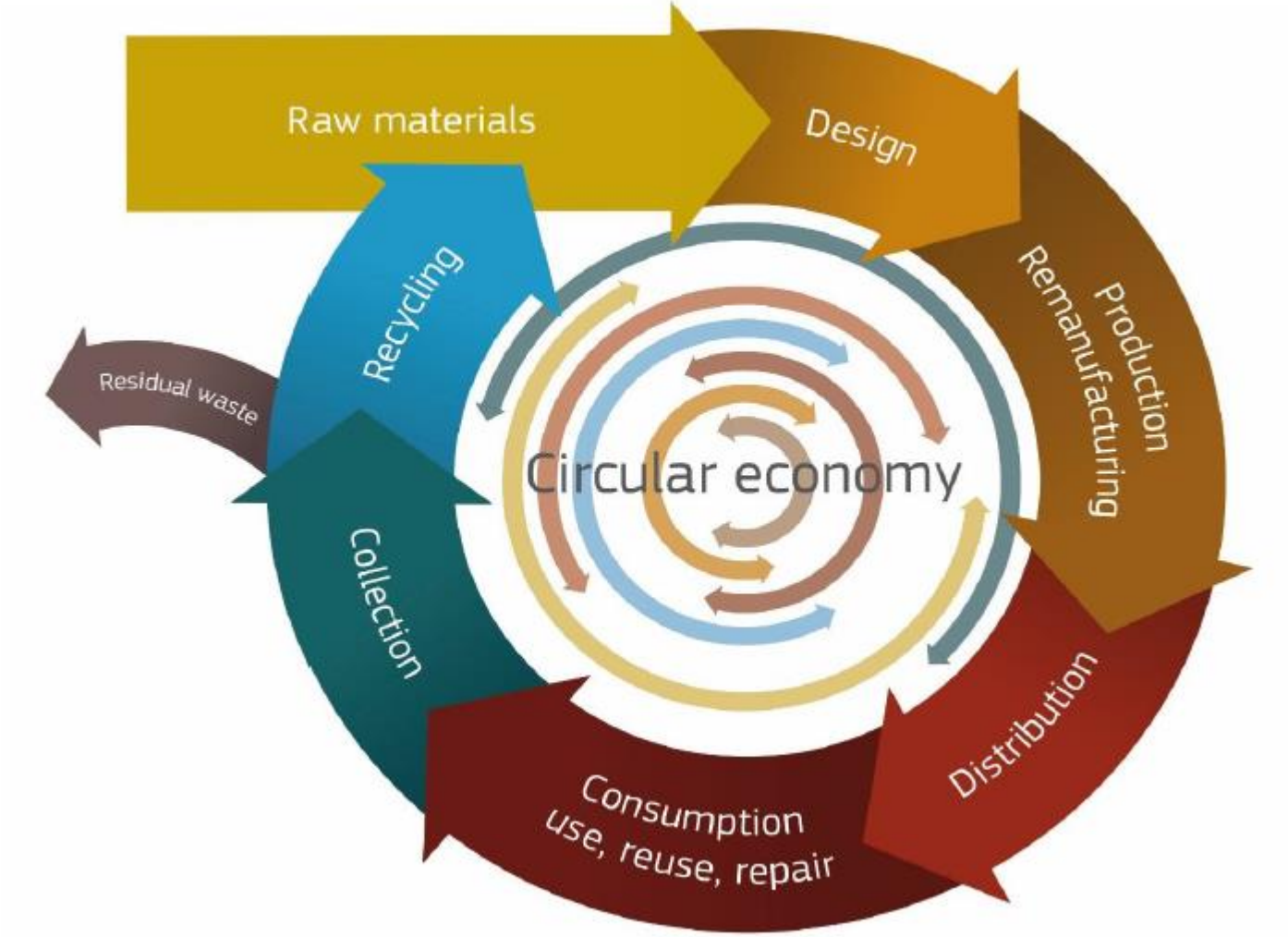

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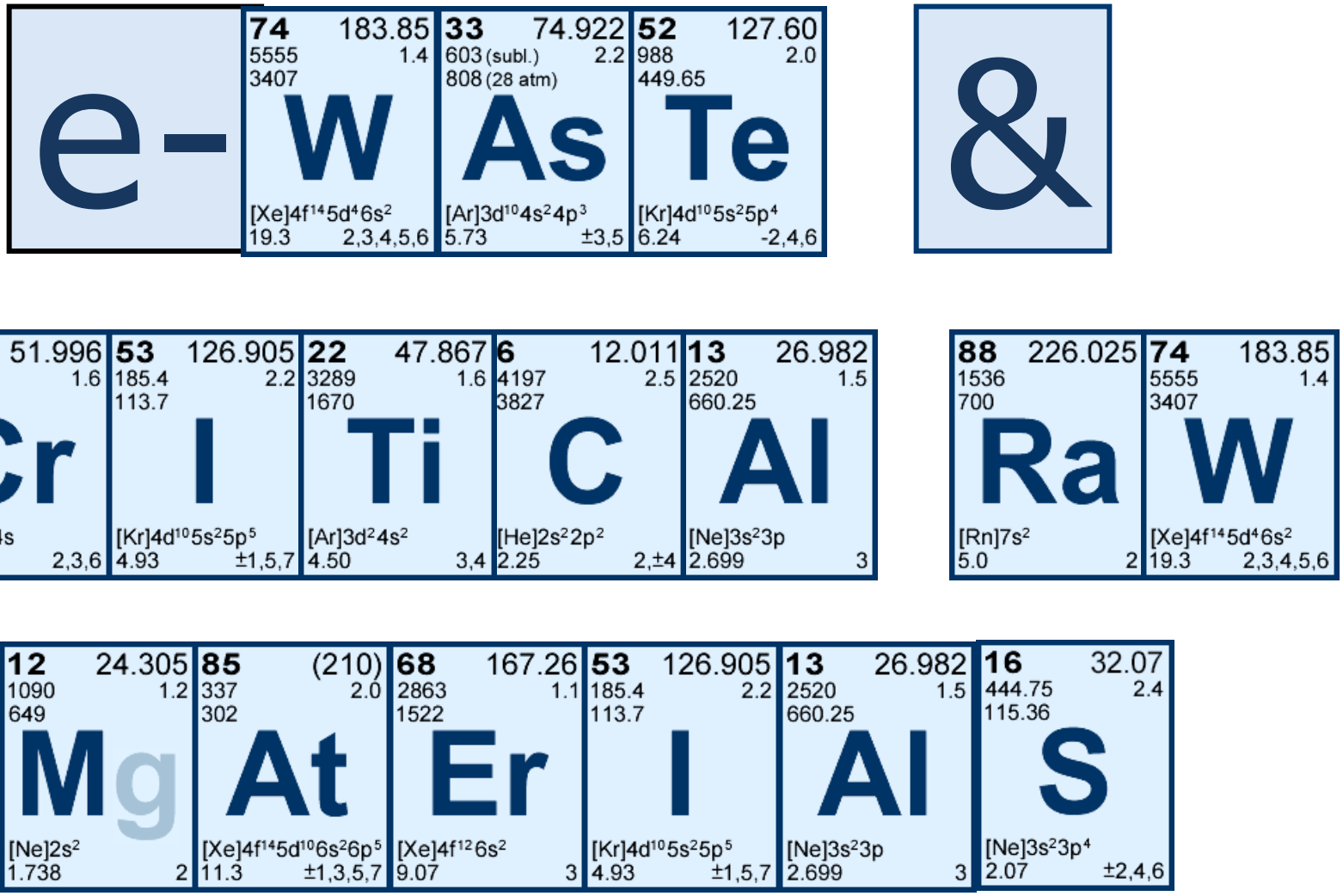
E-Waste and critical raw materials



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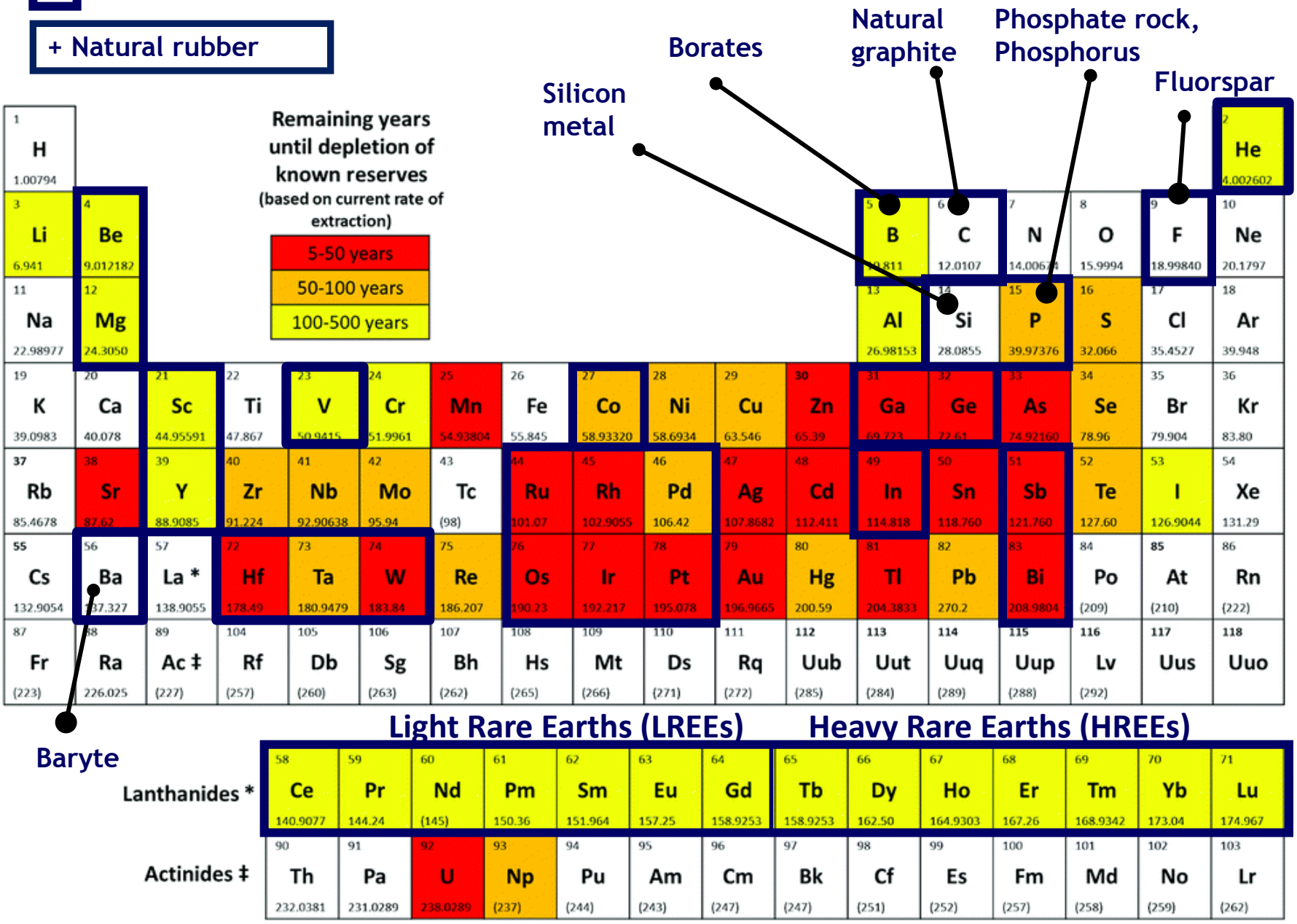
E-Waste and critical raw materials

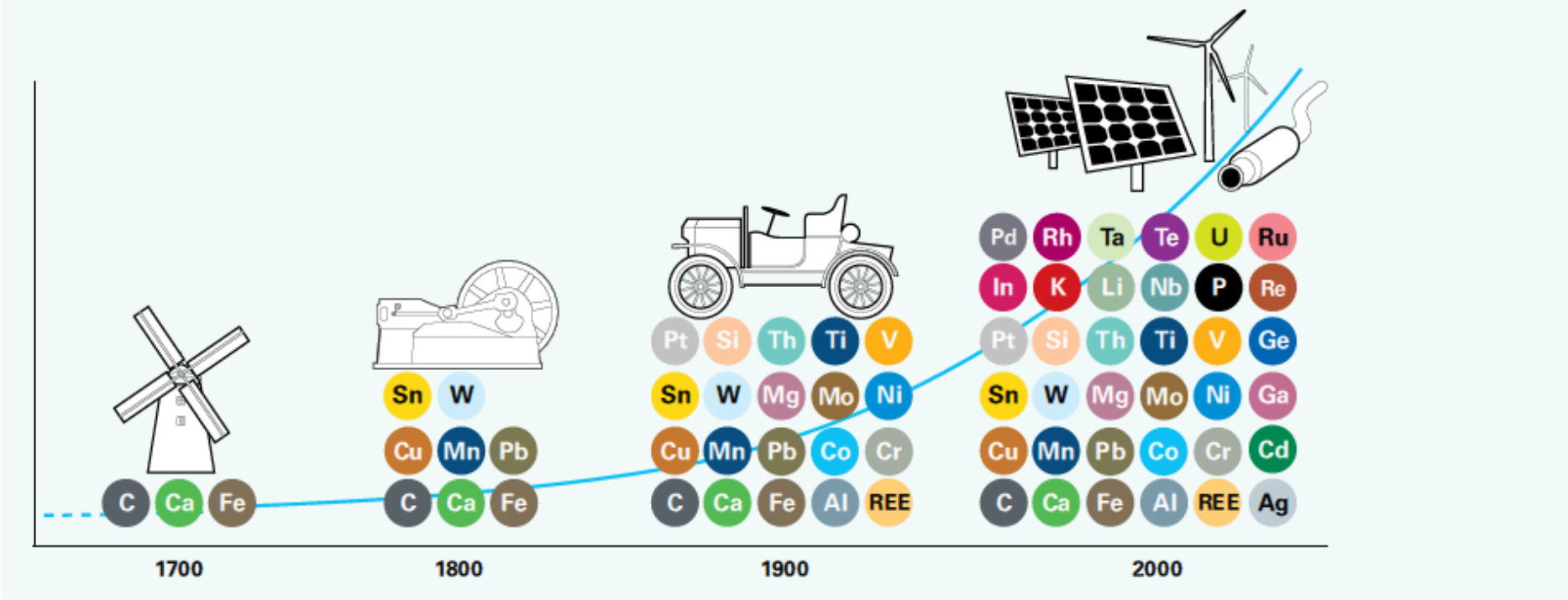
EU critical raw materials (2017)

+ Natural rubber



Reasons why a material becomes critical

- Low abundance on Earth's crust
- Deposits located in one or very few countries
- Problems in extraction and/or work-up
- Lack of alternatives in strategic applications
- Absent or inadequate recycling network



Elements widely used in energy pathways

N.B. Position on the time axis is indicative only

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E-Waste and critical raw materials

What's in *your* mobile?

Recyclable materials in the typical cell phone.

(percentages indicate content of phone)

Plastics:
In case and circuit board
(~40%)

Glass & ceramics:
In LCD screen, chips
(~20%)

Copper:
Circuit board, wires, connectors
(~10%)

Nickel:
NiCD or NMH batteries
(~2-10%)

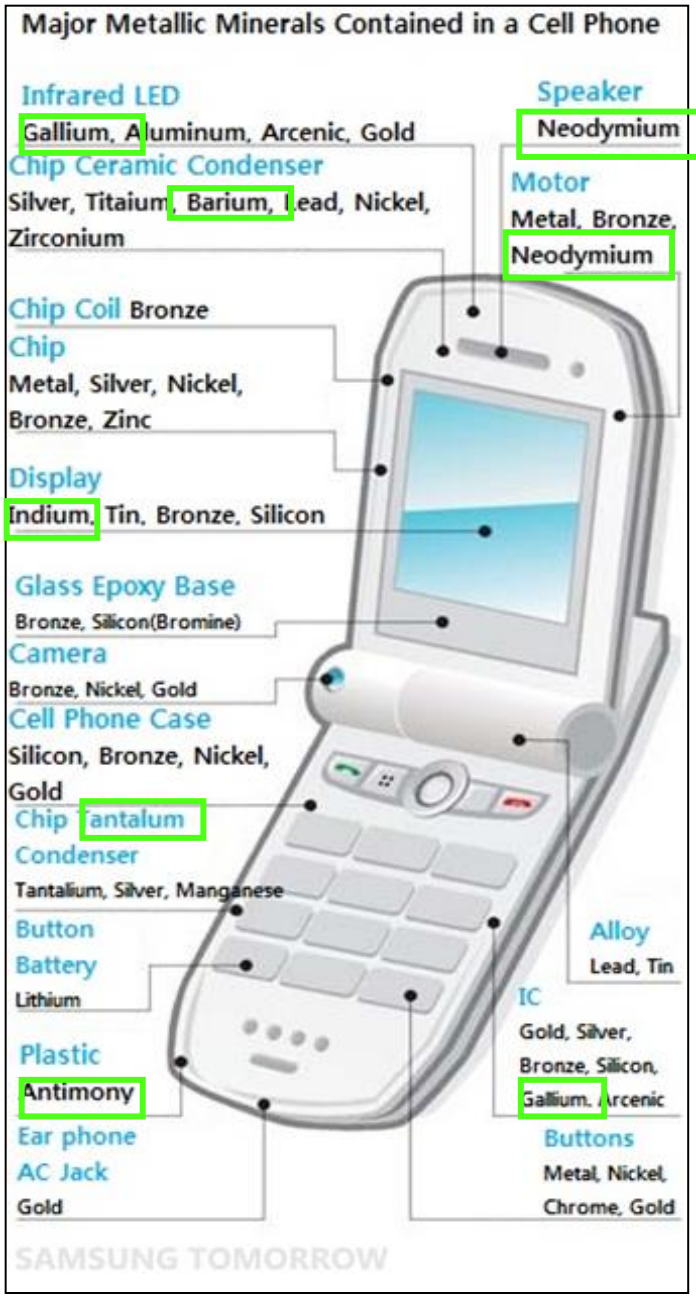
Aluminum:
Case, frame, batteries
(~3%)

Steel, ferrous metal:
Case, frame, charger, battery
(~10%)

Minor and trace elements in circuit board:
Antimony, Barium, Bismuth, Bromine, Calcium, Gold, Lead, Manganese, Palladium, Ruthenium, Silver, Strontium, Sulfur, Tantalum, Tin, Tungsten, Yttrium, Zinc, Zirconium.
(~0.1-1%)

Other minor and trace elements:
Arsenic (LED), Beryllium (connectors), Lithium (battery), Chromium (case), Titanium (frame, case)
(~0.1-1%)

Source: United Nations Environmental Program, 2009.



ELEMENTS OF A SMARTPHONE

ELEMENTS COLOUR KEY: ALKALI METAL | ALKALINE EARTH METAL | TRANSITION METAL | GROUP 13 | GROUP 14 | GROUP 15 | GROUP 16 | HALOGEN | LANTHANIDE

SCREEN

49 In Indium
8 O Oxygen
50 Sn Tin

Indium tin oxide is a mixture of indium oxide and tin oxide, used in a transparent film in the screen that conducts electricity. This allows the screen to function as a touch screen.

13 Al Aluminium
14 Si Silicon
8 O Oxygen
19 K Potassium

The glass used on the majority of smartphones is an aluminosilicate glass, composed of a mix of alumina (Al_2O_3) and silica (SiO_2). This glass also contains potassium ions, which help to strengthen it.

39 Y Yttrium
57 La Lanthanum
65 Tb Terbium
59 Pr Praseodymium
63 Eu Europium
66 Dy Dysprosium
64 Gd Gadolinium

A variety of Rare Earth Element compounds are used in small quantities to produce the colours in the smartphone's screen. Some compounds are also used to reduce UV light penetration into the phone.

ELECTRONICS

Copper is used for wiring in the phone, whilst copper, gold and silver are the major metals from which microelectrical components are fashioned. Tantalum is the major component of micro-capacitors.

29 Cu Copper
47 Ag Silver
79 Au Gold
73 Ta Tantalum

Nickel is used in the microphone as well as for other electrical connections. Alloys including the elements praseodymium, gadolinium and neodymium are used in the magnets in the speaker and microphone. Neodymium, terbium and dysprosium are used in the vibration unit.

28 Ni Nickel
66 Dy Dysprosium
59 Pr Praseodymium
65 Tb Terbium
60 Nd Neodymium
64 Gd Gadolinium

Pure silicon is used to manufacture the chip in the phone. It is oxidised to produce non-conducting regions, then other elements are added in order to allow the chip to conduct electricity.

14 Si Silicon
8 O Oxygen
51 Sb Antimony
33 As Arsenic
15 P Phosphorus
31 Ga Gallium

Tin & lead are used to solder electronics in the phone. Newer lead-free solders use a mix of tin, copper and silver.

50 Sn Tin
82 Pb Lead

BATTERY

3 Li Lithium
27 Co Cobalt
8 O Oxygen
6 C Carbon
13 Al Aluminium

The majority of phones use lithium ion batteries, which are composed of lithium cobalt oxide as a positive electrode and graphite (carbon) as the negative electrode. Some batteries use other metals, such as manganese, in place of cobalt. The battery's casing is made of aluminium.

CASING

Magnesium compounds are alloyed to make some phone cases, whilst many are made of plastics. Plastics will also include flame retardant compounds, some of which contain bromine, whilst nickel can be included to reduce electromagnetic interference.

6 C Carbon
12 Mg Magnesium
35 Br Bromine
28 Ni Nickel

THE RECYCLING RATES OF SMARTPHONE METALS

COLOR KEY: < 1% RECYCLE RATE | 1–10% RECYCLE RATE | 10–25% RECYCLE RATE | 25–50% RECYCLE RATE | > 50% RECYCLE RATE | NON-METAL (OR RECYCLE RATE UNKNOWN)

SCREEN

TOUCH: INDIUM TIN OXIDE
Mainly used in a transparent film over the phone's screen that conducts electricity. This allows the screen to function as a touch screen.

GLASS: ALUMINA & SILICA
On most phones the glass is aluminosilicate glass, a mix of aluminium oxide & silicon dioxide. It also contains potassium ions, which help strengthen it.

COLORS: RARE EARTH METALS
A variety of rare earth metal-containing compounds are used to help to produce the colors in a smartphone's screen. Some of these compounds are also used to help reduce light penetration into the phone. Many of the 'rare earths' occur commonly in the Earth's crust, but often at levels too low to be economically extracted.

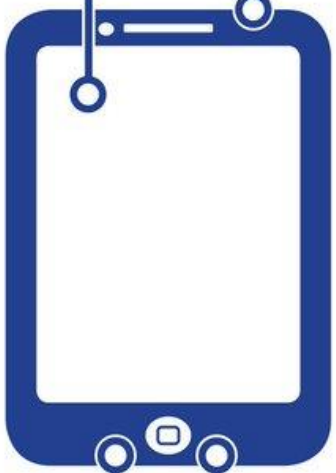
ELECTRONICS

WIRING AND MICROELECTRONICS
Copper is used for wiring, and for microelectrical components along with gold and silver. Tantalum is the major component in microcapacitors.

MICROPHONES AND VIBRATIONS
Nickel is used in the microphone and for electrical connections. Rare earth element alloys are used in magnets in the speaker and microphone, and the vibration unit.

THE SILICON CHIP
Pure silicon is used to manufacture the chip, which is then oxidized to produce nonconducting regions. Other elements are added to allow the chip to conduct electricity.

CONNECTING ELECTRONICS
Tin and lead were used in older solders; newer, lead-free solders use a mix of tin, copper and silver.

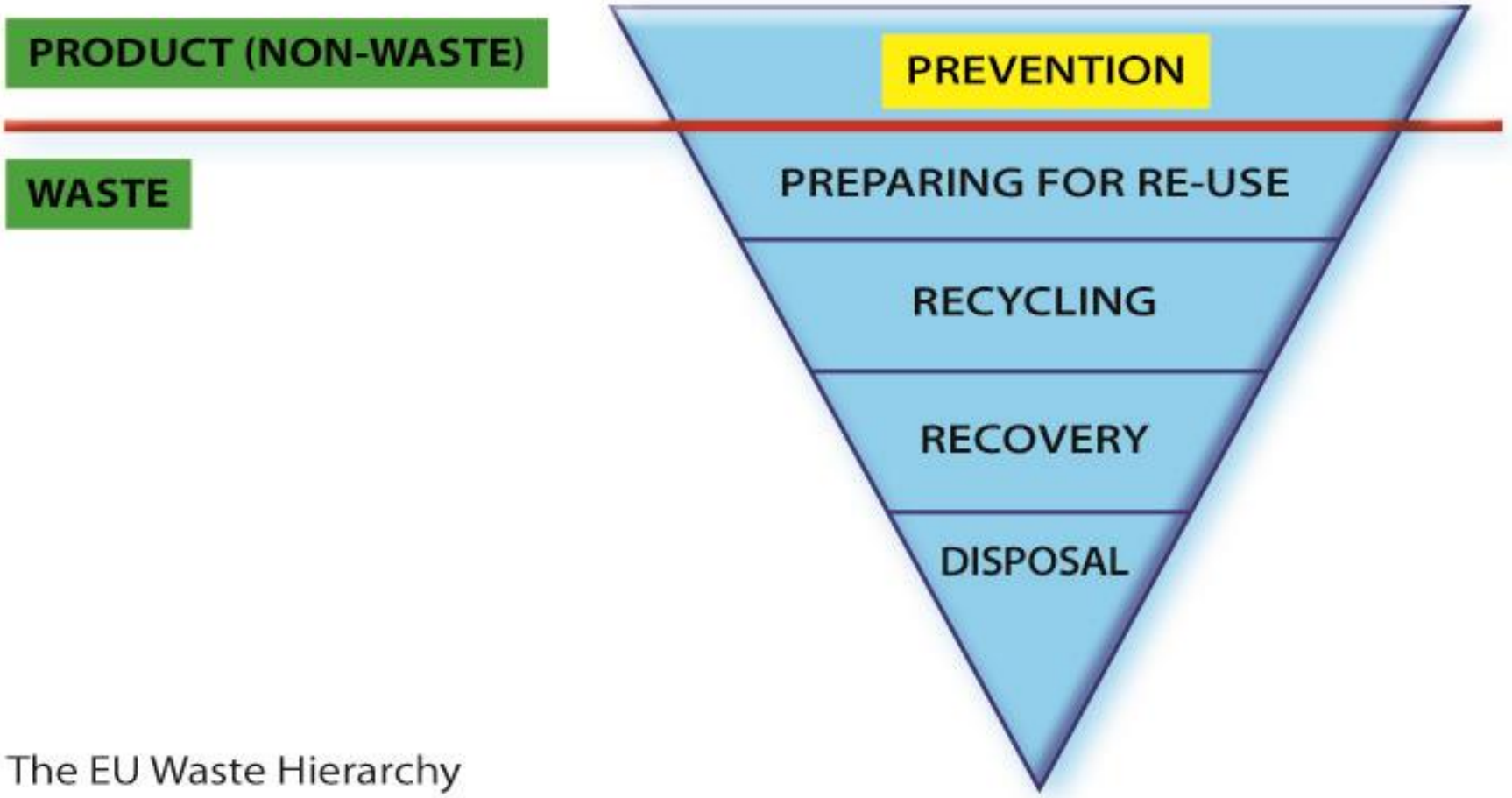


BATTERY

Most phones use lithium ion batteries, composed of lithium cobalt oxide as a positive electrode and graphite (carbon) as the negative electrode. Sometimes other metals, such as manganese, are used in place of cobalt. The battery casing is often made of aluminium.

CASING

Magnesium alloy is used to make some phone cases, while many others are made of plastics, which are carbon-based. Plastics will also include flame retardant compounds, some of which contain bromine, and nickel can be included to reduce electromagnetic interference.



The EU Waste Hierarchy

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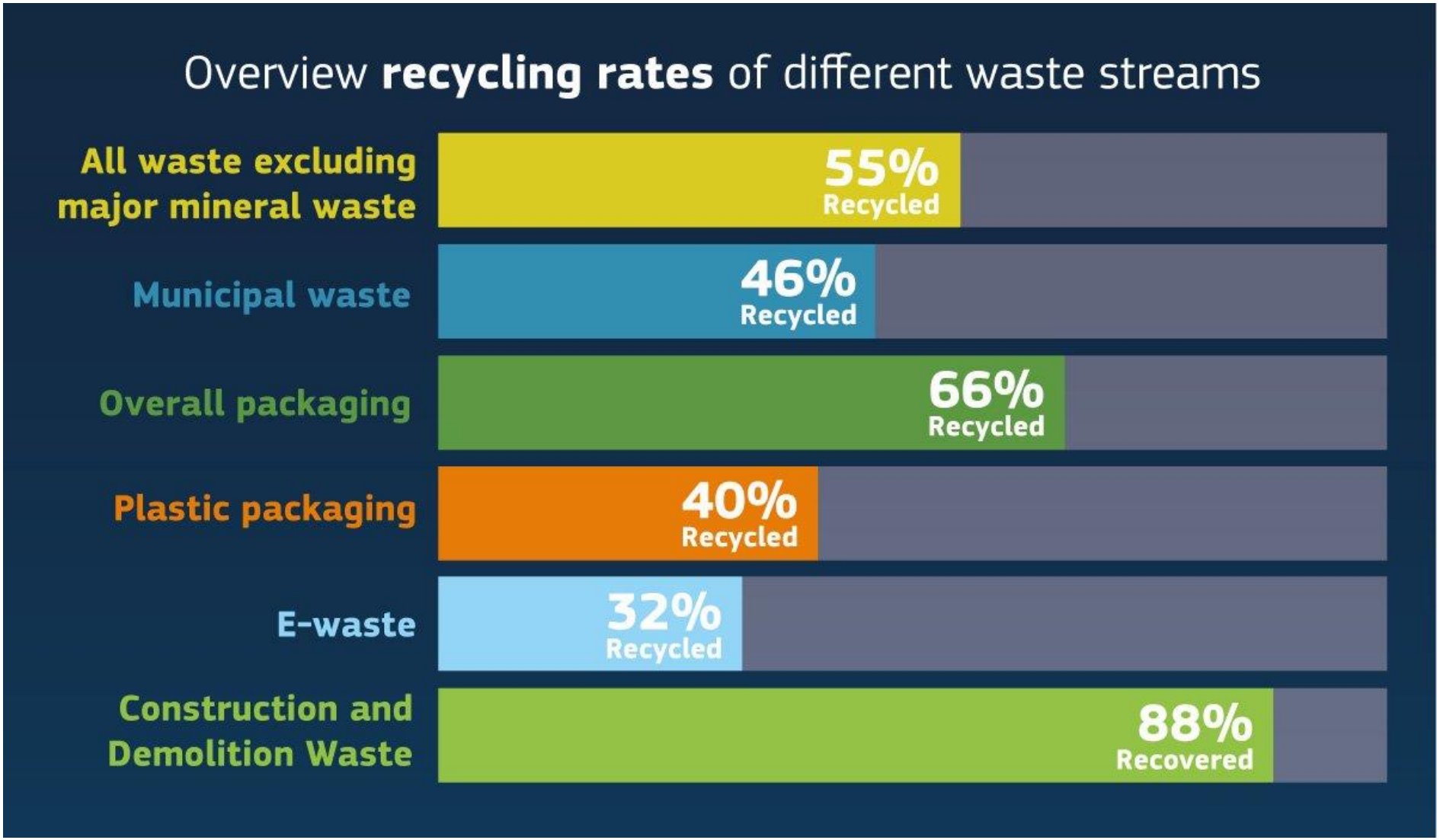
E-Waste and critical raw materials

eurostat


Overview recycling rates of different waste streams
All waste excluding major mineral waste
55% Recycled
Municipal waste
46% Recycled
Overall packaging
66% Recycled
Plastic packaging
40% Recycled
E-waste
32% Recycled
Construction and Demolition Waste
88% Recovered

Urban Mining Process: Reclamation of valuable raw materials and metals from urban waste streams.

Landfill

C&D
Construction & Demolition Material

MSW
Municipal Solid Waste

E-Waste
Electronic Waste & Appliances

Tires
Car, Truck, Rubber Products

Restore

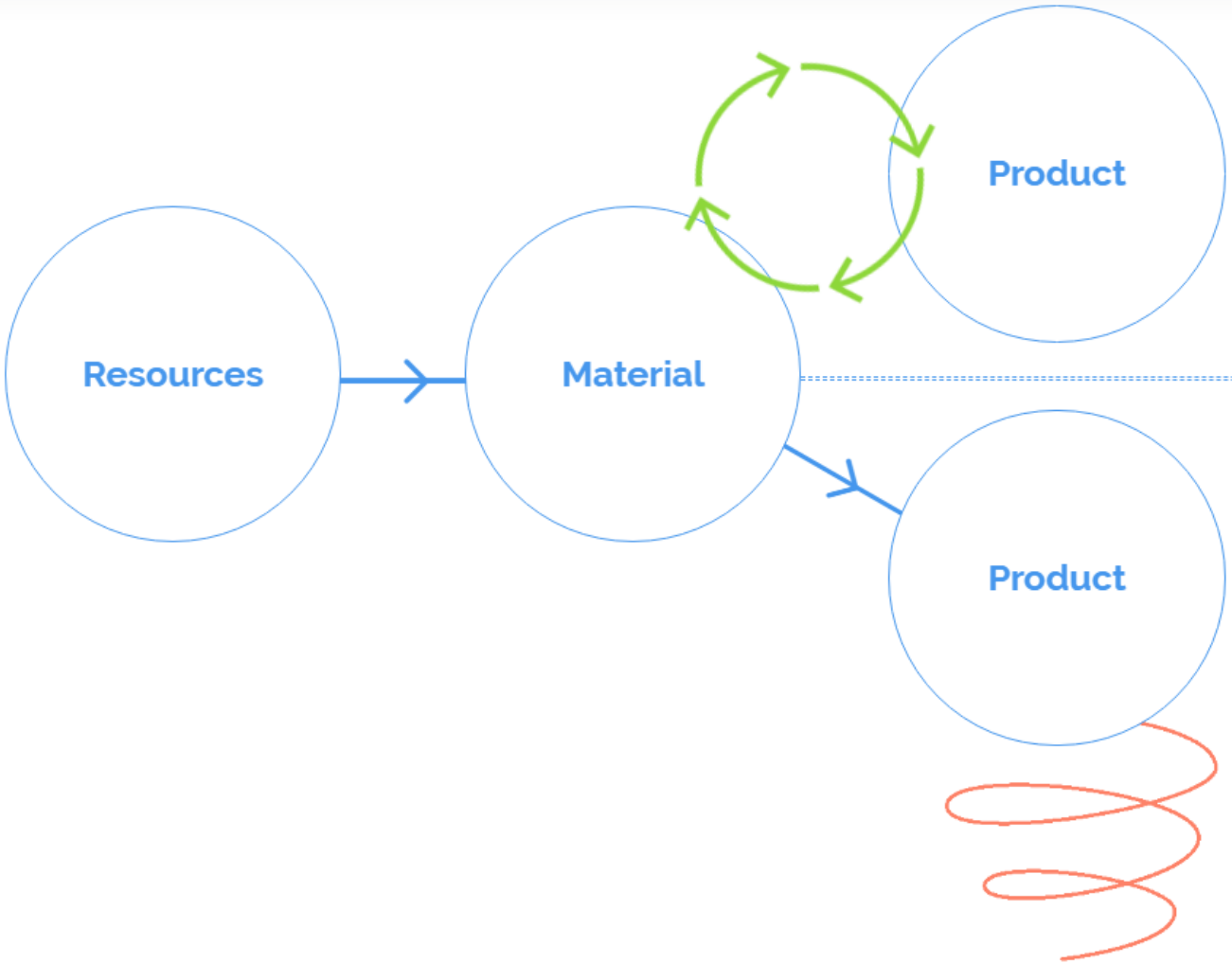
Waste-to-Organic
Compost, Mulch

Waste-to-Energy
Biofuels, Carbon Black

Waste-to-Material
Metal, Plastic, Rubber

Urban Mining Goal: Monetize urban waste streams in order to produce revenue, businesses and jobs.

A vaste can become a treasure!



METAL recycles forever™

Non-permanent material spiral to end of life

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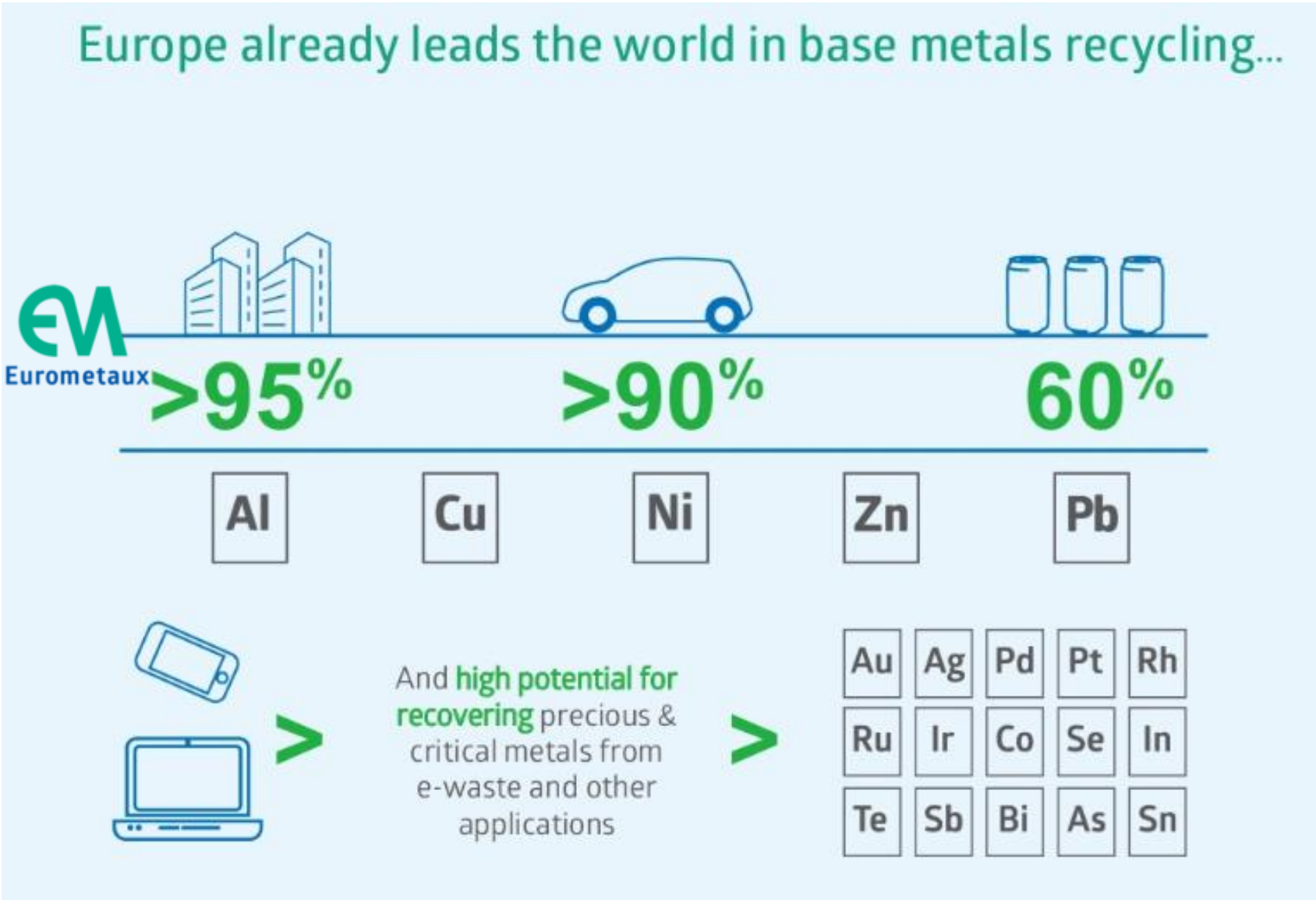

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E-Waste and critical raw materials

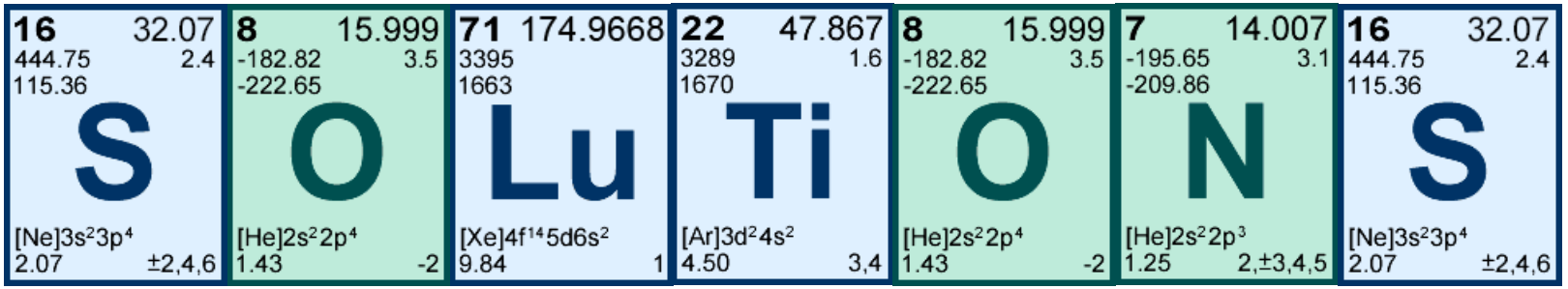
...but too many metals still escape the loop

Eurometaux

€4.3bn of **base metals** are exported annually, without guarantee of quality treatment

65% of EU **e-waste** is not properly recycled

- **33%** recycled under non-compliant conditions
- **15%** exported without guarantee of proper treatment
- **17%** discarded or scavenged



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Education

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Promotion of proper e-waste disposal

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For customers:repair, buy less, buy better, dispose properly

For manufactures

Long-term design

"Fair" materials

Good working conditions

Ease reuse & recycle

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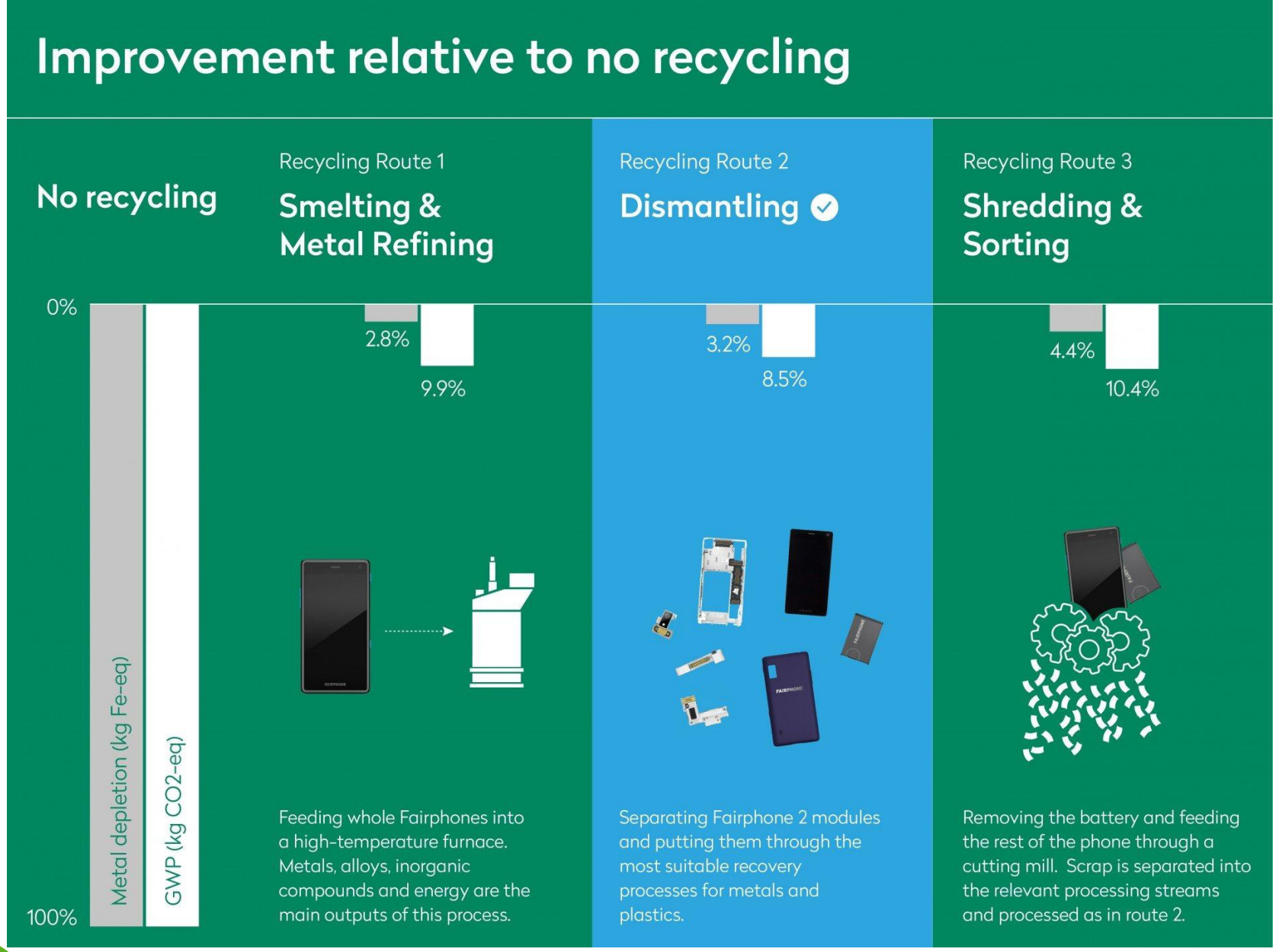
E-Waste and critical raw materials



E-MINING @ SCHOOL

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E-Waste and critical raw materials

ISOF CNR

PuzzlePhone is the long-lasting smartphone with three easy-to-change modules. Repair and customize your device easily - make it last and make it your own. PuzzlePhone is reliable, upgradeable, and repairable!

Need more power? Did you break your screen? Need a special module with extra sensors? All are easily replaced - by the user!

1 Brain

The Brain contains critical electronics: the CPU, GPU, RAM, memory, and cameras.

2 Spine

The Spine is the structure: the high-res display. Core spine elements will be available in a variety of sizes and materials.

3 Heart

The Heart contains the battery: it will be the enabler of secondary electronics and features chosen by the user.

Project Ara

Ara smartphones with individual modules separated

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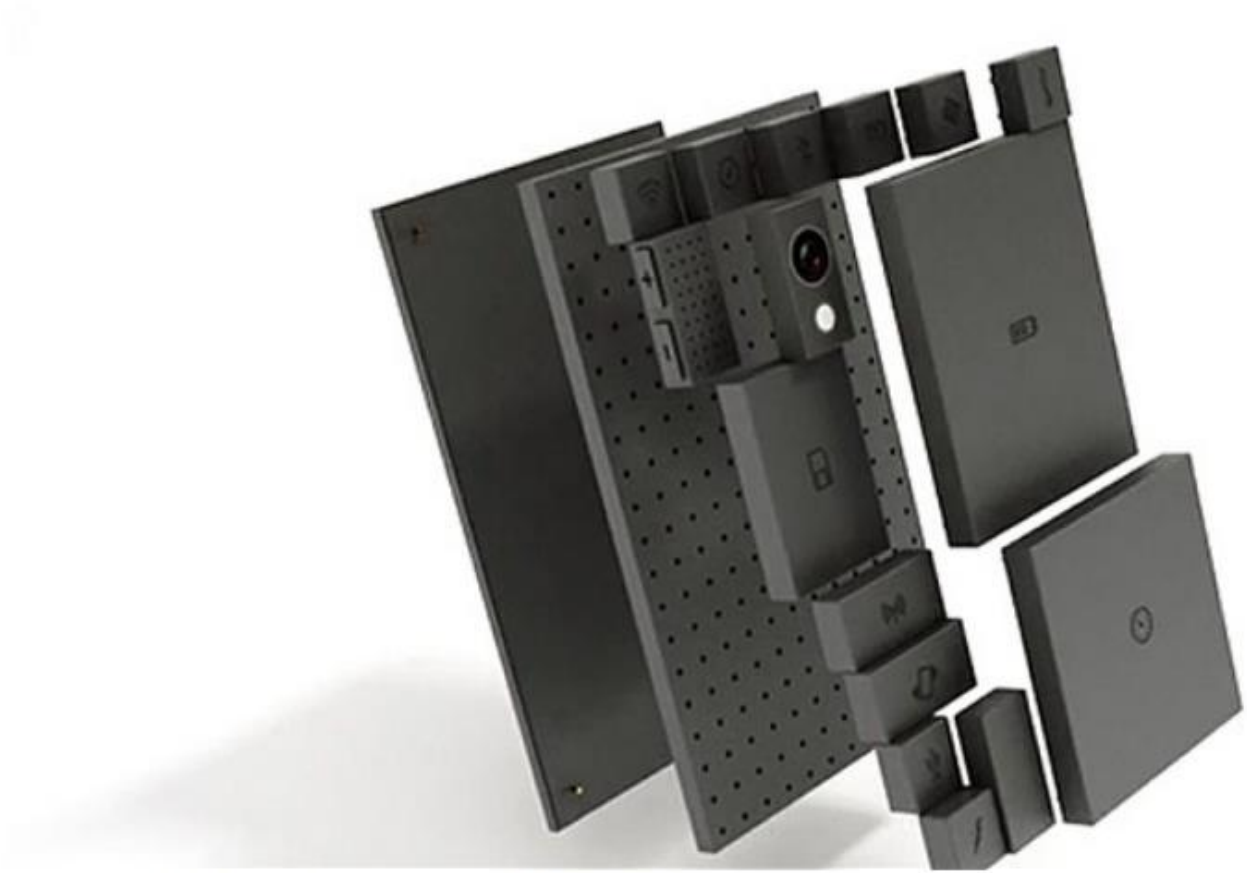
E-Waste and critical raw materials

Phonebloks: a phone that can be built like Lego

Phonebloks is a smartphone made up of separate parts that can be swapped and replaced like Lego so it lasts for ever and can be customised



A screenshot of Phoneblok's design featured in the video Photo: DAVE MOVIES