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BASE IMPACTS® DATA DOCUMENTATION

CATEGORY: METALS

3 levels of documentation are available for the datasets in Base Impacts®:

- A **general documentation** explaining general information on the datasets and data general requirements
- A **sectorial documentation:** one document per sector describing the available datasets and their characteristics (technological representativeness, geographical representativeness), and providing the information on the datasets in a common layout. Information comes from the consultation specifications, the dataset commissioner technical proposal and the metadata
- The **datasets metadata** can be viewed directly in the datasets sheets. They include more detailed information (flow diagrams, Etc.)

This document is the category documentation for metals.

CONTENTS

A. PRESENTATION OF THE DATASETS

1. List of available datasets

The following datasets are available:

Technological representativity		Geographical representa-tivity	Dataset type
STEEL - Intermediate products			
Steel, coil, cold rolled	for EEE (50% recycling)	Europe	LCI results
	for clothing (0% recycling)	Europe	LCI results
	for furniture (100% recycling)	Europe	LCI results
Steel, coil, hot rolled	for furniture (100% recycling)	Europe	LCI results
Steel, coil, finished cold rolled	for EEE (50% recycling)	Europe	LCI results
	for clothing (0% recycling)	Europe	LCI results
	for furniture (100% recycling)	Europe	LCI results
Steel, coil, hot dip galvanized	for EEE (50% recycling)	Europe	LCI results
	for clothing (0% recycling)	Europe	LCI results
	for furniture (100% recycling)	Europe	LCI results
Steel, coil, tinplated	for industrial and commercial packaging (39,3% recycling)	Europe	LCI results
	for household packaging (66,7% recycling)	Europe	LCI results
	for any packaging (54% recycling)	Europe	LCI results
Steel, coil, electrolytic chrome-coated (ECCS) (= tin-free)	for EEE (50% recycling)	Europe	LCI results
	for furniture (100% recycling)	Europe	LCI results
Steel, coil, organic coated	for EEE (50% recycling)	Europe	LCI results
	for furniture (100% recycling)	Europe	LCI results

Technological representativity		Geographical representa-tivity	Dataset type
Stainless steel, coil, cold rolled (304)	for EEE (50% recycling)	Europe	LCI results
	for clothing (0% recycling)	Europe	LCI results
	for furniture (100% recycling)	Europe	LCI results
Steel, wire rod	for EEE (50% recycling)	World	LCI results
STEEL - Processes			
Steel part, turning	10% losses	World	Partly terminated dataset
	5% losses	World	Partly terminated dataset
Steel sheet, scouring (= deburring)		World	Partly terminated dataset
Steel sheet, galvanisation		World	Partly terminated dataset
OTHER METALS - Intermediate products			
Copper mix (99,999% from electrolysis)		World	LCI results
Brass (CuZn20)		Europe	Partly terminated dataset
Lead		Europe	Partly terminated dataset
Monel (nickel alloy)		Europe	LCI results
Titanium		World	LCI results
Zamak zinc alloy (ZnAlMgCu)		Europe	LCI results
Aluminium extrusion profile		Europe	LCI results
Aluminium sheet		Europe	LCI results
OTHER METALS - Processes			
Metal sheet stamping (20% loss)		World	Partly terminated dataset
Cold rolling (high impact metal)		Europe	Partly terminated dataset
Cold rolling (low impact metal)		Europe	Partly terminated dataset
Metal drilling (high impact metal)		World	Partly terminated dataset
Metal drilling (low impact metal)		World	Partly terminated dataset
Turning (high impact metal)		World	Partly terminated dataset

Technological representativity	Geographical representa-tivity	Dataset type
Turning (low impact metal)	World	Unit process
Casting (high impact metal)	World	Partly terminated dataset
Casting (low impact metal)	World	Partly terminated dataset
Hot rolling (high impact metal)	Europe	Partly terminated dataset
Hot rolling (low impact metal)	Europe	Partly terminated dataset
Electroplating (estimation)	Europe	Partly terminated dataset

Table 1 : Available datasets

2. Structure of available datasets

The following diagram is used to present the structure of the datasets:

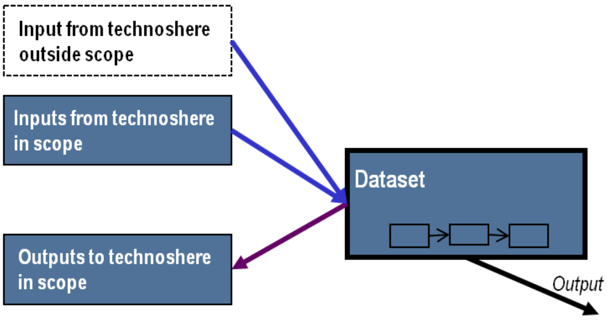

Figure 1 : Structure of the datasets

Some datasets are **"partly terminated systems" datasets, which means they cannot be used alone to model a given product, but must be aggregated with other datasets.**

When aggregating a partly terminated system with a process data (e.g. "Steel hot dip galvanized" with "Steel part turning"), the waste rate of the process must be taken into account. The average waste rates, given in the metadata, are the following:

Process		Waste rate
Steel part, turning	10% losses	10%
	5% losses	5%
Steel sheet, scouring = deburring		0%
Steel sheet, galvanisation		0%
Stamping		20%
Cold rolling (high impact metal)		0%
Cold rolling (low impact metal)		6,6%
Metal drilling (high impact metal)		47%
Metal drilling (low impact metal)		3%
Turning (high impact metal)		18%
Turning (low impact metal)		1%
Casting (high impact metal)		47%
Casting (low impact metal)		37%
Hot rolling (high impact metal)		2%
Hot rolling (low impact metal)		11%
Electroplating (estimation)		0%

Table 2: Waste rates of the process dataset available in the database

The "partly terminated systems" datasets include the following elements:

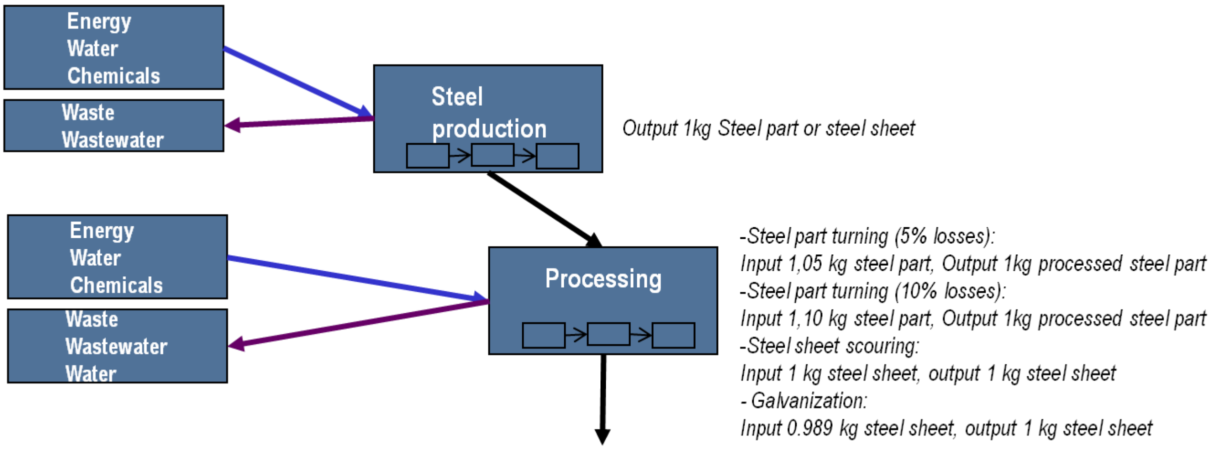

Figure 2 : Structure of the datasets – "partly terminated systems"

For instance, if the modeler needs to model a 1 kg steel part made by a turning process with 5% losses from a steel wire rod, the following elements must be modeled by taking into account the yield of the processes:

- 1 kg "steel part turning (5% losses)"
- 1 x 1,05 kg "steel wire rod"

In a similar way, if the modeler needs to model a 1 kg steel sheet made by galvanisation of a finished cold rolled steel sheet, the following elements must be modeled by taking into account the yield of the processes:

- 1 kg "galvanization steel sheet"
- 1 x 0,989 kg "finished cold rolled steel"

For some partly terminated dataset, the electricity consumption of the process must also be aggregated (i.e. added) with country specific electricity dataset.

Process	Electricity (MJ/kg)
Stamping	0,5
Cold rolling (high impact metal)	0,46
Cold rolling (low impact metal)	0,72
Metal drilling (high impact metal)	2,5
Metal drilling (low impact metal)	0,77
Turning (high impact metal)	150[1]
Turning (low impact metal)	1,3
Casting (high impact metal)	8,8
Casting (low impact metal)	0,77

[1] WARNING : Error in the metadata, it is written 130 MJ/kg.

Process	Electricity (MJ/kg)
Hot rolling (high impact metal)	0,23
Hot rolling (low impact metal)	0,67
Electroplating (estimation)	0,58

For instance, if the modeler needs to model a 1 kg steel part made by a stamping process in France from a steel wire rod, the following elements must be modeled by taking into account the energy of the process and the yield of the process:

- 1 kg “Stamping (20% losses)”
- 0,5 MJ Electricity grid mix, FR
- 1 x 1,20 kg “steel wire rod”

3. Technical specifications

3.1. End-of-life recycling rates

The recycling rate varies depending on the final product.

Worldsteel and Eurofer datasets are calculated with average European recycling rates. Therefore the datasets needed to be adapted to integrate the different values of R_2 for each sector.

The following ends of life recycling rates were used:

- EEE: 50%
- industrial and commercial packaging: 39%
- household packaging: 67%
- any packaging: 54%
- clothing: 0%
- furniture : 100%

Dataset including a recycling rate has been built on the basis of two processes coming from Worldsteel data:

- **P0 : “Value of scrap RER”** (UUID of the dataset: 788ca72b-70b5-41ed-bee2-eca7acc9f5e8)
  And
- **P1 : “organic coated steel, RER “**(UUID: 46640b9e-78cf-4057-ab0e-ea38509a23eb)

As the P1 dataset does not represent a 100 % virgin steel but includes **5.2% recycled content** and is based on a mix of the technology BOF (blast oxygen furnace) and EAF (electric arc furnace), representative of the market, the aggregation consisted to adapt it in order to match with the BPX 30-323 formula so that the recycling rate in France is taken into account (e.g. 54% for packaging application).

For instance, for the packaging application, the formula calculation is: P1+0.052*P0-0.54*P0

B. SCOPE OF THE DATASETS

1. Reference flow, functional unit

The processes are provided for 1 kg of output.

2. System boundaries

2.1. Steel foreground system boundaries

Scope

This data set includes steel production, from cradle to steel factory gate.

Inputs included in the Life Cycle Inventory relate to all raw material inputs, including steel scrap, energy, water, and transport. Outputs include steel and other co-products, emissions to air, water and land.

Further information is given in the Worldsteel LCA Methodology Report.

Details on the processing, the steel product manufacturing route, can be found in Appendices 2 and 3 of the Worldsteel LCA Methodology Report from 2011.

Cut-off for each unit process:

- **Steel products (Worldsteel datasets):**

Criteria are set out in the methodology report for the recording of material flows and to avoid the need to pursue trivial inputs/outputs in the system. These are outlined below:

  - All energetic inputs to the process stages are recorded, including heating fuels, electricity, steam and compressed air.
  - The sum of the excluded material flows must not exceed 5% on the basis of mass or energy or be environmentally relevant. However, in reality at least 99.9% of material inputs to each process stage are included.
  - Waste representing less than one percent of total waste tonnage for given process stages are not recorded unless treated outside of the site.
  - Site input tonnages are weighed by relatively few inputs such as iron ore, pellets, limestone, scrap, dolomite, olivine, serpentine, metallic additions, refractories, coke, sinter, hot metal, and intermediate steel products which account for >99% of material inputs to each process stage.
  - The datasets cover at least 95% of mass and energy of the input and output flows, and 98% of the environmental relevance (according to expert judgment).

- **Stainless steel (Eurofer datasets):**

The following cut-off criteria are applied:

  - Mass: If a flow is less than 1% of the cumulative mass of all the inputs and outputs of the stainless steel system, it may be excluded, providing its environmental relevance or energy relevance is not a concern.
  - Energy: If a flow is less than 1% of the cumulative energy of all the inputs and outputs of the stainless steel system, it may be excluded, providing its environmental relevance or mass relevance is not a concern.
  - Environmental relevance: If a flow meets the above criteria for exclusion, yet is thought to have a potentially significant environmental impact, it will be

included. As a general rule, all measured environmental releases should be included.
The sum of the excluded material flows (upstream flows) must not exceed 5% of mass, energy or environmental relevance.

- **Processes:** The datasets cover at least 95% of mass and energy of the input and output flows, and 98% of the environmental relevance (according to expert judgment).

2.1.1. Steel products

Datasets are provided for different types of steel products. The applications of each steel product are presented in the table below:

Application	1 = preferable 2 = possible	Plate	Pipe	Hot Rolled Coil	Pickled Hot Rolled Coil	Cold Rolled Coil	Finished Cold Rolled Coil	Electro-Galvanized	Hot-Dip Galvanized	Organic Coated	Tin Plate	Electrolytic Chromed Coated Steel	Section Rolling	Rebar	Engineering Steel	Wire Rod
Frame-Work	Profiles			1	1	2		2	1				1			
	Framing								1							
Automotives	Body in white				2		1	1	1	2						
	Structural parts				1		1	1	1	2						
	Engine														1	
	drives equipements														1	
	transmissions														1	
	wheels				1											
	tyres															1
Construction	Structural parts	1	1	1					2	1			1			
	walls elements							1	1	1						
	Basement												1	1		
	Concreete reinforcement													1		
	Cladding			2				1	1	1						
	Roofing								1	1						
	Farm building walls								2	1						
	Gutter system (ducts)								1	1						
	Chimney ducts			2												
	construstion components			2	2			1	1	1						
	Farm building components								2	1						
	Doors and garages								2	1						
	Fences								2							
	Stairs			1					2							
	Tiles								2	1						
	Ceilings components							1	1	1						
	Floor components			1				2	1							
	Inside decoration panels									1						
	partition walls							2	1	1						
	inside panels food industry									1						
	security rails on roads								1							
Home appliances	furnnitures						2	1		1						
	white goods						1	1	1	1						
	heating, ventilation and air conditioni						1	1	1	1						
Packaging	Steel Food & General Line Cans									1	1	1				
	Pails											1				
	Beverage cans									1	1	1				
	Drums						1	1								
Machinery	Rail												1			
	Machines	2					1								1	
	Pipes		1													
Others	tubes			1	2		1									
	pools								2	2						
	water tanks								1							
	greenhouses								2	2						
	signs								2							
	tools														1	
	dies														1	
	wires													1		1

Figure 3: Application of the steel products by sector (source: Worldsteel)

The description of the steel products is presented in the following paragraphs (source: Worldsteel).

2.1.1.1. Cold rolled coil

Cold Rolled Coil is used as primary material for finished cold rolled coils and coated coils.

The production process is the following:

- Hot rolled coil is obtained with steel coil rolled on a hot-strip mill; can be further processed (typical thickness between 2 - 7 mm) ;
- Steel Pickled Hot Rolled Coil is hot rolled steel from which the iron oxides present at the surface have been removed in a pickling process;
- Cold Rolled Coil is obtained by a further thickness reduction of a pickled hot rolled coil. This step is achieved at low temperature in a cold-reduction mill. Typical thickness between 0.15 - 3 mm. Typical width between 600 - 2100 mm.

2.1.1.2. Hot rolled coil

Obtained by rolling Steel coil on a hot-strip mill.

Typical thickness between 2 - 7 mm. typical width between 600 - 2100 mm.

It can be found on the market in coil or in sheets and is further processed into finished products by the manufacturers. The various types of hot rolled steel have applications in virtually all sectors of industry: transport, construction, shipbuilding, gas containers, pressure vessels, energy pipelines, etc. Hot rolled steel sheet with an anti-slip surface and a diamond or teardrop pattern are typically used for stairs, industrial floors and tailboards for goods vehicles.

2.1.1.3. Finished Cold Rolled Coil

Finished Cold Rolled Coil is obtained by heat treatment (annealing) and strain-hardening of cold rolled steel in a way to achieve final mechanical properties making the steel suitable for further uses (forming and bending).

Classified into the following:

- formable steels,
- high strength formable steels,
- weathering structural steels,
- structural steels,
- hardenable steels.

Typical thickness between 0.3 - 3 mm. Typical width between 600 - 2100 mm.

They have excellent forming properties, electromagnetic properties, paintability, weldability, and are suitable for fabrication by forming, pressing and bending.

Applications include domestic applications, automotive applications, lighting fixtures, electrical components (stators, rotors) and various kinds of sections roofing applications, profiled sheets, wall elements, etc.

2.1.1.4. Hot-Dip Galvanized Steel

Obtained by passing cold rolled coil through a molten zinc bath, in order to coat the steel with a thin layer of zinc to provide corrosion resistance.

Typical thickness between 0.3 - 3 mm. Typical width between 600 - 2100 mm.

They have excellent forming properties, paintability, weldability, and are suitable for fabrication by forming, pressing and bending.

Applications include domestic applications, building applications (e.g. wall elements, roofing applications), automotive applications (e.g. body in white for vehicles underbody auto parts), lighting fixtures, drums and various kinds of sections applications, profiled sheets, etc.

2.1.1.5. Tinplated steel

Tin-plated steel is obtained by electro plating a thin finished cold rolled coil with a thin layer of tin. It can be found on the market in coil or in sheets and is further processed into finished products by the manufacturers.

Typical thickness between 0.13 - 0.49 mm. Typical width between 600 - 1100 mm.

Tin plated steel is used primarily in food cans, industrial packaging (e.g. small drums)

2.1.1.6. ECCS steel (= tin-plated)

ECCS steel stands for Electrolytic Chrome Coated Steel.

ECCS steel is obtained by electro plating a thin finished cold rolled coil with a thin layer of chrome. It can be found on the market in coil or in sheets and is further processed into finished products by the manufacturers.

Typical thickness between 0.13 - 0.49 mm. Typical width between 600 - 1100 mm.

ECCS is used primarily in food cans, industrial packaging (e.g. small drums).

2.1.1.7. Organic-coated steel

Organic-coated steel is obtained by coating a steel substrate with organic layers such as paint or laminated film. The substrate is mainly hot-dip galvanized coil but may also be electrogalvanized coil, finished cold rolled coil or tin-free steel. It can be found on the market in coil or in sheets and is further processed into finished products by the manufacturers.

Typical thickness between 0.15 - 1.5 mm. Typical width between 600 - 1300 mm

Used in all activity sectors e.g. construction (roof, wall and ceiling claddings, lighting, radiators etc), general industry (e.g. office furniture, heating, ventilating, air conditioning), domestic appliances (refrigerators, washing machines, small kitchen appliances, computer casings, VCR & DVD casings, etc) and packaging.

2.1.1.8. cold rolled Stainless steel

This dataset represents a 18/10 stainless steel with 18% chromium and 10% nickel.

Stainless steels are manufactured from mixtures of stainless scrap, carbon steel scrap and ferro-alloys of Cr, Ni and Mo. The proportions of these raw materials can vary greatly, depending upon the steel grade and other factors.

The production process is the same as cold-rolled steel, only the composition differs.

The stainless steel product may be used in a wide range of industrial sectors including automotive, construction, packaging, chemicals plant and equipment, food and drinks preparation and storage, kitchen appliances and utensils.

2.1.1.9. Wire rod

Wire rod is a rolled steel product, produced from a semi and having a round, rectangular or other cross-section. Particularly fine cross-sections may be achieved by subsequent cold forming (drawing). Wire rod is wound into coils and transported in this form.

2.1.1.10. Steel sections

A steel section rolled on a hot rolling mill. Steel Sections include I-beams, H-beams, wide-flange beams, and sheet piling. It can be found on the market for direct use. This product is used in construction, multi-story buildings, industrial buildings, bridge trusses, vertical highway supports, and riverbank reinforcement.

This dataset includes raw material extraction (e.g. coal, iron, ore, etc.) and processing, e.g. coke making, sinter, blast furnace, basic oxygen furnace, hot strip mill. Details on the steel product manufacturing route can be found in Appendices 2 and 3 of the 2011 worldsteel LCA Methodology Report. The steelmaking processes are shown in the flow diagram. Inputs included in the Life Cycle Inventory relate to all raw material inputs, including steel scrap, energy, water, and transport. Outputs include steel and other co-products, emissions to air, water and land. Further information is given in the 2011 worldsteel LCA Methodology Report.

2.1.2. Steel processes

2.1.2.1. Steel part turning

The process represents turning of shafts with different diameters over the length, with manual setup and operation of the lathe.

2 datasets are provided, with different loss rates (5% or 10% of removed material).

Infrastructure is not considered.

2.1.2.2. Steel part scouring

Removing of burrs, leftover edges and bumps created during the machining and extruding processes.

2.1.2.3. Steel sheet galvanisation

The process consists in immersion of a steel part in an electrolytic bath. The electrolytic action deposits a coating of pure zinc on the surface of the steel part.

2.2. Other metals foreground system boundaries

Scope:

The data set covers all relevant process steps / technologies over the supply chain of the represented cradle to gate inventory.

2.2.1. Other metals

2.2.1.1. Copper mix (99,999% from electrolysis)

Data cut-off and completeness principles:

Coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Technology description and included processes:

Three copper production routes were modelled for the global copper mix: electrolyte copper 99,99% world -mix. Outokumpu was modelled for Chile, ISA smelt for Australia and the Mitsubishi process for Indonesia.

The Australian route was modelled on data based from the largest Australian copper producing company. For verification the mines Alumbrera (Argentina) and Ernest Henry (Australia) were used.

The modelling of the Indonesian route is based on the largest copper producer.

The Chilean route is modelled with industrial data and verified with information available to the public.

The copper ore is mined (opencast and underground), milled and in most cases concentrated in a flotation process on-site. The concentrate is carried to a copper production site where it is roasted and melted. The most common and here represented smelting processes are the Outokumpu process, the ISA smelt and the Mitsubishi process.

Outokumpu flash furnace: Roasting and melting happens in a combined process called Outokumpu Flash Furnace. Concentrate feed mixture; flux and additional fuel are fed into a special sealed furnace. The heat of the exothermal reaction of parts of iron and sulphur melts the particles and a copper matte is created. For the modelling, industrial and literal data of an Outokumpu oven were used. The Outokumpu process was modelled for copper production in Chile.

Mitsubishi process: In a Mitsubishi process, 98% blister copper is produced, not 40-70% copper stone. A Mitsubishi plant consists of three interconnected furnaces: a bath smelting furnace, an electric slag cleaning furnace and a converting furnace. The slag of the converting furnace contains about 10-15% copper and is given as granulate into the smelting furnace. The Mitsubishi Process was modelled for Indonesia.

ISA smelt: The ISA smelt reactor is a vertical cylinder with an installed lance, which reaches into the melting slag. The mixture of concentrate and additives is brought into the reactor from the top and the concentrate reacts with the air and oxygen injected into the melt through the lance. The injection of the oxygen causes turbulences, which accelerate the reaction. The exhaust from the reactor flows through a lost heat-boiler in which steam for the process is produced. The chilled gases are directed through an electrostatic filter, which separates the dust before the gas flows to the sulphuric acid plant. The final product of the ISA smelt process is copper matte. The ISA smelt process was modelled for Australia. Afterwards the anodes are casted after a converter (anode oven). These anodes are used in an electrolysis to receive the electrolytic copper 99,99%.

Data sources:

Outokumpu Technology, 2004

Mitsubishi Materials, 2004

Stoffmengenflüsse und Energiebedarf bei der Gewinnung ausgewählter mineralischer Rohstoffe

Gresik Smelter - copper production in Indonesia, 2004

National Mining Association, 1999-2004

Non-ferrous metals market, 1992-2004

Mining in Chile, 1999-2004

Mining Pollution Inventory in Australia, 2002-2003

Mining in Chile, 2000-2004

Sustainability report WMC, 2002

World Mine Cost Data Exchange Inc., 2000-2004

Minerals Yearbook, 2001-2004

MIM Environment and Community Report, 2002

Reference Document on Best Available Techniques in the Non Ferrous Metal Industry, 2000

Life Cycle Assessment of Primary Copper Cathode

2.2.1.2. Brass (CuZn20)

Data cut-off and completeness principles:

Coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles

Technology description and included processes:

Brasses are alloys of copper and zinc and are medium and strength engineering materials. By varying the share of copper and zinc, the properties of the brass can be changed. The data set describes a copper (80%) -zinc (20%) alloy (CuZn20) melting and casting process. The melting process of copper and zinc is done in an electrical crucible furnace where the most power is used. The natural gas, which is a second energy resource, is used during the casting as process heat. The brass in Europe is produced mainly based on secondary material. The recycling system is well developed, so secondary brass is available to a large extent. Anyway, primary material of copper and zinc needs to be added (estimation: 90% secondary material, 10% primary material).

The brass technology is based on an estimate from copper recycling data; the copper data is primary industry data which represents European data.

Input of Brass Scrap 0,95 kg. Scrap is considered burden free.

Data sources:

World Mine Cost Data Exchange Inc., 2000-2004

Minerals Yearbook, 2001-2004

Reference Document on Best Available Techniques in the Non Ferrous Metal Industry, 2000

European update Study on LCA of Copper products

2.2.1.3. Lead

Data cut-off and completeness principles:

Coverage of at least 90 % of mass and energy of the input and output flows, and 95 % of their environmental relevance (according to expert judgement).

Technology description and included processes:

The common process chain used for the dataset is from mining via ore dressing, roasting, melting and refining. The mining is a mi out of open cast and underground mining what produces some overburden. The next ore dressing step concentrates the ore to a higher lead content via flotation processes. The roasting / sintering process is important to oxidise the sulphidic lead ore which is than feed to the furnace. The technology used is NOT representative for the consumer mix in Germany or Europe as mentioned in the "use advice" because in these data are no secondary production of lead considered. The 3 main smelting technologies are imperial smelting furnace, blast furnace and QSL furnace. The imperial smelting furnace is used normally for high zinc containing concentrates and is used for producing 96% lead which is then refined in kettles to the lead grade of 99.99%. The blast furnace is the second production process which is a typical lead concentrate smelting step which is followed by a lead refinery. The QSL process is the most environmental friendly one considered in this dataset and contributes to the German mix with 20%. The QSL process is an energy efficiency smelting process which is as well followed by refining process. In the following there are the 3 main production routes displayed.

Input of lead srap 0,1kg. Scrap is considered burden free.

Data sources:

World Mine Cost Data Exchange Inc., 2000-2004

Minerals Yearbook, 2001-2004

Reference Document on Best Available Techniques in the Non Ferrous Metal Industry, 2000

Mining Pollution Inventory in Australia, 2002-2003

The Green LaneTM, 2003

GaBi databases 2006

2.2.1.4. Monel (nickel alloy)

Data cut-off and completeness principles:

Coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Technology description and included processes:

Monel is the most important of the nickel-cooper alloys. It contains around 67% nickel, 30% copper and small amount of iron and manganese. The database represents an average based on weight of the following alloys: Monel 400, Monel 40, Monel 404, Monel K500, Monel R405.

Data sources:

ULLMANN'S Encyclopedia of Industrial Chemistry

Special Metals Corporation group

Principles of Engineering Metallurgy, L Krishna Reddy, New Age International, Jan 1, 2007 - 260 page

2.2.1.5. Titanium

Data cut-off and completeness principles:

Coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles".

Technology description and included processes:

Titanium metal is produced from TiO_2 sands (ilmenite and rutile). Following mining, which is performed with dredging technology, beneficiation takes place. Electrostatic and magnetic separation techniques are used to enrich the concentrate. The concentrate is transformed with chloride to $TiCl_4$. For titanium metal, pure $TiCl_4$ is necessary therefore a cleaning process occurs which produces high purity $TiCl_4$. The clean $TiCl_4$ is conveyed in a reduction furnace (Kroll process) where magnesium is the reduction agent. The product from the reduction furnace is called titanium sponge. The remaining magnesium chloride is conveyed to the magnesium electrolysis to recycle chlorine for further use in the chlorination process and to recycle magnesium for the Kroll process. The sponge is pressed around electrodes and is melted to a homogenous titanium metal (99, 99% Ti).

Data sources:

Titantium Statistics and Information

Titantium and Titantium Dioxide

World Mine Cost Data Exchange Inc., 2000-2004

Minerals Yearbook, 2001-2004

Information on: Titanium, 1999-2004

Reference Document on Best Available Techniques in the Non Ferrous Metal Industry, 2000

2.2.1.6. Zamak zinc alloy (ZnAlMgCu)

Data cut-off and completeness principles:

Coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles".

Technology description and included processes:

Zamak (formerly trademarked as ZAMAK and also known as Zamac) is a family of alloys with a base metal of zinc and alloying elements of aluminium, magnesium, and copper. Zamak alloys are part of the zinc aluminium alloy family; they are distinguished from the other ZA alloys because of their constant 4% aluminium composition. Alloy composition is described below, values are given in % by weight Al4,1 Mg0,045 Cu0,1 Zn95,71.

Density: 6,6 g/cm3

Data sources:

ULLMANN'S Encyclopedia of Industrial Chemistry

Eastern Alloys, Inc.

2.2.1.7. Aluminium extrusion profile (uncompliant)

WARNING: Aluminium industry often considers a majority of hydraulic and nuclear electricity in their electricity consumption mix. This is due to the fact that they are often located near hydro-electric or nuclear plant. This is not compliant with BPX rules[2] and ADEME specifications for Base Impacts that industrial electricity consumption should be modeled with national mix from Base Impacts. This incompliancy for instance leads to double counting in electricity production.

Data cut-off and completeness principles:

99% cut-off criteria (mass) applied for non-hazardous inputs and outputs except alloying elements which are not considered. No cut-off criteria for hazardous products or emissions (e.g. PAH, PFC, BaP, etc.). Infrastructure is not included. All ancillary processes (electricity, caustic soda, etc.) are included.

Technology description and included processes:

Aluminium profiles are produced through the extrusion process. These profiles are produced from aluminium ingots called billets (usually cylinders) which are pressed at hot temperature (400-500°C) through shaped dies. Aluminium billets are produced by DC (Direct Chill) casting in cast houses. Primary and recycled aluminium as well as alloying elements (Mg, Si, etc.) are used for producing aluminium billets. Primary aluminium production comprises the following 3 steps: bauxite mining, alumina production and aluminium production by electrolysis in smelters. The electric energy production used in European smelters has been modelled using a specific electricity model[3]. Aluminium imports have also been considered in this electric model. The recycling rate (78% for sheet and 78% for profile) includes metal loss during collection, processing and melting. Collection rates have been defined through studies or estimates while the ESSUM model has been used to calculate the metal yield during melting (please email lci@eaa.be for details).

This data set can be used for LCA studies related to products made in Europe and which include aluminium profiles. The data set includes the burden and credit associated with the

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[2] Which allows to claim a benefit only in case of self-consumption.

[3] See potential incompliancy detailed in the WARNING

recycling of aluminium scrap over the whole life cycle using the substitution methodology for taking into account the recycling phase. The substitution methodology considers that recycled aluminium substitutes primary aluminium so that only metal losses during the various phases need to be balanced by primary aluminium. The used average recycling rate is 78% for aluminium extruded products.

Aluminium profiles are used as structural components in many sectors like in building (window frames, balcony, scaffolding, etc.), in transportation (BIW, bumpers, seat frames, etc.) or in engineering. Thanks to the high versatility of the cross-sectional shape, aluminium profiles can integrate many functions in addition to the structural properties. Aluminium profiles can be formed and joined with other components. Aluminium profiles can be anodised or/and coated.

Data sources:

GaBi databases 2006

European Reference Life Cycle Data System" (ELCD), v 1.0.1, 2007

Life Cycle Inventory Data Primary Aluminium, 2005

2.2.1.8. Aluminium sheet (uncompliant)

WARNING: Aluminium industry often considers a majority of hydraulic and nuclear electricity in their electricity consumption mix. This is due to the fact that they are often located near hydro-electric or nuclear plant. This is not compliant with BPX rules[2] and ADEME specifications for Base Impacts that industrial electricity consumption should be modeled with national mix from Base Impacts. This incompliancy for instance leads to double counting in electricity production.

Data cut-off and completeness principles:

99% cut-off criteria (mass) applied for non-hazardous inputs and outputs except alloying elements which are not considered. No cut-off criteria for hazardous products or emissions (e.g. PAH, PFC, BaP, etc.). Infrastructure is not included. All ancillary processes (electricity, caustic soda, etc.) are included.

Technology description and included processes:

Aluminium sheets are produced from aluminium ingots called slabs (usually rectangular-shape) which are hot rolled at temperature around 400-500°C and then cold rolled. Typical thickness of aluminium sheets is comprised between 0.2 and 4 mm. The slabs are produced by DC (Direct Chill) casting in cast houses. Primary and recycled aluminium as well as alloying elements (Mg, Si, etc.) are used for producing aluminium slabs. Primary aluminium production comprises the following 3 steps: bauxite mining, alumina production and aluminium production by electrolysis in smelters. The electric energy production used in European smelters has been modelled using a specific electricity model[3]. Aluminium imports have also been considered in this electric model. The recycling rate (78% for sheet and 78% for profile) includes metal losses during collection, processing and melting. Collection rates have been defined through studies or estimates while the ESSUM model has been used to calculate the metal yield during melting (please email lci@eaa.be for details).

This data set can be used for LCA studies related to products made in Europe and which include aluminium sheet material. The data set includes the burden and credit associated with the recycling of aluminium scrap over the whole life cycle using the substitution methodology for taking into account the recycling phase. The substitution methodology considers that recycled aluminium substitutes primary aluminium so that only metal losses during the various phases need to be balanced by primary aluminium. The used average recycling rate is 78% for aluminium sheets.

Aluminium sheets are used in many sectors like packaging (can, containers), building (roofing, facade panels), transport (closures, BIW), engineering or for specific applications like lithographic sheets. Aluminium sheets can be formed and joined with other components in complex applications. Aluminium sheets can be anodised or/and coated. Typical thickness of aluminium sheets is between 0,2 and 4 mm. Aluminium foil (thickness < 200 µm) is not considered in this generic data set.

Data sources:

GaBi databases 2006

European Reference Life Cycle Data System" (ELCD), v 1.0.1, 2007

Life Cycle Inventory Data Primary Aluminium, 2005

2.2.2. Other metals, processes

2.2.2.1. Metal sheet stamping (20% loss)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Technology description and included processes:

Sheet metal stamping involves the mechanical deformation of a metal sheet into a press. It is divided into five and different types of processes:

- swaging or coining: the reduction of the original metal thickness by applying a certain force to it

-bend forming: bends or shapes metal in angular or radial forms

-draw forming: stretch forms material into various shapes

-deep draw forming: same as above, but metal is drawn to a greater depth

-punching or blanking: involves only a cutting process.

The process can be a single stage operation where every stroke of the press produces the desired form on the sheet metal part, or could occur through a series of stages. All processes involve sheet metal and lubricant as input and electricity to move the sheet between successive hits as well as power the hydraulic press. Outputs are stamped sheet and metal scrap.

Open input flows should be defined by the user (see example in page 6):

-Electricity [Electric power]: 0,5 MJ

-Metal hot rolled coil [Metals]: 1,20 kg

Data sources:

The Metal Stamping Process: Your Product from Concept to Customer

2.2.2.2. Cold rolling (high impact metal)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment). For electricity input, value for production of stainless steel used ("worst case scenario").

Technology description and included processes:

First, the hot strip is descaled in a pickling line before being rolled in a multistand tandem mill or in a reversing stand. Cold rolling occurs with the metal below its recrystallization temperature (usually at room temperature), which increases the strength via strain hardening up to 20%. Cold-rolled sheets and strips come in various conditions: full-hard, half-hard, quarter-hard, and skin-rolled. Full-hard rolling reduces the thickness by 50%, while the others involve less of a reduction.

Open input flows, should be defined by the user:

-Electricity [Electric power]: 0,464 MJ

-Metal hot rolled coil [Metals]: 1,000 kg

Data sources:

Theoretical Minimum Energies To Produce Steel for Selected Conditions

Cold rolled sheet

Individual industry data

2.2.2.3. Cold rolling (low impact metal)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

This partially aggregated data set can be used for all LCA/CF studies where cold rolling of low impact metals (e.g. copper, aluminium, brass...) is involved. However, it was modelled based on aluminium cold rolling process, and may not exactly reflect the inventory for other metals (especially scrap quantity and energy consumption per kg output). Combination with inputs and output flows listed below and others using this commodity enables the generation of user-specific (product) LCAs.

Technology description and included processes:

The hot rolled strip is heated up to approx. 100°C during each pass and large quantities of coolant have to be poured over the rolls to keep a thermal equilibrium. After each of the three to four passes, the coils have to be cooled down to room temperature for several hours. During each cold rolling pass, a material hardening is affected by the deformation process of the strip. Depending on the grain structure mainly influenced by the alloy composition, one or two annealing sessions for recrystallization have to be integrated into the production program to permit a continuation of the rolling passes and to fulfil the final requirements of the product specification. The strip rolling process itself can be done with different types of rolling mills. For small coil weights up to 5 tons, reversing rolling mills are still used. For normal coil weights between 10 and 15 tons, non-reversing single-stand rolling mills are common. For high coil weights up to 25 tons, and large production volumes, multi-stand tandem rolling mills are used.

Open input flows, should be defined by the user:

-Electricity [Electric power]: 0,716 MJ

-Metal hot rolled coil [Metals]: 1,066 kg

Data sources:

EAA Environmental Profile Report for the EU Aluminium Industry, EAA, April 2008

Aluminium Rolling Mill Technology: Future Concepts in Thin-strip and Foil Rolling, 2002

Handbook of Aluminum: Vol. 1: Physical Metallurgy and Processes, CRC press, 2003

2.2.2.4. Metal drilling (high impact metal)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

This partially aggregated data set can be used for all LCA/CF studies where drilling of high impact metals (e.g. steel, stainless steel, titanium alloy...) is involved. However, it was modelled based on alloyed steel part machining, and may not exactly reflect the inventory for other metals (especially scrap quantity and energy consumption per kg output). Combination with inputs and output flows listed above and others using this commodity enables the generation of user-specific (product) LCAs.

Technology description and included processes:

Data scaled from a 44.5 kg alloyed steel part input, 22 kg chips output from machining. Machining of the complete part by drilling and milling on a machining center. Machining is operated without lubricant: It means dry machining only air-cooled. Several tools are used for machining this part. A maximum number of tools with carbide inserts are used from 50 mm to 16 mm for diameters, and solid carbide tools from 12 to 3 mm.

Open input flows, should be defined by the user:

-Electricity [Electric power]: 2,53 MJ

-Metal hot rolled coil [Metal parts]: 1,47 kg

Data sources:

Manufacturing Processes Reference Guide

Metals Machinability

Machining Titanium and Its Alloys

2.2.2.5. Metal drilling (low impact metal)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment.

This partially aggregated data set can be used for all LCA/CF studies where drilling of low impact metals (e.g. aluminium, copper, magnesium) is involved. However, it was modelled based on aluminium part machining, and may not exactly reflect the inventory for other metals (especially scrap quantity and energy consumption per kg output). Combination with inputs and output flows listed above and others using this commodity enables the generation of user-specific (product) LCAs.

Technology description and included processes:

Data from machining of an aluminium part. Machining of the complete part by drilling on a machining center. Machining is operated with lubricant/coolant which runs in closed circuit (hence not accounted here) Several tools are used for machining this part.

Open input flows, should be defined by the user:

-Electricity [Electric power]: 0,773 MJ

-Metal hot rolled coil [Metal parts]: 1,03 kg

Data sources:

Manufacturing Processes Reference Guide

Metals Machinability

Machining Titanium and Its Alloys

2.2.2.6. Turning (high impact metal)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment). Machinery is not included.

A representative technology of turning for aluminium is considered.

Technology description and included processes:

Turning is a metal cutting process which is performed with a lathe and can be used for the generation of cylindrical surfaces. Typically the workpiece is rotated on a spindle and the tool is fed into it radially, axially or both ways simultaneously to give the required surface.

The term turning, in the general sense, refers to the generation of any cylindrical surface with a single point tool. More specifically, it is often applied just to the generation of external cylindrical surfaces oriented primarily parallel to the workpiece axis.

The generation of surfaces oriented primarily perpendicular to the workpiece axis are called facing. In turning, the direction of the feeding motion is predominantly axial with respect to the machine spindle. In facing a radial feed is dominant.

Tapered and contoured surfaces require both modes of tool feed at the same time often referred to as profiling. The cutting characteristics of most turning applications are similar. For a given surface only one cutting tool is used. This tool must overhang its holder to some extent to enable the holder to clear the rotating workpiece. Once the cut starts, the tool and the workpiece are usually in contact until the surface is completely generated. During this time the cutting speed and cut dimensions will be constant when a cylindrical surface is being turned.

In the case of facing operations the cutting speed is proportional to the work diameter, the speed decreasing as the center of the piece is approached. Sometimes a spindle speed changing mechanism is provided to increase the rotating speed of the workpiece as the tool moves to the center of the part.

Several parameters are important for processing: Cutting speed, depth of cut, feed rate, length of cut, initial diameter, final diameter, material removal rate and machining power. There is a material dependency.

In this dataset Titanium alloy is cut, 1.2mm depth and 100mm length with 0.15 mm/revolution. The material removed is 15% of the original input. Lathes can be operated with a CNC, computerized numerical control, or manually. Electricity is required for both operational modes. Energy depends on the parameters above, but mainly on the machine itself and cutting speed. 47.3MJ electricity is required to remove 10cm3 (with a density of Titanium of 45g/10cm3). There are several different lathes available. This dataset is based on a MHP lathe.

Operating conditions control three important metal cutting variables: metal removal rate, tool life and surface finish. Correct operating conditions must be selected to balance these three variables and to achieve the minimum machining cost per piece, the maximum production rate and/or the best surface finish whichever is desirable for a particular operation.

Turning can be performed dry or wet, with lubricous fluids. Heat generated due to friction can readily be reduced by using a lubricant. Lubricous fluids serve for cooling and carrying away the chips as well as an increase of tool life. For this dataset use of lubricants was estimated (100L per month [as 50% of a total of 200L per machine])

Open input flows, should be defined by the user:

-Electricity [Electric power]: 154,118 MJ[4]

-Metal [Metal parts]: 1,17647 kg

Data sources:

Energy analysis in turning and milling

[4] WARNING : Error in the metadata, it is written 130 MJ/kg

2.2.2.7. Turning (low impact)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment). Machinery is not included.

A representative technology of turning for aluminium is considered.

Technology description and included processes:

Turning is a metal cutting process which is performed with a lathe and can be used for the generation of cylindrical surfaces. Typically the workpiece is rotated on a spindle and the tool is fed into it radially, axially or both ways simultaneously to give the required surface. The term turning, in the general sense, refers to the generation of any cylindrical surface with a single point tool. More specifically, it is often applied just to the generation of external cylindrical surfaces oriented primarily parallel to the workpiece axis. The generation of surfaces oriented primarily perpendicular to the workpiece axis are called facing. In turning, the direction of the feeding motion is predominantly axial with respect to the machine spindle. In facing a radial feed is dominant. Tapered and contoured surfaces require both modes of tool feed at the same time often referred to as profiling.

The cutting characteristics of most turning applications are similar. For a given surface only one cutting tool is used. This tool must overhang its holder to some extent to enable the holder to clear the rotating workpiece. Once the cut starts, the tool and the workpiece are usually in contact until the surface is completely generated. During this time the cutting speed and cut dimensions will be constant when a cylindrical surface is being turned. In the case of facing operations the cutting speed is proportional to the work diameter, the speed decreasing as the center of the piece is approached. Sometimes a spindle speed changing mechanism is provided to increase the rotating speed of the workpiece as the tool moves to the center of the part.

Several parameters are important for processing: Cutting speed, depth of cut, feed rate, length of cut, initial diameter, final diameter, material removal rate and machining power. There is a material dependency.

In this dataset Aluminium is cut, 150 m/min, 1.2mm depth and 100mm length with 0.15 mm/revolution. The material removed is 1% of the original input.

Lathes can be operated with a CNC, computerized numerical control, or manually. Electricity is required for both operational modes.

Energy depends on the parameters above, but mainly on the machine itself and cutting speed. 3.5MJ electricity is required to remove 10cm3 (with a density of Aluminium of 27g/10cm3). There are several different lathes available. This dataset is based on a MHP lathe.

Operating conditions control three important metal cutting variables: metal removal rate, tool life and surface finish. Correct operating conditions must be selected to balance these three variables and to achieve the minimum machining cost per piece, the maximum production rate and/or the best surface finish whichever is desirable for a particular operation.

Turning can be performed dry or wet, with lubricous fluids. Heat generated due to friction can readily be reduced by using a lubricant. Lubricous fluids serve for cooling and carrying away the chips as well as an increase of tool life. For this dataset no use of lubricants was assumed, as only very little material is removed.

Open input flows, should be defined by the user:

-Electricity [Electric power]: 1,3 MJ

-Metal [Metal parts]: 0,01 kg

Data sources:

Energy analysis in turning and milling

Turning tools and operations

Metal Cutting Processes 1 – Turning

2.2.2.8. Casting (high impact metal)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Technology description and included processes:

Casting involves pouring liquid metal into a mold, which contains a hollow cavity of the desired shape, and then allowing it to cool and solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process.

Casting is most often used for making complex shapes that would be difficult or uneconomical to make by other methods. Metalcasting casting methods vary widely among various alloys and cast products. For example iron casting processes, the predominant casting method is the greensand process.

The greensand process uses a sand mold prepared with a mixture of sand, clay, water, and typically seacoal as the organic component. The typical greensand molding processes consist of sand being squeezed, or somehow compacted, on a steel pattern. When the pattern is removed, the sand retains the form of the pattern. The mold consists of two halves, a cope (top) and drag (bottom). Depending on the type of castings being produced, a core is sometimes used, such as when the castings produced require internal passages.

Steel casting production is evenly split among greensand, chemically-bonded, and permanent mold processes. Energy required for steel casting processes is higher than for cast iron.

Nonferrous casting processes are dominated by high-pressure die casting. This process consists of water-cooled metal patterns as molds. Holding furnaces at die cast machines are sometimes used to superheat or maintain metal at ideal pouring temperatures. Permanent mold processes do not use pressure to force metal into the mold, but can use a vacuum to assist in drawing metal into the mold.

Sand casting is applied in this dataset. Most of total facility energy requirement is required for melting metals in a furnace (typically 60-70%). Theoretical melting energy depends on the melting temperature of the metal. Additional energy is required for mold preparation, finishing, cooling and transportation within the production site. Partly energy for compressed air is additionally required. Induction melting requires more electrical energy than cupola melting, which is fueled with coke. Steel cannot be cupola melted. Therefore all steel is either arc-furnace melted or induction-furnace melted.

Yields can be between approximately 50 and over 90% (for pipe production). Scrap rate is between 4-7%. In this dataset yield and scrap losses sum up to 47% of the input.

Open input flows, should be defined by the user:

-Electricity [Electric power]: 8,8 MJ[5]

-Metal [Metal parts]: 1,47 kg

[5] WARNING : Error in the Metadata, it is written “4.4 MJ thermal energy from natural gas is required”.

Data sources:

Theoretical / Best practice energy use in metalcasting operations

Energy use in selected metalcasting facilities 2003

2.2.2.9. Casting (low impact)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Technology description and included processes:

See previous casting technology general description.

This process consists of water-cooled metal patterns as molds. The nonferrous alloy is then forced into the mold under pressure, forming a very high-quality part with high yields of 70 to 75 percent.

Zinc facilities typically create between 6 to 8 percent dross that contains 30 to 40 percent zinc.The mold is excluded from this dataset.

Open input flows, should be defined by the user:

-Electricity [Electric power]: 0,77 MJ[6]

-Metal [Metal parts]: 1,37 kg

Data sources:

Theoretical / Best practice energy use in metalcasting operations

Energy use in selected metalcasting facilities 2003

2.2.2.10.Hot rolling (high impact metal)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

Technology description and included processes:

Hot rolling is a metalworking process that occurs above the recrystallization temperature of the material. The starting material is usually large pieces of metal, like semi-finished casting products, such as slabs, blooms, and billets. If these products came from a continuous casting operation the products are usually fed directly into the rolling mills at the proper temperature, then coiled. In smaller operations the material starts at room temperature and must be heated. This is done in a gas- or oil-fired soaking pit for larger workpieces and for smaller workpieces induction heating is used.

Open input flows, should be defined by the user:

-Electricity [Electric power]: 0,235 MJ

-Metal rolling ingot [Metal parts]: 1,02 kg

Data sources:

Theoretical Minimum Energies To Produce Steel for Selected Conditions

Cold rolled sheet

Individual industry data

[6] WARNING : Error in the metadata, it is written « 2.9 MJ thermal energy from natural gas is required”

2.2.2.11.Hot rolling (low impact metal)

Data cut-off and completeness principles:

Coverage of at least 95% of mass and energy of the input and output flows, and 98% of their environmental relevance (according to expert judgment).

This partially aggregated data set can be used for all LCA/CF studies where hot rolling of low impact metals (e.g. copper, aluminium, brass...) is involved. However, it was modelled based on aluminium hot rolling process, and may not exactly reflect the inventory for other metals (especially scrap quantity and energy consumption per kg output). Combination with inputs and output flows listed above and others using this commodity enables the generation of user-specific (product) LCAs

Technology description and included processes:

In the hot strip production process, traditionally the molten metal is cast after refining and alloying processes into 10 to 25-ton slabs in semi-continuous casters, then preannealed, hot-rolled in single-stand or tandem hot rolling mills and, at a strip thickness of 6 to 2.5 mm, coiled at a temperature of approx. 300°C.

Open input flows, should be defined by the user:

-Electricity [Electric power]: 0,67 MJ

-Metal rolling ingot [Metal parts]: 1,112 kg

Data sources:

EAA Environmental Profile Report for the EU Aluminium Industry, EAA, April 2008

Aluminium Rolling Mill Technology: Future Concepts in Thin-strip and Foil Rolling, 2002

Handbook of Aluminum: Vol. 1: Physical Metallurgy and Processes, CRC press, 2003

2.2.2.12.Electroplating (estimation)

Data cut-off and completeness principles:

Coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to expert judgement). For further details please see the document "GaBi Databases Modelling Principles"

Technology description and included processes:

This data set includes the electroplating process for metals.

Open input flows, should be defined by the user:

-Electricity [Electric power]: 0,576 MJ

Data sources:

ULLMANN'S Encyclopedia of Industrial Chemistry

2.3. Background system boundaries

Background system boundaries follow the rules defined by PE International.

C. DATA SOURCES AND QUALITY

1. Data quality requirements

Quality requirements for Base Impacts® datasets are detailed in the general Base Impacts® documentation.

No specific quality requirements were set for the steel datasets.

2. Types and sources of data

Data set is based on a weighted average site-specific data (gate-to-gate) of European steel producers. Electricity grid mix is country-specific. Other upstream data (e.g. iron ore production) are based on global averages from the steel industry.

The datasets were created with the use of the following elements and references:

- Data collected on site by steel industry experts in accordance with the worldsteel methodology and ISO 14040 standards, and consistency-checked by worldsteel LCA-experts.
- European coke, sinter, pellet, hot metal, slab production based on wordsteel site specific data.
- Metallurgical coal data based on global IEA statistics and information from the GaBi database.
- Iron ore data obtained from iron ore producer.
- Other upstream data based on the GaBi database, including country specific electricity.
- Worldsteel Life Cycle Inventory Study for Steel Industry Products, 2011
- GaBi databases 2006
- Fertigungsverfahren Band 5: Blechbearbeitung, 1995
- Gardena Manufacturing GmbH, written communication, 2006

3. Data quality

3.1. Technological representativeness

- Steel products: Unknown quality level

- Steel processes:

3.2. Time-related coverage

- Steel products: Unknown quality level

Steel (Worldsteel): Reference year 2007, Based on annual data from a 12 month period between 2005 and 2008 provided by each participating site from which an annual average is calculated.
Stainless steel (Eurofer): Reference year 2008, Annual average, site-specific data for one year.

- Steel processes:

Reference year 2011, data collection period 2008-2012, annual average

3.3. Geographical coverage

- Steel products: Unknown quality level

Steel (Worldsteel): Data set is based on a weighted average site-specific data (gate-to-gate) of global steel producers in Europe. Electricity grid mix is country-specific. Other upstream data (e.g. iron ore production) are based on global averages from the steel industry.

Stainless steel (Eurofer): The data set represents cradle-to-gate data based on average site-specific data (gate-to-gate) of European stainless steel producers. The electricity grid mix is representing the country specific grid situation. Other upstream data (e.g. chromium, nickel or molybdenum) are based on global averages from the specific industrial associations.

- Processes : World :

3.4. Precision

- Steel products: Unknown quality level

- Processes:

3.5. Completeness

- Steel products: Unknown quality level

- Processes:

3.6. Consistency

- Steel products: Unknown quality level

- Processes:

4. Multi-functionality and allocation procedure

4.1. Foreground system allocation procedure: Allocation of recycling impacts and benefits

4.1.1. Context: methodology for the calculation of the impact of materials

The calculation of the impacts of materials must include an allocation of the impacts and benefits of recycling.

The BPX 30-323-0 requires calculating the impact of the materials life-cycles as follows (collection-rate based formula, valid for steel and aluminum):

$E_M = E_V - R_2 E_V + R_2 E_R$ + *(other impacts)*

With:

— E_M Impacts of the material;

— E_V Impacts tied to extracting or producing the primary raw material + impacts tied to processing the raw material into virgin raw material;

— E_R Impacts tied to collecting recycled waste + impacts tied to sorting recycled waste + impacts tied to reclamation + impacts tied to processing operations generating useable raw materials;

— R_2 National recycling rate for the considered application.

This shows the need of independent datasets for both:

- virgin material
- recycled material

4.1.2. Context: steel production process, Worldsteel and Eurofer datasets

Two processes exist for the production of steel:

- The BOF (blast oxygen furnace) route is primary ore-based which generally uses up to 35% scrap input. The steelmaking stage of this route is carried out using the basic oxygen furnace.
- The EAF (electric arc furnace) route is predominantly a 100% scrap-based steelmaking process.

Data generally combine both virgin material and recycled material. Therefore, it is not possible for steel producers to calculate an inventory for virgin material. An inventory for BOF process without scrap input would be a “virtual” production.

For the methodological approach to account for the recycling of stainless steel please contact the European Confederation of Iron and Steel Industries, Eurofer (European data): www.eurofer.org.

4.1.3. Implementation of Worldsteel and Eurofer datasets in Base Impacts

The Worldsteel and Eurofer inventories are used in Base Impacts.

The environmental impacts associated to the Worldsteel and Eurofer steel datasets are recalculated in Base Impacts depending on the recycling rate. The datasets are modified by combining it with a “value of scrap” dataset.

Indeed, Worldsteel and Eurofer propose 2 types of inventories:

- One inventory called "Value of scrap" representing the credits of recycling. It is the difference between 100% virgin sourced BOF and 100% scrap sourced EAF. It represents E_V – E_R. This data is an LCI for steel scrap, calculated using the Worldsteel recycling methodology. It should be used to account for the burden of using steel scrap within the steel making process and the credit for the end of life recycling of steel within a product. The net amount of scrap should be used (recycling rate - scrap input). The "value of scrap" is calculated on the basis of the steel product cradle-to-gate LCIs. These underlying datasets include raw material extraction (e.g. coal, iron, ore, etc.) and processing, e.g. coke making, sinter, blast furnace, basic oxygen furnace, hot strip mill, etc.
- Inventories for steel products (sections, galvanized) with end of life recycling benefits included. In parameters of BPX formula, it would represent $(1-R_2)*E_V + R_2*E_R$

The following assumptions are made:

- In the BPX formula, E_V is the BOF route considering 100 % of virgin materials and E_R is the EAF route considering 100 % of scrap. However, in reality, BOF route also processes some scrap. Therefore, for a specific amount of scrap, the calculation will consider all scrap being processed into EAF while in reality a part of it is processed into BOF. In other words, the impacts of scrap processing into the BOF converter are considered equivalent to those of the EAF, which is a conservative assumption. In fact, the actual impacts are lower because there is an excess of melting energy in converter used to melt the scrap.
- Data from Worldsteel and Eurofer include a yield for the electric furnace: more than 1 kg of scrap is needed to produce 1 kg of steel. This is not directly reflected in the BPX formula. Considering the yield is also conservative and closer to reality.

Both are conservative assumptions.

The database provides the inventories with different values for R2 depending on the sector: the Worldsteel datasets were modified with the help of the data "value of scrap" (representing E_V - E_R).

Indeed:

- the inventories provided by Worldsteel or Eurofer (WS/E) are the following:
  $E_{M(WS/E)} = (1-R_{2(WS/E)})*E_V + R_{2(WS/E)}*E_R = E_V - R_{2(WS/E)}\ E_{M(value\ of\ scrap)}$
- the required inventories are the following:
  $E_M = (1-R_2)*E_V + R_2*E_R = E_V - R_2\ E_{M(value\ of\ scrap)}$
- The calculation is therefore:
  $E_M = E_{M(WS/E)} - R_{2(WS/E)}\ E_{M(value\ of\ scrap)} + R_2\ E_{M(value\ of\ scrap)}$

In conclusion, the BPX formula has been respected with minor changes.

4.2. Other metals

For lead and brass datasets which include a recycled material content, BPX30-323 was also applied with some minor adaptation.

The calculation of the impacts of materials must include an allocation of the impact and benefits of recycling.

The BPX 30-323-0 requires calculating the impact of the materials life-cycles as follows:

EM = EV + EDaval + a R1 (ERamont/ρ1 – EV*σ1 – EDamont/ρ1) + (1-a) R2 (ERaval – ρ2*σ2*EV' - EDaval) + Ve (Ecf - r3n*PCI*Echaleur_cf - r4n*PCI*Eélec_cf - EDaval)

In blue, we show "other than recycling" end-of-life impacts.

For metals, a = 0 according to BPX30-323-0.

For simplification it is considered that EV = EV', ERamont = ERaval and ρ2*σ2=1

So the simplified formula, valid for lead and brass is:

$E_M = E_V - R_2 E_V + R_2 E_R$ + *("other than recycling" end-of-life impacts)*

With:

— E_M Impacts of the material;

— E_V Impacts tied to extracting or producing the primary raw material (E_{Va}) + impacts tied to processing the raw material into virgin raw material (E_{Vb});

— E_R Impacts tied to collecting recycled waste (E_{Ra}) + impacts tied to sorting recycled waste (E_{Rb})+ impacts tied to reclamation (E_{Rc}) + impacts tied to processing operations generating useable raw materials (E_{Rd});

— R_2 National recycling rate for the considered application.

For lead and brass data, the following assumptions were made by the data providers:

- No impacts are accounted for waste collection, sorting and transport: ERa = ERb = ERc = 0.
- No distinction is made in the production of virgin material and the production of secondary material ($E_{Vb} = E_{Rd} = E_{prod}$)
- Recycling rate is considered identical to recycled content (R2 = R1)

This means that the impact of lead and brass life-cycles is:

$E_M = E_{Va} + E_{prod} - R_1 E_{Va} - R_1 E_{prod} + R_1 E_{prod}$

⬄ $E_M = E_{Va} + E_{prod} - R_1 E_{Va}$

⬄ $\mathbf{E_M = (1- R_1)*E_{Va} + E_{prod}}$

This implies that lead and brass data where provided with recycled material input burden free. Scrap rate (recycled content) are indicated in each dataset.

For Aluminium (from ELCD database), it is stated in the metadata that the datasets includes the burden and credit associated with the recycling of aluminium scrap over the whole life cycle using the substitution methodology for taking into account the recycling phase. The substitution methodology considers that recycled aluminium substitutes primary aluminium so that only metal losses during the various phases need to be balanced by primary aluminium. The used average recycling rate is 78% for aluminium extruded products.

4.3. Background system allocation procedure

Background system allocation procedure follows the rules defined by PE International.

D. CRITICAL REVIEW

All Base Impacts® datasets follow the ILCD Entry Level requirements, which require a review either internal with public report or external.

The steel datasets were reviewed by internal review:

- Raw data: Validation of data sources, Sample tests on calculations, Cross-check with other source, Expert judgement
- Unit process(es), single operation, black box: Energy balance, Element balance, Cross-check with other source, Cross-check with other data set, Expert judgement, Mass balance, Compliance with ISO 14040 to 14044
- LCI results or Partly terminated system: Energy balance, Element balance, Cross-check with other source, Cross-check with other data set, Expert judgement, Mass balance, Compliance with ISO 14040 to 14044
- LCIA results : Cross-check with other source, Cross-check with other data set, Expert judgement, Compliance with ISO 14040 to 14044
- Documentation: Expert judgement, Compliance with ISO 14040 to 14044, Documentation
- Life cycle inventory methods : Compliance with ISO 14040 to 14044
- LCIA results calculation : Expert judgement, Compliance with ISO 14040 to 14044
- Goal and scope definition: Expert judgement, Compliance with ISO 14040 to 14044

E. REPORTS FOR MORE INFORMATION

The following documents should be used for more information:

- Gabi Modelling Principles 2013
- General Base Impacts® documentation
- Review report, available in the metadata of each dataset

F. ADMINISTRATIVE INFORMATION

1. Commissioner

- Steel products: Worldsteel and Eurofer
- Steel processes: PE International.
- Other metals: PE International.
- Other metals processes: PE International.
- Aluminium : ELCD

2. Dataset modeler

- Steel products: Worldsteel and Eurofer
- Processes: PE International.
- Other metals: PE International.
- Other metals processes: PE International.
- Aluminium : ELCD

APPENDIX: DATA NEED AND DATA SELECTION

A Technical Committee on steel datasets specifications was held on 23 June 2011 to identify the steel datasets required for environmental labeling.

The conclusions of this Technical Committee were a synthesis of data need for steel.

The datasets identified by the Technical Committee are provided in Base Impacts®, with the following modifications:

Consultation specification	**Implementation in Base Impacts®**	**Justification**
Steel – intermediate products (Europe)		
Acier profilé	Steel section (Europe) Steel plate (Europe)	
Acier laminé	Steel, coil, cold rolled (Europe, recycling % for EEE, clothing and furniture) Steel, coil, finished cold rolled (Europe, recycling % for EEE, clothing and furniture) Steel, coil, hot rolled (Europe, recycling % for furniture)	
Acier rond et fil d'acier	Steel, wire rod (World, recycling % for EEE)	Data availability
Acier galvanisé	Steel, coil, hot dip galvanized (Europe, recycling % for EEE, clothing and furniture)	
Acier inoxydable	Stainless steel, coil, cold rolled (304) (Europe, recycling % for EEE, clothing and furniture)	
Acier étamé	Steel, coil, tinplated (Europe, recycling % for EEE, clothing and furniture)	
Valeur des ferrailles	Value of scrap (world)	
Steel - processes (Europe)		
Fabrication avec enlèvement de matière	Steel part, turning (World, 10% and 5% losses)	
Fabrication sans enlèvement de matière		The following process couldn't be delivered due to data availability : cutting (découpe), assembling (assemblage), bending (pliage), stamping (estampage)
Traitement de surface avec ajout de matière	Steel, coil, electrolytic chrome-coated (ECCS) (= tin-free) (Europe, recycling % for EEE and furniture) Steel, coil, organic coated	The following process couldn't be delivered due to data availability : anodizing

	(Europe, recycling % for EEE and furniture) Steel sheet, galvanisation	(anodisage)
Traitement de surface sans ajout de matière	Steel sheet, scouring (= deburring)	The following process couldn't be delivered due to data availability : shotpeening (grenaillage)
Other metals – intermediate products		
Copper (RER) Brass (RER) Lead (RER) Monel (NiCuMo) (RER) Titan (GLO) Zamak (RER)	Idem except World for copper instead of Europe	
Stamping (RER) Setting (GLO) sheet rolling (GLO) Drilling (GLO) Turning (GLO) Casting (GLO)	Setting not provided Stamping provided for World Sheet rolling provided for Europe Sheet rolling, drilling, turning and casting provided for high and low impact metal + Hot rolling (high and low impact metal) + Electroplating	
Aluminium	Aluminium extrusion profile (ELCD) Aluminium Sheet (ELCD)	