Environmental assessment of steel reuse and recycling

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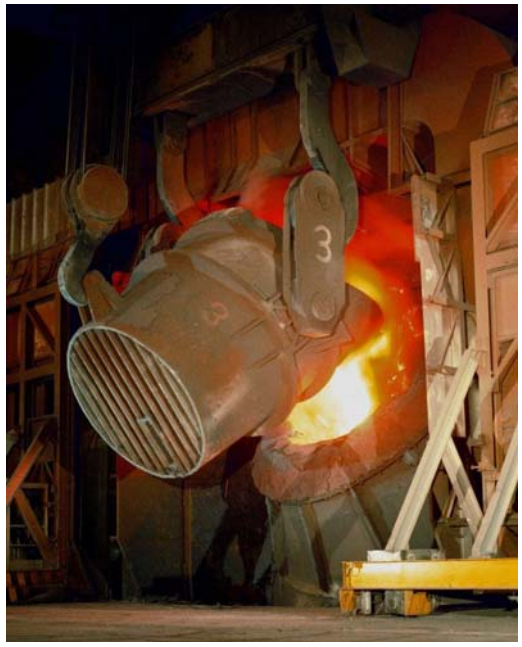
The challenge

- Climate change and global warming
- Sustainable resource use and the circular economy
- How to assess the environmental impacts of steel construction products

Steel production

Primary production BOS

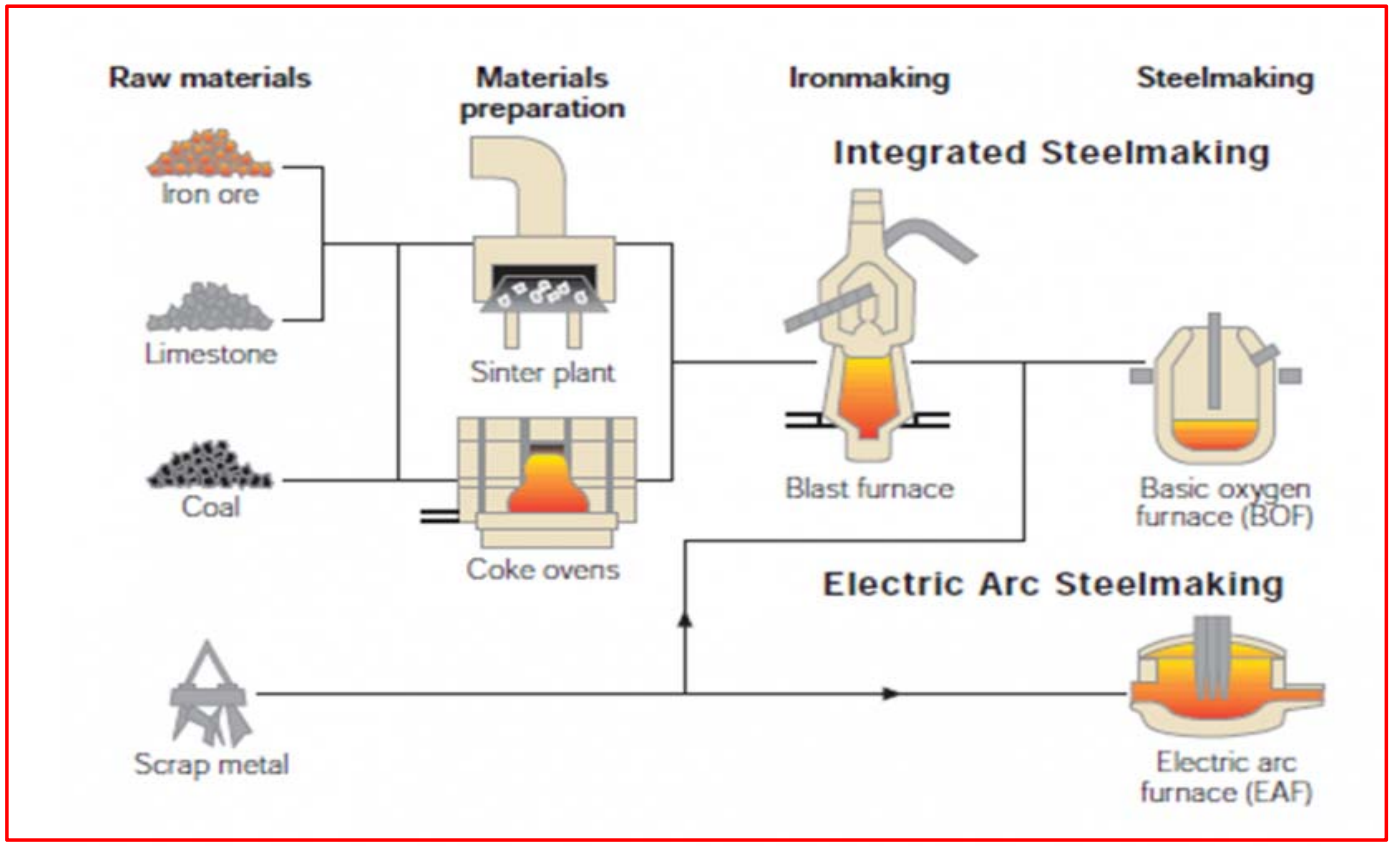


GHG emissions 2.5kgCO_2e/kg

Secondary production EAF

GHG emissions 0.5kgCO_2e/kg

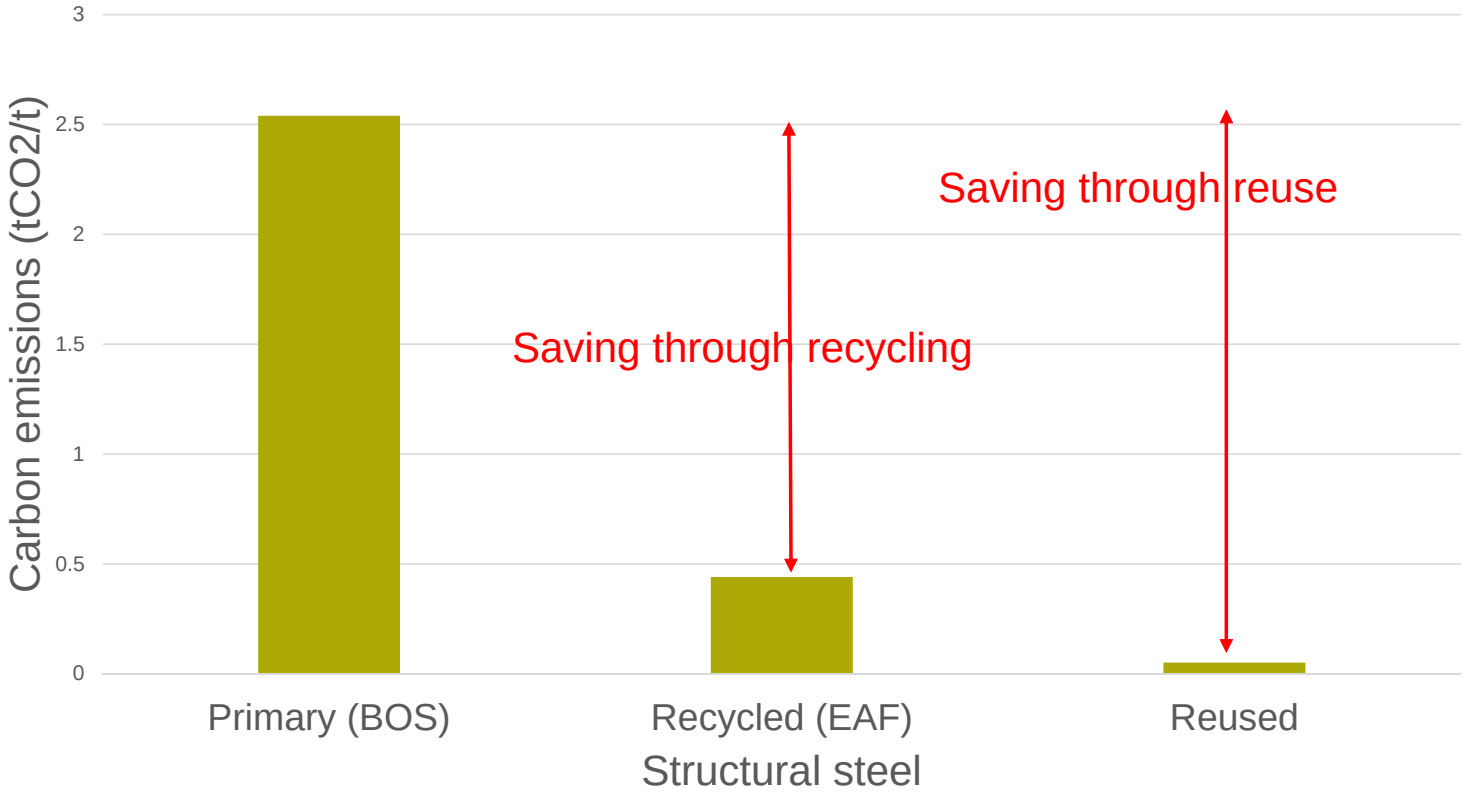
Closed loop steel production



Steel construction impacts

- Primary steel production has high environmental impacts
- But steel is highly recyclable and reusable
- How do you account for this for long-lived products like buildings?
  - Particularly wrt the need to address global warming in the short-term

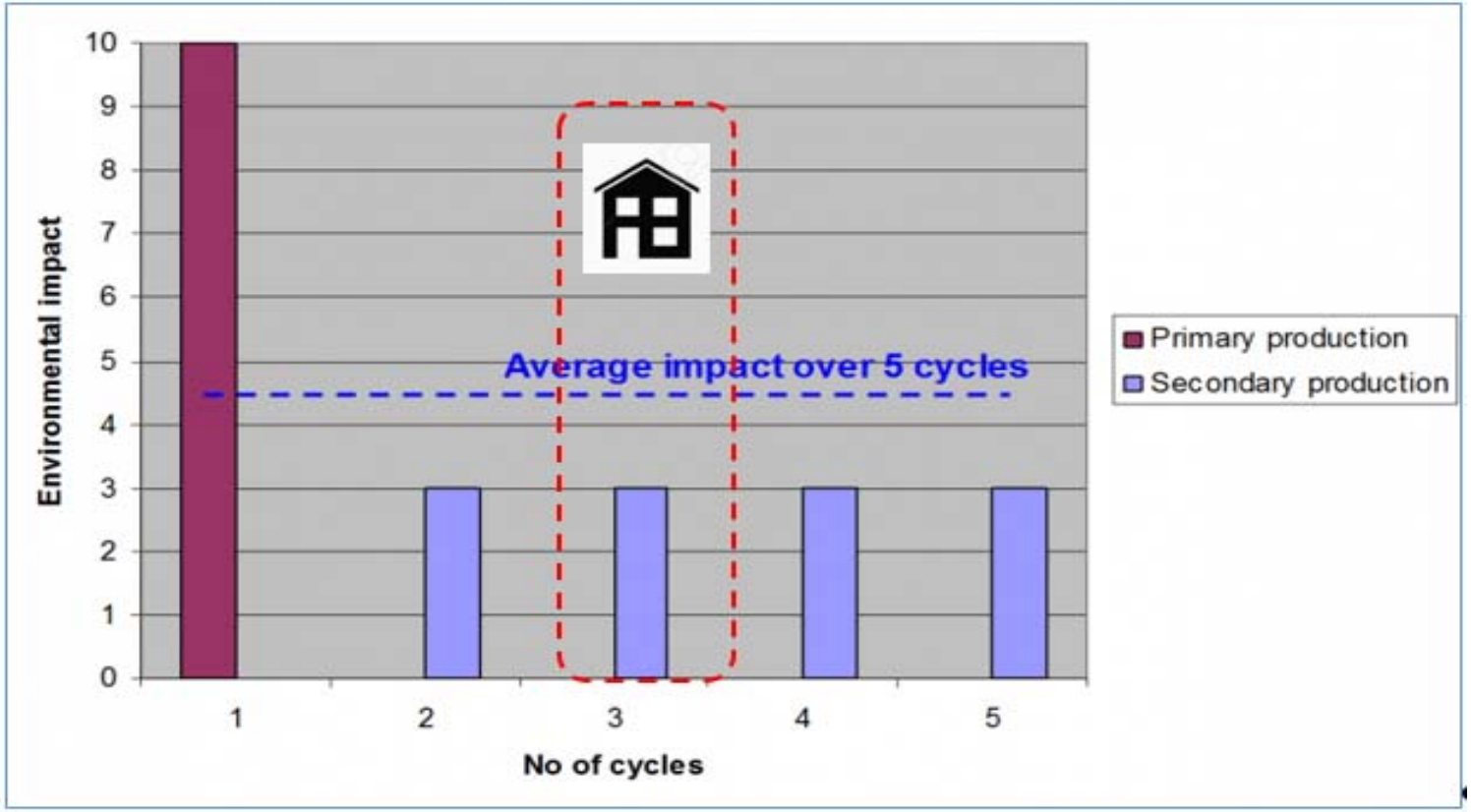
Carbon footprint of structural steel



Life cycle assessment

- Most robust and respected assessment methodology
- Incompatibility between different product life cycles and the scope of assessment
  - **Steel** theoretically has an infinite life cycle, through multiple recycling stages
  - Whereas **building** assessments are generally limited in scope, to the lifetime of the building

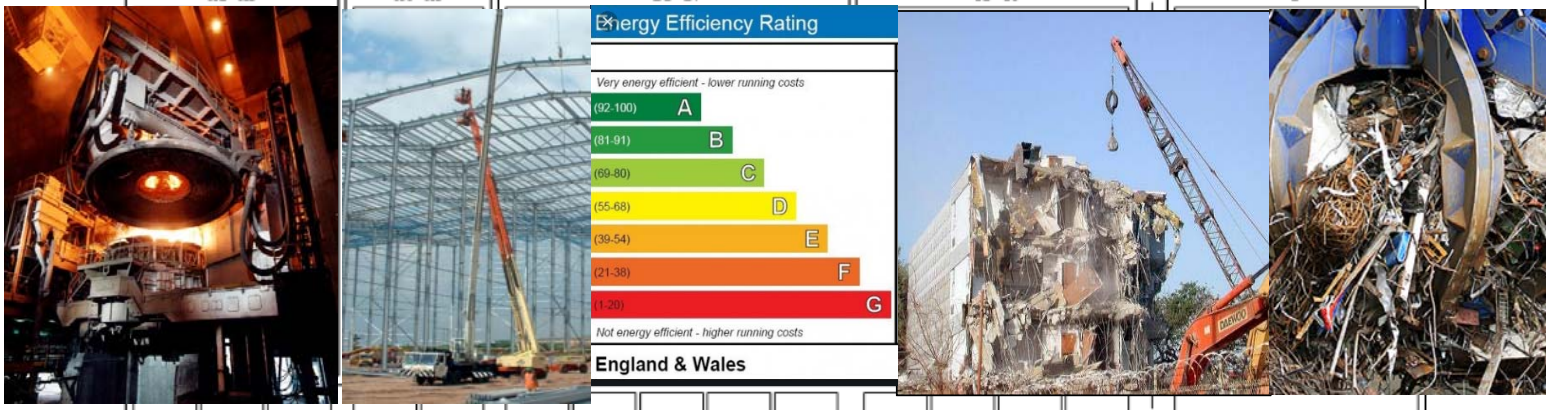
Different life cycles and scope



CEN TC350 standards

- Sustainable construction assessment standards
- **EN 15804** – Product category rules for EPDs
- **EN 15978** – Environmental assessment of buildings
- **Module D** declares potential loads and benefits of materials leaving the product system
  - Based on net flows (input – output)
  - Impacts based on substitution of primary production
  - Quality factors applied to take account of any loss of functional equivalence

CEN TC350 modular approach



	A1 - A3			A4 - A5		B1 - B7					C1 - C4				D
Cradle to gate + modules C and D	Mand.	Mand.	Mand.								Mand. [b]	Mand. [b]	Mand. [b]	Mand. [b]	Mandatory [b]
Cradle to gate + modules C and D with options	Mand.	Mand.	Mand.	Opt.	Opt.	Opt.	Opt.	Opt.	Opt.	Opt.	Mand.	Mand.	Mand.	Mand.	Mandatory
						Optional									
						Optional									
Cradle to grave	Mand.	Mand.	Mand.	Mand.	Mand.	Mand.	Mand.	Mand.	Mand.	Mand.	Mand.	Mand.	Mand.	Mand.	Mandatory
						Mandatory									
						Mandatory									

CEN TC350 and PEF

- PEF - Product Environmental Footprint
- CEN mandate (2017) to amend EN 15804 and 15978 to align with the PEF methodology
- Including:
  - Rules and guidance on ‘cradle to grave’ EPD
  - Development of EoL formulae for Modules A, C and D

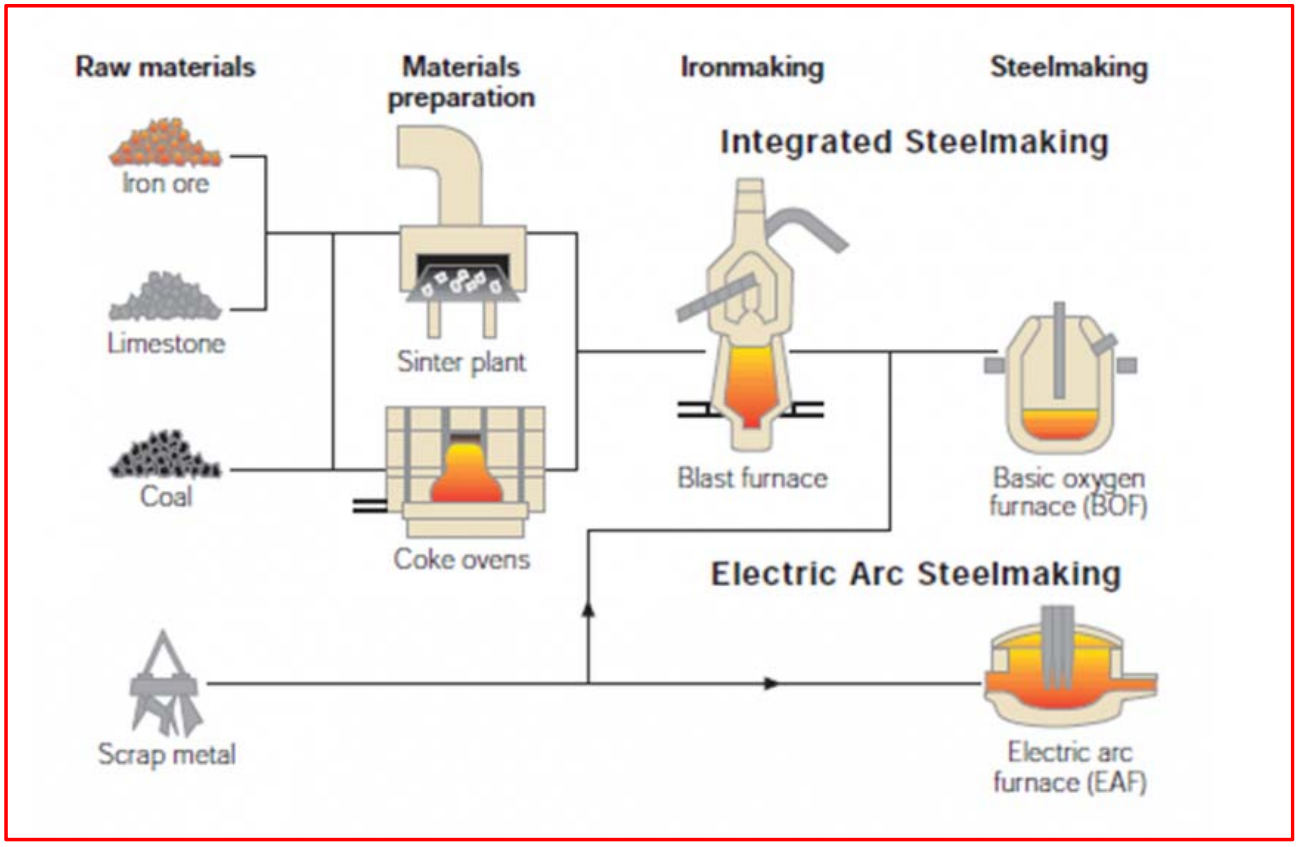
CEN T ar approach

	A1 - A3								C1 - C4				D
	PRODUCT ST								END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
	A1	A2					B5		C1	C2	C3	C4	D
	Raw material supply	Transport	Manufacturing				Refurbishment scenario		Deconstruction demolition	Transport	Waste processing scenario	Disposal scenario	Reuse, recovery, recycling, potential scenario
Cradle to gate + modules C and D	Mand.	Mand.	Mand.						Mand. [b]	Mand. [b]	Mand. [b]	Mand. [b]	Mandatory [b]
Cradle to gate + modules C and D with options	Mand.	Mand.	Mand.				Opt.	Opt.	Mand.	Mand.	Mand.	Mand.	Mandatory
Cradle to grave	Mand.	Mand.	Mand.				Mand.	Mand.	Mand.	Mand.	Mand.	Mand.	Mandatory

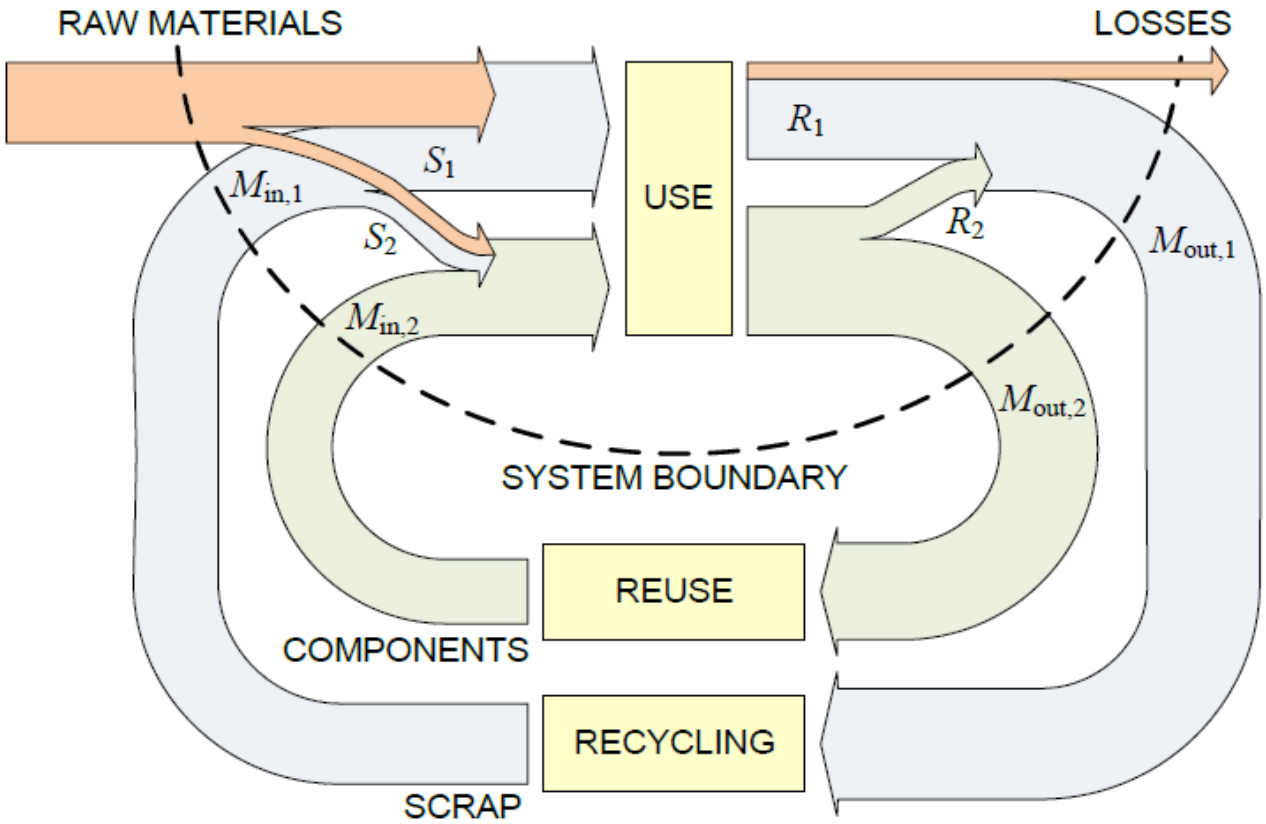
Mandatory

Mandatory

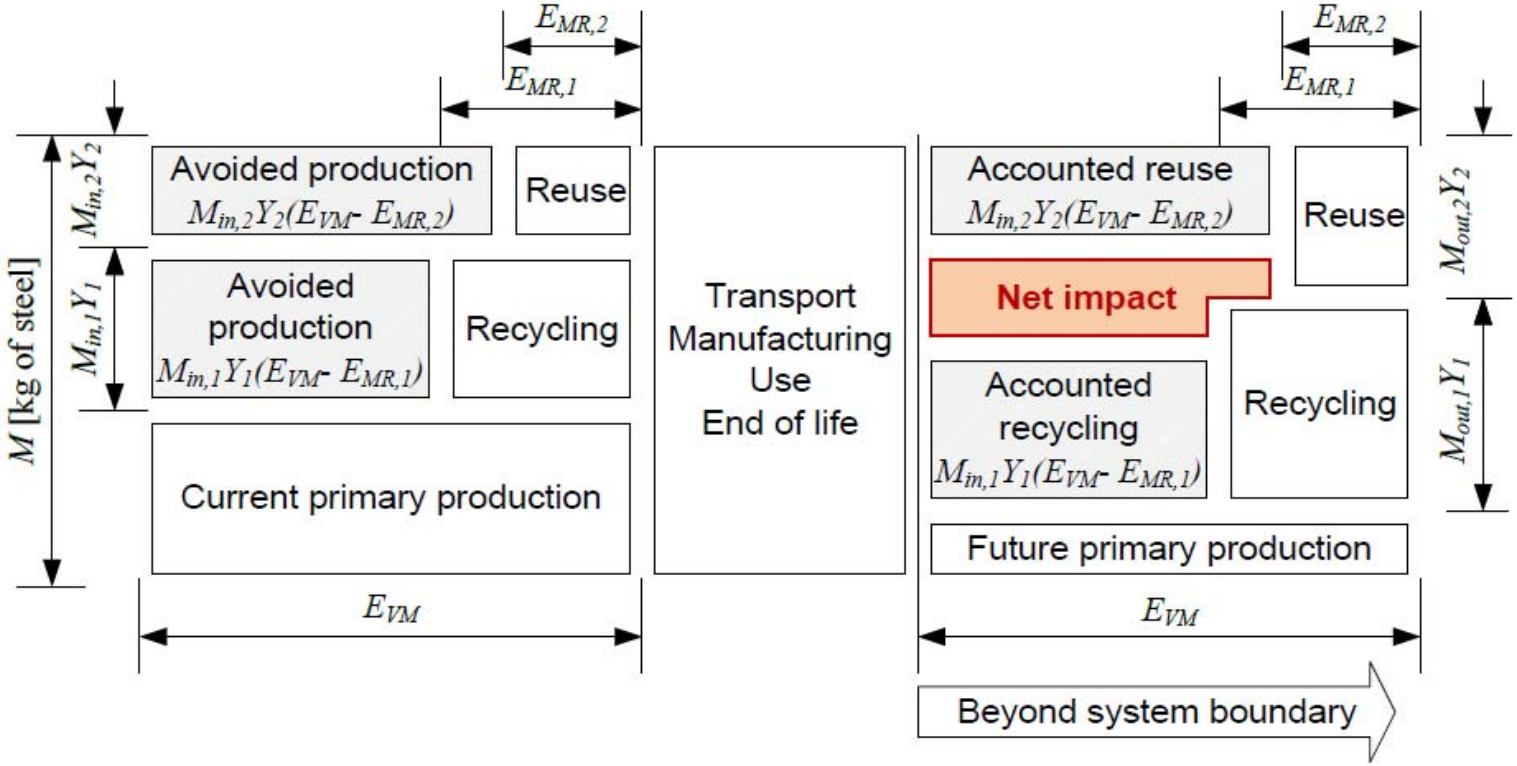
Closed loop steel production



PROGRESS system boundary including reuse



Incorporating reuse



Module D benefits – recycling and reuse

$$X_{recycling} = \left(M_{out,scrap} - M_{in,scrap}\right) \cdot \left(E_{MR,recycling} - E_{VM}\right) \cdot Y$$

$$X_{reuse} = \left(M_{out,components} - M_{in,components}\right) \cdot \left(E_{MR,reuse} - E_{VM}\right)$$

Module D = Net flow x Impact saving x Yield

Burden/benefit

Relative to primary production

factor

Nine simplified scenarios

Production route	End-of-life scenario	$M_{in,\ scrap}$	$M_{in,\ comp}$	$M_{out,\ scrap}$	$M_{out,\ scrap}$	Module A	Module D
Primary	Recycling	0	0	1	0	2	-1.5
Primary	Reuse	0	0	0	1	2	-2
Primary	Disposal	0	0	0	0	2	0
Recycled	Recycling	1	0	1	0	0.5	0
Recycled	Reuse	1	0	0	1	0.5	-0.5
Recycled	Disposal	1	0	0	0	0.5	1.5
Reused	Recycling	0	1	1	0	0	0.5
Reused	Reuse	0	1	0	1	0	0
Reused	Disposal	0	1	0	0	0	2

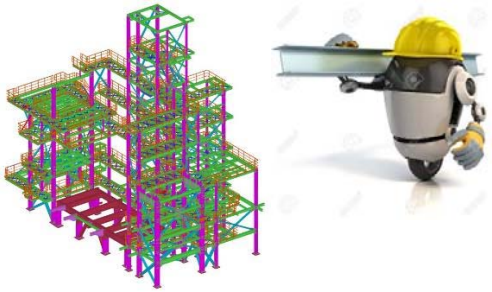
Reuse today

Production route	End-of-life scenario	$M_{in,\ scrap}$	$M_{in,\ comp}$	$M_{out,\ scrap}$	$M_{out,\ scrap}$	Module A	Module D
Primary	Recycling	0	0	1	0	**2**	-1.5
Primary	Reuse	0	0	0	1	**2**	-2
Primary	Disposal	0	0	0	0	**2**	0
Recycled	Recycling	1	0	1	0	**0.5**	0
Recycled	Reuse	1	0	0	1	**0.5**	-0.5
Recycled	Disposal	1	0	0	0	**0.5**	1.5
Reused	Recycling	0	1	1	0	**0**	0.5
Reused	Reuse	0	1	0	1	**0**	0
Reused	Disposal	0	1	0	0	**0**	2

Benefit reflected in Module A

Design for deconstruction and reuse

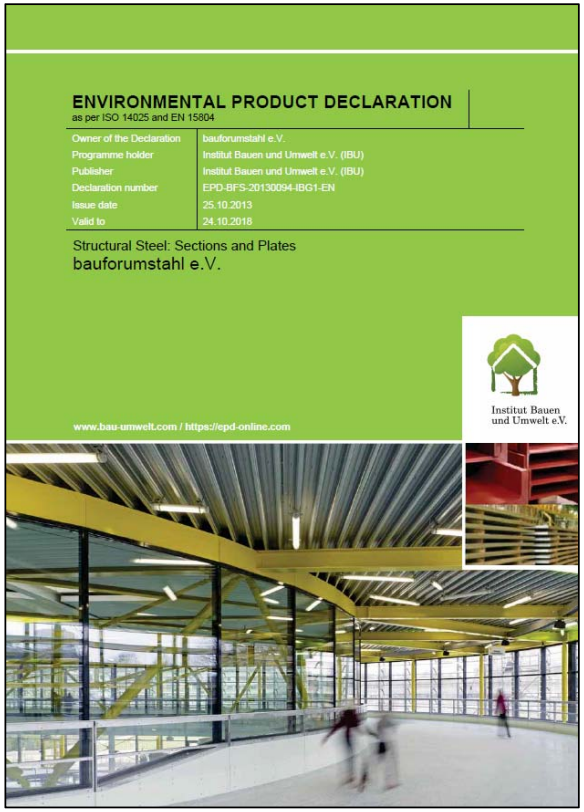
Production route	End-of-life scenario	$M_{in,\ scrap}$	$M_{in,\ comp}$	$M_{out,\ scrap}$	$M_{out,\ scrap}$	Module A	Module D
Primary	Recycling	0	0	1	0	2	-1.5
Primary	**Reuse**	0	0	0	1	2	**-2**
Primary	Disposal	0	0	0	0	2	0
Recycled	Recycling	1	0	1	0	0.5	0
Recycled	**Reuse**	1	0	0	1	0.5	**-0.5**
Recycled	Disposal	1	0	0	0	0.5	1.5
Reused	Recycling	0	1	1	0	0	0.5
Reused	**Reuse**	0	1	0	1	0	**0**
Reused	Disposal	0	1	0	0	0	2



Benefit reflected in Module D

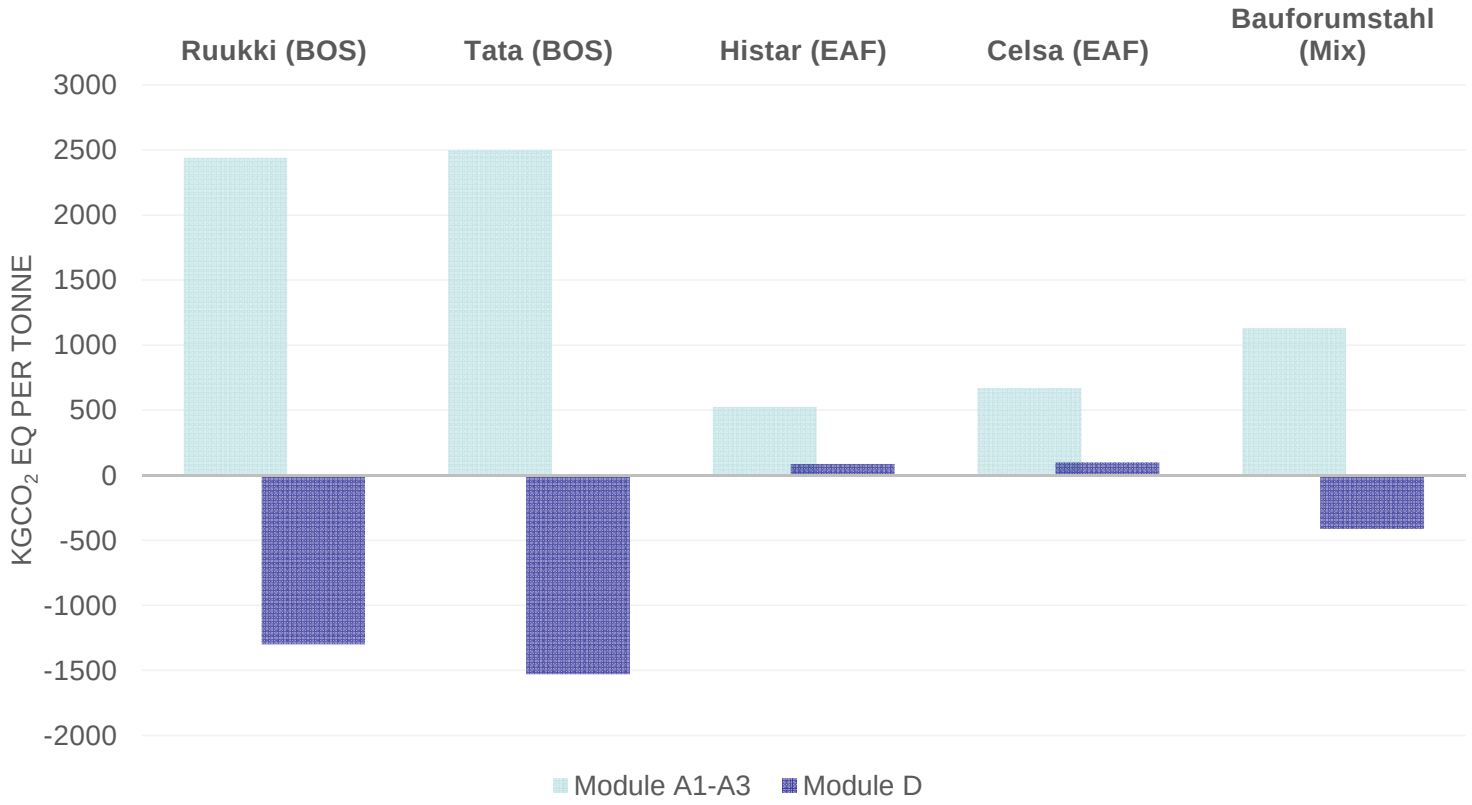
Construction steel EPDs

- There are several constructional steel EPDs
- Mostly to CEN TC350
- Most use worldsteel net scrap recycling approach
- Mill specific and (average) generic EPD are available



Construction steel EPDs

Structural steel EPD data



Conclusions

- Methodology developed used to account for reuse (and recycling) in PROGRESS and REDUCE
  - Shows benefit for reuse today (Module A1-A3)
  - Shows the benefit for DfD and future reuse (Module D)
  - Approach is compatible with current TC350 and PEF approaches
- Mill-specific data rather than average – greater transparency
  - But generic data may be appropriate at concept design stage

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