EUROFER Stainless Steel LCI study

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Motivation

- Following the Rio summit in 1992:
  - **"The Environment" moved up everyone's agenda**
  - **End users were asking for "environmentally friendly" products and so manufacturers wanted LCI data, to contribute to LCAs**
  - **Good quality data defining the environmental impacts of our processes were needed, in order to evaluate the potential for improvements.**

Why a Stainless Steel LCI ?

- Stainless steels are very versatile and widely used materials; their corrosion resistance and longevity make them very popular, but "environmental" clarity was missing.
- A previous study had been carried out for carbon steels (IISI).
- EUROFER, assisted by the ECOBILAN experts, was able to develop a suitable database involving the vast majority of the European stainless steel producers.

Objectives

- Provide a basis for impact assessments of stainless steel products.
- Provide benchmarking data to identify areas for improvement within the process.
- Support communication with our stakeholders.
- Support responses to environmental claims against stainless steel.
- Train people in our industry in the field of LCA.

Frame of the study

Grades and surface conditions

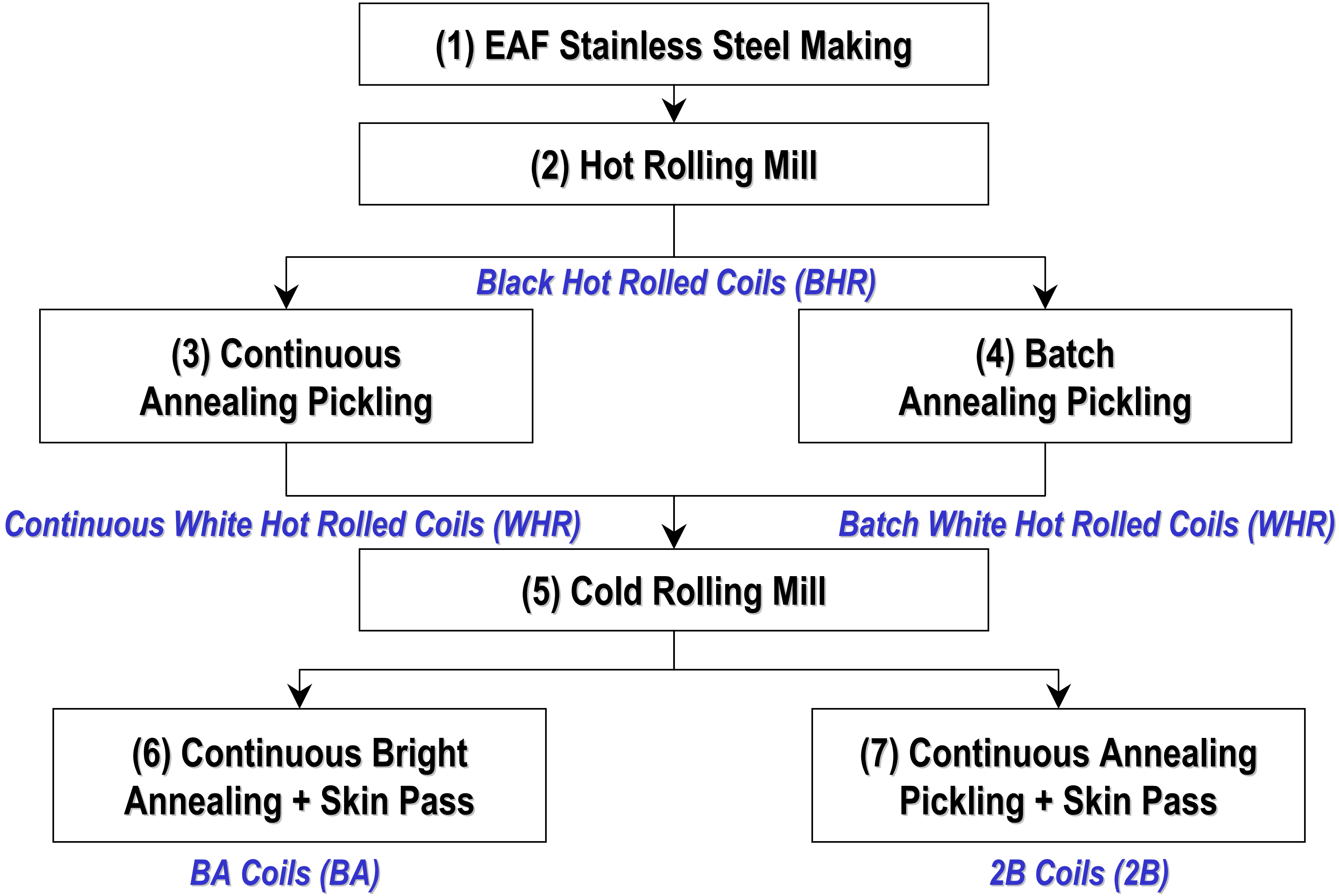
Grades	409	430	304	316	2205
Alloy types	Ferritic		Austenitic		Duplex
Content by weight %	11% Cr	17% Cr	18% Cr 8% Ni	18% Cr 12% Ni 2.5% Mo	22% Cr 5% Ni 3% Mo
Sheets' surface conditions	BHR WHR 2B	BHR WHR 2B BA	BHR WHR 2B BA	BHR WHR 2B BA	BHR WHR 2B

BHR : Black hot rolled
WHR : White hot rolled

2B : Cold rolled - Pickled + Skin pass
BA : Cold rolled - Bright annealed

Frame of the study

Process stages : synthetic view



Life Cycle Inventory

The "cradle" to "cradle" system

Raw Materials Extraction

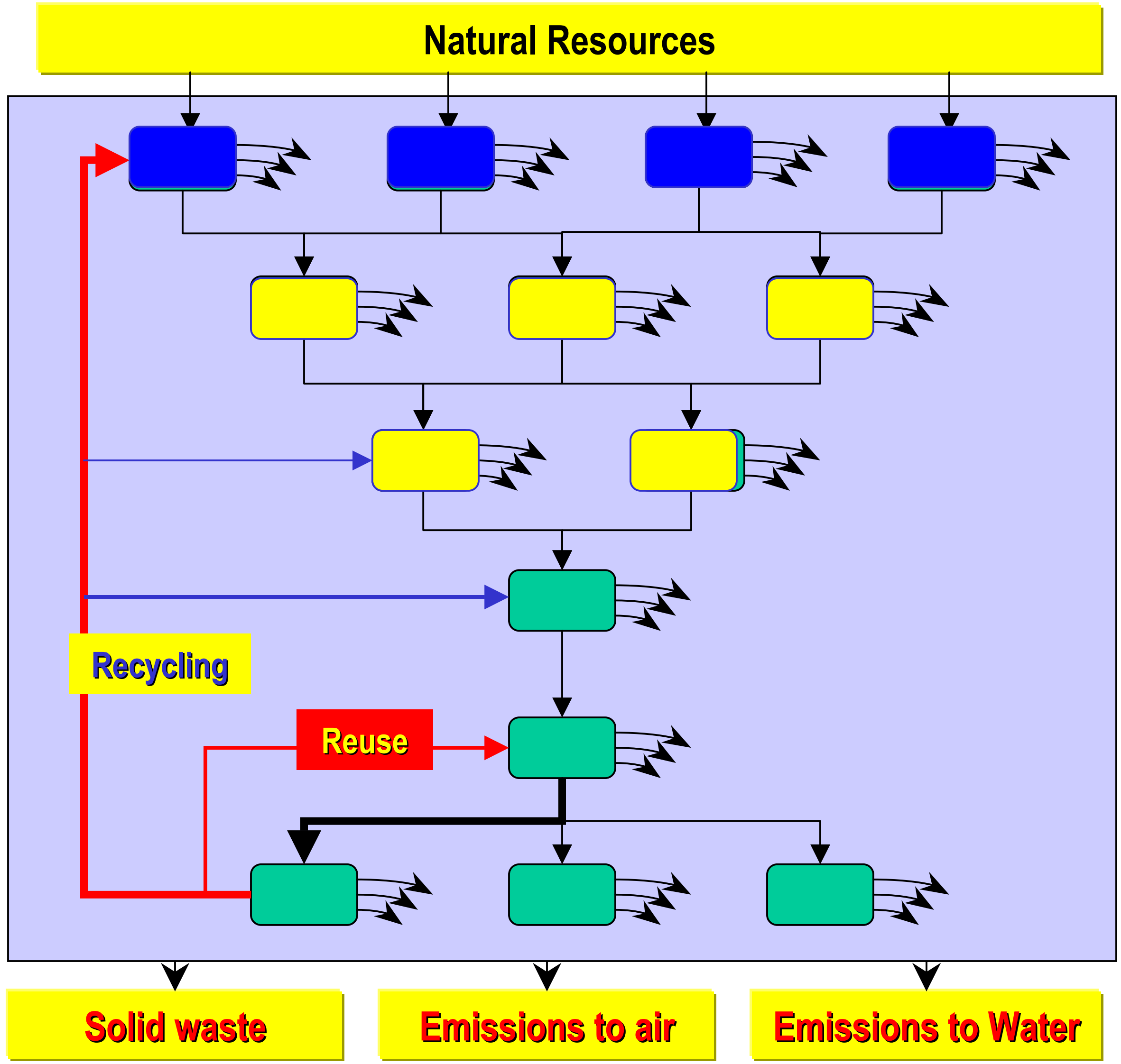
Materials Production

Intermediate Products

Product Manufacturing

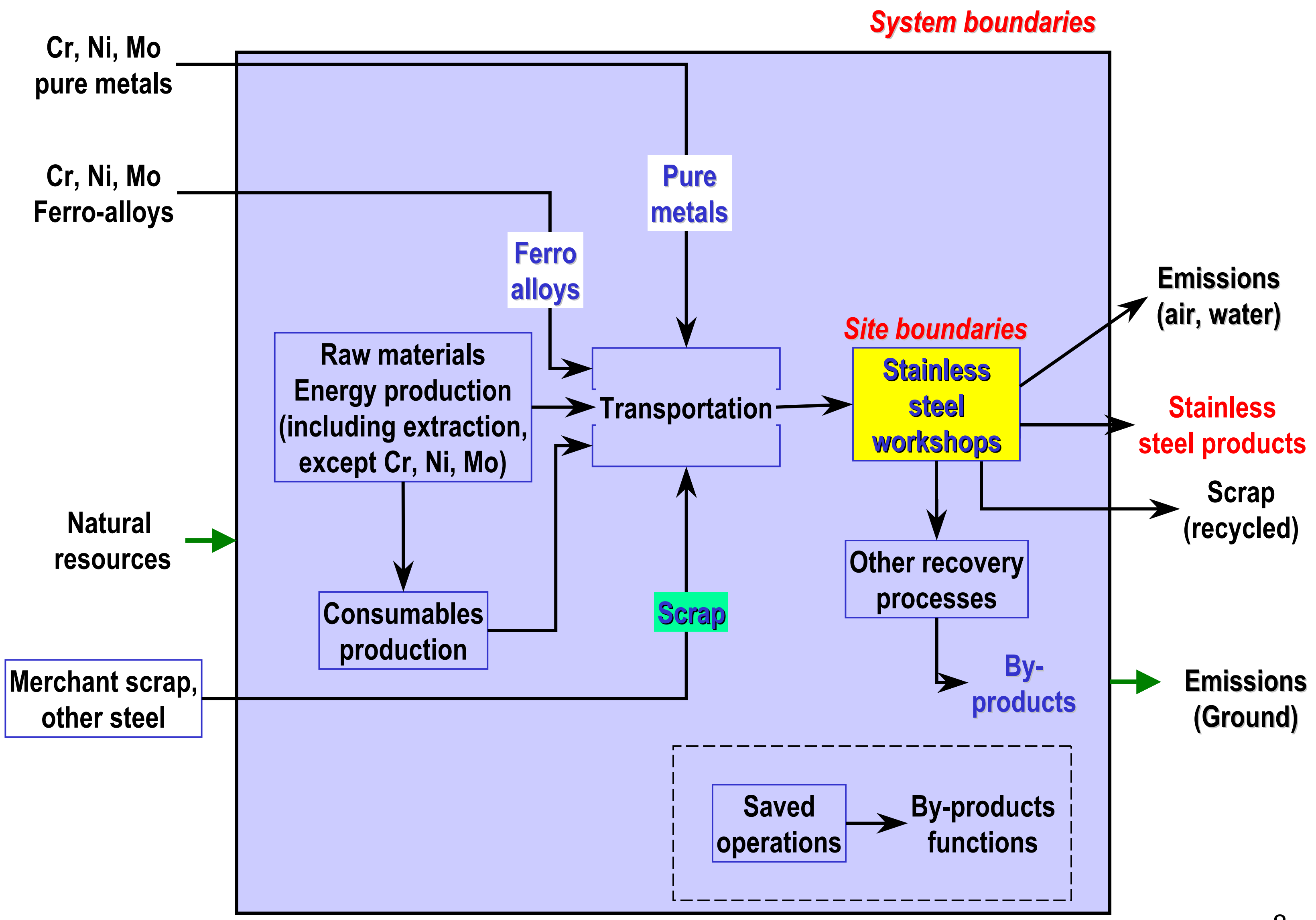
Use

End of Life



Life Cycle Inventory: EUROFER study

The "cradle" to "gate" system



Collecting the data

Process stage questionnaire

- 7 worksheets, 1 per unit process;
- Other inputs or outputs tables:
  - 1 worksheet for energy production;
  - 1 for the effluents;
  - 1 for transportation of raw materials and semi-finished products;
  - 1 for the determination of the routes between different sites of the same company;
  - 1 for inputs and outputs depending on the grades (inputs of the EAF)

Collecting the data

Questionnaire data types

- Measured
  - from continuous measurements;
- Averaged
  - from spot measurements;
- Calculated
  - from statistical or indirect methods (e.g. SO_2);
- Estimated
  - When no better information: e.g. transportation distance of some raw materials;
- Unknown

The data base at a glance

The main results categories

- Inputs
  - Raw materials in the ground
  - Metals and ferro-alloys
  - Water intake
  - Scrap
  - Miscellaneous inputs

- Outputs
  - Emissions to air
  - Emissions to water
  - Waste
  - Recovered Matter

- Energy Indicators

Working with the LCI data

Objectives

- Select the most relevant from 889 flows:
  - Highest data values
  - Hazardous compounds (with regard to health and environment)
  - “Hot spots” even for low values, related to threats of tighter regulation (politics!)
- Prepare readily understandable graphic views

Showing the results for a given route

Sources and process stages

- Sources
  - Ferro-products
  - Fuel production
  - Electricity production
  - Raw materials
  - Transport
  - By-products
  - Site

- Processes involved in a given route
  - Process 1
  - Process 2
  - … Process n
  - Utilities
  - Water intake

Mean values for 304 2B Coil (for 1 tonne)

Inputs: Raw Materials

Flow	Unit	Quantity
(r) Chromium (Cr, ore)	kg	159,2131818
(r) Coal (in ground)	kg	1084,158273
(r) Dolomite (CaCO3.MgCO3, in ground)	kg	48,60535455
(r) Iron (Fe, ore)	kg	154,9569091
(r) Lignite (in ground)	kg	116,8741455
(r) Limestone (CaCO3, in ground)	kg	242,9585455
(r) Manganese (Mn, ore)	kg	18,76907273
(r) Molybdenum (Mo, ore)	kg	0,970445185
(r) Natural Gas (in ground)	kg	293,1247273
(r) Nickel (Ni, ore)	kg	55,90772727
(r) Oil (in ground)	kg	360,9903636

Mean values for 304 2B Coil (for 1 tonne)

Inputs: Scrap

Flow	Unit	Quantity
Stainless Steel Scrap (304, from external supply)	kg	502,4904545
Stainless Steel Scrap (316, from external supply)	kg	5,320859455
Stainless Steel Scrap (409, from external supply)	kg	15,97287909
Stainless Steel Scrap (430, from external supply)	kg	6,592498455
Steel Scrap (low alloy, from external supply)	kg	20,91885455
Carbon Steel Scrap	kg	187,1359182

Mean values for 304 2B Coil (for 1 tonne)

Inputs: Water and Energy

Flow	Unit	Quantity
Water Used (direct cooling or process, total)	litre	75735,13636
Water Used (indirect cooling, total)	litre	8435,409091

Energy indicator	Unit	Value
E Feedstock Energy	MJ	4045,923
E Fuel Energy	MJ	57939,600
E Non Renewable Energy	MJ	59584,527
E Renewable Energy	MJ	2424,078
E Total Primary Energy	MJ	62042,536
Electricity	MJ ele	9691,726

Mean values for 304 2B Coil (for 1 tonne)

Outputs: Air

Flow	Unit	Quantity
(a) Carbon Dioxide (CO_2, fossil)	g	6183152,727
(a) Carbon Monoxide (CO)	g	14129,73182
(a) Chromium (Cr III)	g	24,93037273
(a) Chromium (Cr III, Cr VI)	g	119,3759745
(a) Chromium (Cr VI)	g	0,122884645
(a) Dioxins (unspecified)	g	7,67958E-06
(a) Molybdenum (Mo)	g	6,560222691
(a) Nickel (Ni)	g	76,0908
(a) Nitrogen Oxides (NO_x as NO_2)	g	21146,85455
(a) Particulates (unspecified)	g	7914,111818
(a) Sulphur Oxides (SO_x as SO_2)	g	41218,97273

Mean values for 304 2B Coil (for 1 tonne)

Outputs: Water

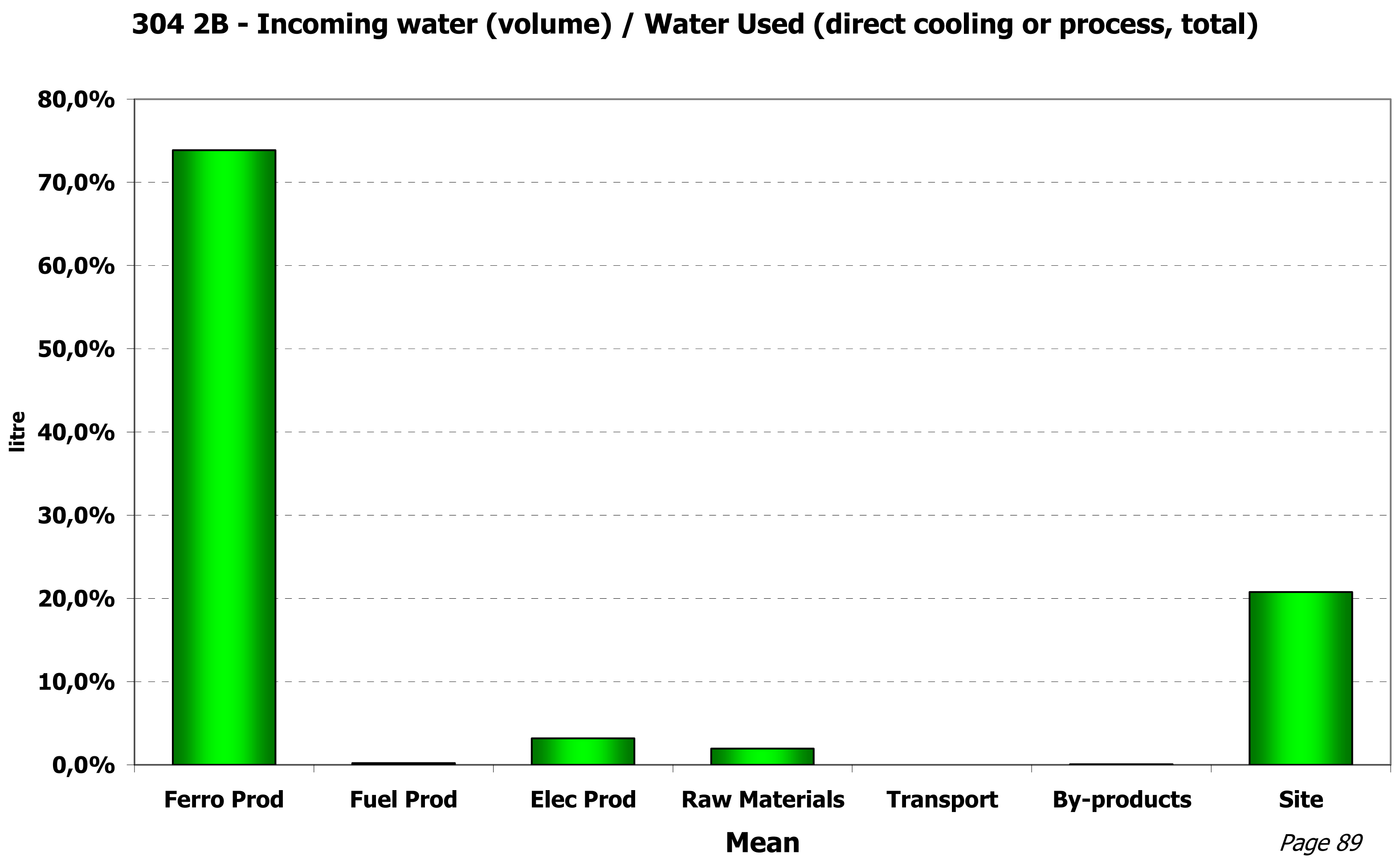
Flow	**Unit**	**Quantity**
(w) Acids (H^+)	g	103,243
(w) Ammonia (NH_4^+, NH_3, as N)	g	126,854
(w) Cadmium (Cd^{++})	g	0,074
(w) Chromium (Cr III, Cr VI)	g	2,788
(w) COD (Chemical Oxygen Demand)	g	2770,215
(w) Copper (Cu^+, Cu^{++})	g	0,451
(w) Fluorides (F^-)	g	153,388
(w) Hydrocarbons (unspecified)	g	74,758
(w) Iron (Fe^{++}, Fe^{3+})	g	227,467
(w) Lead (Pb^{++}, Pb^{4+})	g	1,785
(w) Manganese (Mn II, Mn IV, Mn VII)	g	6,453
(w) Nickel (Ni^{++}, Ni^{3+})	g	11,732
(w) Nitrate (NO_3^-)	g	3611,607
(w) Nitrogenous Matter (unspecified, as N)	g	4253,326
(w) Silicon Dioxide (SiO_2)	g	433,909
(w) Sulphurated Matter (unspecified, as S)	g	1839,604

Flow charts

Depiction of the LCI results in a more readily digestible format

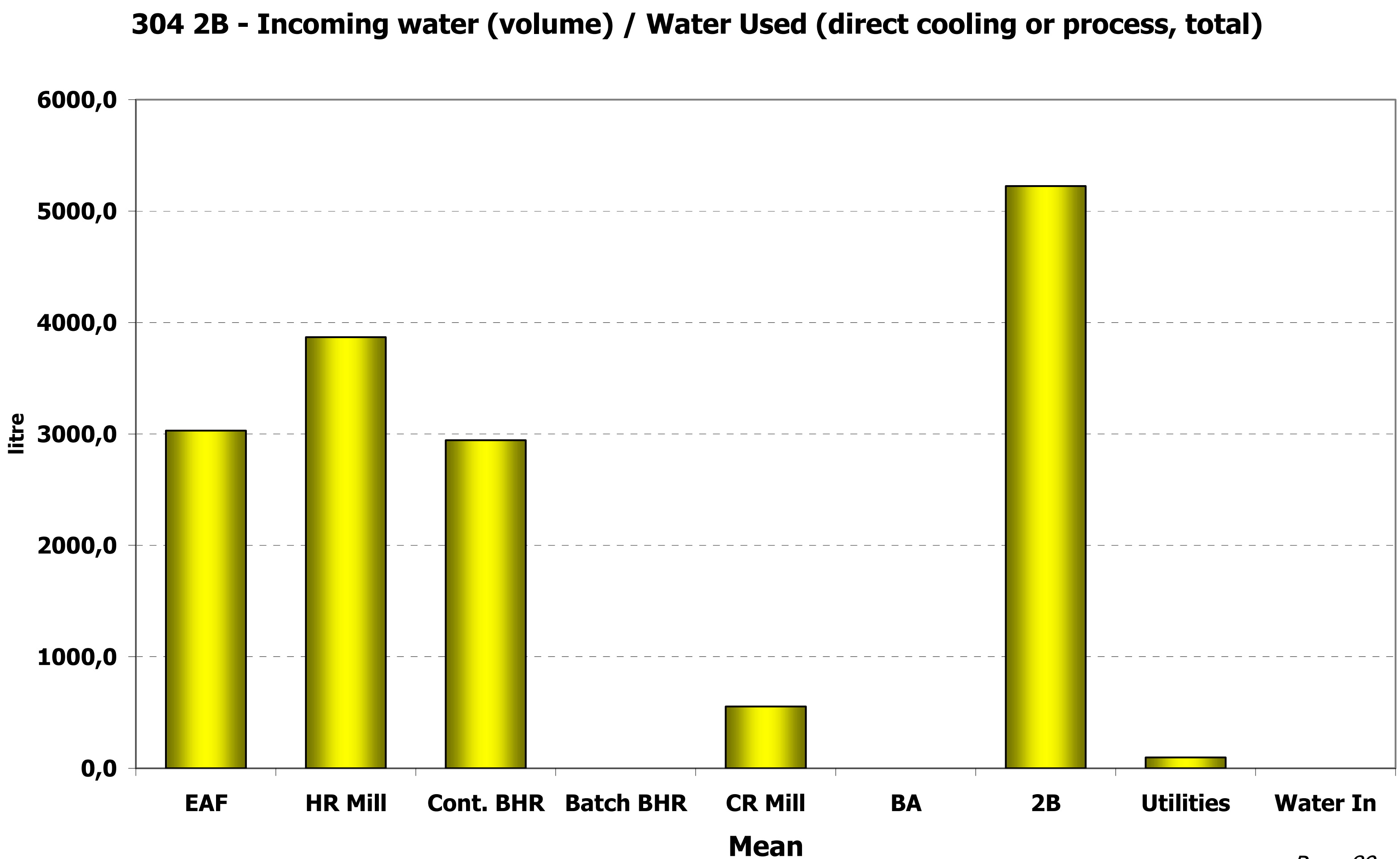
Contribution of the sources (%)

Input: Water



Contribution of the process stages

Input: Water



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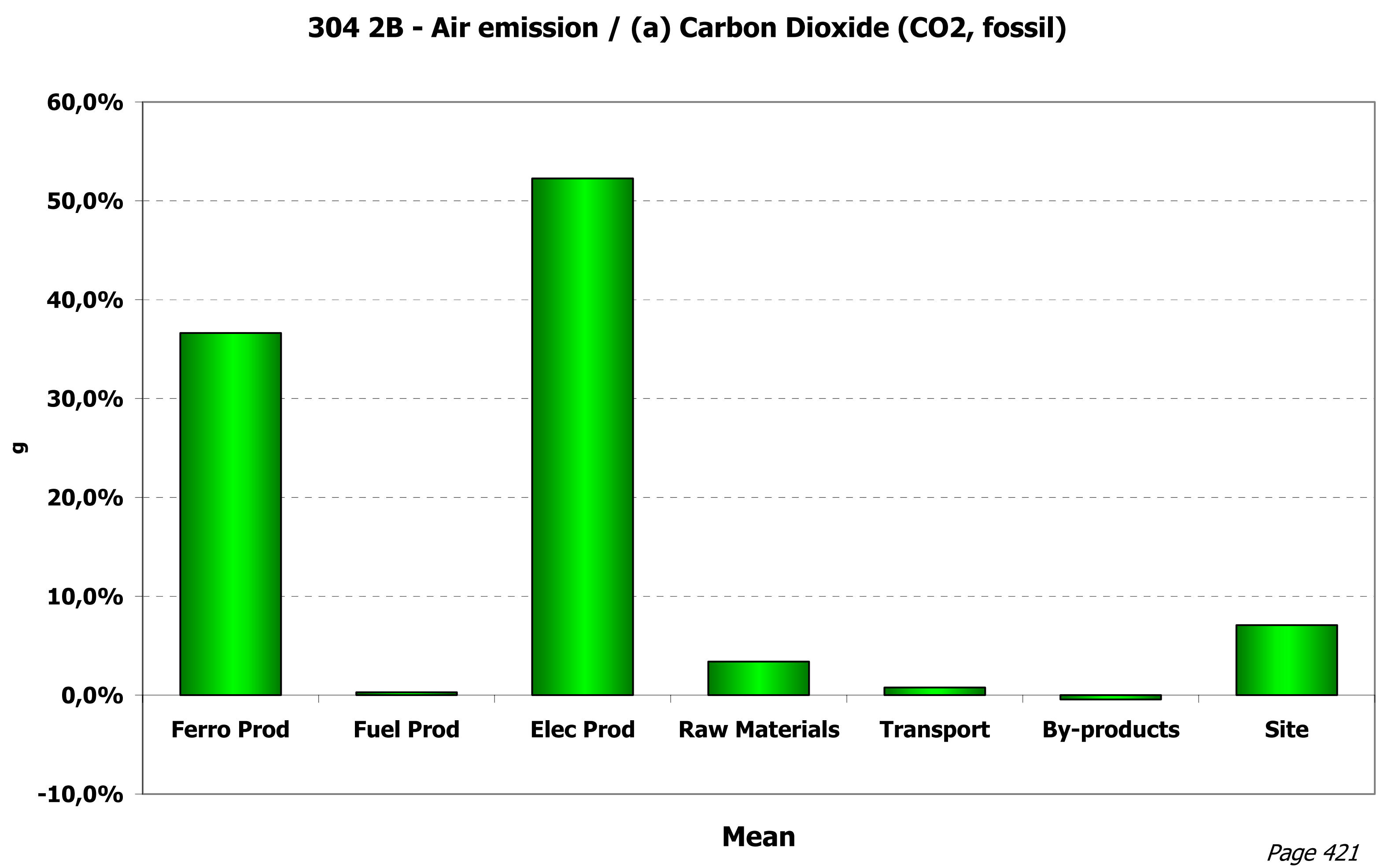
Contribution of the sources (%)

Emissions to air: CO_2



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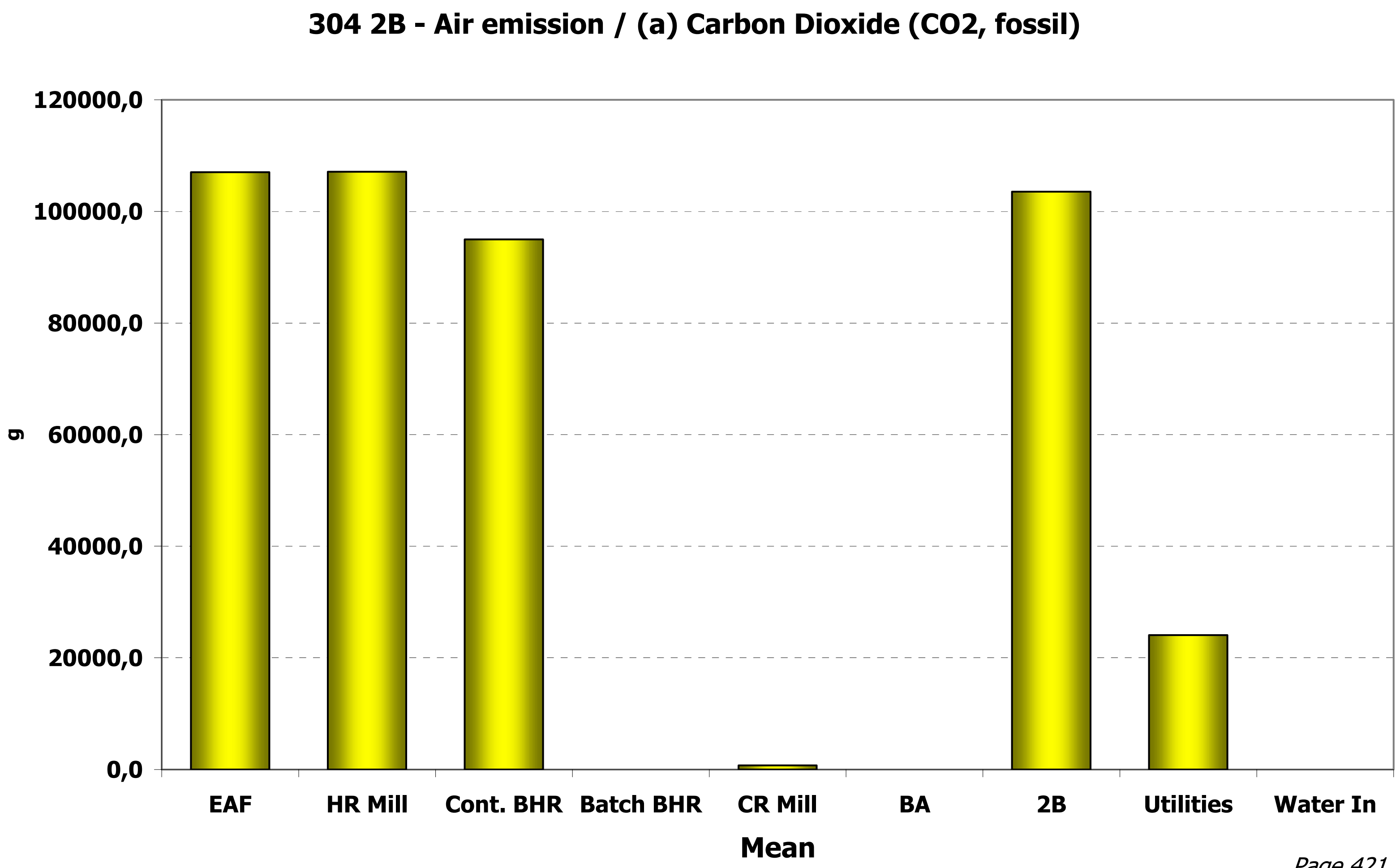
Contribution of the process stages

Emissions to air: CO_2



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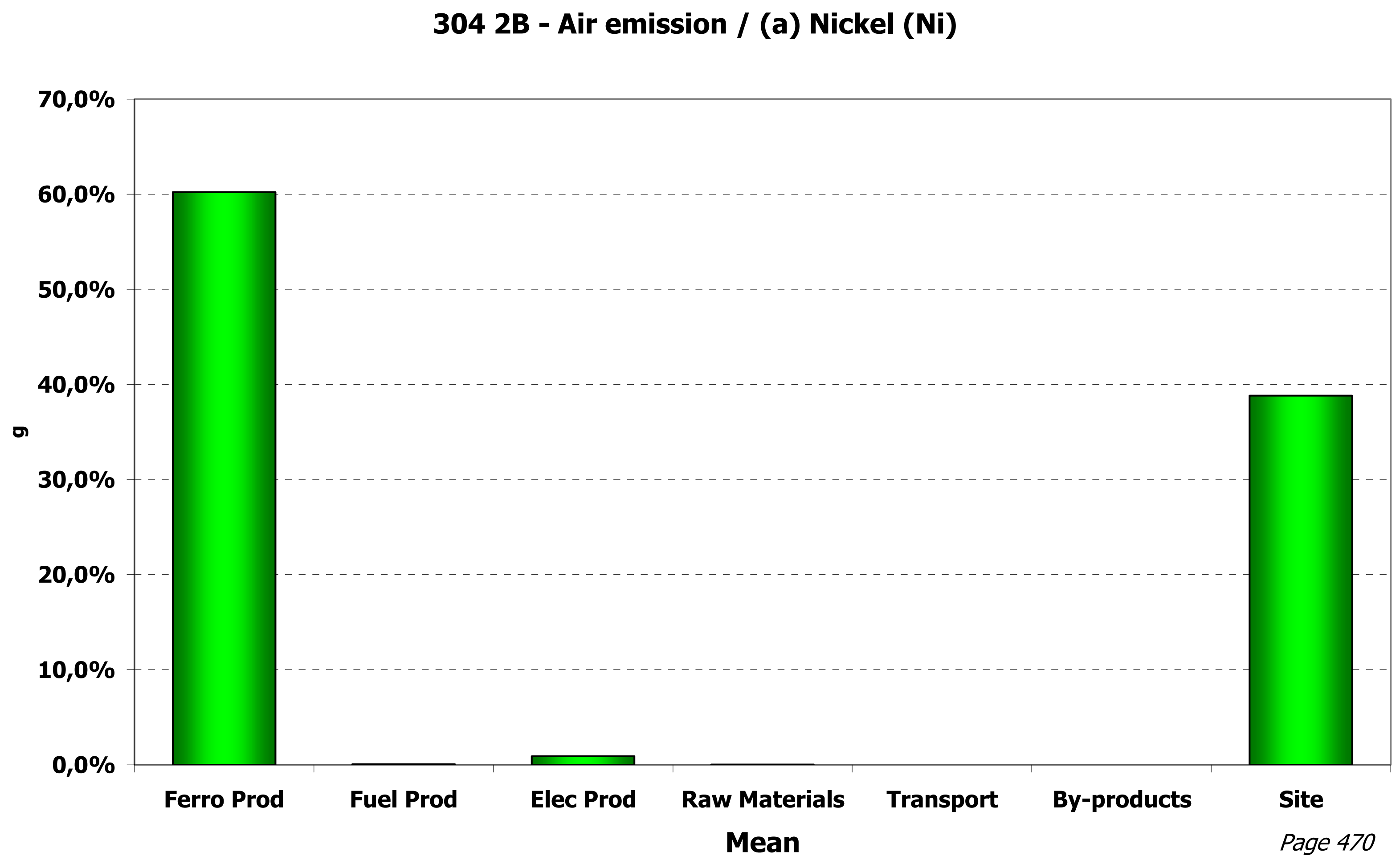
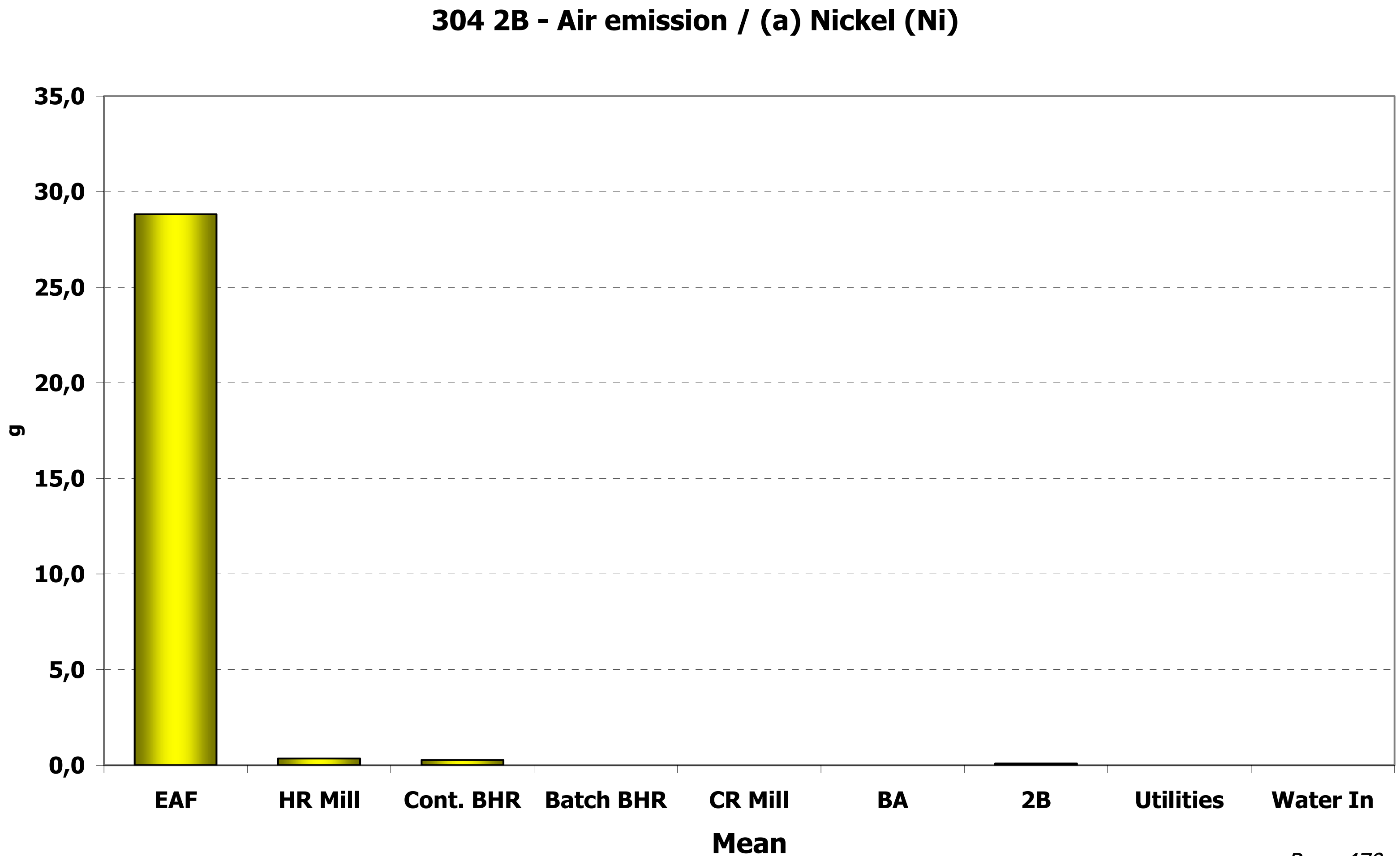
Contribution of the sources (%)

Emissions to air: Ni



Contribution of the process stages

Emissions to air: Ni



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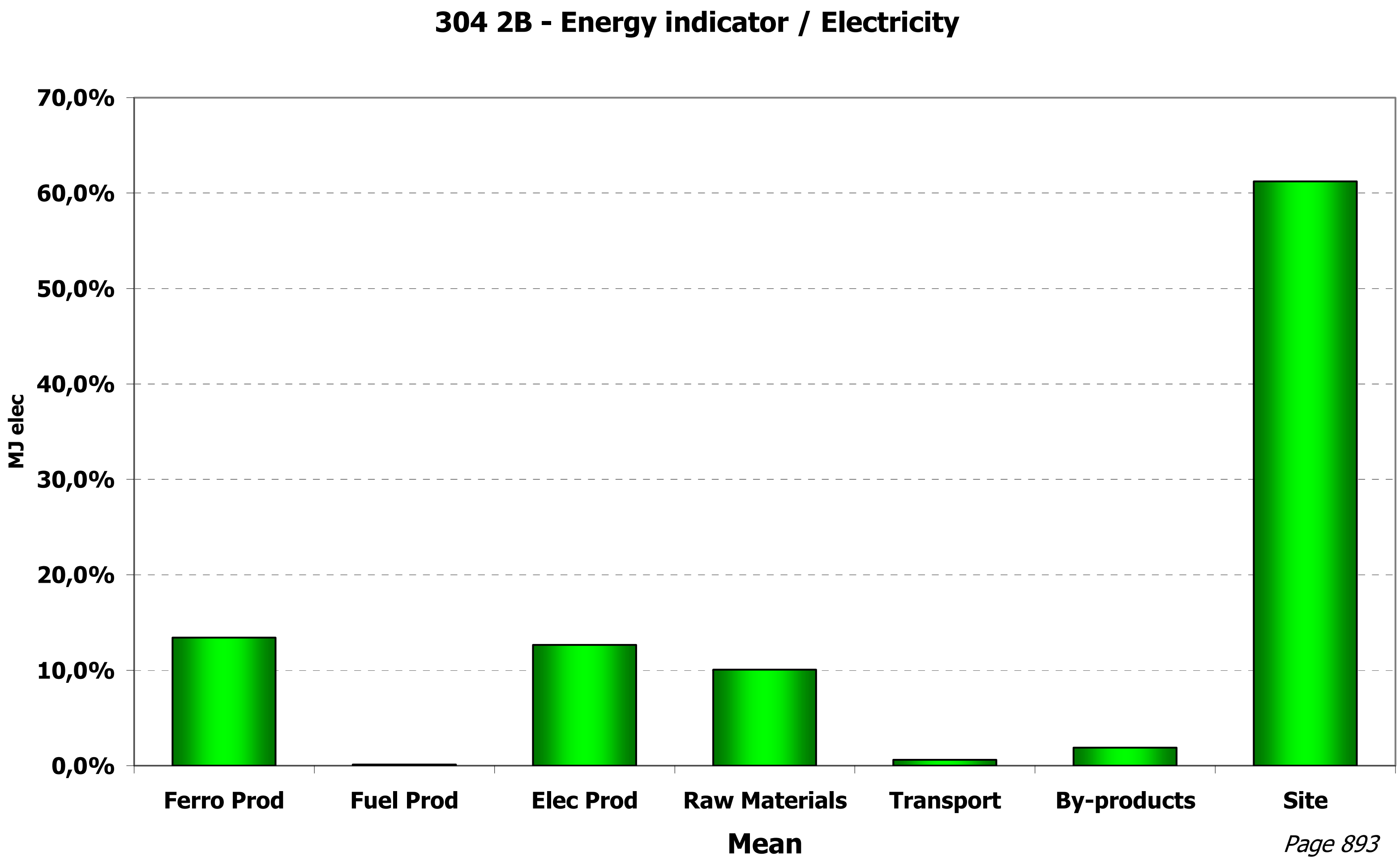
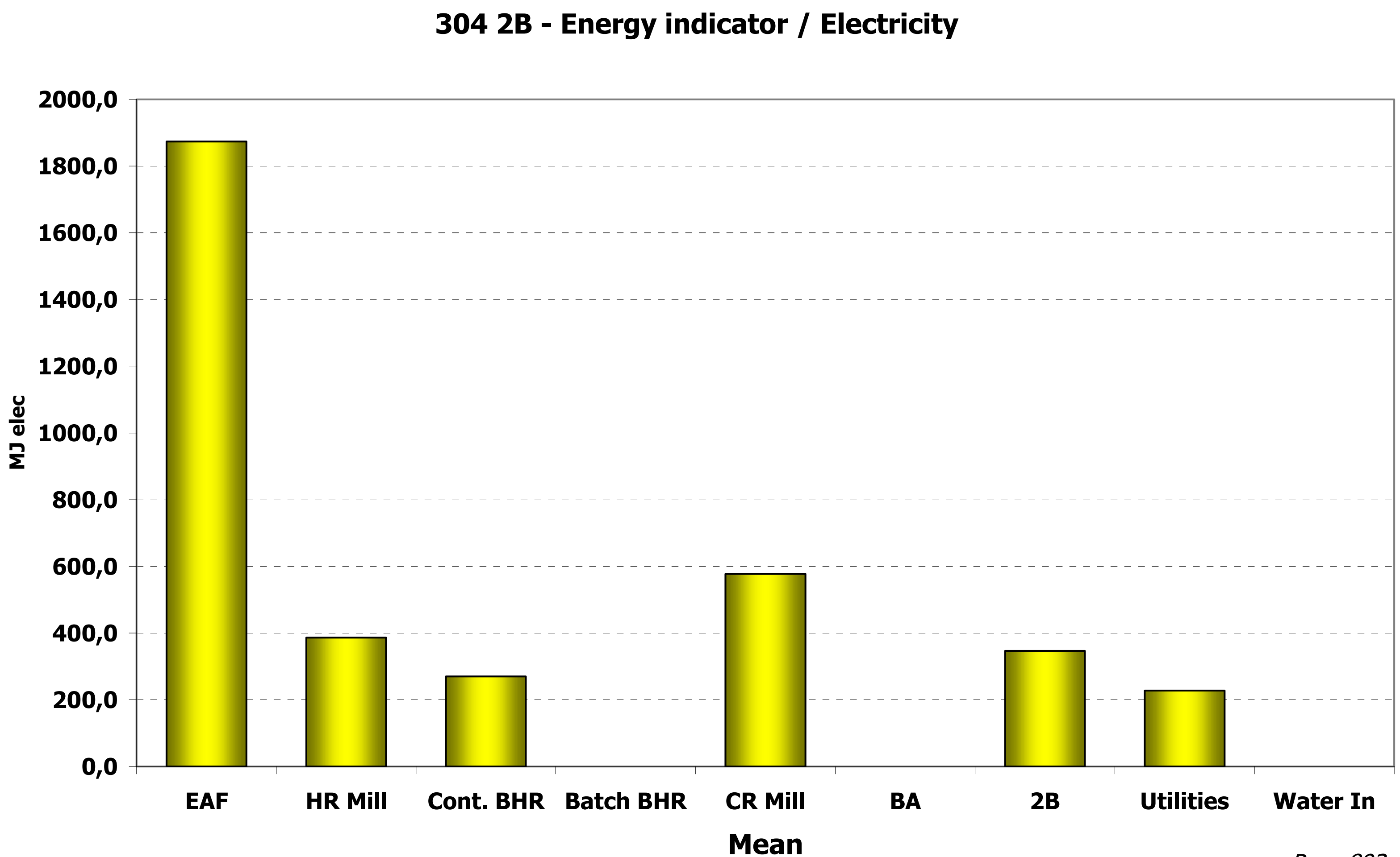
Contribution of the sources (%)

Energy: Electricity



Contribution of the process stages

Energy: Electricity



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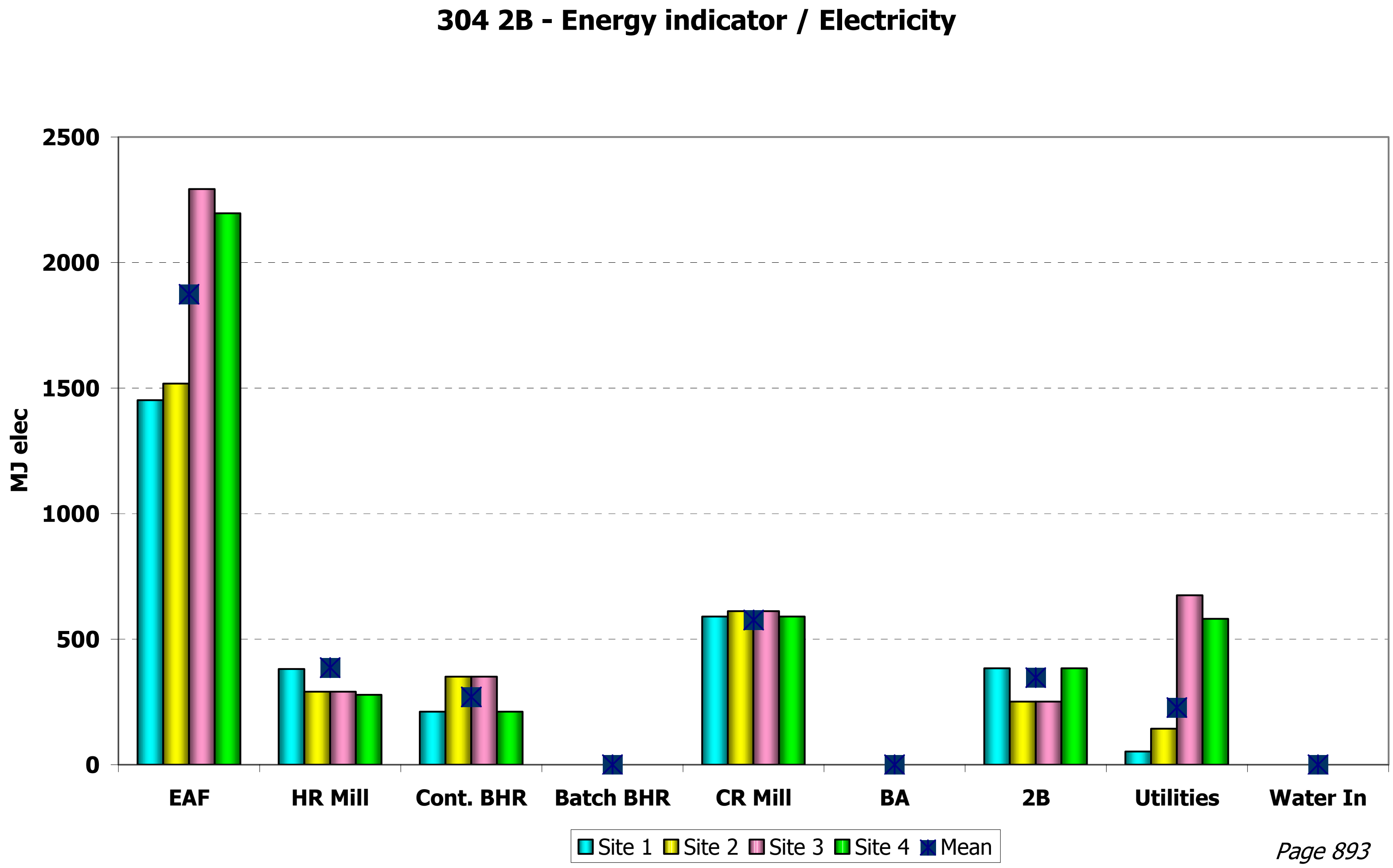
Benchmarking between sites / producers

Energy: Electricity



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Problems & complexities

- Easy to overstate the data requirements.
- Hence, a lot of time and effort can be spent on looking for data that finally proves to be inconsequential.
- However, only when you have the first set of data can you truly decide what are the key flows.
- The “updating” LCI should be quicker and easier than the first, but will it be better?

Raw materials (metals & scrap)

Problems & complexities, continued

- Different sources of alloying metals. Not all were included in the LCI studies, so affecting average values; and non-included sources may be used in EU stainless steel production.
- Scrap is a variable but generally high percentage feedstock for stainless steel production: should we/can we factor in first production parameters, recycling efficiency, number of cycles?
- Do our assumptions match the presumptions of the data users?

Problems & complexities, continued

• “Beyond the gate” introduces many Complexities:

• Stainless steel is a very widely used product with a huge range of applications (industrial, architectural, domestic and medical). Some of these use large quantities, others use much less; and some products have lives of at least decades while others may be short-lived.

• Taken together with the question of recycling statistics and their reliability, “beyond the gate” is a problem that will not be easily tackled.