Research Fund for Coal & Steel

LVS3

Large Valorisation on Sustainability of Steel Structures

BACKGROUND INFORMATION: LCA METHODOLOGY

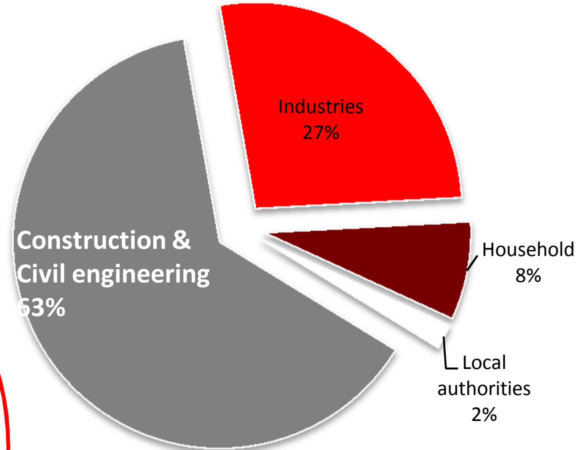
ArcelorMittal

June 2014

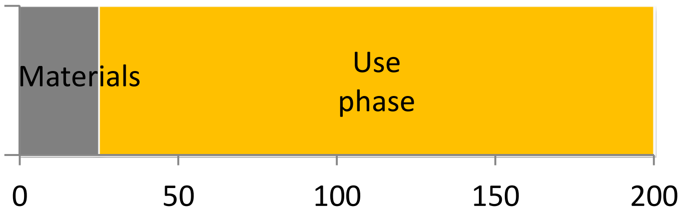
Context of the construction sector

In Europe, the construction sector represents:

Share of deposited wastes in France



Distribution of energy consumption of a building (kWh/m².year)



We spend **90%** of our time **inside buildings**

Sources: Ademe, EU commission

Agenda

1) Basic notions

- Sustainable development and life cycle thinking
- Life cycle assessment

2) Environmental assessment of buildings

- Scales of assessment
- Environmental product declarations
- CEN TC350: Context, main concepts
- Focus on module D

3) Environmental assessment of steel

- The cycle of steel
- Benefits of recycling

1) Basic notions

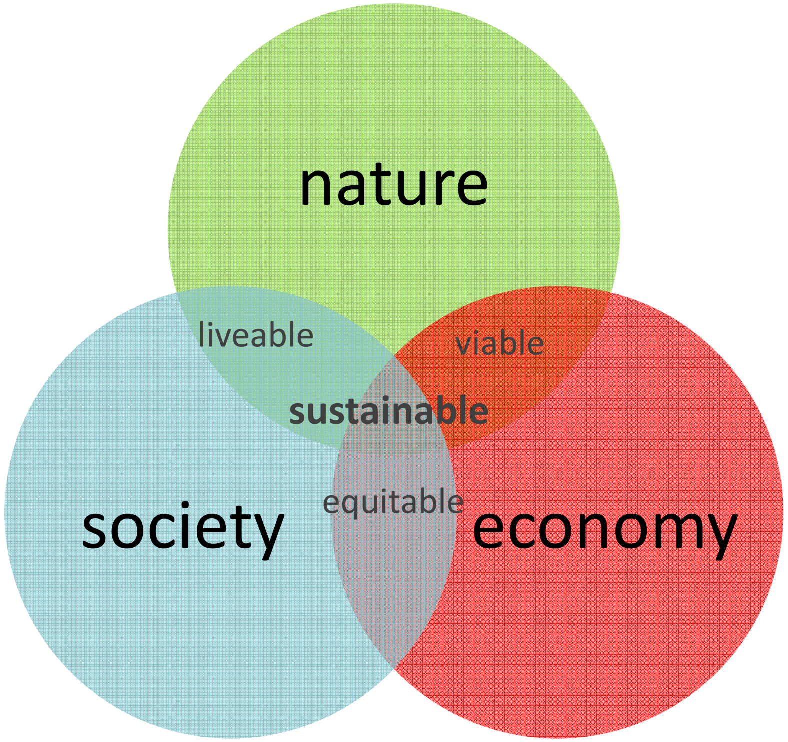
Sustainable development

“sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs.“

Brundtlandt Report

(World Commission on Environment & Development, 1987)

3 pillars of sustainable development



Why is it so critical?

- Understand and anticipate where our supply chain costs might increase in the future due to environmental issues
- Understand where our supply chain can be impacted by societal issues
- Demonstrate the sustainable value of steel products & solutions through
  - Environmental benefits of steel and cost effectiveness
  - Local societal impact on stakeholders (job created, etc.)
  - Social benefits of material products and solutions (cans, bridges, etc.)
  - Capacity to integrate low income populations into the value chain
  - …
- Decisions of today outlines issues future generations will have to deal with
- Steel industry should be part of the solution

> “The world cannot succeed without business as a committed solution provider to sustainable societies and ecosystems”
> WBCSD President Bjorn Stigson

Environmental assessment tools

- Environmental Management System (site/company specific, ISO 14000)
- Greenhouse Gases (GHG) Protocol (Company level, site level)
- Life Cycle Assessment (LCA), LC Costing, Social LCA (product/service specific)
- Eco-design, Design for X
- Health Risk Assessment, Ecosystem Risk Assessment
- Indicators (GRI, IBGN, Ecological footprint…)
- Cost-Benefit Analysis, Environmental Economy
- ….

Life Cycle Thinking

- The way to identify possible improvements to goods and services in the form of lower environmental impacts and reduced use of resources across all life cycle stages.

Source: JRC

LCT in European Policy

- The **Sustainable Consumption and Production Action Plan** aims to reduce the overall environmental impact and consumption of resources associated with the complete life cycles of goods and services (products)
- **Integrated Product Policy Communication** (COM(2003)302)
- **Thematic Strategy on the Sustainable Use of Natural Resources** (COM(2005)670)
- Thematic Strategy on the **Prevention and Recycling of Waste** (COM(2005)666)

Life cycle thinking : Why?

1. Local action vs global impact
2. Shift of pollution from one life cycle stage to another
3. Shift of pollution from one environmental impact to another

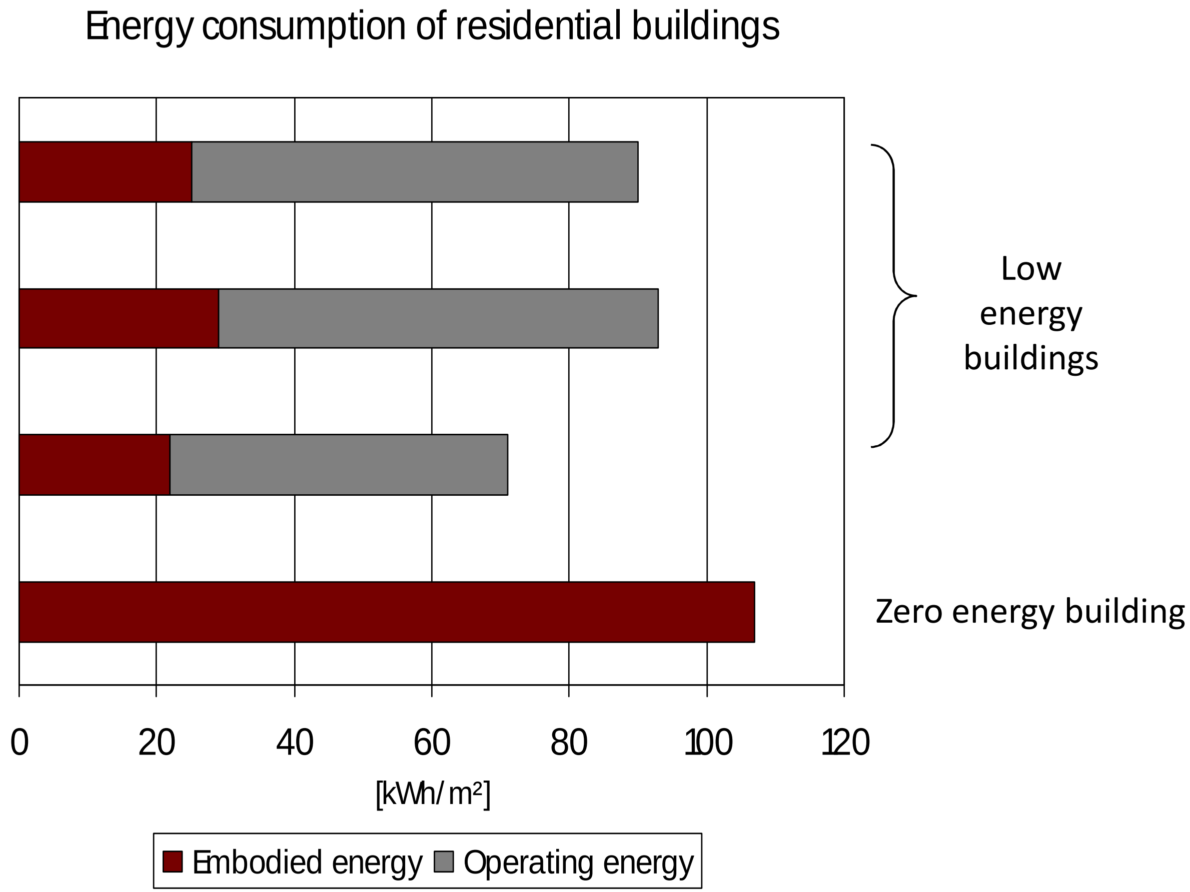
1 – Local action vs global impact

Credit : CIRAIG

1 – Local action vs global impact

Credit : CIRAIG

2 – Shift of pollution from one life cycle stage to another

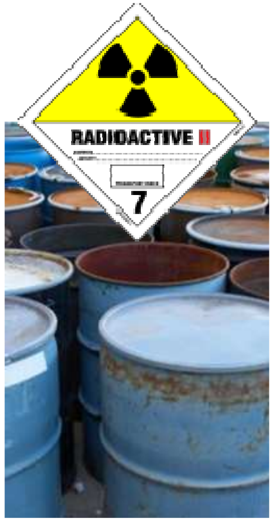


Source: Energy and Buildings 42 (2010) 1592–1600

3 – Shift of pollution from one environmental impact to another

Prevent displacing environmental problems!

But other emissions



Credit : CIRAIG

Life Cycle Assessment

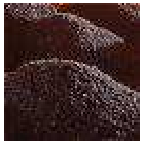
- Definition

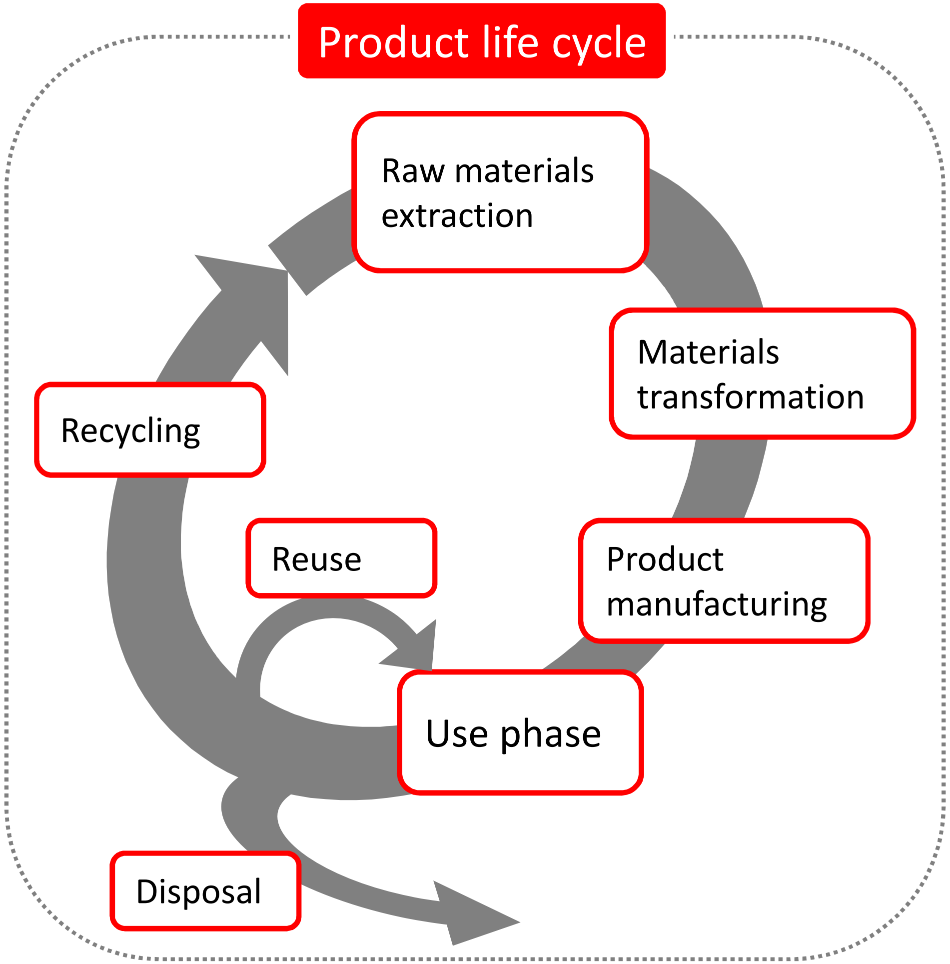
> Analyses the potential environmental burdens of a product or service in its production, use phase and disposal (end of life).

- Benefits
  - Internal
    - Detection of strategic risks and environmental issues
    - Development of sustainable products based on environmental information ⇨ Ecodesign
    - Communication with politics and authorities
  - External
    - Improvement of image due to ecological considerations
    - Supporting environmental innovations and decrease of environmental impacts
    - Competitive advantage by inclusion of environmental aspects

Life Cycle Assessment

Consumption of resources

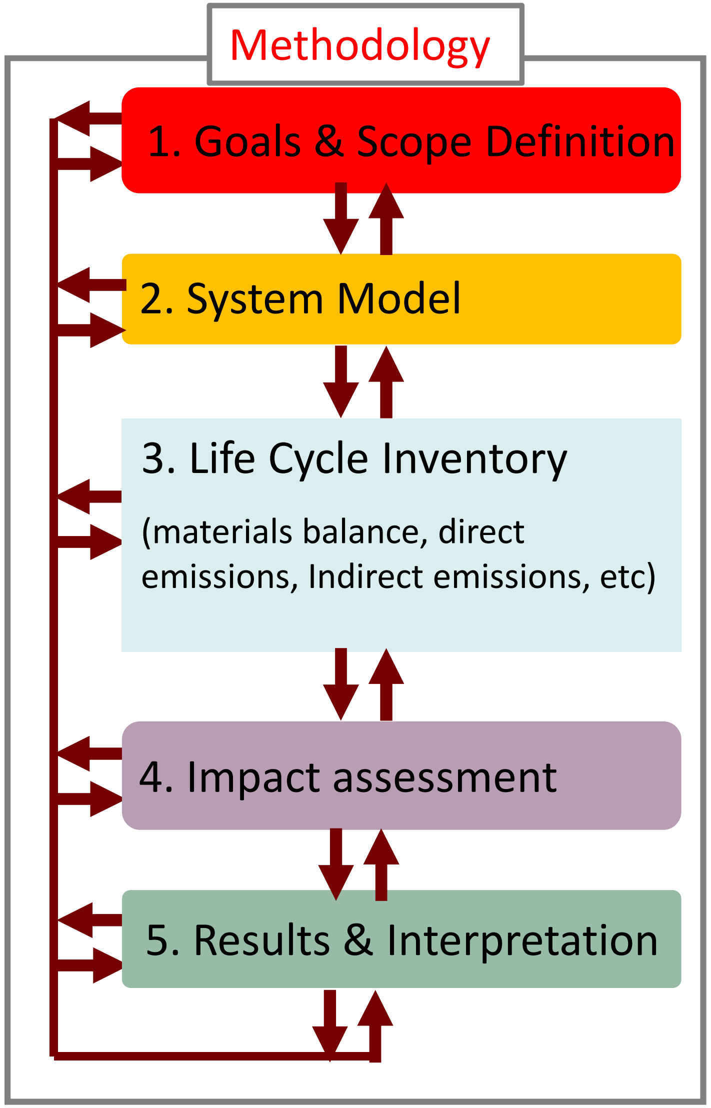




Emissions and wastes to the environment

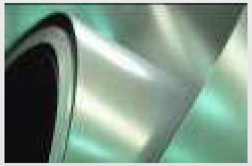
Life Cycle Assessment

- Generic method, for all products and services, providing environmental information following international standards (ISO 14040 and 14044)
- These standards do not impose a preferred method for allocation, indicators, frontiers of the system under study ⇨large degree of freedom
- An LCA does not address
  - REACH
  - Environmental risk
  - Worker safety
  - Economic and social issues
  - Companies’ carbon footprint



Life Cycle Assessment

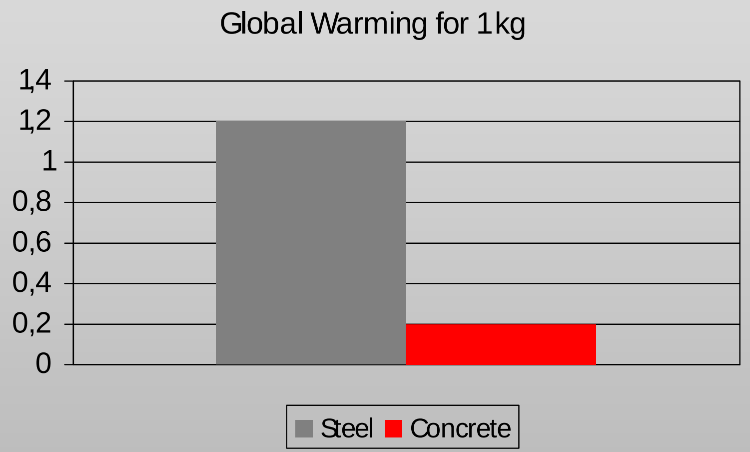
- Keyword #1, the functional unit: object of an LCA study
  - Examples: 1m² of cladding, 1 beam for a specific span and load, 1kg of cement
  - *Comparisons between products only for equivalent functions*



vs.

1kg steel

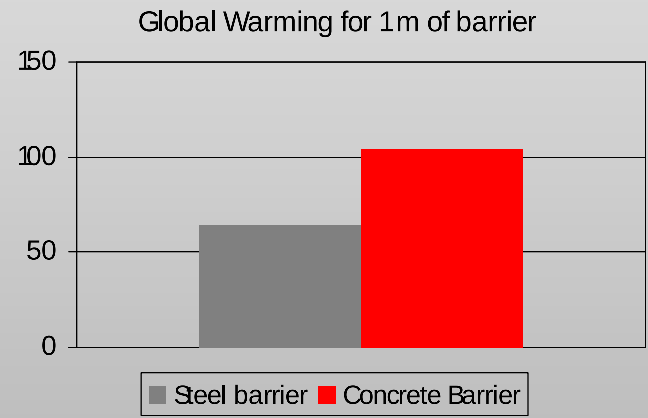
1kg concrete



vs.

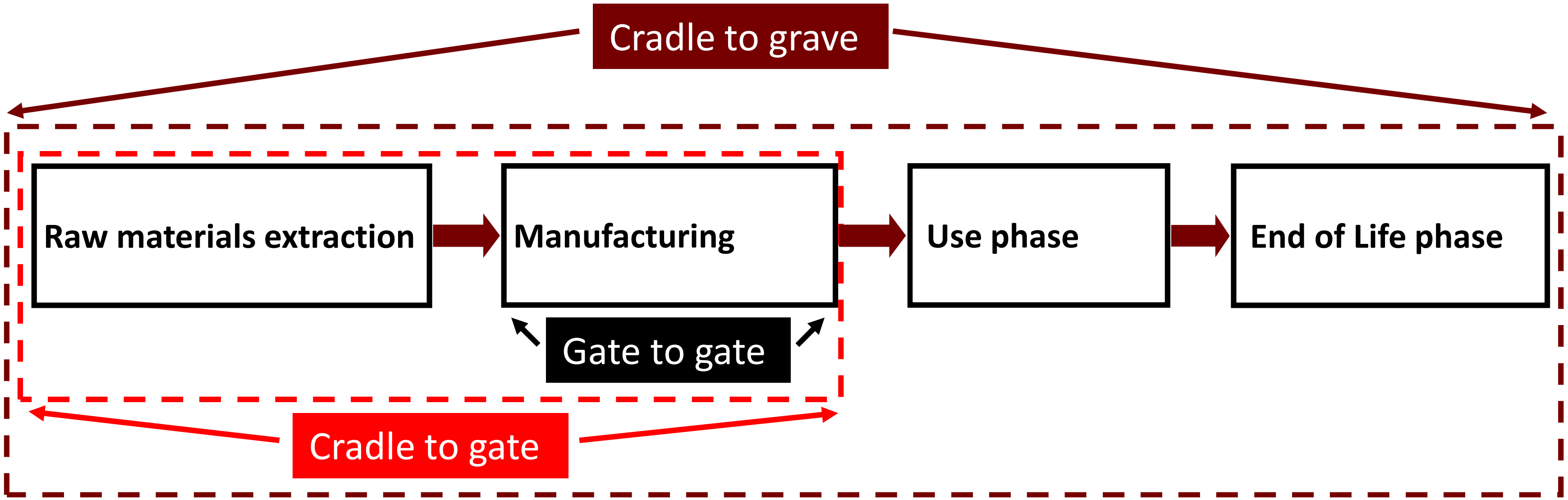
1m steel barrier

1m concrete barrier



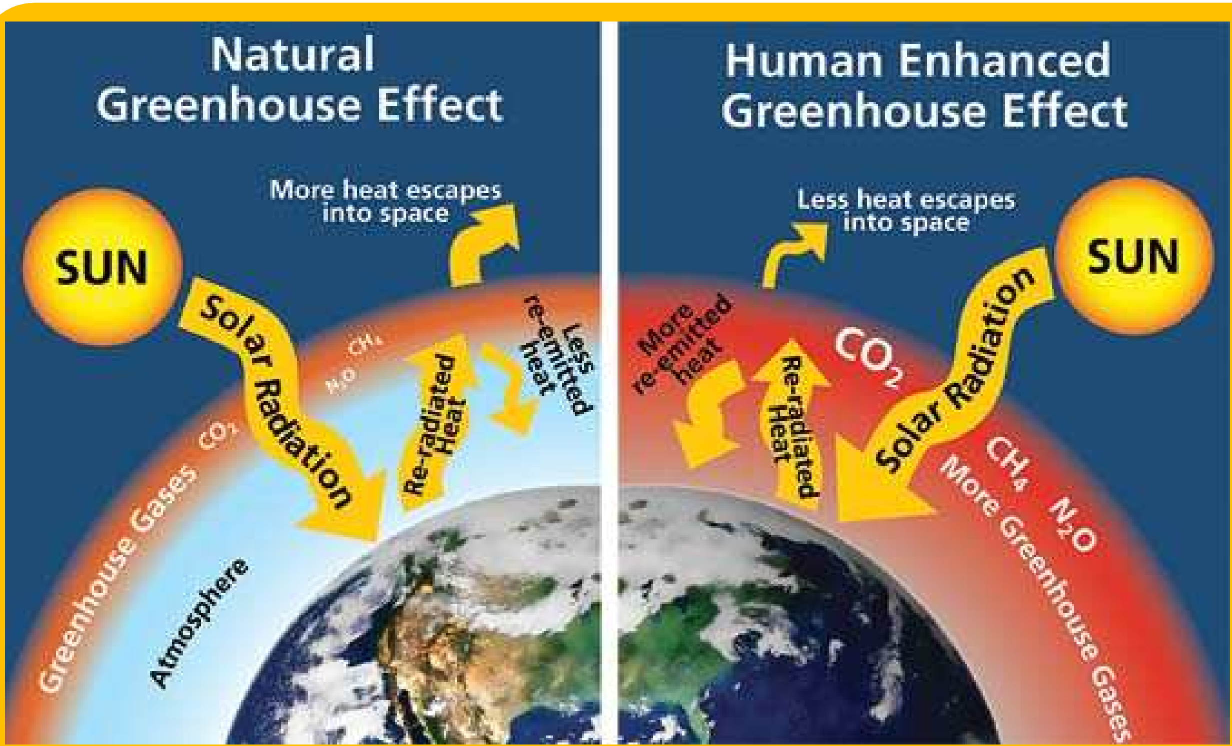
Life Cycle Assessment

- Keyword #2, the frontiers of the system
  - In transport and construction fields, use phase can account for 80-90% of the environmental burdens



Life Cycle Assessment

- Keyword #3, the environmental indicators
  - Consumptions, emissions and wastes are transformed into impacts
  - Example: Global Warming Potential (GWP)



Naturally occurring greenhouse gases normally trap some of the sun’s heat, keeping the planet from freezing.

Human activities, such as the burning of fossil fuels, are increasing greenhouse gas levels, leading to an enhanced greenhouse effect. The result is global warming and unprecedented rates of climate change.

http://www.nps.gov/goga/naturescience/climate-change-causes.html

Life Cycle Assessment

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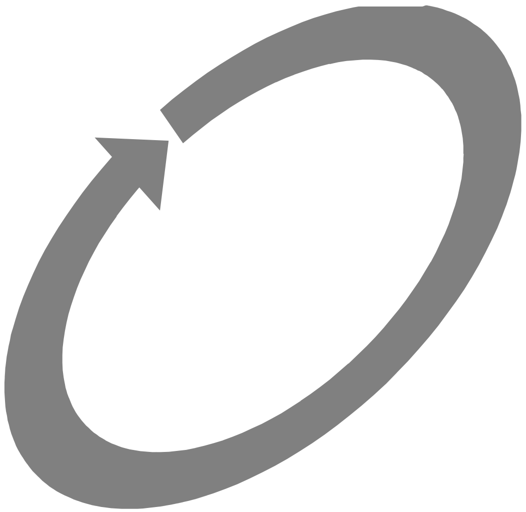
Product life cycle



Emissions of greenhouse gases	Conversion into GWP impact
	Model developed by the IPCC
100 kg CO_2	1 * 100 kg CO_2eq
10 kg CH_4	25 * 10 kg CO_2eq
1 kg N_2O	298 * 1 kg CO_2eq

GWP = 648 kg CO_2eq

Life Cycle Assessment

- Keyword #4, the peer review
  - Performed by an independent expert, in addition to a panel of interested parties for comparative assertions
  - Cost 7k€ – 20k€
- Compliance to different standards depending on the type of study
  - Generic LCA studies: ISO 14040 – 44
  - Generic environmental declaration: ISO 14025
  - Environmental declaration for construction products worldwide: ISO 21930
  - Environmental declaration for construction products in Europe: EN 15804
  - Environmental declaration for construction products in France: either NF P01-010 or NF EN 15804, after 2014, only EN 15804

Life Cycle Assessment

- Keyword #5, data
- In practice, a gigantic amount of data is necessary to model the all the life of a product (quarries, energy conversion, landfill, transportation means, etc)
  - Need for generic databases providing reliable averages for specific geographical areas (e.g. the production of 1kWh of electricity in France)
- Many databases exists, each with their own quality
  - Industrial databases (worldsteel, Plasticseurope, Betie, etc - free)
  - Ecoinvent (Swiss research centres – largest database in the world – mostly theoretical modelling – expensive)
  - GaBi (German consulting company – work with industries incl worldsteel – expensive)
  - Inies (for construction product FDES – not necessarily verified – former French standard – free)
  - Diogen (focused on civil engineering products – former French standard – free)

Life Cycle Assessment

- Methodological issues raising debates among practitioners
  - Allocation (share of impacts between by-products)
    - Distinction between by-products and wastes
    - Physical (weight, stoechiometry) or economic basis
    - May have large influence on the result
  - End-of-life
    - Accounting for the benefit of recycling
    - Benefit for user or producer of the scrap?
    - What about downcycling, valorisation etc?
  - Data sources
    - Quality of data
    - Representativeness
    - Consistency between methods (frontiers, allocation)

2) Environmental assessment of buildings

Many levels of assessment

1. Components (facades, roofing, structural elements etc) can bedescribed by EPD, often gathered by a program holder

Institut Bauen und Umwelt e.V.

EPD

2. Energy efficiency is either regulated or labelled
   - RT 2012 (FR)
   - Minergie (CH)
   - PassivHaus (DE) etc

3. Building certifications evaluate the complete building, and might integrate social and economical aspects

breeam

LEED

4. Full building LCA: assessment of the complete life cycle of the building, taking into account its constituting materials and its thermal efficiency

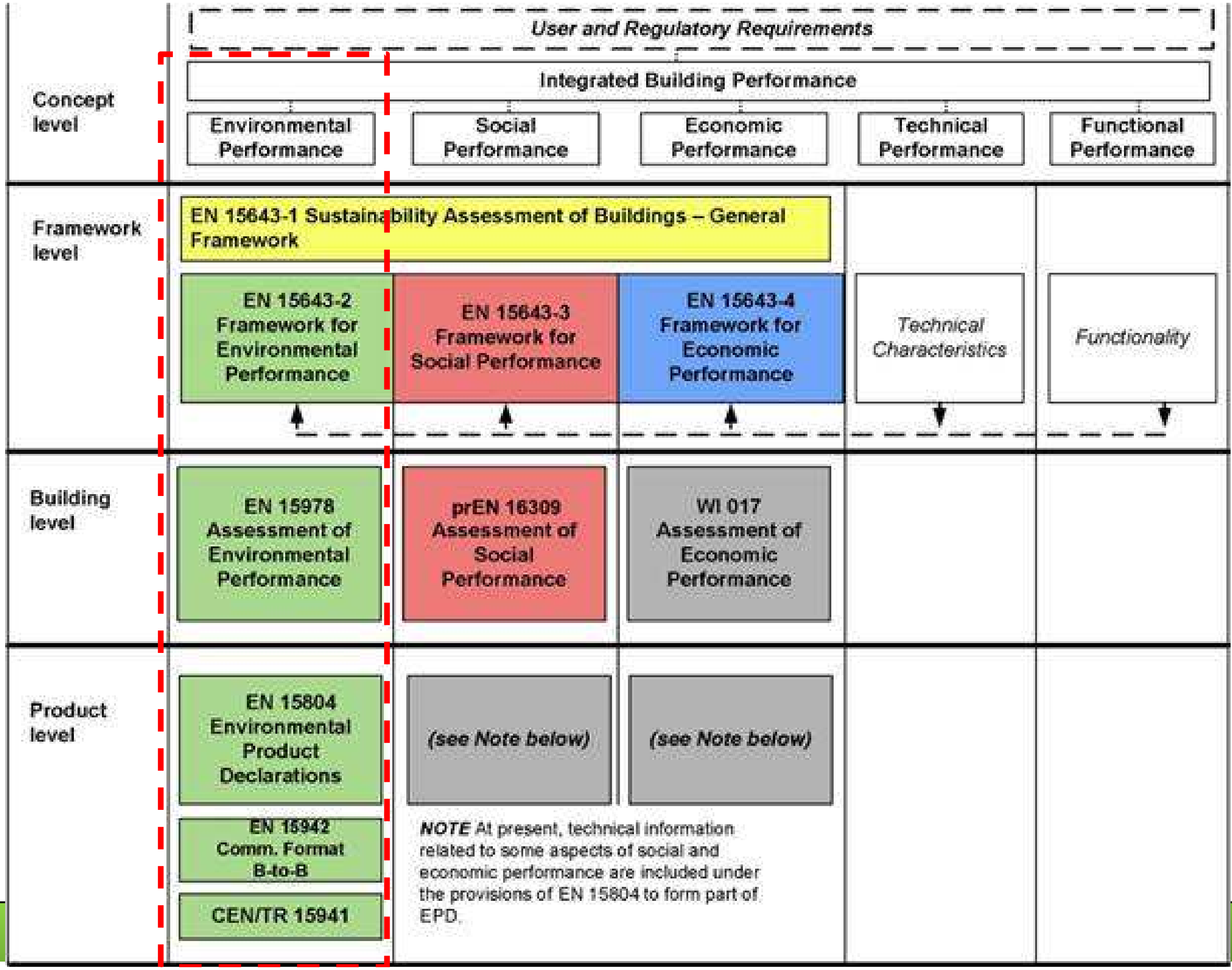
Standardization of the environmental assessment of buildings: The works of the CEN TC350

Context

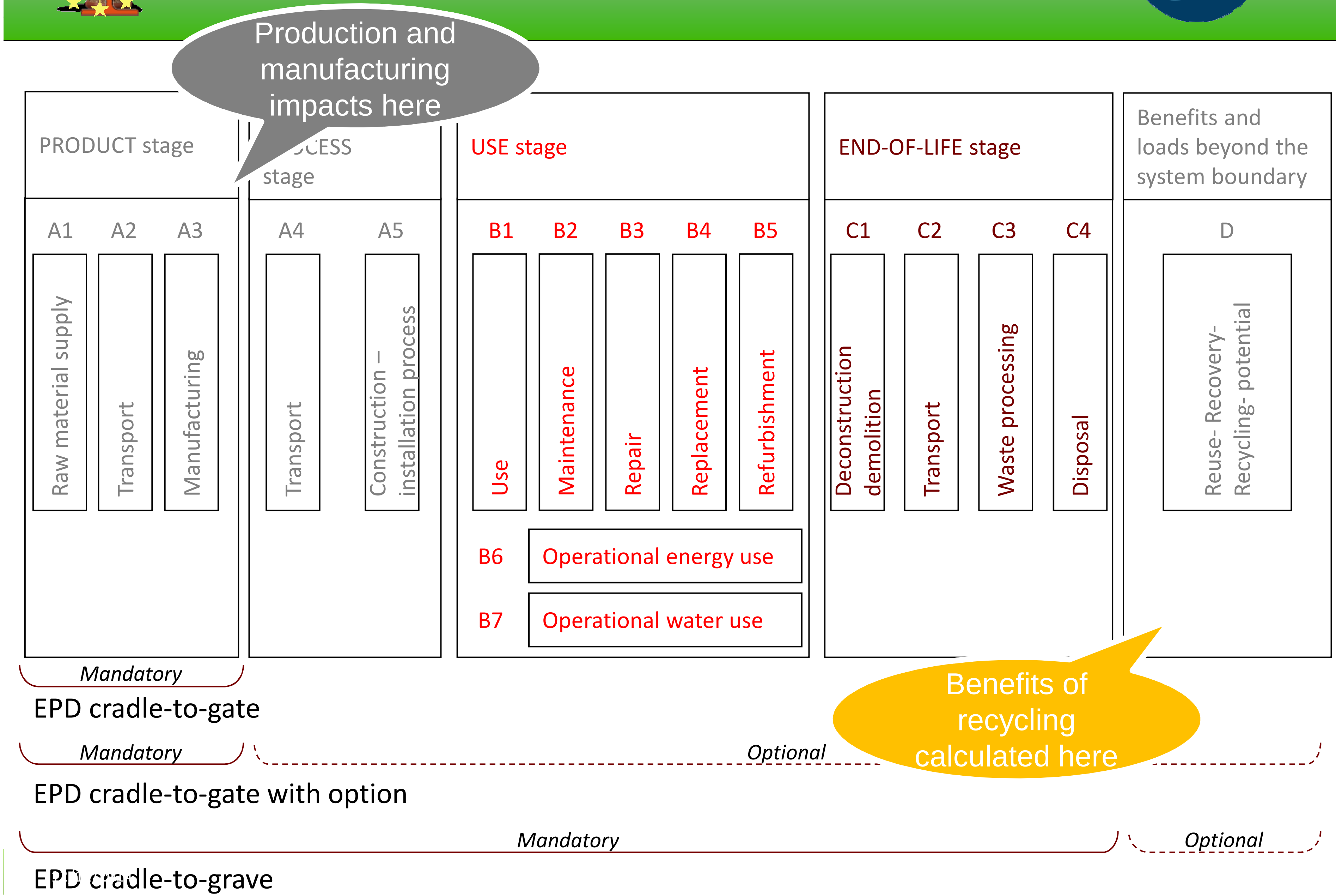
- European Commission mandate to the CEN committee for the development of horizontal standardized methods for the assessment of the integrated environmental performance of buildings

CEN/TC350 Structure

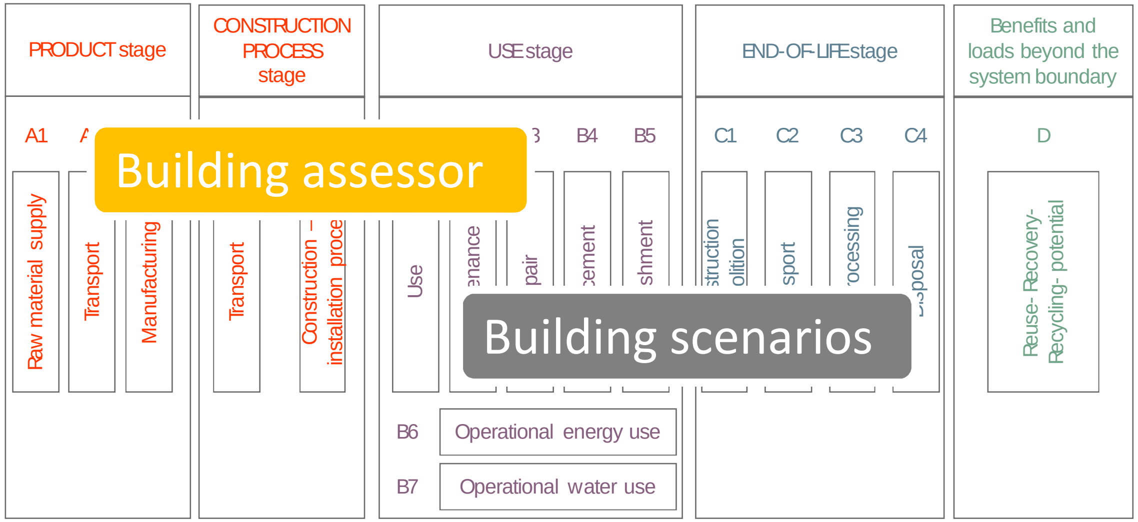
- 3 pillars, 4 levels



Key concept: modularity

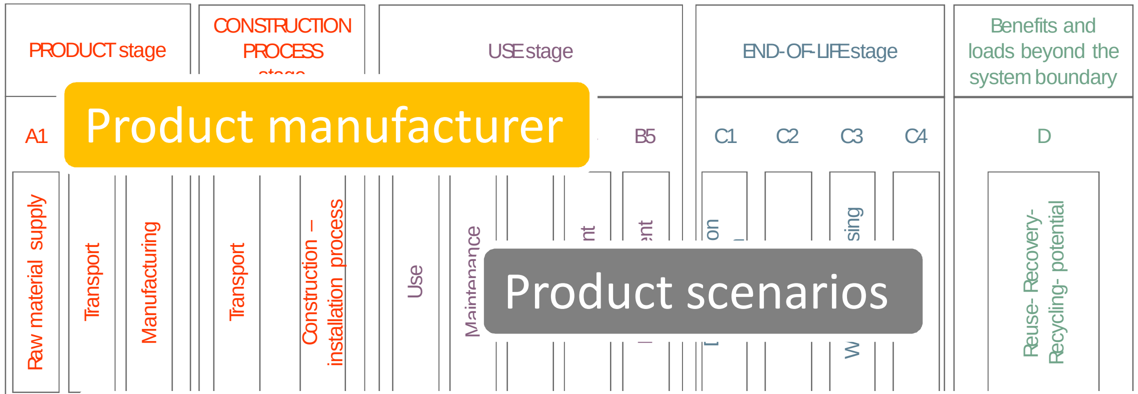


Modularity over 2 levels



Building level
EN 15978

Product level
EN 15804



Transparency: no aggregation between modules
Product data integrated at building level
Comparison at building or system level only

Parameters describing environmental impacts						
GWP [kgCO2eq]	ODP [kgCFCeq]	AP [kgSO2eq]	EP [kgPO4eq]	POCP [kgEtheneq]	APD-elements [kgSbeq]	ADP-fossil fuels [MJ NCV]

Parameters describing resource use, primary energy					
Use of renewable primary energy excluding renewable primary energy resources used as raw materials [MJ NCV]	Use of renewable energy resources used as raw materials [MJ NCV]	Total use of renewable primary energy (primary energy and primary energy resources used as raw materials) [MJ NCV]	Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials [MJ NCV]	Use of non renewable energy resources used as raw materials [MJ NCV]	Total use of non renewable primary energy (primary energy and primary energy resources used as raw materials) [MJ NCV]

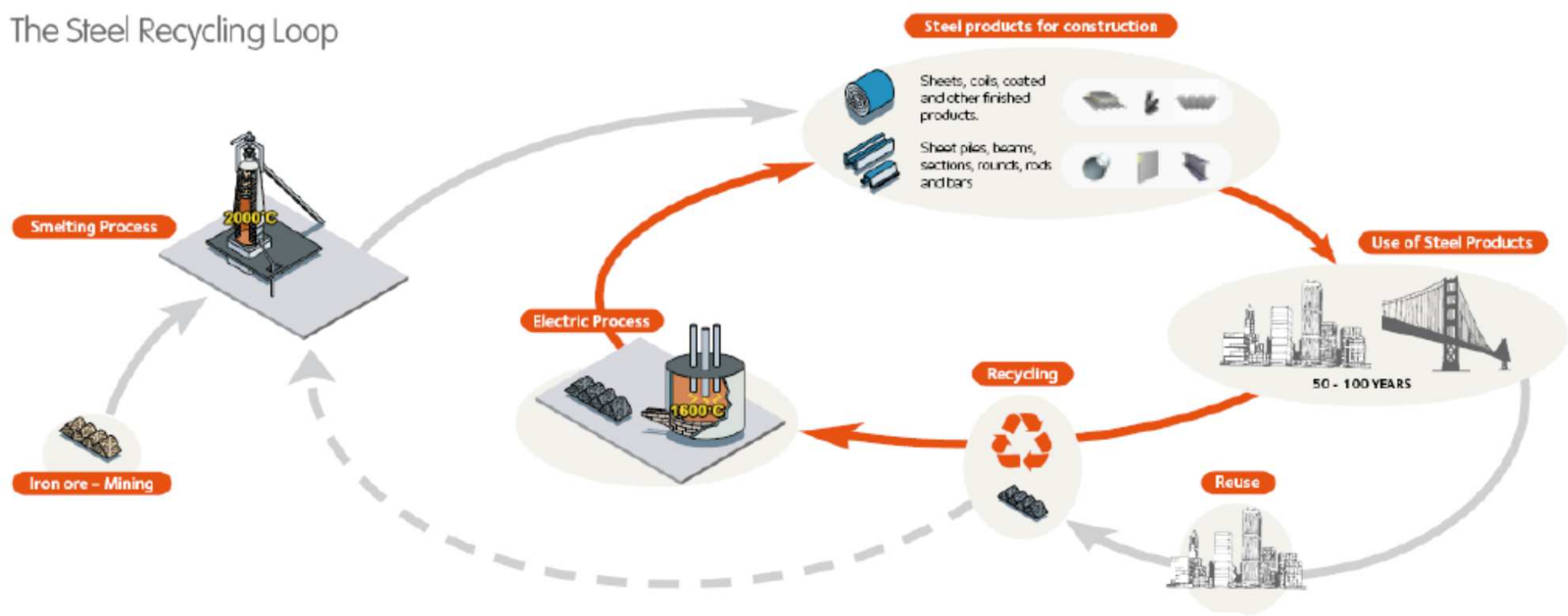
Parameters describing resources use, secondary materials and fuels, and use of water				
Use of secondary material [kg]		Use of renewable secondary fuels [MJ]	Use of non renewable secondary fuels [MJ]	Use of net fresh water [m3]

Other environmental information describing waste categories			Other environmental information describing output flows			
Hazardous waste disposed [kg]	Non hazardous waste disposed [kg]	Radioactive waste disposed [kg]	Components for reuse [kg]	Materials for recycling [kg]	Materials for energy recovery [kg]	Exported energy [kg]

3) Environmental assessment of steel

Steel production

- Two main routes for one product: steel
  - BF/BOF route (mainly primary)
  - EAF route (mainly secondary)



2 routes = 1 product

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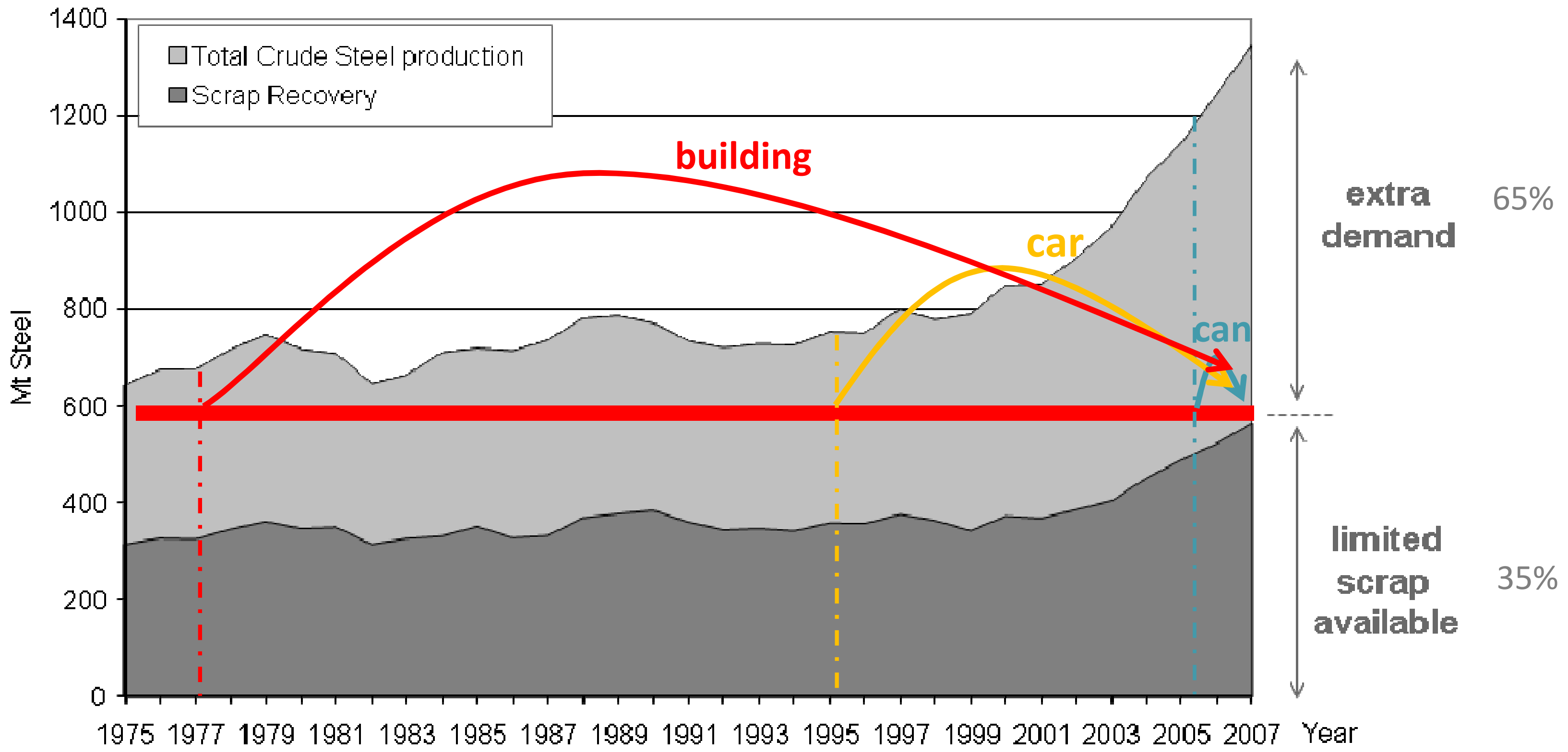
Demand of steel vs. scrap offer

Increase of steel demand + Lack of available scrap = Percentage of primary production still high



Production of steel per process and region, 2007

	Production milion metric tons	Oxygen %	Electric %	Open hearth %	Other %	Total %
Austria	7.6	90.7	9.3	-	-	100.0
Belgium	10.7	66.8	33.2	-	-	100.0
Bulgaria	1.9	53.8	46.2	-	-	100.0
Czech Republic	7.1	90.6	9.4	-	-	100.0
Finland	4.4	70.4	29.6	-	-	100.0
France	19.2	61.3	38.7	-	-	100.0
Germany	48.6	69.1	30.9	-	-	100.0
Greece	2.6	-	100.0	-	-	100.0
Hungary	2.2	77.6	22.4	-	-	100.0
Italy	31.5	36.7	63.3	-	-	100.0
Latvia (e)	0.6	-	0.4	99.6	-	100.0
Luxembourg	2.9	-	100.0	-	-	100.0
Netherlands	7.4	97.8	2.2	-	-	100.0
Poland	10.6	58.3	41.7	-	-	100.0
Portugal (e)	1.4	-	100.0	-	-	100.0
Romania	6.3	69.6	30.4	-	-	100.0
Slovak Republic	5.1	92.3	7.7	-	-	100.0
Slovenia	0.6	-	100.0	-	-	100.0
Spain	19.0	22.1	77.9	-	-	100.0
Sweden	5.7	66.1	33.9	-	-	100.0
United Kingdom	14.3	78.8	21.2	-	-	100.0
European Union (27)	209.5	59.6	40.2	0.3	-	100.0
Turkey	25.8	24.8	75.2	-	-	100.0
Others	4.1	36.4	63.6	-	-	100.0
Other Europe	29.8	26.4	73.6	-	-	100.0
Russia	72.4	56.9	26.6	16.4	-	100.0
Ukraine	42.8	51.4	3.8	44.8	-	100.0
Other CIS	9.5	50.3	41.7	8.0	-	100.0
CIS	124.7	54.5	20.0	25.5	-	100.0

	Production milion metric tons	Oxygen %	Electric %	Open hearth %	Other %	Total %
Canada	15.6	59.2	40.8	-	-	100.0
Mexico	17.6	26.0	74.0	-	-	100.0
United States	98.2	41.1	58.9	-	-	100.0
NAFTA	131.3	41.2	58.8	-	-	100.0
Argentina	5.4	48.1	51.9	-	-	100.0
Brazil	33.8	75.9	24.1	-	-	100.0
Chile	1.7	72.5	27.5	-	-	100.0
Venezuela	5.0	-	100.0	-	-	100.0
Others	3.4	22.4	77.6	-	-	100.0
Central and South America	49.3	61.3	38.7	-	-	100.0
Egypt (e)	6.2	16.1	83.9	-	-	100.0
South Africa	9.1	49.7	50.3	-	-	100.0
Other Africa	3.3	38.9	61.1	-	-	100.0
Africa	18.7	36.5	63.5	-	-	100.0
Iran (e)	10.1	22.7	77.3	-	-	100.0
Saudi Arabia	4.6	-	100.0	-	-	100.0
Other Middle East	1.4	-	100.0	-	-	100.0
Middle East	16.1	14.1	85.9	-	-	100.0
China (e)	489.2	89.9	10.1	-	0.0	100.0
India (e)	53.1	39.9	58.2	1.9	-	100.0
Japan	120.2	74.2	25.8	-	-	100.0
South Korea	51.6	53.4	46.6	-	-	100.0
Taiwan, China	20.9	52.1	47.9	-	-	100.0
Other Asia	19.1	-	100.0	-	-	100.0
Asia	754.1	78.1	21.7	0.1	0.0	100.0
Australia	7.9	80.8	19.2	-	-	100.0
New Zealand	0.8	72.5	27.5	-	-	100.0
World	1,342.4	66.3	31.2	2.5	0.0	100.0

(e): estimate

35% - 65%

European Union (27)	115.6

World	481.9

55% - 45%

Scrap consumption Europe and world

Recycling in LCA: a key stake for steel

- Recycled content and End Of Life recycling rate

Production phase
Use of recycled materials

→

Use phase

→

End of Life phase
Recycling of materials

Recycled content

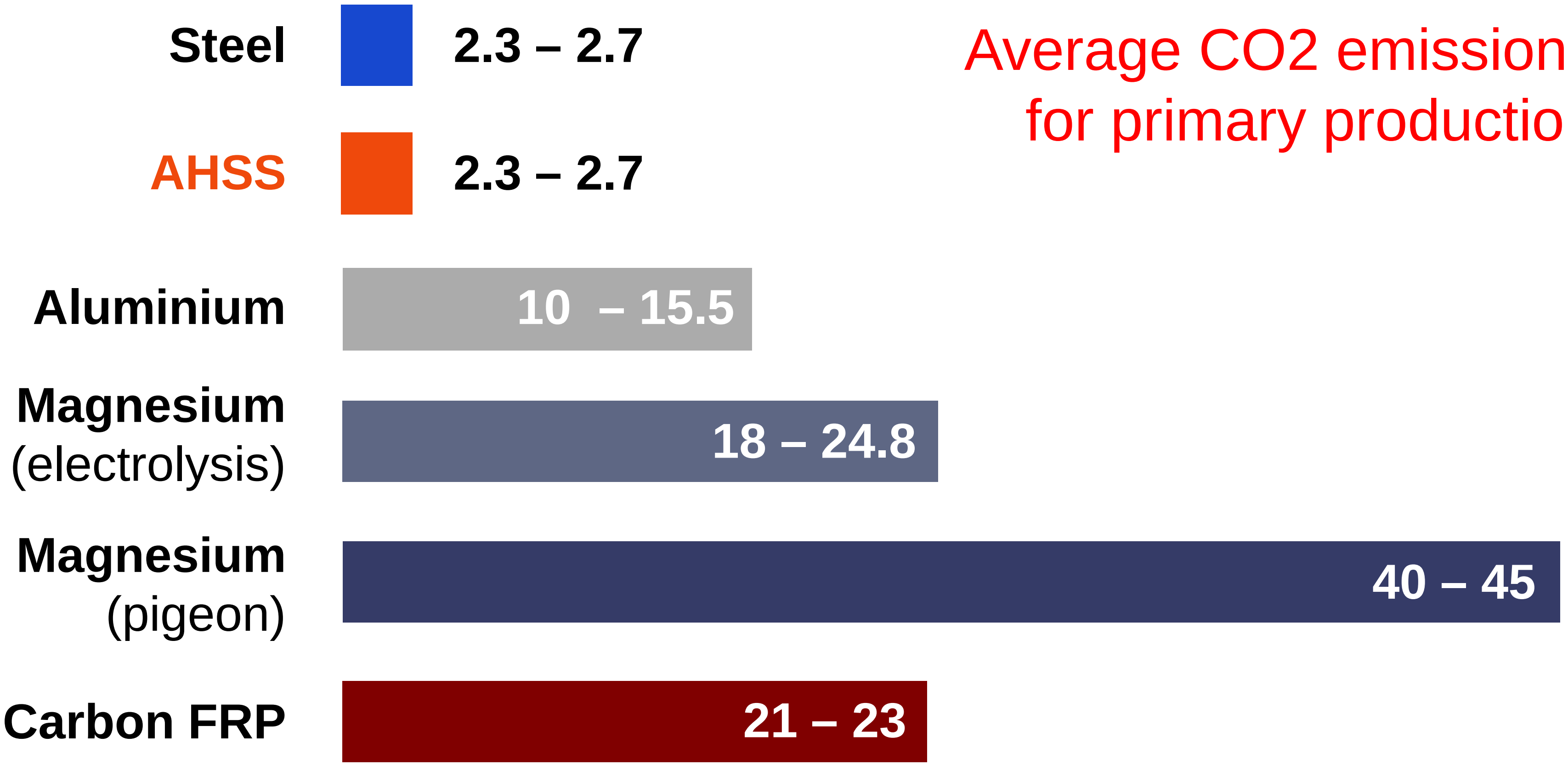
- Focus on the product
- Consider the past recycling of materials
- Supported by materials having a limited number of recycling cycles and a low recycling rate (polymers, concrete…)

Recycling rate

- Material scale
- Takes into account the environmental advantage of future recycling
- Supported by metal industries: address the future of products is more important

CO_2 emissions of several materials

Average CO_2 emissions for primary production



Focus on Module D

Module D: frontiers

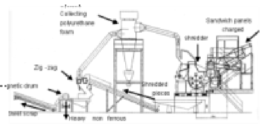
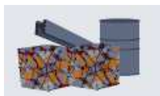
Module C

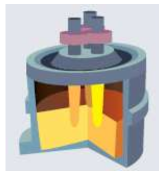
C1 **deconstruction** (include sorting, dismantling, demolition) → **C2** Transport (from deconstruction site to scrap recycling site) → **C3** Waste processing (shearing, shredding, sorting, separation on site) → scrap STOCK → **D** **Transport** (from scrap stock to secondary treatment) → **D** **Secondary Processing to reach Fonctional equivalence** (from scrap to slab) → Benefit/load

D **Avoided impacts** (blast furnace route from iron ore to slab) → Benefit/load

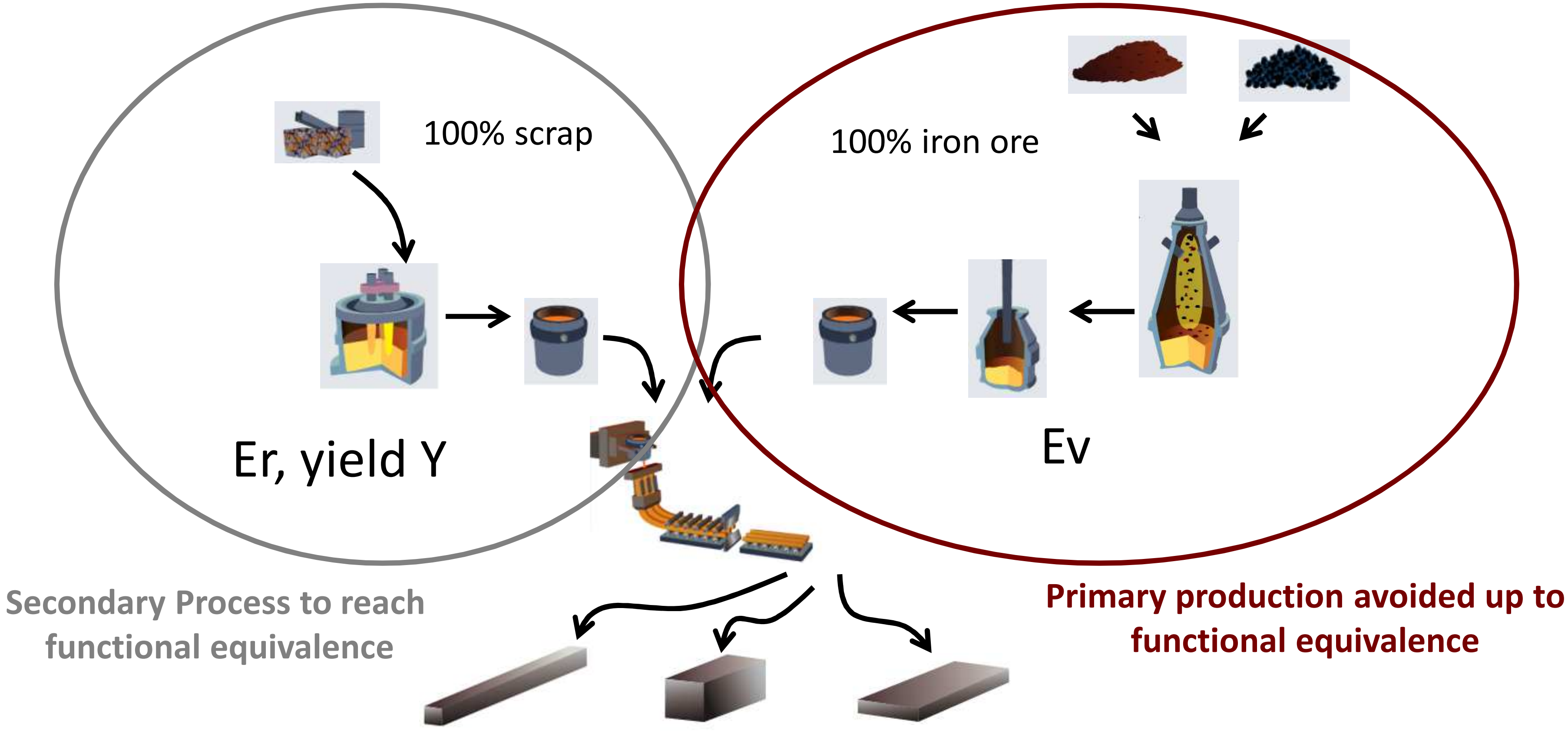
End of waste status






Module D: calculation example with steel



Benefit = Y (Ev – Er)

Ref: worldsteel data 2010

Module D: ‘Net’ benefits and loads

RC = recycled content,
RR = Recycling rate end of life,
Ev = Impacts of material virgin production
Er = Impacts of material secondary production
Ev’ = Impacts of substituted material virgin production
Er’ = Impacts of substituted material secondary production

$$\text{Net Benefit} = \underbrace{RR(Ev'-Er')}_{\text{total potential benefit of recycling the collected stock}}-\underbrace{RC(Ev-Er)}_{\text{reduced by the benefit already taken into account upstream to obtain a “net” benefit}}$$

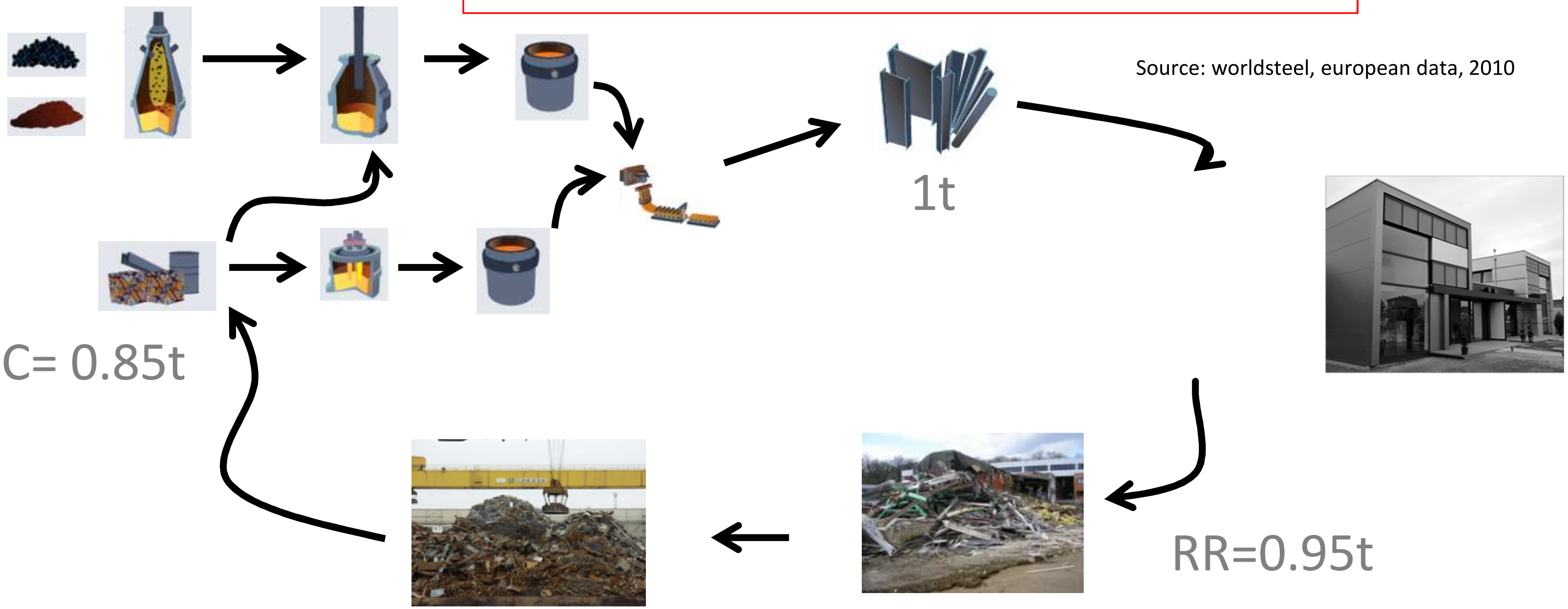
total potential benefit of recycling the collected stock

reduced by the benefit already taken into account upstream to obtain a “net” benefit

Ref: worldsteel data 2010

Application with steel sections

Module A= mix production = 1,15 tCO2eq



Module D = (RR-RC)*Y*(Ev-Er) = (0,95-0,85)*1,6 = 0,15 tCO2eq

GWP section = 1,15 – 0,15 = 1,00 tCO2eq

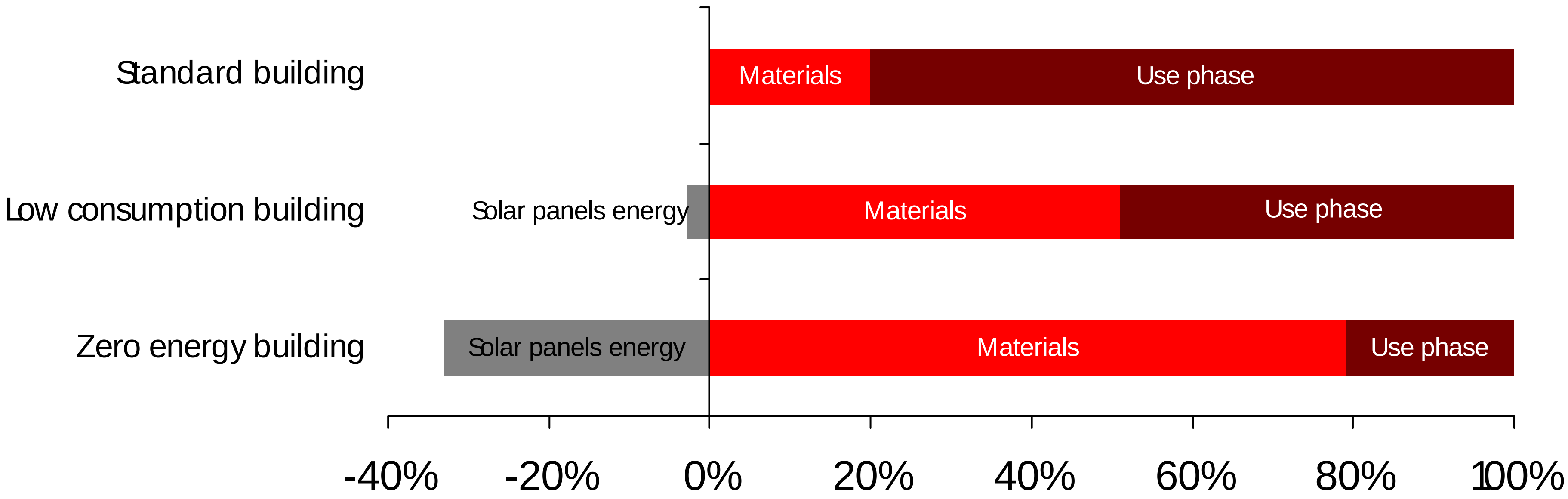
Ref: worldsteel data 2010

Module D

- In Module D, Life cycle thinking is respected and the time dimension is integrated
- Module D is a clear incentive for recycling or reuse or energy recovery
    - What's the value of my waste at the end of life?
- Module D is applicable for all materials
- Issues
    - Optional (problem of comparison)
    - Need some practice to precise the rules

Conclusions

- Share of impacts
  - TODAY
    - Impacts mostly distributed during the use phase (~80% of the total life cycle impacts)
    - Policies efforts oriented on buildings energy efficiency
    - Development of passive or positive energy constructions
  - TOMORROW
    - Materials share is growing from the increase of insulation materials
    - Measure to reduce: EPDs required in more and more tenders and certification schemes
    - Resource efficiency with the objective of reducing wastes



Illustrative figures

Conclusions

- Life Cycle Assessment is the proper tool for environmental assessment of buildings
  - Focus on the use phase no longer sufficient
  - The end-of-life of the building must be assessed too: reuse and recycling rewarded (module D)
  - Carbon dioxide is not the only pollutant: a full environmental impacts assessment is required

- The social pillar is coming: beyond the indicators of LCA
  - We spend 90% of our time in buildings: Air quality / comfort / acoustic must be addressed as well
  - Urban scale vs. building scale