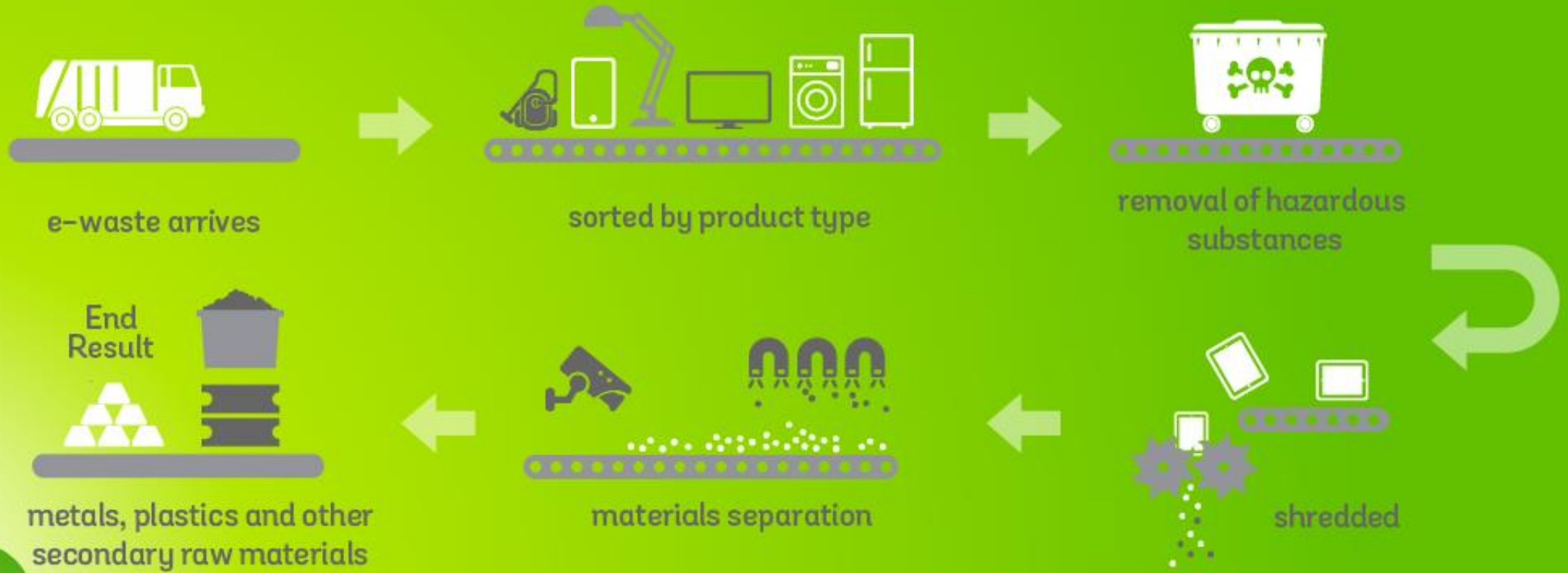
What happens in an **e-waste recycling plant?***



*obviously this makes it look more simple than it really is!
Recycling of e-waste is complex and the process can vary depending on many factors

International E-Waste Day

weeeforum

Challenges in recycling e-waste

- Some common metals are well recycled already, but many others are not recycled at all.
- Several challenges exist in the recovery of the materials from e-waste:
  - Miniaturization of components, small concentrations of precious elements, integrated components -> difficult to separate many materials from e-waste.
  - Plastics in e-waste are challenging because they often contain hazardous substances.
  - Important to increase collection rate.

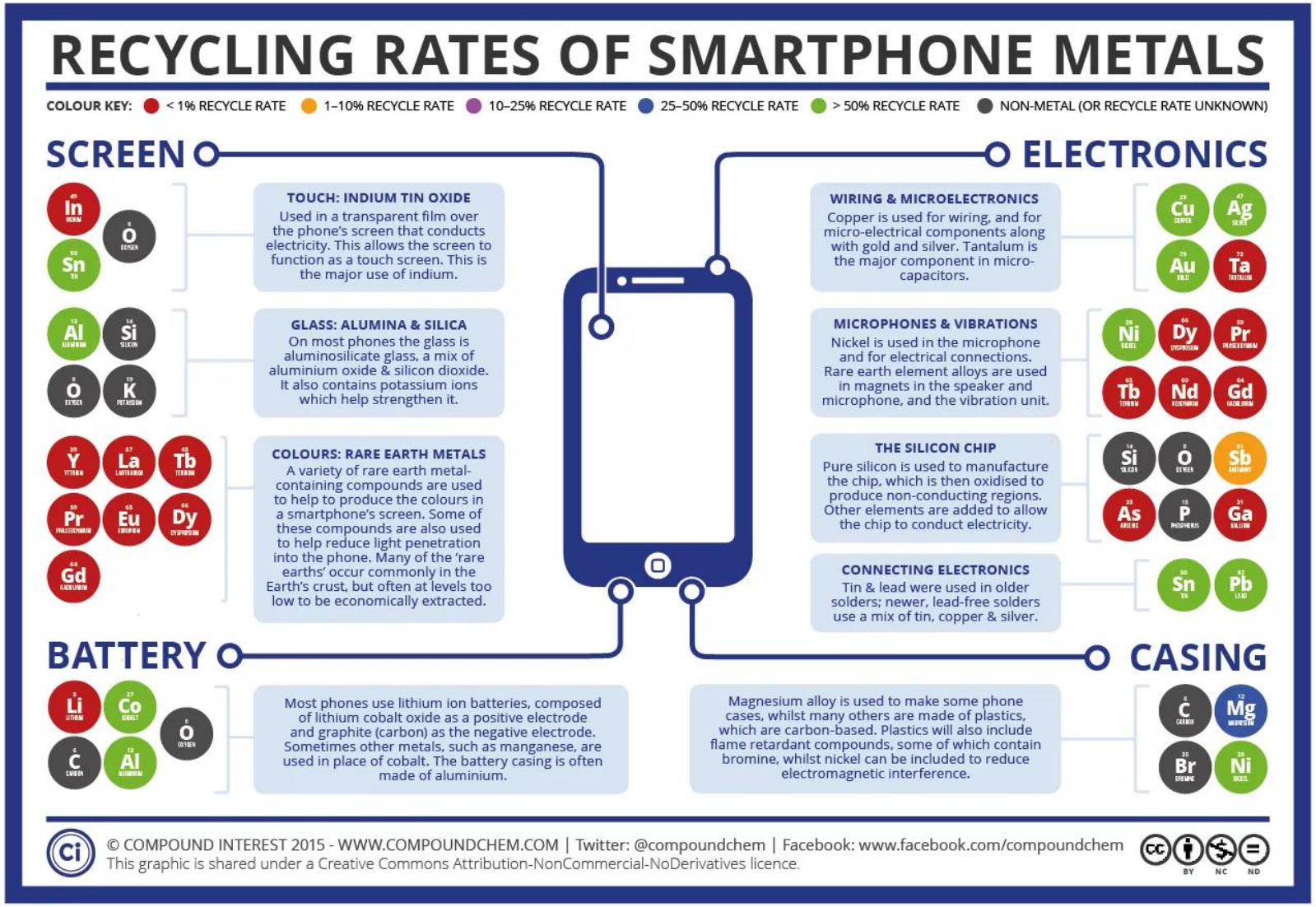


Figure: https://www.compoundchem.com/2015/09/15/recycling-phone-elements/

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Hazardous substances in e-waste

- In addition to valuable and scarce materials, e-waste contains many substances hazardous to environment and health. These include for example heavy metals and other substances that might be carcinogenic or bio-accumulate in the food chain.
    - Lead, mercury, cadmium, brominated fire retardants
    - Proper recycling of e-waste is important to avoid harm to the environment and people's health.

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Recycling of e-waste outside Europe

- Some part of the e-waste generated in Europe ends up to developing countries in Asia and Africa. There e-waste is often recycled in informal sector using low-tech approaches and sometimes hazardous practices.
  - For example, the recovery of valuable metals might be carried out by burning cables in the open air and acid leaching without necessary safety measures.
  - This might result in hazardous substances (such as heavy metals, dioxins and other toxins) being released into the local environment causing harm to human health and to the environment.

Figure: https://commons.wikimedia.org/wiki/File:E-waste_workers.jpg

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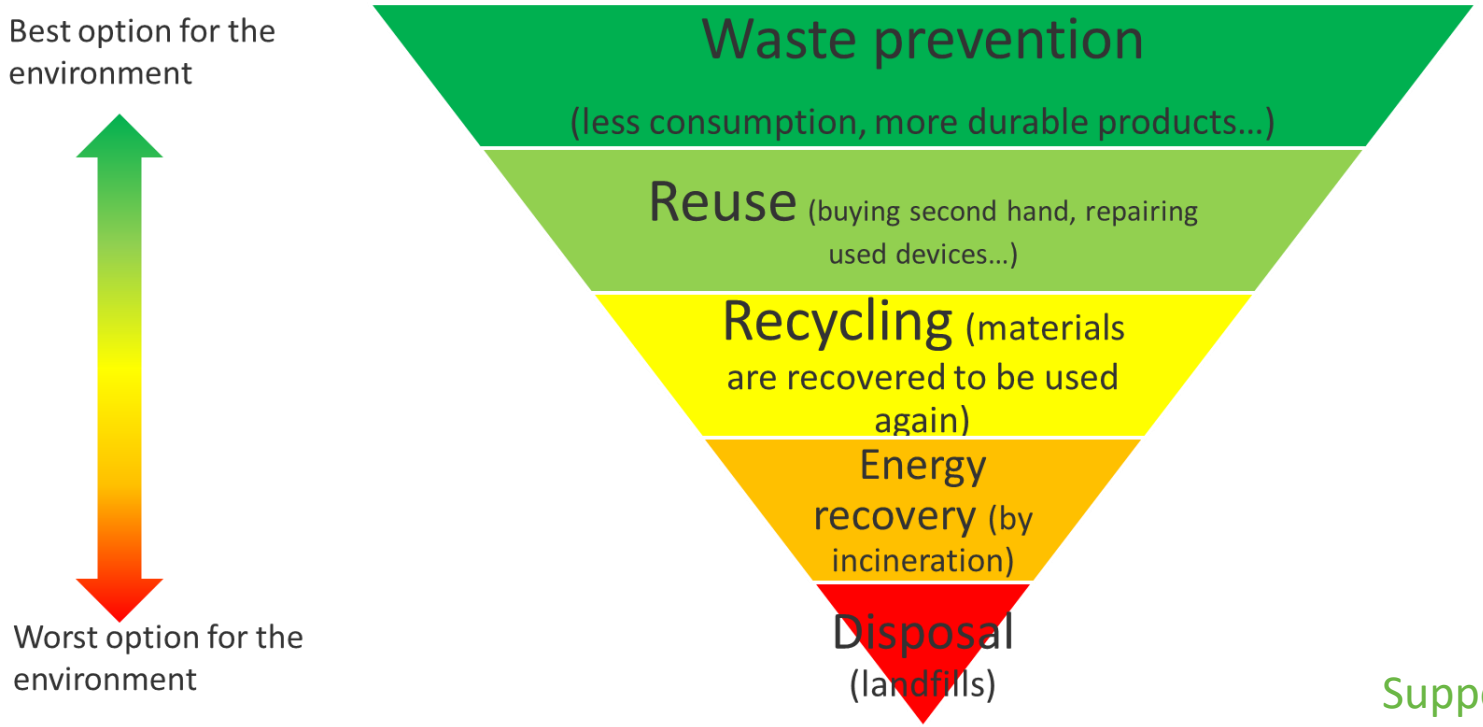
Recycling is important but not a solution to everything…

- Most important is to reduce waste in the first place
- Prolonging the lifetime of the devices is the most important measures consumers can take to reduce the environmental impacts of their electronics.



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To discuss: electronics and recycling

- How many discarded mobile phones or other electronics do you have stored in your home?
    - Which devices? Why not recycled? What about functional devices which are not in use anymore?
- If you have recycled, where did you bring the old devices? Or do you know how to recycle electronics?
- When you bought new electronics last time, what happened to the old ones?
- When you buy new electronics, do you consider ecological aspects among other features?
- Have you repaired old/broken electronics?
- How could consumers be motivated to recycle their e-waste? What could be the reason behind low collection rates?

Figure: Fairphone, am example of modular design of electronics, which enables repairing and replacing of certain components https://www.flickr.com/photos/fairphone/28275505528/in/album-72157632717840706/

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Raising public awareness on electronic waste as a source of valuable materials

- EIT RawMaterials project 2019-2020
- Information on e-waste, circular economy, and materials and lifecycle of electronics for teachers and schoolchildren
- More information and materials available: https://aware-eit.eu/

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