The Special Importance of Metals in a Circular Economy

62nd IFC PORTOROZ 2022

Prof. Dr.-Ing. Rüdiger Deike ▪ Portorož, 15.09.22

Table of content

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1. Sustainability becomes law

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Sustainable Development Goals (SDG)

https://www.bundesregierung.de/breg-de/themen/nachhaltigkeitspolitik/die-deutsche-nachhaltigkeitsstrategie-318846

Environmental objectives become law

EU Taxonomy should give a clear definition of what does sustainable mean

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REGULATION (EU) 2020/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2020

on the establishment of a framework to facilitate sustainable investment and amending Regulation (EU) 2019/2088

Article 1

Subject matter and scope

1. This Regulation **establishes the criteria for determining whether an economic activity qualifies as environmentally sustainable** for the purposes of establishing the degree to which an investment is environmentally sustainable.
2. This Regulation applies to:
   - (a) measures adopted by Member States or by the Union that set out requirements for **financial market participants** or issuers in respect of financial products or corporate bonds that are made available as environmentally sustainable;
   - (b) financial market participants that **make available financial products**;
   - (c) **undertakings which are subject to the obligation to publish a non-financial statement** or a consolidated non-financial statement pursuant to Article 19a or Article 29a of Directive 2013/34/EU of the European Parliament and of the Council(68), respectively.

https://eur-lex.europa.eu/legal-content/de/TXT/?uri=CELEX%3A32020R0852

Environmental objectives become law

EU Taxonomy should give a clear definition of what does sustainable mean

REGULATION (EU) 2020/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2020

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Article 9

Environmental objectives

For the purposes of this Regulation, the following shall be environmental objectives:

(a) climate change mitigation;

(b) climate change adaptation;

(c) the sustainable use and protection of water and marine resources;

(d) **the transition to a circular economy**;

(e) pollution prevention and control;

(f) the protection and restoration of biodiversity and ecosystems.

https://eur-lex.europa.eu/legal-content/de/TXT/?uri=CELEX%3A32020R0852

2. What are the characteristics of a circular economy

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Key product value chains following EU's Circular Economy Action Plan

https://eur-lex.europa.eu/legal-content/de/TXT/?uri=CELEX%3A32020R0852

Fundamentals to realize a Circular Economy

3. Current status of global metal production and consumption

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Development of mine production and per capita mine production of different metals

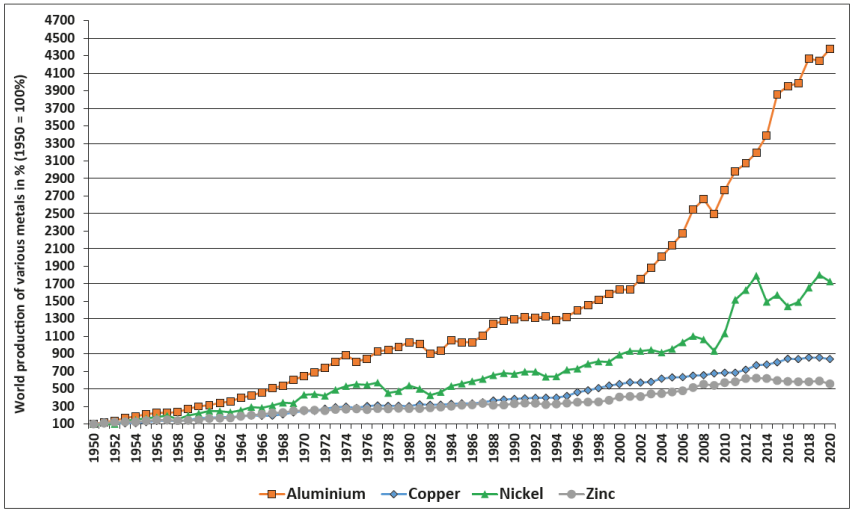

Figure 2: Developments in global mined production of aluminum, copper, nickel and zinc compared to production levels in 1950 (100%) according to data from the Mineral Yearbook of the U.S. Geological Survey [12].

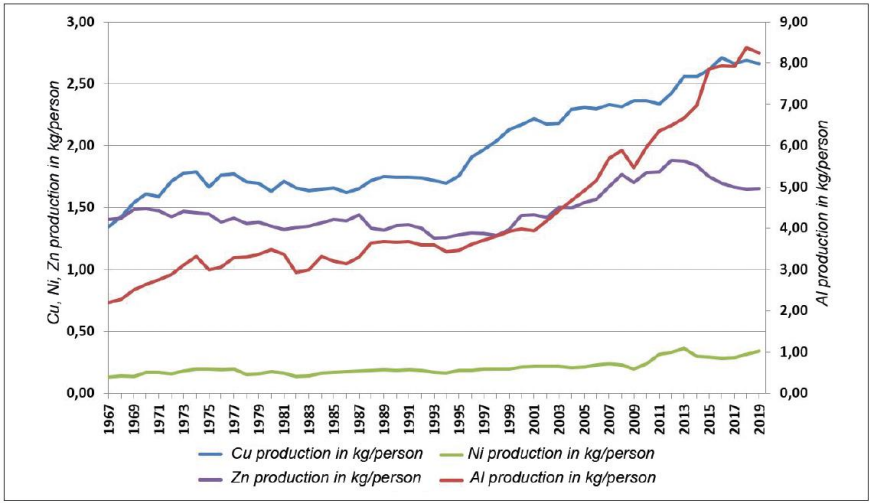

Figure 3: Developments in global per capita mined production of aluminum, copper, nickel and zinc according to data from the Mineral Yearbook of the U.S. Geological Survey [12] and the World Bank [7].

Deike, R.: *What is happening on the commodity markets – and what the future holds?,* CASTING PLANT & TECHNOLOGY 3/2021, p.32-43 16, https://doi.org/10.17185/duepublico/74989

Development of metal consumption in USA and Germany in the last decades

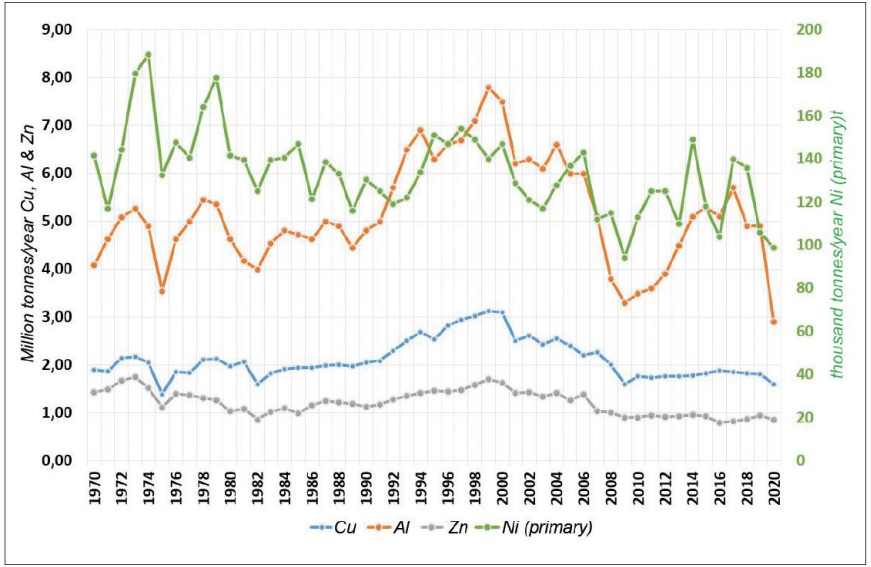

Figure 5: Metal consumption in the USA between 1970 and 2020 according to data from [12].

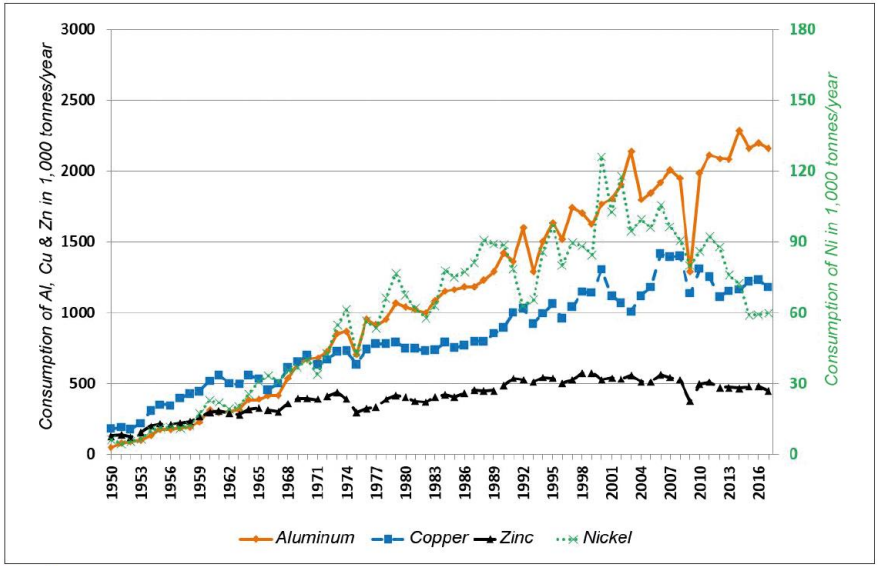

Figure 4: Metal consumption in Germany between 1950 and 2017 according to data from [11].

Deike, R.: *What is happening on the commodity markets – and what the future holds?,* CASTING PLANT & TECHNOLOGY 3/2021, p.32-43 16, https://doi.org/10.17185/duepublico/74989

Development of global crude steel production and iron, steel and malleable casting production

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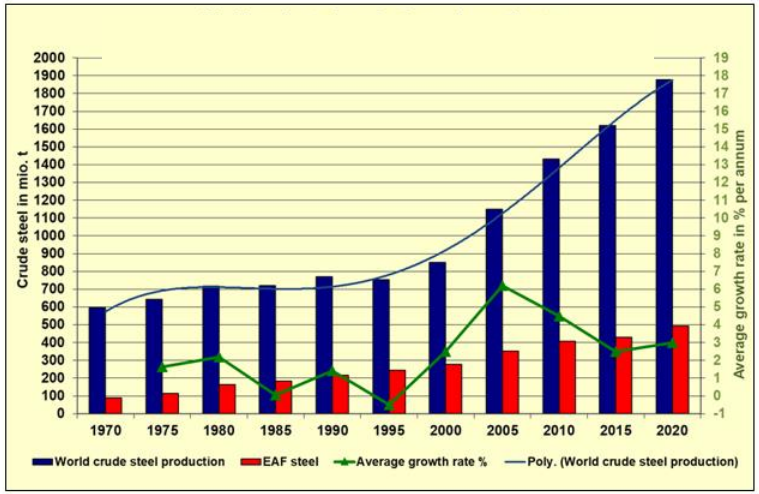
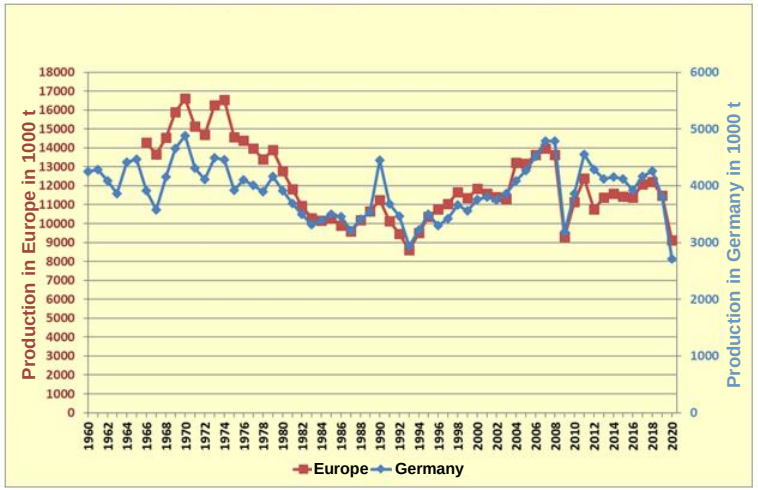
World Crude Steel Production 1970 to 2020



According to data of the World Steel Association, https://worldsteel.org/

Iron, Steel and Malleable Casting Production in Europe 1960 to 2020



According to data of European Foundry Association, https://www.caef.eu/

Deike, R.: *Rohstoffmärkte in herausfordernden Zeiten*, Deutscher Gießereitag 2022, Münster, 05.05.2022

4. Scientific-technical basics of recycling processes

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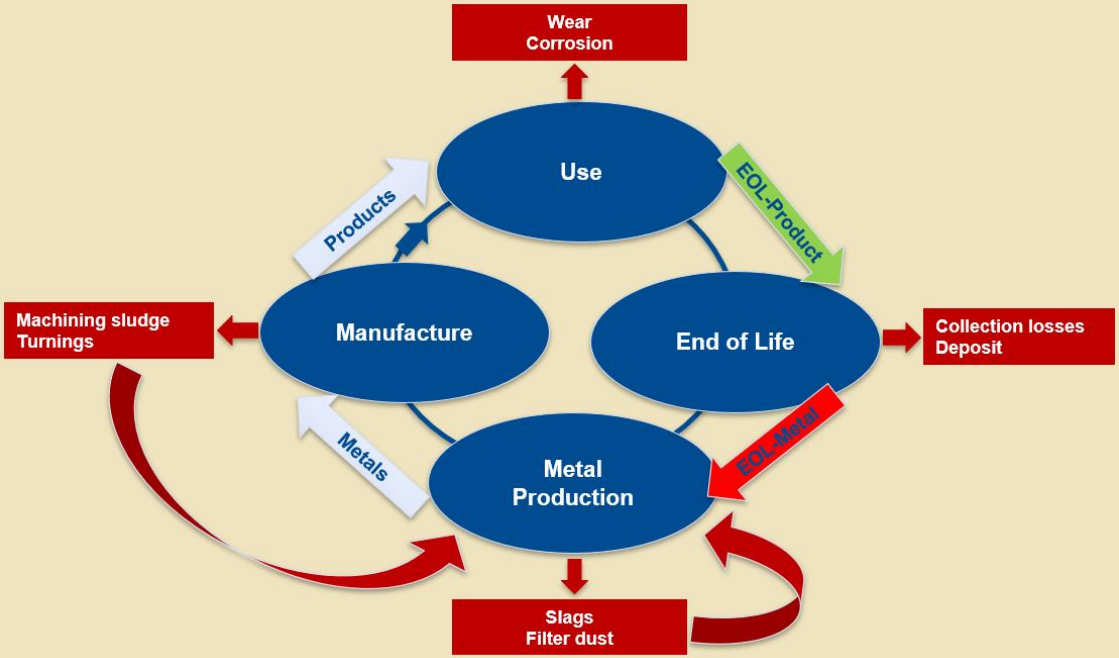
What is the difference between recycling rate and recycled content?



End-of-Life Recycling Rate

$$\frac{\text{Recycled EOL Metal}}{\text{EOL Product}}$$

Recycled Content

$$\frac{\text{Use of scrap in metal production}}{\text{Use of scrap + Primary metal}}$$

Deike, R.: *The importance of the foundry industry in a circular economy*, 57th International Foundry Conference, Portorož, 13. - 15.09.2017

The foundry industry is doing today what the EU wants for the future

Foto: Soschinski/BDG

Deike, R., 2020. Bedeutung der Gießerei-Industrie in einer Circular Economy. https://doi.org/10.17185/duepublico/71307

Responsible raw material consumption

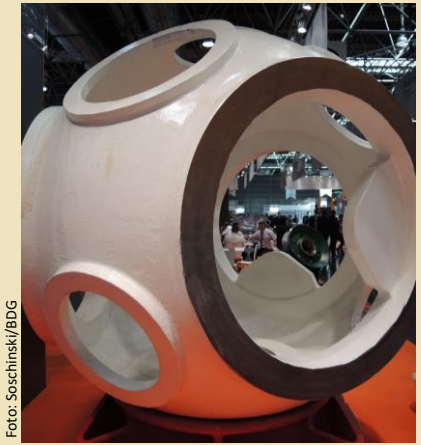


Foto: Soschinski/BDG

Foto: Soschinski/BDG

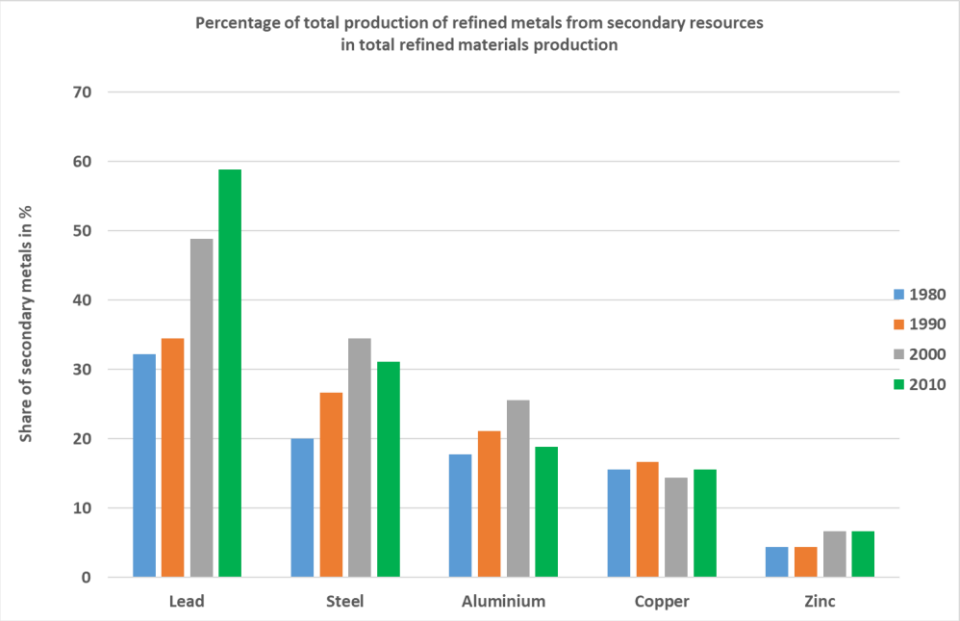
Deike, R., 2021. Die Bedeutung energieintensiver metallurgischer Betriebe: Unter dem Aspekt des Recyclings von Eisen, Stahl und NE-Metallen. https://doi.org/10.17185/duepublico/74510

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

For the production of products for future industries

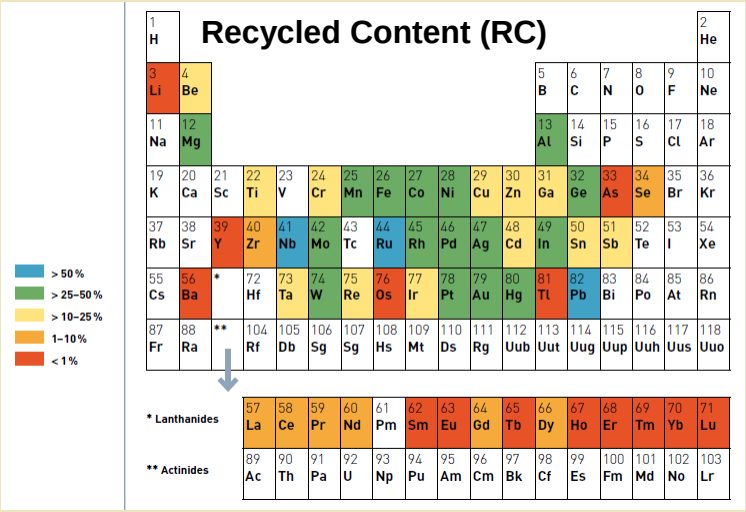
With end of life the process starts again in a closed loop

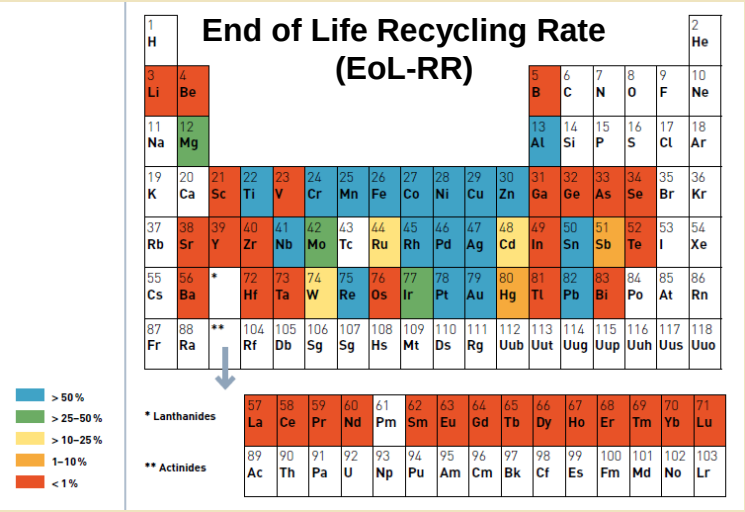
Shares of secondary metals in total global production (5-years moving average)



According to data of OECD: Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences, OECD Publishing, Paris, 2019, https://doi.org/10.1787/9789264307452-en

Recycled content and EoL-recycling rate of different metals





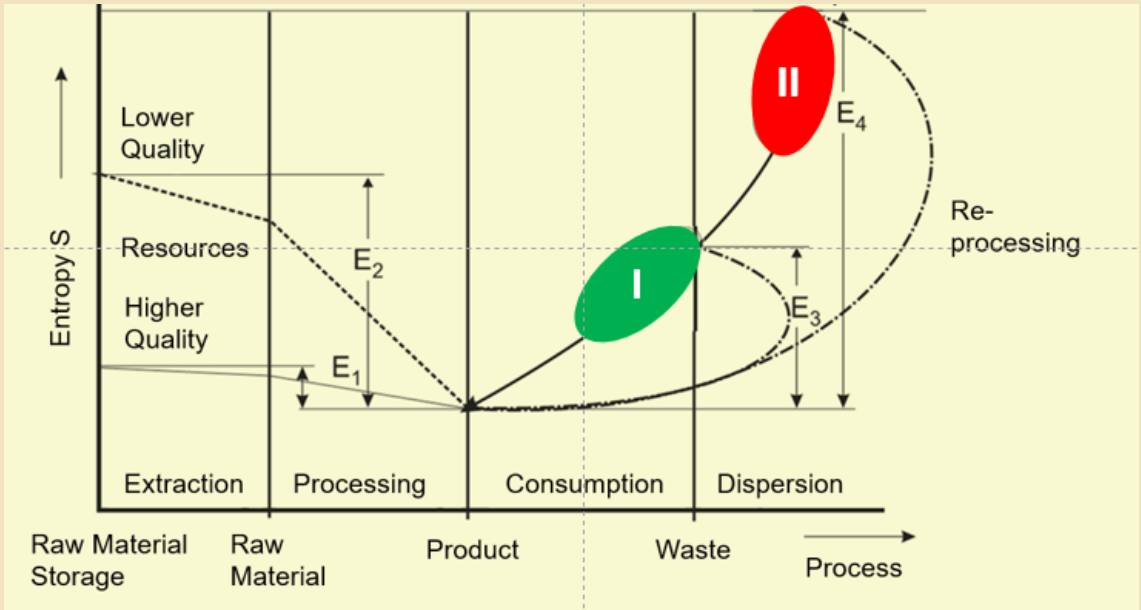
In periods of economic growth, the primary metal share grows faster than the secondary share, so that the recycled content (RC) decreases and is substantially smaller than the EoL-recycling rate. In addition the recycled content is dependent on the availability of secondary raw material.

UNEP International Resource Panel: Recyling rates of metals, 2011, https://wedocs.unep.org/20.500.11822/8702

What is the main problem of recycling? Is there a difference?

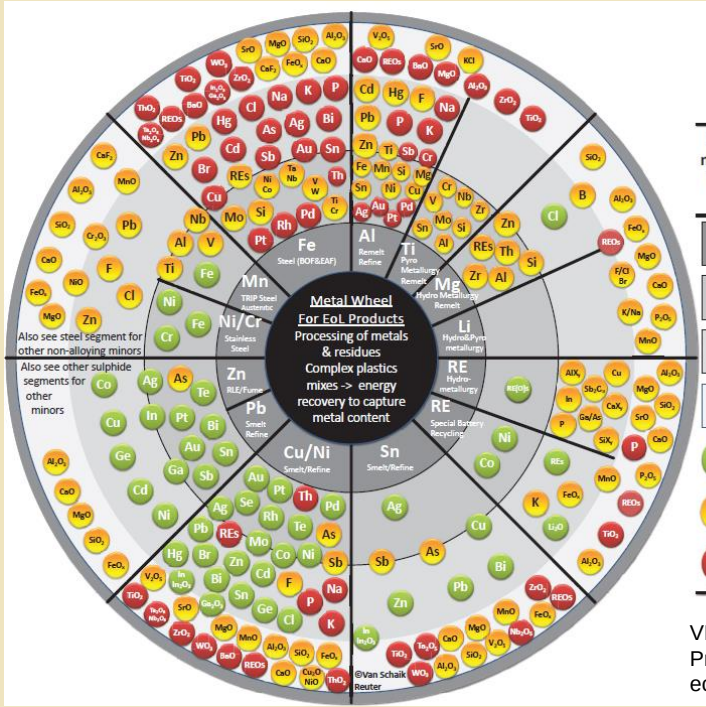
Deike, R.: *New Perspectives for Brazilian-German Research on Circular Economy*, 5th anniversary of the UA-Ruhr-Latin America office, Rio de Janeiro, 04.10.16

The importance of entropy in metal production



Deike, R.: *Die zukünftige Bedeutung des Recyclings metallischer und oxidischer Reststoffe unter dem Aspekt veränderter globaler Rohstoffmärkte*, in Rohstoffeffizienz und Rohstoffinnovationen (Hrsg. U.Teipel u. R.Schmidt), Fraunhofer Verlag, Stuttgart, 2011

The Metal Wheel – depicting various losses and recoveries possible on the back of various carrier metallurgical system



Economically viable destinations of complex EoL designed functional material combinations, scrap, residues etc. to metallurgical processing infrastructure (each segment) to produce refined metal, compounds and alloys in best available technology

- **Circular Economy's carrier metals processing infrastructure**
  Extractive Metallurgy's Backbone, the enablers of a Circular Economy (CE) as it also recovers technology elements used e.g. in renewable energy infrastructure, IoT, eMobility etc.
- **Dissolves mainly in carrier metal if metallic (mainly pyrometallurgy)**
  Valuable elements recovered from these or (dissipative) lost (metallic, speiss, compounds, alloy in EoL also determines destination as also the metallurgical conditions in flowsheet).
- **Compounds mainly to dust, slime, speiss (mainly hydrometallurgy)**
  Collector of valuable minor elements as oxides/sulphates/chlorides etc. and mainly recovered in appropriate metallurgical infrastructure if economical.
- **Mainly to benign lower value building material products**
  Relatively lower value but inevitable part of society and materials processing. A sink for metals and loss from the CE system as oxides/ compounds. Dissipative losses.

- **A** **Mainly recovered element**
  Compatible with Carrier Metal as alloying Element or can be recovered in subsequent Processing.
- **B** **Mainly element in alloy/compound, lost if in incorrect stream/scrap/module**
  With possible functionality, not detrimental to Carrier Metal or product (if refractory metals in EoL product report to slag / slag also intermediate product for cement etc.).
- **C** **Mainly element lost, not always compatible with carrier metal or product**
  Detrimental to properties and cannot be economically recovered e.g. Au dissolved in steel or aluminium will be lost.

VERHOEF, E., DIJKEMA, G. & REUTER, M.A. (2004): Process knowledge, system dynamics and metal ecology – Journal of Industrial Ecology, 8, 1-2: 23-43.

5. Examples for metal recovery from dissipative distributions

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Recovery of valuable metals in dissipative distribution from slags and filter dust of high alloyed steel production.

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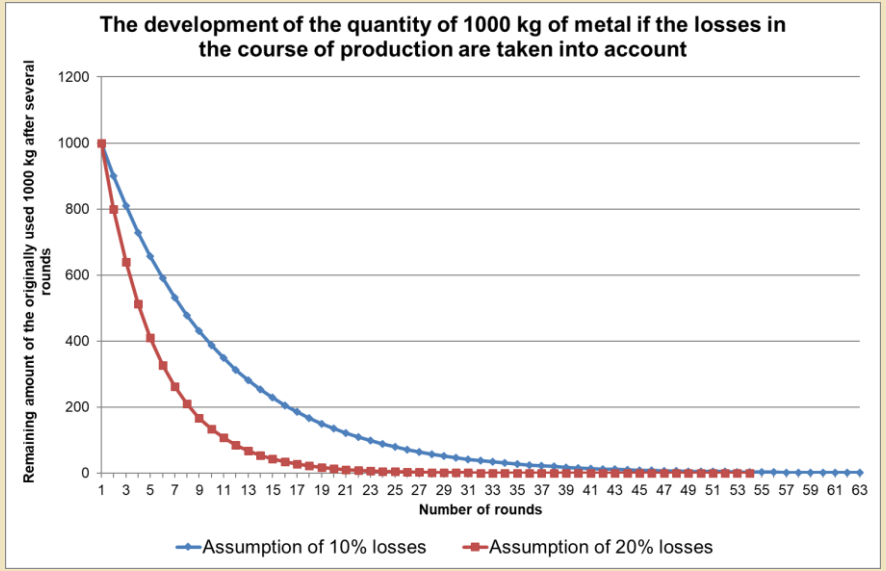
GEFÖRDERT VOM

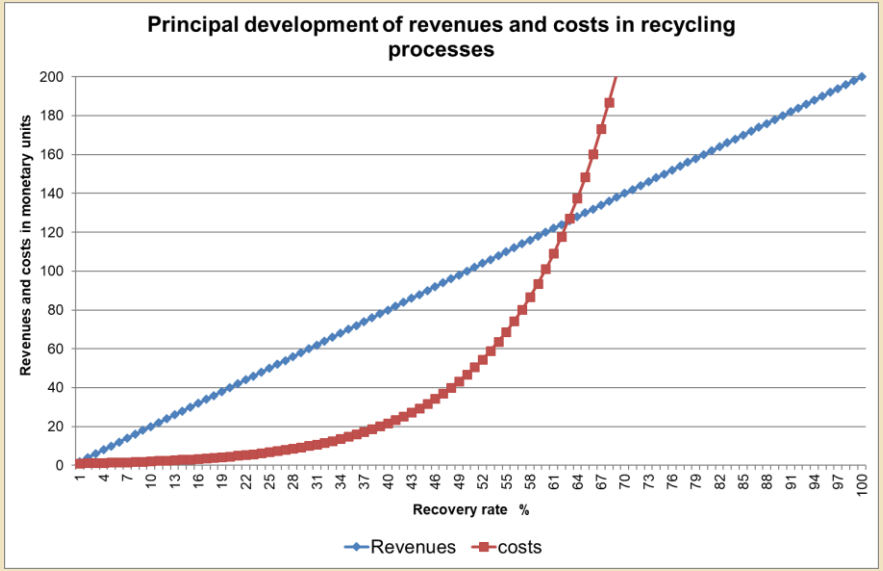
Bundesministerium für Bildung und Forschung

Direkter Einsatz von selbstreduzierenden Briketts in den Aggregaten der Stahl- und Gießereiindustrie zur Verbesserung der Ressourcenbilanz (DIBRAS, FKZ: 01DN14040)

Technical and economical importance of the degree of recovery

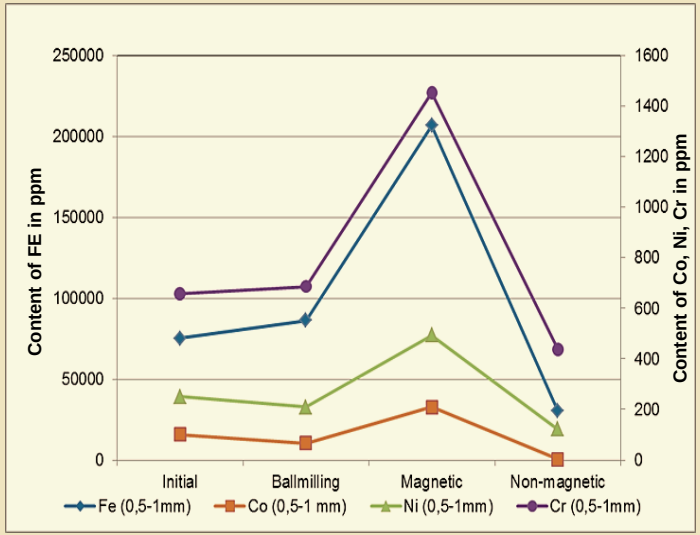


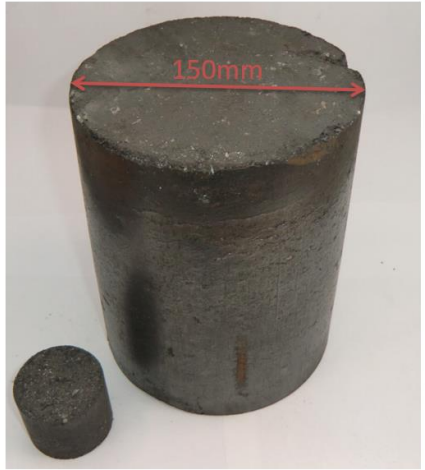
Deike, R.; Rabelo de Lima, A.R.; Mapa Clemente, D.: *Rückgewinnung von Metallen aus Oxiden metallurgischer Schlacken aus der Herstellung legierter Stähle*, Berliner Recycling und Rohstoffkonferenz, Berlin, 20.03.2018

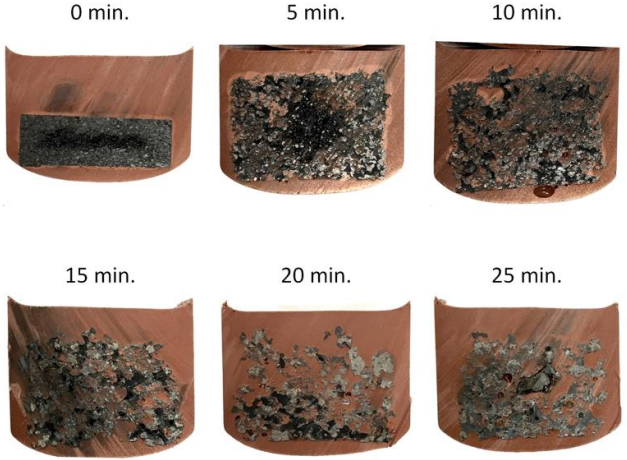


According to R. Bunge,*: Recycling ist gut, mehr Recycling ist besser – oder nicht?,* Berliner Recycling und Rohstoffkonferenz, Berlin 08.03.16

DIBRAS
Self reducing briquettes for the recovery of Cr, Mo, V, W from EAF-Slags of high alloyed steel production



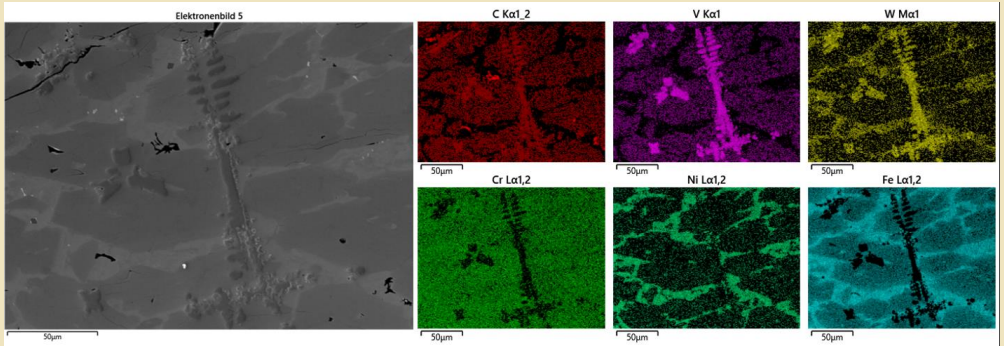




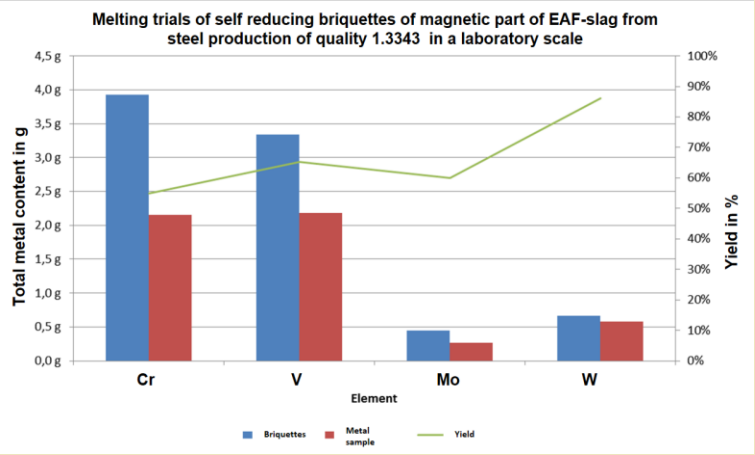
Deike, R.; Ulum, R.; Schubert, D.; Foppe, M.; Gellermann, C.; Lutz, S.: *The recycling potential of metals from MSW incineration residues*, Mining the Technosphere Potentials and Challenges, Drivers and Barriers, TU Vienna, 02.10.15, http://iwr.tuwien.ac.at/fileadmin/mediapool-ressourcen/CD_Labor/Mining_the_Technosphere/Presentations/1._Deike.pdf

Deike, R.: DIBRAS - Direkter Einsatz von selbstreduzierenden Briketts in den Aggregaten der Stahl- und Gießereiindustrie zur Verbesserung der Ressourcenbilanz, BMBF r4-Abschlusskonferenz | Goslar | 3. bis 5. September 2019

SEM image with element mapping



Elementgehalt in Gew.-%	C	O	Mg	Al	Si	Ca	V	Cr	Mn	Fe	Ni	Mo	W
Matrix	9,95						9,36	17,65	1,40	54,28	4,45	1,10	1,81
Schlacke	5,40	38,46	7,35	15,47	16,92	12,42	0,94	1,15	1,65	0,23			



Deike, R.: *DIBRAS - Direkter Einsatz von selbstreduzierenden Briketts in den Aggregaten der Stahl- und Gießereiindustrie zur Verbesserung der Ressourcenbilanz, BMBF* r4-Abschlusskonferenz | Goslar | 3. bis 5. September 2019

Recovery of valuable metals in dissipative distribution from bottom ash of waste to energy plants.

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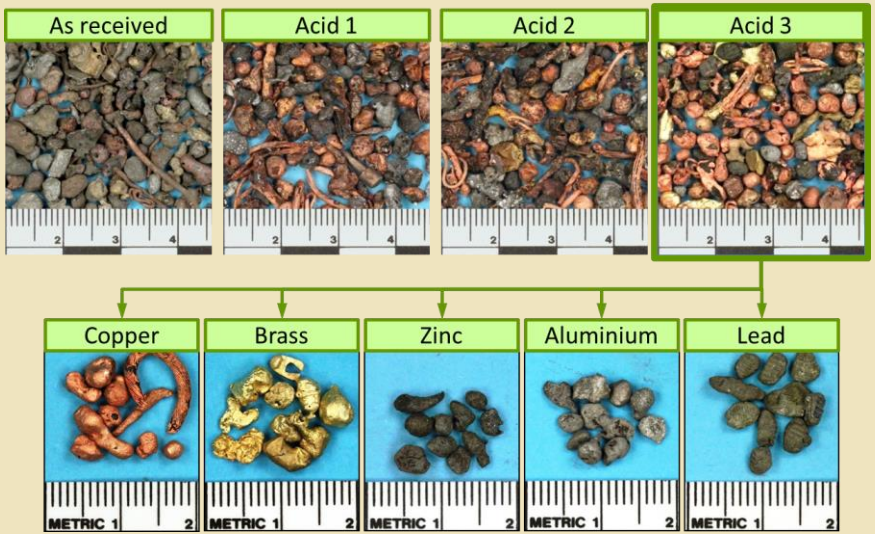
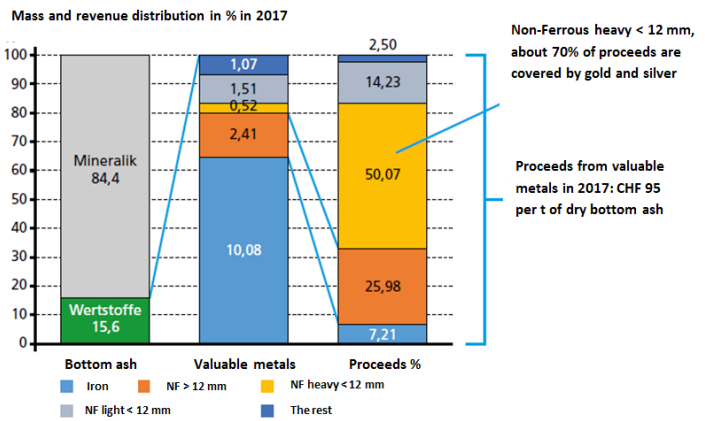
Bundesministerium für Bildung und Forschung

Einsatz von MV-Schlacke als Rohstoff für die Zementherstellung (EMSARZEM, FKZ: 033R265H)

Distribution of different metal fractions in bottom ash and their economic importance at KEZO



Deike, R., Brümmer, A.: Qualitätssicherung bei der Schlackenaufbereitung – neue Herausforderung, ZAR –Stiftung Zentrum für Nachhaltige Abfall- und Ressourcennutzung, Hinwil, 21.03.2012



If the metal yields are divided among the types of metal, the following list per ton of dry bottom ash results:

- Copper: CHF 25
- Gold: CHF 21
- Silver: CHF 8
- Rest: CHF 41

Böni, D.: Thermo-Recycling: Effiziente Gewinnung von Wertstoffen aus der Trockenschlacke, Mineralische Nebenprodukte und Abfälle 5, Hrsg. S.Thiel und E. Thomé-Kozmiensky, TK-Verlag (ISBN: 978-3-944310-41-1), 2018

EMSARZEM
Bottom ash from waste to energy plants as raw material for cement production

As-received MV-Slag (0 – 10 mm)

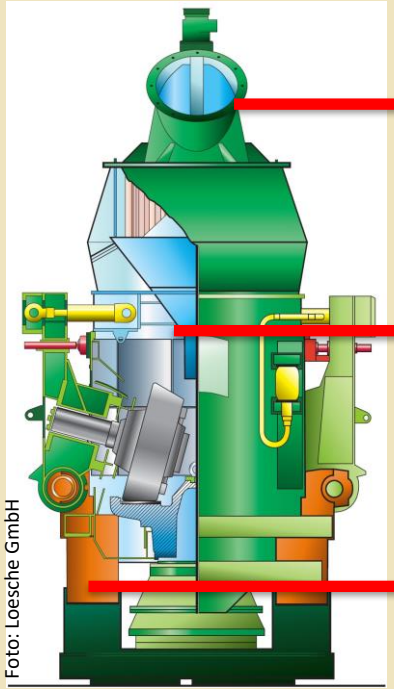
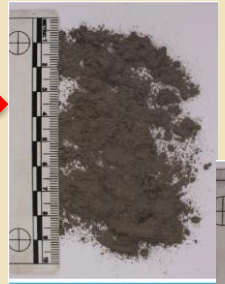


Foto: Loesche GmbH



SICHTERFEINGUT

GRIEßE

REJECT

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EMSARZEM
Metal concentration with magnetic and eddy current separation

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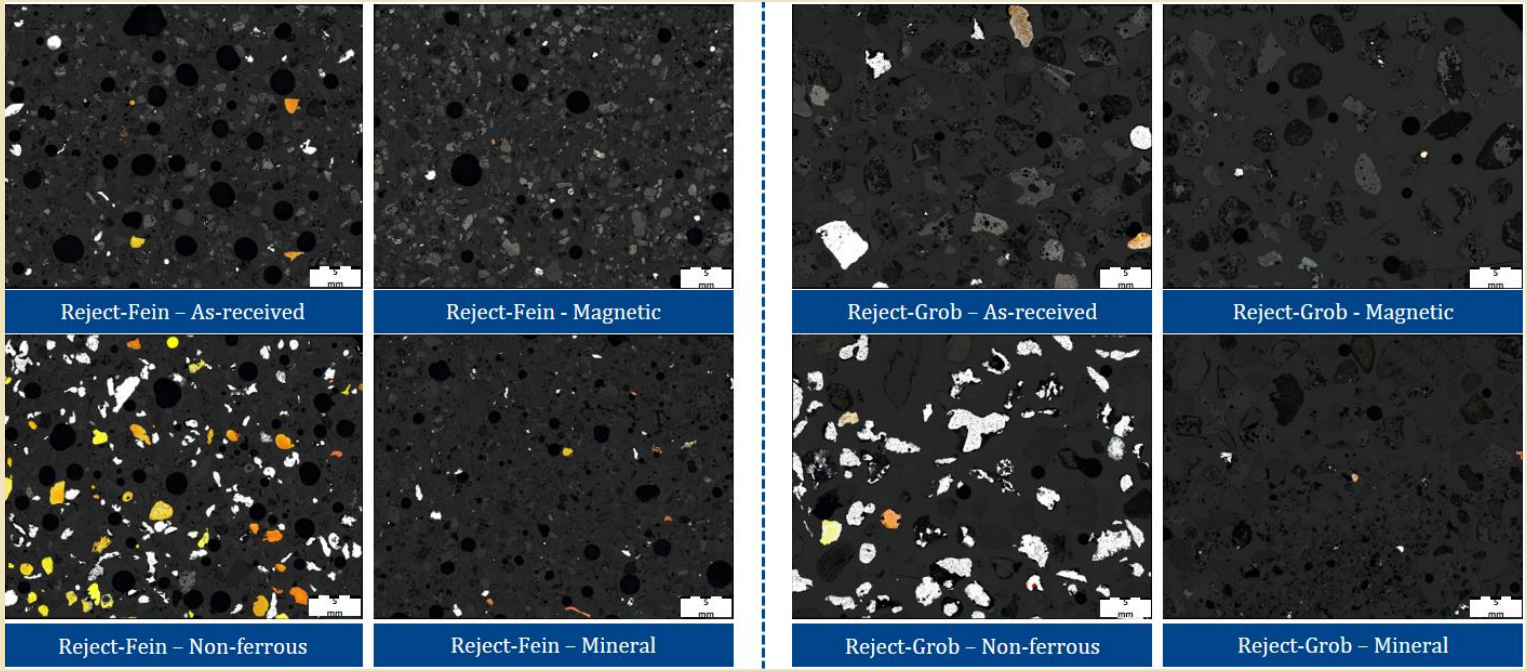

Industrial plant for deoiling valuable machining chips

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Kontinuierliche Öl und Metallrückgewinnungs-Prozessanlage für Schlämme und Späne (KOMPASS, FKZ: 033R159B)

KOMPASS
Industrial plant for deoiling valuable machining chips

6. Economic Outlook into the global metal world

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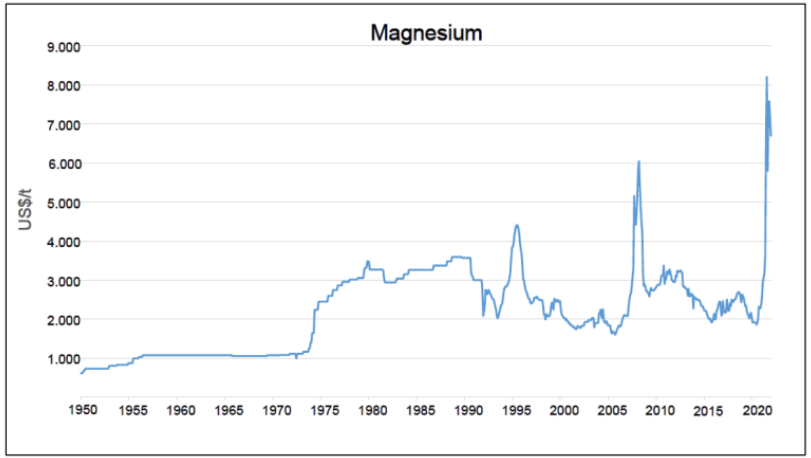
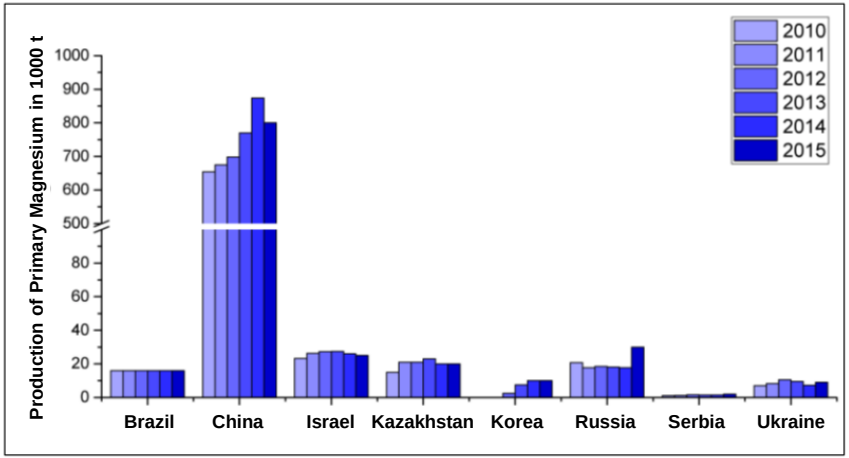
Factors beyond fundamentals and effects on developments in commodity prices

Price Developments for Magnesium



With the kind permission of the Bundesanstalt für Geowissenschaften und Rohstoffe

Global Production of Primary Magnesium 2010 to 2015



Kahrl, A..: Entwicklung alternativer Entschwefelungsmittel und eines Zugabeverfahrens in der Gießereiindustrie zur nachhaltigen Substitution von Magnesium, Dissertation, Universität Duisburg-Essen, 18.06.2020

Deike, R.: *Rohstoffmärkte in herausfordernden Zeiten*, Deutscher Gießereitag 2022, Münster, 05.05.2022

Factors beyond fundamentals and effects on developments in commodity prices

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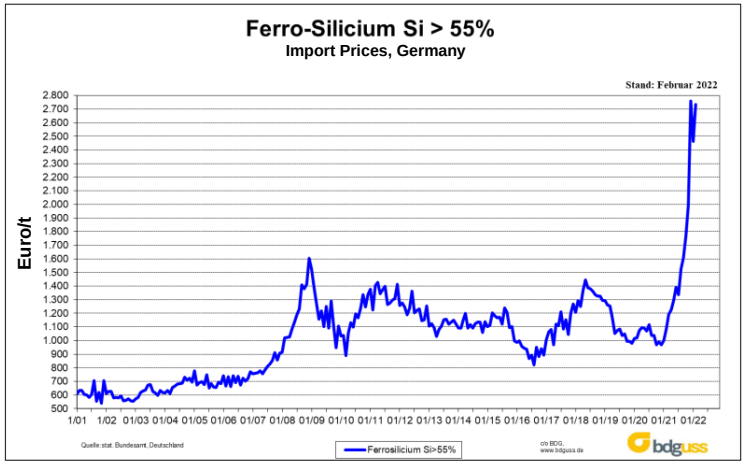
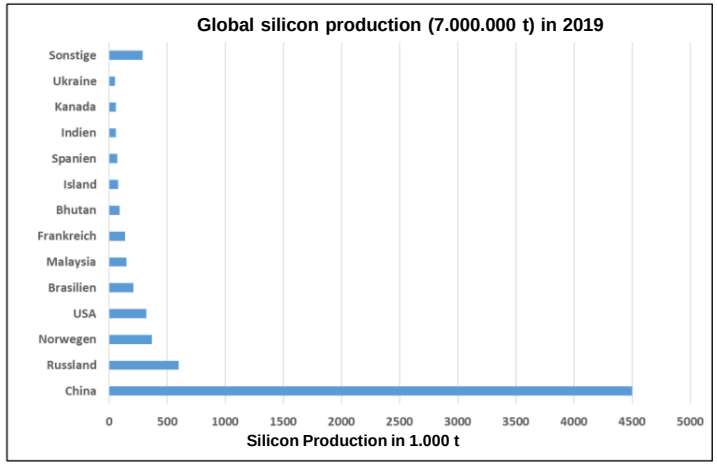
Price Developments for FeSi > 55%



With the kind permission of the BDG

FeSi accounts for 64% of global silicon production



According to data of USGS, https://www.usgs.gov/

Deike, R.: *Rohstoffmärkte in herausfordernden Zeiten*, Deutscher Gießereitag 2022, Münster, 05.05.2022

Key Product Value Chains following EU's Circular Economy Action Plan

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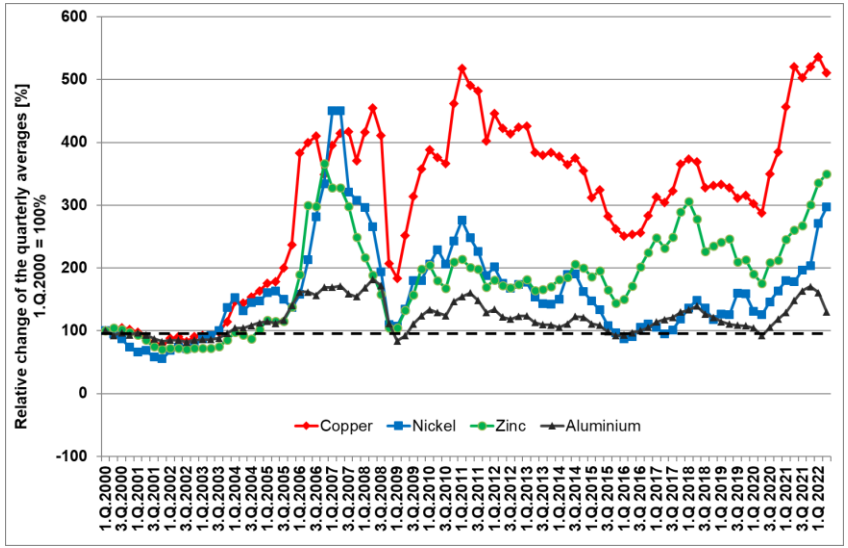
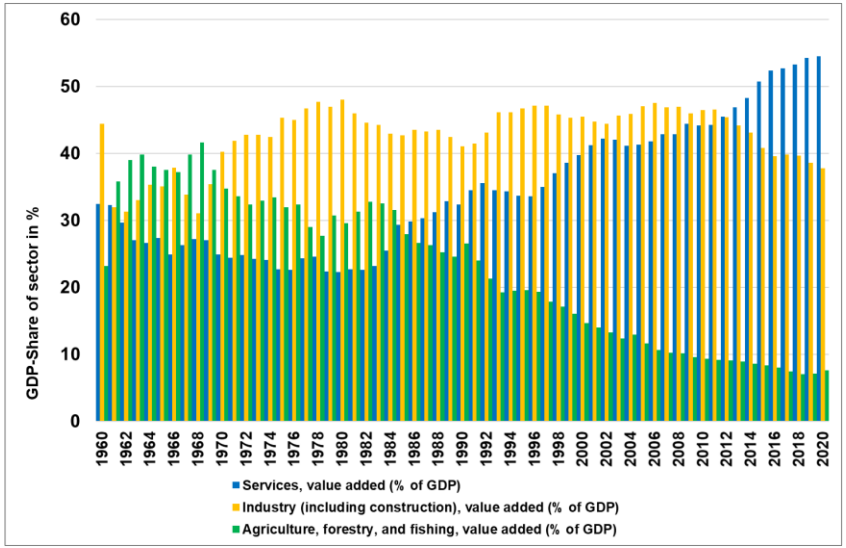
Price Development of different Industrial Metals 2000 to 2022



According to data of LME, https://www.lme.com/

GDP-Share of Sectors in China 1960 to 2020



According to data of the worldbank, https://data.worldbank.org/indicator

The development of future raw material markets depends among other things on the economic development in China

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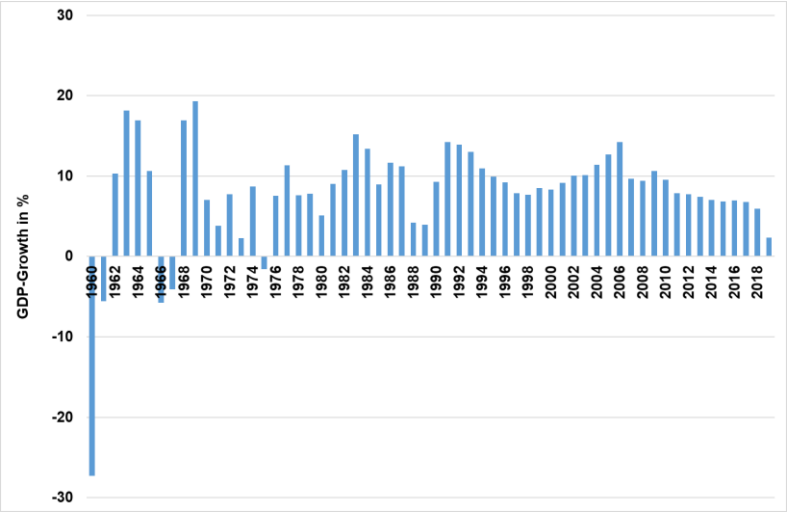
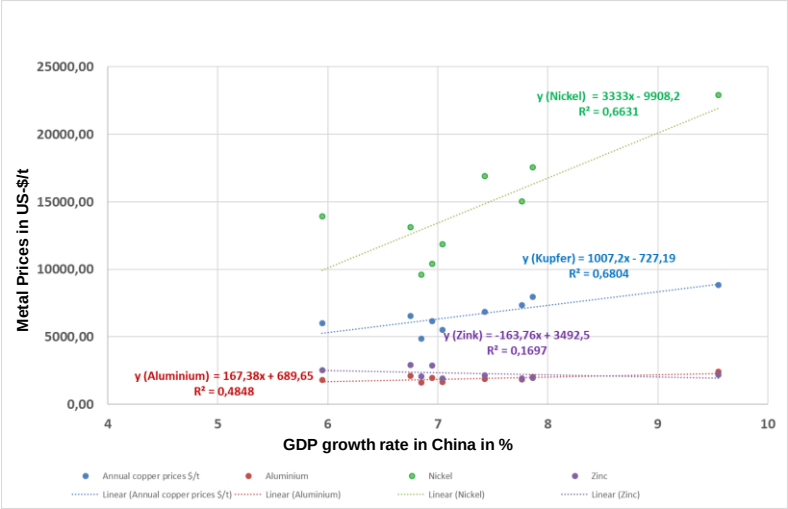
Annual Growth of GDP in China



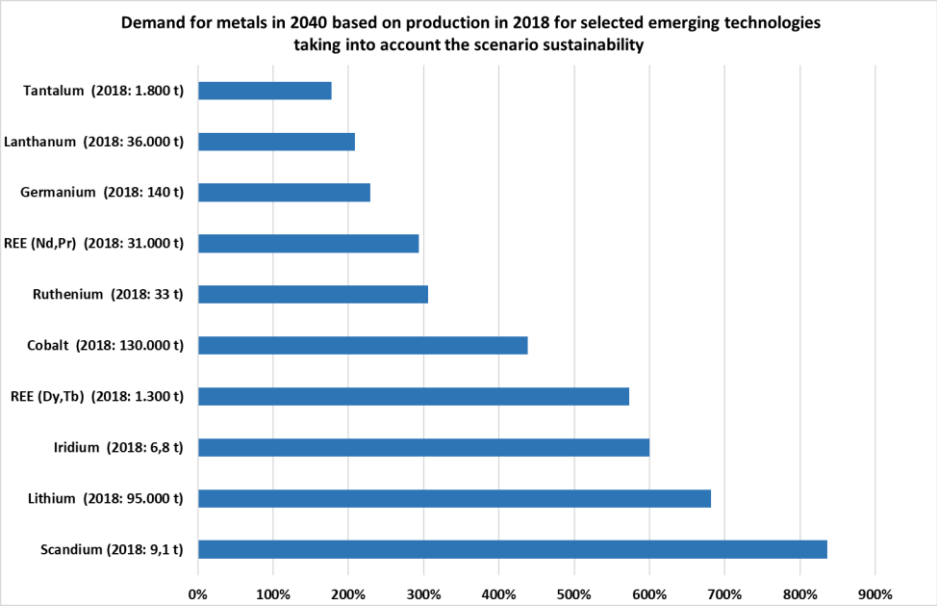
According to data of the worldbank, https://data.worldbank.org/indicator

Development of metal prices in relation to GDP growth in China 2011 to 2019



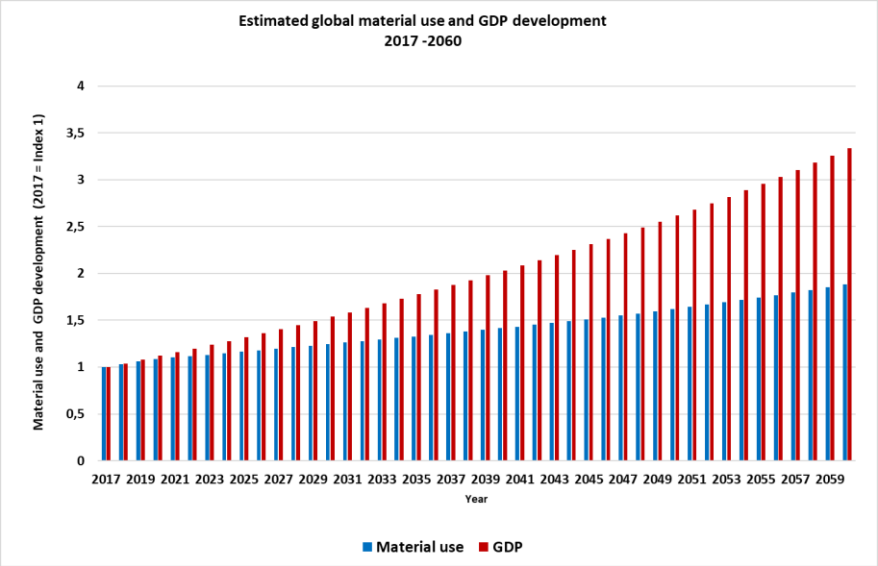
According to data of the worldbank, https://data.worldbank.org/indicator

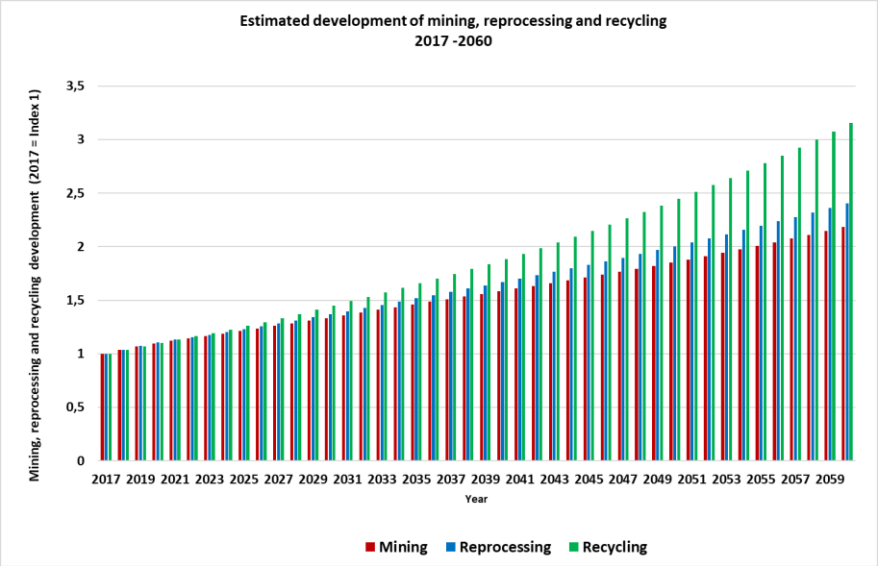
Forecast demand of metals for selected emerging technologies in 2040



According to data of DERA Deutsche Rohstoffagentur: Rohstoffinformation 50 (2021), Rohstoffe für Zukunftstechnologien 2021, https://www.deutsche-rohstoffagentur.de/DERA

Forecast developments of global key indicators





According to data of OECD: Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences, OECD Publishing, Paris, 2019, https://doi.org/10.1787/9789264307452-en

Thank you for your attention!

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