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ELECTRIFICATION EUROPE

2019 INTERNATIONAL SUMMIT

Solutions for a Decarbonized Society

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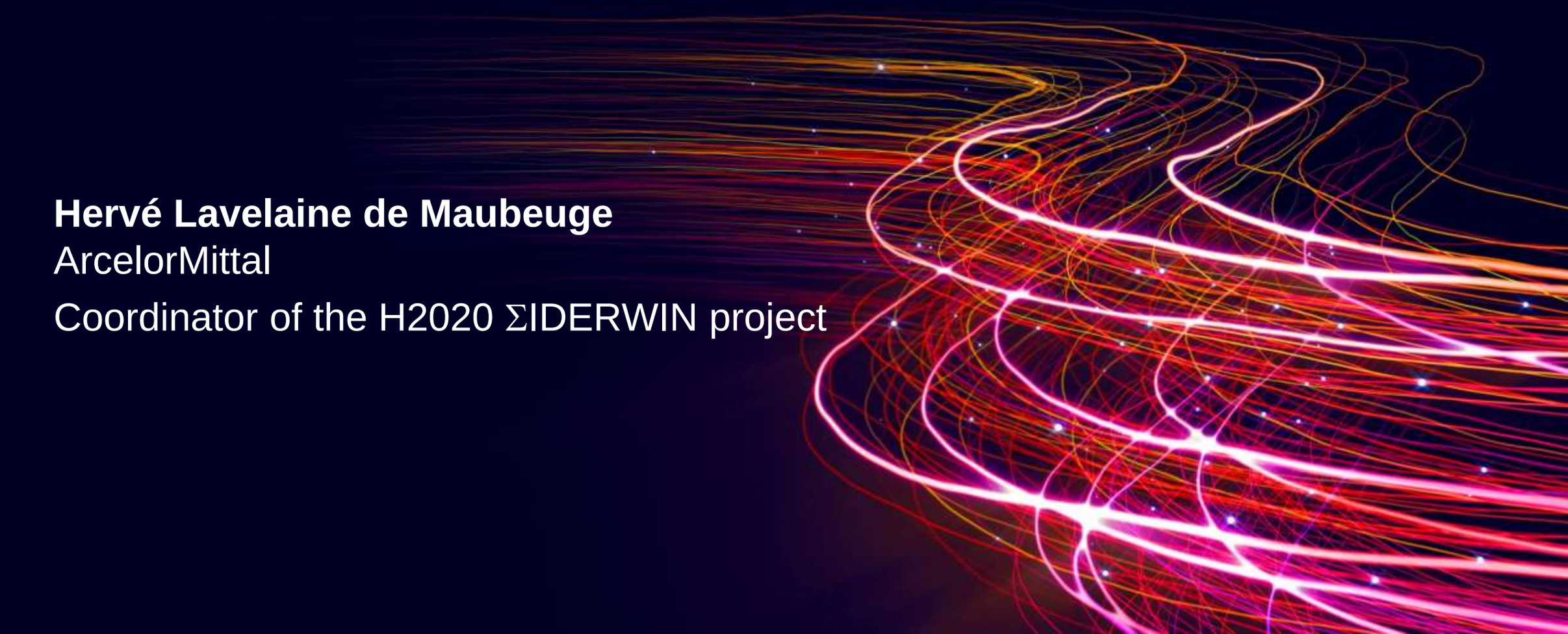
Track B : Decarbonizing Buildings and Industry
Session 3B: Decarbonizing Industry

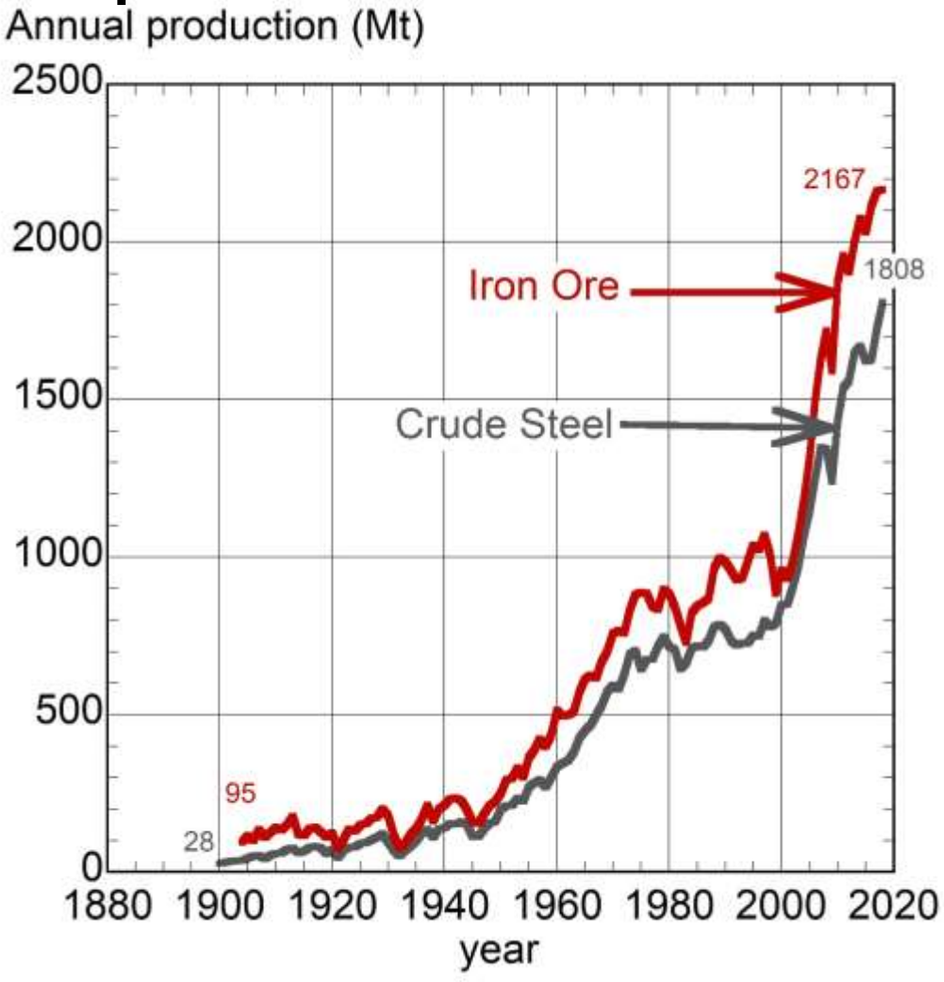
Decarbonisation of primary steel production by electrification



Hervé Lavelaine de Maubeuge
ArcelorMittal
Coordinator of the H2020 ΣIDERWIN project

Decarbonisation of steel production by electrification

- **Steel production**

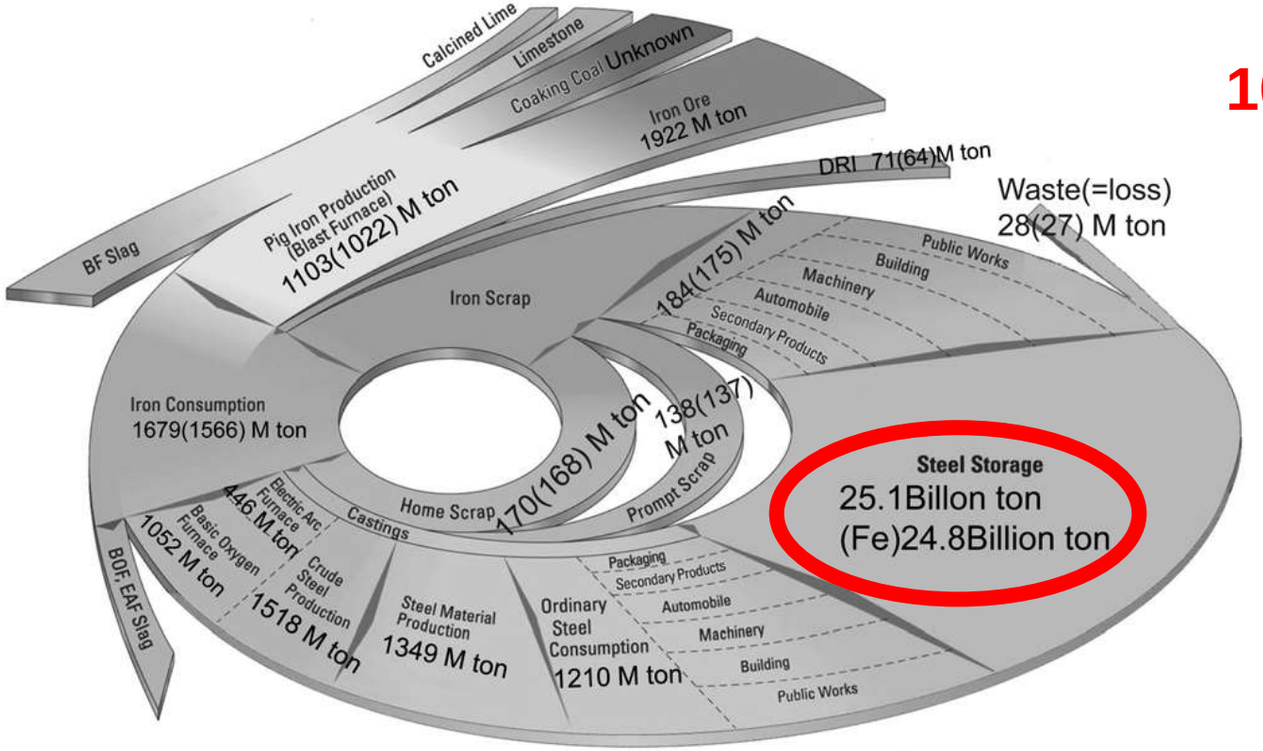


WorldSteel statistics, USGS

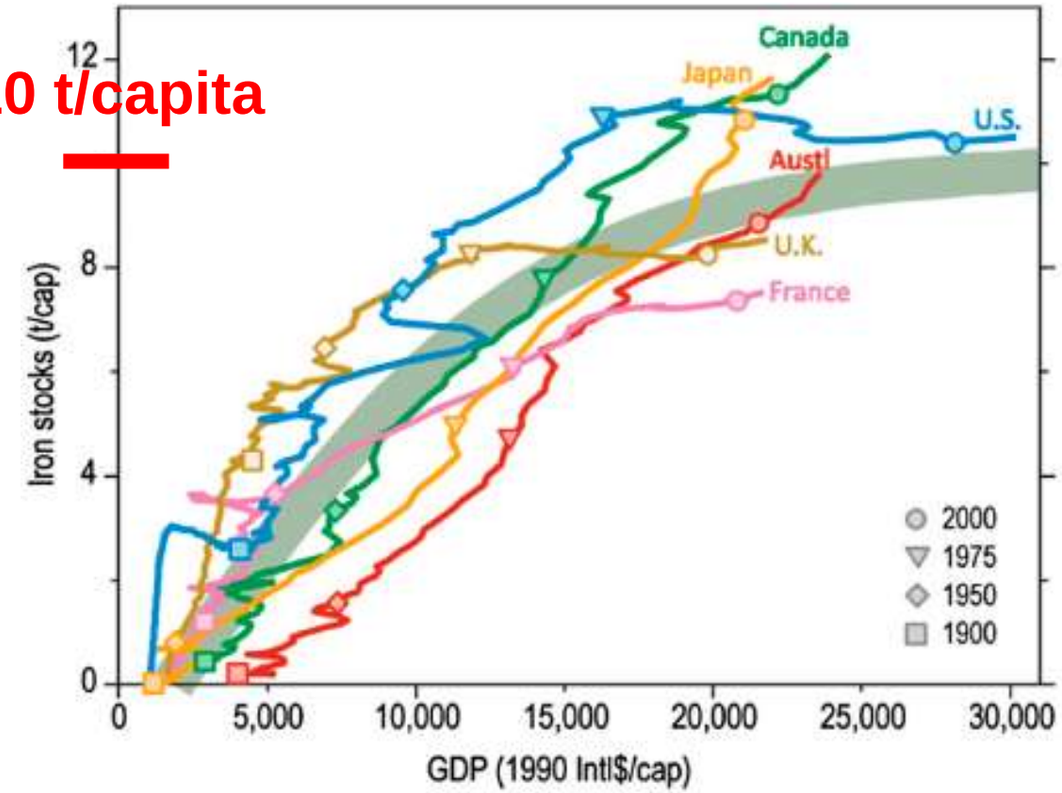
- **1 808 Mt of crude steel.**
- **71% primary steel.**
- **2 167 Mt of iron ore.**
- **Fe = 18 x Al, in tonnage.**
- **Fe = 84 x Cu, in tonnage.**
- **Iron ore: second raw material transported by seaborn trade.**

Decarbonisation of steel production by electrification

- **Steel use**



10 t/capita



Nobuhiko TakamaTsu, Kimitoshi Yonezawa, Hironori ueno, Wakana Tamaki and Seiichi HaYasHi

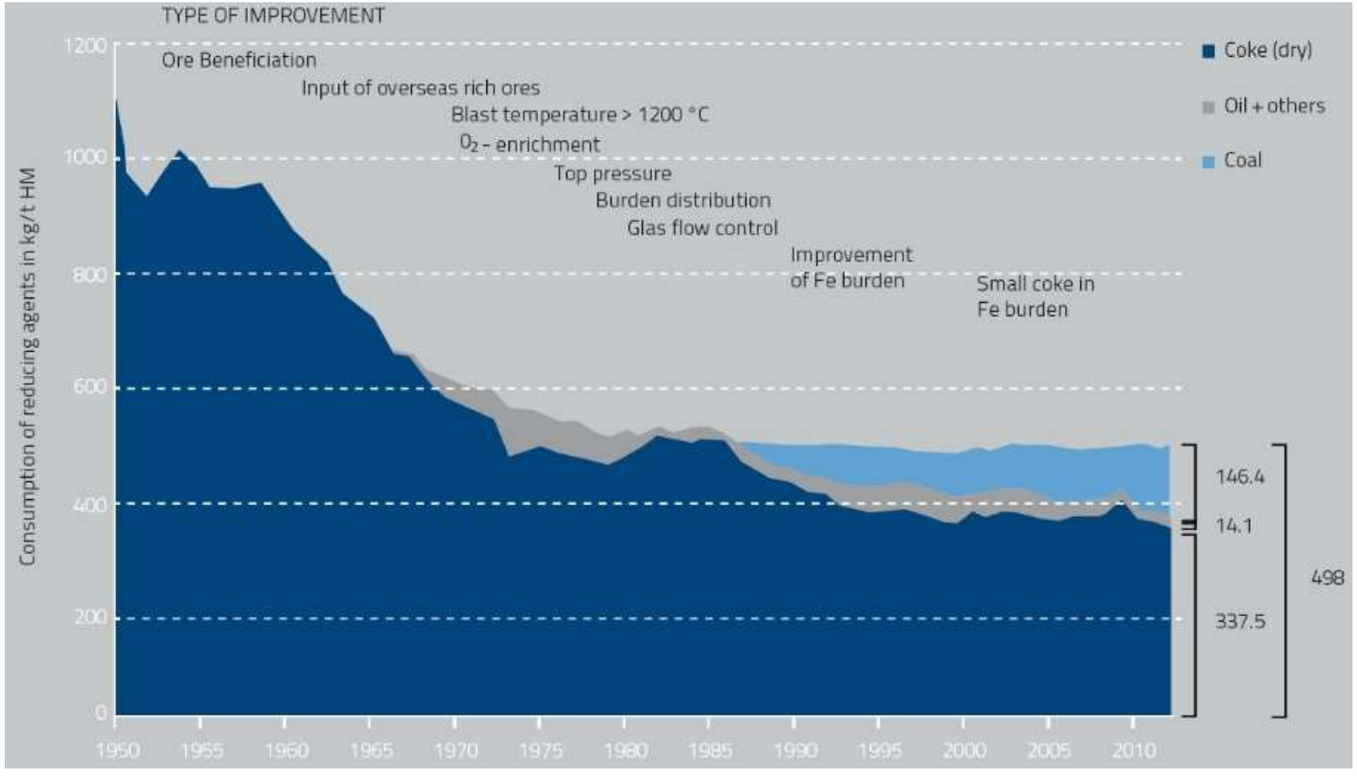
Tetsu-to-Hagané Vol. 100 (2014) No. 6

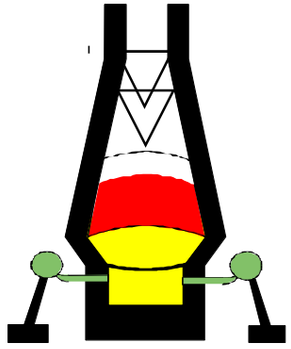
D. Müller et al. Patterns of Iron Use in Societal Evolution (2011)

Decarbonisation of steel production by electrification

- **CO_2 emissions**

Use of reducing agents in the blast furnace in Germany





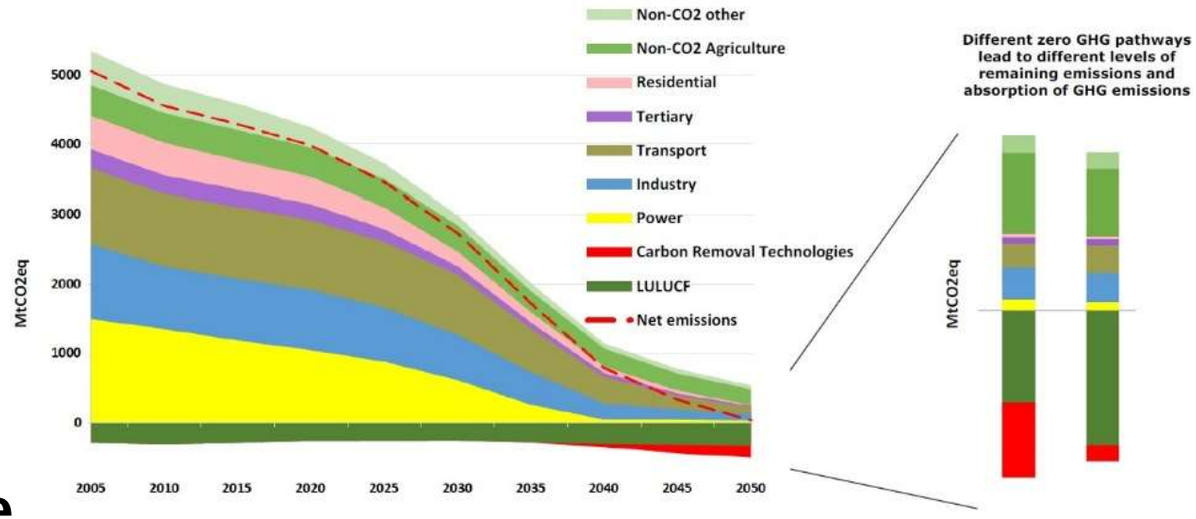
~600 kg_{Carbon}	
20 GJ or 5.5 MWh	per t_{Steel}
2 t_{CO2}	

The steel industry generates between 7 and 9% of direct emissions from the global use of fossil fuel. *WorldSteel*

A Steel Roadmap for a Low Carbon Europe Eurofer (2013)

Decarbonisation of steel production by electrification

- **Climate neutral Europe by 2050**
  - **The goal is to reach net-zero emissions by 2050. Switching to low and zero carbon energy sources such as renewables-based electrification.**
  - **Steel emissions are process-related from chemical reactions other than combustion which are difficult to reduce.**

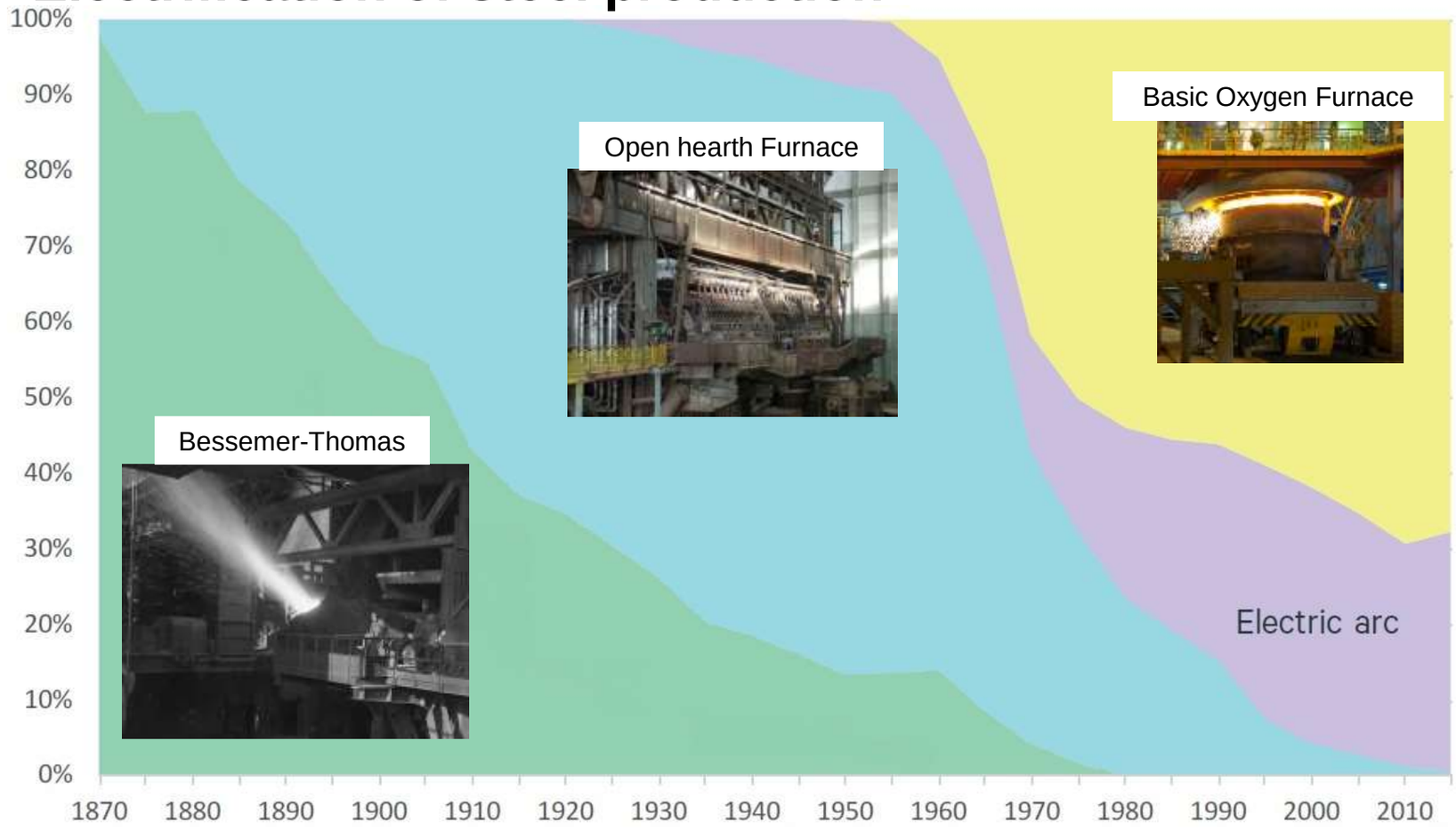


European Commission - Strategy for a climate neutral Europe by 2050 (2018)

European Commission - A Clean Planet for all (2018)

Decarbonisation of steel production by electrification

- **Electrification of steel production**



Jernkontoret (2016)

Electrification of secondary steel

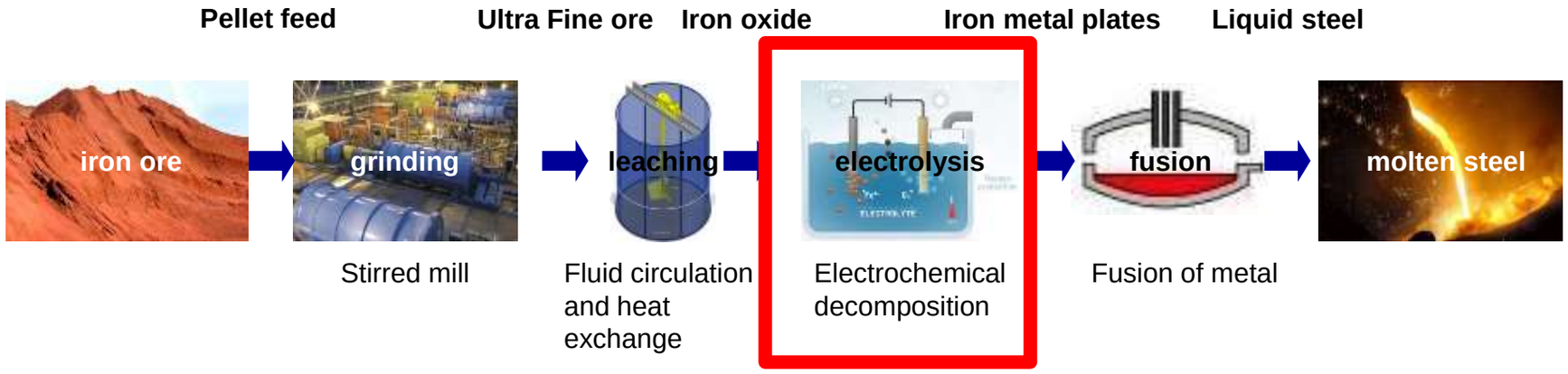
=

⅓ of crude steel

Decarbonisation of steel production by electrification

- **Electrification of primary steel production**

$$\tfrac{1}{2}Fe_2O_3 \rightarrow Fe + \tfrac{3}{4}O_2$$



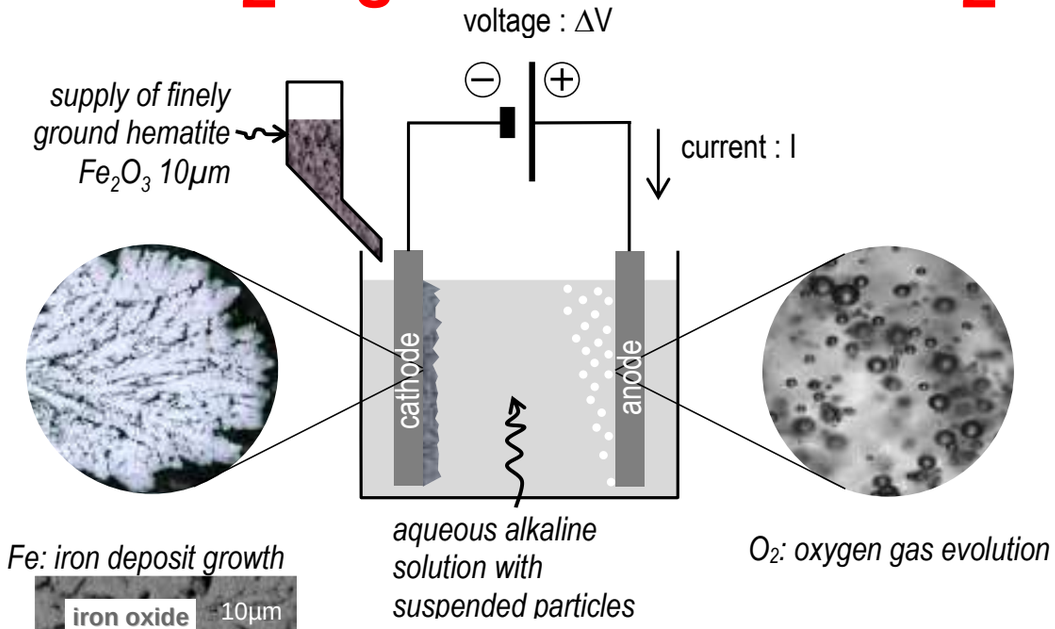
  - **A new processing route for steel.**
  - **Overall energy consumption 3.6 $MWh.t^{-1}_{Fe}$ or 13 $GJ.t^{-1}_{Fe}$.**
  - **Reduction by 31% of the direct energy use.**
  - **Reduction by 87% of the direct CO_2 emissions.**

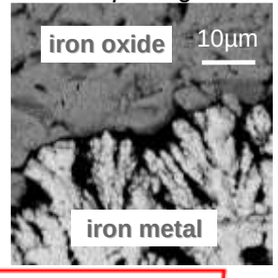
Electrification of today Europe primary steel production 100 $Mt.a^{-1}$ would require 360 $TWh.a^{-1}$ compared to 35 $TWh.a^{-1}$ for 70 $Mt.a^{-1}$ of secondary steel

Decarbonisation of steel production by electrification

- **Iron Electrowinning**

$$\tfrac{1}{2}Fe_2O_3 \rightarrow Fe + \tfrac{3}{4}O_2$$





- **Low temperature electrolysis: 110°C.**
- **Conductive aqueous alkaline electrolyte medium 50wt% NaOH - H_2O.**
- **No separator as membrane or diaphragm between electrodes.**
- **Electrolysis is applied to 10 µm hematite solid particles rather than dissolved ions.**
- **High reaction rate with current density 1000 $A.m^{-2}$.**
- **Low distance between electrodes 1cm.**
- **Cathodic iron grown as self-standing, stiff, compact and conveyable metal plates.**
- **Full recovery of anodically produced O_2.**
- **Non-consumable anode.**
- **Non critical elements in electrode materials, Ni anodes.**

Siderwin

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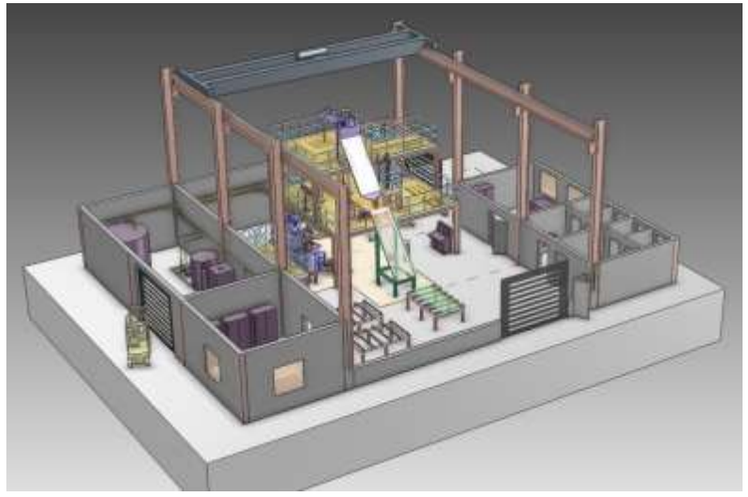
Decarbonisation of steel production by electrification

- **ΣIDERWIN project**

  - **5 years project 2017-2022**
  - **Budget: 6.8 M€ includes 2.2 M€ for pilot.**
  - **7 different countries.**
  - **12 partners : 4 Companies + 4 SMEs + 4 RTO**
  - **Multisectorial: steel, non-ferrous and power.**
  - **Coordinated by ArcelorMittal.**
  - **https://www.siderwin-spire.eu/content/home**

Decarbonisation of steel production by electrification

- **ΣIDERWIN project – TRL6 pilot**



- **Electrodes** **2.75x1 m**
- **Current intensity** **3kA**
- **Power** **6kW**
- **Electrolyte volume** **300L**
- **Production: iron metal samples of 100kg.**

- **Continuous and automated iron ore supply.**
- **Gas oxygen collection.**
- **Metal harvesting system.**
- **Vertical extension for low footprint.**

- **Flexible metal production, interruptible for grid controlled by a communication system.**
- **Enlarged iron oxide sources.**

Decarbonisation of steel production by electrification

- **ΣIDERWIN project for future mass steel production**
  - **Oxygenation of the atmosphere.**
  - **Reduction of wastes from mineral industries.**
  - **Participation in electric grid balancing.**
  - **Massive electricity storage.**
  - **Direct production of primary steel.**

Decarbonisation of steel production by electrification

- **ΣIDERWIN project**
  - **This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768788".**

  - **"This study reflects only the author's views and the Commission is not responsible for any use that may be made of the information contained therein"**