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# Waste management in the informal sector and e-waste management

Summer School Addis Ababa
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## Agenda

1. What is the informal sector?
    1. Examples from e-waste management in Ghana
    2. The informal sector in waste management
    3. Integrating the informal sector: approaches, examples, impacts
2. E-waste treatment in Germany

# Informal (e-)waste management in Ghana

# What the media says about Agbogbloshie

The worlds largest e-waste dump?!

**Where your computer goes to die: Shocking pictures of the toxic 'electronic graveyards' in Africa where the West dumps its old PCs, laptops, microwaves, fridges and phones**

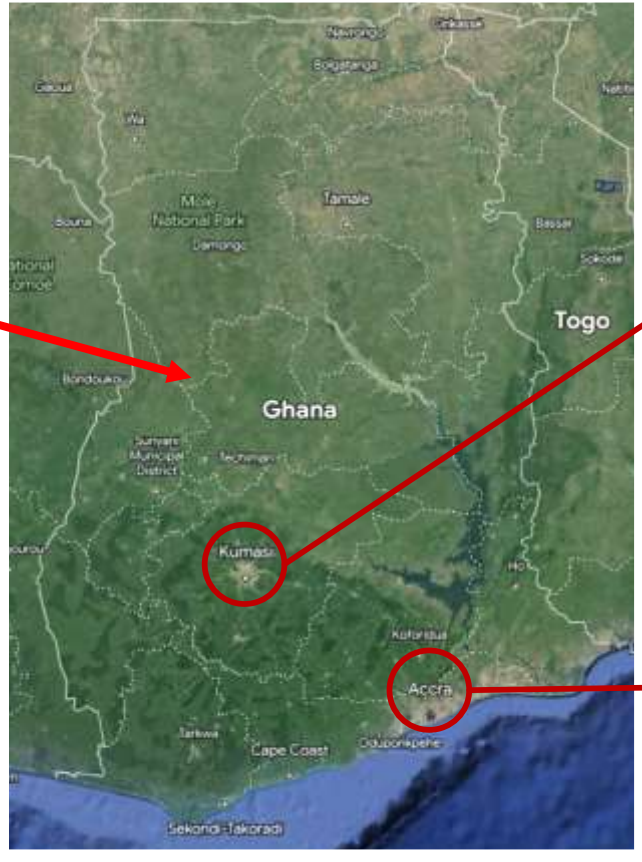

**Elektromüll aus aller Welt landet in Ghana**

Täglich kommen in Ghanas Tiefseehafen Tema Container voller Elektrogeräte an. Sie sind gefüllt mit Laptops, Handys, Kühlschränken und Fernsehern. Es ist der Wohlstandsschrott der Industrienationen.

Ref.: www.theguardian.com;http://www.dailymail.co.uk; https://www.planet-wissen.de

# Introduction

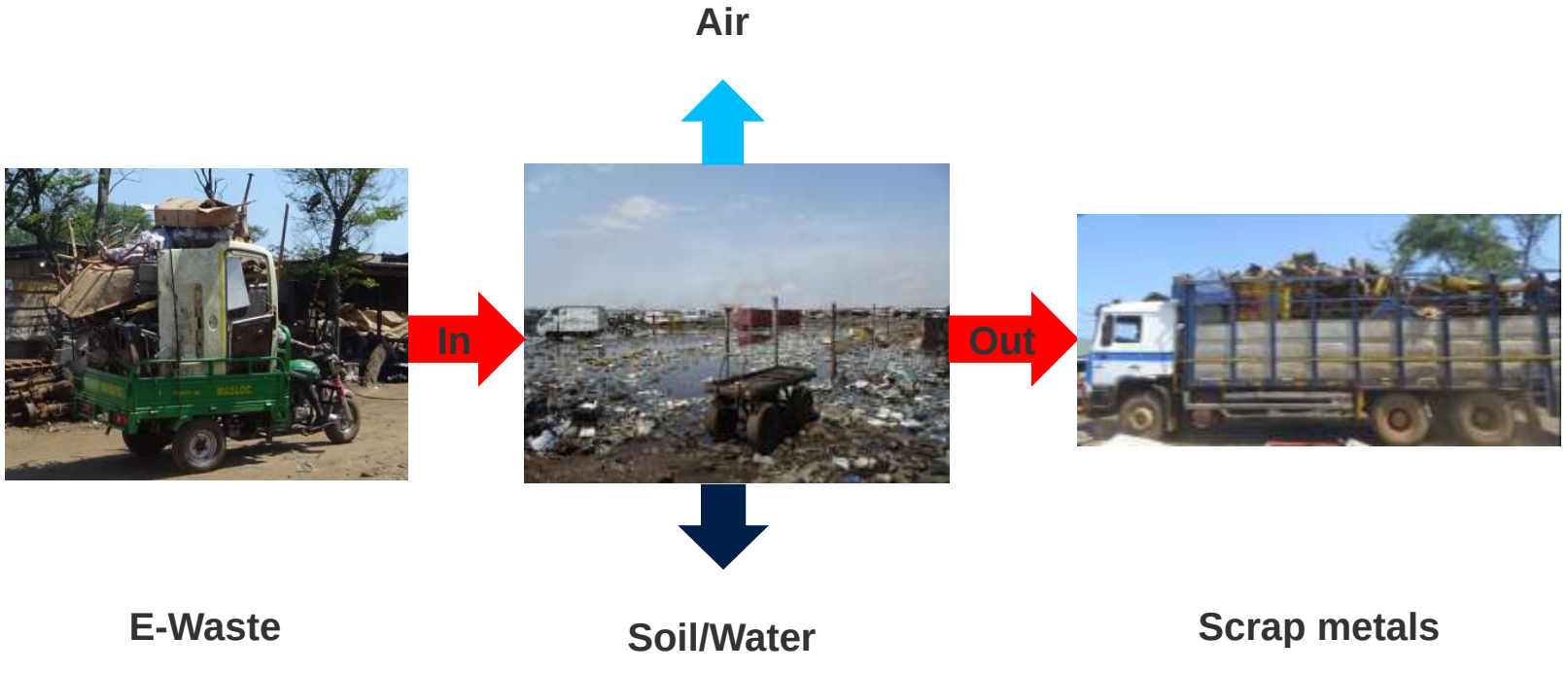
Location of informal scrapyards in Ghana



# Agbogbloshie Scrapyard

# Workflow



# Impressions

# Impressions

# Impressions

Health and safety

# Impressions

Environmental pollution

# Impression

Spreading of pollutants

# Collection and weighing

# Sorting and aggregation

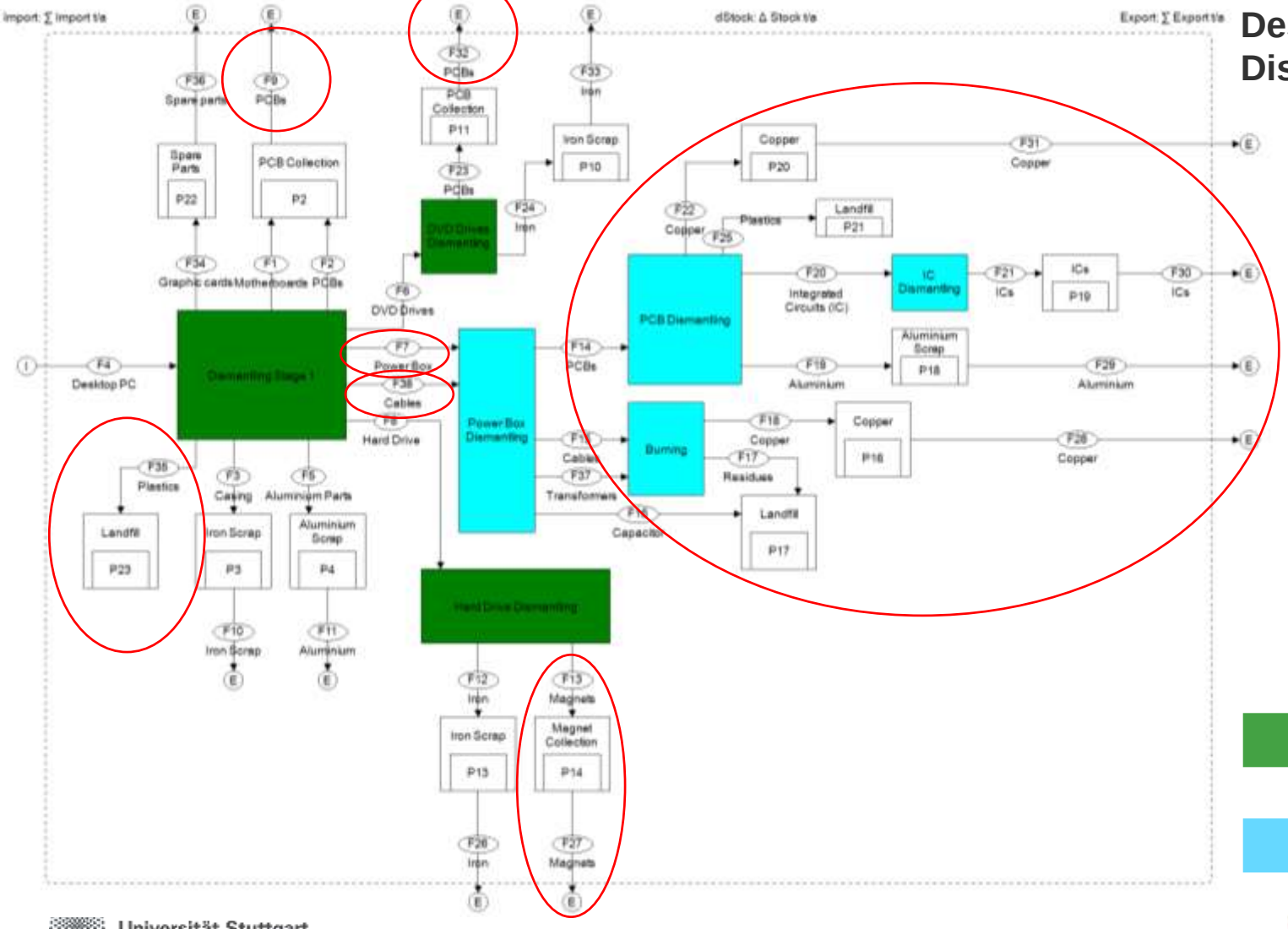
# Small shops

# Informal repair and recycling shop in Tamale

# Informal plastic recyclers in Tamale

# Impressions informal sector e-waste, scrap and car waste management

# Desktop Computer Dismantling




Nigerians

Dagombas

# What is the informal sector?

## Definition

Definition of International Labour Organisation (ILO)

- existence of no or **very low entrance barriers**;
- use of **local resources**;
- mainly **family enterprises or self-employed individuals**;
- mainly **small enterprises**;
- use of relatively **labour-intensive and adapted, local technologies**;
- acquisition of required **skills outside of the formal schooling system**;
- **unregulated markets** with high competition;
- **no access to (public) social security schemes** and
- **low income and low level of organization** (unions)

# The informal waste sector (IWS) in low-and middle- income countries

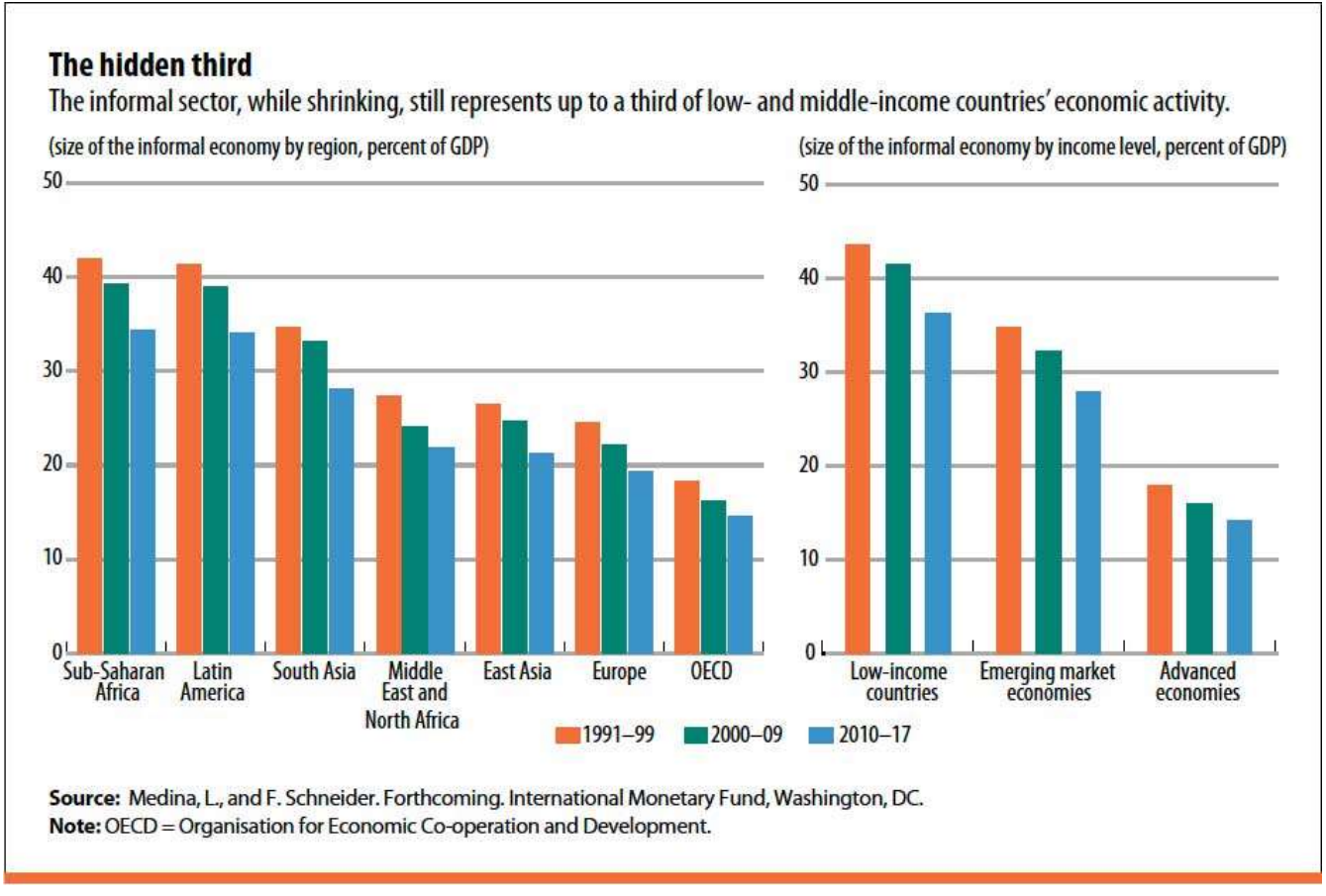
Characteristics of People in the Informal Waste Sector

- Mostly **migrants, from rural areas, or from neighbouring areas**
- **Child labour** is common
- **Women** of all ages participate actively in the IWS
- **Elderly individuals** of retirement age that either do not receive pensions or the pensions they receive are insufficient for their needs
- **Disabled individuals** unable to find regular employment

# Child labour

Upper West Region, Wa, Ghana

# One third of economic activity



## Policy Implications of Measuring the Informal Economy

Why are policymakers interested in the informal sector?

### ECONOMIC PERSPECTIVE

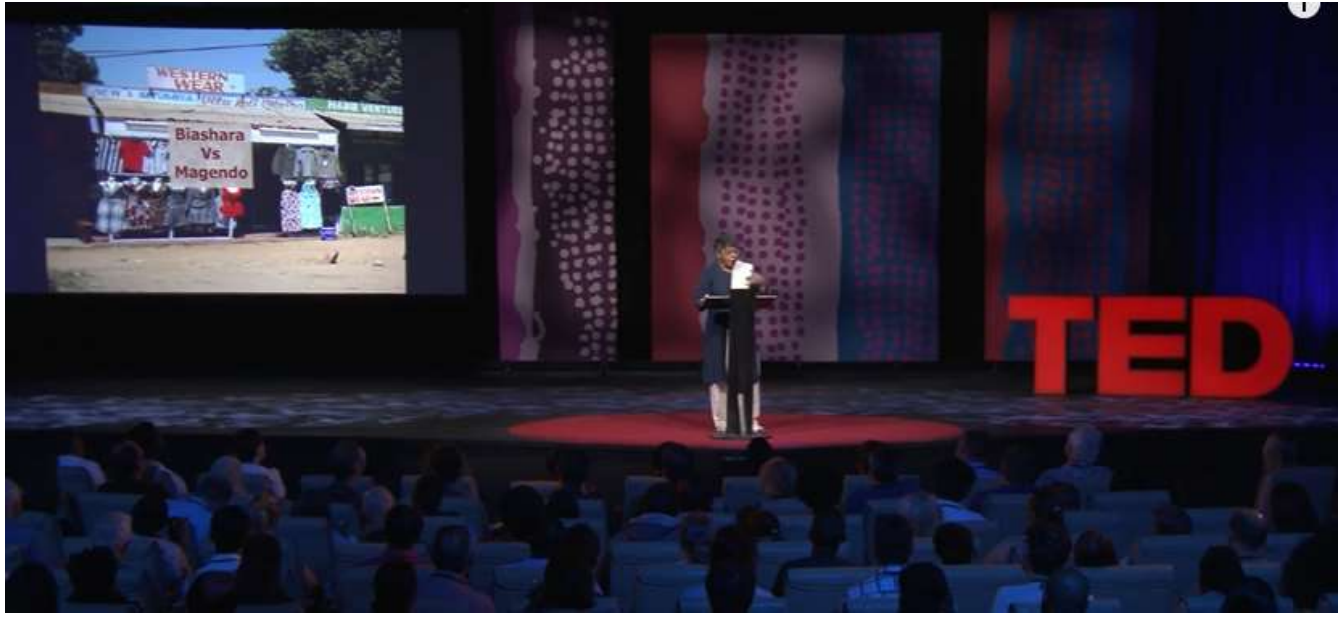
- Economic **growth and productivity**
- Low **productivity and low tax revenue**
- Limit the government's ability to spend on social programs and invest in public goods

### SOCIAL PERSPECTIVE

- Provide **employment and income** to persons who might otherwise be unemployed
- Lower and uncertain income
- Exclusion from social protections
- Inequality and poverty

# Hidden opportunities of the informal economy

- https://www.youtube.com/watch?v=d0a0eXJ5TJM



# The informal sector in waste management

# Misconceptions about the Informal Waste Sector

- **Myth # 1:** Informal recycling is a recent phenomenon
- **Myth # 2:** All scavengers are indigent and extremely poor
- **Myth # 3:** Scavenging is a marginal activity
- **Myth # 4:** Scavenging is a disorganized activity
- **Myth # 5**: Scavenging has a minimal economic impact
- **Myth # 6:** Scavengers are a nuisance that must be eliminated
- **Myth # 7:** Scavenging has no place in modern waste management systems

# The informal waste sector in low-and middle- income countries

Main Activities

- Informal waste collection

# The informal waste sector in low-and middle- income countries

Main Activities

- Informal recovery of recyclables

# The informal waste sector in low-and middle- income countries

Main Activities

- Informal recovery of recyclables (Picture: Northern Region, Tamale, Ghana)

# The informal waste sector in low-and middle- income countries

Main Activities

- Manufacturing activities

# The informal waste sector in low-and middle- income countries

Main Activities

- Provision of services

# Types of informal waste workers

- **Itinerant waste-buyers**, who go from door to door and collect and buy recyclable materials
- **Street waste-pickers**, who recover recyclable materials from mixed waste on the streets
- **Municipal waste collection crews**, who recover recyclable materials while transporting them to disposal sites
- **Waste-picking at dumpsites**
- **Middlemen or informal traders/small junkshop/workshops**
- **Informal dismantlers (e-waste, scrap, cars)**

## Problems related to the informal (waste) sector

Impacts

- **Poor working and living conditions**
- Production taking place **outside the regulated economy**
- **Driving child labour**, school absences and incomplete school education for adults
- **Health** (lack of protective clothing or equipment, lack of water and sanitation infrastructure)
- **Suffer the social stigma**, subjected to harassment, self-perception
- **Data:** The part of the economy that is missing or not easily covered in official statistics

## Dangers

Upper East Region, Ghana

# Benefits related to the informal (waste) sector

The informal sector contributes significantly to resource efficiency as well as to environmental and climate protection

- Financial contribution, **income generation**
- **Cost reductions to formal waste management systems**
- **Job creation**: informal waste management systems generate between ten and forty times more jobs than systems in a high-income country (Linzner and Lange (2013))
- **Collection/retreiving of valuables works good**, for e-waste better than in the formal sector
- **Contribute significantly to recycling rates** in low-and middle-income countries (up to 45% of the generated waste (in some cases even more))
- **Contribution in waste management**: China: 17-38%; Mali 100%

# Integrating the informal sector: approaches, examples, impacts

# Policy making for the informal sector

- Measures to include this sector in waste management systems are necessary
- Can effect informal sector positively or negatively
- major element: raising awareness of political decision-makers
  - Action learning
  - Integration of IS in waste management planning


Policy making for Solid Waste Management should include all relevant stakeholders

## Strengthening the informal sector as an economic actor

Strong informal workers are stable entrepreneurs and reliable partners

- Require the same (technical, financial and management) capacity and services as formal enterprises
  - mostly excluded because they lack the necessary legal status
- **Examples:**
  - technical processes and quality control
  - health and safety and environmental standards
  - business management
  - access to credit or loans
  - networking with stakeholders from the formal private sector

# Strengthening the organisational capacities of the informal sector

- **Informal waste sector organisation forms**: community-based organisations, cooperatives, associations, labour unions, etc.
- **Creating an identity** for their members (“environment professionals”)
- Support for **their members in establishing networks and exchanging experience**
- Provision of services to members such as access to micro-credit, health insurance, training, opportunities to exchange experience
- Awareness raising of public authorities (“**the invisible sector becomes visible**”)
- Representation of members’ interests
- Official partners of municipalities for provision of services and collaboration (integration of IS)

# What is e-waste?

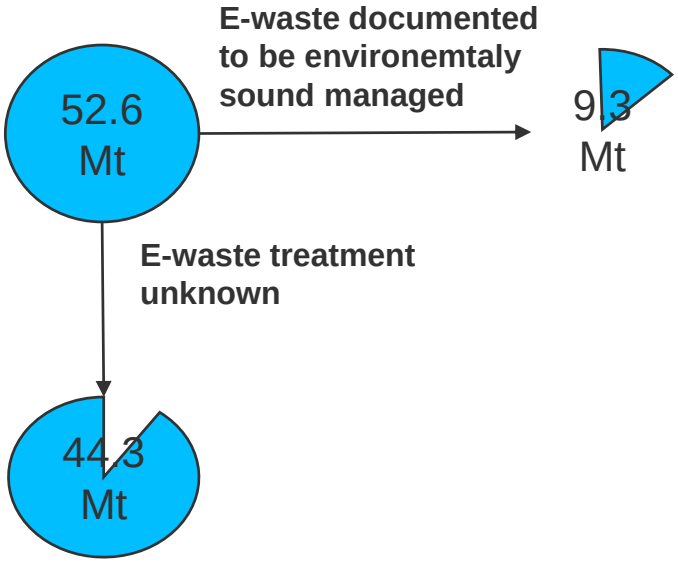
# What is e-waste?

- There **is global inconsistency** in the understanding and application of the term “e-waste” in both legislation and everyday use
- **Electrical and Electronic Equipment (EEE):** “Any household or business item with circuitry or electrical components with power or battery supply.”
- **WEEE (WasteEEE) or E-waste:** “E-Waste is a term used to cover items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention of re-use.” [1]

WEEE Directive  European collection groups

1. **Temperature exchange equipment**
2. **Screens and monitors,** and equipment containing screens having a surface greater than 100 $cm^2$
3. **Lamps**
4. **Large equipment** (any external dimension more than 50 cm) including, but not limited to: Household appliances; IT and telecommunication equipment; etc.This category does not include equipment included in categories 1 to 3.
5. **Small equipment** (no external dimension more than 50 cm) including, but not limited to: consumer equipment; equipment reproducing sound or images, musical equipment; etc.
6. **Small IT and telecommunication equipment** (no external dimension more than 50 cm)

# Global e-waste generation in 2019

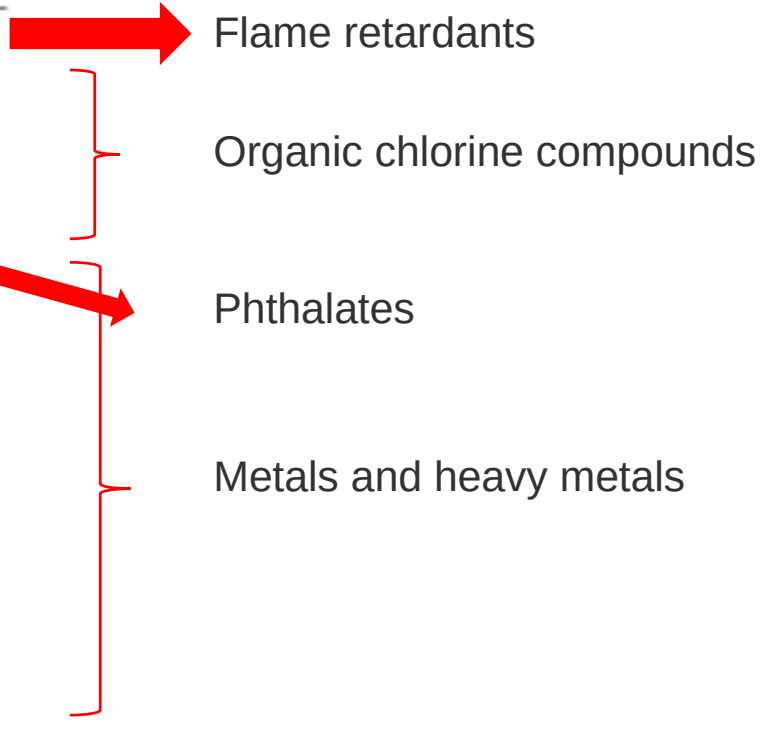



- **17%** of global e-waste is documented to be recycled in enviornemntally sound facilities
- **$10 billion** USD of raw material recovered
- **4 Mt** of raw materials could be made available for recycling
- **15 Mt** of CO2 -eq net saving through the recycling of secondary raw materials

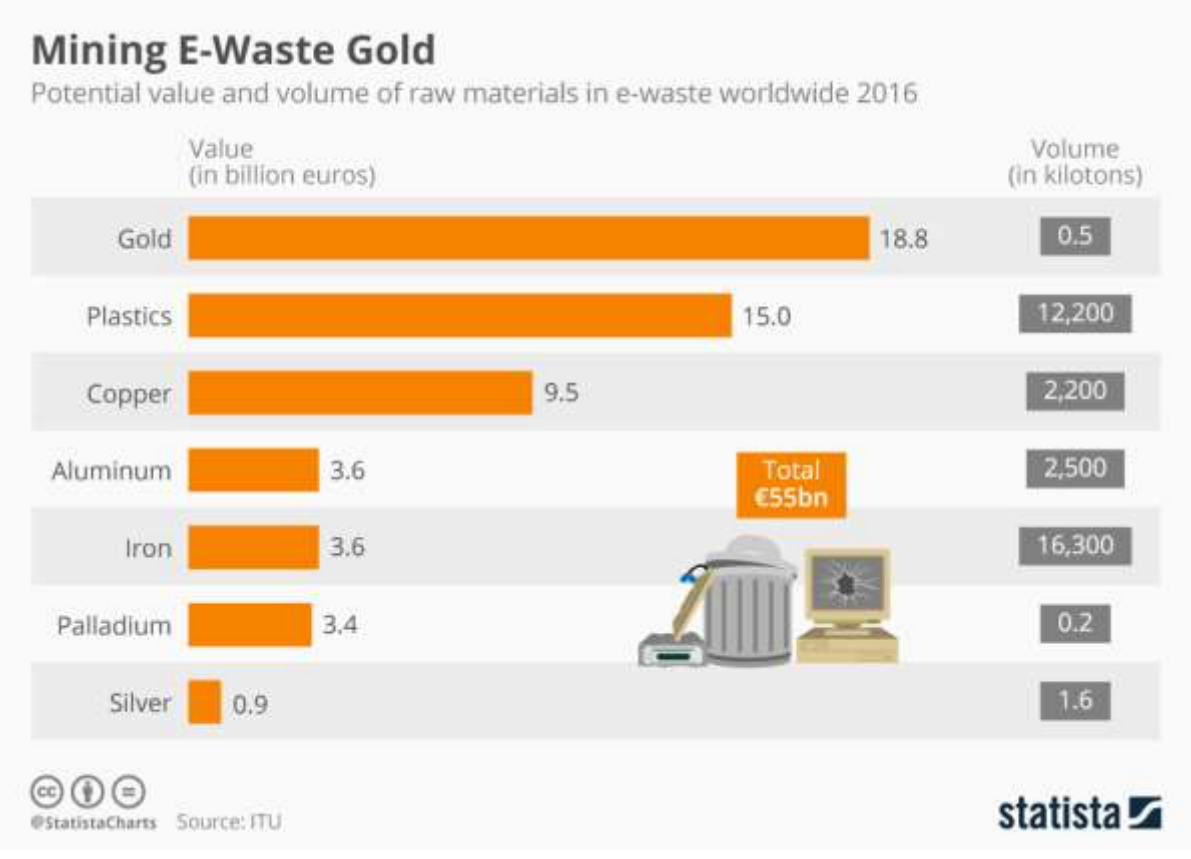
- **83%** treatemtent of e-waste is unknown, likely dumped, traded or recyceld in a non-compliant way
- **47.6 billion USD** value of raw material
- **98 Mt CO2 –eq** emissions of untreated refrigerants
- **71 kt** brominated flame retardants
- **50 t** of mercury

# Pollutants

| Contaminant | Relationship with e-waste |
|---|---|
| Polybrominated diphenyl ethers (PBDEs) polybrominated biphenyls (PBBs) tetrabromobisphenol-A (TBBPA) | Flame retardants |
| Polychlorinated biphenyls (PCB) | Condensers, transformers |
| Chlorofluorocarbon (CFC) | Cooling Units, insulation foam |
| Polycyclic aromatic hydrocarbons (PAHs) | Product of low temperature combustion |
| Polyhalogenated aromatic hydrocarbons (PHAHs)Polychlronated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) | Product of low temperature combustionof PVCs and other plastics |
| Americium (Am) | Smoke detectors |
| Antimony | Flame retardants, plastics |
| Arsenic (As) | Doping material for Si |
| Barium (Ba) | Getters in cathode ray tubes (CRTs) |
| Beryllium (Be) | Silicon-controlled rectifiers |
| Cadmium (Cd) | Batteries, toners, plastics |
| Chromium (Cr) | Data tapes and floppy discs |
| Copper (Cu) | Wiring |
| Gallium (Ga) | Semiconductors |
| Indium (In) | LCD displays |
| Lead (Pb) | Solder, CRTs, Batteries |
| Lithium (Li) | Batteries |
| Mercury (Hg) | Fluorescent lamps, batteries, switches |
| Nickel (Ni) | Batteries |
| Selenium (Se) | Rectifiers |
| Silver (Ag) | Wiring, switches |
| Tin (Sn) | Solder, LCD screens |
| Zinc (Zn) | |
| Rare earth elements | CRT screens |

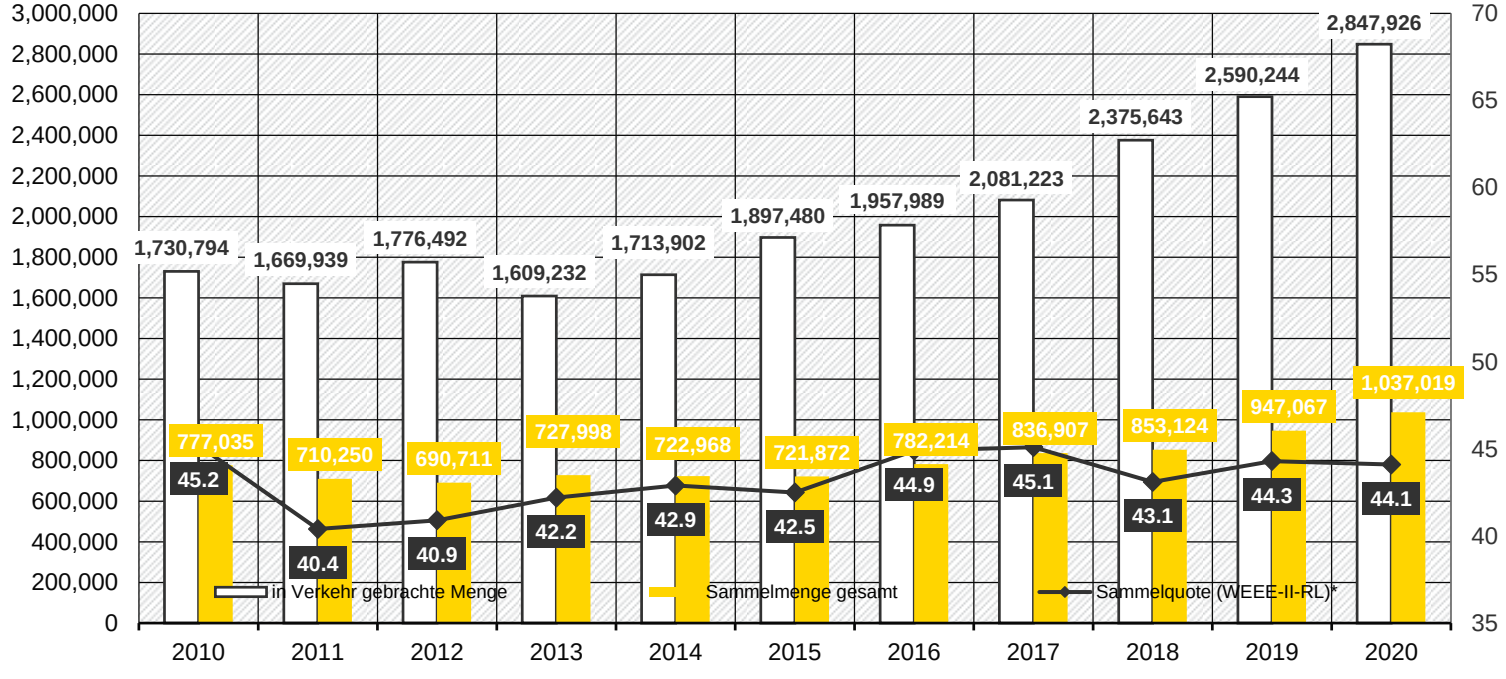


# Valuable materials in e-waste



# Quantities placed on the market, collection quantities and rates of WEEE in Germany

in tons and %




Take back rate = Tacke back quantity * 100/ (Mean value of the quantity placed on the market of the three previous years)

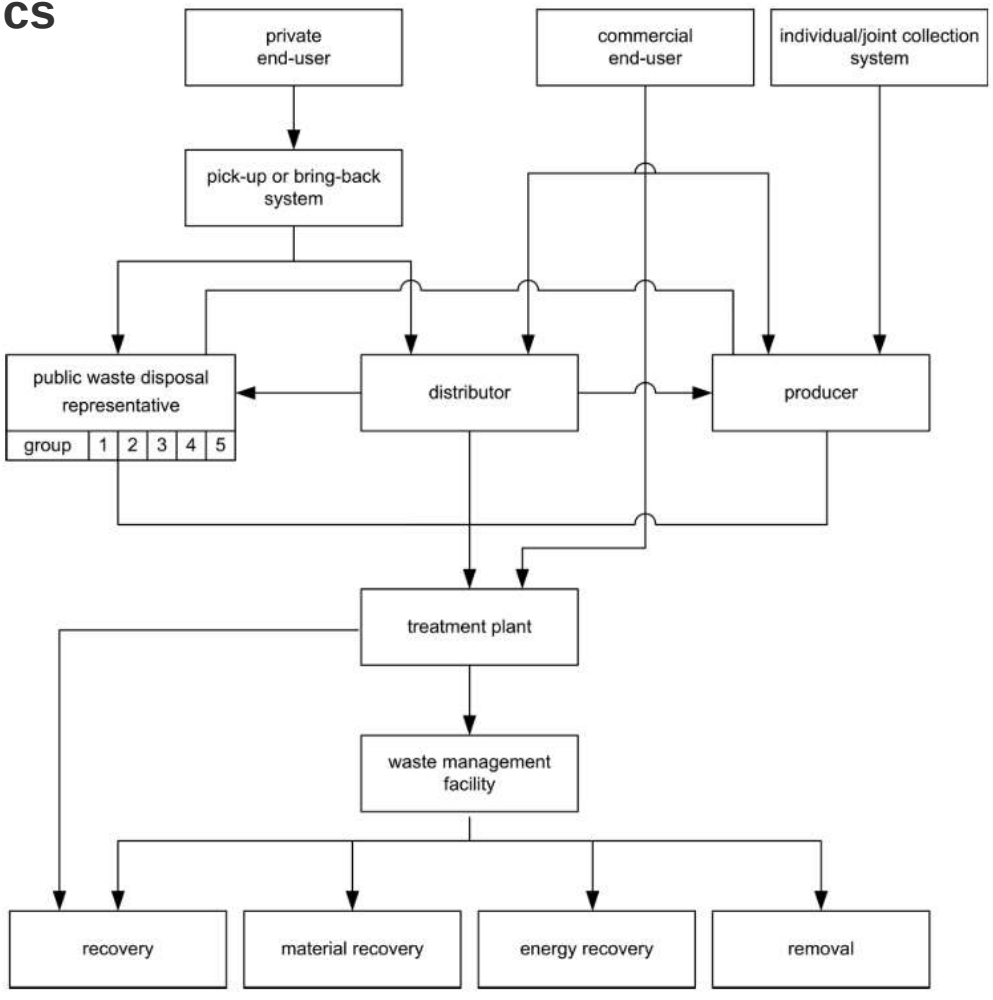
# Binding duties of manufacturers in Germany

- Taking back old appliances from the public waste disposal authorities
- Reporting of WEEE taken back, reused and recovered in a joint place
- Establishment of a joint collection point for WEEE
- Notification of the quantities placed on the market
- Treatment and recycling of e-waste

# Collection and registration logistics

**Targets:**

- High collection rate
- Possibility of reuse
- Minimisation of transport damage
- Optimisation of transport (short transport routes and suitable means of transport)
- Traceability of material flows Possibilities for a continuous improvement of the processes for those involved in operations




Quelle: VDI

# Collection and registration logistics

## BRING BACK SYSTEMS

In bring-back systems, WEEE is brought to the collection point by the last owner

- Collection at recycling centres
- Used electrical and electronic products truck
- Depot container collection

## PICK UP SYSTEMS

WEEE is picked up by collection vehicles

- Bulk waste-accompanying collection or front-door pick-up
- Take-back by distributors (collection when delivering new equipment)

## Transport and Handling

Group 1: Large domestic appliances, vending machines

### SUITABLE FORM OF COLLECTION

- covered roll-off container: Damage to equipment is avoided, re-use is possible, container is covered.

### UNCIUTABLE FORM OF COLLECTION

- non-covered container: Damage is unavoidable, release of hazardous components, re-use impossible.

## Transport and Handling

Group 2: Refrigerators

### SUITABLE FORM OF COLLECTION

- covered roll-off container: Damage to equipment is avoided

### UNCIUTABLE FORM OF COLLECTION

- non-covered container: possible damage to refrigerant circuits; items are contaminated with leaking coolant

## Transport and Handling

Group 3: Information and telecommunication equipment, entertainment electronics equipment

### SUITABLE FORM OF COLLECTION

- covered skips

### UNCIUTABLE FORM OF COLLECTION

- non-covered roll-off container: The shifting cargo leads to massive destruction.

## Transport and Handling

Group 4: Gas-discharge lamps

### SUITABLE FORM OF COLLECTION

- post pallets

### UNCIUTABLE FORM OF COLLECTION

- cartons

## Transport and Handling

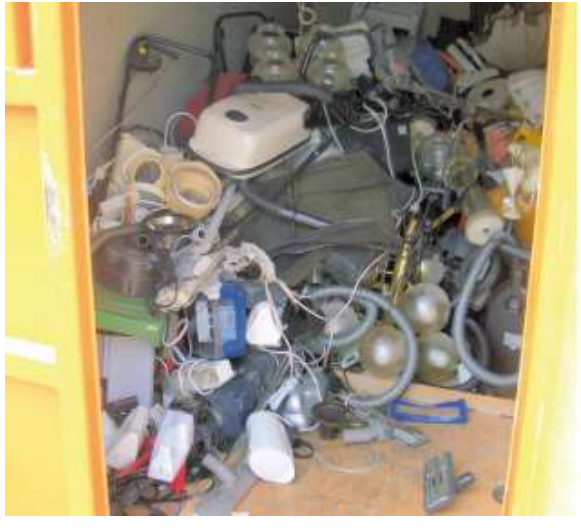
Group 5: Small domestic appliances, lamps, electric and electronic tools, toys, sport etc.

### SUITABLE FORM OF COLLECTION

- items sorted in mesh boxes

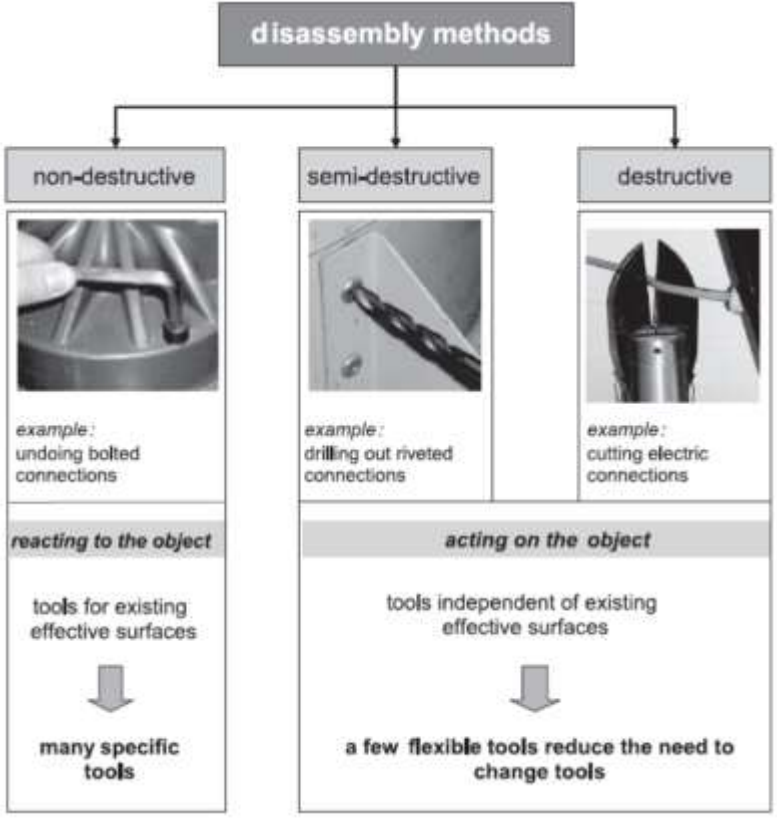
### UNCIUTABLE FORM OF COLLECTION

- loose in bulk



## Disassembly methods

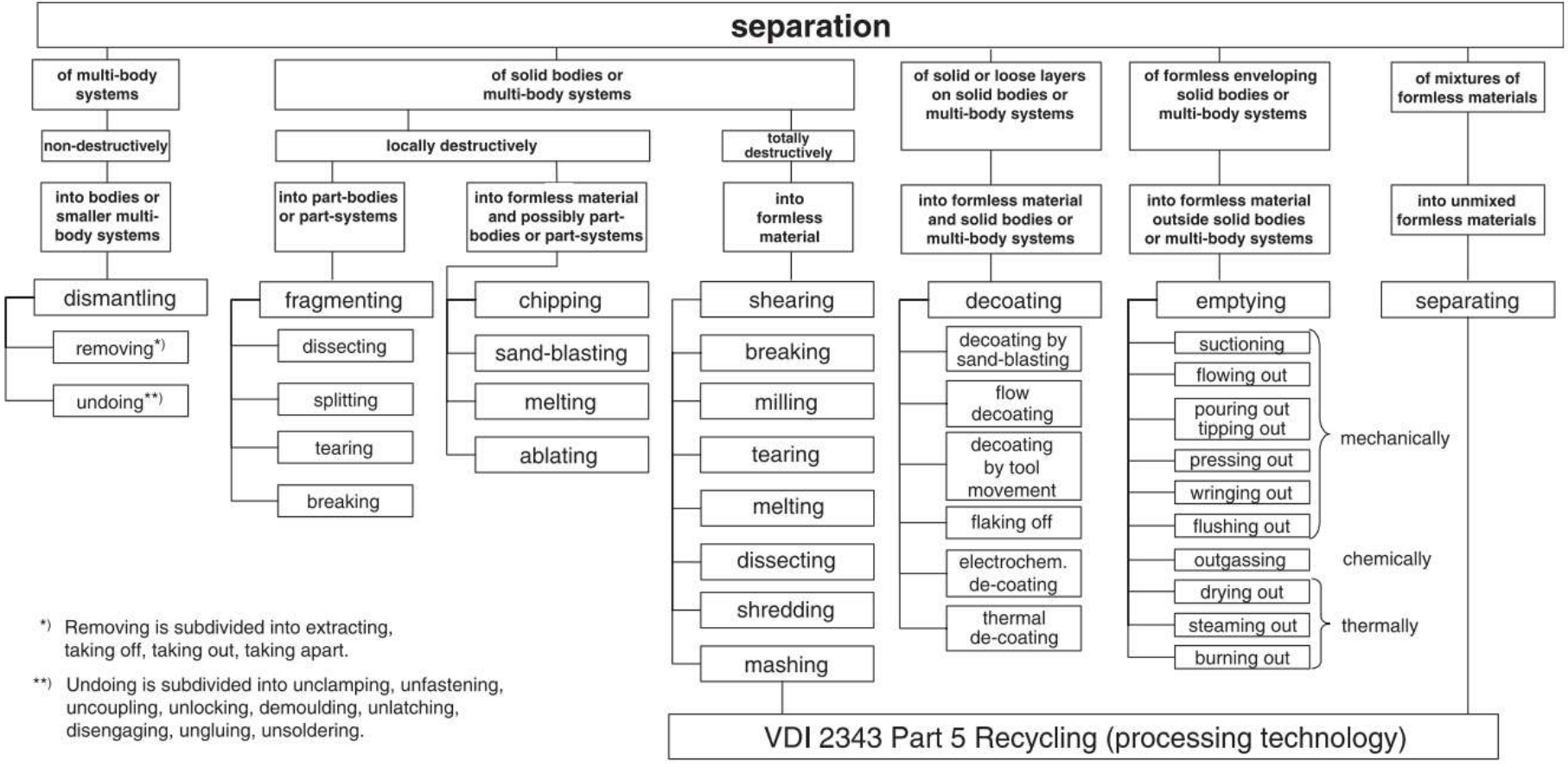
Separation of compounds




- separation of harmful substances and components
- recovery of functional modules and components
- enrichment of recyclable materials
- recovery of materials that cannot be separated through process engineering

- **Non-destructive disassembly**: recovery of components primarily for reuse
- **Destructive disassembly**: offers greater flexibility
- **Semi-destructive disassembly:** accepts damage to or spoilage of low-value parts such as connecting elements

# Disassambly- Classification of separation methods




*) Removing is subdivided into extracting, taking off, taking out, taking apart.

**) Undoing is subdivided into unclamping, unfastening, uncoupling, unlocking, demoulding, unlatching, disengaging, ungluing, unsoldering.

# Preparation techniques

- **Preparation of e-waste or fractions comprises their crushing, sizing, and sorting in corresponding preparation plants.**

1. Separation of harmful or undesirable materials
2. Creation of flows of material for the purpose of recycling and/or non-harmful disposal

# Composition in % by weight

| Components | Collection group 1 | Collection group 2 | Collection group 3 | | Collection group 4 | Collection group 5 |
|---|---|---|---|---|---|---|
| | | | without VDUs | only VDUs | | |
| Iron and steel | 60 to 75 | 60 to 70 | 30 to 40 | 5 to 15 | 1 | 25 to 40 |
| Nonferrous metals, nonferrous composites, stainless steel | 10 to 15 | 3 to 5 | 10 to 15 | 2 to 5 | 1 | 5 to 10 |
| Plastics | 8 to 12 | 15 to 20 | 30 to 50 | 20 to 30 | 1 to 5 | 30 to 65 |
| Hard-faced printed-circuit boards, incl. precious metals | < 1 | < 1 | 3 to 8 | 1 to 5 | – | < 5 |
| Harmful substances | < 1 | < 2 | < 1 | < 1 | < 1 | < 1 |
| Glass | 5 to 10 | < 1 | < 2 | 60 | > 90 | < 2 |
| Other (inert material, wood, etc.) | 1 to 10 | < 5 | 10 to 20 | 5 | | 1 to 4 |

- 1 Large household devices
- 2 Cooling devices
- 3 IT and telecommunication devices
- 4 Lamps
- 5 Small household devices

# Requirements on preparation techniques

| Requirements | Collection group 1 | Collection group 2 | Collection group 3 | | Collection group 4 | Collection group 5 |
|---|---|---|---|---|---|---|
| | | | without VDUs[b)] | only VDUs[b)] | | |
| Legally-set material recovery quota[a)] | 75 % | 75 % | 65 % | 65 % | 80 % | 50 % |
| Removal of harmful substances | o | + | o | + | + | o |
| Crushing for decomposition | + | + | + | o | + | + |
| Extraction of single-variety plastic fractions | – | + | + | + | – | + |
| Separation of circuit boards | + | - | + | + | – | + |
| Extraction of iron fractions | + | + | + | + | o | + |
| Separation of non-ferrous fractions | + | + | + | + | + | + |
| Extraction of glass fractions | – | + | – | + | + | – |

– not possible/required  o possible/required in certain cases  + required

a) ElektroG  b) visual display units

# Preparation techniques

## Crushing

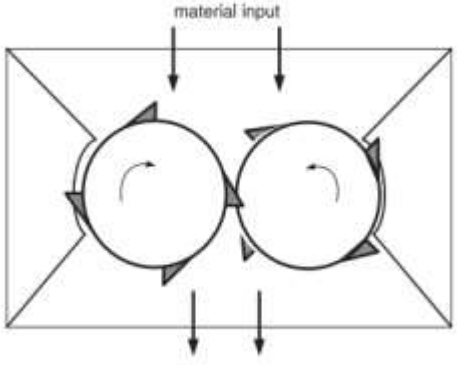



Figure 1. Rotary shears

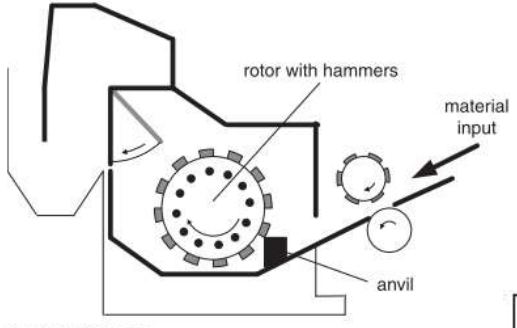



Figure 2. Shredder

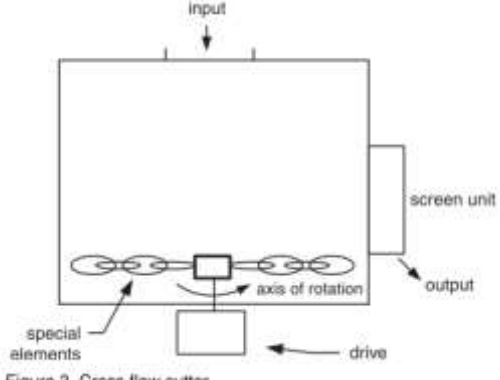



Figure 3. Cross flow cutter

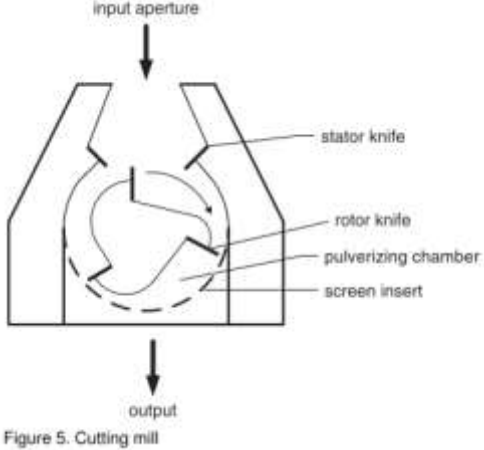



Figure 5. Cutting mill

| Machine/plant | Areas of application |
|---|---|
| Rotary shear | pre-crushing, e.g. for refrigerators, cathode-ray tubes |
| Shredder, impact mill | crushing and material separation, e.g. for larger household devices, separated circuit boards, VDU glass, printers, vacuum cleaners |
| Cross flow cutting unit | crushing and material separation, e.g. for refrigerators, printers, vacuum cleaners |
| Cutting mill | follow-up crushing, e.g. for cables and plastics |

# Preparation techniques

## Sizing

- two procedures are used in industry: screen sizing and flow sizing

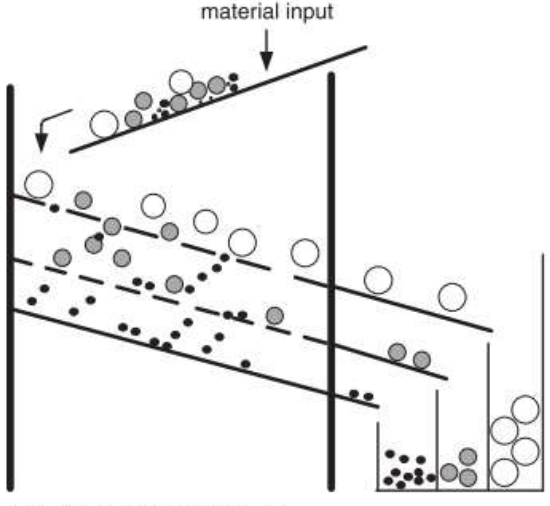



Figure 6. Screen sizing principle

# Preparation techniques

## Sieving

| Sizing procedures | | |
|---|---|---|
| **Screen machinery** | **Areas of application** | **Advantages/disadvantages** |
| Stationary grates and screens | coarse source material | very robust, high throughput rate, low costs; separation is not precise |
| Mobile grates (rolling grates, rod sizers) | coarse source material | poorly suitable for rod- or board-shaped material |
| Rotating drum screens (schematic sketch see Figure 7) | coarse to medium source material | simple design, vibration-free operation; minimal height difference, difficult to exchange the screen tray; high energy consumption, minimal self-cleaning effect, danger of blockages, large overall length (footprint) |
| Throw screens and flat screens (oscillating screens, tumbler screens, ballistic screens) (schematic sketches see Figure 8 and Figure 9) | not hard-to-screen material (energized screen casing)<br>hard-to-screen material (energized screen tray) | low investment costs; need for frequent cleaning<br>low maintenance requirements, high level of wear and tear<br>particle-form separation (ballistic screen) |

# Preparation techniques

## Sorting

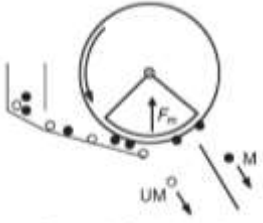



Figure 10. Principles of operation for separation effected via drum-design magnetic separators

$F_m$ magnetic force
M magnetic
UM non-magnetic

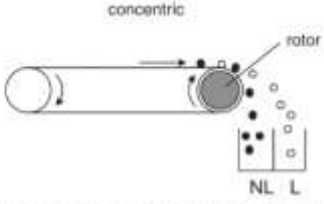



Figure 12. Principle of operation of eccentric and concentric eddy-current separators

L conductor
NL non-conductor

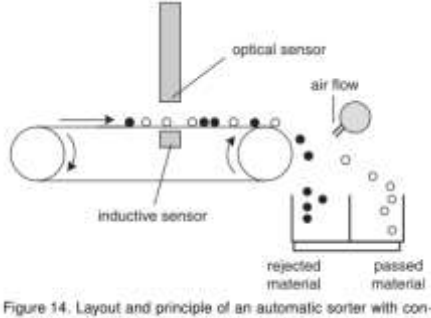



Figure 14. Layout and principle of an automatic sorter with conveyor belt – optical sensor combined with inductive sensor

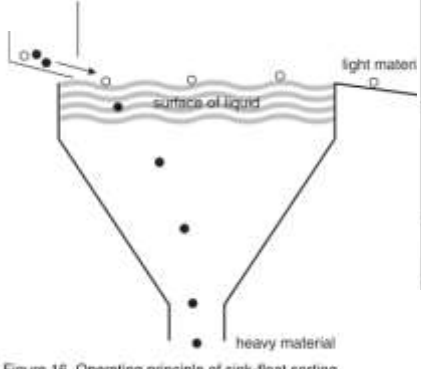



Figure 16. Operating principle of sink-float sorting

| Procedure | Machine\unit | Area of application |
|---|---|---|
| Sorting in magnetic field | overbelt magnetic separator | separation of iron (Fe) and bulk material with iron content from conveyor-belt systems; separation of materials with higher iron content of small and medium particle size |
| | drum-design magnetic separator | separation and retrieval of iron (Fe) and bulk material with iron content in preparation processes; separation of materials with higher iron content which, by reason of particle size, shape, and wear require direct material contact<br>appropriate for higher volume and mass flows |
| | eddy-current separator | Separation of non-ferrous (NF) metals and composites in preparation systems. NF separator comes downstream of the magnetic separator. Principle of operation: conductivity/density ratio, giving a high yield of magnesium and copper |
| Sorting in electrical field | induced-roll separator | separation of electrical conductors and non-conductors as well as materials with different electrical load potential; retrieval or separation of (dry) undersize metals in the range of 0 mm to 6 mm |
| Sensor-supported sorting with automatic picking procedure | NIR sensor | separation and retrieval, from mixed flows, of plastics – according to polymer type and composite type (metal/plastic) – and also non-ferrous metals |
| | induction sorting | separation and retrieval of plastics and metals from mixed flows |
| | X-ray sorting | separation and retrieval of plastics and glass according to material-specific density, regardless of particle size, particle shape, piece weight, or surface colour |
| Sorting by density | sink-float process | separation of plastics and metals in a wet mechanical process based on the materials' different densities |
| | separating tables (pneumatic tables, wet washing tables) | preparation of cables, separation of metals |
| Inertia force separator | cyclone | separation of light and heavy material from fine fractions |
| | classifier | separation of light and heavy material |

# Material flows resulting from preparation

Table 12. Recycling and removal paths

| Fraction | Examples of recycling or removal paths |
|---|---|
| Ferrous metals | steelworks, non-ferrous smelteries, foundries |
| Non-ferrous metals | aluminium foundries, copper smelteries, refineries |
| Glass | glassworks, construction industry |
| Plastics | extrusion companies, granulation companies, waste-to-energy power plants and other power plants, cement works, petrochemical industry |
| Light shredder fraction | waste-to-energy power plants, other power plants, cement works |
| Circuit boards | manufacture of copper and precious metals (usually foundries) |
| Other | waste-to-energy power plants and other power plants, construction industry, backfilling |
| CFCs/HCFCs/HFCs/hydrocarbons | high-temperature combustion or decomposition plants, recycling plant for hydrocarbons |

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# Thank you!

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