



# JOURNÉE TECHNIQUE 2022

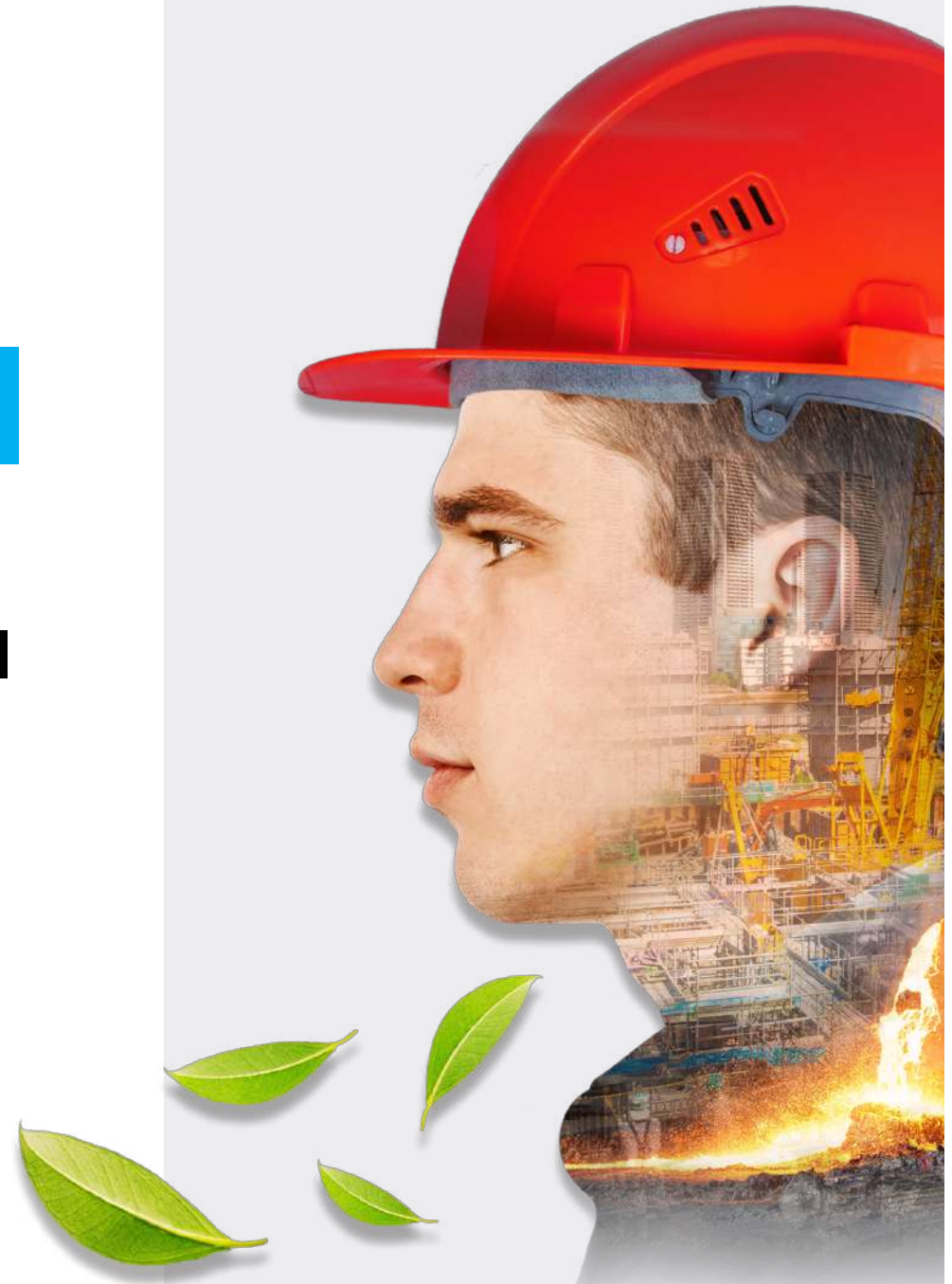
**LES MATÉRIAUX ALTERNATIFS :**  
une opportunité exceptionnelle pour  
atteindre la neutralité carbone



# The transformation of the steel industry and its effects on the slag value chain

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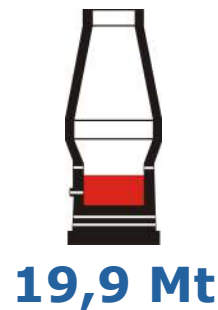


- Service provider focused on research, consultancy and advocacy for slag and by-products of the steel industry for 70 years (since 1950)
- Registered non-profit association based in Duisburg at the heart of the European steel industry
- 45 employees with a wide variety of professional backgrounds: Engineers and natural scientists, Technicians (chemistry lab, construction materials etc.),
- 34 member companies from the steel, cement and slag processing industry
- Annual sales of 5.5 million €
- More information on [www.fehs.de](http://www.fehs.de)
- EUROSLAG: European ferrous slag association with 26 members from 16 countries, see [www.euroslag.org](http://www.euroslag.org)

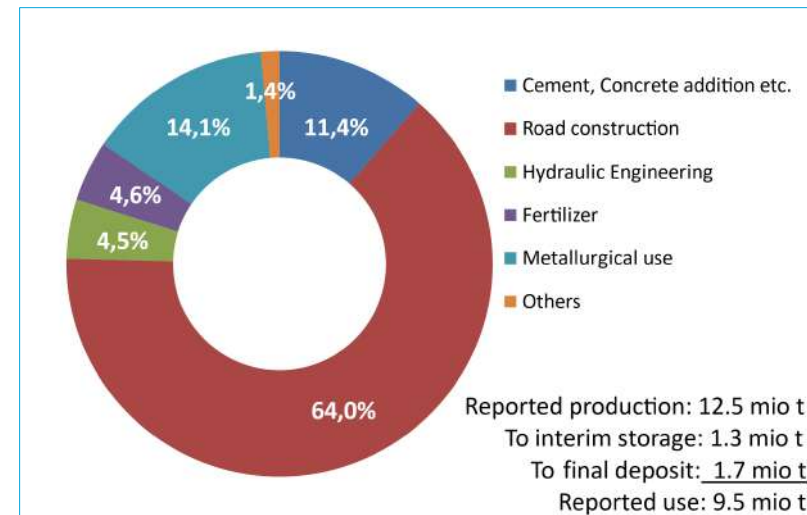
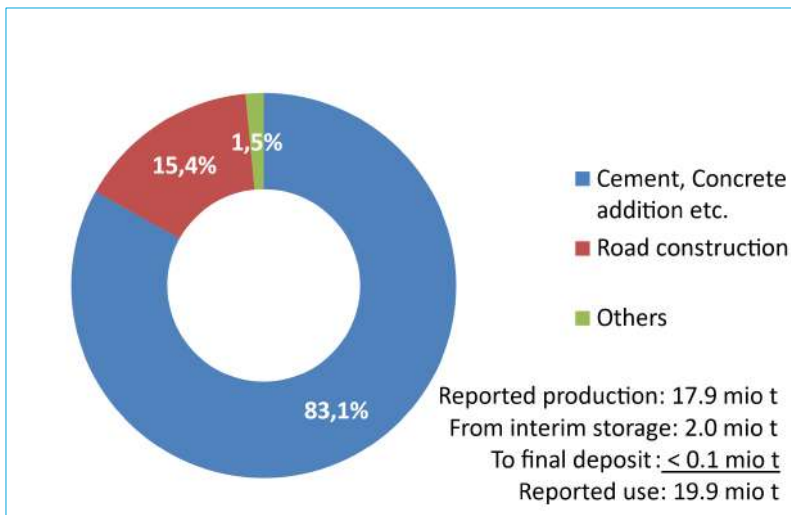
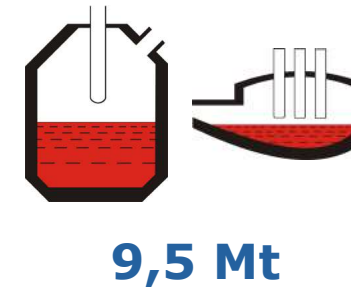


## The utilization of ferrous slag based products is on a high level in Europe!

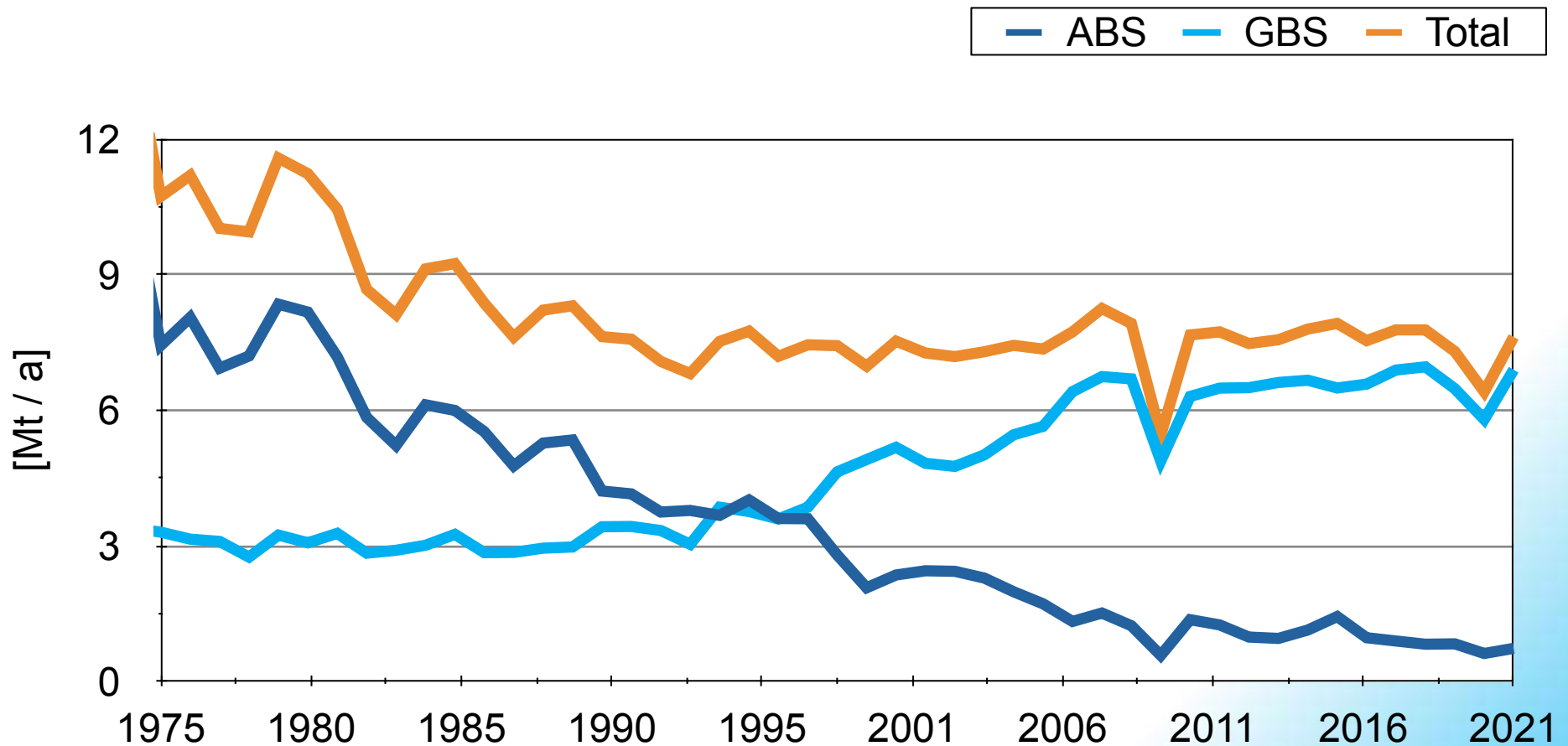
(figures 2021, total ferrous slag production: 42 million tons (25,2 Mt BFS + 16,8 Mt SFS))



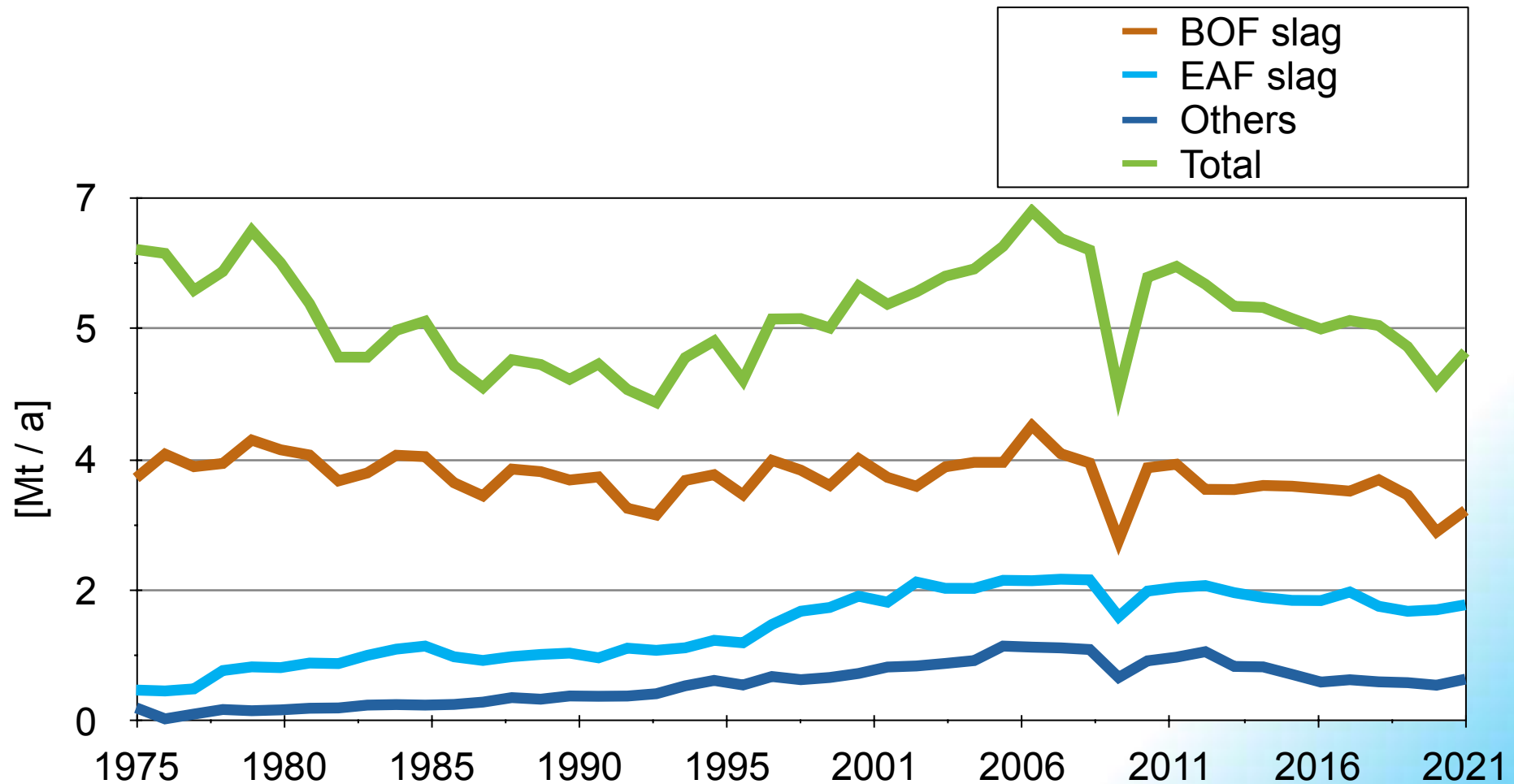
**Production:**  
**30,4 Mt**  
**Utilisation:**  
**29,4 Mt**  
(= 97 %)



In Germany, granulation rates of blast furnace slag have increased up to 90 % (Europe 80 %) !



Looking at steel making slag, the share of EAF slag has increased over the years! (figures for Germany)



Europe (EU 27) accounts for about 9.5 % of global CO<sub>2</sub> emissions of 34.8 billion tons (2020). The European steel industry annually emits 70 million tons of CO<sub>2</sub>. (just scope 1 without electricity and fossil fuel, which equals 40-50 million tons additionally)

### CO<sub>2</sub> Emissions in Europe (EU 27):

Total:	3.3 billion tons
Energy:	2.5 billion tons (75%)
Industry:	315 million tons (9.5 %)
Steel Industry:	70 million tons

Source: EEA/German Federal Environmental Agency  
([www.umweltbundesamt.de](http://www.umweltbundesamt.de))



To meet the Paris Climate targets the EU has set very ambitious CO<sub>2</sub> reduction targets, which require a fundamental transformation process especially for the integrated route of steelmaking!

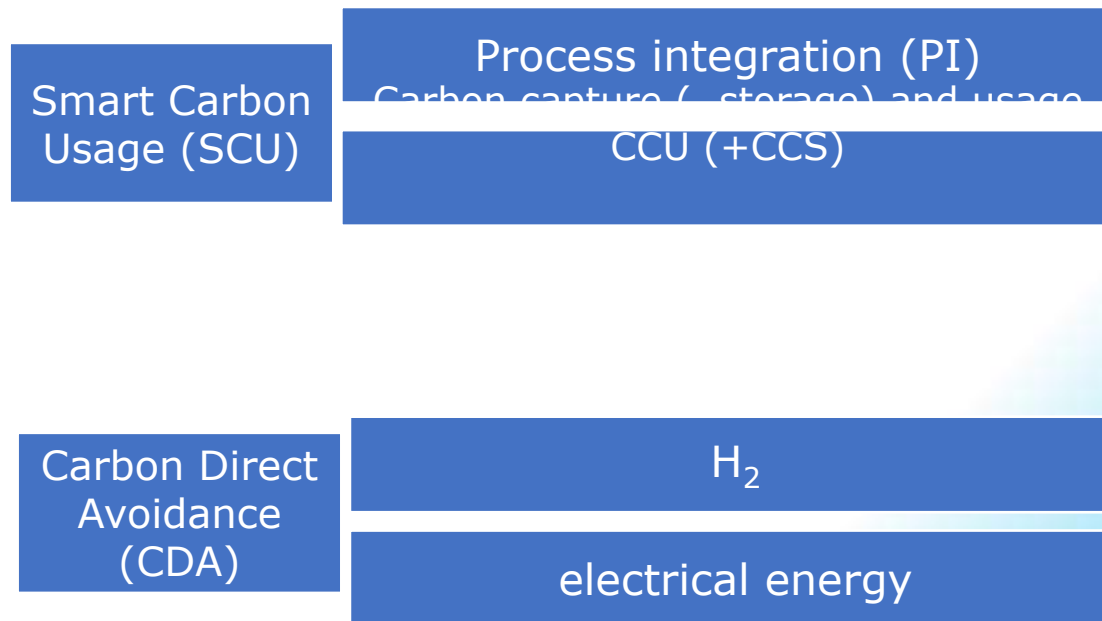
- The EU aims to become carbon neutral by 2050 – an economy with net zero greenhouse gas emissions.
- First milestone is a reduction of CO<sub>2</sub>-Emissions by 55% until **2030** (base year 1990).
- Energy intensive industries like the steel industry aim to become carbon neutral by 2050.
- The steel industry has boosted R & D to manage this transformation process.





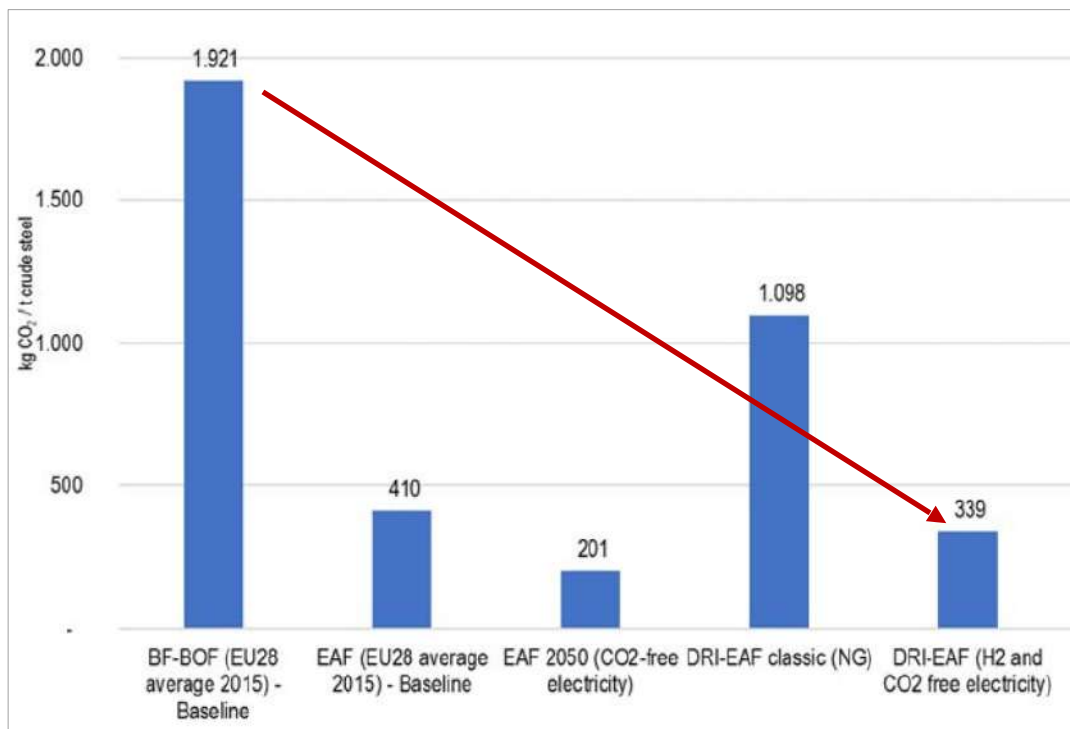
Main focus of the steel industry is to directly avoid CO<sub>2</sub> emissions by using hydrogen instead of coke to reduce iron ore and by replacing any other than green energy with energy from renewable sources.

- Carbon Capture and Usage (CCU)
- Storage and Usage of CO<sub>2</sub> (CCS + CCU)
- Reducing CO<sub>2</sub> (H<sub>2</sub> in Blast Furnace)
- DRI/HBI in Blast Furnace
- New Processes for hot metal production
  - Direct Reduction
  - HIsarna
  - Plasma smelting
- Combination of different pathways



Source: *LowCarbonFuture.eu*

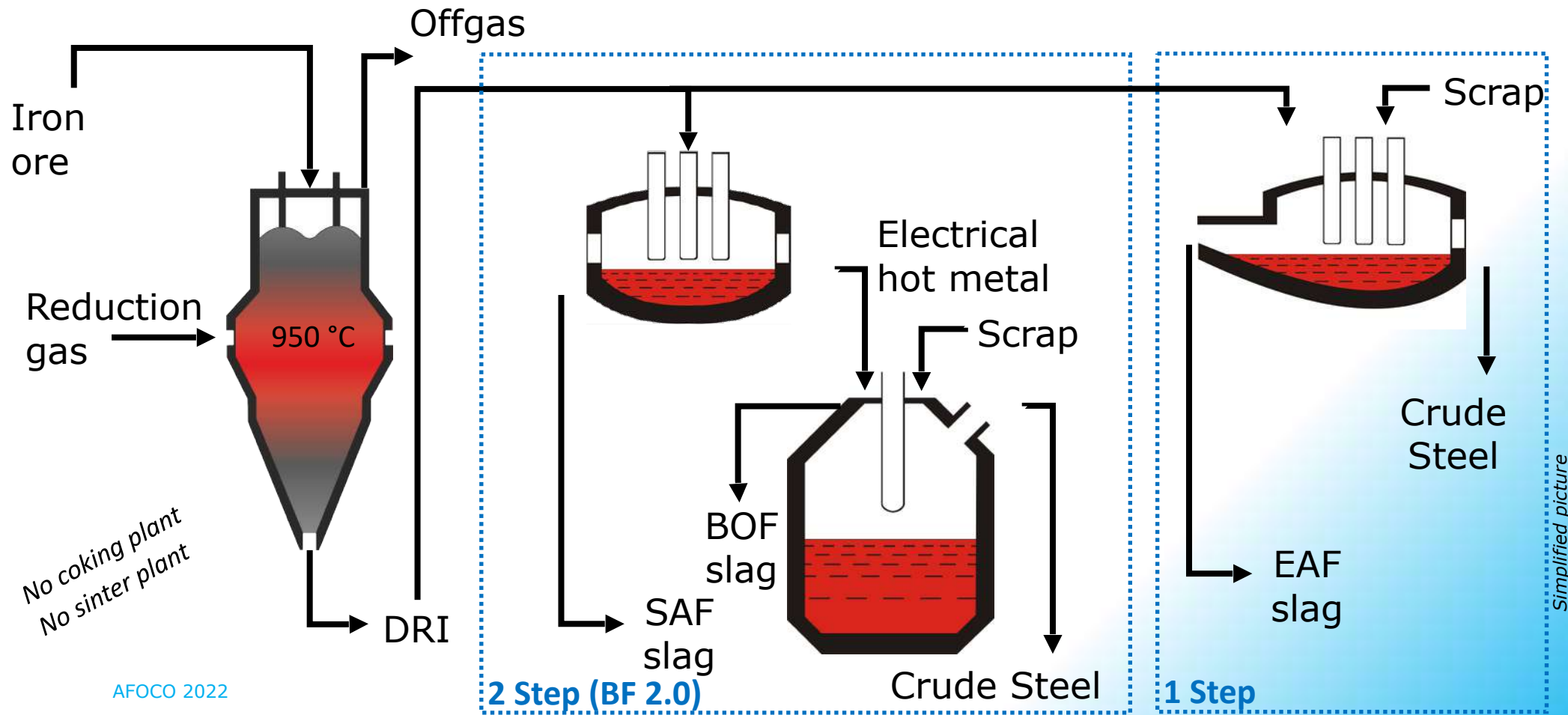
By replacing the (coke reduction based) integrated BF-BOF route with the (hydrogen reduction based) DRI-EAF route, specific CO<sub>2</sub> emissions can be reduced by about 82%.

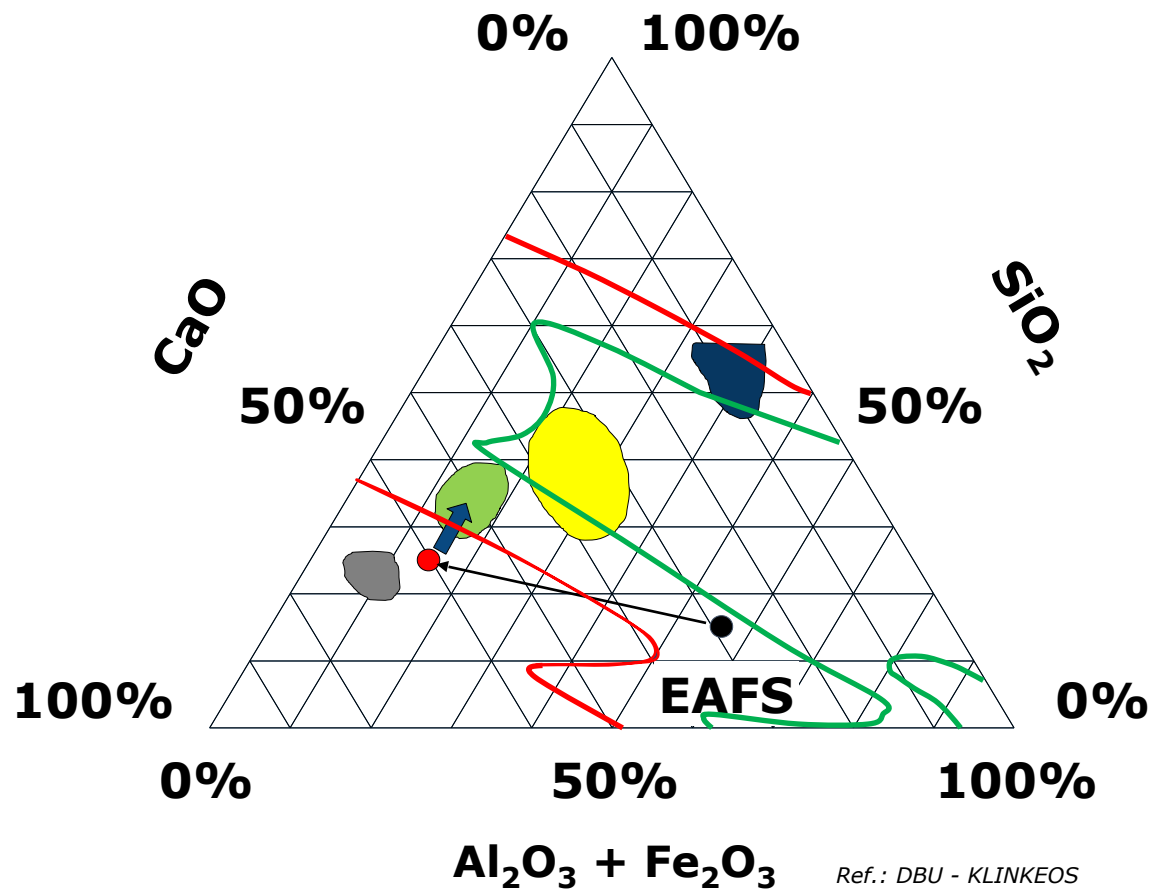


CO<sub>2</sub> Emissions in kg CO<sub>2</sub> / t crude steel of different steel making routes (incl. emissions for Pellets and DRI/HBI)

Source: Lungen, Hans Bodo: Wege zur Minderung von CO<sub>2</sub>-Emissionen in der Eisen- und Stahlindustrie in Europa, VDEh, Mai 2021

Basically, there are 2 different ways of future DRI based crude steel production in a transformed steel industry (DR + EAF / DR + SAF + BOF).





- Silica-rich fly ash
- Calcaerous fly ash
- Granulated BF slag
- Portland cement clinker


— 1600° C  
— 1300° C

## Projects:

2013-2015  
DBU: *KLINKEOS*

2017-2018  
DBU: *DIREKT*

2019-2021  
BMW/AiF: *PROEOS 2*

2021-2024  
BMBF: 

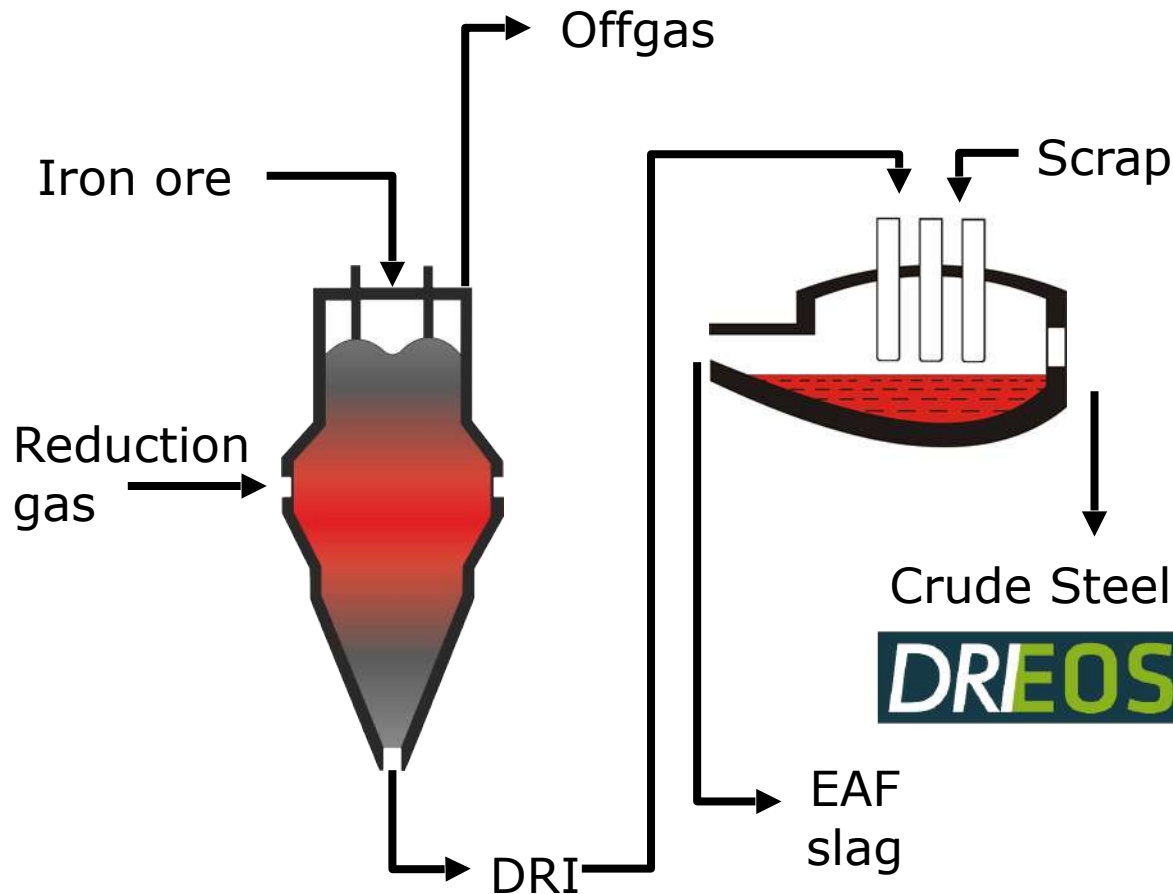
2022-2025  
BMBF: **DREOS**

Scrap  
based

DRI-  
based



The research project „DRI-EOS“ is working on a DRI based EAF slag for the cement industry.



- DRI/slag ratio?
- Lime / dolomite addition?
- Iron oxide content?
- Suitable for cement industry?

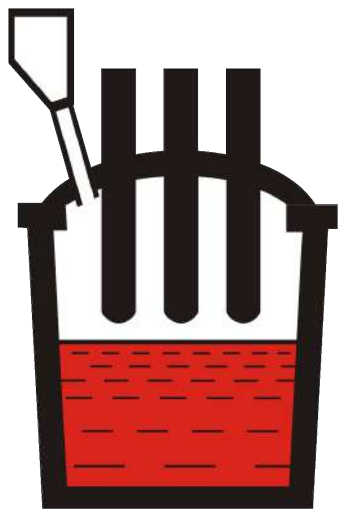


Coordinator: FEhS

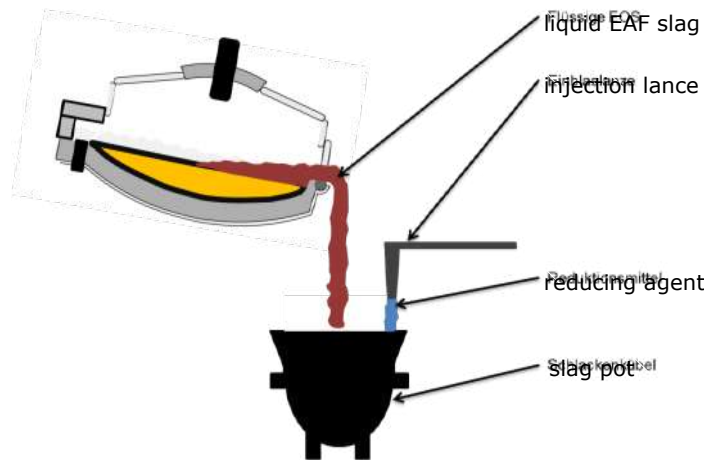
Project duration:

07/2022 – 06/2026

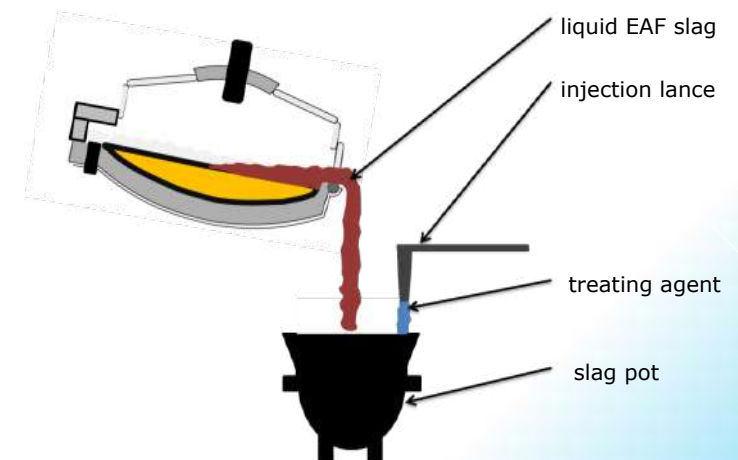
The EAF slag will probably have to be optimized to meet requirements (technological and environmental performance) for cementitious applications.



Secondary Slag Metallurgy

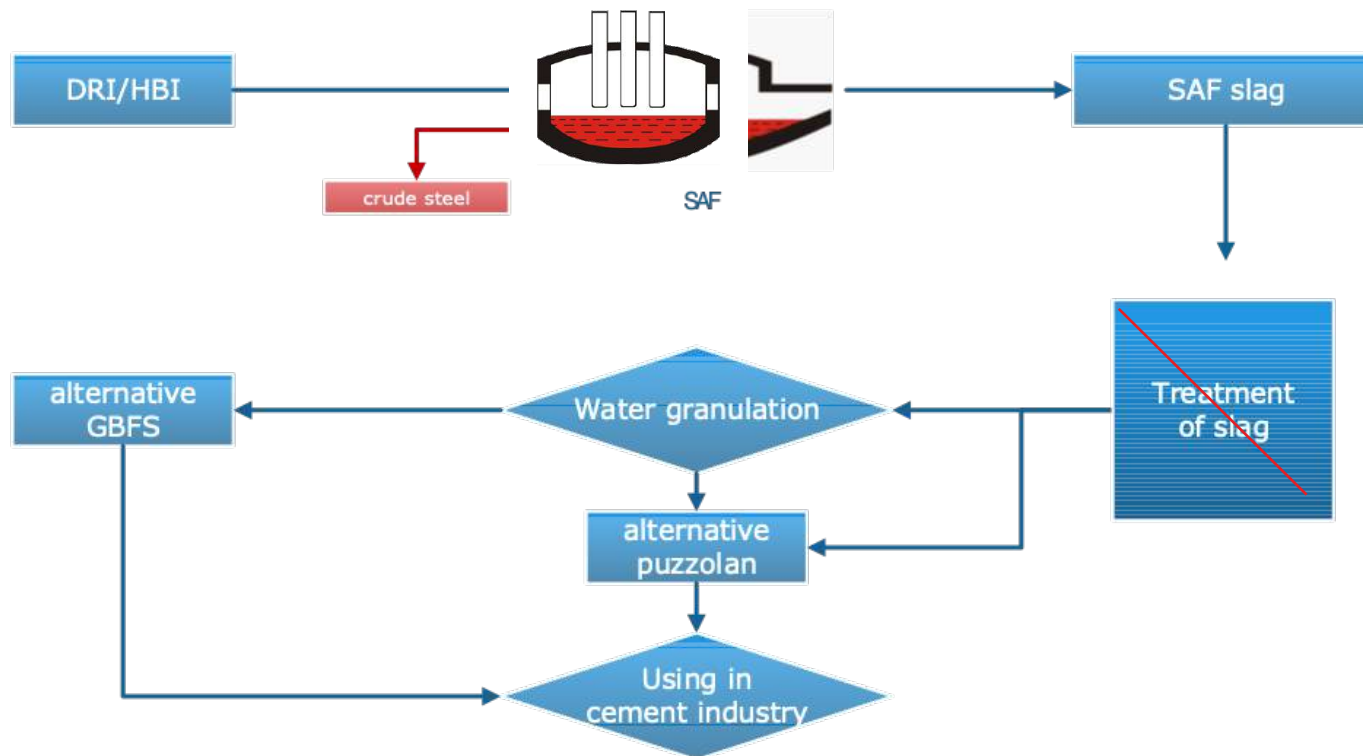


Reduction + treating during tapping



Treating during tapping

The reserach project „SAVE CO2“ aims to directly produce a SAF slag for the cement industry without treatment steps to be taken.



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Offen im Denken

05/2021 – 04/2025



**Afoco**  
Créateur de Matériaux Alternatifs

2022

When it comes to chemical composition of main components we expect that DRI based EAF slag will be more similar to scrap based EAF slag, while DRI based SAF slag will be in the range of BF slag.

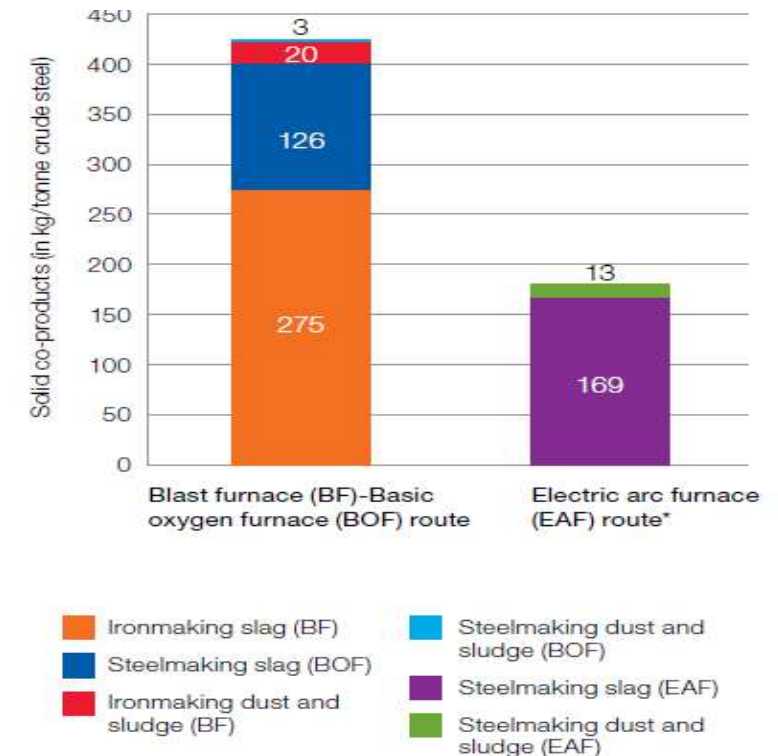
	BF slag	BOF slag	EAF slag (scrap)	EAF slag (DRI+scrap)	SAF slag (DRI)
CaO	34 – 43	43 – 53	20 – 36	?	?
SiO <sub>2</sub>	35 – 40	11 – 18	10 – 18		
MgO	7 – 16	1 – 8	3 – 7		
Al <sub>2</sub> O <sub>3</sub>	8 – 12	1 – 5	4 – 9		
Fe <sub>2</sub> O <sub>3</sub>	0,1 - 1,0	20 – 31	29 – 48		
MnO	0,1 - 1,0	2,5	4- 8		

Ref.: FGSV: Merkblatt über die Verwendung von Eisenhüttenschlacken im Straßenbau, 2013

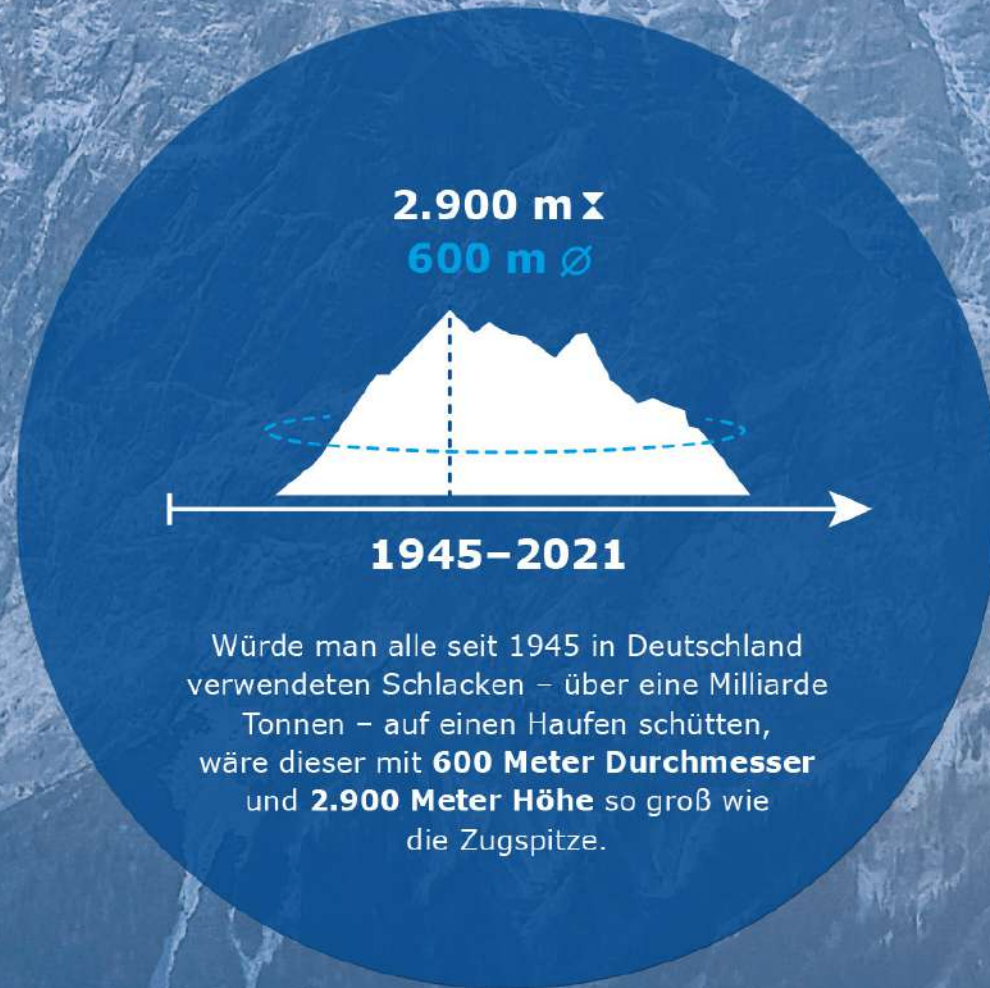


## Main finding for the slag value chain: the “slag mix” will be substantially different in future!

- Decrease in Blast Furnace Slag (GBS/ABS) and Basic Oxygen Furnace Slag (BOF) despite high GBS demand by the cement industry !
- Increase in Electric Arc Furnace Slag (EAF)
  - CO<sub>2</sub> reduction targets
  - General shift towards scrap as raw material
- “ New slag types” due to new iron and steel making processes (direct reduction – different slag types in the EAF)
- R & D to secure for the utilization of these slags!
- **And: We need to change the regulatory framework for cementitious and concrete applications!**



Source: worldsteel 2018



Slag based construction materials and fertilizers are best practice examples for circular economy and the preservation of natural resources!



**The use of ferrous slags is without any doubt a significant contribution  
to an effective circular economy!**

**Prof. Dr. Klaus Töpfer**

(former Minister for Environment in Germany and former Executive Director  
of the United Nations' Environmental Programme)

**THANK YOU FOR  
YOUR ATTENTION**

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