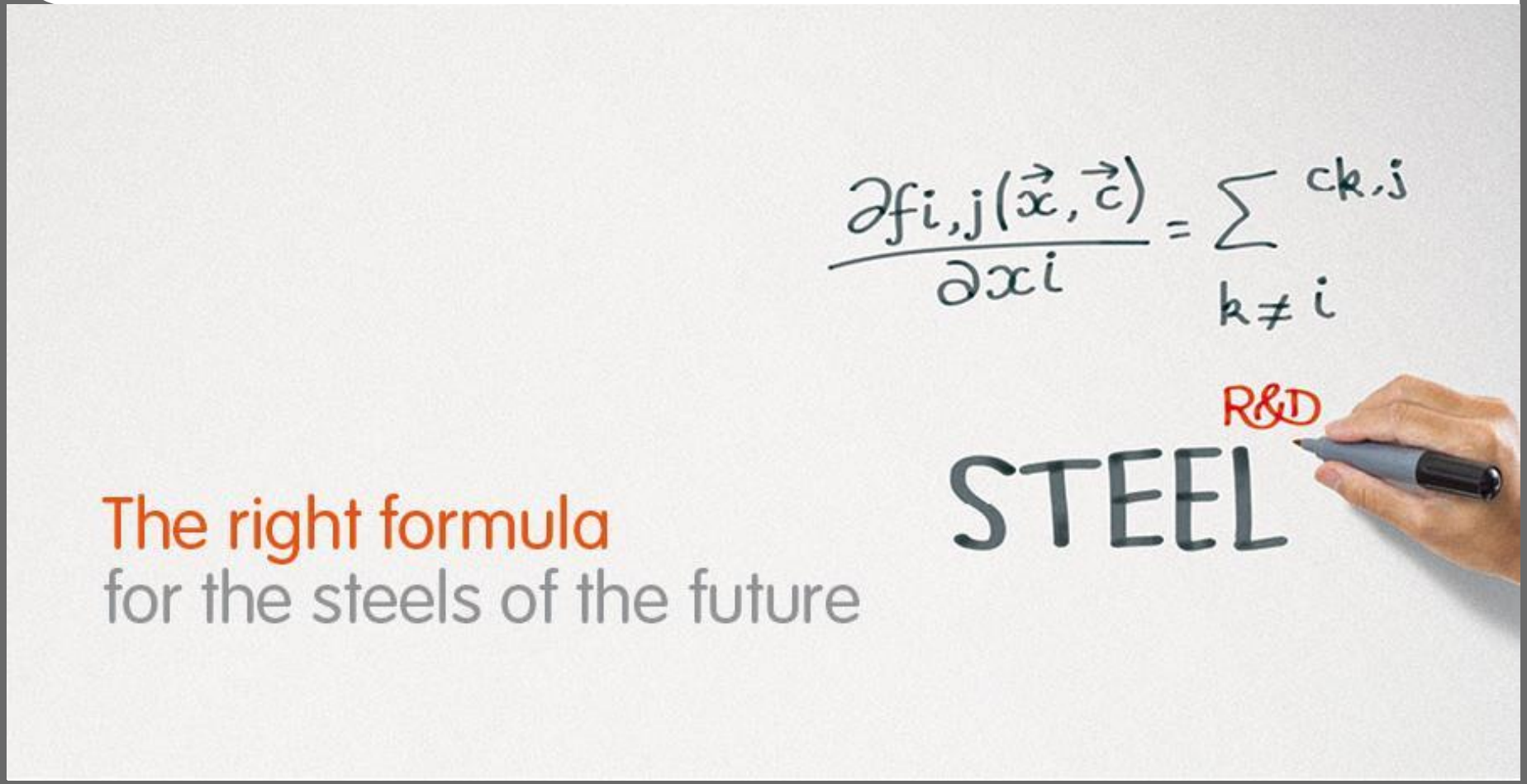
ArcelorMittal

SIDERWIN project

ETIPWind Sector Coupling Round Table

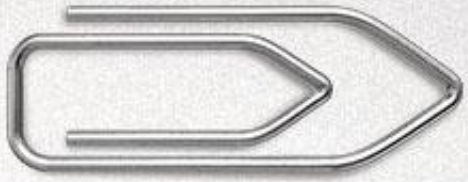


Outlook

1. Steel production
   - Main figures
   - Conventional process
2. SIDERWIN project
   - Technical route
   - Objectives
3. Steel – Energy coupling
   - Past and present
   - Future

Steel production

Lightweight, ...

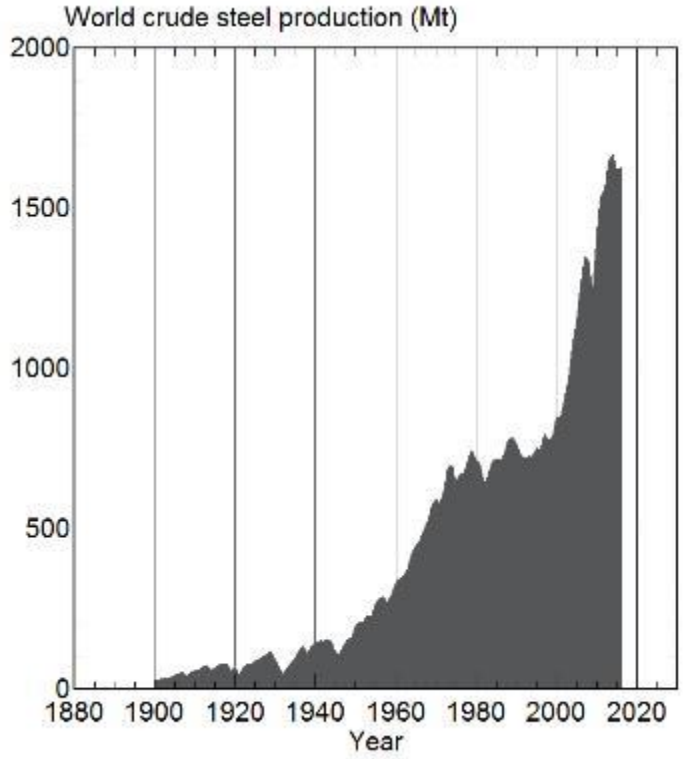


sustainable design

Our constant goal

Steel production

- World steel production (2016)

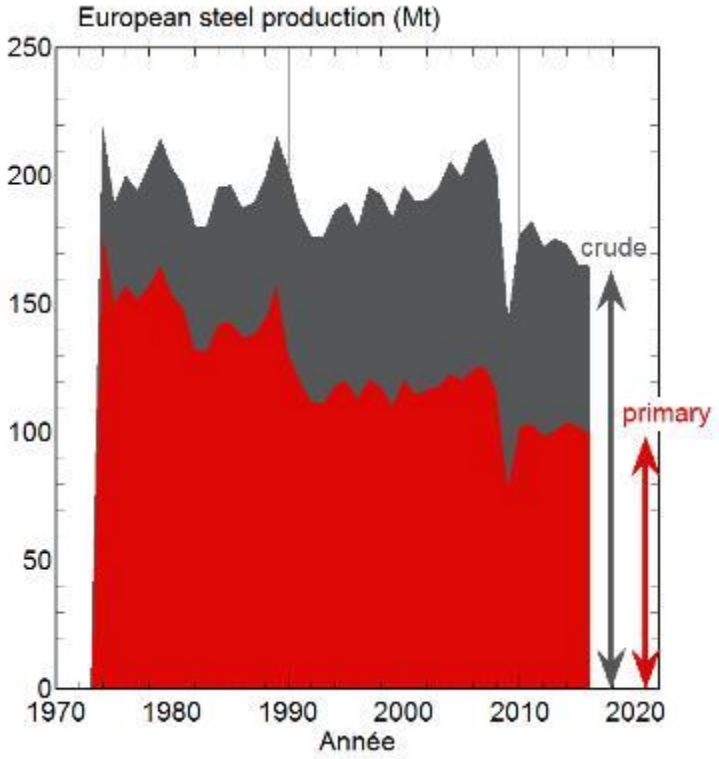


https://www.worldsteel.org

- 1 628 Mt crude steel.
- 75% primary steel.
- 1000 G$ turnover.
- BAU scenarios predict 2.0 à 2.5 Gt in 2050.
- Accounts for 6.7% GHG emissions.

Steel production

- European steel production (2016)

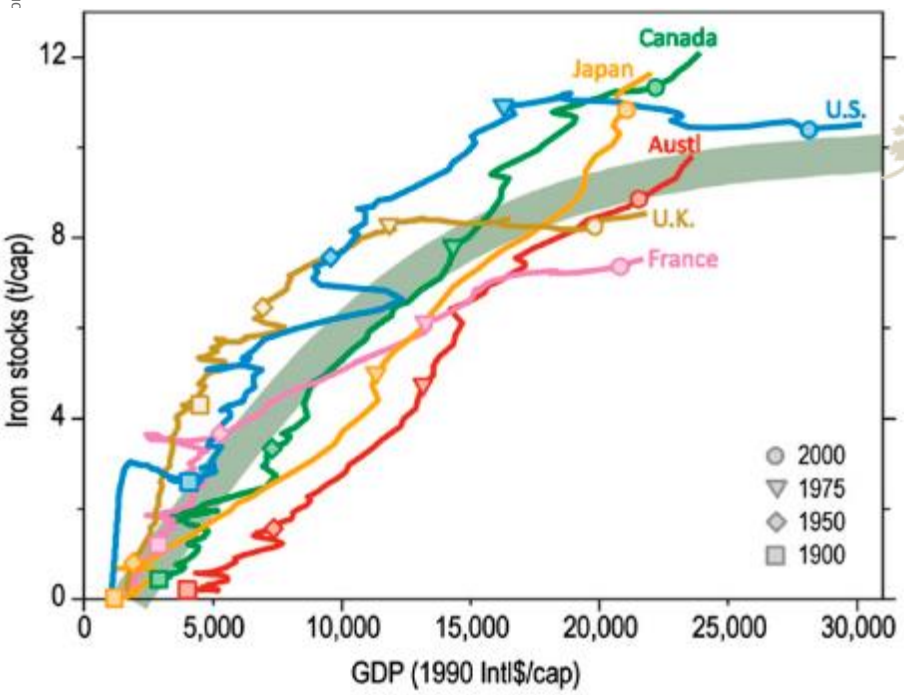


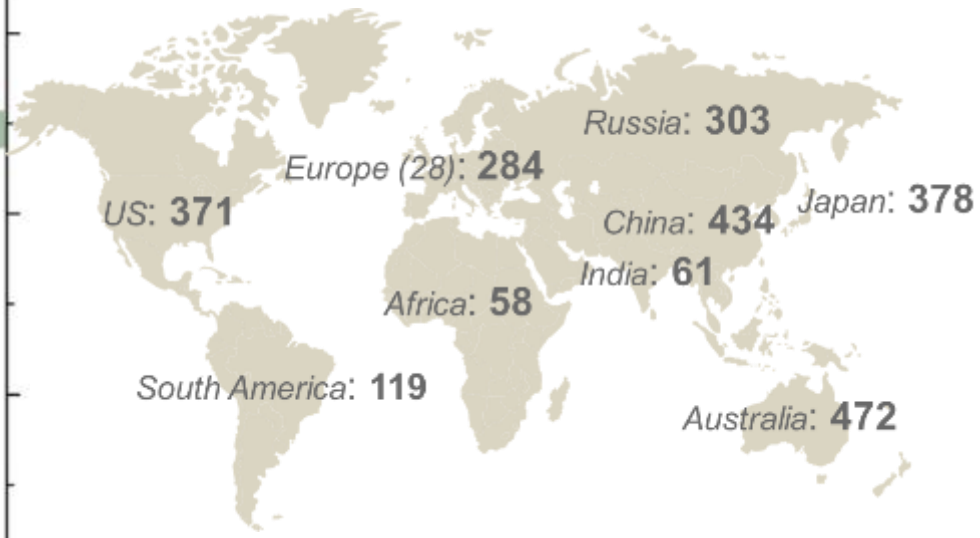
https://www.worldsteel.org

- 162 Mt crude steel (2016).
- 60% primary steel.
- 320 000 employees.
- 170 G$ turnover.
- 1.4% GDP.
- Second world largest productor.
- 236 Mt expected in 2050.
- Accounts for 5.3% GHG emissions.

Steel production

- Steel consumption per capita





- 20 Gt of steel in use worldwide

Steel production

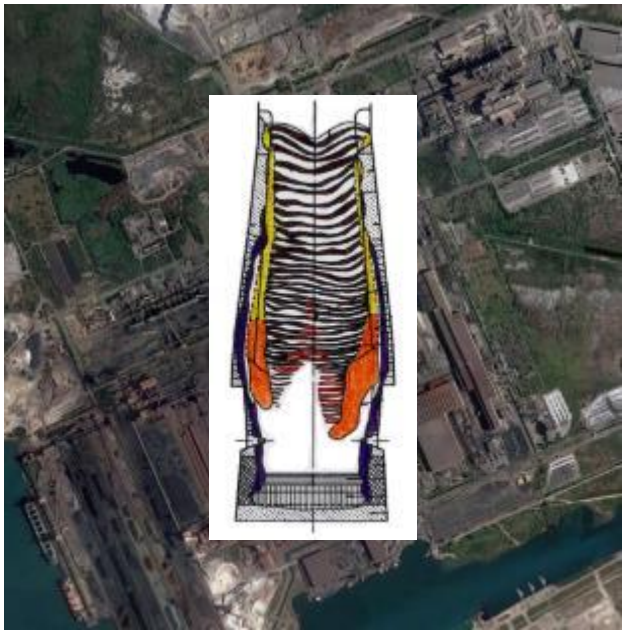
- Steel production process: Blast Furnace Route

$$Fe_2O_3 + C + O_2 \rightarrow CO_2 + Fe$$

1.5t 0.5t 1.83t 1.0t

coke

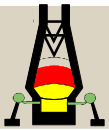
Iron ore

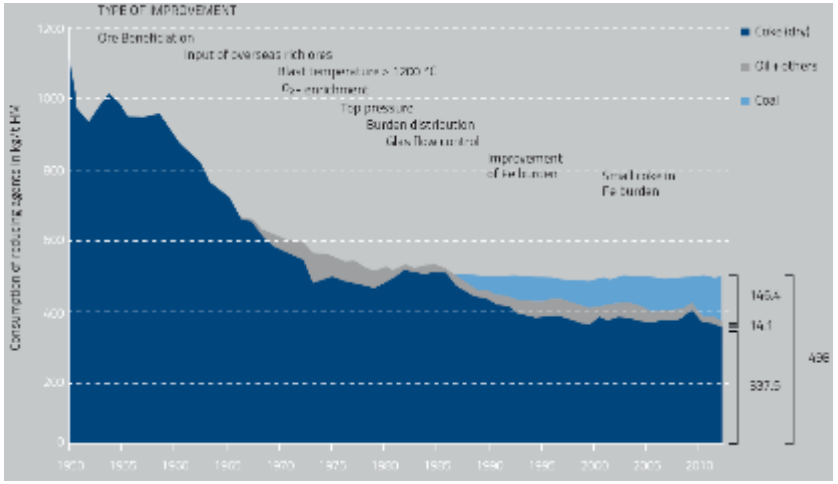


Hot Rolled Coil

Steel production

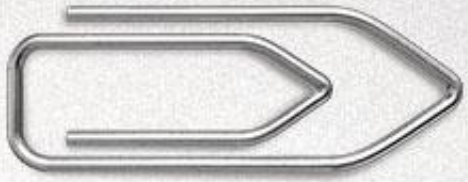
- Steel production process:
  - 87 % of produced steel is recycled.
  - Mean residence time of steel is 16 years.
  - Scrap demand exceeds supply.
  - Process has reached a high energetical maturity.

	
	Blast Furnace
Energy	18.6 $GJ.t^{-1}_{steel}$
	5.2 $MWh.t^{-1}_{steel}$
CO_2	1.83 $t.t^{-1}_{steel}$



SIDERWIN project

Lightweight, ...



sustainable design

Our constant goal

SIDERWIN project

- Addressing primary Steel production in the its simplest chemical route.

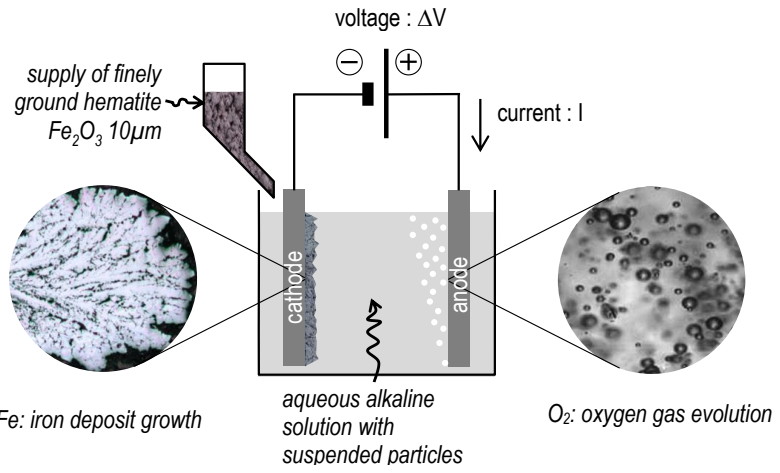
$$\tfrac{1}{2}Fe_2O_3 \rightarrow Fe + \tfrac{3}{4}O_2$$

2 Gt.a^{-1} 1.2 Gt.a^{-1}

- Potential for very low direct emissions of green house gases.
- Direct decomposition of oxides.
- Production of iron metal.
- Energy supplied as electricity.
- Treatment of naturally occurring oxides.
- Breakthrough compared to conventional routes.

SIDERWIN project

- Electrochemical route for the decomposition of iron oxides:



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

- Low temperature electrolysis: 110°C.
- Aqueous alkaline electrolyte medium.
- Electrolysis is applied to solid particles rather than dissolved ions.
- Anodic gaseous O_2 production.
- Non-consumable anode.
- Cathodic Iron grown as solid state deposit.
- Non critical elements in electrode materials, anodes in Ni.

SIDERWIN project

Siderwin

ArcelorMittal

2017-2022 6.8M€

HORIZON 2020

SPIRE

9 Operated final form

8 Tested final form

7 Full-scale prototype

6 Engineering-scale prototype

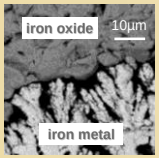
5 Configuration matches final application

4 Components integration

3 Proof-of-concept

2 Corroborate basic observations

1 Basic experimental work



2017

2009

2007

2006

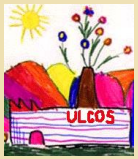
2005

VALORCO

IERO

ASCoPE

ulcos



ADEME

ANR

SIXTH FRAMEWORK PROGRAMME

SIDERWIN project

- Technological development of iron metal production by electrolysis:

- Steady operation: thermal, hydraulic, electric.
- No separator as membrane, diaphragm between electrodes.
- Distance between electrodes 1cm.
- Productivity x3 compared to Ni et Co.
- Self-standing, stiff, compact and conveyable metal plates.
- Low voltage ΔV=1.6V.
- Full recovery of oxygen gas.
- Cheap construction materials.

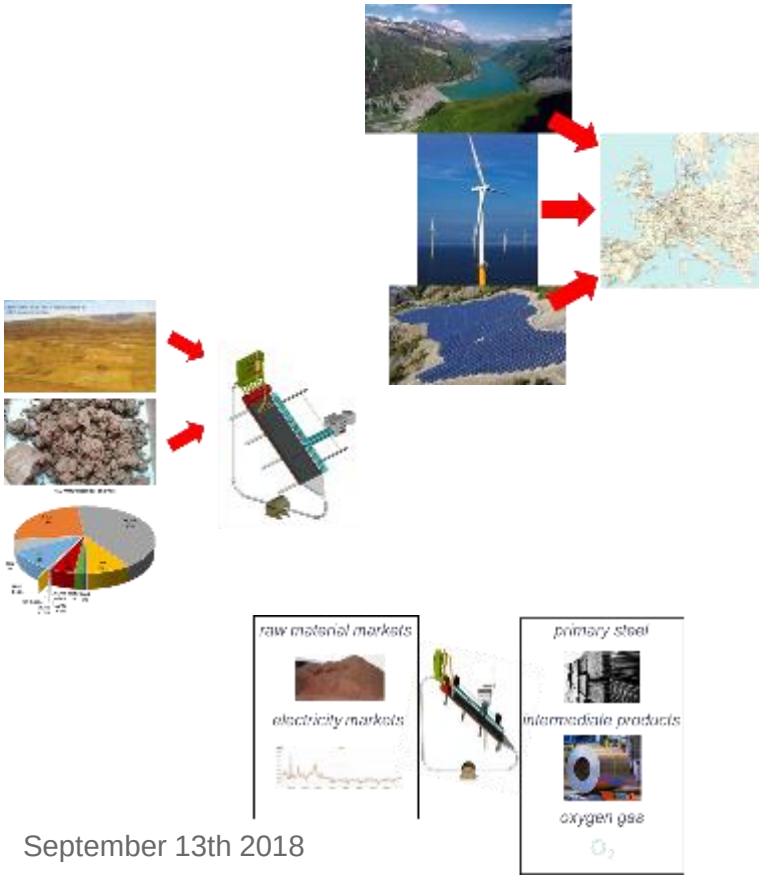
SIDERWIN project

- Development of key components to achieve TRL5

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

SIDERWIN project

- Operation in a relevant environment TRL6



Flexible metal production:
- Contribute to integration of RES.
- Integration to power grid.

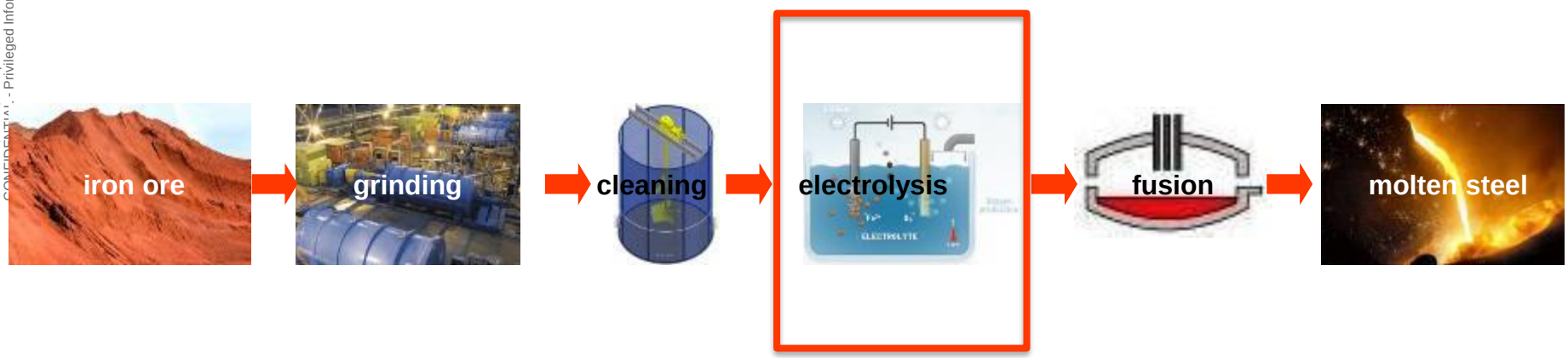
Enlarge iron oxide sources:
- Non-conventional feedstock.
- Residues from Al, Ni and Zn metallurgies.

Develop new business models:
- New service as residue treatment.
- New service as Demand Side Response.

SIDERWIN project

- Objectives :

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



SIDERWIN project

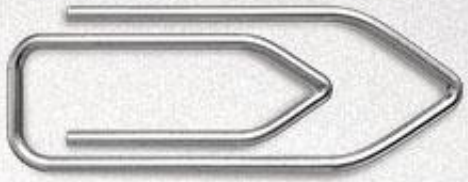
- 5 years project 2017-2022
- Budget: 6.8 M€ includes 2.2 M€ for pilot.
- 7 different countries.
- 12 partners : 4 Companies + 4 SMEs + 4 RTO
- Multisectorial: steel, non-ferrous and power.
- Coordinated by ArcelorMittal.

SIDERWIN project

https://www.siderwin-spire.eu/content/home

Coupling steel production with RES

Lightweight, ...



sustainable design

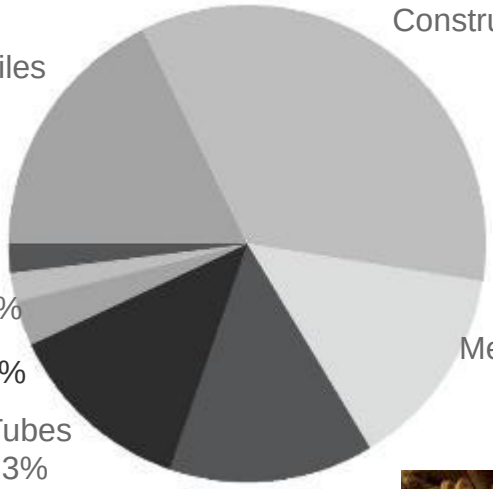
Our constant goal

Coupling steel production with RES

- « true steel use » 144Mt in Europe 2015

Automobiles
18%

Construction
35%



Other 2%

Other transport 2%

Domestic appliances 3%

Mechanical enginering
14%

Tubes
13%

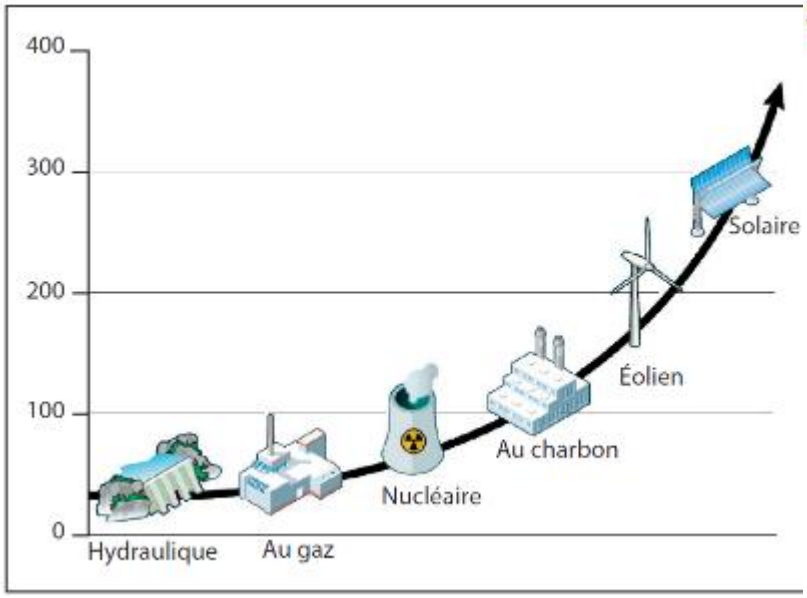
Metal goods
14%

Coupling steel production with RES

- Steel – Energy coupling:
  - No steel without energy – No energy without steel

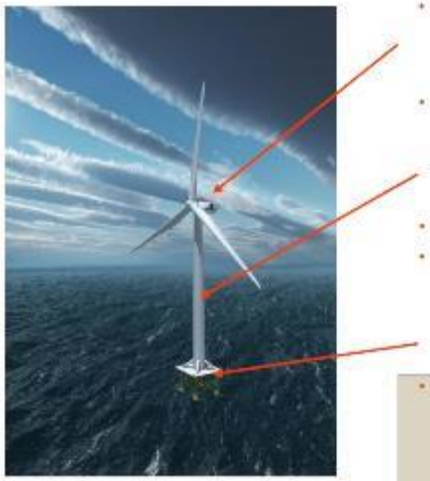
Coupling steel production with RES

- Wind energy is a steel intensive power source



Quantité d'acier pour différentes technologies de l'énergie, en kilogrammes par mégawatt. Source : Albanese *et al*., 2011, Investor Seminar

Steel consumption in a wind turbine



- Nacelle: steel frames + plastic shells:
  - ca 40-80 t of steel for structure (tubular, longs)
  - 3-10 t electrical steels for generator
- Tower
  - Onshore: 130-180 t of plate depending on the model
  - Onshore high-rise: up to 400 t plate/HRC (bolted)
  - Offshore: 200-300 t of plate
- Transition piece (for monopiles) ~250-500 t
- Foundation:
  - Monopile: 800 t (3MW) to 1500 t (6MW) +TP 400 t
  - Jacket: 550 t (5MW) to 700 t (8MW) + 400 t for piles
  - Onshore & gravity offshore - rebars
- Average consumption of steel per turbine :
  - Onshore: 250 t
  - Offshore 3,6MW: 1300 – 1700 t
  - Offshore 8MW: 1600 - 3000 t