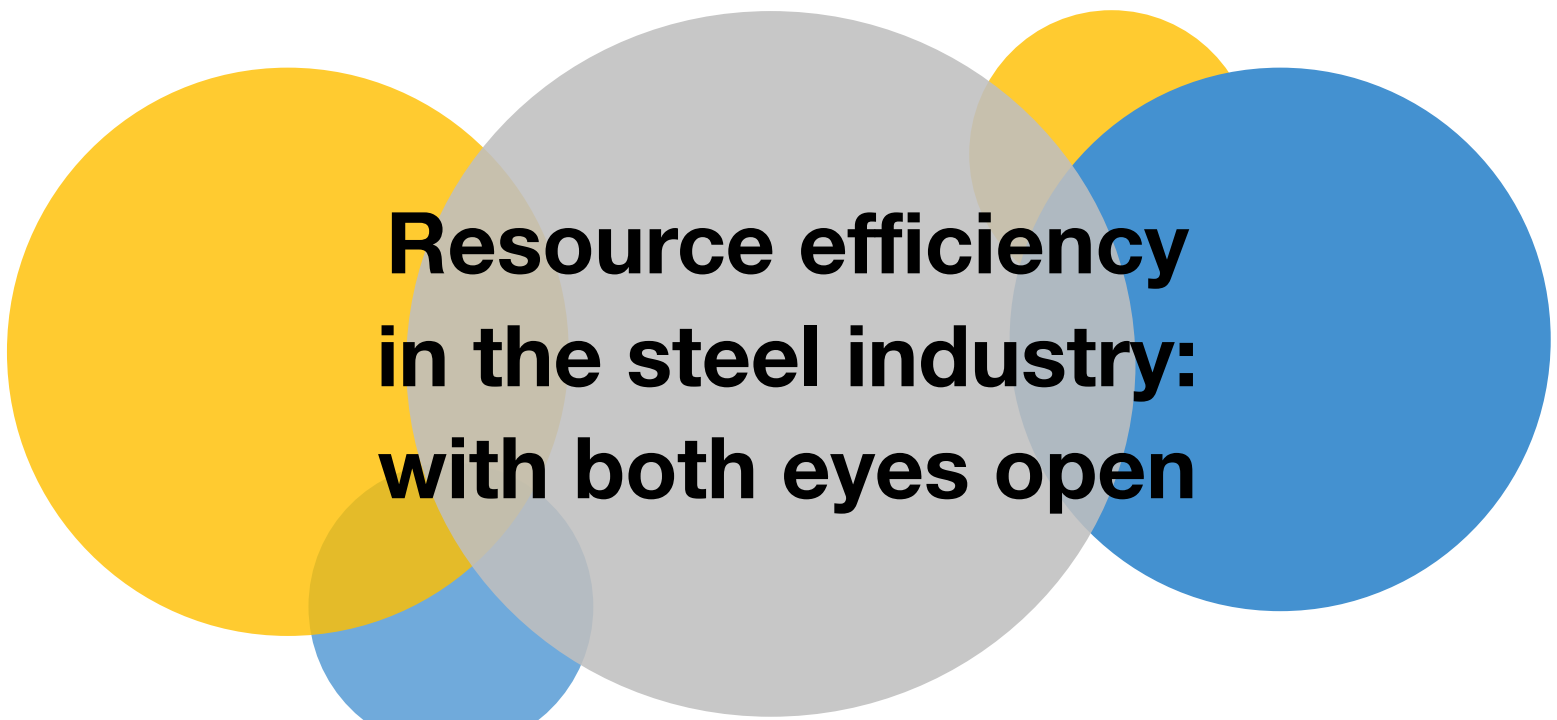


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Resource efficiency in the steel industry: with both eyes open



**UNIVERSITY OF
CAMBRIDGE**

**IEA Global Iron & Steel
Low-Carbon Technology Roadmap
20 November 2017, Paris**

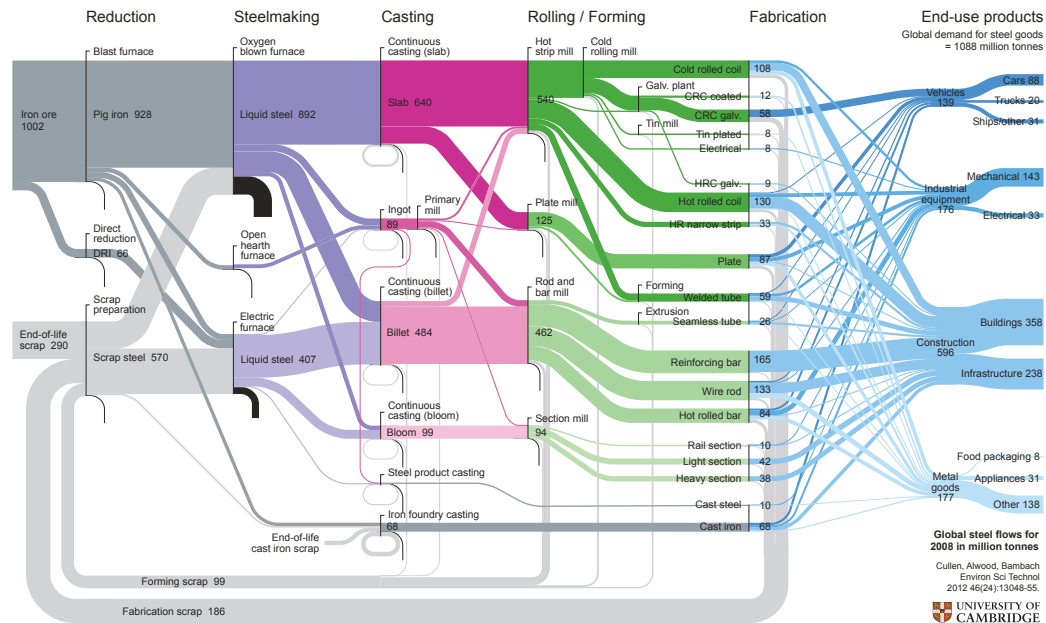


resource
efficiency
collective

Resource Efficiency Collective is a research initiative at Cambridge University. Together, we seek answers to a challenging question: how can we deliver future energy and material services, while at the same time reducing resource use and environmental impact?

- ★ Tracking of resource flows across entire systems
- ★ Understanding multiple resource flows concurrently
- ★ Considering both scale and the improvement potential of possible interventions
- ★ Using Sankey diagrams to explore and communicate resource systems

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with both eyes open

SUSTAINABLE MATERIALS

WITHOUT THE HOT AIR



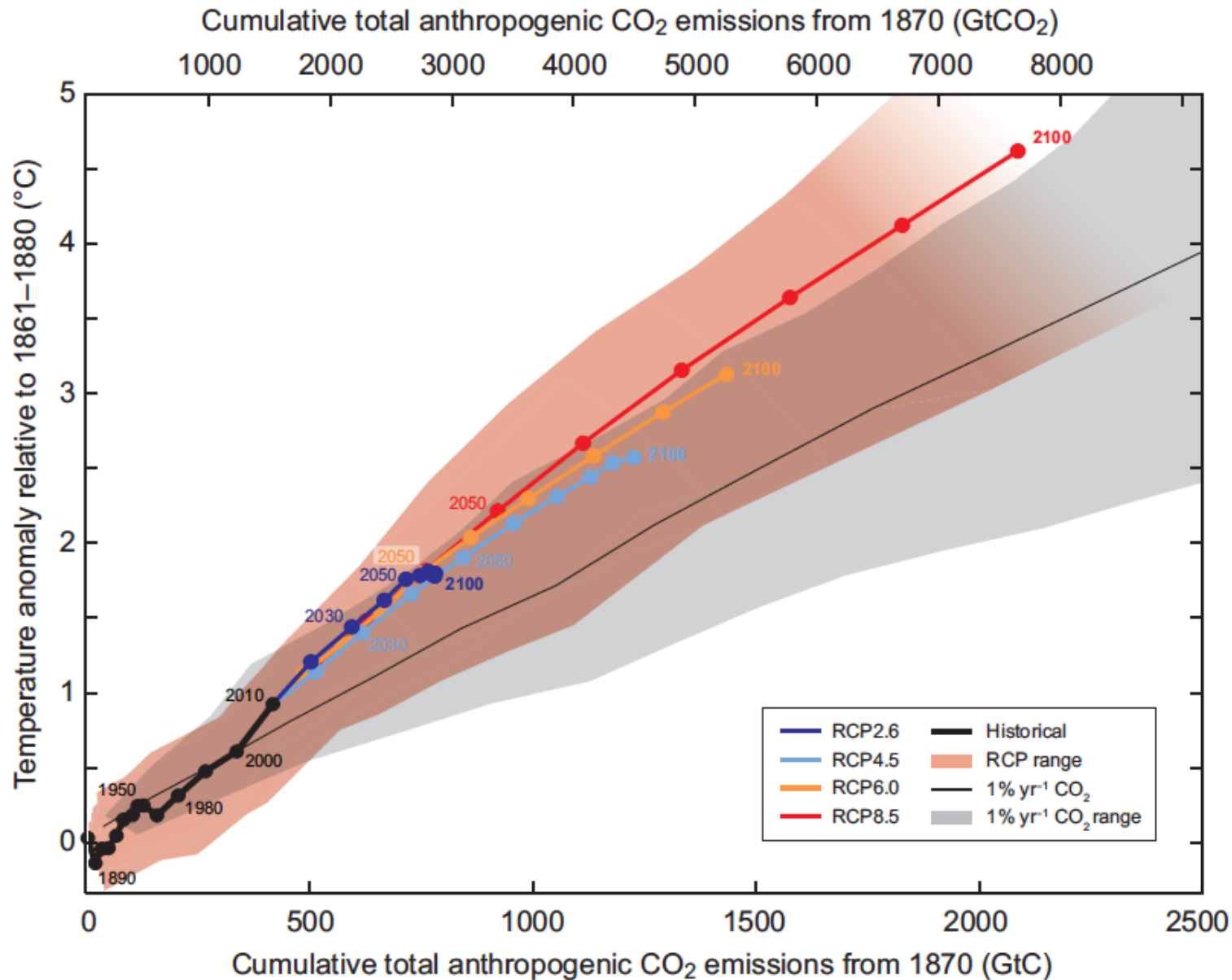
**MAKING BUILDINGS,
VEHICLES & PRODUCTS
EFFICIENTLY
AND WITH LESS
NEW MATERIAL**

JULIAN M ALLWOOD & JONATHAN M CULLEN

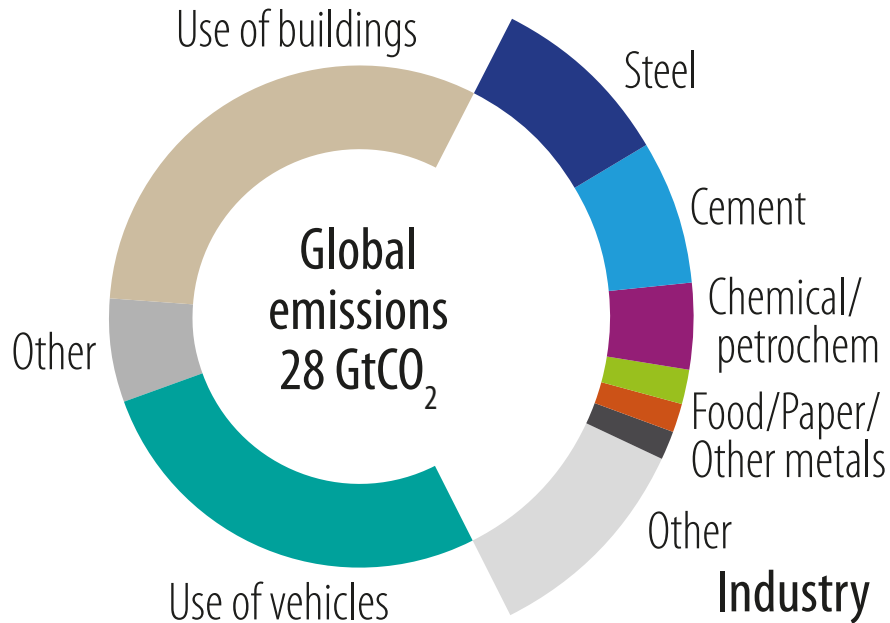


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www.withbotheyesopen.com

Motivation : climate change

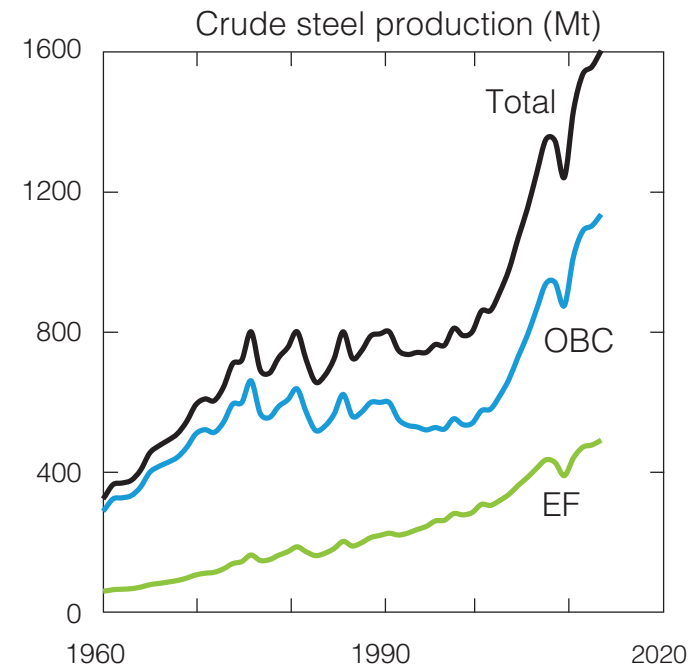
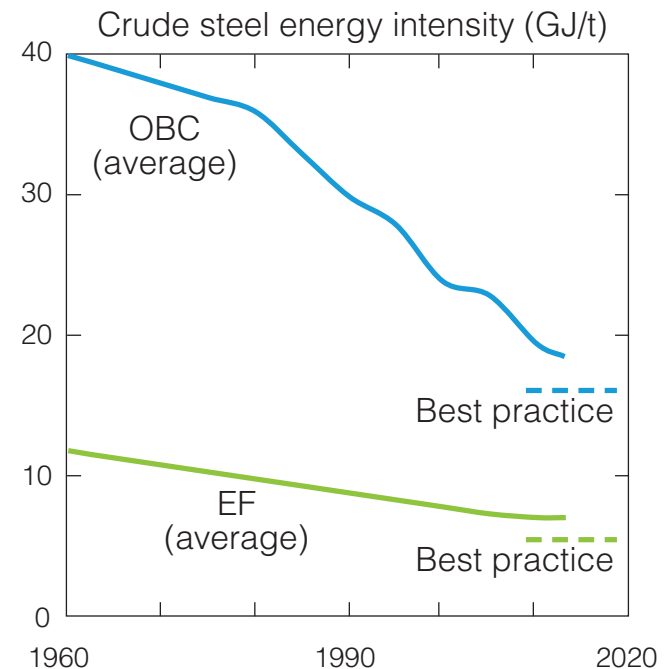


Industry and materials



Global demand for materials is expected to more than double by 2050

Halving absolute emissions by 2050 will require at least a **75% cut in emissions per tonne**



With one eye open

50% emission reduction per tonne
0% reduction in absolute emissions

Energy efficiency

Few efficiency gains left, perhaps 10–20%

Novel processes

DRI, HIsarna, Smelt Reduction, Electrolysis, Hydrogen, Inert anodes, Multipolar cells

Recycling

Increase recovery to 90%

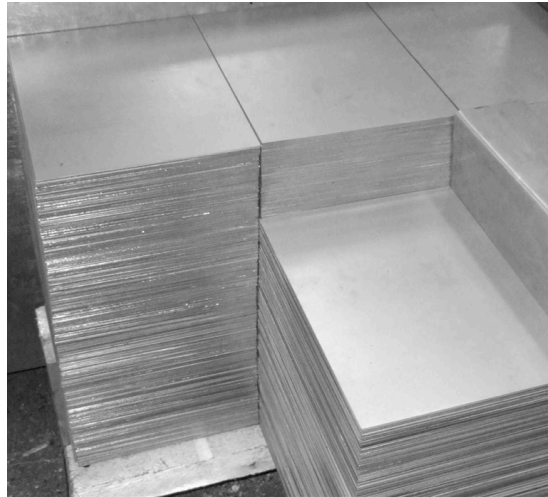
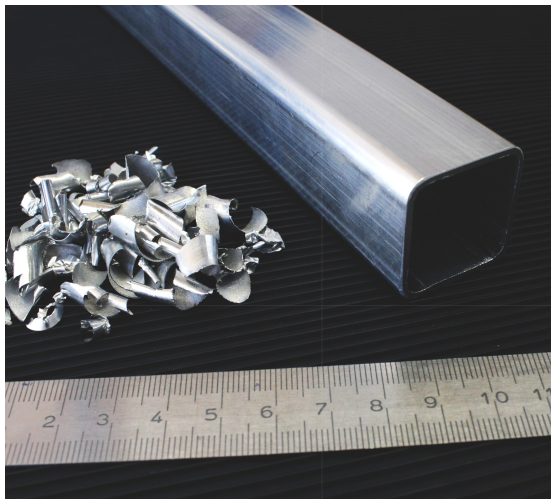
Low carbon energy

Renewables, nuclear CCS (carbon capture and storage)



With both eyes open

75% emission reduction per tonne
50% reduction in absolute emissions



Use less by design
30% saving from putting
metal in the right place

Reduce yield losses
 $\frac{1}{4}$ of all liquid metal is
scrapped in production

Divert scrap
if we can't eliminate yield
loss can we divert scrap?

Re-use with no melting
profitable in construction

Longer life products
spread impacts over time

Reduce final demand
more intense use



Material efficiency **could deliver larger energy savings** in energy-intensive industries than energy efficiency

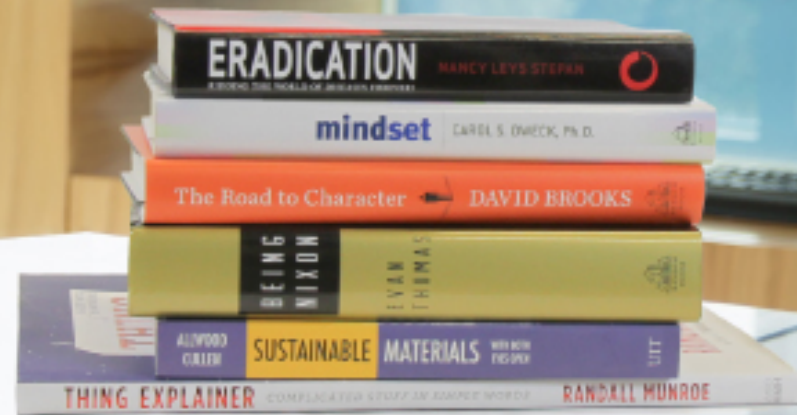
IEA World Energy Outlook 2015

Material Flow Analysis is among the **potentially most useful tools** for addressing these information shortfalls and to guide decision making



OECD 2008

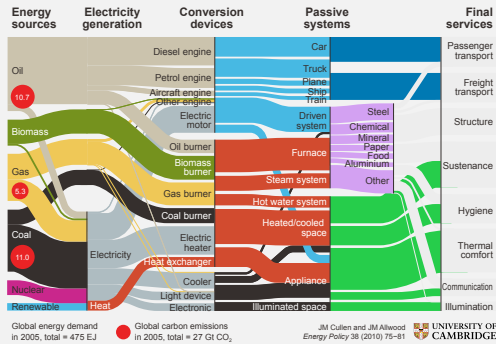
Sustainable Materials : with both eyes open



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**resource efficiency
in the steel industry**

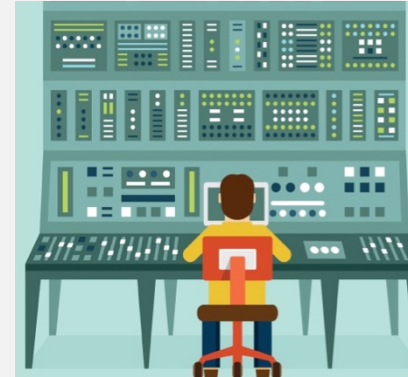


Resource
mapping

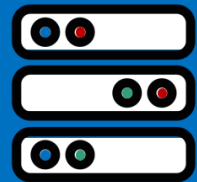


ENERGY &
MATERIALS

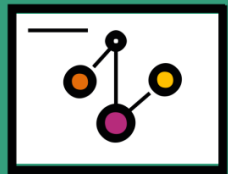
Site-level
resource picture



Control data



CONTROL
DATA



VISUALS

Why should energy and materials be analyzed together?

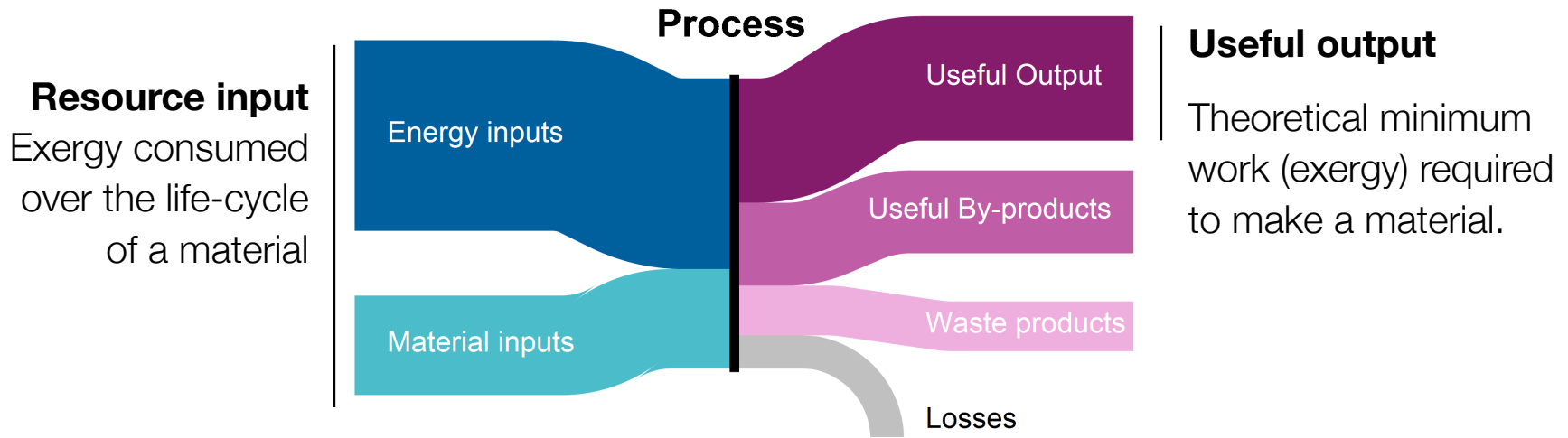


Resources are not comparable because they are measured in different units

Required to give an holistic understanding of resource flows

Resource quality cannot be measured in mass

Measuring resource efficiency with exergy



Resource efficiency (RE%) =

$$\frac{\text{Useful output}}{\text{Resource input}}$$

ENERGY
(joules)

X

Conversion factors
(J/J, J/kg)

=

EXERGY
(joules)

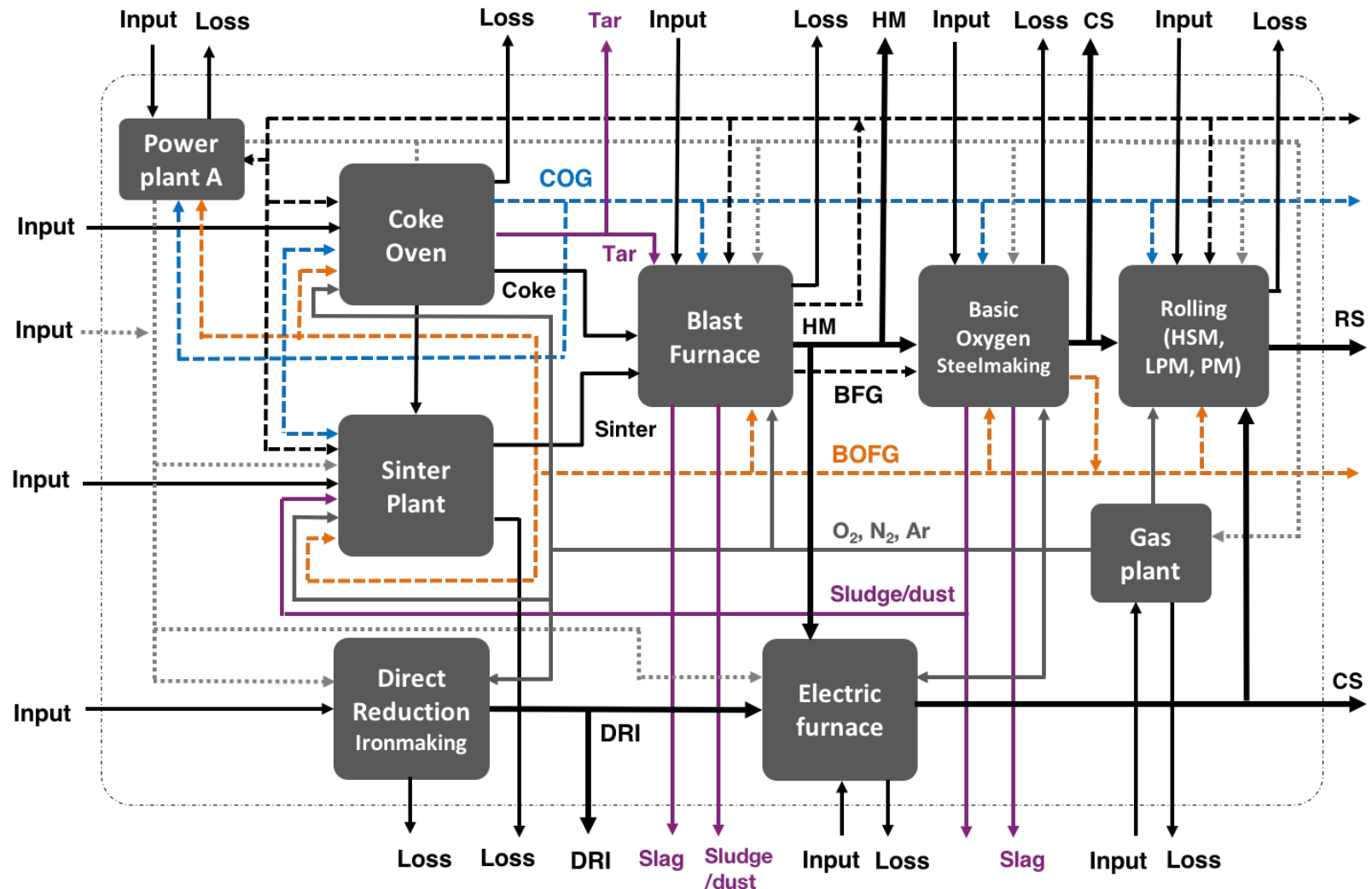
MATERIALS
(kilograms)



Primary steelmaking

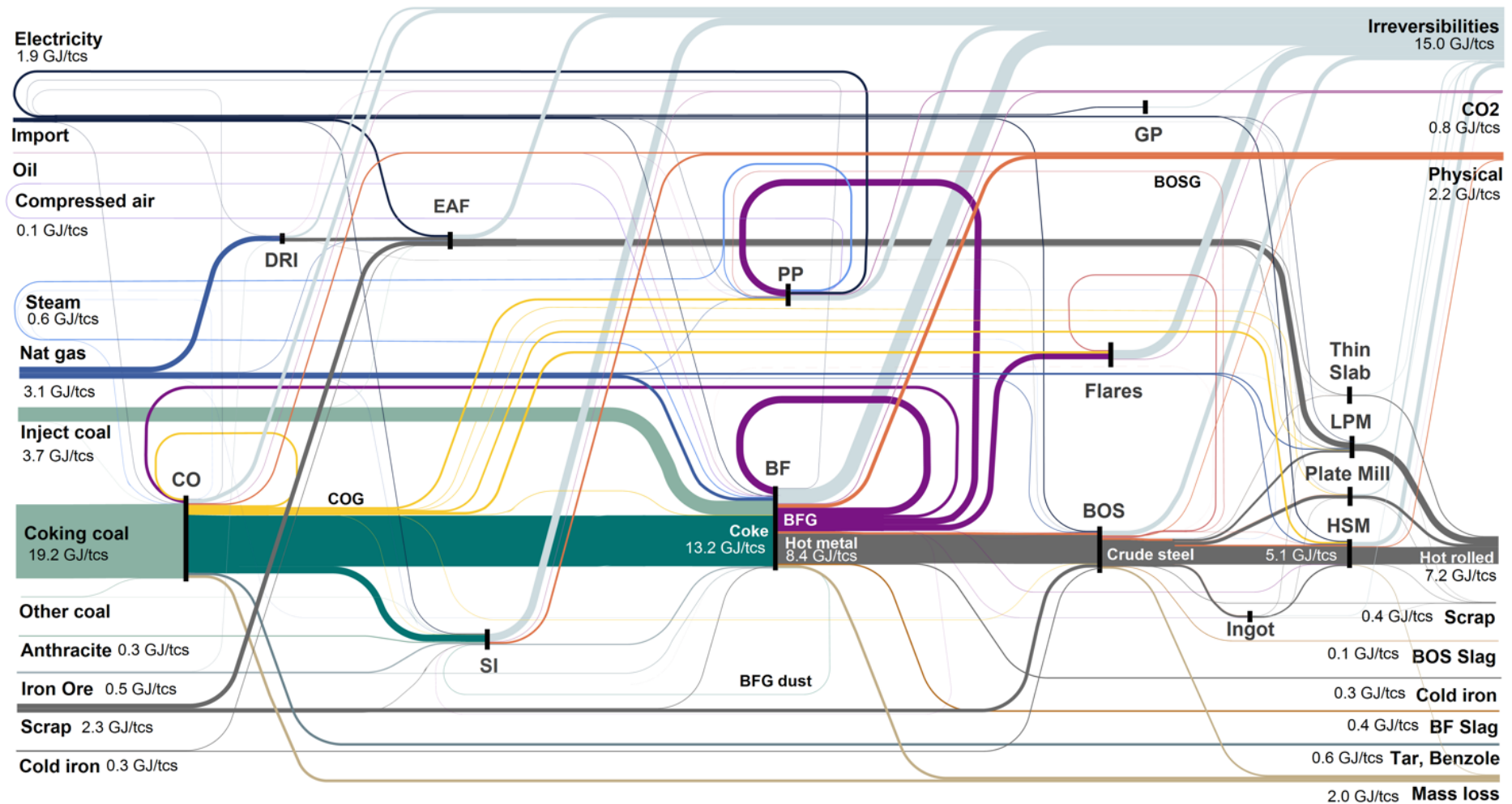
Case study 1

Global average (from 40 plants)



Primary steelmaking

Case study 1

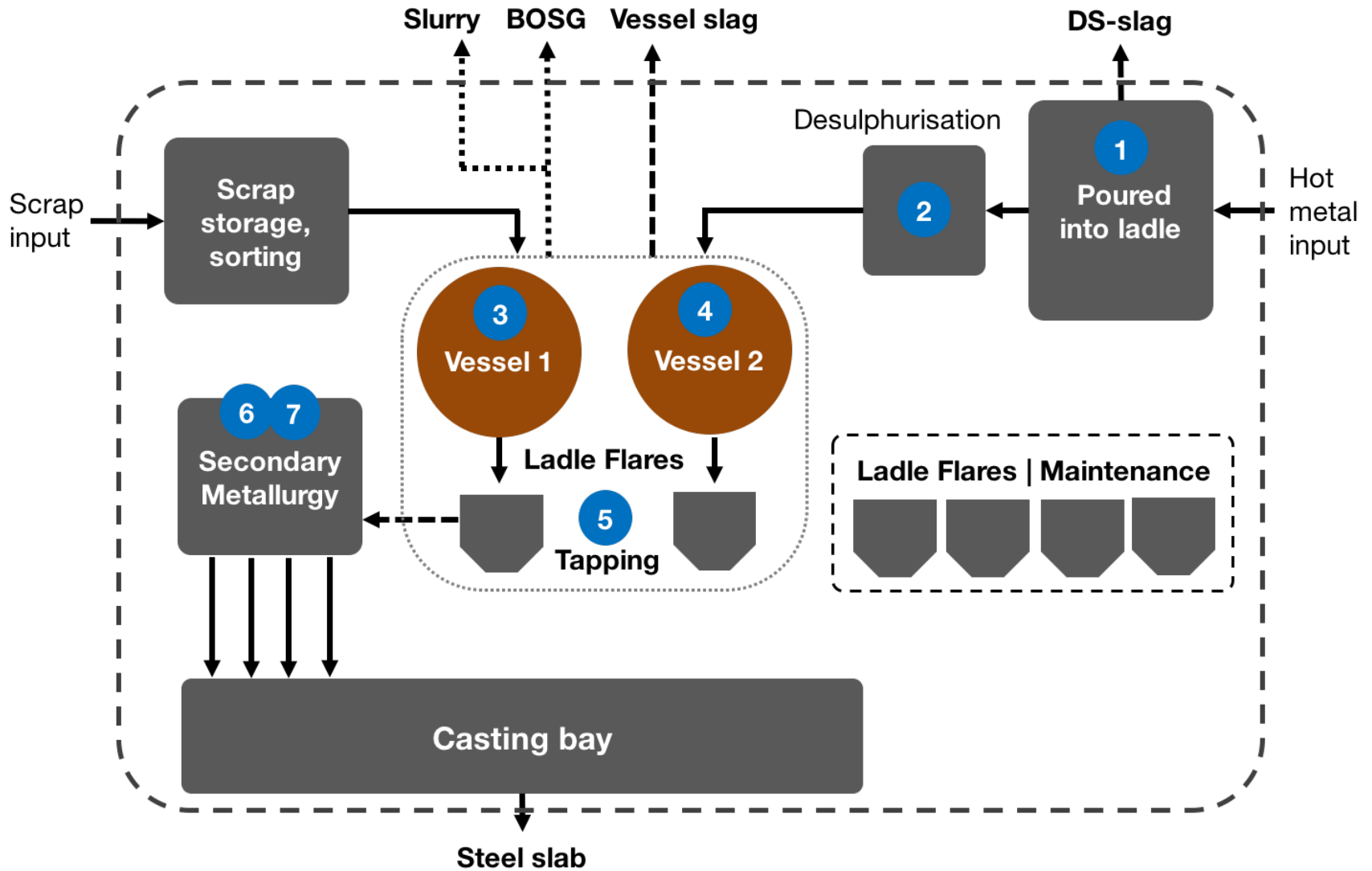


Coke making : 85%
 Sinter plant: 11%
 Blast furnace: 65%
 Basic Oxygen: 80%
 Electric Arc: 63%
 DRI: 54%

Basic oxygen steelmaking plant

Case study 2

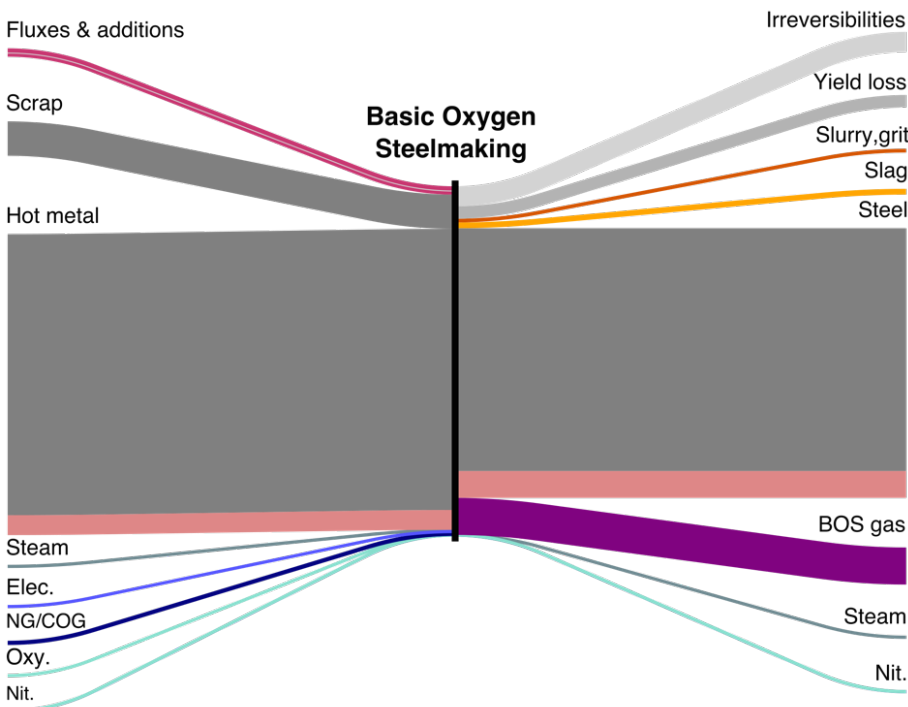
Using real-time control data



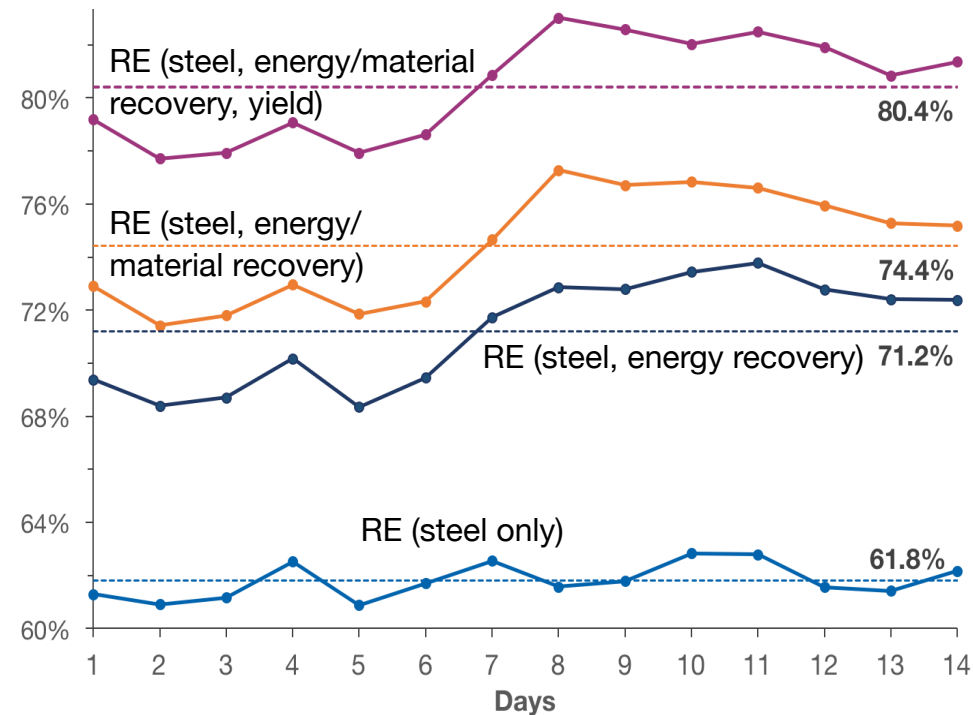
Basic oxygen steelmaking plant

Exergy flows of entire plant (over 14 days)

Case study 2



Summary of the entire plant



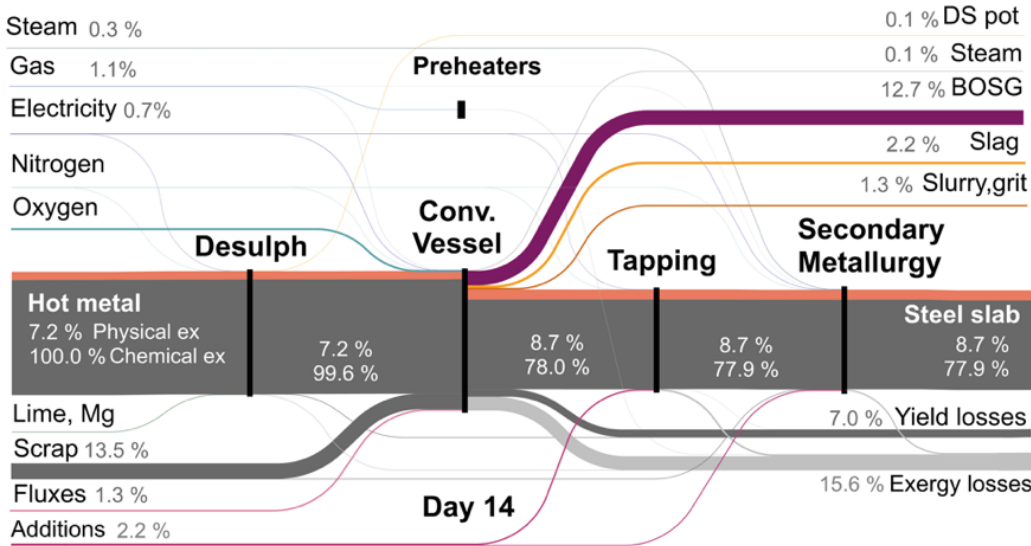
Daily variation in resource efficiency

What is the source of the variation in resource efficiency?

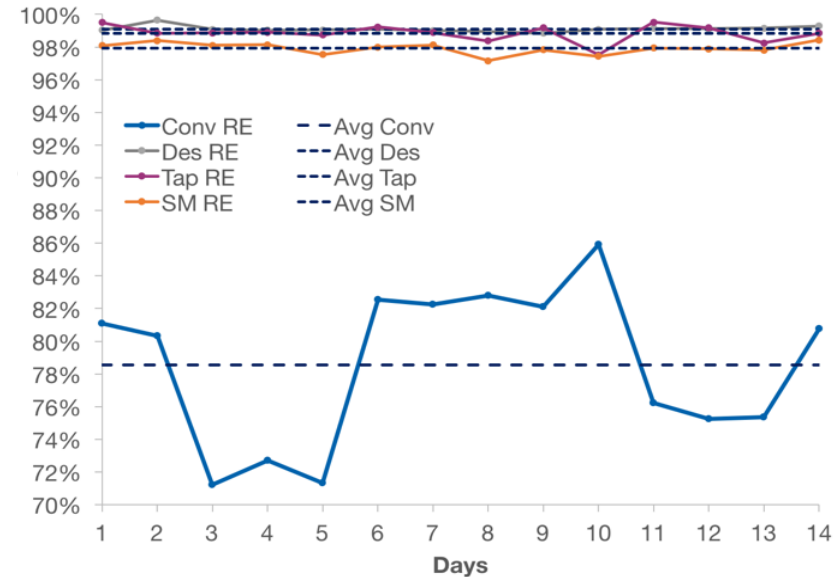
Basic oxygen steelmaking plant

Exergy flows of four sub-processes (over 14 days)

Case study 2



Scale of resource use and structure



Variation in resource efficiency

The largest variation arises in the converter vessel, where the yield losses are greatest and the majority of energy and material by-products are generated

Summary

- ★ **A single resource efficiency metric**

Exergy allows us to combining energy and material efficiency metrics into a single resource efficiency metric

- ★ **Improvement potential**

Both process efficiency and material yield can be analyzed side by side, leading to a wider range of resource saving options

- ★ **Using statistical data or plant control data**

Direct access to control data allows close to real-time analysis of plant resource efficiency, and can be summed up to compare with collated statistical data

- ★ **Resource efficient, low-carbon industry**

A key enabler for a future resource efficient steel industry