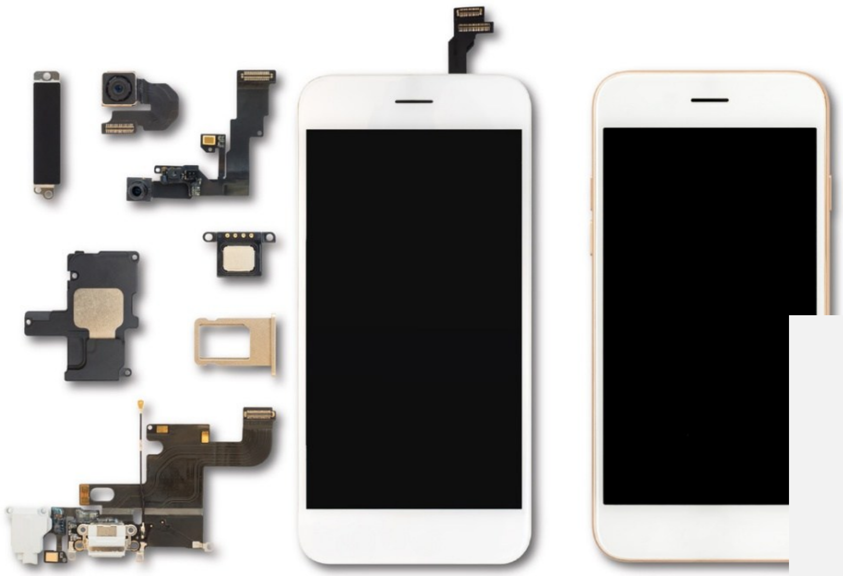

Source: Fotolia/poravute

German Mineral Resources Agency

# Valuable and critical raw materials in smartphones – updated assessment under the EU Critical Raw Materials Act


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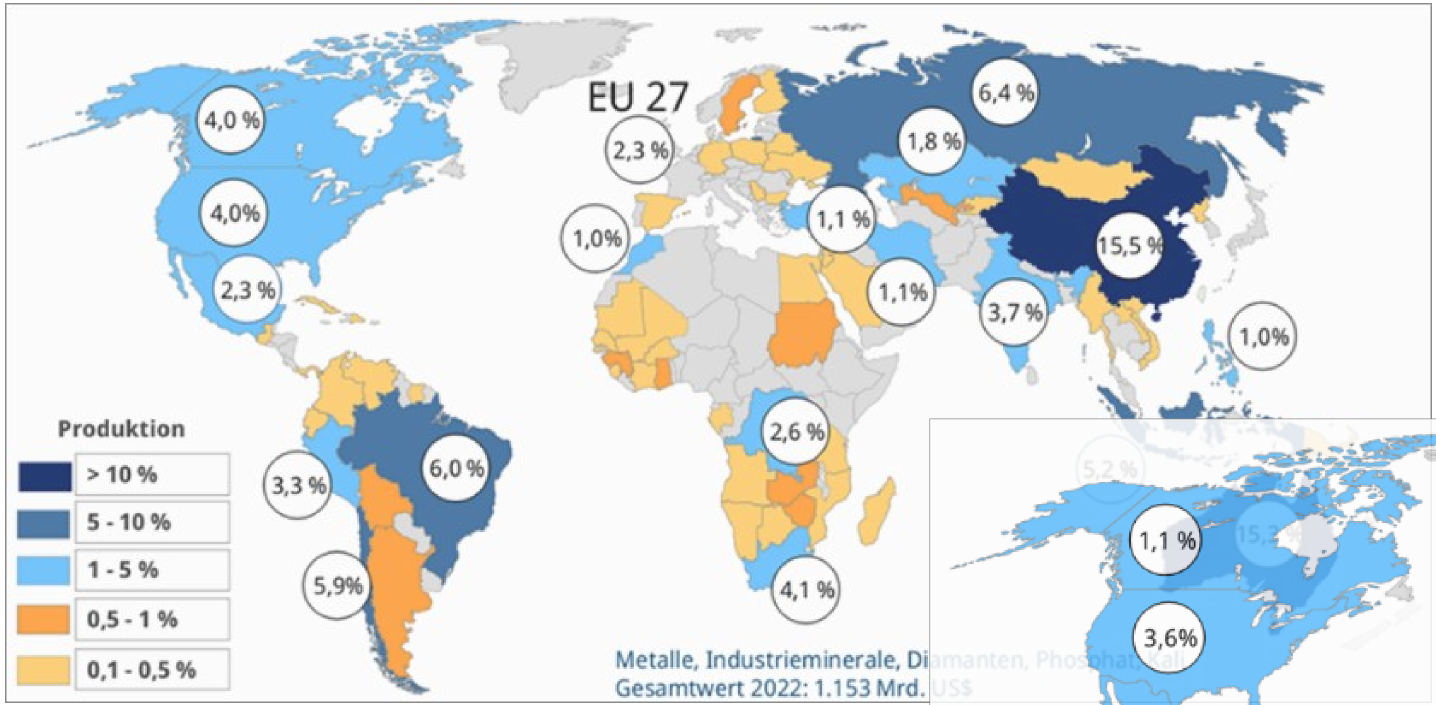
Metal Recycling Expo Frankfurt
June 17, 2026

www.dera.bund.de
www.bgr.bund.de

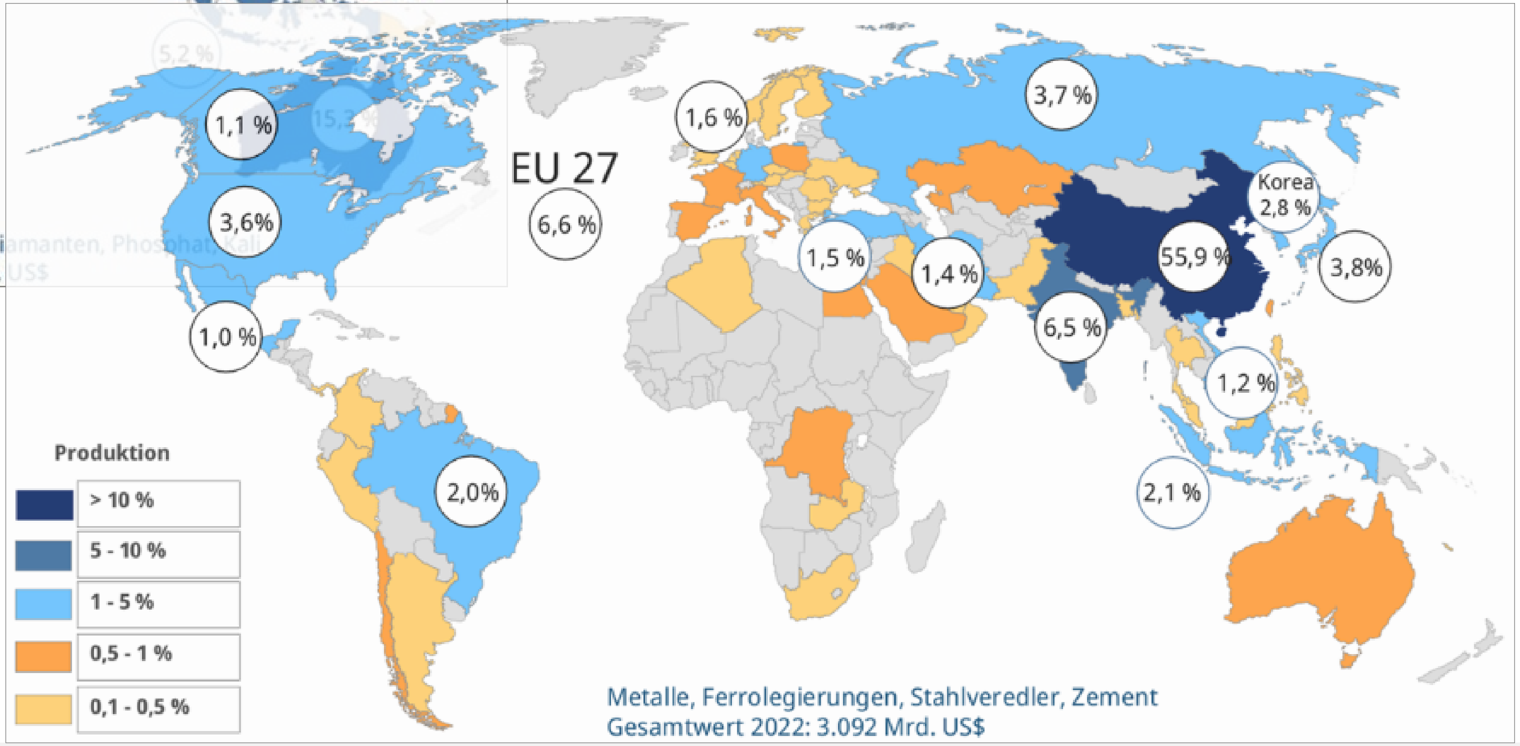
Federal Institute for Geosciences and Natural Resources

# Highly concentrated global raw materials production

~85 % of global mine production (ores, concentrates) from 15 countries




~56 % of refining from one country (China)




Data: BGR

# Context: CRMA – Critical Raw Materials Act


**EU EXTRACTION:**
at least **10%** of the EU's annual consumption from EU extraction

**EU PROCESSING:**
at least **50%** of the EU's annual consumption from EU processing

**EU RECYCLING:**
at least **25%** of the EU's annual consumption from domestic recycling

**EXTERNAL SOURCES:**
not more than **65%** of the Union's annual consumption of each strategic raw material at any relevant stage of processing from a single third country

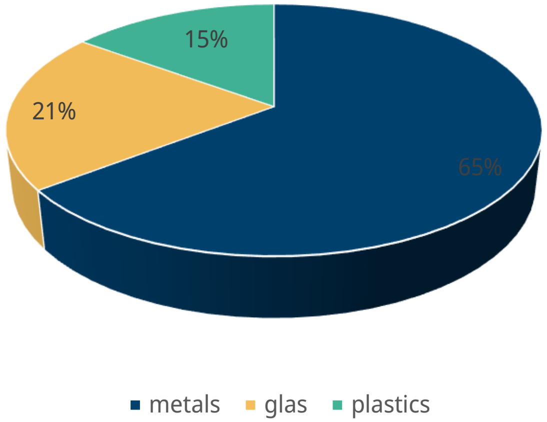
* *https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_22_5523*

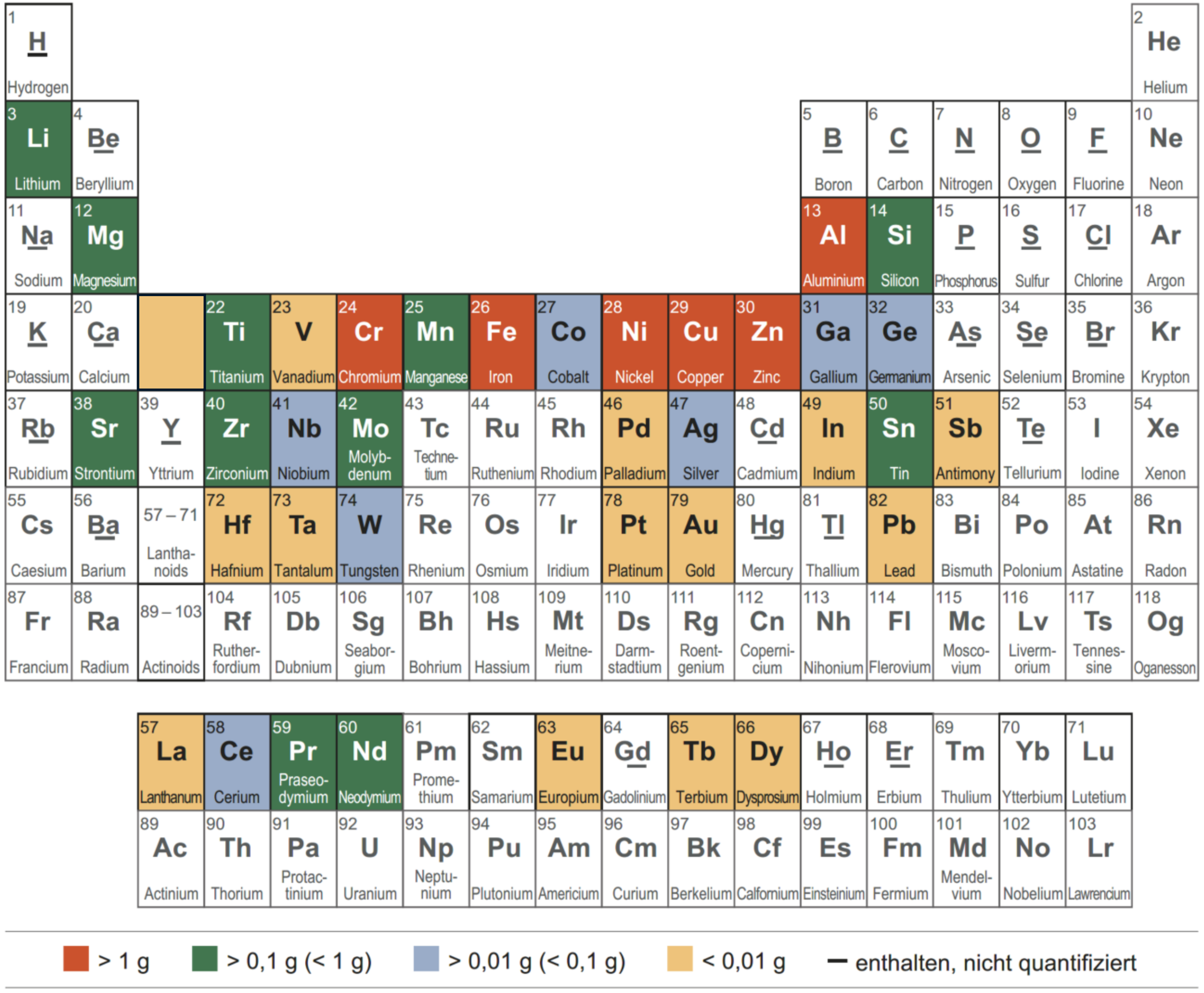
Source: Bookhagen

# Smartphone models 2024 – new measurements

DERA

Smartphone 169 g (incl. battery)




Source: Bookhagen + Hagelüken

# Urban mine?

1.3 bn smartphones globally sold in 2025:

- **29,128 t aluminum → 67.8 million €**
- **13,865 t copper → 122 million €**
- **10,557 t iron → 6.3 million €**
- **8.2 t gold → 800 million €**
- **and 0.86 t Palladium → 28 million €**

Germany's 167 million unused mobile phones contain valuable raw materials:

- approx. 3,700 tonnes of aluminum
- approx. 1,800 tonnes of copper
- and approx. 1.05 tonnes of gold

The contained metal value amounts to approx. **€ 156 million**.

# Smartphones - comparison 2012 with 2024

DERA

*w/o battery

## Smartphone Ø 103 g*
## 2012

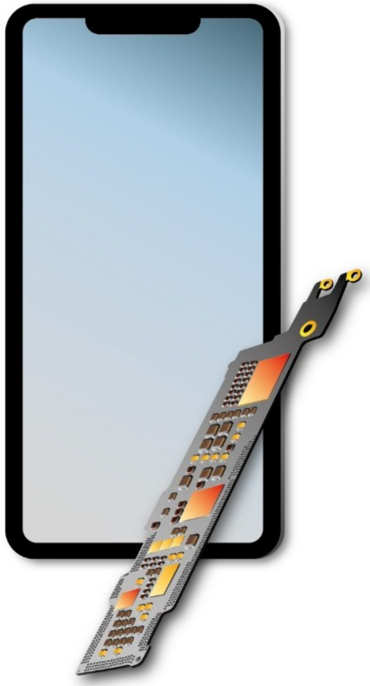
| | |
|---|---|
| 79 196.97 Au GOLD | **Gold** 174 g/t |
| 29 63.546 Cu KUPFER | **Kupfer** 41.500 g/t |
| 46 106.42 Pd PALLADIUM | **Palladium** 16 g/t |
| 13 26.982 Al ALUMINIUM | **Aluminium** 31.900 g/t |
| 31 69.723 Ga GALLIUM | **Gallium** 76 g/t |
| 32 72.64 Ge GERMANIUM | **Germanium** 4 g/t |
| 73 180.95 Ta TANTAL | **Tantal** 321 g/t |
| REE | Rare Earth Elements 2.800 g/t |

**Pure metal value**

2,57€

1,97 €

## Smartphone Ø 122 g*
## 2024



| | |
|---|---|
| 79 196.97 Au GOLD | **Gold** 52 g/t |
| 29 63.546 Cu KUPFER | **Kupfer** 87.600 g/t |
| 46 106.42 Pd PALLADIUM | **Palladium** 5 g/t |
| 13 26.982 Al ALUMINIUM | **Aluminium** 184.100 g/t |
| 31 69.723 Ga GALLIUM | **Gallium** 219 g/t |
| 32 72.64 Ge GERMANIUM | **Germanium** 151 g/t |
| 73 180.95 Ta TANTAL | **Tantal** 34 g/t |
| REE | Rare Earth Elements 4.200 g/t |

**Pure metal value**

1,25 € Prices Jan 2026

0,94 € Prices 2025

less valuable metals decrease recycling profitability

improved resource efficiency and material substitution

Material substitution and improved resource efficiency → reduced contents of Au, Pd and Ta
Increased performance requirements and functionality → higher contents of specialty metals Ga, Ge, REEs

Source: Bookhagen + Hagelüken

# Smartphones 2024

## Gold content

1 tonne Smartphones

**52 g/t**

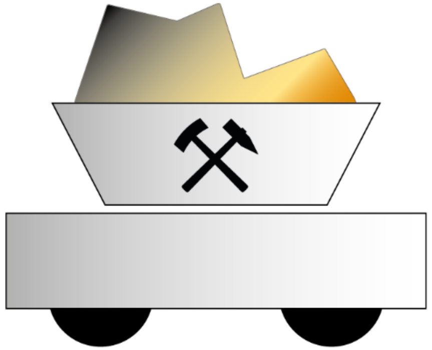
* ca. 8.250 Smartphones = 1 Tonne

17x more gold in smartphones than in gold ore

(2012-smartphones: 58x more gold than ore!)

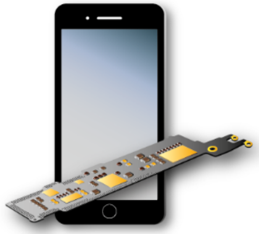
in an average gold ore

**3 g/t**



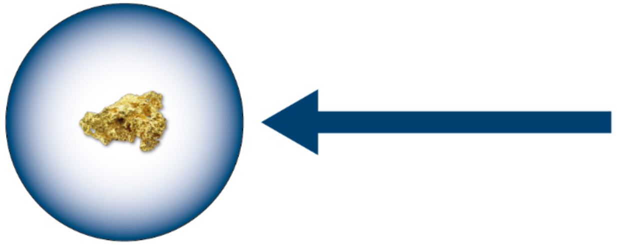
Gold content in 1 smartphone

**0,006 g = 0,80 €**



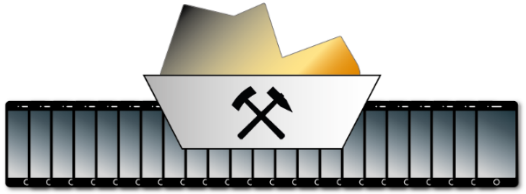
Gold extraction

**1 g**



Required gold ore (rock)

**330 kg** or
**159 Smartphones**



Al most abundant with 184,000 ppm vs Au 52 ppm
But share of total metal value: Al < 5%; Au 63 %; Cu 10 %

*without battery

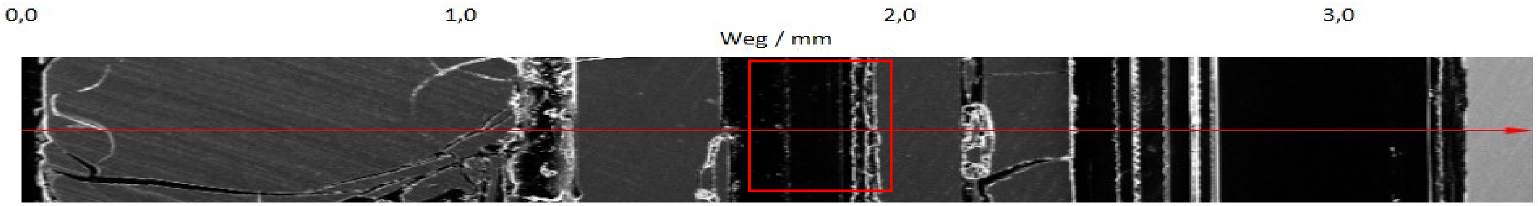
Source: Bookhagen + Hagelüken

# Recycling: Some basic facts & considerations

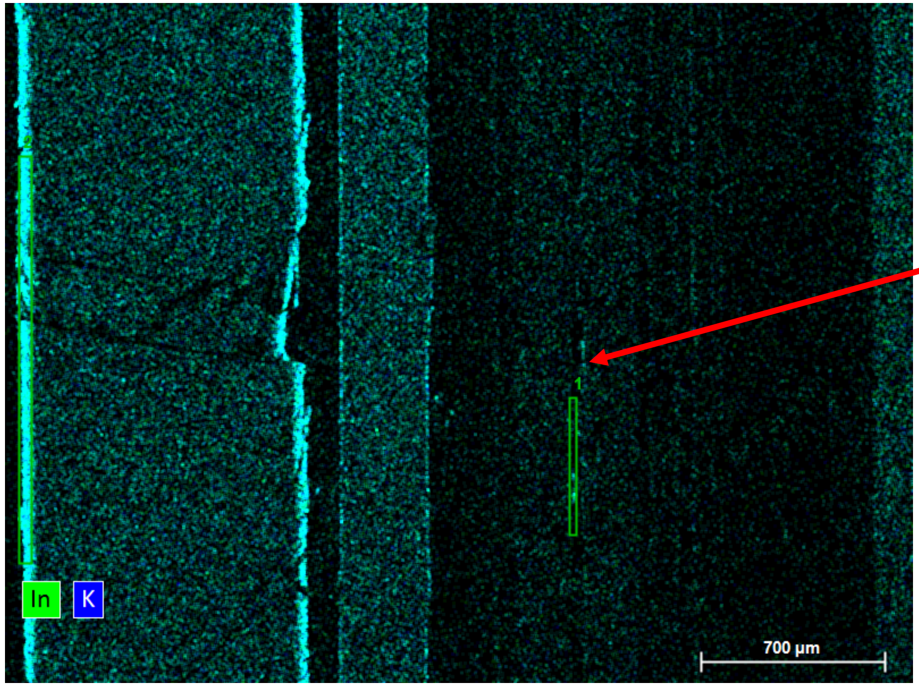
- **Metal value ≠ recycling value**
  → Not all metals can be recycled (economic & technical constraints); even in best processes metal yields < 100%.
- In spite of high metal grades, **one single smartphones is <u>not</u> an "urban mine" deposit**, as the "ore volume" is missing. It needs "millions" of phones to collect & ship to a recycler to make an "anthropogenic deposit" of a reasonable economic size.
- Effective **metallurgical recycling processes are available** in the EU. To benefit from economies of scale and a sophisticated metallurgical infrastructure, smartphones are treated together with other metal bearing fractions in integrated metal smelter-refineries.


- These processes are capable of recovering the **main value carriers Au, Ag, Pd & Cu** (ca. 90% of recycling value) with up to 98% yields. In addition, **further metals** such as Ni, Pb, Sn, Bi, Sb, As, Pt, Ru, ... are **co-refined**.
- It is required to separate the **batteries** from the handsets prior to metallurgical treatment. Batteries can be recycled with high yields for Co, Ni, Cu & Li, but it needs different, dedicated battery recycling processes.

# Example Indium: Display




Source: REM,own measurements




Indium

Source: EDX, own measurements


Source: IFixIT

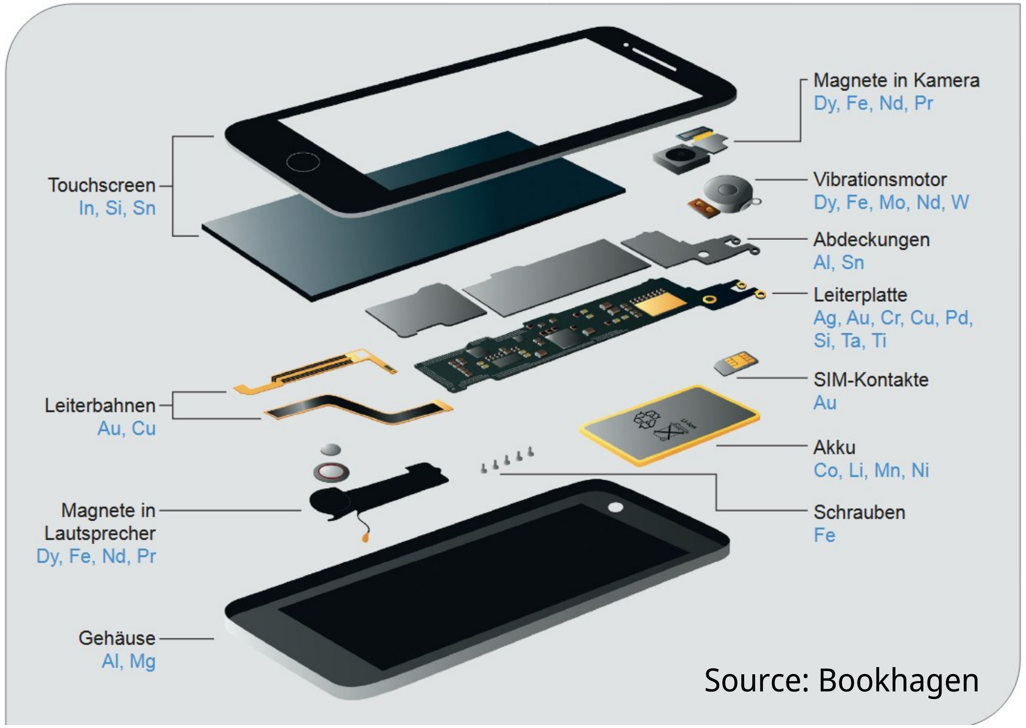
Source: Bookhagen

# Recycling: Current situation & challenges


- At present, smartphone recycling makes only a limited contribution to the supply of critical raw materials.
- Main reason: low collection rates (drawers, waste bin) & high exports at end-of-life (EoL) to non-EU destinations.
- Good **data base** exists for phones put on market but no reliable data about EoL. Highly untransparent Eol-flows.

- Low **metal value** of a single EoL phone (~1 €) does not create sufficient economic incentives for proper collection.
- In particular, the **recovery potential for REE, Ga, Ge & Ta** remains very low due to technical and economic constraints (∑ metal value Ga, Ge, Ta: <0,01 €; REE: 0,03€/smartphone). For these metals, other product groups are better suited for recycling and resource recovery.
- Any **innovation in recycling processes** aiming at recovering additional CRM must secure the existing high recovery rates for Au, Ag, Pd, Cu - as otherwise recycling becomes uneconomic.

# Recycling: improvement approaches




Source: Bookhagen

**Better design** for repair & recycling (removable batteries, modular design).

**Create better data base** for product composition and material flows at EoL (e.g. via digital product passports)

**Prioritization** on the recovery of value carriers, metals of strategic relevance & on avoidance of emitting hazardous substances.

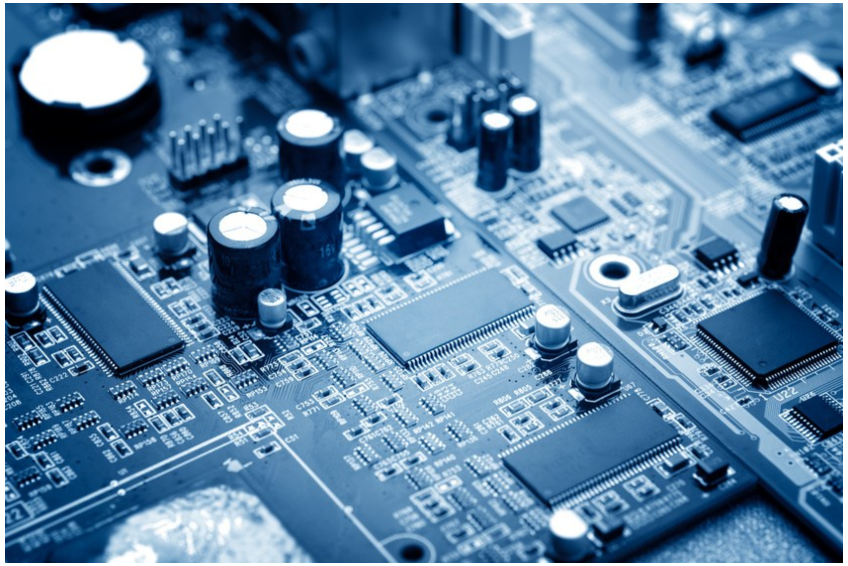
Make use of **state-of-the art recycling processes.**

Create tools & incentives to **significantly increase collection rates** and set-up truly circular business models, addressing the entire lifecycle of electronic devices.

# Take aways - summary

- **Smartphones contain > 50 different metals in a complex composition.** With 1.3 bn units sold globally every year they create a signific metal stock.
- The **metal value** of a 2024 smartphone has almost halved compared to 2012. Even at very high metal prices of Jan 2026 it is only 1.30 €/unit, ~ 90% coming from just 4 value carriers Au, Ag, Pd & Cu.
- Although smartphones contain small amounts of **REE, Ga, Ge, Ta**, they are currently <u>not</u> a potential EU source for these metals.
- Effective **recycling processes** exist to recover the value carriers & other metallurgically compliant metals (some of the CRMs) but **collection** of phones at EoL is very weak.
- Even if collection rates would improve significantly, smartphone recycling could only make a limited contribution to reach the **25% recycling target of the CRMA**.
- But smartphones could act as a **blueprint to overcome structural deficits in CE-approaches** for high grade electronic devices (laptops, tablets, routers, ...). In total, comprehensive recycling of such products at their (extended) EoL could contribute substantially to the supply of valuable and critical raw materials for the EU.
- Even if real circular business models would be achieved for such small IT-equipment, **responsible mining**, ideally intra-EU, will be needed for a secure metal supply.

# Thank you!



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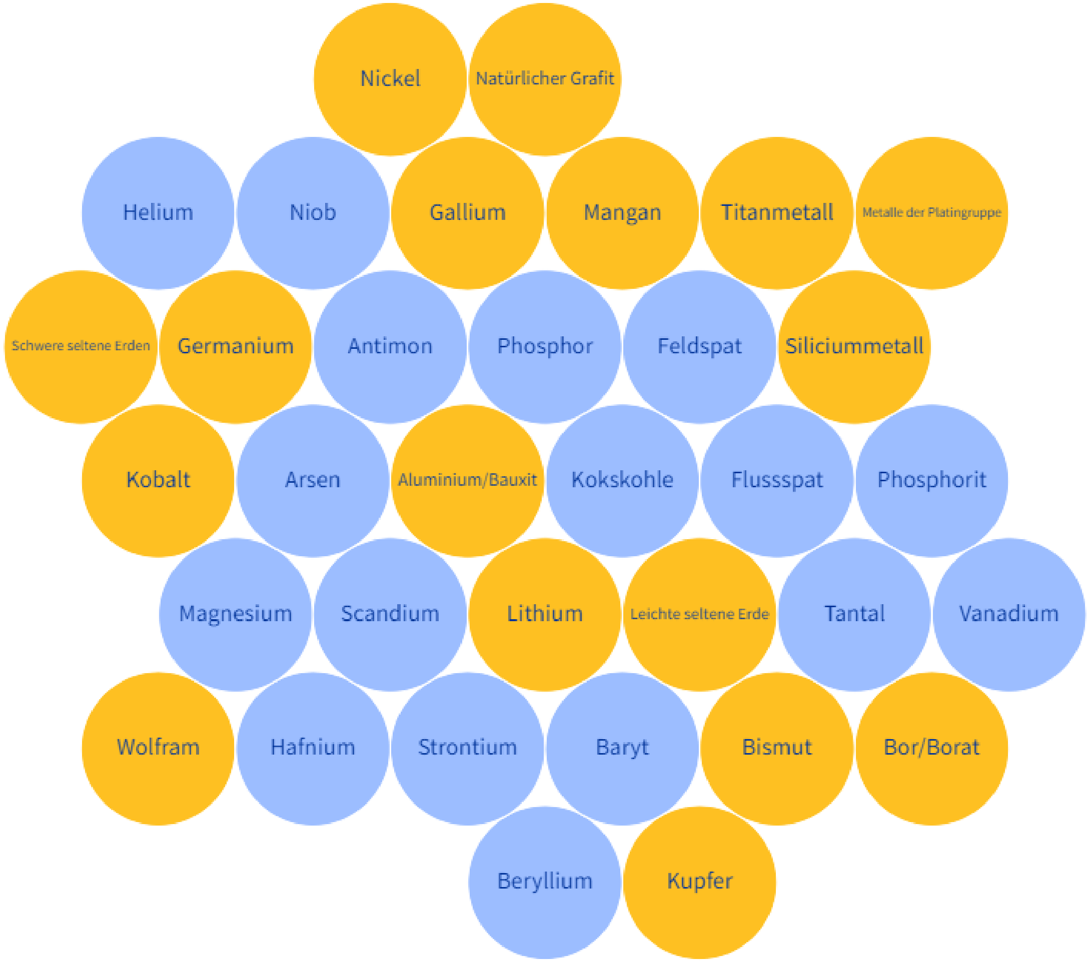
Download-Code of the new report
„Smartphones - Metalle und Recycling“ (German)
on July 1

# Context: EU CRMA


→ List 34 CRMs, of which 17 also strategic (yellow)

→ CRMs: essential to Europe's economy, high supply risk (import dependencies)

→ SRMs: used for green, digital, defence and aerospace applications

** https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_22_5523*

# Germany – Metals (by value, 2024)


**Domestic metal production** ~ 8 Mio €


Import of metals 88 bn € (of which ~13 bn € metals scraps!)

**Import of 11* metals** **83 bn €**


**Recycling of 11* metals** **ca. 36,5 bn €**

→ **metal recycling already plays an important role**

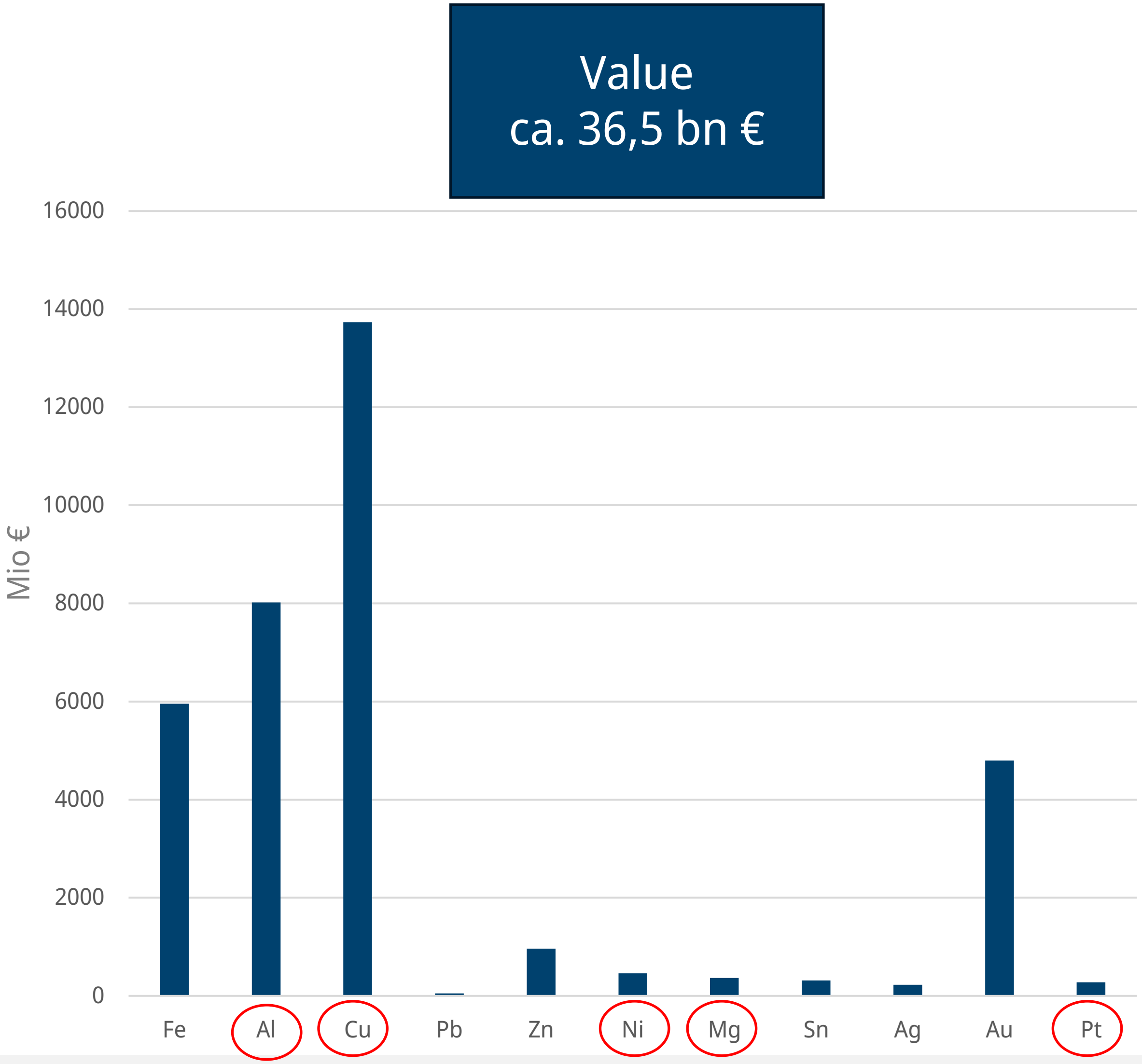
→ **yet: data very limited!**

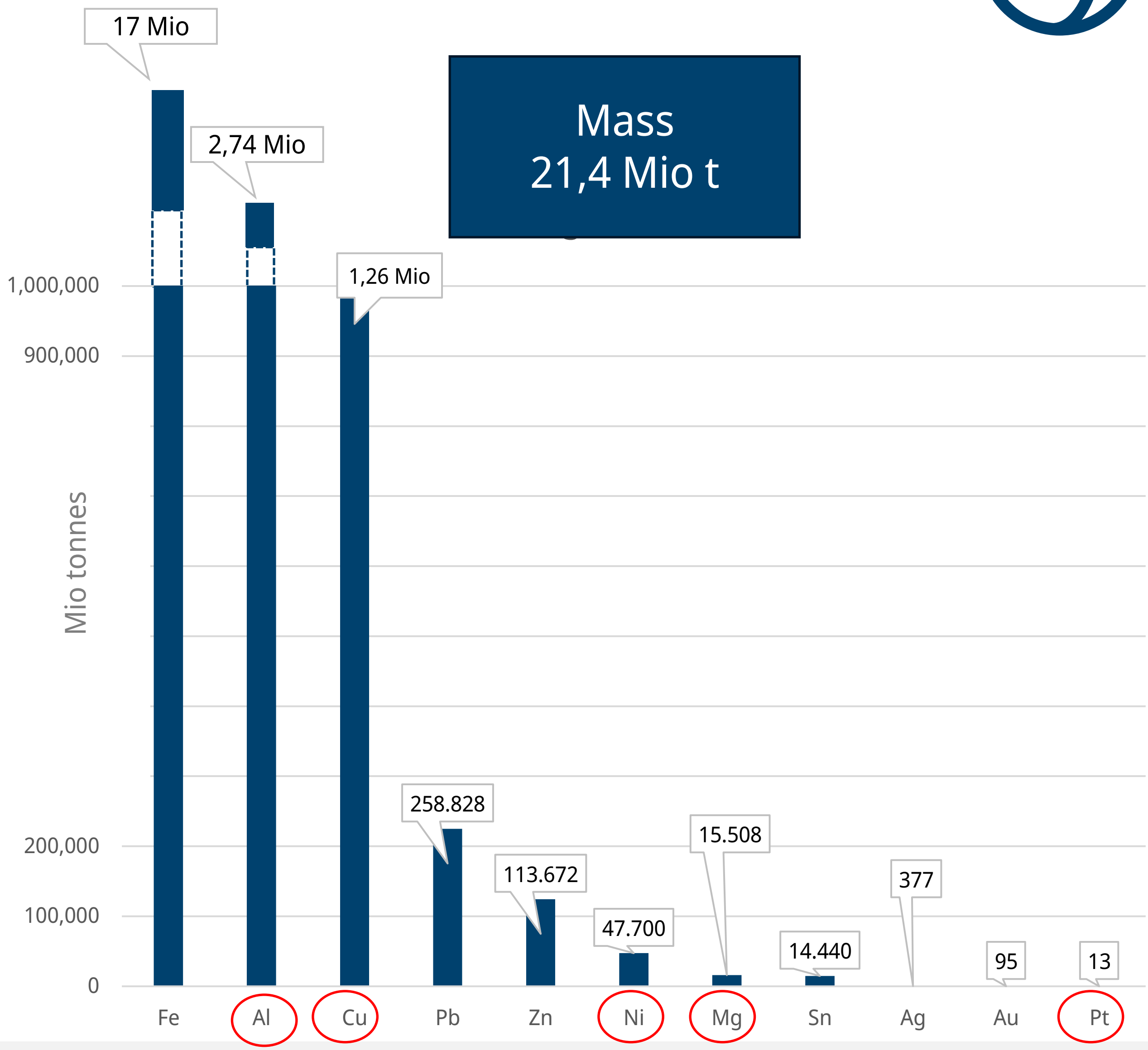
*Al, Cu, Fe, Au, Ni, Pb, Pt, Ag, Zn, Sn, Mg

Yearly updates of data
(BGR Rohstoffsituation Deutschland)

Source BGR

# Metal recycling of 11 metals (2024)




CRMs

Source: BGR /DERA