euromines

EMPA Materials Science & Technology

LCA and Raw-Materials Workshop
Brussels (Belgium), November 15, 2011

Life Cycle Approaches to Raw-Materials Governance

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Content

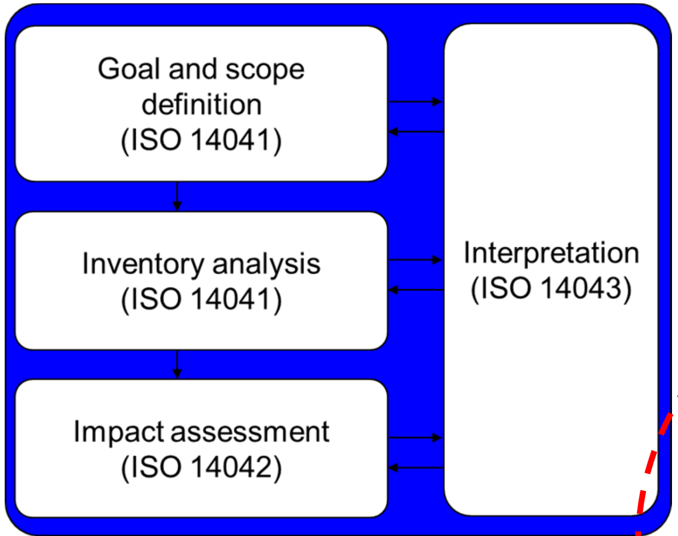
- **LCA and Decision Making**
  Senior Scientist's view
  - Applicabilitiy of LCA framework in decision making

- **UNEP resource panel**
  WG member's view
  - UNEP Resource Panel – what / where / who / when …
  - Report on environmental impacts of metals

- **ecoinvent**
  Deputy Manager's view
  - Metal data in *ecoinvent today* – what, how, where from ?
  - *ecoinvent tomorrow* – changes & their opportunities

Life Cycle Assessment (LCA)

General Aspects / Step 1 – Goal & Scope



Steps of an LCA according to EN ISO 14040, 1997

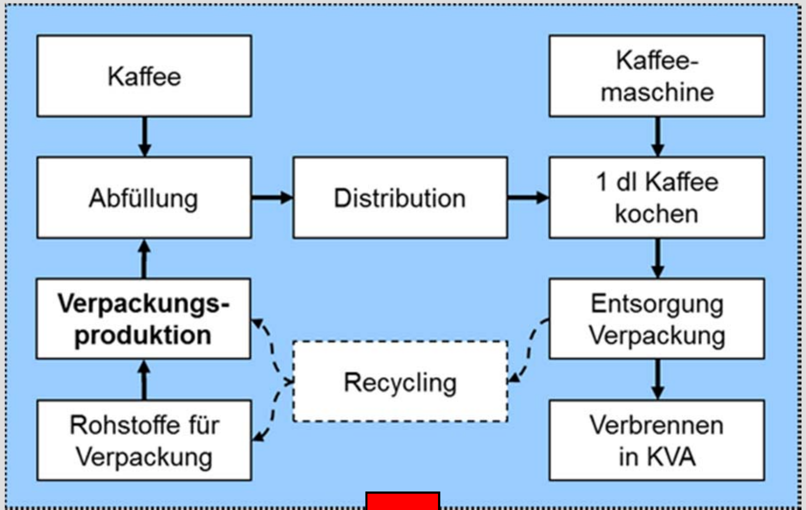
- standardized by ISO 14‘040 series;
- using a „life cycle perspective“ **no** (hidden) **shift** of the environmental impacts can be generated;
- It is a “**relative approach**” with all inputs and outputs of system that are related to a function that is performed for human use.
- This functional perspective allows **establishing a denominator to compare** the **performance of alternatives** which are not comparable in absolute terms.

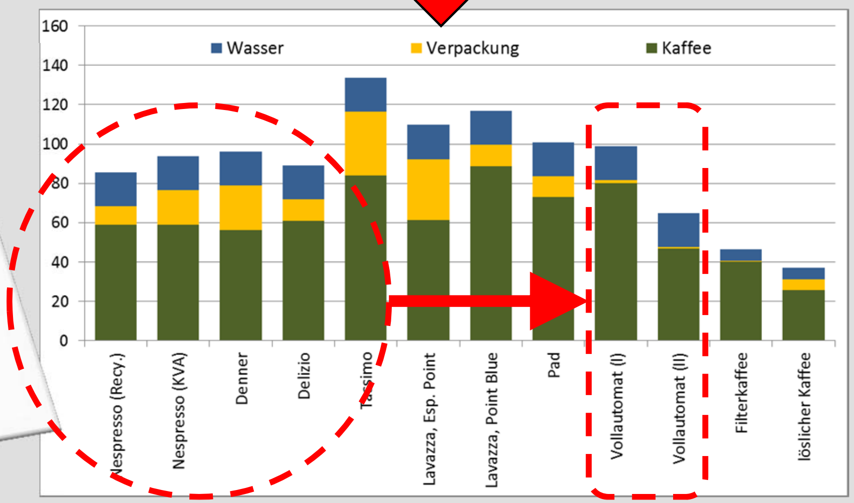
Crucial that LCA study **takes into account all functionalities** and **covers them adequately** by choosing an **appropriate functional unit** & respective system boundaries.

… an Example

Nespresso – the aluminium coffee capsule

F.U. **one cup of coffee**





Swiss Radio DRS
«**Espresso**»
April 5, 2011

Press Release
May 10, 2011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Medienmitteilung

Dübendorf, St. Gallen, Thun, 10. Mai 2011

Ökobilanz von Kaffeekapseln unter der Lupe

Auf den Kaffee kommt es an

Wie umweltfreundlich sind die verschiedenen Kapselsysteme und andere Zubereitungsarten für Kaffee? Empa-Forschende nahmen die Ökobilanzen der verschiedenen Systeme unter die Lupe. Resultat: Auf den Inhalt kommt es an. Die Wahl des Kaffees beeinflusst die Ökobilanz viel stärker als die Wahl zwischen Kapsel, Vollautomat und Filterkaffee.

Kapselsysteme für Kaffee sind praktisch und deshalb sehr beliebt. Punkto Umweltfreundlichkeit bestehen jedoch grosse Fragezeichen. Der Empa-Ökobilanz-Experte Roland Hischier hat vor kurzem verschiedene Kapselsysteme sowie Vollautomaten, Filter- und löslichen Kaffee untersucht und eine vereinfachte Ökobilanz erstellt. Dabei zeigt sich, dass der Inhalt entscheidend ist. «Eine bewusste Kaffeewahl ist auf jeden Fall das Beste für die Umwelt», so Hischier. Wer umweltfreundlichen Kaffeegenuss will, solle auf Kaffees mit Nachhaltigkeitslabel setzen.

Life Cycle Assessment (LCA)

Data availability for such studies …

etc. etc. etc.

- A life cycle inventory (LCI) database comprises **Standard-Data** of often used processes & materials;
- **facilitates** to the user to **establish** an LCA study.

Life Cycle Assessment (LCA)

Step 2 – Inventory Analysis

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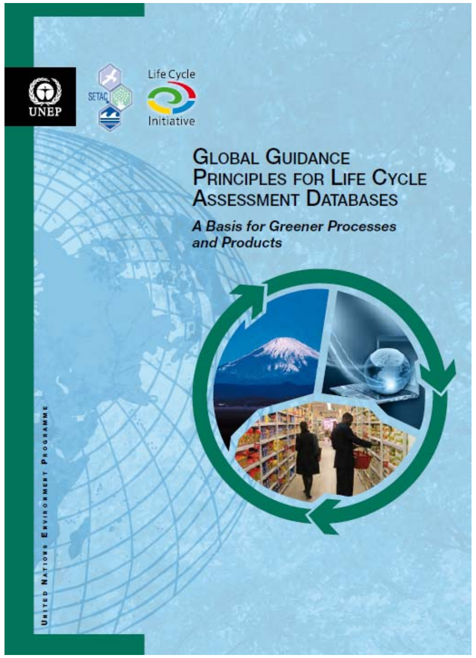

UNEP report (2011)
Global Guidance Principles for Life Cycle Assessment Databases: A Basis for Greener Processes and Products

- *[UNEP report]* Providing **high-quality, unit process level datasets** begins with targeted data s… data collection … the end re… mind, which will result in datasets **that are consistent, complete, and exchangeable**.

Datasets for 1 kg of metal !

- In order that the **same dataset** can be used **in various environments** (databases), **gate-to-gate datasets** need to be provided; allowing only **a consistent & reliable use** in such an environment.

Reliable & comprehensive life cycle inventories of all **materials** have to be established & made publically available!

UNEP Resource Panel
Introduction

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- The International Resource Panel was **set up in 2007** to develop **holistic approaches** to the **management of global resources**.
- Co-chaired by **Ernst U. von Weizäcker** & **Ashok Khosla** (president International Union for Conservation of Nature, IUCN).
  - **Working groups**: biofuels, **global metal flows**, **environmental impacts**, decoupling, priorisation
  - So far **published reports**:
    - Assessing biofuels: towards sustainable production and use of resources (2009)
    - **Metal stocks in society (2010)**
    - Priority products and materials: assessing the environmental impacts of consumption and production (2010)
    - Decoupling natural resource use and environmental impacts from economic growth (2011)
    - **Recycling Rates of Metals (2011)**
  - More at http://www.unep.org/resourcepanel/

International Resource Panel

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Working group on global metal flows

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- Background:
  - Global metals flows are in centre of **3R** (Reduce, Reuse, Recycle) **Initiative** launched in 2005.
  - The Kobe 3R Action Plan (who was adopted in 2008) calls for **collaboration to achieve sustainable resource circulation** on a **global** scale, placing high priority on the promotion of environmentally sound management of re-usable and recyclable resources. Major world economies should support & collaborate with developing countries in aim of **establishing international sound material-cycle society**.
- Mission & Objectives
  - Group aims at contributing to **promotion of reuse & recycling activities** of metals & **establishment of international sound material-cycle society** by providing scientific & authoritative assessment studies on global flows of metals.
    - Assessment of the **quantity of metal stocks**
    - Assessment of the **current** metals **reuse and recycling activities**
    - Describe current global metals flows and provide the **scientific evidence** that **recycling metals is better than mining** them

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Working group on global metal flows

= the metals challenge =

- **Metals are essential for economic development**
  - Base metals like steel and aluminum, mainly for buildings and infrastructure
  - Precious and specialty metals, like palladium and indium for modern/clean technologies
- **Global demand for metals is increasing**
  - E.g. copper and aluminum have doubled in the past 2 decades
  - Rising demand in emerging economies and developing countries
  - Very strong demand growth for many precious and specialty ('technology') metals
- **The increasing global demand for metals causes many problems and challenges**
  - Increasing environmental pressures from extraction and manufacturing of raw materials
  - Growing dependence on regional or economic concentrations of natural resources
  - Increasing risks of international crisis (e.g. war lord activities in parts of Africa)
  - Social tensions among local populations (land owner issues etc.)

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= metal stocks in society =

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- **The metals stocks in society are increasing worldwide**
  - In-use stock of copper has grown in the US from 73 to 238 kg per capita (1932-1999)
  - The world average is 50 kg copper per capita (2000)
  - In-use stock of steel in China is 1.5 tons (2004) per capita, but in the USA it is 11-12 tons per capita (2004)
  - If the whole world would copy the industrialized countries the global in-use metal stocks would be 3 to 9 times present levels
  - For many technology metals, like indium and rhodium, more than 80% extracted from natural resources was in the past 3 decades

- **There is a substantial shift in metals stocks from below ground to above ground**
- **These “mines above ground” have growing potential for future metals supply**

E.g. average lifetime of copper in buildings is 25 to 40 years, but for metals in cell phones and PCs it (much) less than 5 years

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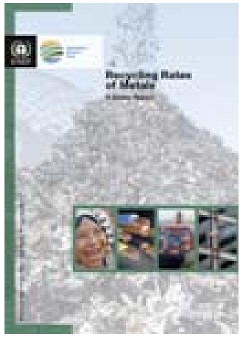
Working group on global metal flows

= Recycling of Metals =

- **Enhanced recycling of metals from in-use stocks is a key solution for SD**
- **The production of metals from secondary raw materials reduces environmental impacts compared to primary metals production**
  - High energy savings and reductions of greenhouse gas emissions
  - Secondary steel causes 75% less GHG emissions compared to primary steel
  - GHG emissions of secondary aluminum production are about 12 times lower than of primary aluminum production
  - Recycling reduces the pressure on biodiversity, water resources etc.



- **Recycling of metals moderates dependencies on natural resources, which are often concentrated in insecure regions**
- **Recycling ensures sustainable access to potentially scarce metals**
- **Recycling creates new jobs and income all over the world**

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Report on Environmental Impacts of Metals

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- **Main research question**: What are the environmental impacts of (global) use of metals over the whole life cycle?
- Literature with regard to the environmental impacts of metals and their use is brought together, & conclusions are drawn with regard to impacts themselves, their causes, and possible options to reduce them. All conclusions are **based on existing literature**; **no new research** is conducted for this report.
- **Structure** of report:
  1. Introduction
  2. Metals in the Environment
  3. Metals in Society: sources of metal emissions
  4. Metals production and energy use
  5. Other potential implications related to metals
  6. Potential life cycle impacts of metals
  7. Conclusions and recommendations
- Report is concentrating on those metals (i) where **data are available**, (ii) are of **societal relevance** and (iii) are of **environmental relevance** –

  i.e. on Fe, Cu, Zn, Al, Ni, Cr, Pb, Sn, Hg, Cd, As, Au, Pt, Pd, Rh, Co, Mo

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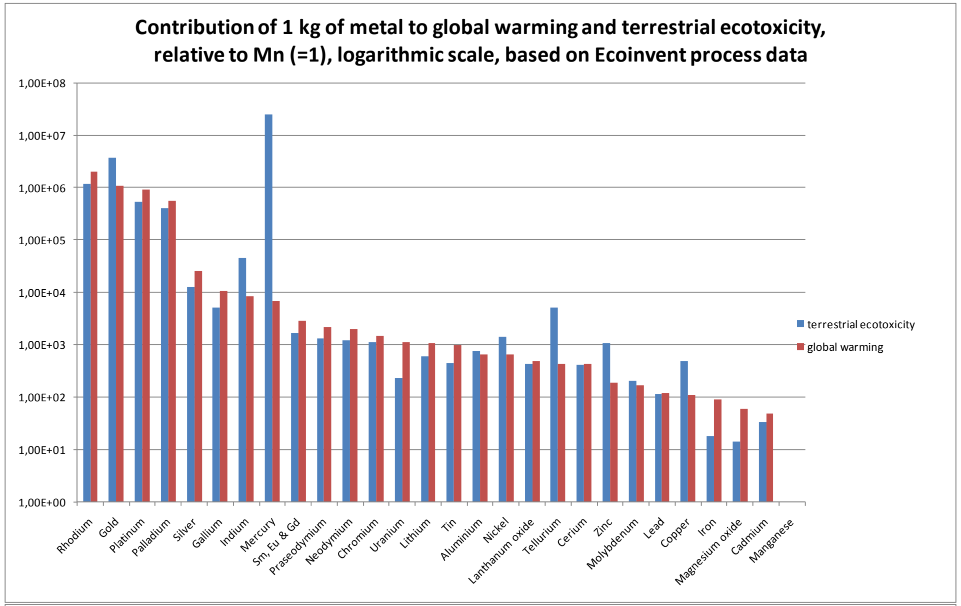
Report on Environmental Impacts of Metals

(exemplary excerpt of content)

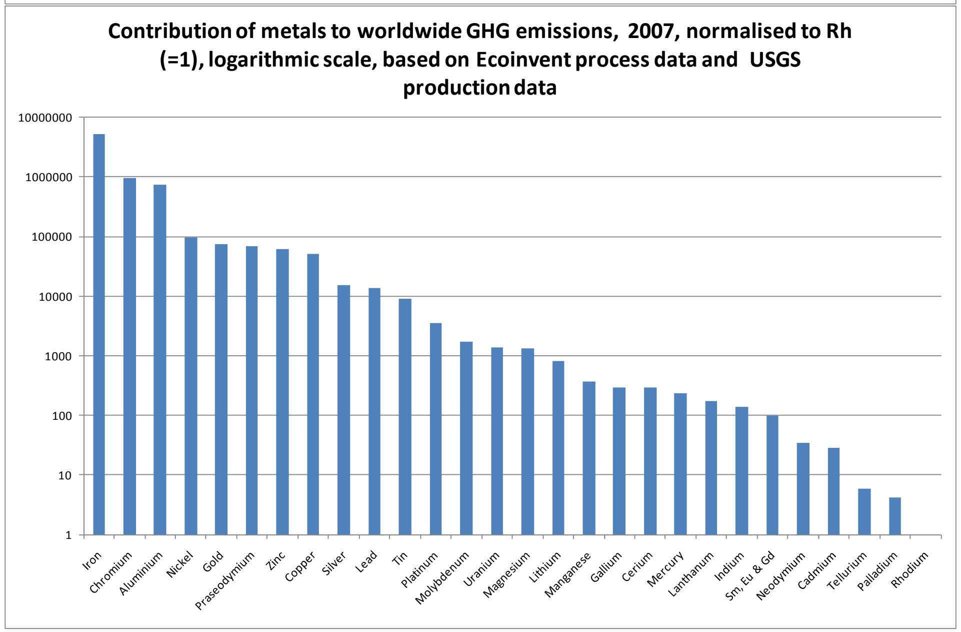


Contribution of 1 kg of metal to global warming and terrestrial ecotoxicity, relative to Mn (=1), logarithmic scale, based on Ecoinvent process data

GWP / kg metal

1. **Rhodium**
2. **Gold**
3. **Platinum**

12. Chromium
16. Aluminium
17. Nickel
24. Copper
25. Iron



Contribution of metals to worldwide GHG emissions, 2007, normalised to Rh (=1), logarithmic scale, based on Ecoinvent process data and USGS production data

GWP / annual production

1. **Iron**
2. **Chromium**
3. **Aluminium**
4. Nickel
5. Gold

8. Copper
12. Platinum
28. Rhodium

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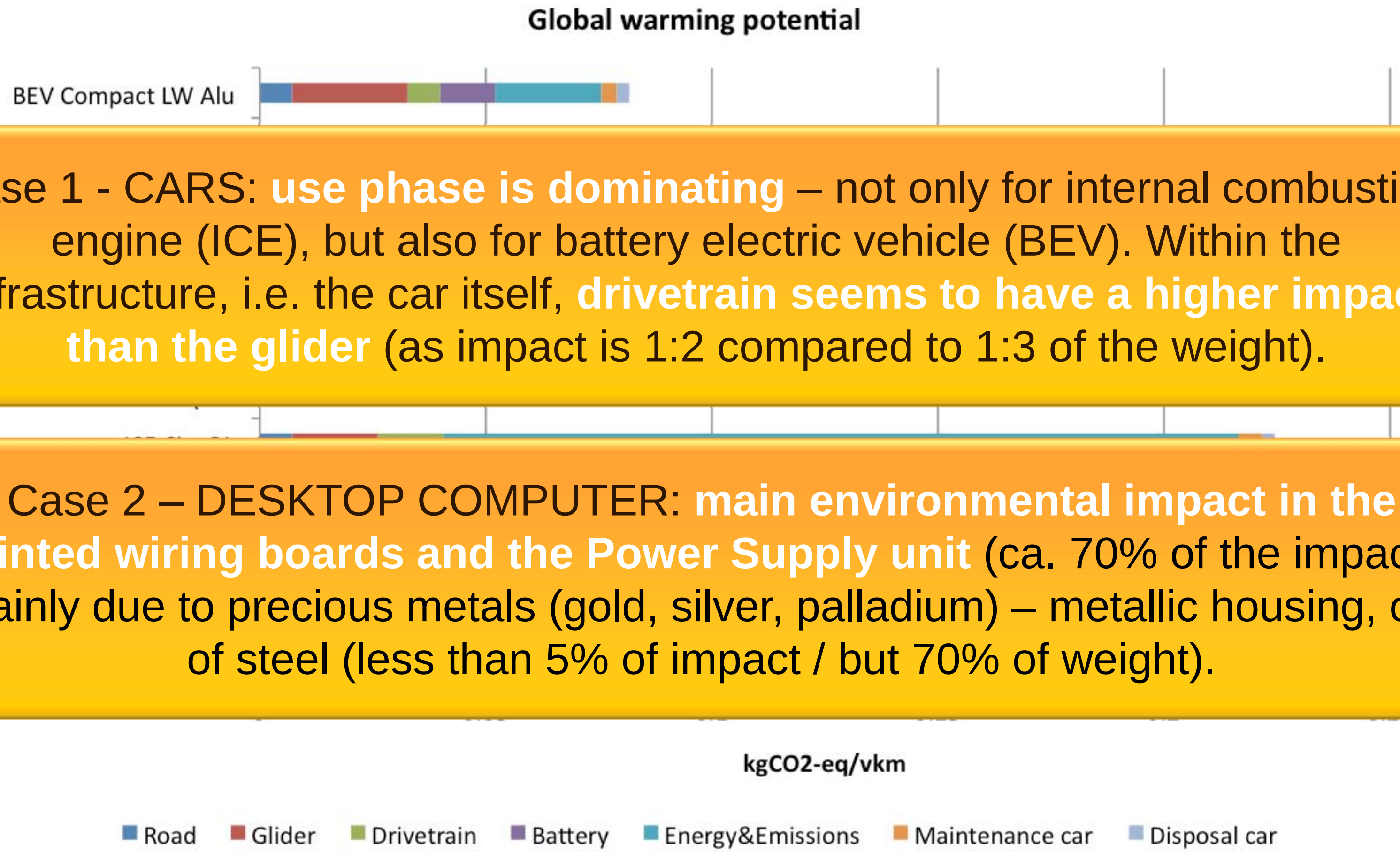
Report on Environmental Impacts of Metals

(exemplary excerpt of content)



Case 1 - CARS: **use phase is dominating** – not only for internal combustion engine (ICE), but also for battery electric vehicle (BEV). Within the infrastructure, i.e. the car itself, **drivetrain seems to have a higher impact than the glider** (as impact is 1:2 compared to 1:3 of the weight).

Case 2 – DESKTOP COMPUTER: **main environmental impact in the printed wiring boards and the Power Supply unit** (ca. 70% of the impact), mainly due to precious metals (gold, silver, palladium) – metallic housing, out of steel (less than 5% of impact / but 70% of weight).

Next steps: (i) discussing in IRP / (ii) **peer review** organized by IRP / (iii) compile final report based on review comments

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Coverage in ecoinvent data v2.2

Metal	LCIA results				
	ARD	CER	GWP	AP	ETP
Iron (Fe)	0.26 - 3.6	3.5 - 76.6	0.39 - 4.53	0.002 - 0.024	0.1 - 28.2
Copper (Cu)	0.02 - 4.32	0.89 - 111	0.1 - 5.24	0.0002- 2.16	0.073 - 204
Zinc (Zn)	0.8 - 2.8	5.4 - 56.1	0.42 - 3.4	0.006 - 0.05	0.62 - 40.3
Aluminium (Al)	0.01 - 6.11	0.38 - 194	0.02 - 12.4	0.0001- 0.056	0.02 - 22.5
Nickel (Ni)	0.35 - 5.4	14.6 - 187	1.7 - 10.9	0.004 - 7.22	1.2 - 38.6
Lead (Pb)	0.005 - 1.96	0.25 - 25	0.035 - 2.12	0.0005- 0.054	0.025 - 4.1
Molybdenum (Mo)	1.3 - 6.4	24 - 151	1.2 - 7.7	0.024 - 0.16	18.2 - 243
Chromium (Cr)	14	577	27	0.1	345
Tin (Sn)	11	320	17	0.5	17
Mercury (Hg)	5	180	12	0.09	196
Cadmium (Cd)	26 - 29	17 - 68	0.8 - 3.9	0.005 - 0.03	0.6 - 2.2
Gold (Au)	18 - 28900	745 - 614000	852 - 44700	1.9 - 745	596 - 421000
Platin Group Metals (Pt, Pd, Rh)	95 - 20100	3900 - 685000	446 - 34700	1 - 33400	312 - 81600
Cobalt (Co)	5	130	8.3	0.08	4

ARD: Abiotic Resource Depletion (expressed in kg resources)

CER: Cumulative Energy Demand (expressed in MJ-Equivalents)

GWP: Global Warming Potential (expressed in kg CO_2-Equivalents)

AP: Acidification Potential (expressed in kg SO_2-Equivalents)

ETP: Ecotoxicity Potential (expressed in CTU_e)

Only Arsenic (As) is missing in ecoinvent data v2.2 !

ecoinvent today

current coverage in area of metals (excerpt)

Metal	Data characterisation / description		
	System boundaries	covered technology	data source(s)
Iron (Fe)	Cradle-to-gate, i.e. from the iron ore extraction resp. the collection of iron scrap to the produced primary, secondary steel.	Primary & secondary production; using blast furnace, basic oxygen furnace	Main sources: Roth et al. (1999) and IPPC (2000)
Copper (Cu)	Cradle-to-gate, i.e. from the ore extraction resp. the collection of copper scrap to the produced primary, secondary copper.		The production is modelled for global situation, based on data from various sources.
Zinc (Zn)	Cradle-to-gate, i.e. from the ore extraction (lead-zinc ore) to the produced primary zinc (secondary zinc is not taken into account).	Primary production – mix of 20% pyro- and 80% hyrometallurgical processes – of high-grade (SHG) primary zinc.	Values taken from Ayres et al. (2002), Xiao et al. (2003), IPPC (2001) and EEA (1999b)
Aluminium (Al)	Cradle-to-gate, i.e. from the bauxite extraction resp. the collection of aluminium scrap to the produced primary, secondary aluminium	Primary & secondary production; using Bayer process for Al(OH)3, Hall-Héroult cells with prebaked C-anodes or Söderberg-anodes for primary aluminium production; aluminium melting furnace for secondary production.	Production is modelled for the European situation, primarily based on data from EAA (2000) and personal communications. The mining represents a world-wide situation, based on Mori & Adelhardt (1998).
Nickel (Ni)	Cradle-to-gate, i.e. from the ore extraction (part of nickel-copper ore) to the produced primary nickel (secondary nickel is not taken into account).	Primary production – mix of pyro- and hyrometallurgical processes – of class I primary nickel.	Data mainly based on Hilbrans & Hinrichs (1999), plus description taken from Kerfoot (1997).
Lead (Pb)	Cradle-to-gate, i.e. from the ore extraction (lead-zinc ore) resp. the collection of lead scrap to the produced primary, secondary lead.	Primary & secondary production; using the sinter/blast furnace (ISP) and direct smelting process for primary production, remelting of lead acid batteries for secondary production.	Values taken from Ayres et al. (2002), Xiao et al. (2003), IPPC (2001) and EEA (1999a)
Molybdenum (Mo)	Cradle-to-gate, i.e. from the ore extraction (copper-molybdenite ore) to the produced primary	Primary production – mix of 20% pyro- and 80% hyrometallurgical processes (using the respective	The production is modelled for global situation, based on data from various

ecoinvent data v2.2 is **not using** – with one exception (aluminium) – the **information published by the respective industry association** … due to the fact that only aggregated data are published from the latter one!

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- **Broader** data supply base
  - With new tools allowing contributions from LCA experts;
  - A limitation of a dataset on technology description;
- **More content** / more **completeness**
  - on the level of the entire database;
  - on the level of each individual dataset;
- **More Transparency** by a more close documentation
- **More Consistency**
  - (automatic) linking via Market models;
  - Database wide system models are applied

ecoinvent tomorrow
Objective

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More active participation of LCA community

- Broader supply base; easier for 3rd parties to contribute with new data or corrections to existing data
- All contributions will still be subject to our strict quality control, review & validation procedures before entering into the database
- Review by the International editorial board
  - Activity editors, for each industry activity and for household activities
  - Cross-cutting editors, to ensure consistency & monitor developments across the entire database (for specific (groups of) emissions, for geographical areas, scenarios, ec.)

- … in order to provide **most up-to-date, relevant, reliable, transparent & accessible LCI data** for users all over the world.

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Swiss Centre for Life Cycle Inventories

ecoinvent tomorrow
«Tools»

Tool for data suppliers and editors to **create, edit, review** & to **upload datasets** for ecoinvent database version 3

EcoEditor

Quality Guidelines

Aims to ensure a **coherent data acquisition** & **reporting** across the various activity areas & data providers involved.

International Editorial Board

EcoSpold v2 format

… to **take advantage of all the new developments**, a revision of the ecoSpold format has become necessary.

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Data Supply & Calculation

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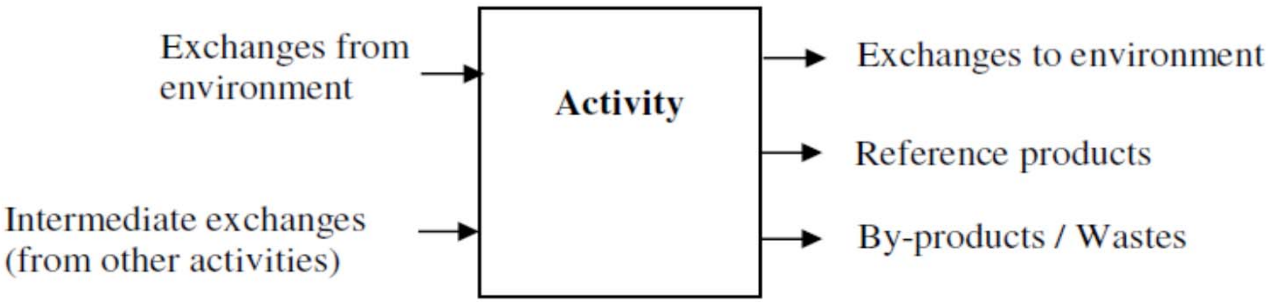
- ecoinvent stores the unit process datasets as **unlinked, multi-product datasets**, i.e. with inputs specified solely in terms of product names, without requiring specification of the supplying activities, and typically with more than one product output.



→ For the purpose of calculating the accumulated system datasets, the **database creates linked, single-product datasets** from the unlinked, multi-product datasets, with the **help of database-wide modelling rules**.

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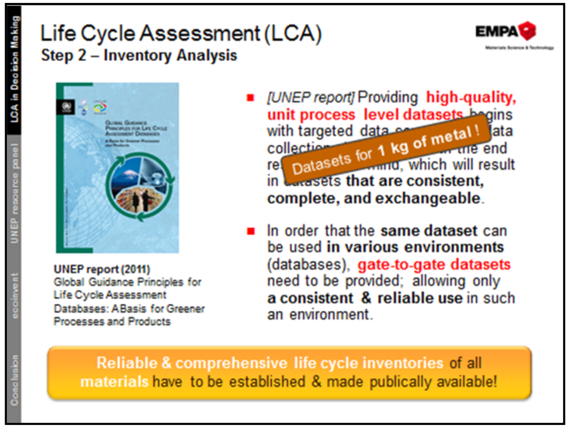
Data Supply



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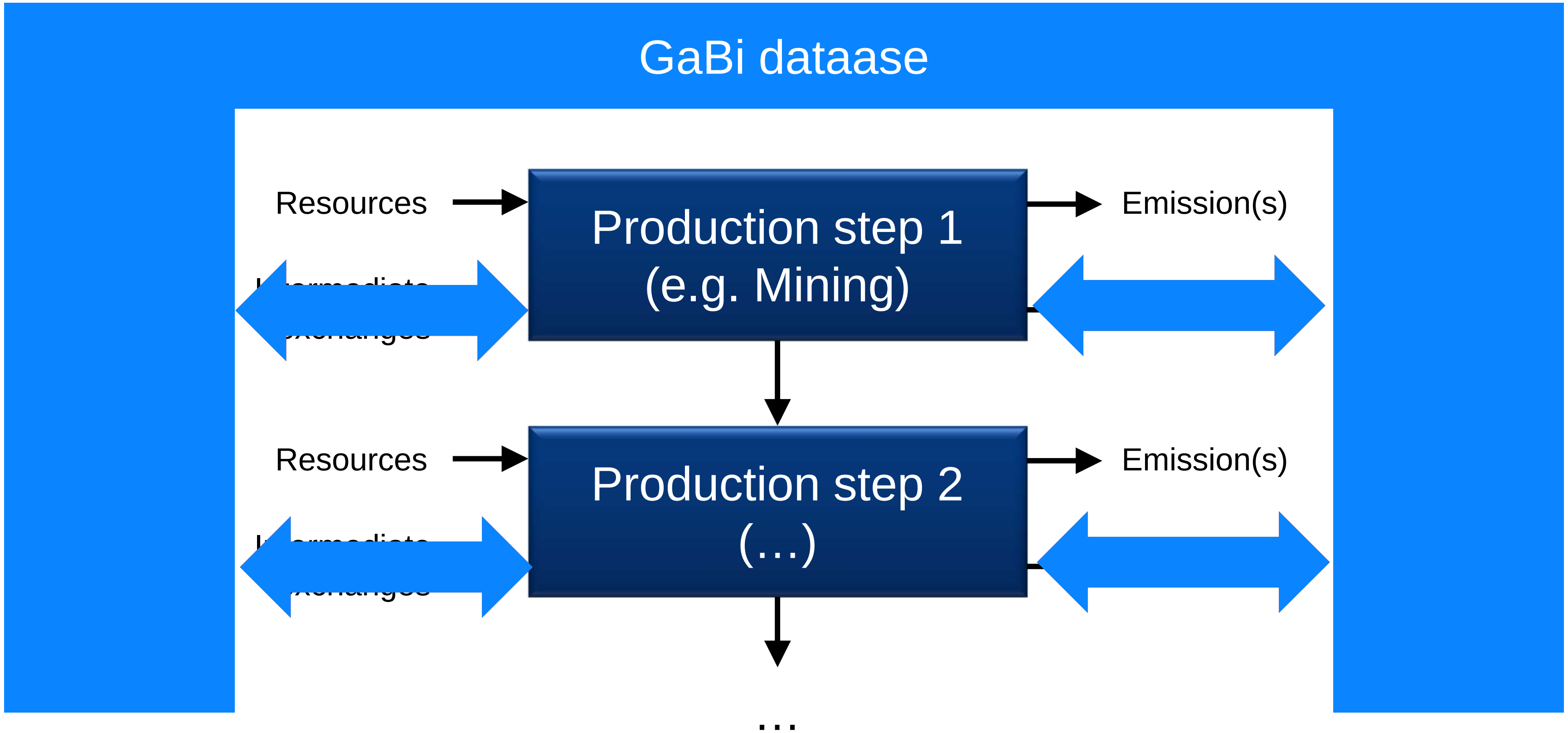

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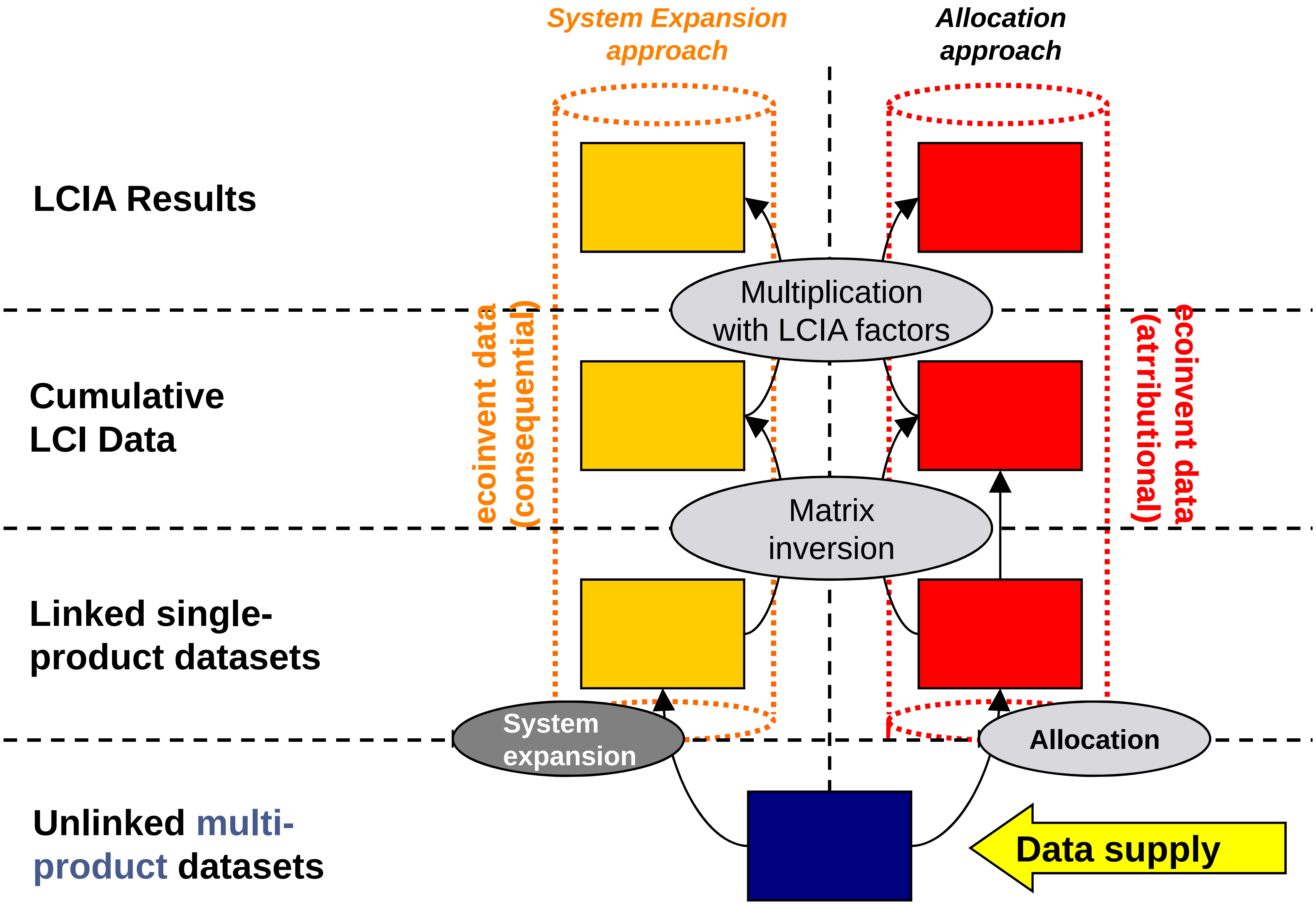
various system models – one single dataset



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Conclusion

- Crucial that LCA study **takes into account all functionalities** and **covers them adequately** by choosing an **appropriate functional unit** & respective system boundaries.

- **Reliable & comprehensive life cycle inventories** of various **metals** have to be established & made publically available!
- In order that **same data** can be used **in various environments** (databases), **gate-to-gate datasets** need to be provided; allowing **a consistent & reliable use** in the various environments.

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