Process chains in recycling

A brief story of an old TV

Collection

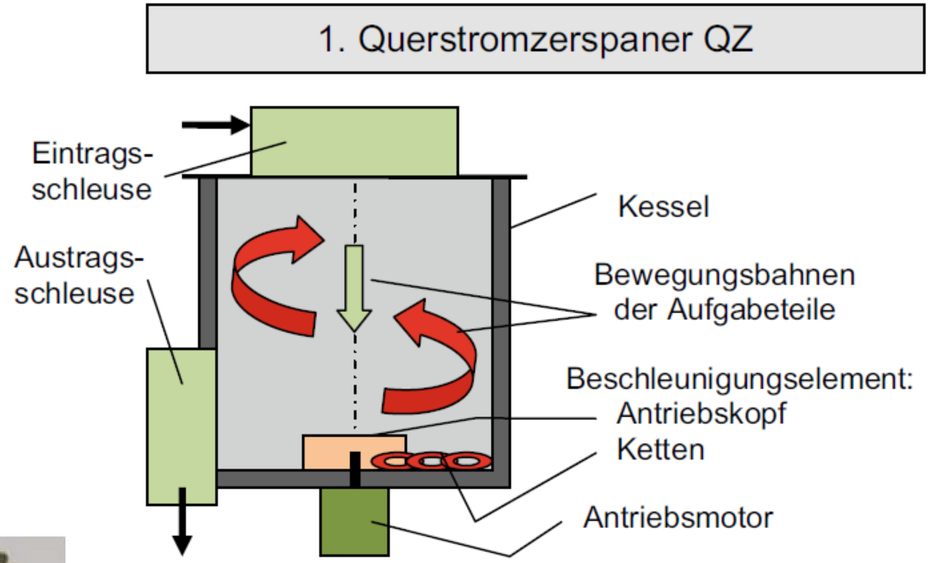
- Old electronic devices are collected locally
- Unlike houshold waste materials they are not picked up directly at home
- Collection systems provide the first chance to separate waste streams

Dismantling and shredding

- Dismantling is always the first step in processing larger pieces
  - Larger building blocks can be separated
  - Assortation for the steps to follow
  - Exclusion of toxins etc. possible

- The large pieces from the dismantling process are broken down to a smaller size by shredding

Shredding

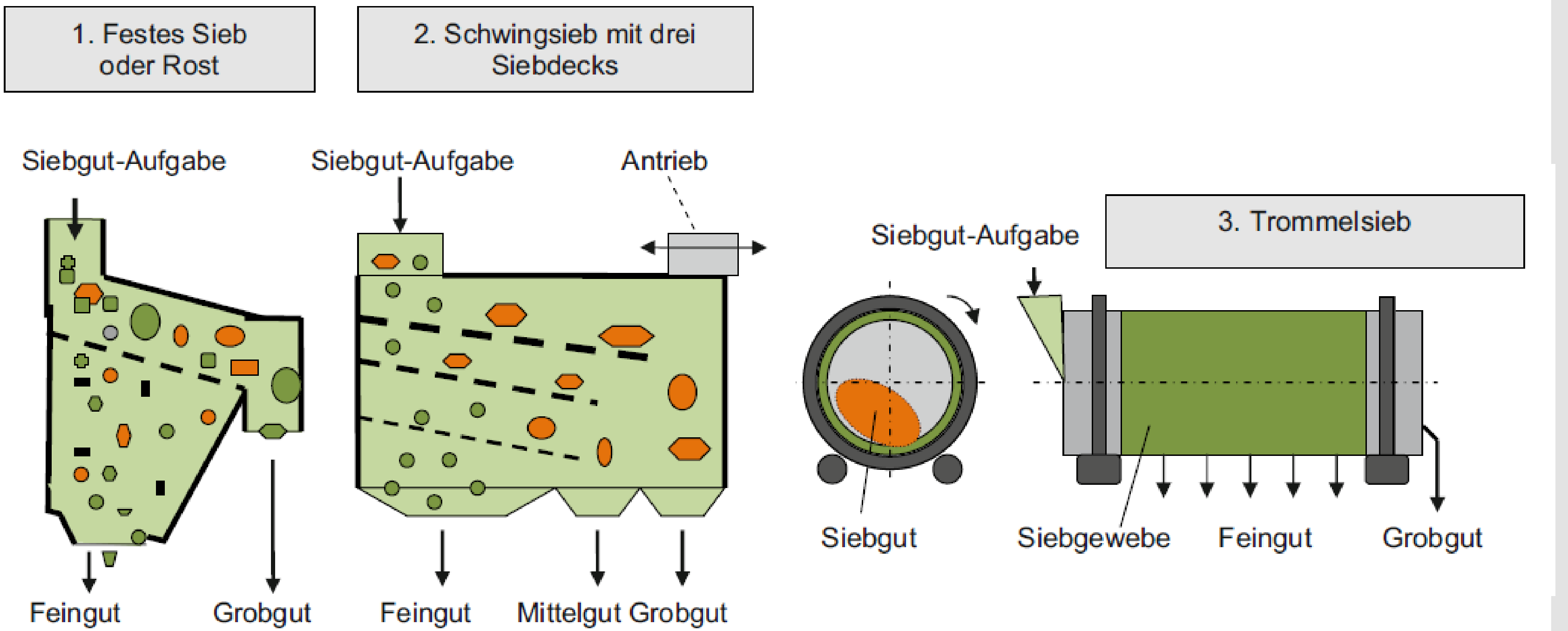

1. Querstromzerspaner QZ
Eintrags-
schleuse
Austrags-
schleuse
Kessel
Bewegungsbahnen
der Aufgabeteile
Beschleunigungselement:
Antriebskopf
Ketten
Antriebsmotor

Keystep: Separation of different grain sizes (sieving)

- Standardization of grain size is of crucial importance for the processes to follow

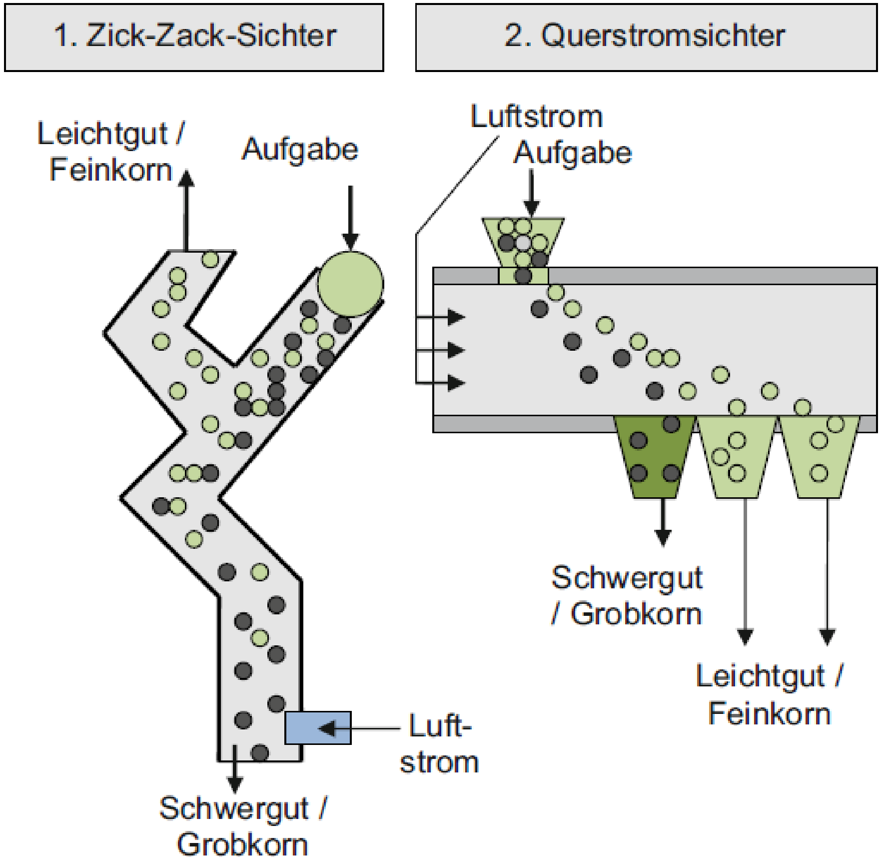
Gemisch Grobfraktion Feinfraktion

Types of sieves



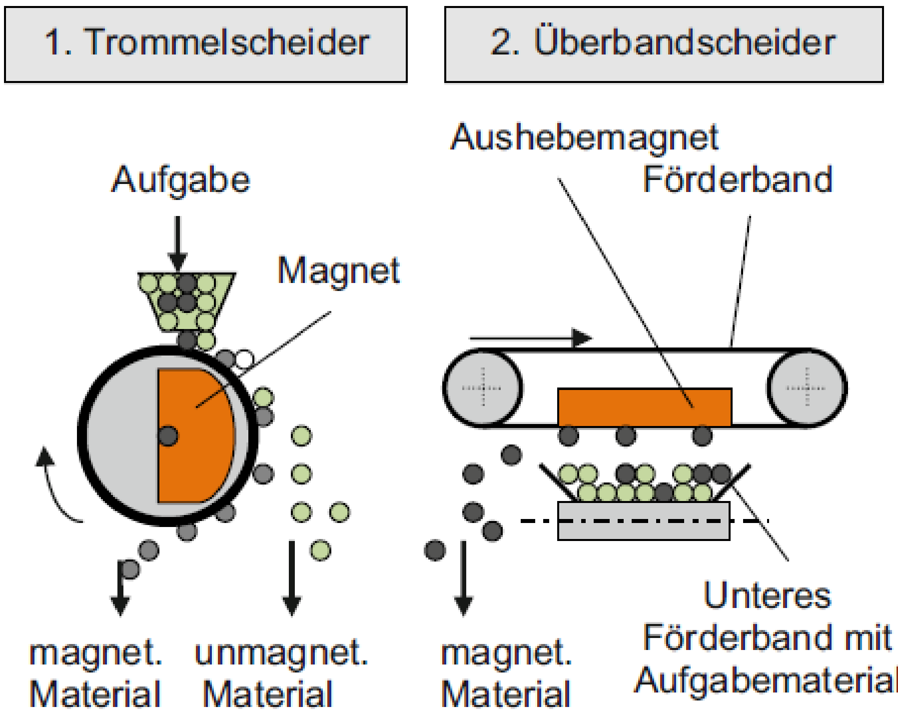
Separation in the gravitation field

- Particles are devided by their sinking/floating behaviour in fluids (air, water, etc.)
- Film



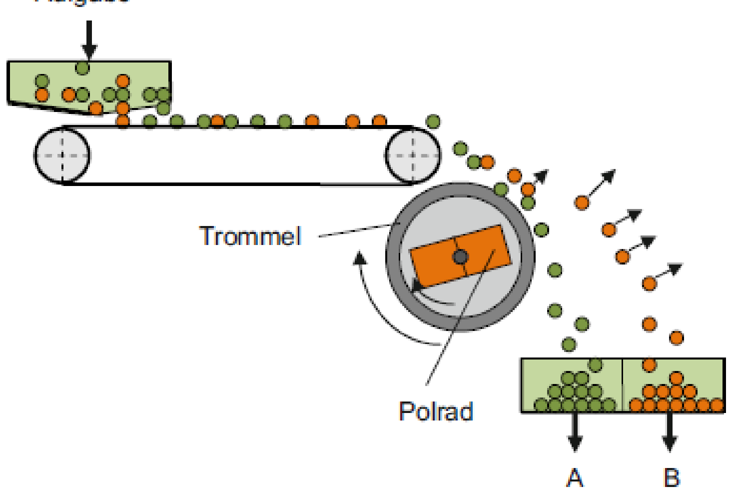
Separation in magnetic fields

- A magnet is used to pick ferromagnetic materials from the waste stream
- i.e. low alloyed steel, Cr-steel, Ni-Cu-alloys (> 65% Ni), cast iron
- Film



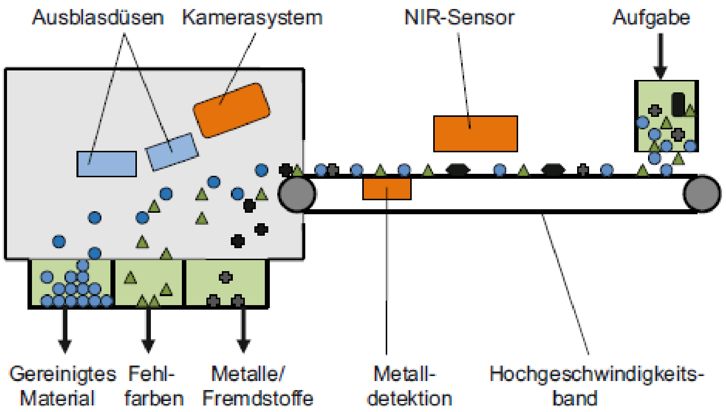
Separation in electromagnetic fields

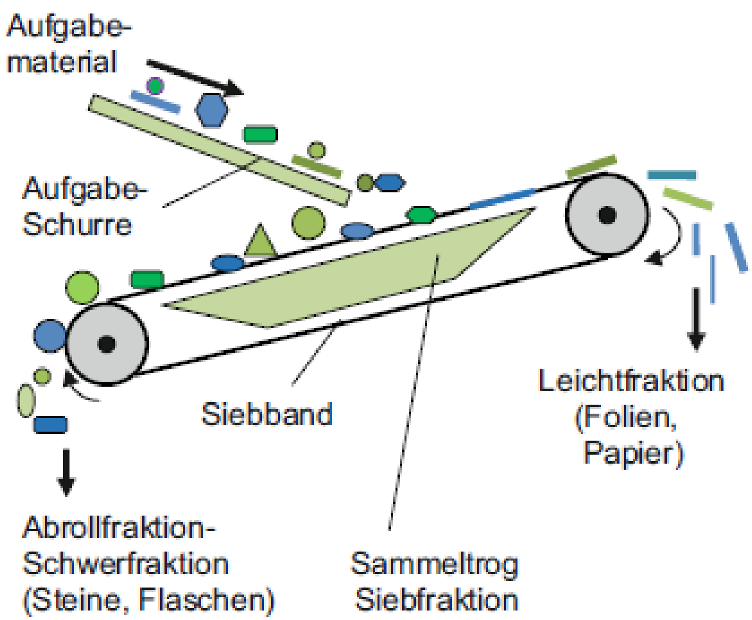
- Eddy-current separators separaty by the conductivity/density ratio
- Basicly conductors are separated from non-conductors
- Grain sizes > 5mm needed
- Absence of ferromagnetic materials is necessary
- Electromagnetic field is induced in conductive grains
  - Repulsion of this material
- Film



A: Leitfähigkeit / Dichte gering
B: Leitfähigkeit / Dichte hoch

Other separation techniques





What happened until now?

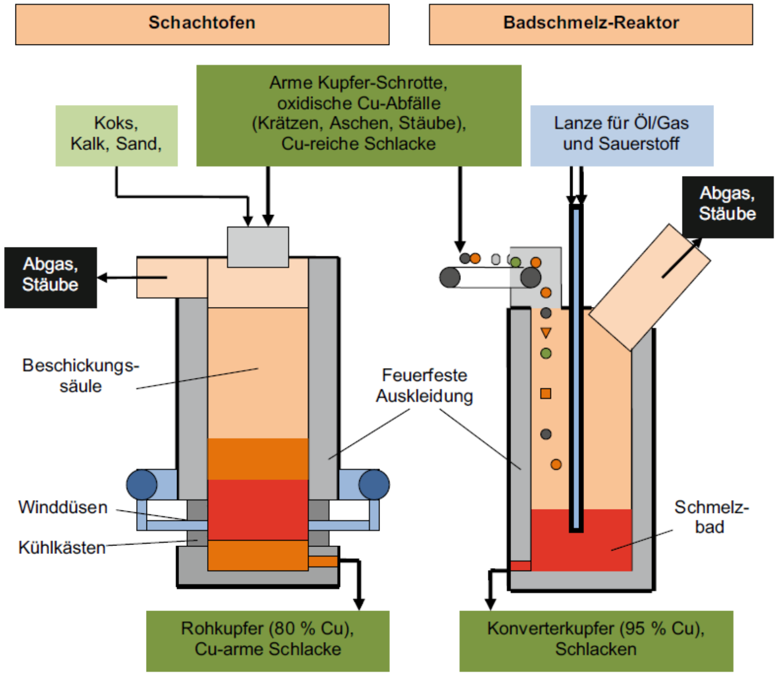
- Collection systems provide a first separation step
- Dismantling and exctraction of toxic materials are important for further processing
- Shredders and mills are used to break different materials appart
- The particles have to be assorted by their grain size (sieving) to make further separation techniques possible
- Separation steps use differences in
  - Density
  - Magnetism
  - Conductivity
  - Optical properties
  - Geometrical properties

What‘s next?

- After sorting the waste particles into fractions of higher content of different kind of metals
  - Pyrometallurgical processes or
  - Hydrometallurgical processes follow

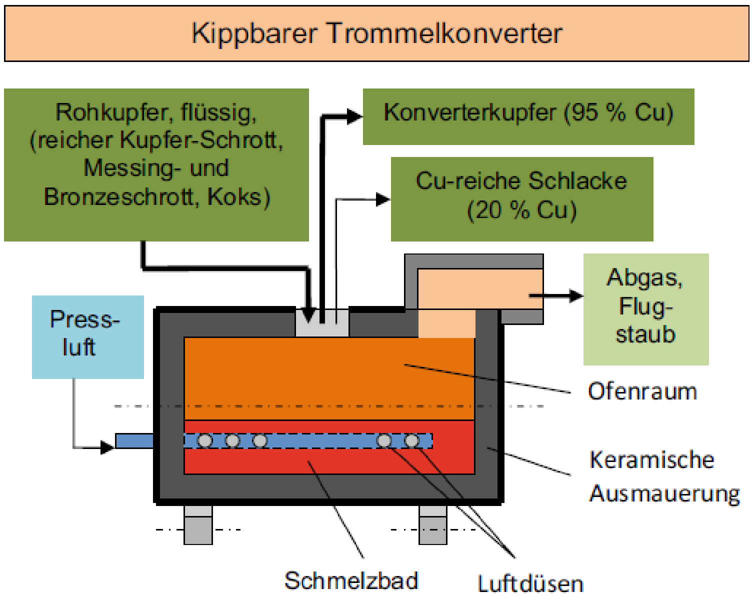
Further treatment of copper – pyrometallurgical approach

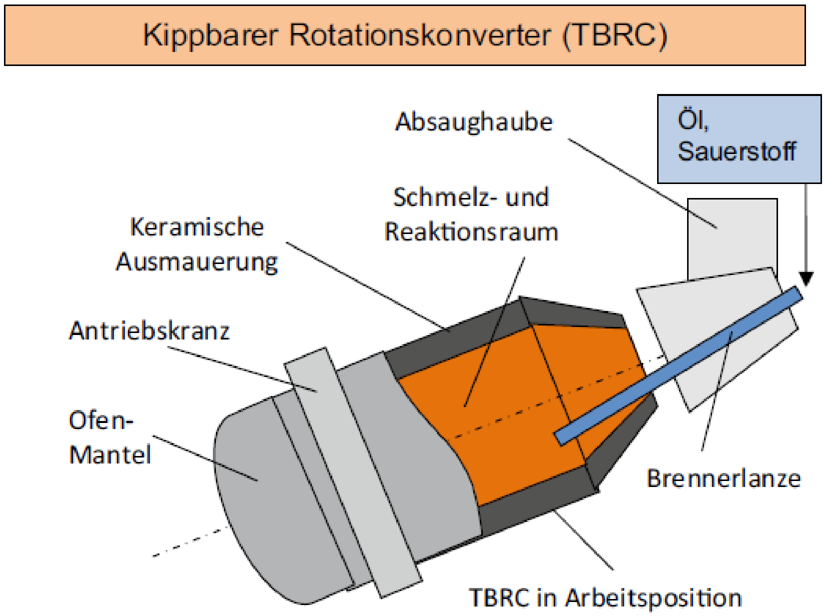
- Copper containing waste is introduced into a furnace to
  - Homogenization of the metal phase
  - Concentration of valuable metals in the molten phase
  - Formation of cinders (FeO-silicate)
  - Collection of dust with ZnO, PbO
  - Treatment of exhaust gases (CO_2, hydrocarbons, SO_2, HCl)
- Copper from this processes consists typically of 75% Cu, 6% Sn, 5% Fe, 3% Ni, 5% Zn, 4% Pb
- Electro-furnaces can be used as well



Converter process

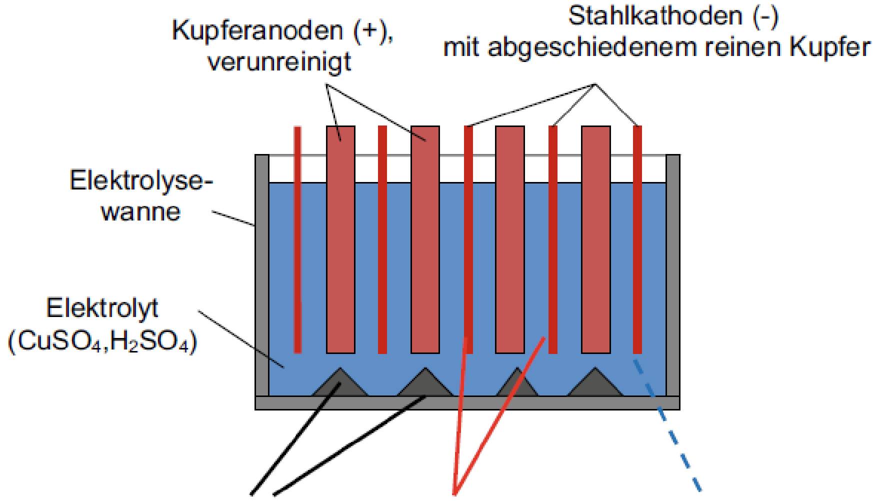
- Selective oxidation
- Extraction of Sn, Pb, Fe, Zn, Al
- Ni and RE-metals remain in the molten copper
- 95 – 98 % copper content





Electrolytical refining

- Requires 99 – 99,5 % copper content
- Outcome: 99,98% Cu



	Anoden-schlamm	Kathoden-Kupfer	Elektrolyt ($CuSO_4$, H_2SO_4)
Normal-Potential (V):	Pt Au Ag +1,6 +1,4 +0,81	Cu +0,35	H Pb Sn Ni Fe Zn 0 -0,13 -0,14 -0,25 -0,44 -0,76
Elektro-chemischer Effekt:	Elektrochemisch unlöslich.	Abscheidung an der Kathode, hochrein, kompakt.	Elektrochemisch löslich. Keine Abscheidung vor dem Kupfer und dadurch Anreicherung dieser Metalle im Elektrolyt.

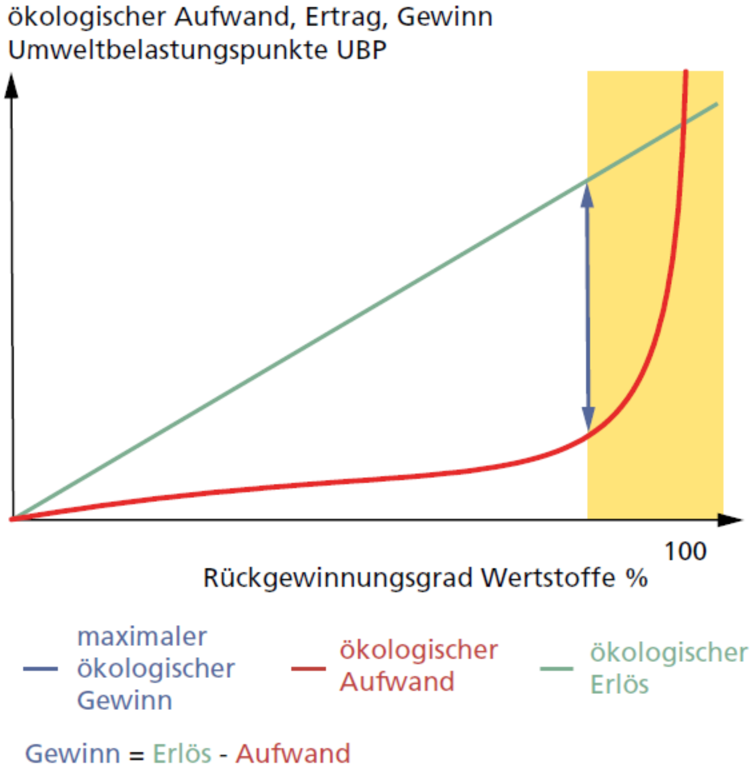
Further treatment of copper – hydrometallurgical approach

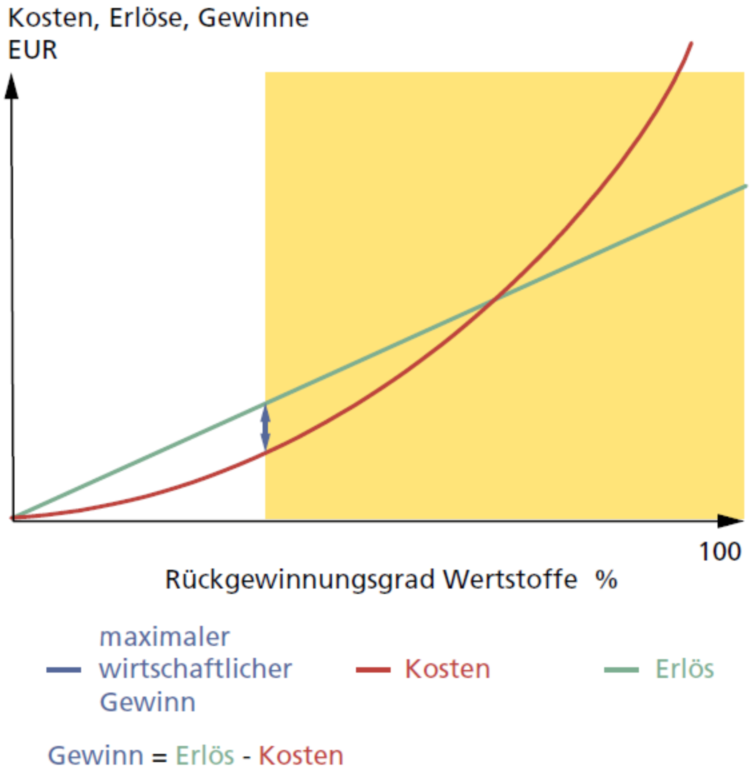
- Only usefull if copper content is rather low
- Leaching
  - with ammoniumcarbonate/ammonia (Cu and Ni)
  - with iron(III)sulphate (not very selective)
  - with sulfuric acid (not very selective)

- Copper recovery from aqueous solutions
  - Electolytic precipitation (reduction) – requires > 15 g/L Cu
  - Cementation with metallic iron (not very selective, 60 – 90% Cu)
  - Thermal decomposition of Cu-tetramincomplex (regeneration of ammonia)
  - Precipitation as hydroxide or sulfide (both less favoured)

Limitations of recycling

- Economical, ecological, thermodynamical





Thank you for your find attention

Treatment of cables and wires