



SIDERWIN project

ETIPWind Sector Coupling Round Table

$$\frac{\partial f_{i,j}(\vec{x}, \vec{c})}{\partial x_i} = \sum_{k \neq i} c_{k,j}$$

The right formula
for the steels of the future





Outlook

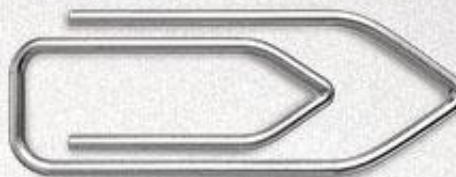
1. Steel production
 - Main figures
 - Conventional process
2. SIDERWIN project
 - Technical route
 - Objectives
3. Steel – Energy coupling
 - Past and present
 - Future



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Steel production

Lightweight, ...



sustainable design



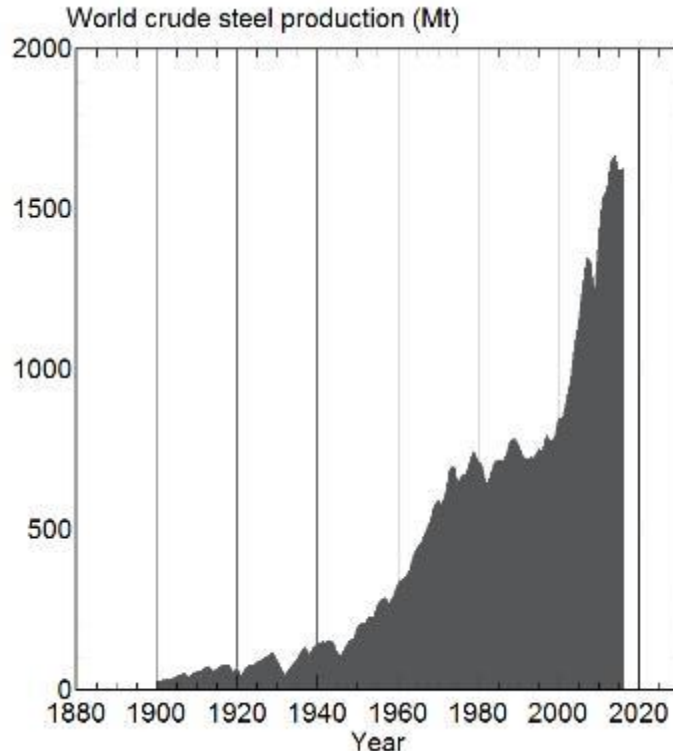
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Steel production

- World steel production (2016)

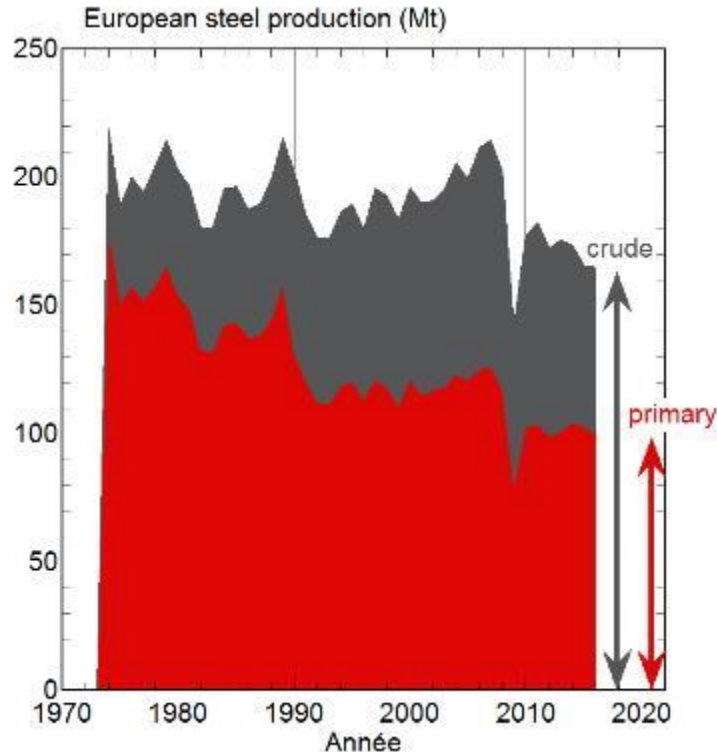


<https://www.worldsteel.org>

- 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)



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

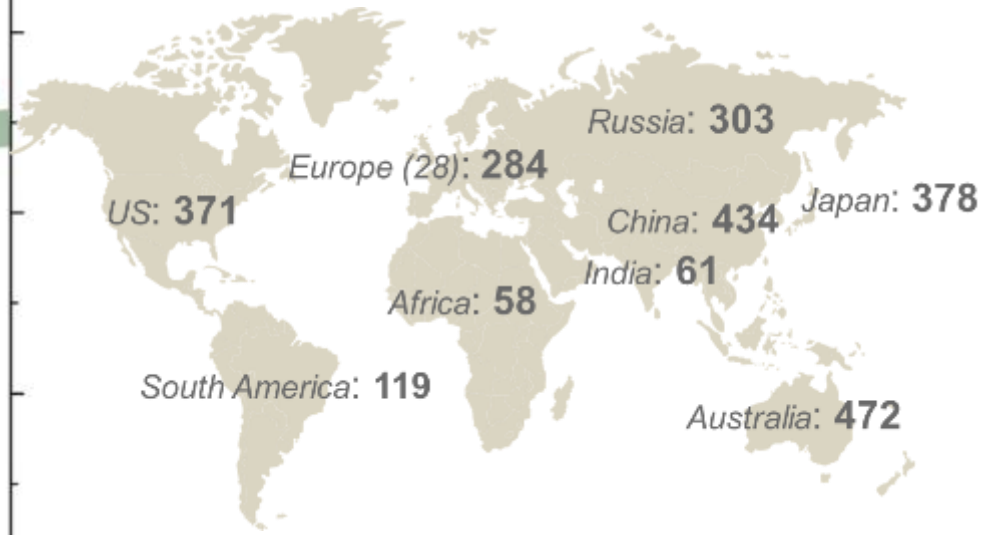
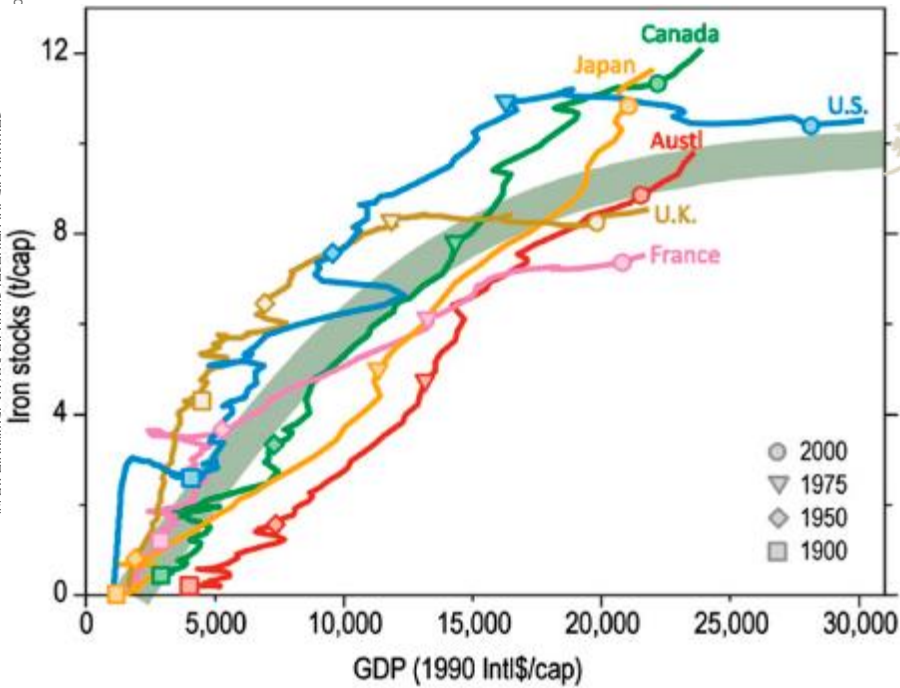
<https://www.worldsteel.org>



Steel production

- Steel consumption per capita

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- 20 Gt of steel in use worldwide

Steel production

- Steel production process: Blast Furnace Route



coke



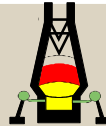
Iron ore

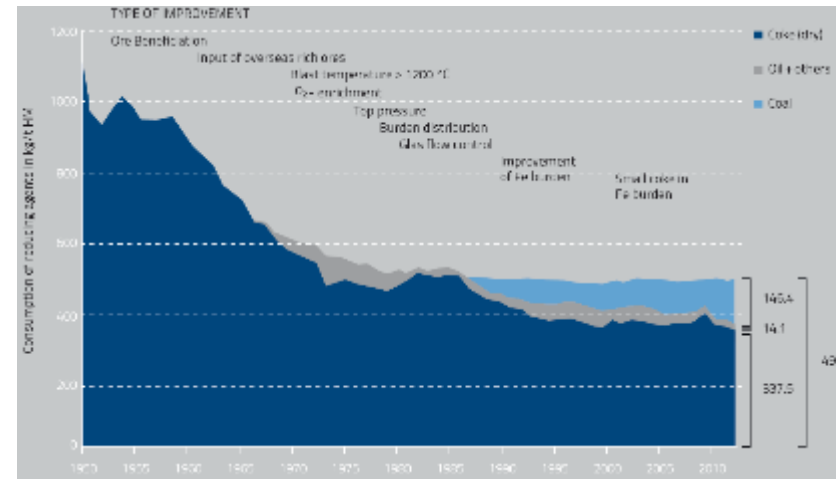


Hot Rolled Coil

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}

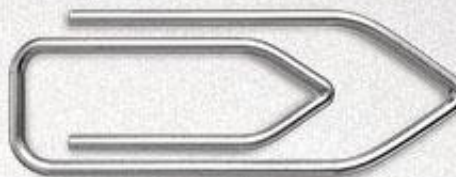




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- Addressing primary Steel production in the its simplest chemical route.



2 Gt.a⁻¹



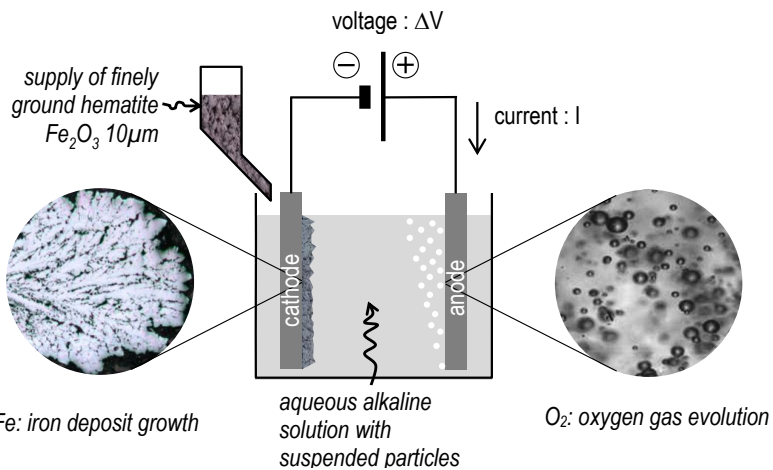
1.2 Gt.a⁻¹



- 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:

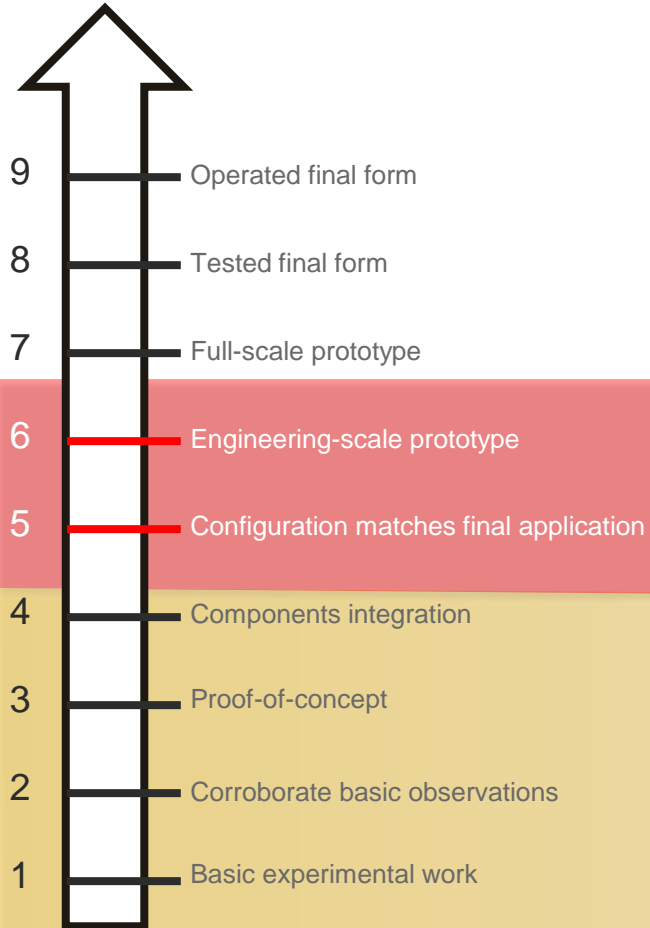


- Low temperature electrolysis: $110^\circ C$.
- Aqueous alkaline electrolyte medium.
- Electrolysis is applied to solid particles rather than dissolved ions.
- Anodic gaseous O_2 production.
- Non-consumable anode.
- Cathodic Iron grown as solid state deposit.
- Non critical elements in electrode materials,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

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2017-2022 6.8M€



IERO

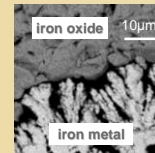


2017

ASCoPE



2009



2007

ulcos

2006



2005



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- Technological development of iron metal production by electrolysis:



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



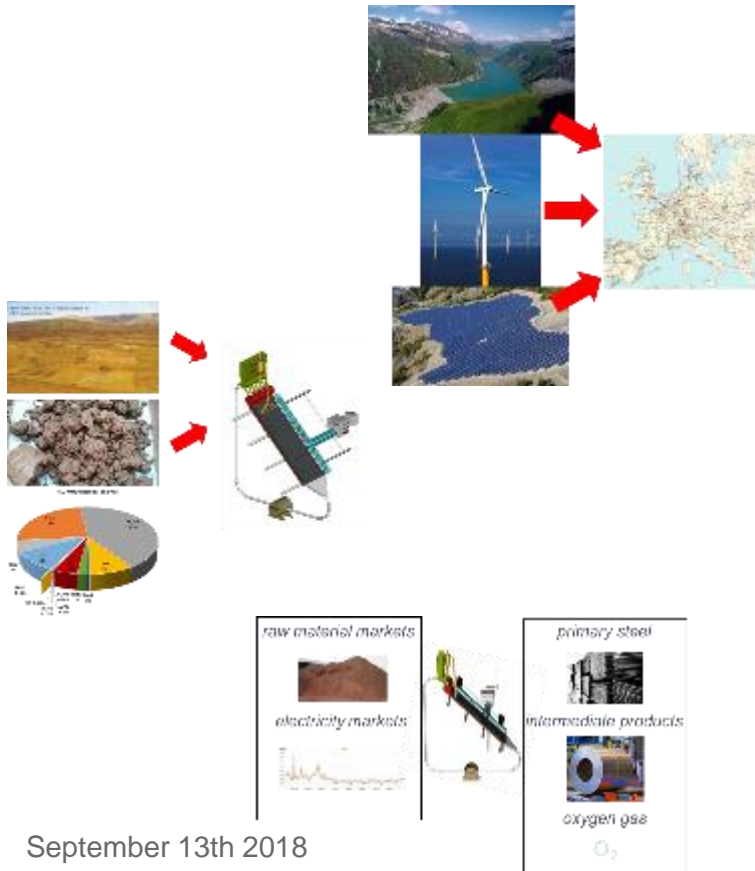
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- Development of key components to achieve TRL5
 - Continuous and automated iron ore supply.
 - Gas oxygen collection.
 - Metal harvesting system.
 - Vertical extension for low footprint.



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.

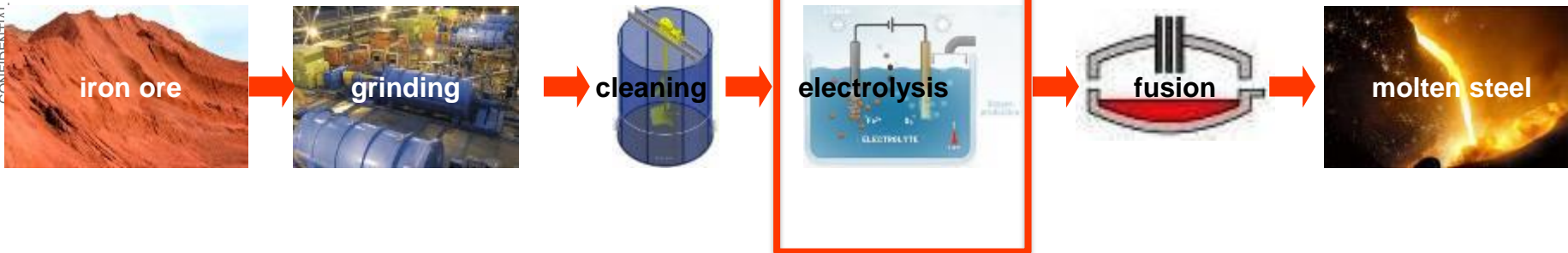
Develop new business models:

- 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 $3.6 \text{ MWh.t}^{-1}_{\text{Fe}}$ or $13 \text{ GJ.t}^{-1}_{\text{Fe}}$.
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.





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SIDERWIN project

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



Siderwin Development of new methodologies for industrial CO₂ free steel production by electroWinning

Development of new methodologies for industrial CO₂ free steel production by electroWinning

SIDERWIN is a European project under the Horizon 2020 framework and the DTI in action.

Our production approach aims to capture CO₂ emissions and maximize CO₂ emissions in steel production.

Based on this premise, SIDERWIN involves a breakthrough innovation compared to the current steel production process, being a highly innovative, energy-efficient process.

The plant will process ultra-thin, low-alloy steel sheets and low-alloy, including three times the thickness, from other manufacturing steel sheets with a significant reduction of energy use.

This process recovers energy and emissions from an intense reaction, also naturally emitting low-emission steel materials like iron oxide and nitrogen gas. By offering a CO₂-free steel production process, the project will contribute to the reduction of the steel production gas emissions. Compared to traditional steelmaking plants, this innovative technology has several positive impacts on steel:

- a reduction for 67% of the direct CO₂ emissions;
- a reduction for 42% of the indirect CO₂ emissions;
- the ability to produce steel from by-products like iron oxides from non-ferrous metal refining, recycling and
- an increased integration with renewable energies in a more flexible process.

The project is led by ArcelorMittal, the world's leading steel and mining company. The company has been leading the CO₂ system for the replacement of the technology in use in the EU, 2017, through the manufacturing of 5 different pilot plants, proving the potential of the technology. With this solid background, ArcelorMittal partnered by 12 additional innovative European partners, and is developing a 3 million-tonne industrial plant to validate the technology at TRL 4.

1000000 ton/year in 2022 project to validate the feasibility of the technology at TRL 4

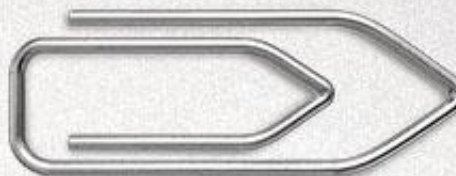
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Coupling steel production with RES

Lightweight, ...



sustainable design



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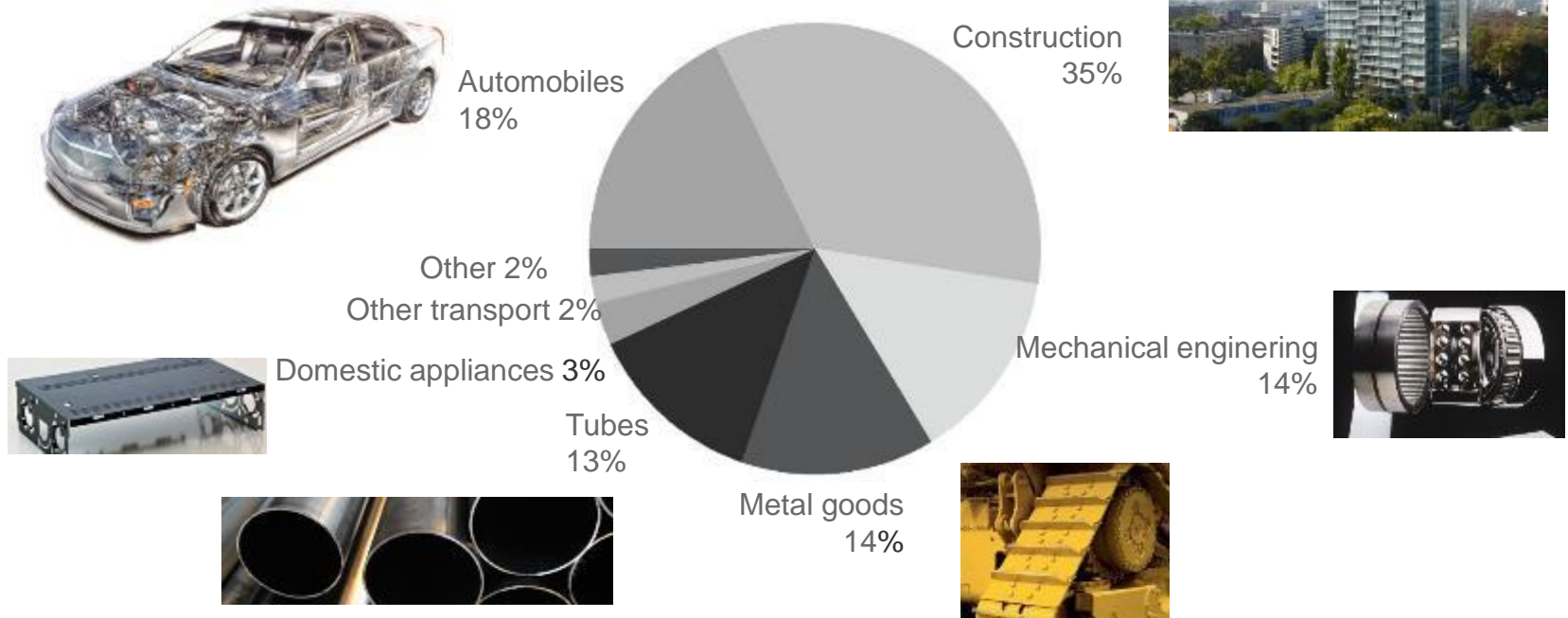
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Coupling steel production with RES

- « true steel use » 144Mt in Europe 2015



Coupling steel production with RES

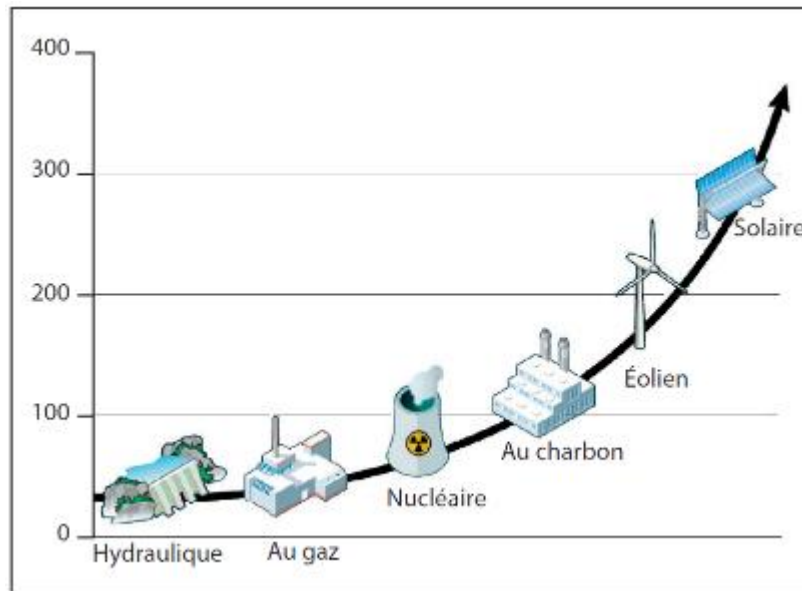
- Steel – Energy coupling:
 - No steel without energy – No energy without steel





Coupling steel production with RES

- Wind energy is a steel intensive power source



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 - re-bars

Average consumption of steel per turbine :	
- Onshore:	250 t
- Offshore 3,6MW:	1300 – 1700 t
- Offshore 6MW:	1600 - 3000 t

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

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