Draft concept for a data and knowledge information system on mineral mining and trade and related environmental and socio-economic issues:

Part II
Draft concept of raw material profiles

Draft for workshop participants
(Brussels, 20 June)

Öko-Institut e.V.

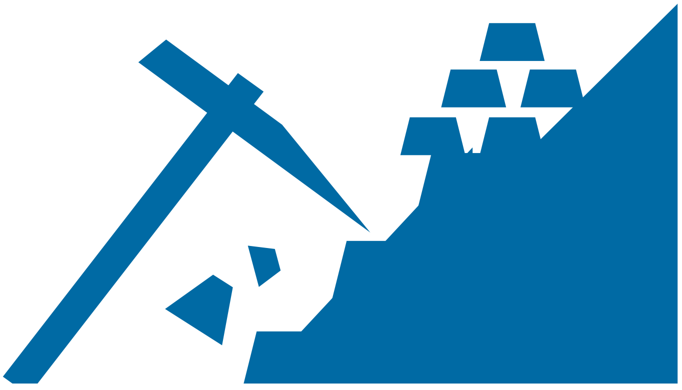
STRADE

Part II

Draft concept of raw material profiles

Content:

- **Global production and reserves**
- **Global demand**
- **EU trade**
- **Recycling / substitution / material efficiency**
- **Mining & development**
- **Human rights**
- **Environmental issues**
- **Initiatives for responsible mining**



Preface

This document is Part II of the “Draft concept for a data and knowledge information system on mineral mining and trade and related environmental and socio-economic issues”. Part I examines the necessity and feasibility of a data and knowledge information system on mineral mining and trade and related environmental and socio-economic issues.

The data is broadly structured into:

- Part II – Raw-material-specific information and
- Part III – Country-specific information.

Part II here presents a concrete example of compiling a raw material profile and offers iron as the example. The data collection for these examples does not claim completeness but builds on easily available data to illustrate the underlying concept and serve as a basis for a general discussion of the structure of the information system. Further data collection will be necessary to elaborate comprehensive raw material and country profiles if the STRADE team and the requested stakeholders agreed upon their principal architecture.

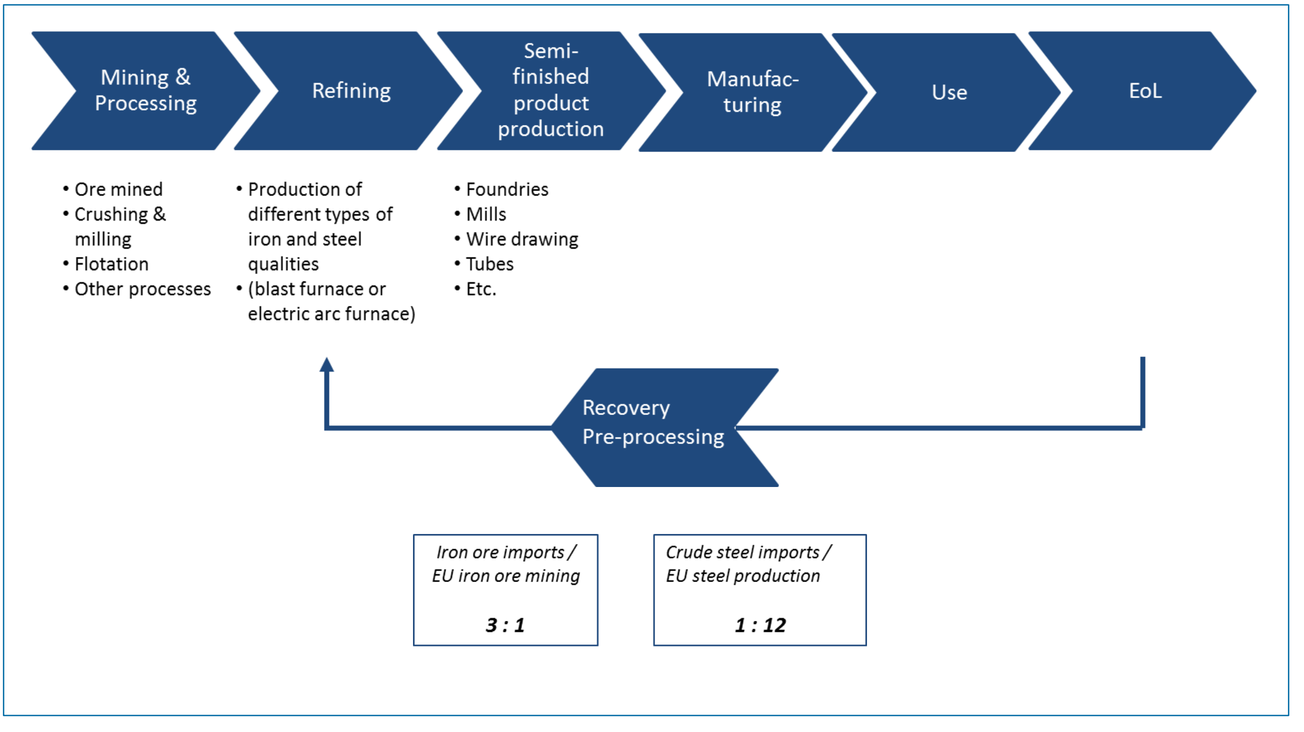
Introduction

Introduction
Overview

Key data on iron

Iron (Fe) is the fourth most abundant element in the Earth's crust, with a concentration of 4.7%. Iron has the highest production volume of all metals globally – in 2016 2.2 billion tonnes iron ore (usable) were mined. Almost every industrial sector depends on iron; moreover Europe is the second largest manufacturer of steel and iron globally.

Supply chain



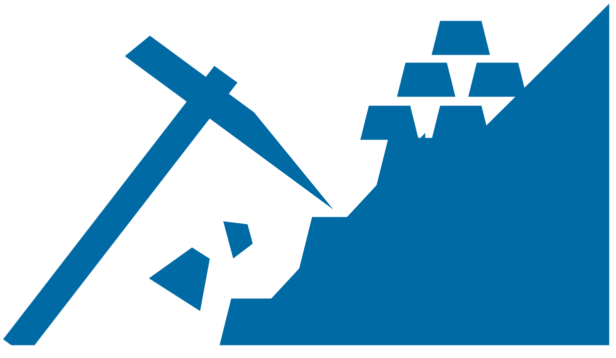
Reference

- Used source for mining data: BGS
- Used source for import iron ore data: COMTRADE Further source: Eurostat
- Used source for crude steel import and production: eurofer.eu
- European Commission 2014
- USGS 2017

Further Reading

- Detailed information on the main production processes are available on www.eurofer.eu

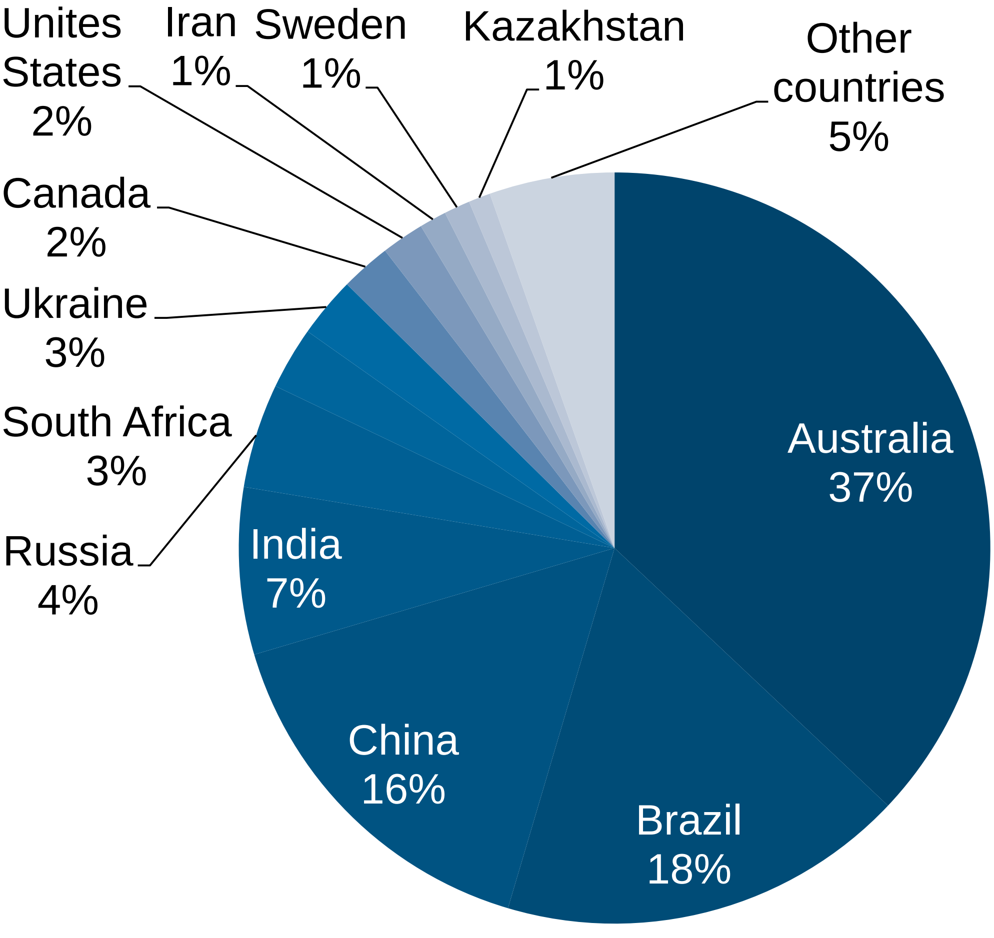
Global production and reserves



Global production and reserves

Primary production and reserves

Global primary production 2016



Global primary mine production 2016 (usable iron ore):
Total 2,230 million metric tonnes

Reference

- USGS 2017

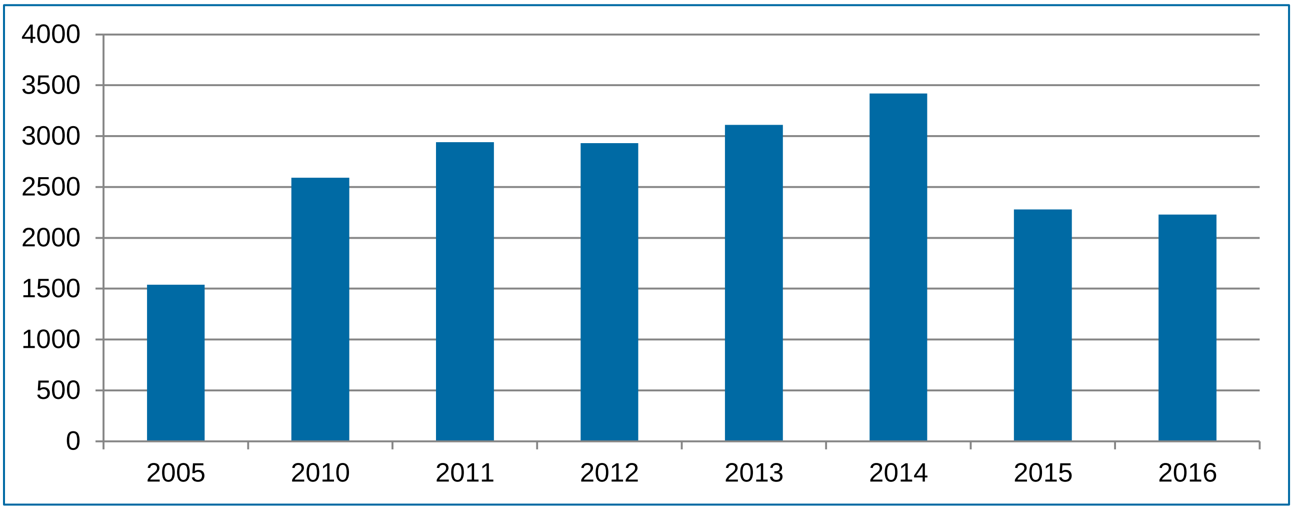
Further Reading:

- BGS
- respective International Study Groups
- UNCTAD (unctad.org)

Global production and reserves

Primary production and reserves

Historical development of primary production



Historical development of primary production (usable iron ore) in million metric tonnes: The decrease in 2015 is a result of new data from China (since 2015 China with usable ore data; before China included with crude ore data – till 2015 China with around 1,300 mio. tonnes; as usable ore ca. 375 mio. tonnes)

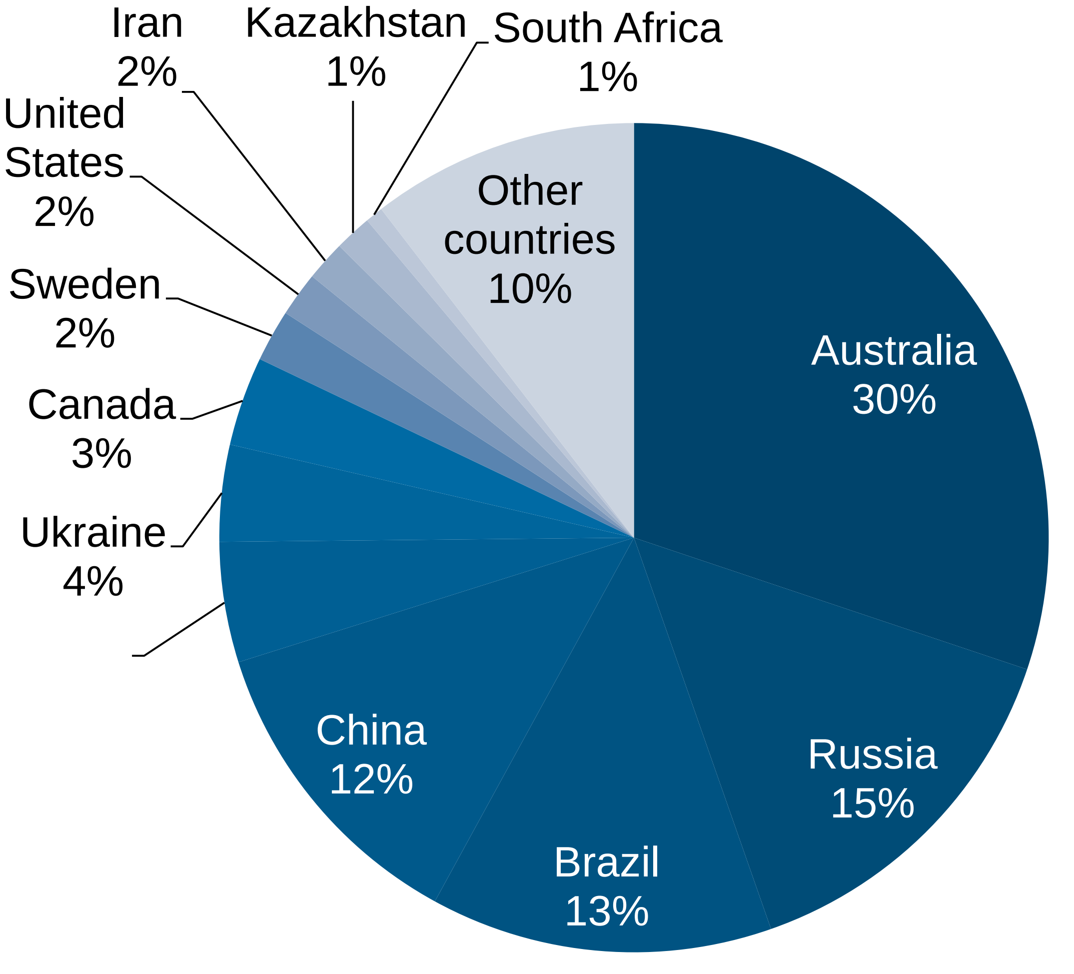
Reference

- USGS 2017

Global production and reserves

Primary production and reserves

Global reserves of crude iron ore



Global reserves of crude iron ore: Total 170,000 million metric tonnes

Reference

- USGS 2017

Global production and reserves

Primary production and reserves

Herfindahl-Hirschman index (HHI)

Herfindahl-Hirschman index (HHI)	
Index refers to	**Value**
Production	1
Reserves	0.3

The Herfindahl-Hirschman index (HHI) is a key figure for measuring concentrations. In this case the concentration of iron ore producing countries. 1 = high concentration of production

Used data: VDI standard 4800

Global production and reserves

Primary production and reserves

Largest iron ore producers in 2014

Corporation	ICMM member	Country	Capacity (Mt)	Capacity (%)
Vale Group	No	Brazil	451,7	17,17
Rio Tinto Group	Yes	UK	378,7	14,39
BHP Billiton	Yes	Australia	310,3	11,79
Fortescue Metals	No	Australia	81,5	3,10
Arcelor Mittal Group	No	UK	79,6	3,03
AnBenGroup	No	China	55,7	2,12
Anglo American Group	Yes	South Africa	50,8	1,93
Metalloinvest	No	Russia	46,8	1,78
Evrazholding Group	No	Russia	46,4	1,76
LKAB Group	No	Sweden	45,2	1,72
Metinvest Holding Group	No	Ukraine	44,7	1,70
Cliffs Natural Resources		USA	42,9	1,63

Reference

- Comtois C, Slack B. Dynamic Determinants in Global Iron Ore Supply Chain [Internet] [cited 2017 Mar 13]. Available from: https://www.cirrelt.ca/DocumentsTravail/CIRRELT-2016-06.pdf.

Global production and reserves

Ore as main-product / by-product

Iron ore is mainly mined as main-product.
Frequent by-products in iron ore mining are: TiO_2, S, Ni, Cu, V
The principal iron-bearing minerals of commercial importance are hematite, magnetite, and goethite/limonite. Others include siderite, ilmenite, chamosite, and pyrite; in the case of ilmenite, Fe is recovered as a companion of TiO_2, while pyrite is roasted to recover S with Fe oxide being recovered as a companion. Fe from ilmenite (and siderite) is used on a local basis, while pyrite and chamosite are virtually no longer important for iron production. Similarly, Fe may have previously been recovered from Ni-Cu deposits such as the Inco Sudbury deposit in Canada. Fe from magnetite was recovered as a co-product of V from the Mapoch mine and Cu from the Palabora mine, both in South Africa. Quantities of Fe produced as a companion are estimated to be a very small percentage of overall global production.

Reference

- Science Advances 2015 (www.advances.sciencemag.org/cgi/content/full/1/3/e1400180/DC1)

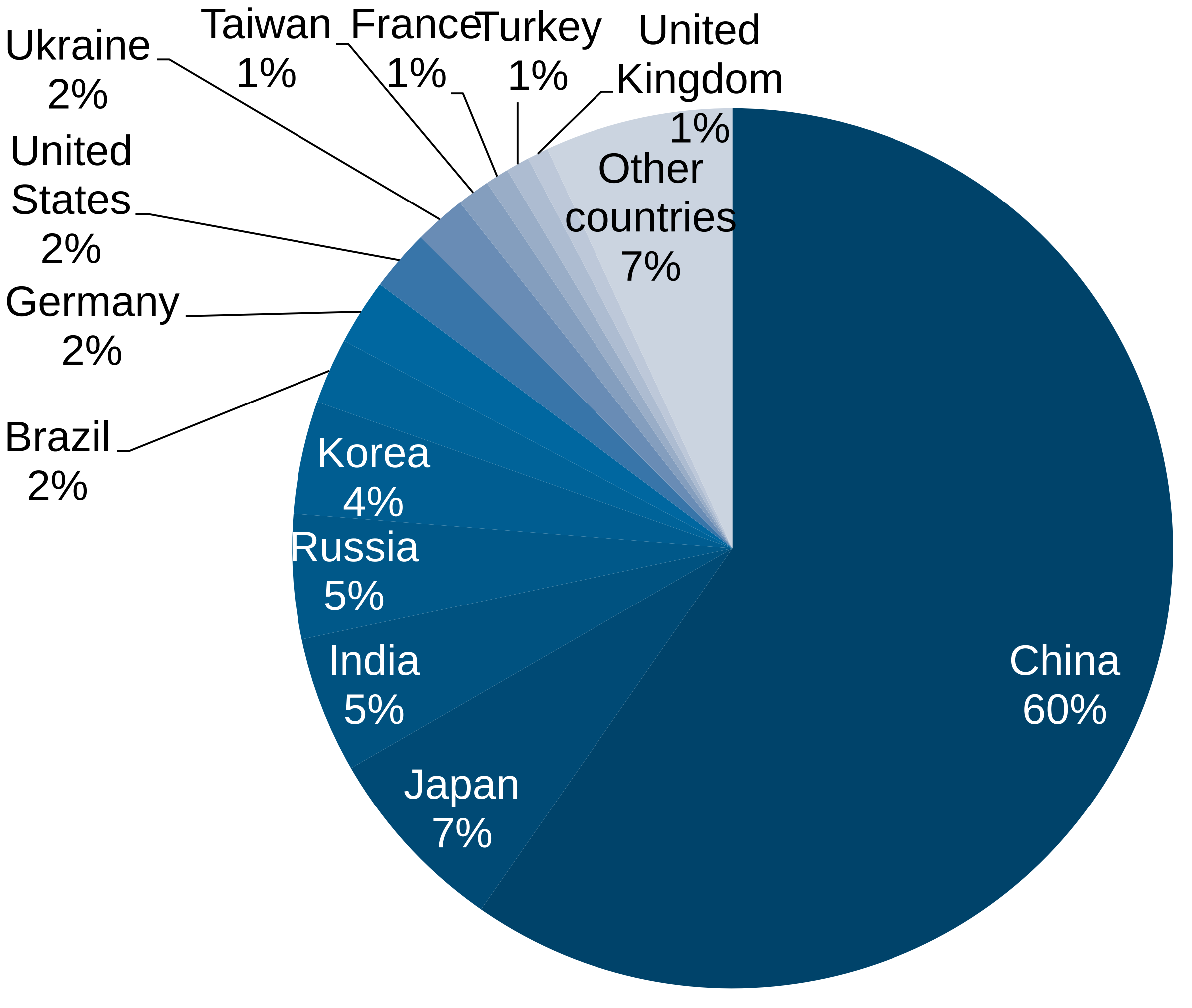
Further reading

- The Metal-Wheel by Reuter and van Schaik (http://eco3e.eu/wp-content/uploads/2011/01/29-metal_wheel.jpg)

Global production and reserves

Intermediate products production

Pig iron global production 2015



Pig iron global production 2015 (World total around 1,160 million metric tonnes of metal)

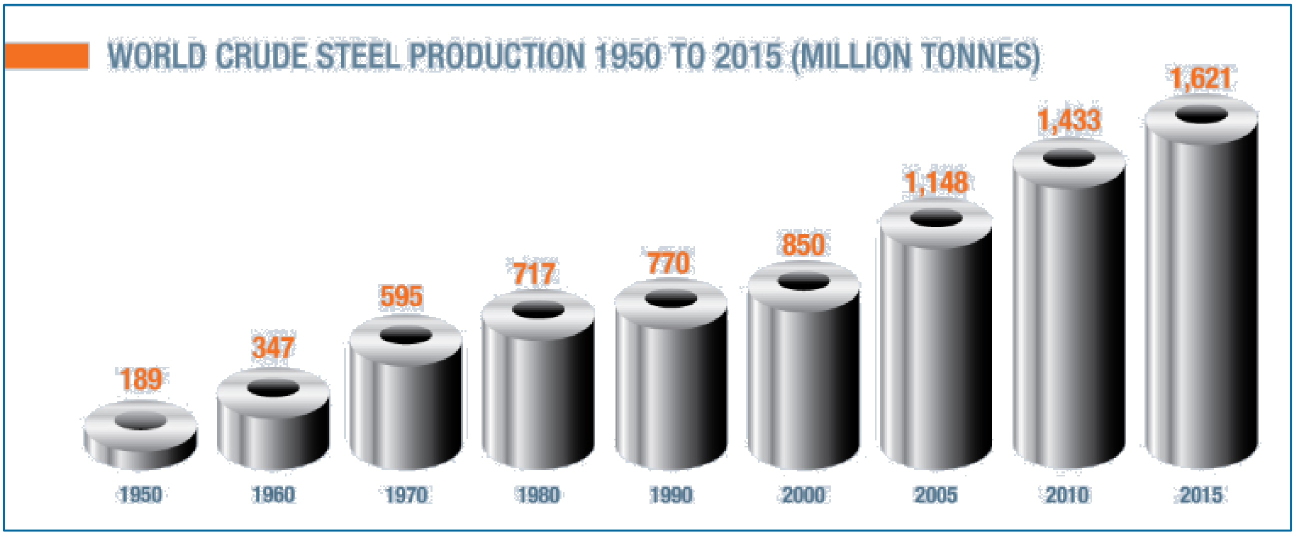
Reference

- USGS 2017

Global production and reserves

Intermediate products production

Historical development of worldwide crude steel production



Reference

- World Steel Association (https://www.worldsteel.org/en/dam/jcr:f9a336d7-8903-4bdf-9ed6-83b27d0ff807/WSiF+2016.pdf)

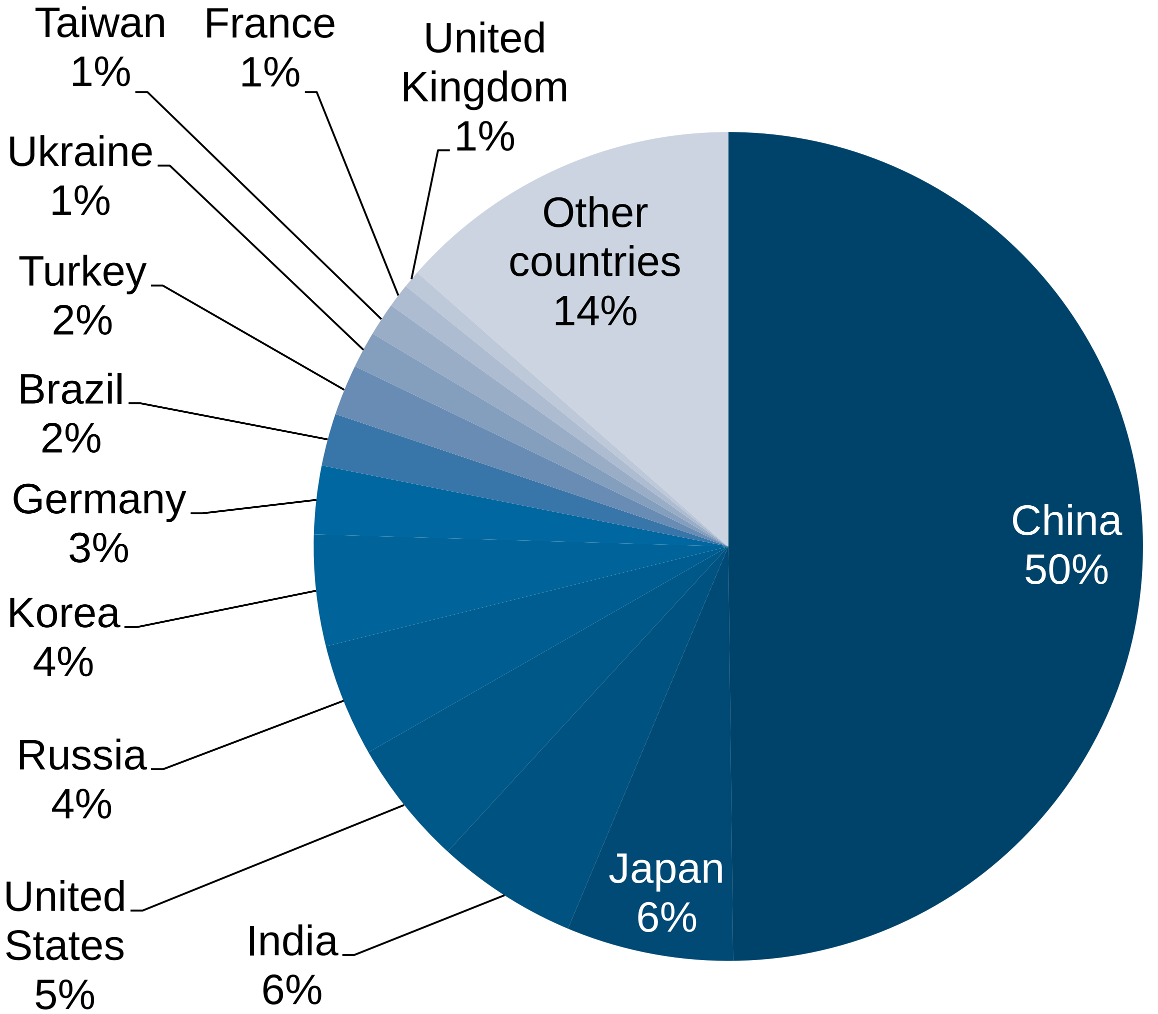
Further reading

- Eurofer (eurofer.eu)

Global production and reserves

Intermediate products production

Historical development of worldwide crude steel production



Crude steel producing countries 2015 (World total around 1,610 million metric tonnes of metal)

Reference

- USGS 2017

Global production and reserves

Intermediate products production

Summary

	EU28	Global
Pig Iron Production		
Crude Steel production (2016)	162 mio. t	1,628.5 mio. t [3]
Stainless Crude production (2015)	7,2 mio.t [2]	n.a.

Reference

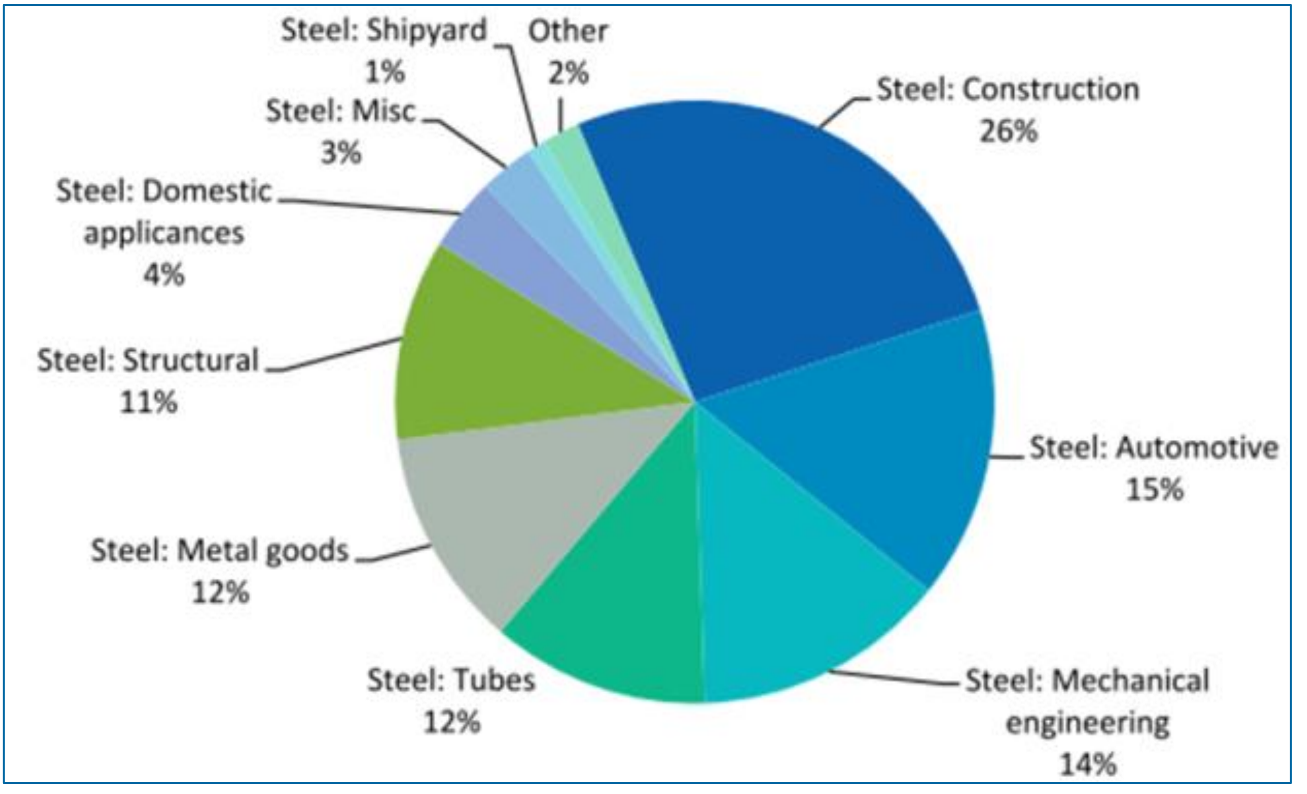
- Eurofer for EU28 crude steel production (http://www.eurofer.org/Facts%26Figures/Crude%20Steel%20Production/All%20Qualities.fhtml)
- Eurofer for EU28 stainless crude production (http://www.eurofer.org/Facts%26Figures/Crude%20Steel%20Production/Stainless.fhtml)
- World Steel Association for global crude steel production (https://www.worldsteel.org/media-centre/about-steel.html)

Global demand

Global demand

Application / end-use

End-use of iron ore in Europe in 2010



Reference

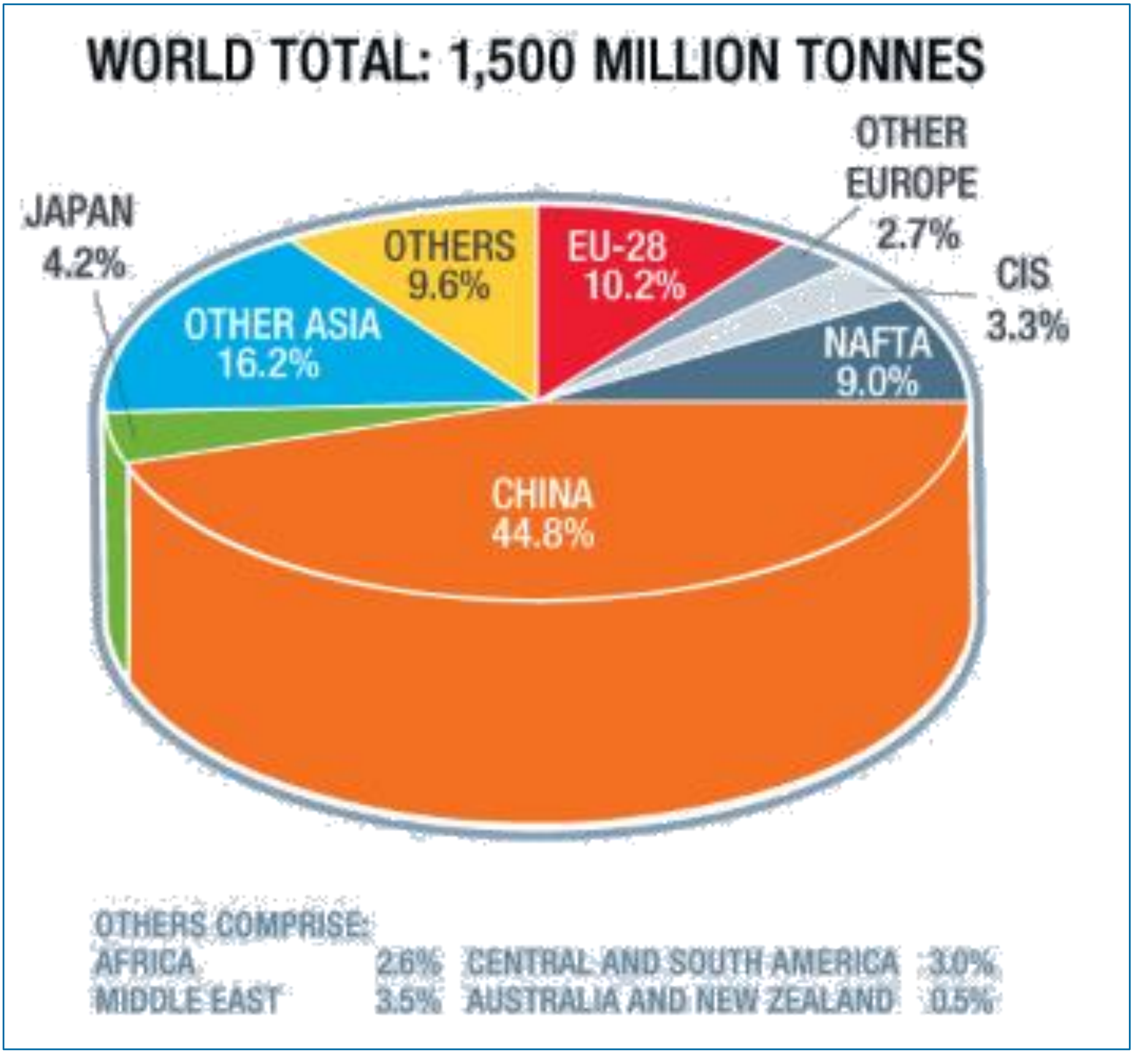
- European Commission 2014

Further reading

- World Steel Association (www.worldsteel.org)

Global demand

Global versus EU demand / consumption



Reference

- World Steel Association - World Steel in Figures 2016 (https://www.worldsteel.org/en/dam/jcr:f9a336d7-8903-4bdf-9ed6-83b27d0ff807/WSiF+2016.pdf)

Further reading

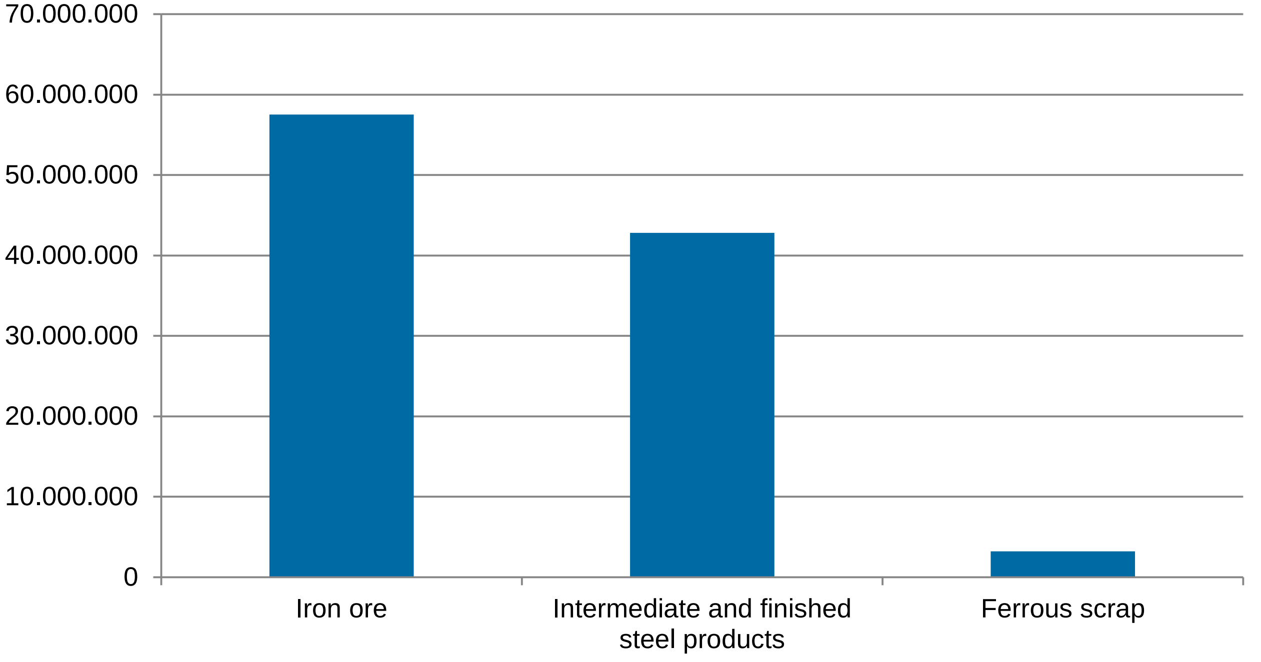
- Eurofer (www.eurofer.org)
- World Steel Association (www.worldsteel.org)

EU trade

EU trade

Extra-EU imports

Specific EU iron gross imports



Ores and intermediate products for EU processing industry; (rough estimation; intra-EU imports excluded; data refer to metal content)

Reference

- STRADE Policy Brief No. 02/2017 (http://stradeproject.eu/fileadmin/user_upload/pdf/STRADEPolBrf_02-2017_RawMaterialFlows_Mar2017_FINAL.pdf)
- COMTRADE (https://comtrade.un.org/data/)

Further reading

- Eurostat
- Comext
- WTO

EU trade

Extra-EU imports

EU28 import of iron ores and concentrates

(HS 2601) in 2015 (Official trade data; no metal content estimated)

Import iron ore from major countries	Million tonnes (in brackets share of total)	Million USD (in brackets share of total)
Brazil	54.5 (47%)	3.4 billion (48%)
Canada	19.0 (17%)	1.3 billion (17%)
Ukraine	16.3 (14%)	1.0 billion (14%)
Total	115.1 (100 %)	7.2 billion (100 %)

EU28 import of stainless steel in primary forms, semi-finished product

(HS 7218) in 2015 (Official trade data; no metal content estimated)

Major EU stainless steel imports (steel in primary forms, semi-finished product) from:	Tonnes (in brackets share of total)	
Russian Federation	13 844 (52%)	24 million (31%)
USA	4 387 (16%)	29 million (37%)
India	2 071 (8%)	5 million (7%)
Worldwide	26 795 (100 %)	79 million (100 %)

Reference

- COMTRADE (https://comtrade.un.org/data/)

Further reading

- Eurostat
- Comext

Further product groups ….

Scrap import is detailed in parameter recycling.

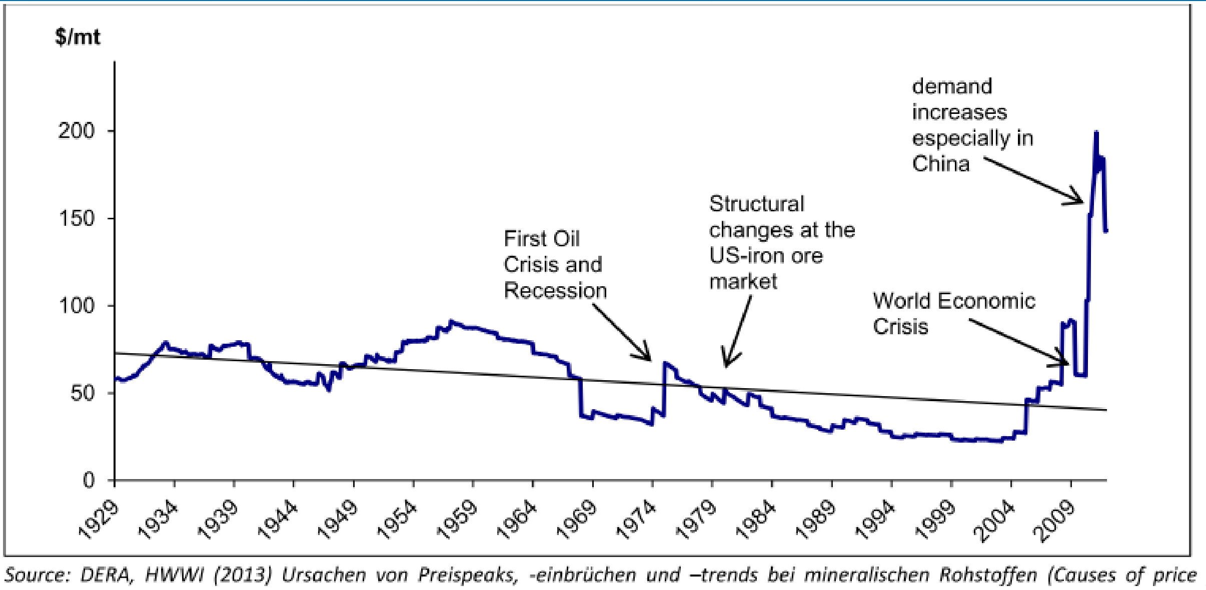
EU trade
Extra EU-exports

Note: The detailed concept for this section on extra EU exports should be elaborated in other projects / research; this issue is not in the STRADE focus.

Possible data sources are:
- COMTRADE
- Associations e.g.
- World Steel Association (https://www.worldsteel.org/en/dam/jcr:37ad1117-fefc-4df3-b84f-6295478ae460/Steel+Statistical+Yearbook+2016.pdf)

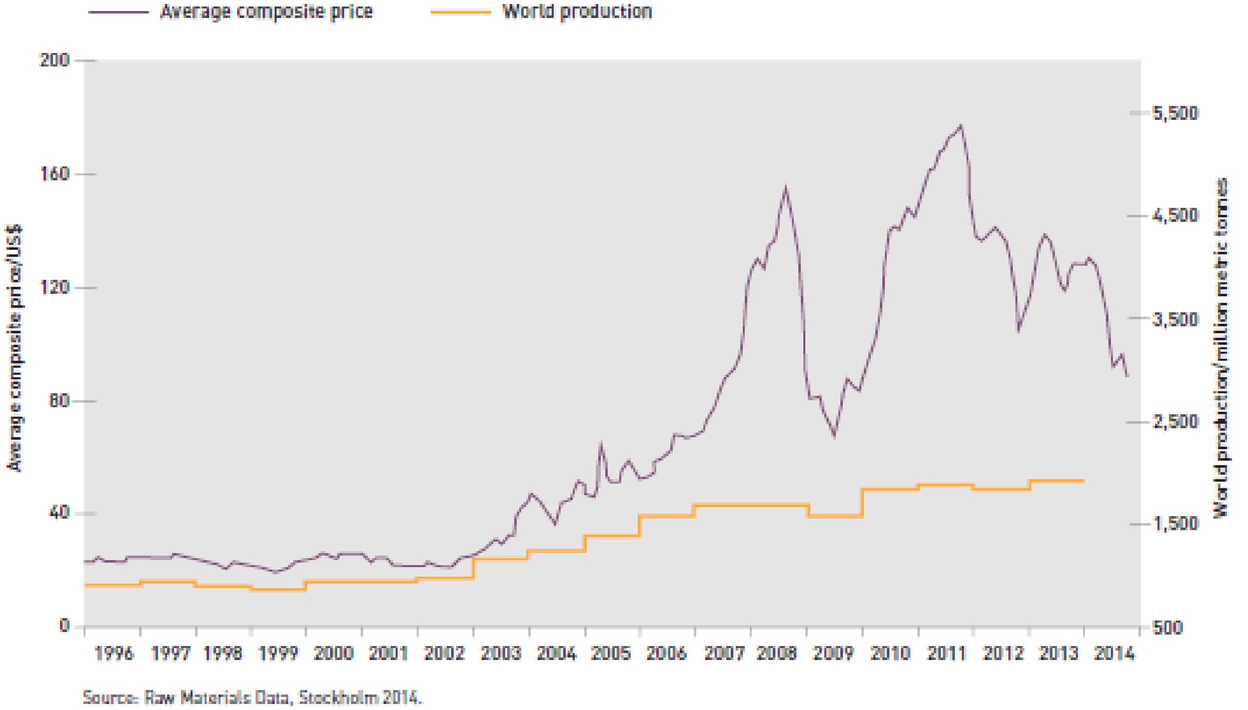
Price history

Development of real iron ore prices (Prices are deflated, 2011 = 100)



Source: DERA, HWWI (2013) Ursachen von Preispeaks, -einbrüchen und –trends bei mineralischen Rohstoffen (Causes of price peaks, collapses and trends of mineral raw materials), Hamburg Institute of International Economics (HWWI) in contract for Deutsche Rohstoffagentur (DERA). April 2013, trend line and translation to English by Fraunhofer ISI

Figure 15: Iron ore prices and production volumes



Source: Raw Materials Data, Stockholm 2014.

EU trade

Prices

Average ore price, Jan-Dec 2016	
Iron ore	93 USD / t

Marketindex 2017; Iron Ore Fines 62% FE spot (CFR Tianjin port), US dollars per metric ton

Reference

- Used data source for price history: EC 2014 (Report on Critical Raw Materials for the EU - Non-Critical Raw Materials Profiles) https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_de
- Used data source for price history: Raw Materials Group "The role of mining in national economies", October 2014
- Used data source for average ore price: Marketindex (http://www.marketindex.com.au/iron-ore)

Further reading

- asianmetal.com
- metalpages.com
- UNCTADstat (http://unctad.org/en/Pages/statistics.aspx)
- IMF (imf.org)

Recycling / substitution / material efficiency

Recycling / substitution / material efficiency

Recycling

Note: The detailed concept for the section on recycling should be elaborated in other projects / research since the STRADE project focuses on primary production. Nevertheless some key data are proposed:

Iron: The end-of-life recycling rate (**EoL-RR**) of iron is between 52 % (USGS 2004) and 90 % (Steel Recycling Institute 2007) in UNEP 2011 and Bowyer et al 2015
Definition EoL RR: The EOL-RR is a measure of the extent to which ferrous metal contained in end - of - life steel products is actually recycled.

Iron: The recycled content (**RC**) content of iron is > 25 – 50% (UNEP 2011)
Definition Recycled Content (RC): The RC indicates the extent to which end - of - life scrap is actually used in making new steel products.

Reference

- UNEP 2011 http://wedocs.unep.org/bitstream/handle/20.500.11822/8702/-Recycling%20rates%20of%20metals%3a%20A%20status%20report-2011Recycling_Rates.pdf?sequence=3&isAllowed=y
- Bowyer et al. 2015 http://www.dovetailinc.org/report_pdfs/2015/dovetailsteelrecycling0315.pdf

Further reading

- BIO by Deloitte. Study on Data for a Raw Material System Analysis: Roadmap and Test of the Fully Operational MSA for Raw Materials Final Report [Internet] [cited 2017 Feb 15]. Available from: http://c.ymcdn.com/sites/www.intlmag.org/resource/resmgr/docs/membership_central/newsletter/2016/February/MSA_Final_Report_02.pdf.

Recycling / substitution / material efficiency

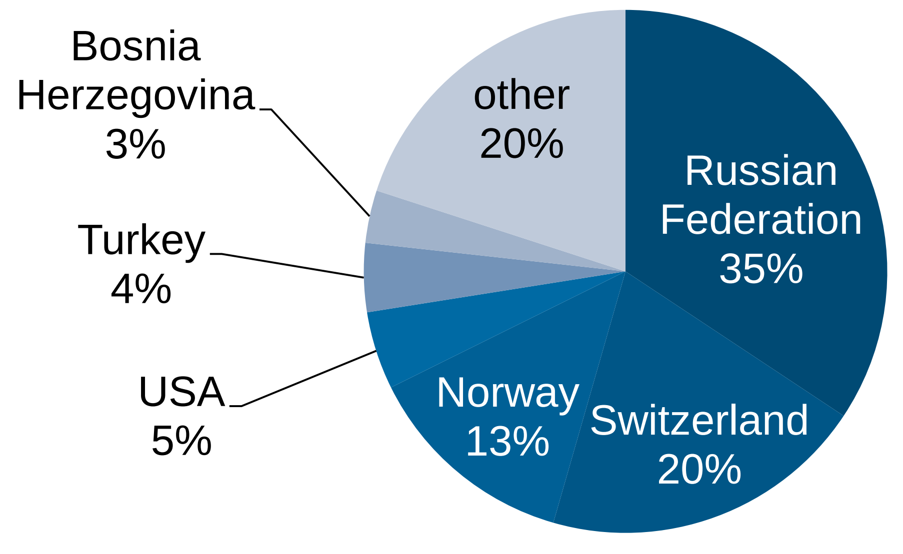
Recycling

EoL-RR and RC for selected product groups

Product Group	EU28		Global	
	EoL	RC	EoL	RC
Stainless steel	n.a.	n.a.	80-90%	60%
…				
…				

Ferrous scraps import to the EU-28 in 2014

main countries [in weight % iron]



Reference

- World Steel Association (http://www.worldstainless.org/Files/issf/Animations/Recycling/Flash.html)
- COMTRADE

Recycling / substitution / material efficiency

Substitutability

Substitutability scores for applications (1 = low substitutability)

Application	Substitutability score
Steel: Construction	1
Steel: Metal goods	1
Other	0.5
Steel: Automotive	0.7
Steel: Shipyard	1
Steel: Domestic appliances	0.7
Steel: Mechanical engineering	0.7
Steel: Structural	1
Steel: Tubes	0.7

Substitutability and effects of increased material efficiency are difficult to express in one indicator. With the above indicator estimation on substitutability is given. Specific research and expert estimation is necessary for substitutability in each application and in material efficiency potential.

Reference

- European Commission 2014

Further reading

- JRC 2016: Substitution of critical raw materials in low-carbon technologies: lighting, wind turbines and electric vehicles (available on https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/substitution-critical-raw-materials-low-carbon-technologies-lighting-wind-turbines-and)
- Graedel, T, Harper, E, Nassar, N, & Reck, B 2015, 'On the materials basis of modern society', Proceedings Of The National Academy Of Sciences Of The United States, 20, Academic OneFile, EBSCOhost, (http://www.pnas.org/content/112/20/6295)

Recycling / substitution / material efficiency

Material efficiency

Data sources / analysis are needed for material efficiency information

Mining & development

Economic contribution

Note: Detailed information on economic contribution of mining in the primary producing countries is elaborated in the countries profiles (Part III). See also Part III for further country-specific information and indicators (e.g. EITI-membership, control of corruption, political stability and absence of violence, job creation, revenues, etc.).

Artisanal and small scale mining (ASM)

ASM in iron ore mining	
Share of artisanal mining	> 4 %
Countries where artisanal mining is practiced	China, DRC

Reference
- Used source for share of artisanal mining: Dorner et al. 2012 (http://www.polinares.eu/docs/d2-1/polinares_wp2_chapter7.pdf)
- Used source for countries where artisanal mining is practiced: Gunson & Jian 2001 (http://pubs.iied.org/pdfs/G00719.pdf)

Further reading
- BGR https://www.bgr.bund.de/DE/Themen/Min_rohstoffe/Downloads/Studie_Zertifizierte_Handelsketten.pdf?__blob=publicationFile&v=2;
- BGR https://www.bgr.bund.de/EN/Themen/Min_rohstoffe/CTC/Concept_MC/ASM-great-lakes/ASM_node_en.html

Human rights

Human rights

Conflicts related to iron

Note: Detailed information on conflicts related to mining see Part III country profiles.

Child labour and forced labour

Note: See Part III country profiles for detailed information in child labour and forced labour in producing countries.

Case studies are provided in BGR study „Human Rights Risks in Mining“ (https://www.bgr.bund.de/DE/Themen/Zusammenarbeit/TechnZusammenarbeit/Downloads/human_rights_risks_in_mining.pdf?__blob=publicationFile&v=2)

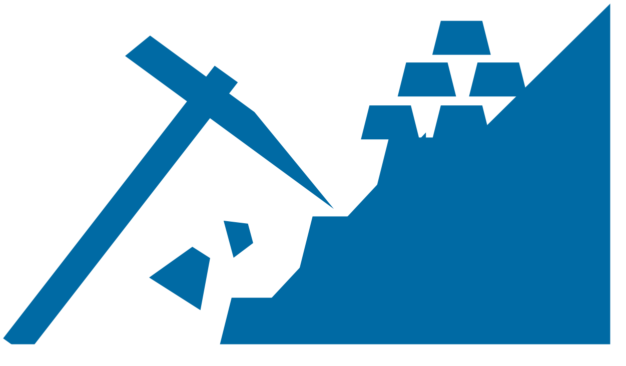
Human rights

Child labour and forced labour

Note: See Part II country profiles for detailed information in child labour and forced labour in producing countries.

Case studies are provided in BGR study „Human Rights Risks in Mining“ (https://www.bgr.bund.de/DE/Themen/Zusammenarbeit/TechnZusammenarbeit/Downloads/human_rights_risks_in_mining.pdf?__blob=publicationFile&v=2)

Environmental issues



Environmental issues

LCA data

	Iron ore [iron ore 46%]	Iron	Steel [Steel]
Cumulative Energy Demand (CED)	63 (MJ/t)	21,1 (MJ/t)	25,6 (MJ/t)
Cumulative Raw Material demand (CRD)	1,0 (kg/t)	4,1 (kg/t)	10,0 (kg/t)

The consumption of energy resources is represented by the **cumulative energy demand (CED).** CED is a measure of the total amount of energy resources used to make a product or provide a service. It also includes the energy contained in the product itself. The CED identifies all non-renewable and renewable energy resources as primary energy values, with the higher heating value (HHV) of the various fuels used in the calculations. No characterization factors are used. This means that the consumption of energy resources is not an impact category based on different impact factors, but a life cycle inventory parameter.

The **cumulative raw material demand (CRD)** is defined as the sum of all used raw material – except of water and air – in weight unit.

Reference

- UBA 2012: Indikatoren / Kennzahlen für den Rohstoffverbrauch im Rahmen der Nachhaltigkeitsdiskussion (https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4237.pdf)

Further reading

- Ecoinvent (www.ecoinvent.ch)
- PROBAS (http://www.probas.umweltbundesamt.de/php/index.php)
- JRC (http://eplca.jrc.ec.europa.eu/)
- World Steel Association

Environmental issues

Association with radioactive substances

Category	Environmental hazard potential according to ÖkoRess methodology
Association with radioactive substances	medium

Data from Chinese iron ore deposits show average activity concentrations of 0.068 Bq/g for Thorium and 0.27 Bq/kg for Uranium (Hua 2011). According to the ÖkoRess methodology, this leads to a medium environmental hazard potential related to association with radioactive substances. (China produces 16 % of global primary mine production)

The risks varies highly between different mining sites and can be mitigated by various technological and management measures. The successful implementation highly depends on the local governance and mining companies' responsible mining practice.

Association heavy metals

Category	Environmental hazard potential according to ÖkoRess methodology
Association with heavy metals	medium

While iron is not a heavy metal itself, ores are commonly associated with elevated concentrations of heavy metals.

The risks varies highly between different mining sites and can be mitigated by various technological and management measures. The successful implementation highly depends on the local governance and mining companies' responsible mining practice.

Reference

- ÖkoRess Project Report (forthcoming): https://www.umweltbundesamt.de/umweltfragen-oekoress
- Hua, L. (2011): The Situation of NORM in Non-Uranium Mining in China. China National Nuclear safety Administration. (http://www.icrp.org/docs/Liu%20Hua%20NORM%20in%20Non-Uranium%20Mining%20in%20China.pdf).

Environmental issues

Acid Mine Drainage

Category	Environmental hazard potential according to ÖkoRess methodology
Acid Mine Drainage	medium

Iron ore is commonly mined from silica-rock deposits. While such formations usually contain sulfidic minerals, iron ore is mainly mined in oxidised form (iron oxides) and therefore from strata where sulfidic minerals have mostly been oxidised and depleted. According to the ÖkoRess methodology, this leads to a medium environmental hazard potential.

The risk varies highly between different mining sites can be mitigated by various technological and management measures. The successful implementation highly depends on the local governance and mining companies' responsible mining practice.

Chemical use

Category	Environmental hazard potential according to ÖkoRess methodology
Use of additives in extraction and benefication	Medium

Iron ores are commonly treated by flotation with the use of chemical additives.

Reference

- ÖkoRess Project Report (forthcoming): https://www.umweltbundesamt.de/umweltfragen-oekoress

Environmental issues

Open pit mining or underground mining

Category	Environmental hazard potential according to ÖkoRess methodology
Mining type	medium

Iron ore is commonly mined from open pits from solid rock formations.

Explanatory note: While underground mining has comparably little impacts in terms of land use and conversion of local ecosystems, open pit mining is much more relevant in this regard. Mining activities on loose material such as alluvial deposits (e.g. dredging in rivers) often has very high impacts on local environments.

Dam bursts / flooding

Incidents since 2000	EU-28	Global, without EU-28
Dam bursts / flooding	…	Bento Rodrigues (Brazil), 2015 Itabirito Regiao (Brazil), 2014 Shanxi (China), 2008 …

Reference
- ÖkoRess Project Report (forthcoming): https://www.umweltbundesamt.de/umweltfragen-oekoress
- http://www.wise-uranium.org/mdaf.html

Note: Further research necessary

Environmental issues

Mining waste

Average ore grade	10-50%
Submarine / riverine tailings disposal [if yes, include countries]	No

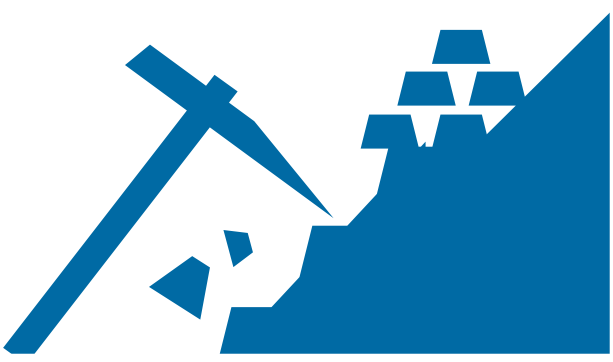
Sites-specific environmental risks

Site-specific environmental risk are detailed in the country profiles (water stress, protected areas, earth quake, mining accidents, Heavy rain/flooding)

Reference

- Priester, Dolega (2015): ÖkoRess – Teilbericht Bergbauliche Reststoffe (https://www.umweltbundesamt.de/sites/default/files/medien/376/dokumente/oekoress_-_teilbericht_bergbauliche_reststoffe.pdf)

Initiatives for responsible mining



Initiatives for responsible mining

Initiatives

Type of initiative	Iron ore / Steel
Specific iron and steel initiatives related to sustainable primary and secondary production	Responsible Steel Stewardship (Australia; global initiative under development)
Initiatives across the whole range of raw materials, including iron and steel:	ICMM (LSM) IRMA (draft) IFC TSM (Canada; Finland) GARD

Global market share of raw materials from different schemes

Initiative	Focus	Contribubtion of initiative to global production
Responsible Steel Stewardship	LSM (large scale mining)	n.a.%
Towards Sustainable Mining (TSM)	LSM	n.a.%
ICMM	LSM	3 of the 12 largest iron ore producers are ICMM members (see above)

Reference

- RSS = Responsible Steel Stewardship (http://steelstewardship.com/steel-stewardship-forum-update/) in Australia; as global initiative under development (http://www.responsiblesteel.org/)
- ICMM = International Council on Mining and Metals (https://www.icmm.com/)
- IRMA = Initiative for Responsible Mining Assurance (http://www.responsiblemining.net/)
- IFC = International Finance Corporation (http://www.ifc.org/wps/wcm/connect/corp_ext_content/ifc_external_corporate_site/about+ifc_new)
- TSM = Towards Sustainable Mining (http://mining.ca/towards-sustainable-mining); Finnish adoption see www.kaivosvastuu
- GARD = Global Acid Rock Drainage Guide (http://www.gardguide.com/images/5/5f/TheGlobalAcidRockDrainageGuide.pdf)

References

- European Commission (2014): Report on Critical Raw Materials for the EU - Non-Critical Raw Materials Profiles [Internet] [cited 2016 Nov 15]. Available from: http://ec.europa.eu/DocsRoom/documents/7422/attachments/1/translations/en/renditions/pdf.
- USGS 2017: US Geological Survey. Mineral Commodity Summaries 2017 https://minerals.usgs.gov/minerals/pubs/mcs/2017/mcs2017.pdf