KU LEUVEN

Sustainable ICT Summer School 2020
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# Circular economy for ICT

Karel Van Acker

KU Leuven

- Why circular economy?
- What options do we have?
- How to steer CE in a resourceful direction?

# A shift in challenges



?

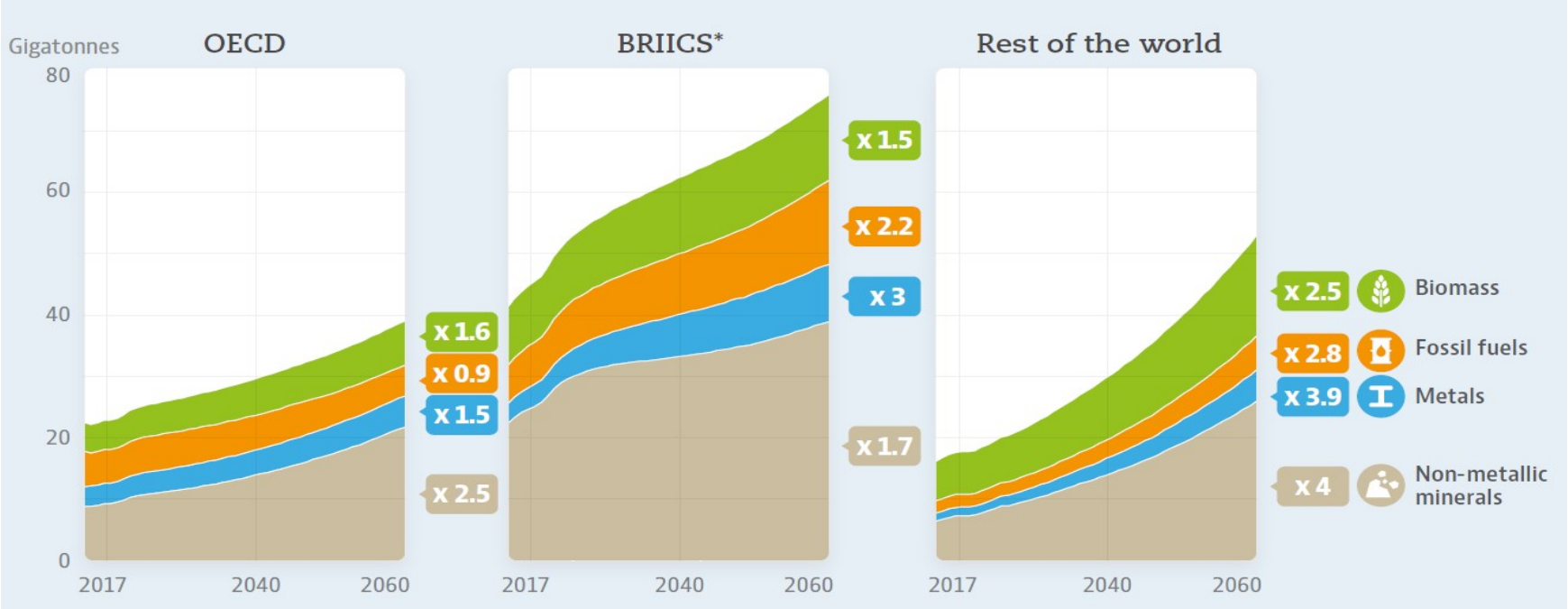
Connectivity, lively memories, …

Are there enough resources available?

What is the impact of mining and production?

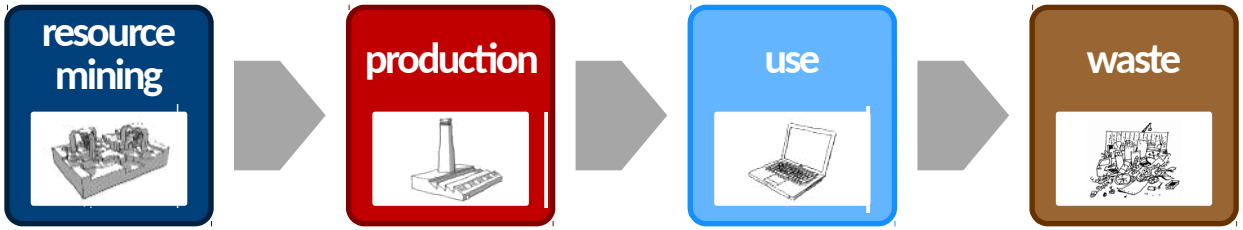
What about waste?

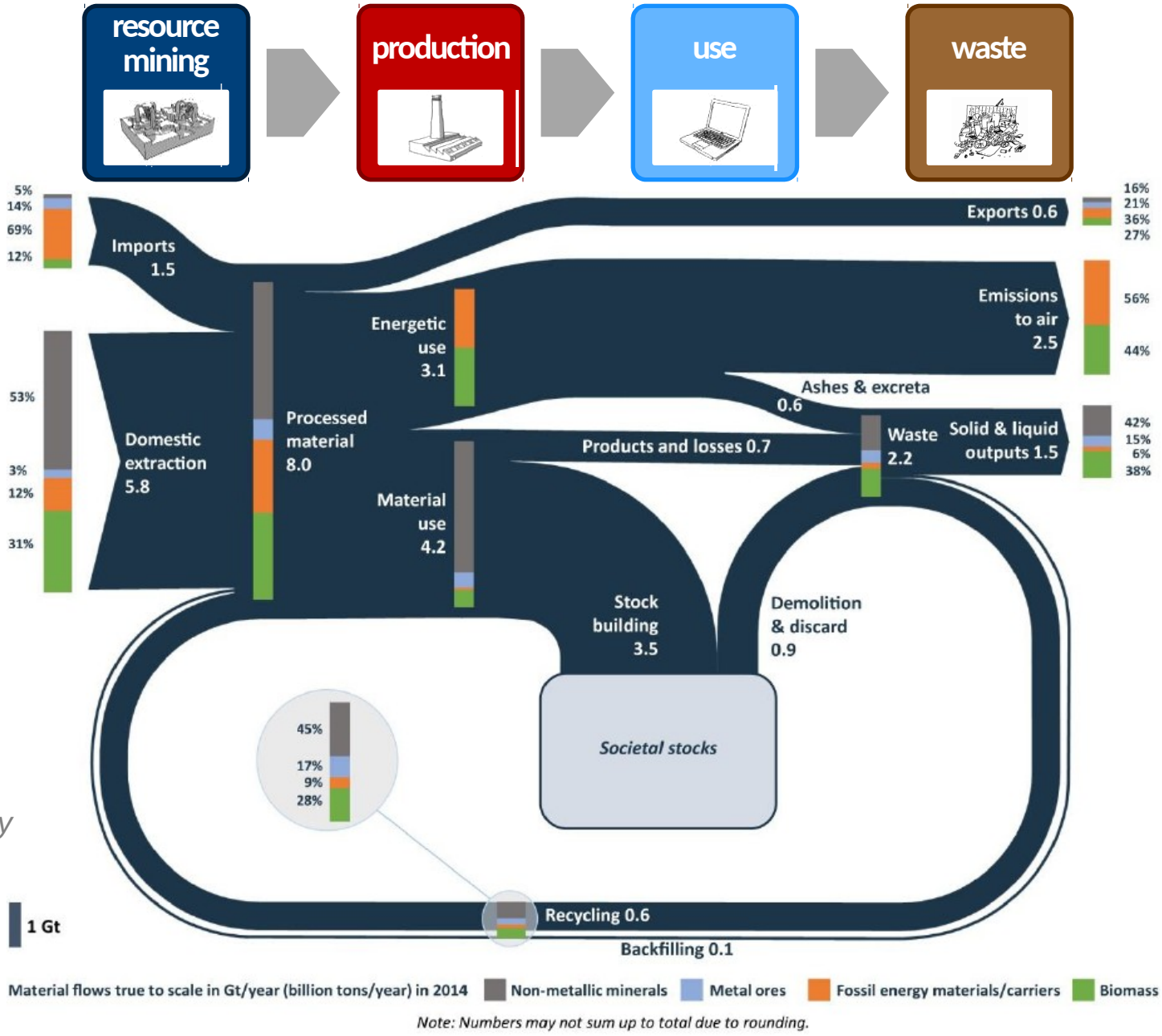
# Consumption volumes – forecast




Global materials use is projected to more than double from 79 Gt in 2011 to 167 Gt in 2060.

source: OECD. (2019). Global Material Resources Outlook to 2060

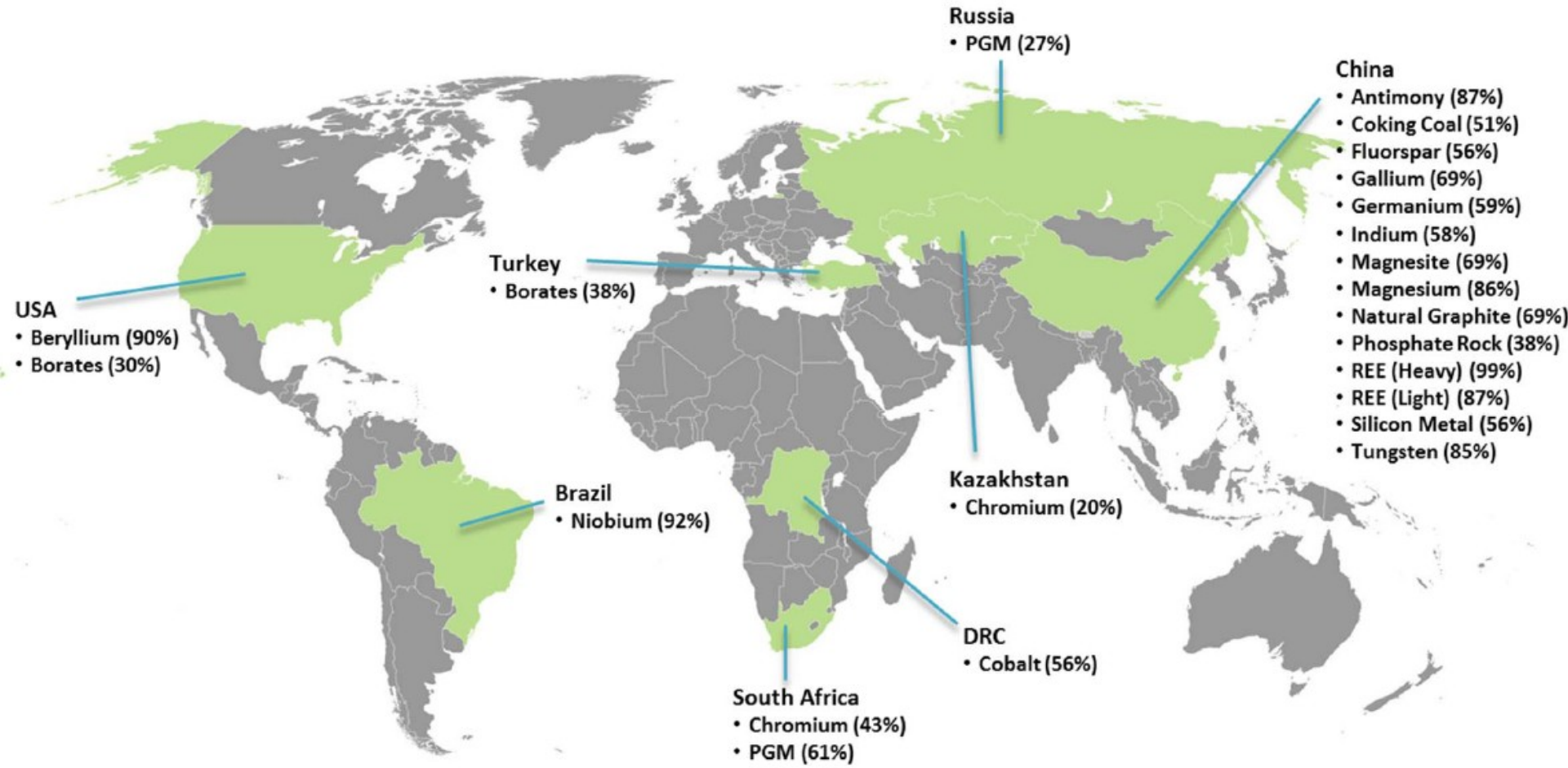

resource mining
production
use
waste



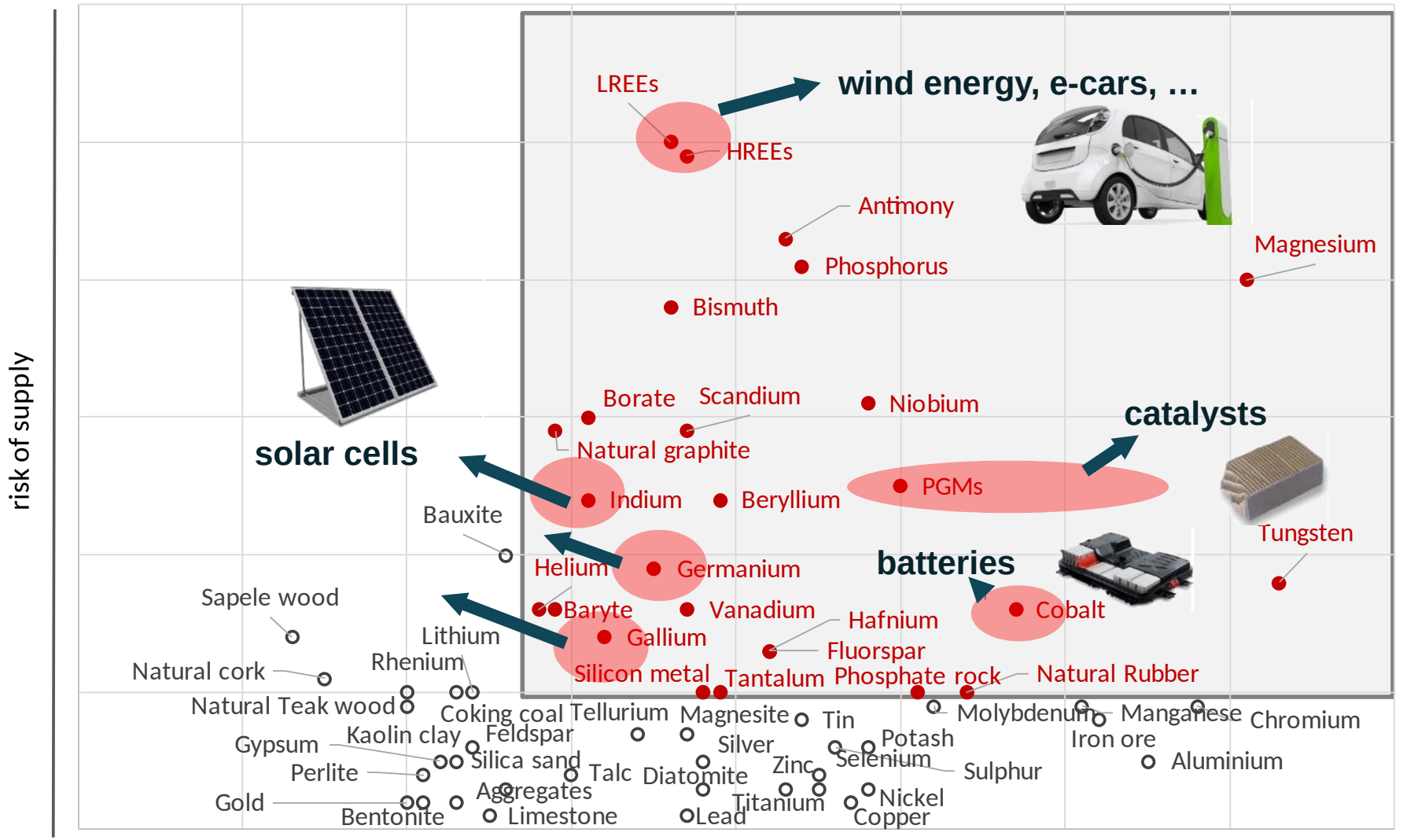

Based on:
Haas, W. (2015),
*Journal of Industrial Ecology*

# Driver 1: Limits to Resource Availability

## How to secure critical and affordable resources?

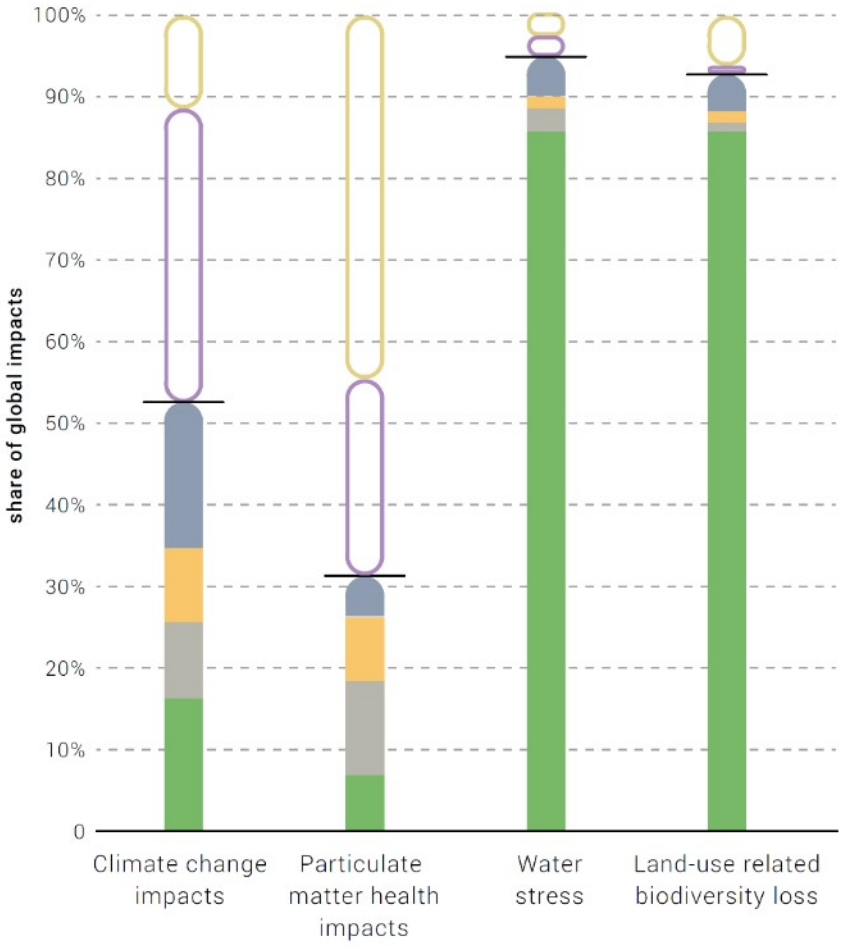


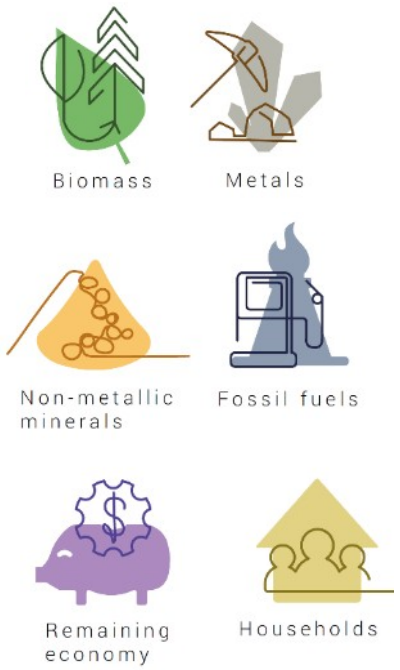
# Critical Raw Materials - EC 2017



# Driver 2: Impact on environment

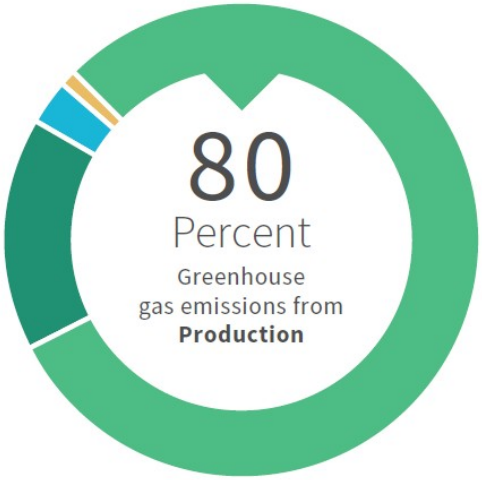
Strong link with climate, biodiversity, water



# Impact on environment of production

## Greenhouse Gas Emissions of a Smartphone




80% Production
16% Customer use
3% Transport
1% Recycling

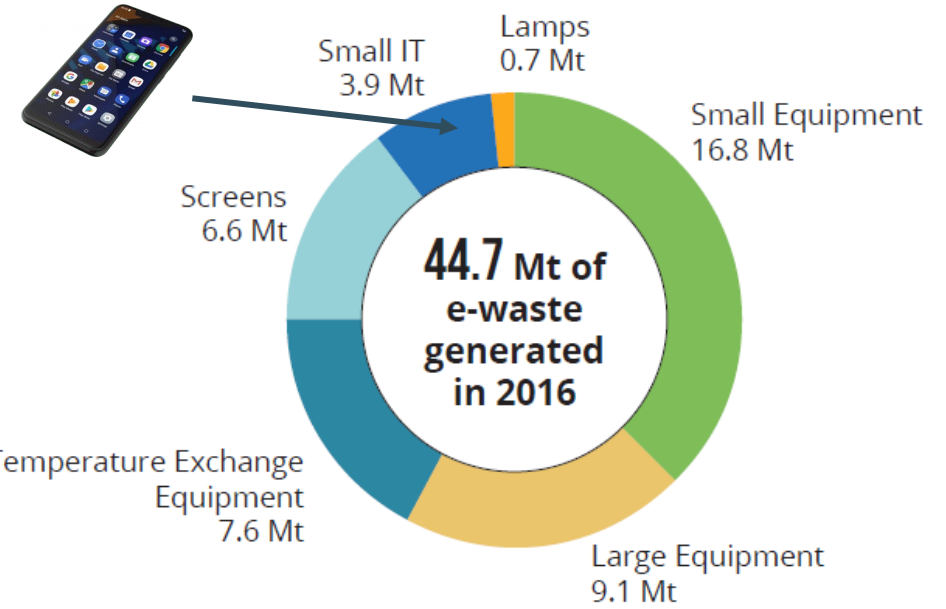
Data taken from iPhone 8–64GB model

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | | | | | | | | | | | | | | | | | He |
| Li | Be | | | | | | | | | | | B | C | N | O | F | Ne |
| Na | Mg | | | | | | | | | | | Al | Si | P | S | Cl | Ar |
| K | Ca | Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr |
| Rb | Sr | Y | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I | Xe |
| Cs | Ba | La | Hf | Ta | W | Re | As | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |
| Fr | Ra | Ac | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
| Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr |

Production
= ±35 kg $CO_{2eq}$ emissions

# Impact of E-Waste




- complex waste streams
- relatively low volumes

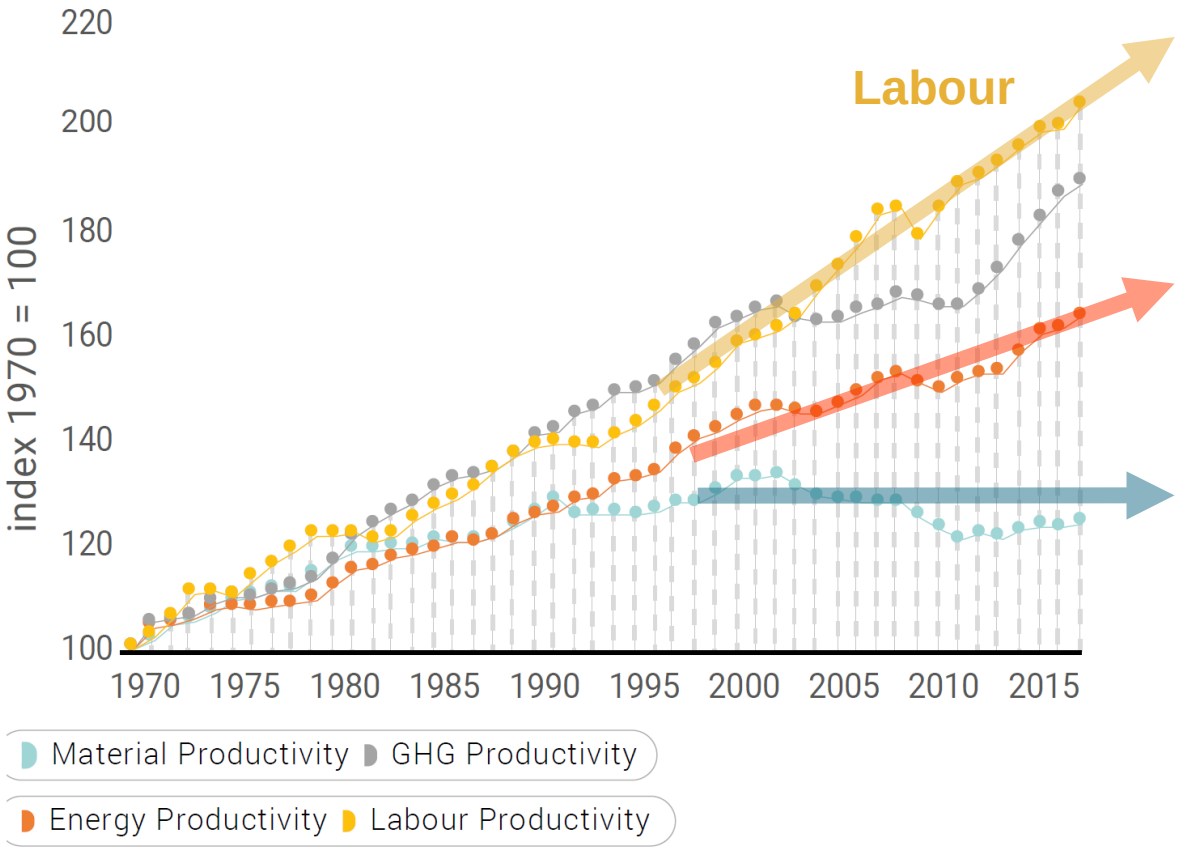
BUT:

- value of materials
  > 50 GEUR
- toxic materials:
  2,2 Mt hazardous (Hg, Cd, Cr)
- only 1/6 is recycled efficiently

→ raising attention for e-waste collection and recycling a.o. through extended producer responsibility (EPR)

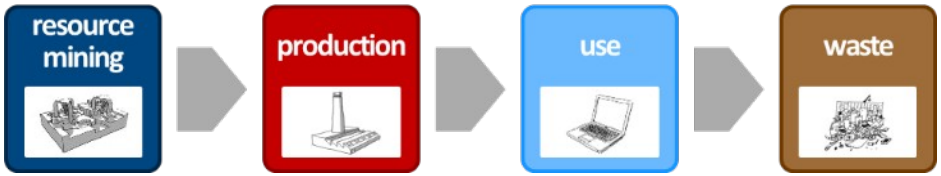
# Driver 3: Resource productivity

FIGURE 2.26 **Global resource productivity (material, energy and $CO_2$ emissions) and labour productivity, index, 1970 – 2017**



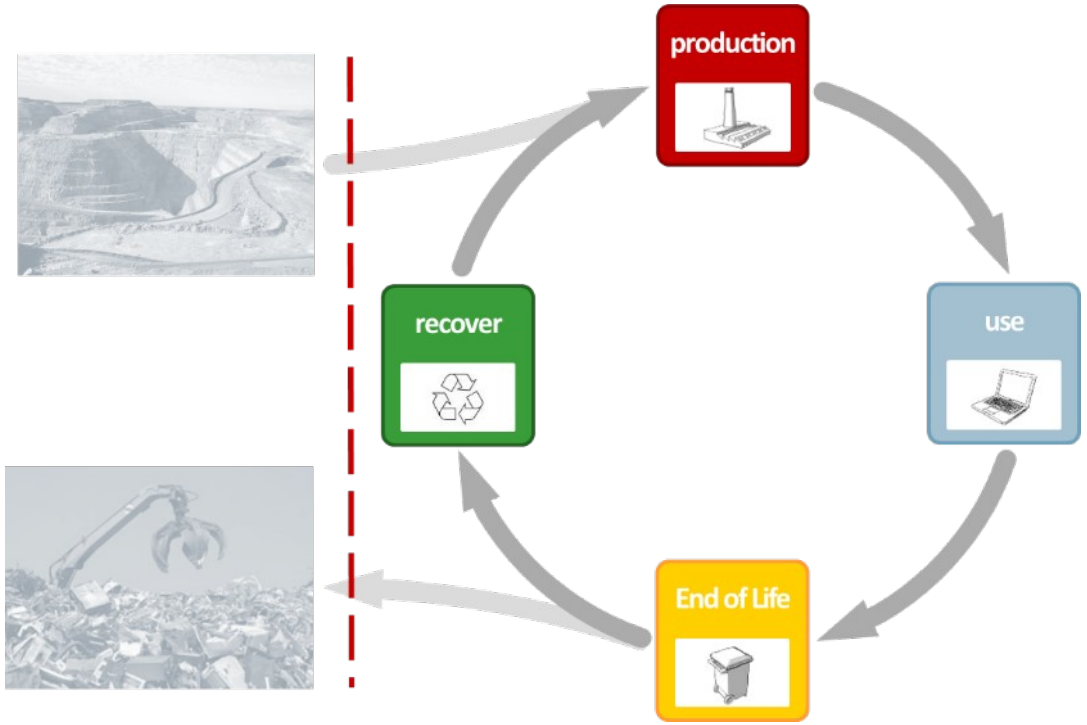

*Source:* EDGAR World Emission Database; IEA World Energy Database; ILO Labour Statstics; UN, 2017a; UNEP & IRP Global Material Flows Database

# From linear to circular economy




High resources consumption…
- Availability
- Waste / lost value
- Impact environment

…Keeping materials in the economy as long as possible at high quality
- Less resources
- Less impact on climate
- Avoids waste



# POTENTIAL

Improved resource efficiency could save Flemish businesses

**3-6 billion euros** per year

that is **2 to 3,5%** of the Flemish GDP

Increased **competitiveness**

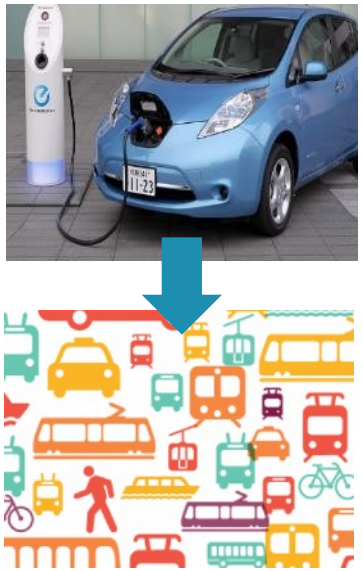
Better **security of supply**

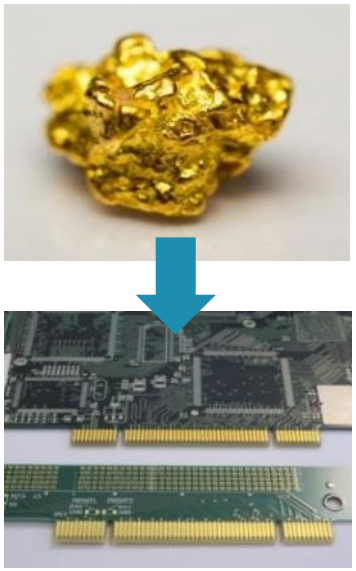
Potentially **27.000 new jobs** in Flanders

- Why circular economy?
- What options do we have?
- How to steer CE in a resourceful direction?

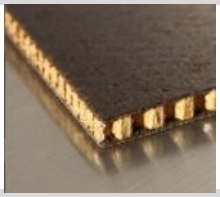
# Circular economy strategies

$$\text{Resources } (\textit{Emissons}) = \text{Societal function} \times \frac{\text{Products}}{\text{Function}} \times \frac{\text{Materials}}{\text{Products}} \times \frac{\text{Resources } (E)}{\text{Materials}}$$





# Circular economy strategies

| Resources (*Emissons*) | = | Societal function | x | $\frac{\text{Products}}{\text{Function}}$ | x | $\frac{\text{Materials}}{\text{Products}}$ | x | $\frac{\text{Resources } (E)}{\text{Materials}}$ |
|---|---|---|---|---|---|---|---|---|
| Reduce | |  | | Repair<br>Share<br>Product-service | | Ecodesign<br>Process intensification | | |
| Improve | |  | | Lifetime↑ | | Functionality of materials ↑ | | Lightweight<br>Biomaterials<br>Substitutes |
| Renew | |  | | Reuse | | Remanufacture | | Recycle<br>Design for recycling |

# Can we make a circular smartphone?

# Demand and lifetime…

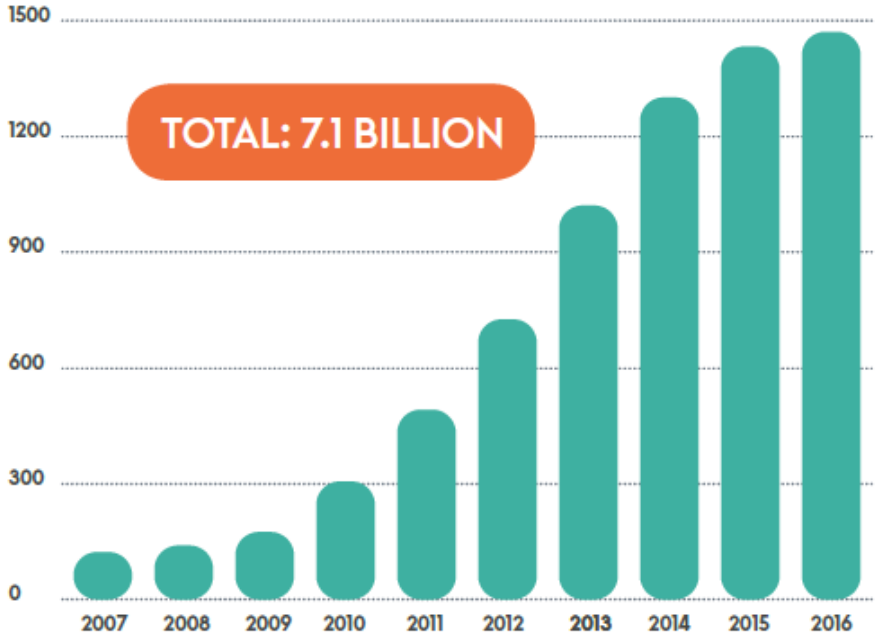



**Table 3.2: Smartphone life cycles by countries, in months, for 2013 - 2015**

| | USA | China | EU5 | France | Germany | Great Britain | Italy | Spain |
|---|---|---|---|---|---|---|---|---|
| 2015 | 21.6 | 19.5 | 20.4 | 21.6 | 18.8 | 23.5 | 17.7 | 20.0 |
| 2014 | 20.9 | 21.8 | 19.5 | 19.4 | 18.2 | 22.0 | 18.7 | 18.2 |
| 2013 | 20.5 | 18.6 | 18.3 | 18.0 | 17.1 | 20.0 | 18.6 | 16.6 |

Source: Kantar World Panel 2016

# Circular economy strategies

Renew

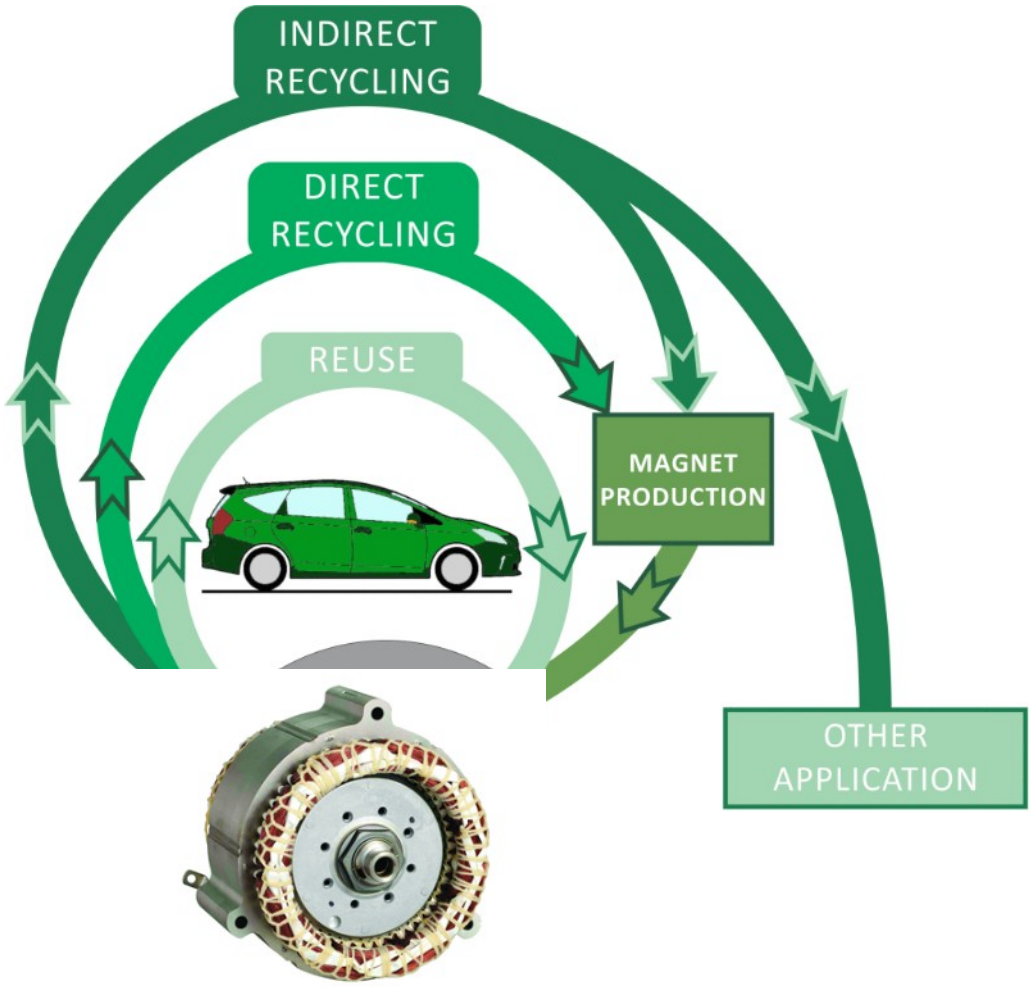
Close materials loops in a clean and efficient way

## Recycling

| Product | Copper (% by wt) | Silver (ppm) | Gold (ppm) | Palladium (ppm) |
|---|---|---|---|---|
| Television board | 10 | 280 | 20 | 10 |
| PC board | 20 | 1000 | 250 | 110 |
| Mobile phone | 13 | 3500 | 340 | 130 |
| Portable audio scrap | 21 | 150 | 10 | 4 |
| DVD player scrap | 5 | 115 | 15 | 4 |
| Average electronics | 13.8 | 1009 | 127 | 51.6 |
| Ore/mine | 0.6 | 215.5 | 1.01 | 2.7 |

Kumar, 2017

# CAVE 1: Recycling or recycling?
## Be aware of impacts

# Recycling/Remanufacturing/Reuse – different levels

- extraction of the chemical elements (e.g. Nd)

▲

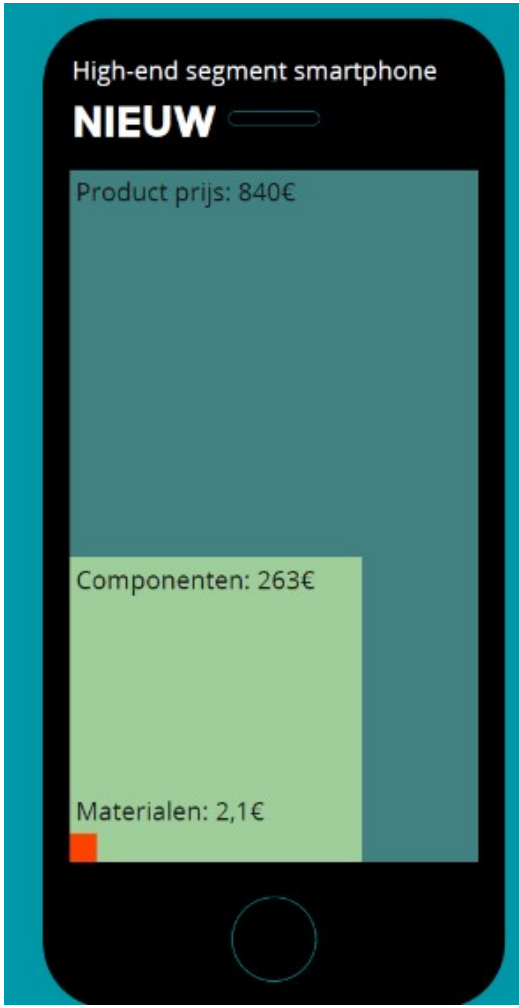
- recovery of alloys
  (e.g. NdFeB of permanent magnets)

▲

- recovery of components

the value of materials in mobile phones is
2% of the total value

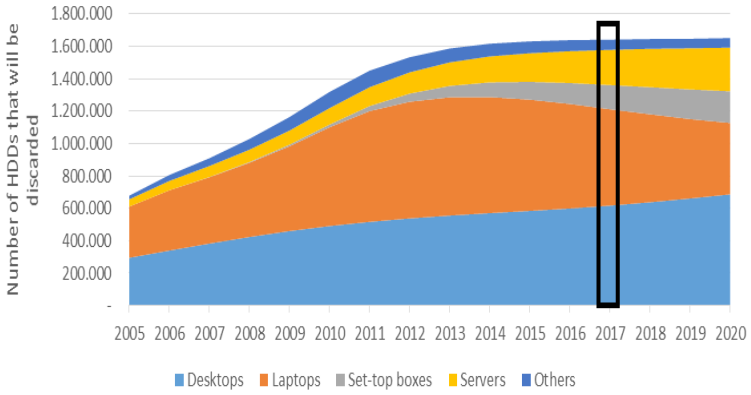
the value of the components is
33% of the total value



# CAVE 2: Better recycling is not only better technology

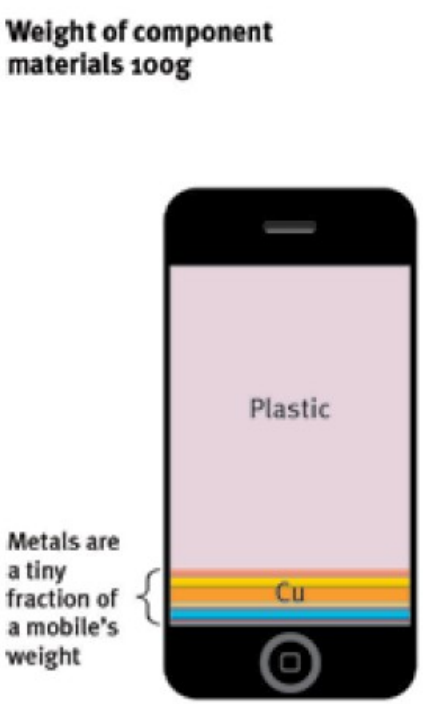
Better design

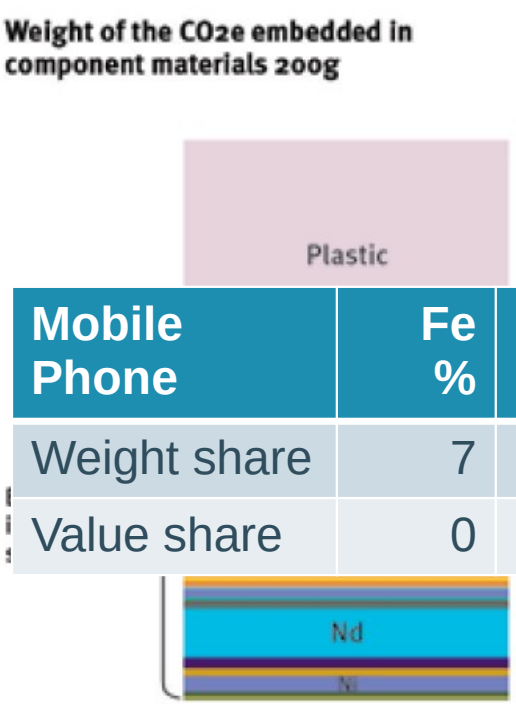

Better collection
(better incentives?)




Better knowledge of material flows
(Material passports?)

# CAVE 3:
# weight based incentives ≠ value based




| Mobile Phone | Fe % | Al % | Cu % | Au % | Ag % | Pd % |
|---|---|---|---|---|---|---|
| Weight share | 7 | 3 | 13 | 0,032 | 0,3 | 0,012 |
| Value share | 0 | 0 | 6 | 71 | 11 | 11 |

source: Green alliance, UK, 2015

# CAVE 4: Is recycling the best option? Look at the system

source: Allwood, 2012, p.282

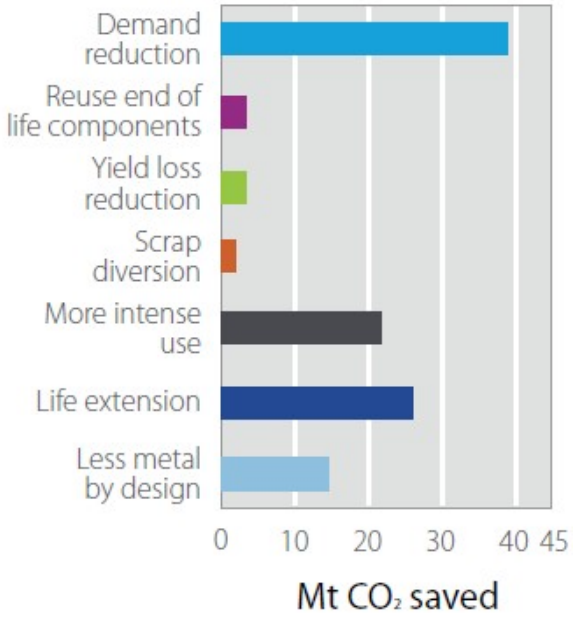



Figure 19.5—Sensitivity analysis for the steel options

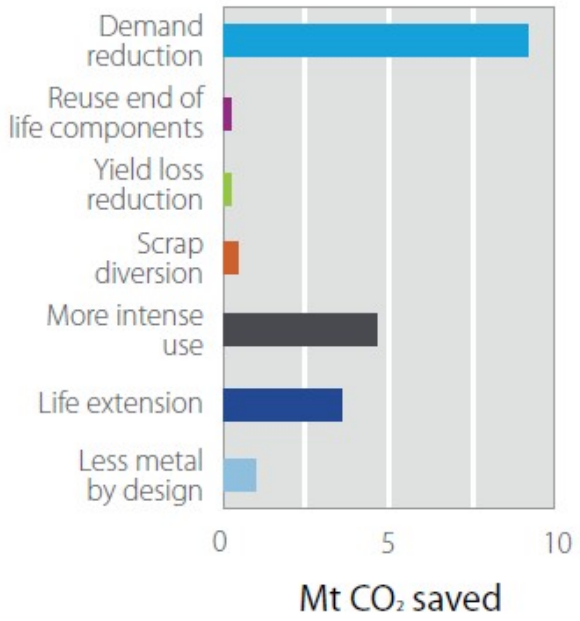


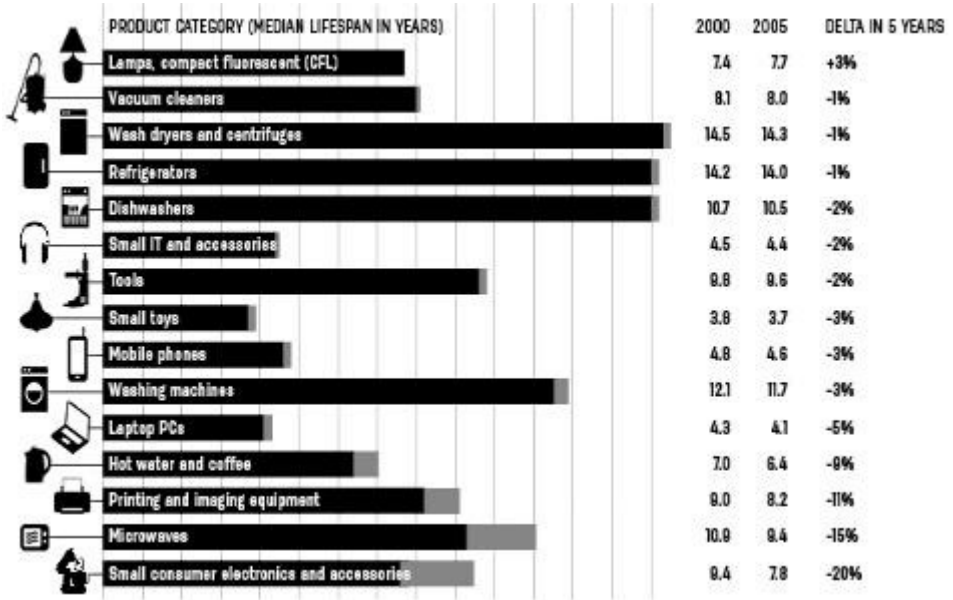

Figure 19.6—Sensitivity analysis for the aluminium options

# Circular economy strategies

Reduce

Do more with less materials consumption
Use all resources with maximum efficiency

- Increasing the functionality?
  Yes, but did we avoid other products?
- Longer lifetime?



# Repair

Reparability??

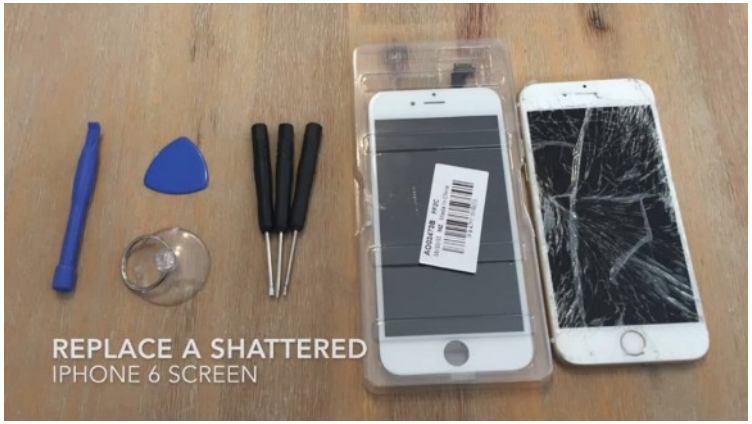
Need for modular design

# Shift to Product Service Systems (PSS)

## - Old business models

- Planned obsolescence
- Producer is no longer owner / responsible
  - property right & problems transferred to consumer
- Bad incentives for material use, waste, recycling, product lifetime, …

Firestation 6, Livermore CA (since 1901)

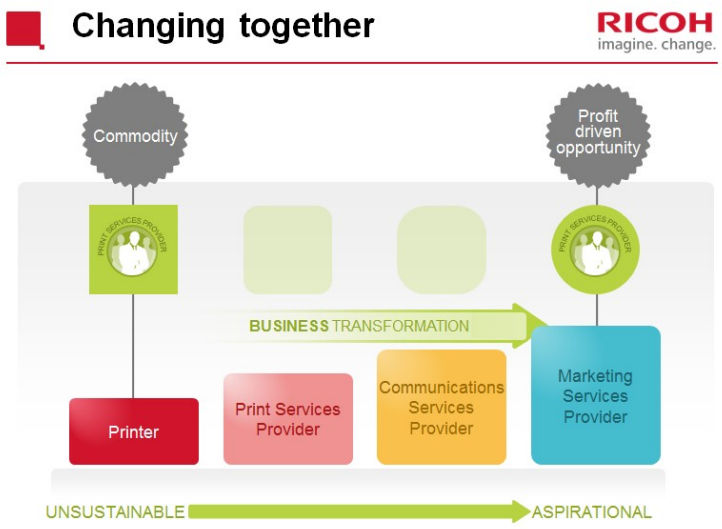


# Shift to Product service systems (PSS)
## - New business models

- Often based on selling SERVICES instead of goods:
- Consumer wants (societal needs):
  - Light (not lamps)
  - Mobility (not a car)
  - Copies/prints (not a printing machine)
  - …
- Producer stays owner of the machine
- Better incentives for durable design, efficient material use, reduction of waste, design for recycling, longer product lifetime, …

# Example: copiers / multifunctionals (B2B)

- Xerox, Canon, Ricoh, …
- Old business model was to sell machines
- All switched long ago to different options for consumers:
  - Buy, lease, pay-per-page, …
- Moving forward into broader service domain of document management systems (paper and digital)



# Example: household appliances (B2C)

- B/S/H household appliances (Bosch) rents household appliances (refrigerators) in Papillon project
- Social aspect is important
  - Replacing old energy guzzling fridges for poorer households (together with *Samenlevingsopbouw West Vlaanderen*)
- Test in B but more experience in NL
  - Blue Movement, Bundles, …

Papillon project

BlueMovement

Bundles
*We love laundry*

| Voorbeeld koelkast met diepvries – klant bij Eandis (met of zonder budgetmeter) | | |
|---|---|---|
| | oude koelkast 15 jaar oud bij start | nieuwe koelkast met Pappillon |
| Papillon | | |
| Energieverbruik per jaar | 591 kWh | 204 kWh |
| Energiekost (10 jaar) | 2128 € | 735 € |
| Reparatie | 300 € | Inbegrepen |
| Huurgeld | - | 694 € |
| Totale kost | 2428 € | 1429 € |

**=> Besparing van 999 € in 10 jaar tijd**

# Why shifting to a new business model?

- Because of the environmental benefits?
  - Rarely unique reason
- Often because of business economics reasons!
  - Cost reduction
    - Lower cost because of efficiency improvements
  - Value increase
    - Better differentiate consumer segments
  - Competitive advantage
    - Lock in consumers, lock out competitors
  - Customer base expansion
    - Attract new consumers

# Environmental advantages

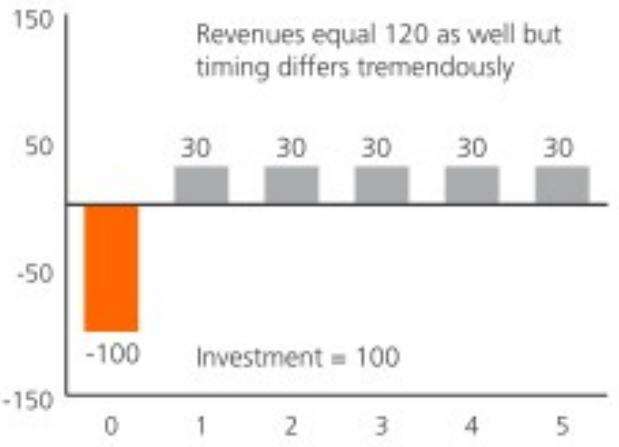
- Producer / service provider faces better incentives for:
  - Longer lifetime of products/components
    (earning money from making things work instead of from fixing them)
  - Material & energy efficiency
  - Remanufacturing & Recycling
  - Waste handling
- But also possible downsides:
  - Will users handle goods with sufficient care? (moral hazard)
  - Rebound effect (more usage in the end)
    - Easier access at lower immediate cost
  - What happens with leased goods at end of contract?
    - Environmental net effect depends on lifetime of good, relative impact in manufacturing – use – waste phase etc…

# Some barriers of PSS

- PSS need longer **pay-back periods**
  - Revenues come in slowly instead of immediately
  - Big (pre)finance requirement
    - How to convince investors (share holders, banks)?

1. Direct sales model


2. Pay per use




Source: - (2015) Rethinking finance in a circular economy, ING

# Some barriers of PSS

- PSS need longer **pay-back periods**
  - Revenues come in slowly instead of immediately
  - Big (pre)finance requirement
    - How to convince investors (share holders, banks)?
  - Good knowledge of “total cost of ownership” needed
- **Rest value** of products becomes important – and hence the dismantability/recyclability
- PSS requires a **long term relationship** with a supplier ⇨ good contracts are crucial
- The user has to be motivated to use the product with care: (financial) “**co-ownership**” of the user

# Are consumer ready for PSS?

- “sharing” in mobility is having more and more success
  - Car sharing (Cambio, Degage, …)
  - Bikes (Blue bike, Swap, e-steps, …)
  - …
- But for other goods it might be more sensitive, because of
  - Hygiene (e.g. cloths)
  - Status (bv. luxury cars)
  - Identity (bv. smartphones)

# Sharing economy

consumers granting each other temporary access to under-utilized physical assets (“idle capacity”), possibly for money


- Why circular economy?
- What options do we have?
- How to steer CE in a resourceful direction?

# Needs for a circular economy

- … a lot of **experiments**
  There are a lot of strategies, but scientific research shows that potential is especially high in *lifetime extension, sharing, repairing*,…
- Evidence-based decisions – better **monitoring**
- Dedicated **incentives and targets**
  (e.g. circular design, value sharing, …)
- … and as a priority incentive:
  stimulate **innovation**
  technological, but also societal, financial, …

*Building a system that survives unplanned stresses, rather than buckles under them, requires many of the same principles as a functional transition to the circular economy (WorldBank)*

# Contact

**Karel Van Acker**
Professor Circular Economy
*Dept. Materials Engineering & Research Centre for Economics and Corporate Sustainability*
*Chairman Sustainability Council KU Leuven*
*Promoter-Coordinator Policy Research Center Circular Economy*

c/o KU Leuven MTM | Kasteelpark Arenberg 44 - box 2450 | BE-3001 Leuven | Belgium
**T** + 32 (0)16 32 12 71 | **M** +32(0)476 21 09 57 |**E** karel.vanacker@kuleuven.be

KU Leuven Institute for Sustainable Metals and Minerals:
https://kuleuven.sim2.be/

Policy Research Centre Circular Economy:
https://ce-center.vlaanderen-circulair.be/en