Green Steel Deal

Gent 28th September 2023

POLITECNICO
MILANO 1863

Green Steel Deal

Carlo Mapelli – Dipartimento di Meccanica, Politecnico di Milano

What is Green Steel?

Nowadays attention is focused on CO_2

2.8 billions tons of CO_2
Corresponding to 5-6% of the overall yearly emissions

…**and CO_2 decrase is driving factor, but green steel is even more extensive concept becuase the decrease of green-house gas emissions has not to affect other environmental aspect:**

- dioxyns emissions
- PAH (Polycyclic Aromatic Hydrocarbons) emissions
- electricity consumption
- Water consumption
- Soil consumption

What is Green Steel?

Production of Steel

without

Emissions of Polluting Elements

CO_2 is not a polluting chemical species, but it is not involved in climate change as the main green house gas

Climate change threats to population health and well-being: The imperative of protective solutions that will last

April 2013 · Global Health Action 6(1):1-9

DOI: 10.3402/gha.v6i0.20816

Source · PubMed

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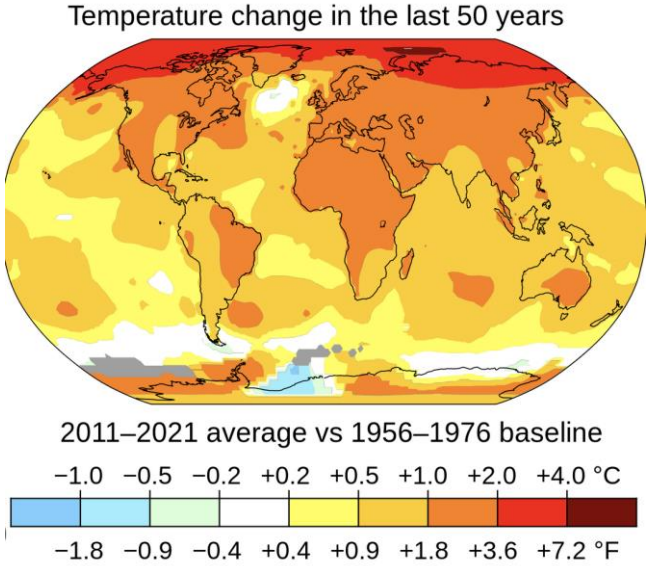
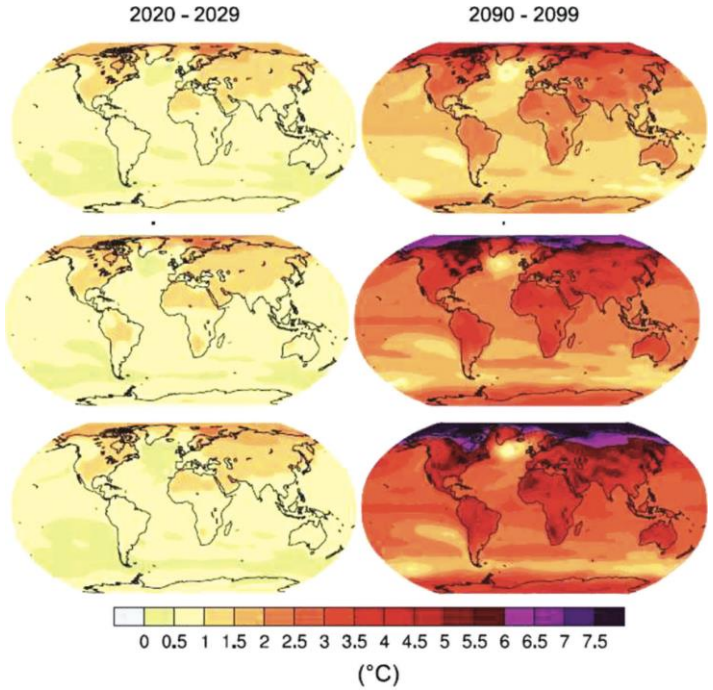
Retraction notice · Corrigendum to 'Climate change threats to population health and well-being: The imperative of protective solutions that will last [Global Health Action, 6 (2013) 20816] DOI: 10.3402/gha.v6i0.20816

Tord Kjellstrom · Anthony J McMichael



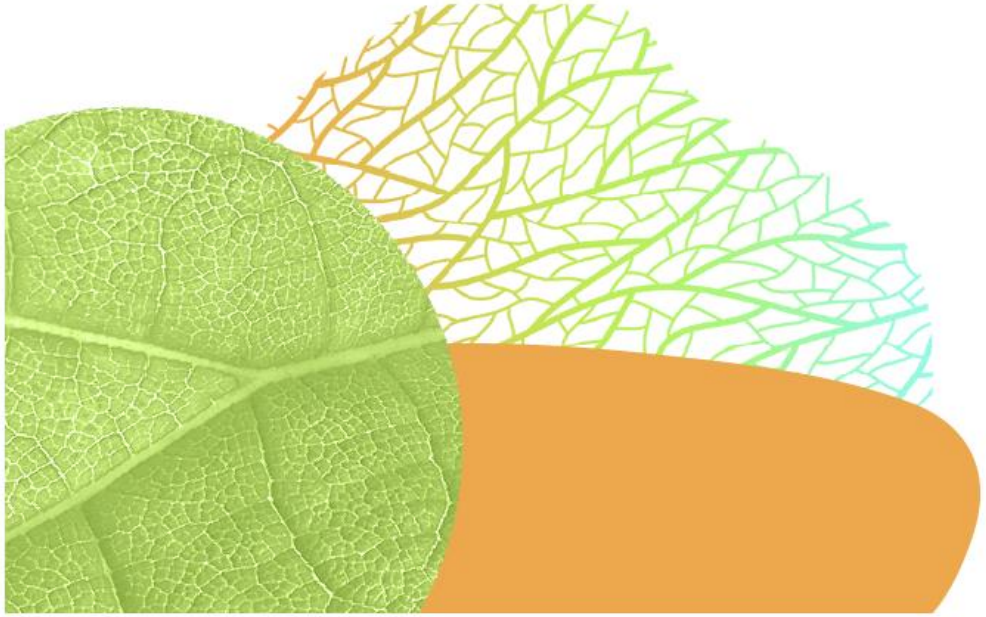


Eco Lable

Arvzero

An example by Arvedi Steel

CBAM
Carbon Border Adjustment Mechanism
1st October 2023



#EUGreenDeal

CARBON BORDER ADJUSTMENT MECHANISM

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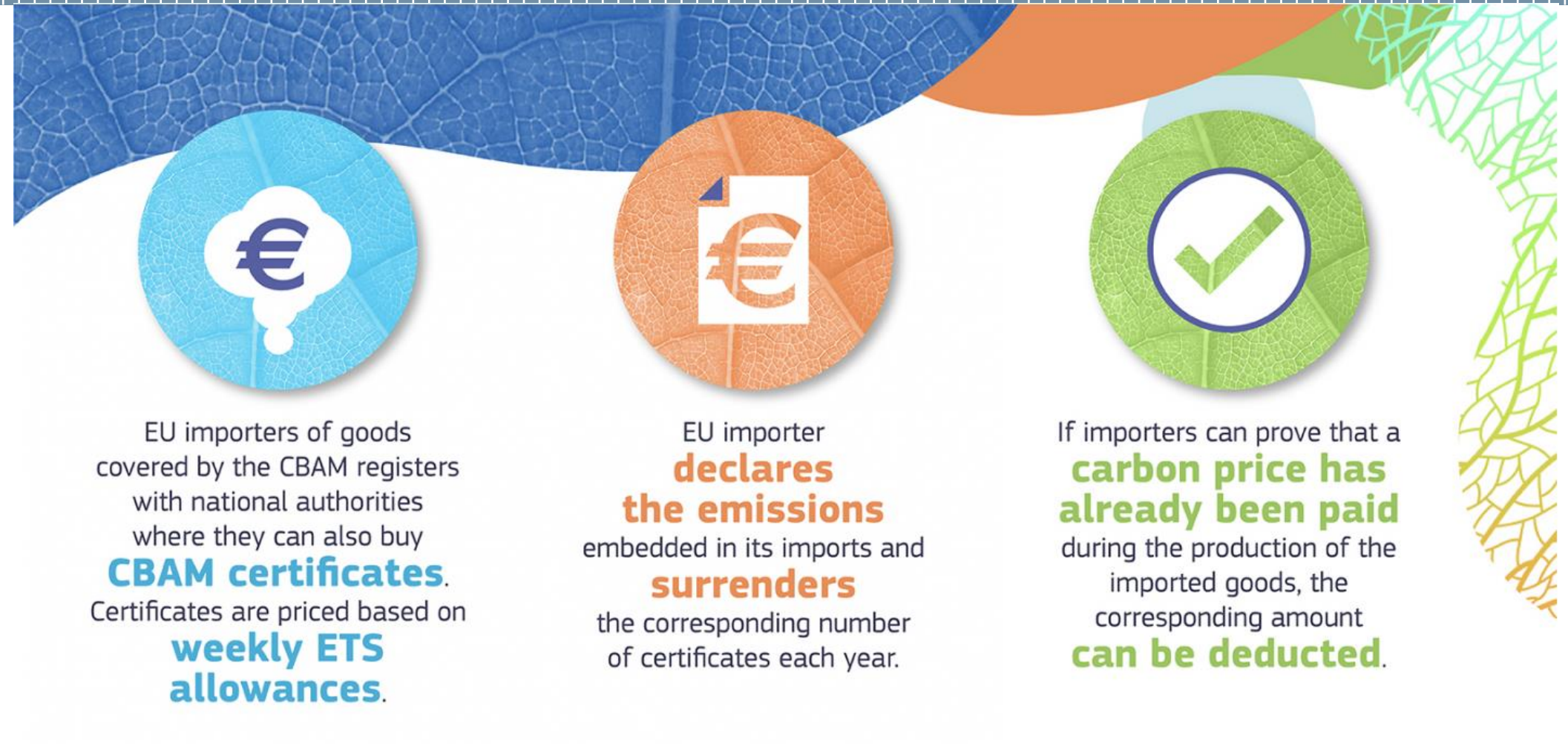
Industrial Sectors covered by CBAM

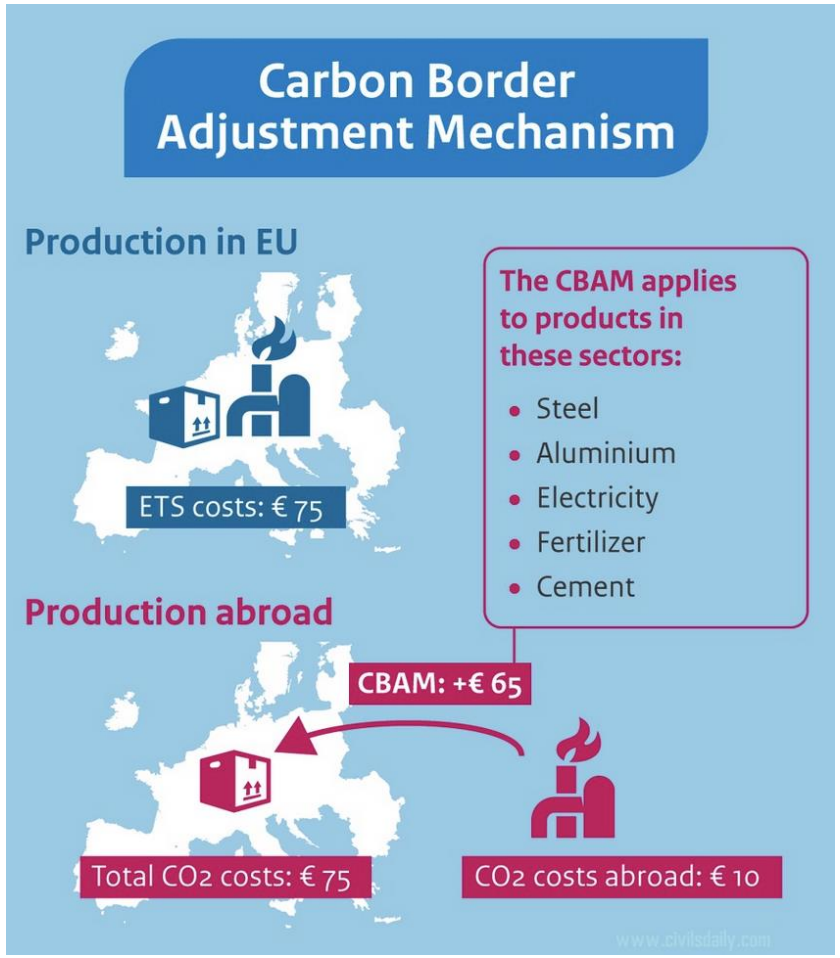
Sectors covered in the first phase of the CBAM - our environmental policy tool to help maximise the European and global impact of our fight against climate change.

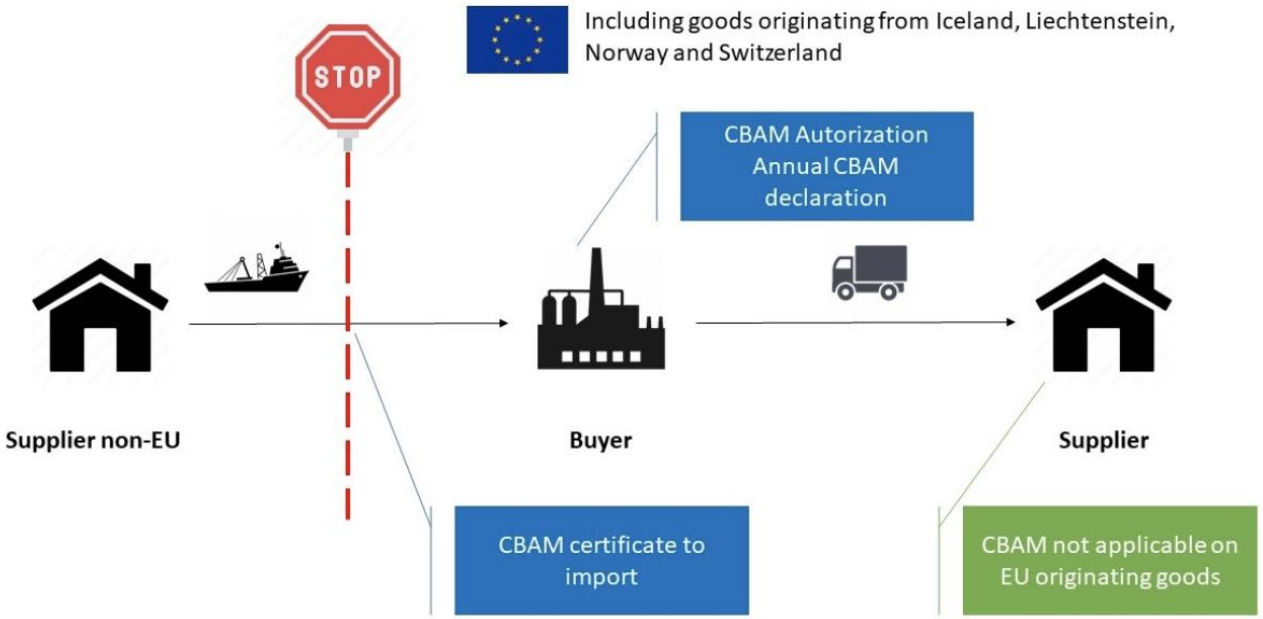
- CEMENT
- IRON & STEEL
- ALUMINIUM
- FERTILISERS
- ELECTRICITY
- HYDROGEN

CBAM
Key Points
1st October 2023



Fundamentals of the adjustment mechanism





Nowadays the allowancies price of CO_2 is 85€/tCO_2

Which are the emission and their categories?

Scope 1

Emissions of GHG Directly Caused by Production Plants

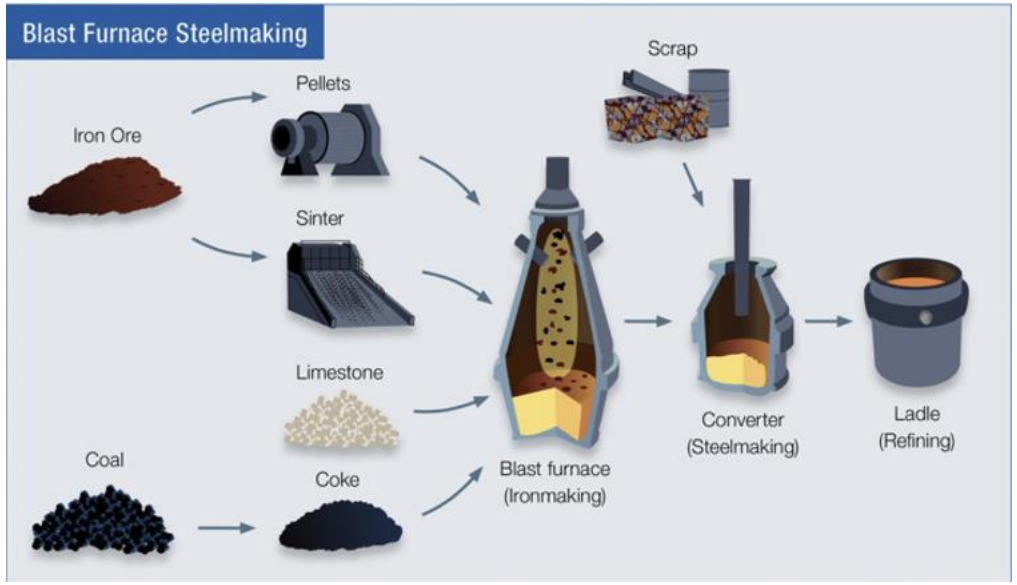
Scope 2

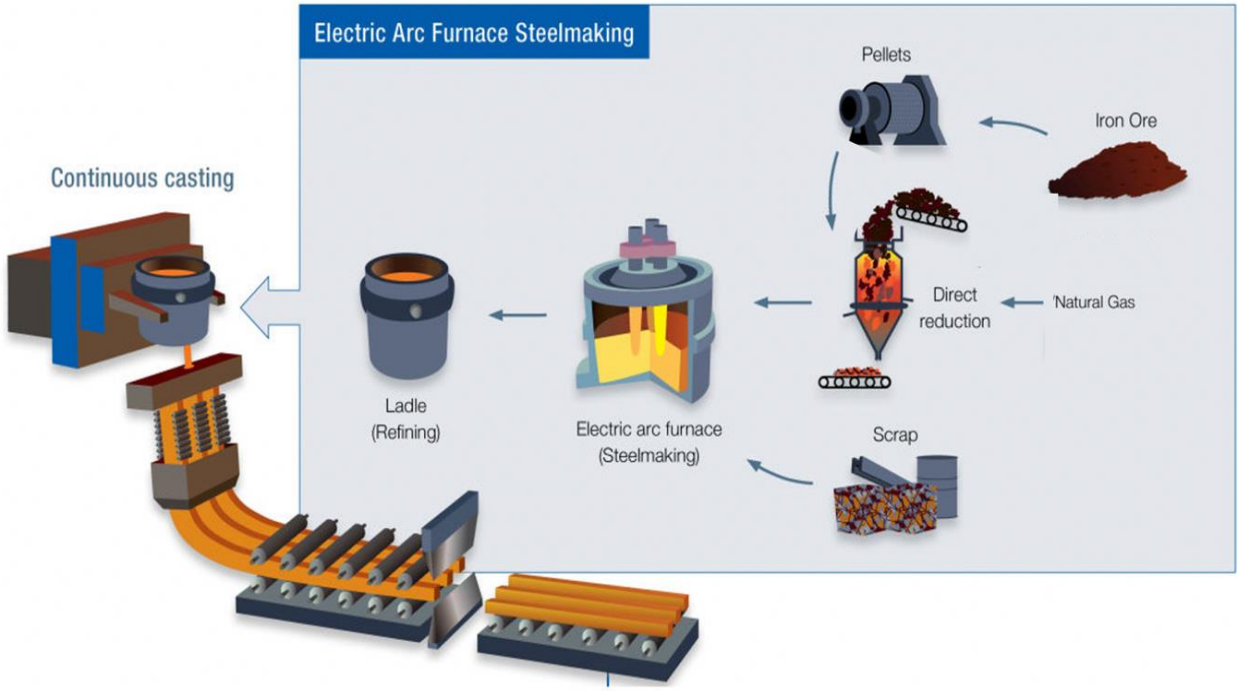
Emissions of GHG Produced by Suppliers Involved in Energy Chain

Scope 3

Emissions Involved in Extraction of Raw Materials and in Logistic Chain of Raw Materials

Main Cycle for Steelmaking





From iron ore and Coke
$2500 kg_{CO2}/t_{steel}$

From scrap
From iron ore and CH_4

$150 kg_{CO2}/t_{steel}$
$850 kg_{CO2}/t_{steel}$

Feasible Options

Carbon Caputure Use and Storage (CCUS)

Electrification of the Process

Biomass Exploitation

Carbon Capture Use and Storage
CCUS

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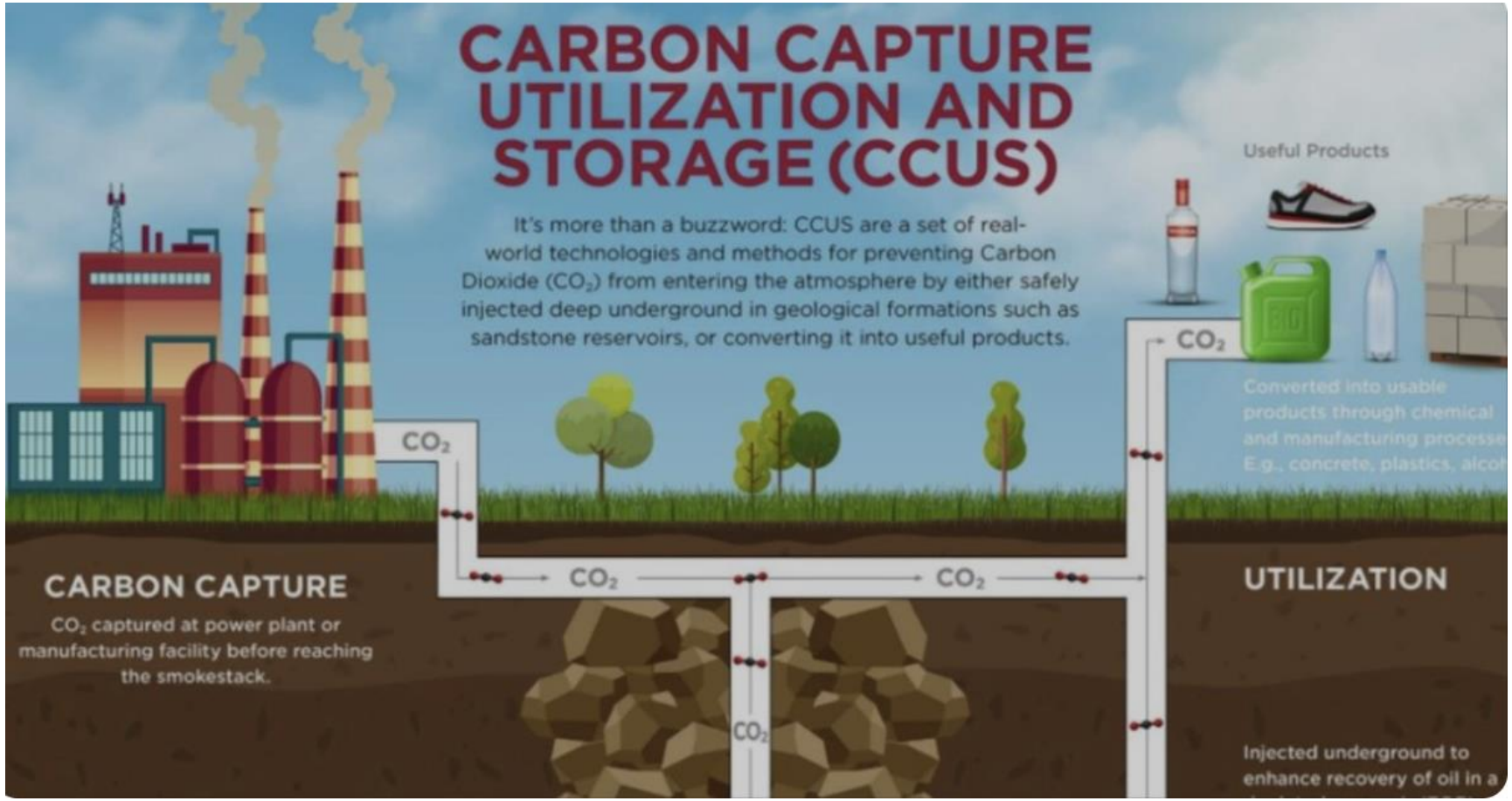
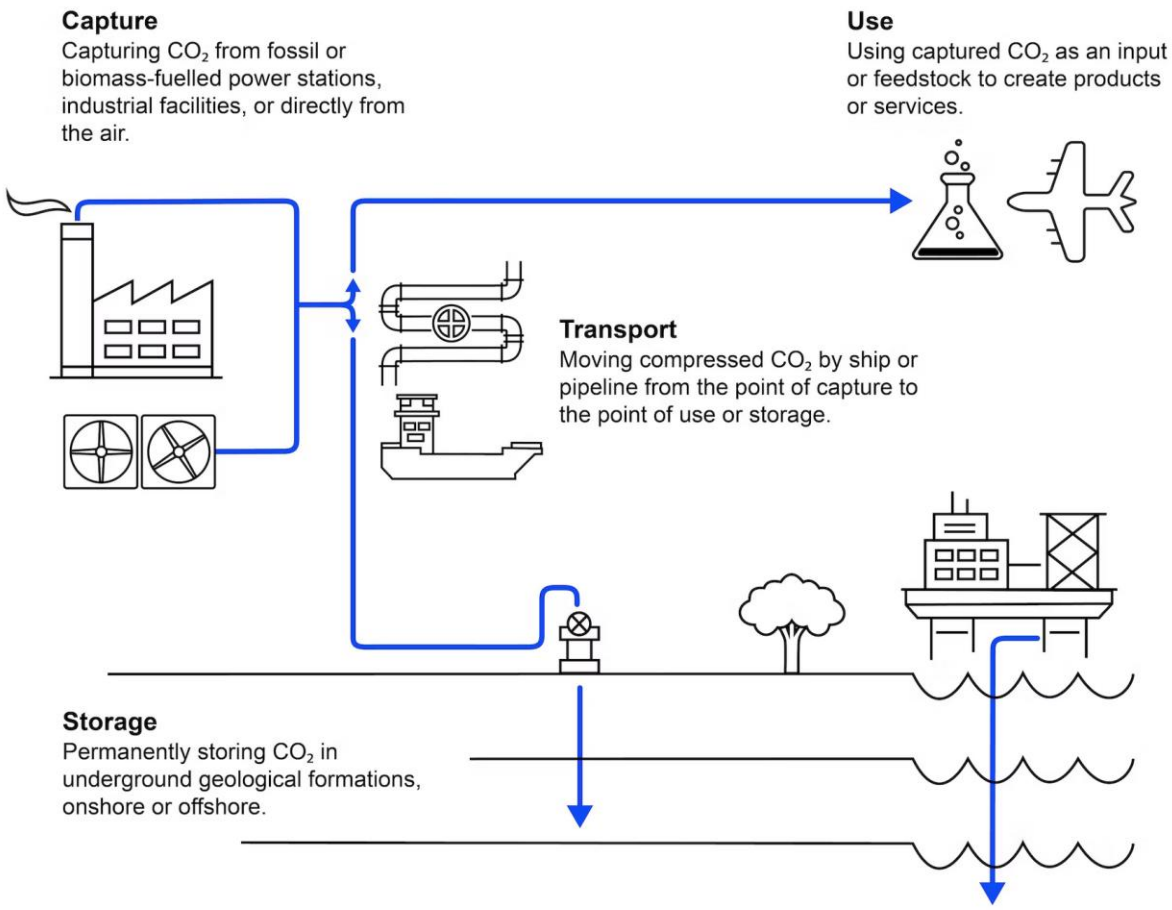
Carbon Capture Use and Storage (CCUS)



Carbon Caputure Use and Storage (CCUS)



Major Initiatives of CCUS worldwide

Ravenna – Northern Adriatic Sea
Italy

Electrification of Steelmaking

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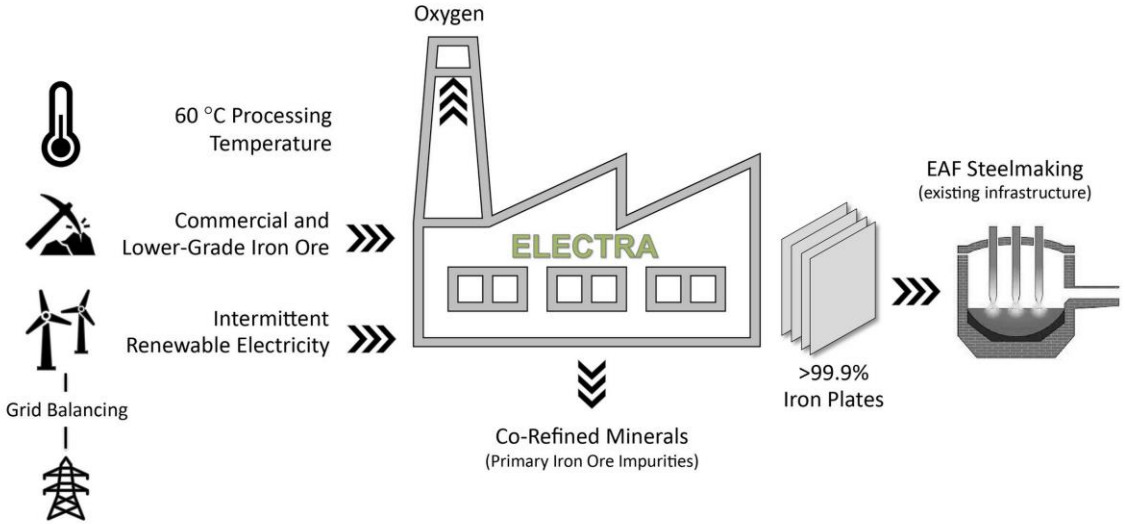
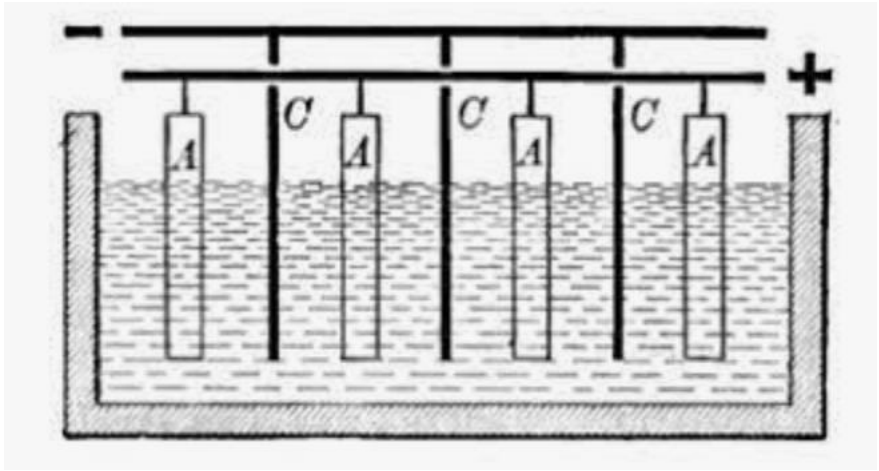
Electrochemical Reduction
electra.earth



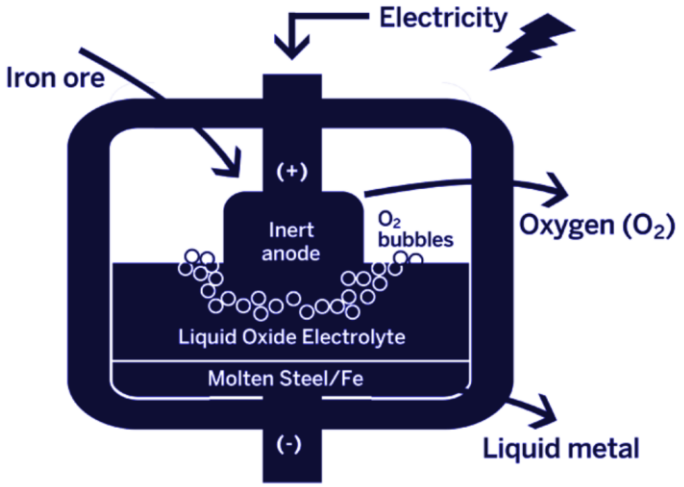


Low-Grade Iron Ore Opportunity

We've cracked the code of dissolving iron ore and removing impurities while retaining iron in aqueous solution, thereby unlocking immense opportunity to use low-grade ores. These ores are treated as waste today because of high levels of phosphorus, silica, and alumina impurities. Using low-grade ores decreases our operating costs and creates economic value.

No one information have been revealed about cost of solvent for iron iron and energy comsumption.

Smelting & Electrowinning
Boston Metals

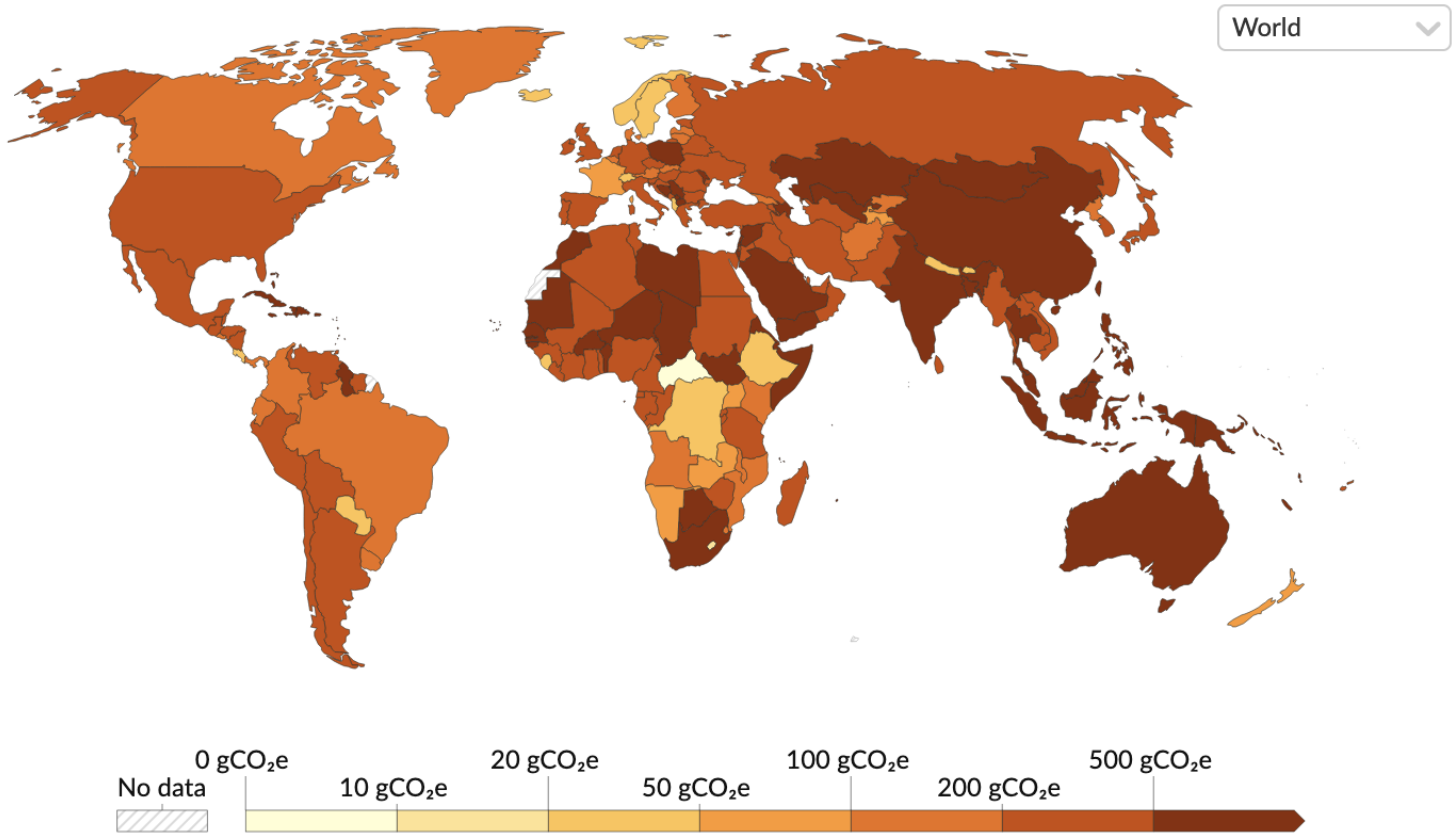


Iron Ore Electricity Iron Oxygen

$$Fe_2O_3 + e^- \rightarrow 2\,Fe + {}^3/_2 O_2$$

Reducing Agent	Electrons
Feedstock	Concentrates or pure oxides
Electrolyte	Molten oxides (CaO, MgO, etc.)
Containment	Refractory or frozen ledge
Temperature	Up to 2,000˚C
Product	Pure metals or alloys

Unrealistic way to energy costs: 4MWh/$t_{\_steel}$



Source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy
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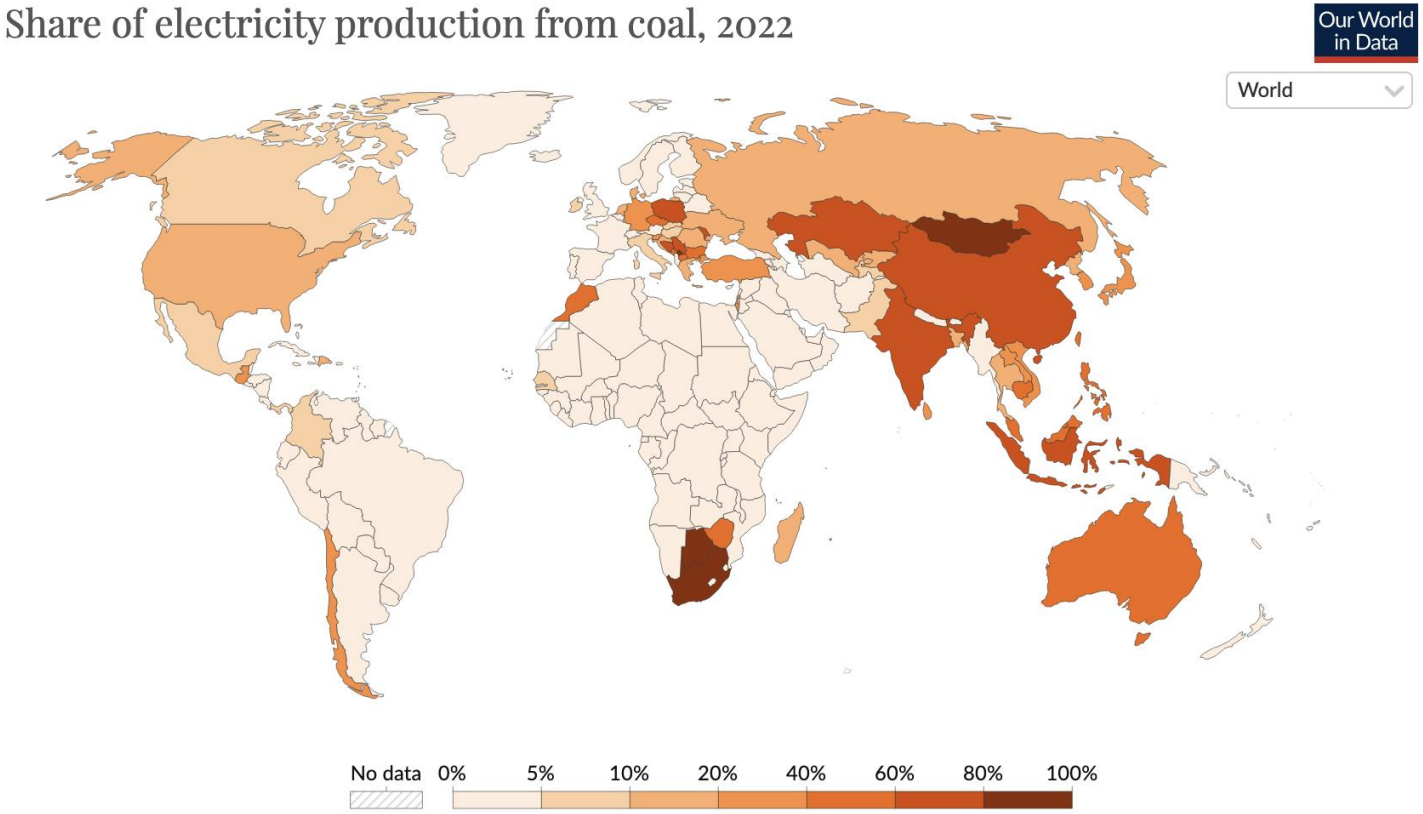
Share of electricity production from coal, 2022
Our World in Data
World
No data
0%
5%
10%
20%
40%
60%
80%
100%
Source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy
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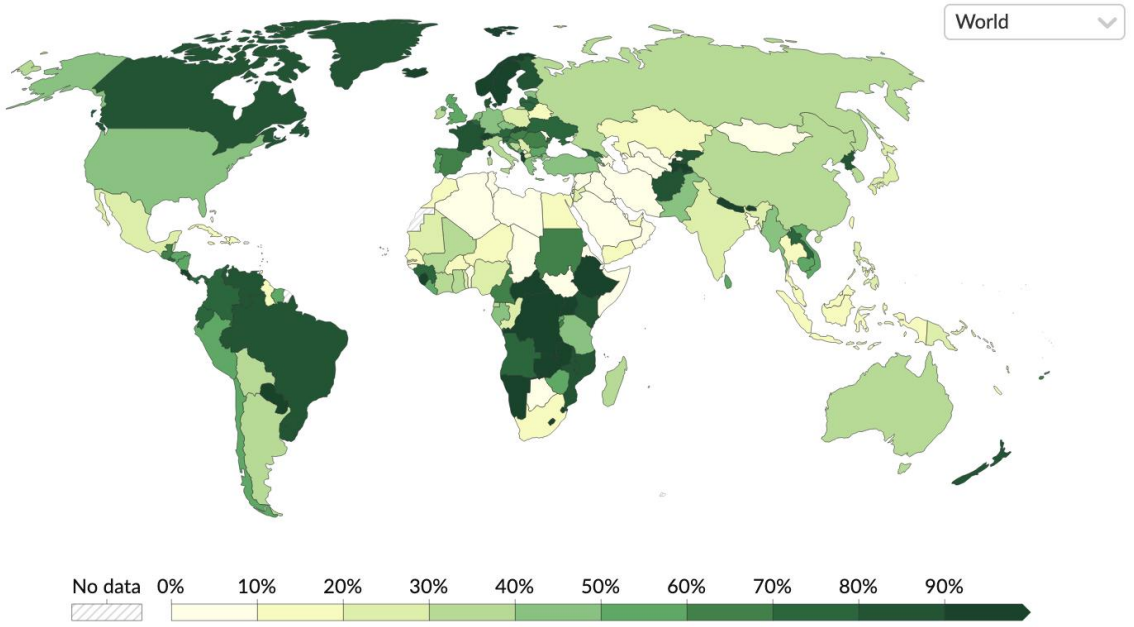
Share of electricity from low-carbon sources, 2022

Low-carbon electricity is the sum of electricity from nuclear and renewable sources (including solar, wind, hydropower, biomass and waste, geothermal and wave and tidal).

Our World in Data



Source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy
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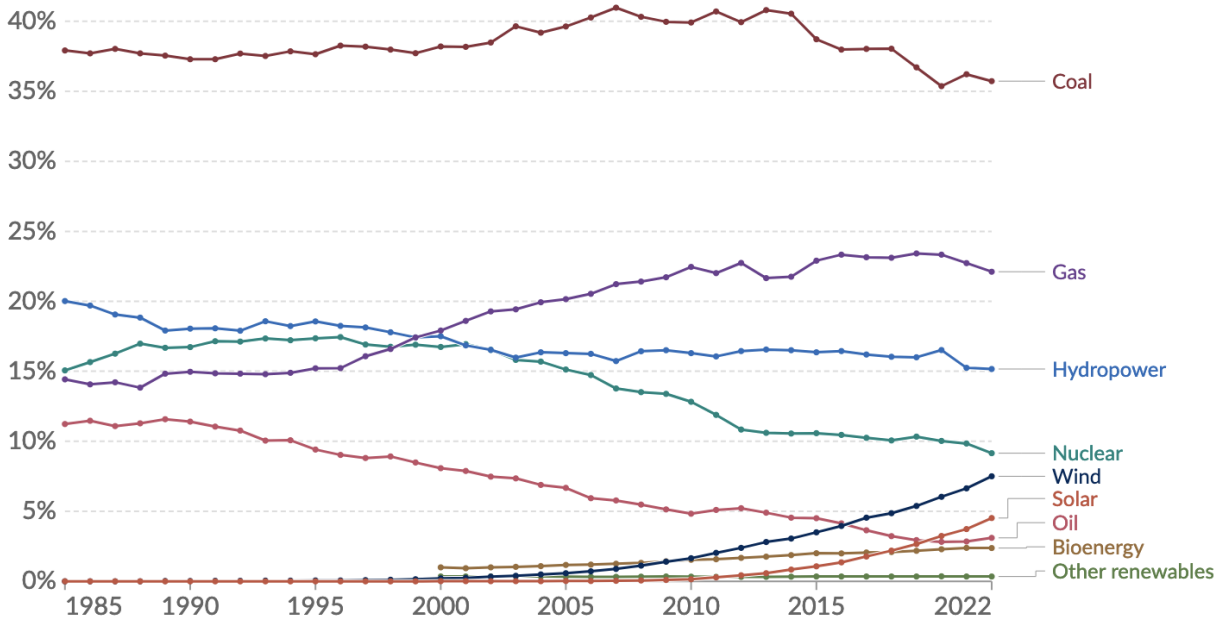
Share of electricity production by source, World

Our World in Data



Source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy
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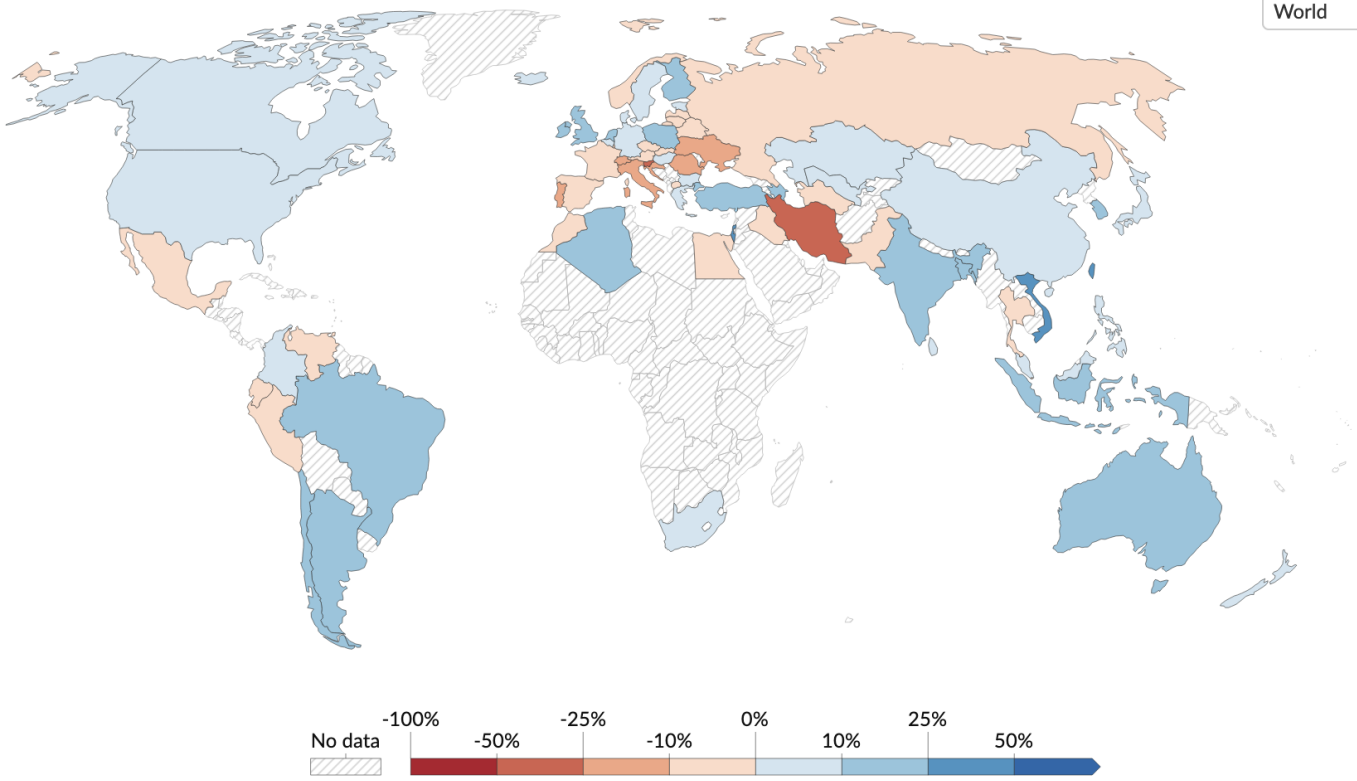
Annual percentage change in renewable energy generation, 2022

Shown is the percentage change in renewable energy generation relative to the previous year. This is the sum of energy from hydropower, solar, wind, geothermal, wave and tidal, and bioenergy.

Our World in Data

World



Source: Energy Institute Statistical Review of World Energy (2023)

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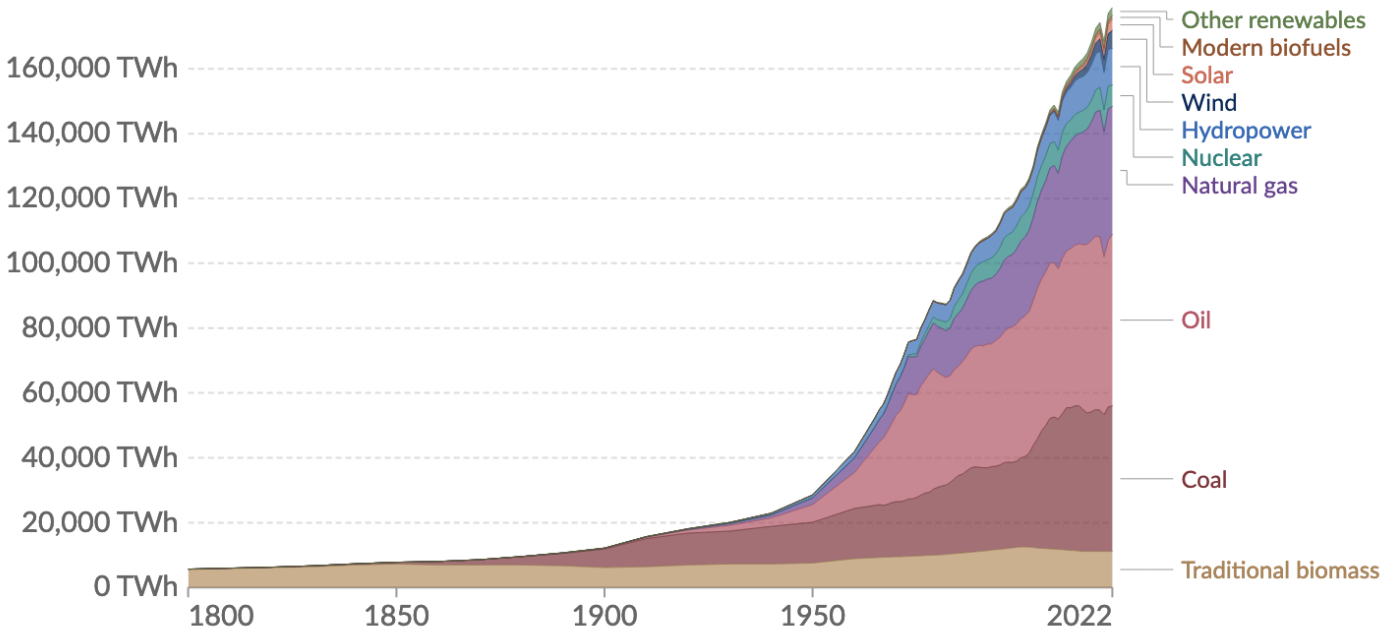
Global primary energy consumption by source

Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.

Our World in Data

All together ⌄ ☐ Relative



Source: Energy Institute Statistical Review of World Energy (2023); Vaclav Smil (2017)
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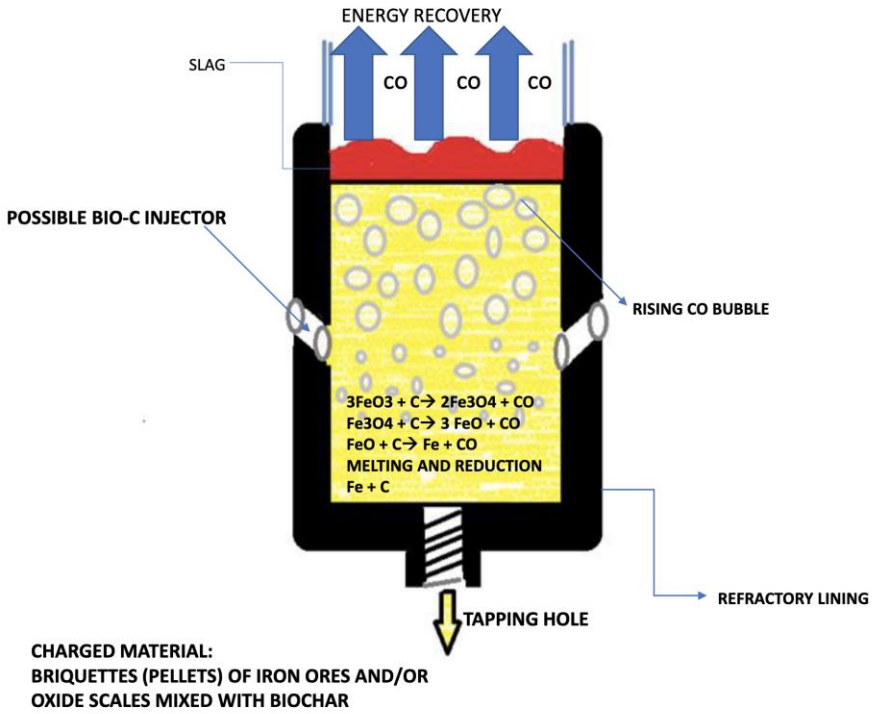
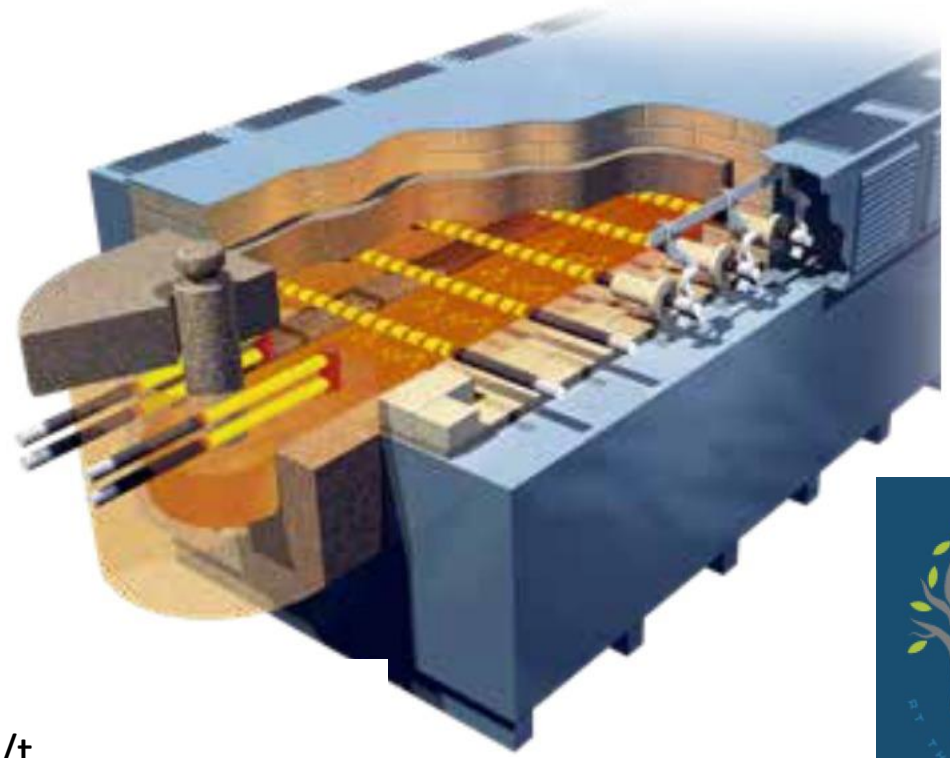
Exploitation of Biomass

I-SMELT
Combination of electricity and biochar (up to 1400°C)





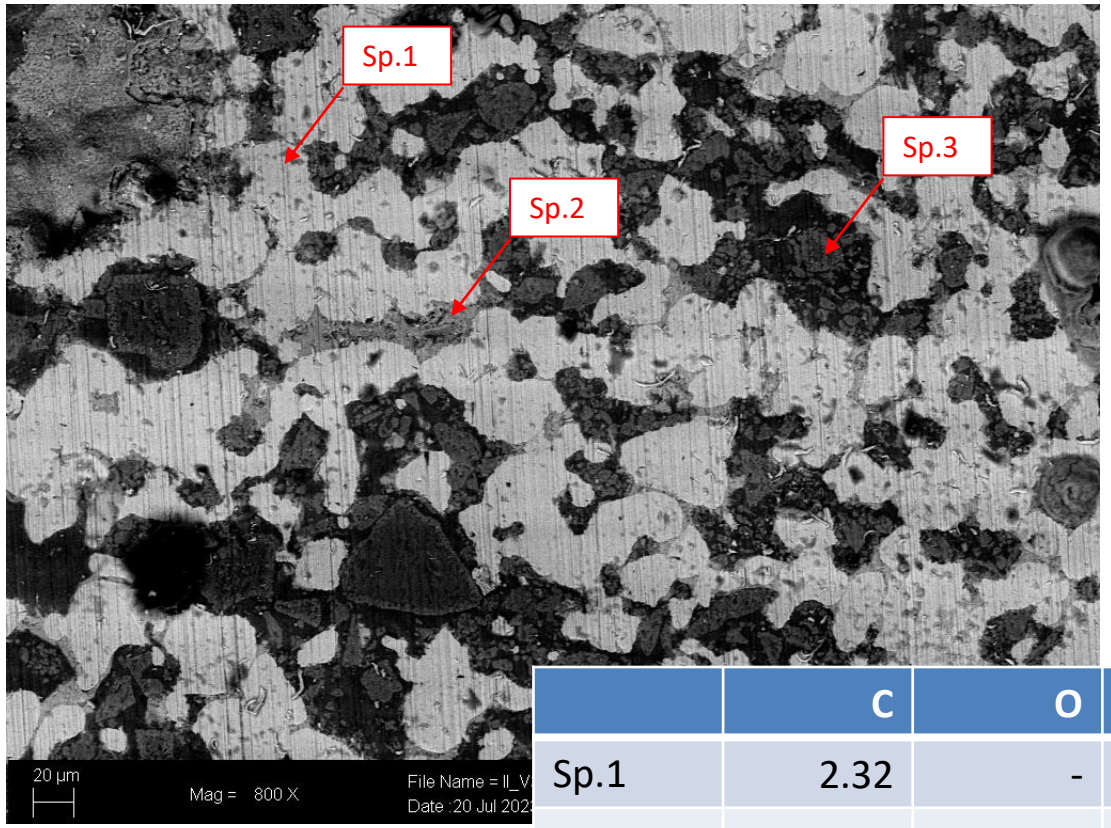
$0.32t_{biochar}$ - $650kWh/t_{Fe}$

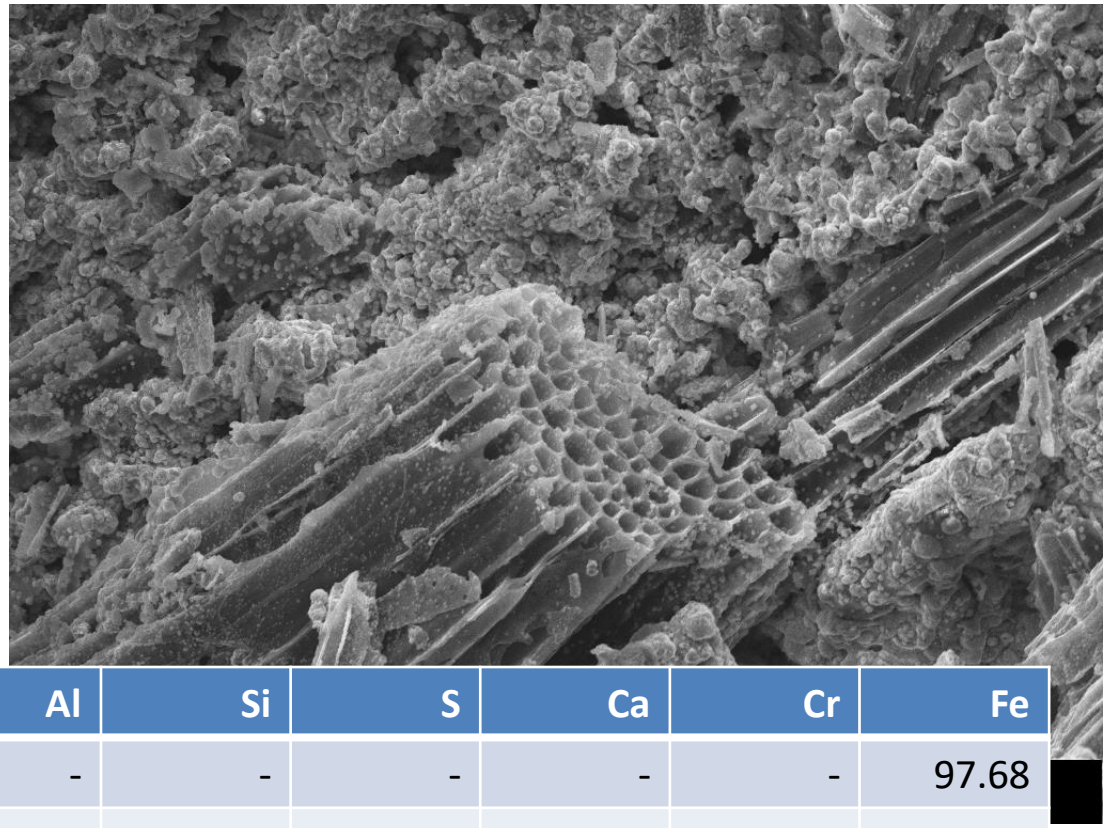
I-SMELT
AT THE PACE OF NATURE'S BREATH
https://www.elsafra.org/i-smelt

Production of sponge iron by I-Smelt process

https://www.elsafra.org/i-smelt

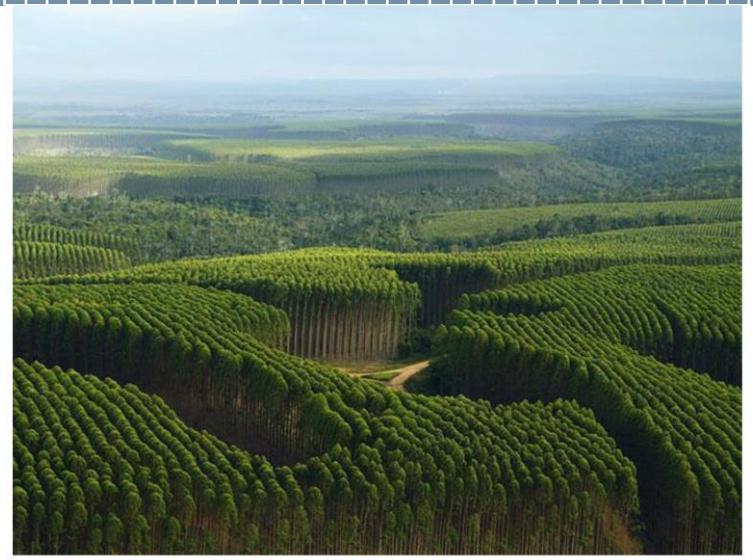
Analisi SEM Miscela II v300 1300 °C

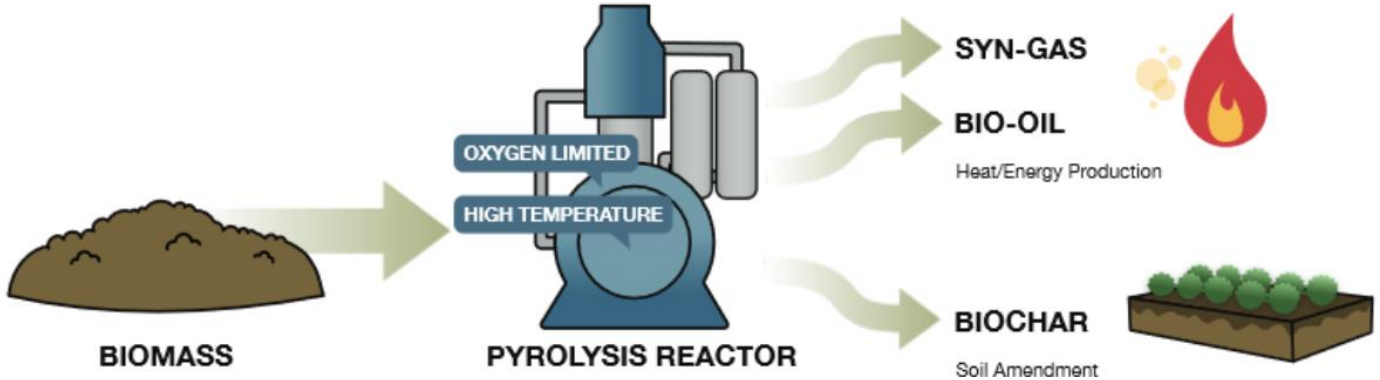




	C	O	Al	Si	S	Ca	Cr	Fe
Sp.1	2.32	-	-	-	-	-	-	97.68
Sp.2	3.05	16.54	-	0.48	-	-	0.48	79.44
Sp.3	-	28.96	7.38	4.16	-	1.62	34.82	16.42

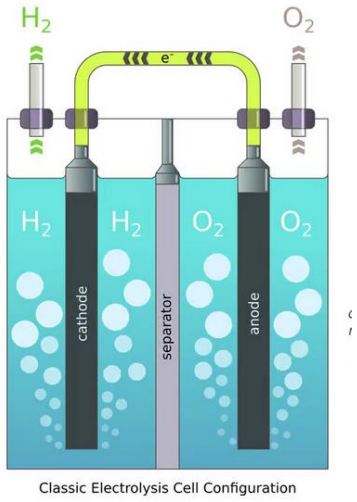
In the smelting process the biochar is not a fuel
but chemical species working as a chemical agent





H_2 obtained from fresh water is not a feasible option

- Production and use of "green" hydrogen are very interesting from the point of view of the elimination of CO_2 but there is a significant penalty in terms of
  - transport safety (at valves and flanges) and storage of large quantities;
  - water consumption;
  - land consumption;
  - electric energy consumption (5kWh/m^3_{H2});
  - high cost of electrolyzers that are based on Ni alloys.



Classic Electrolysis Cell Configuration

$$2H_2O \rightarrow 2H_2+O_2$$

$$2Fe_2O_3+6H_2 \rightarrow 4Fe+6H_2O$$

…a more interesting perspective is assocated with H_2 obtained by CH_4 pyrolysis. The process is comvenient for the production of another raw material that is rich in terms of graphite, graphene and carbon nanotubes

This implies production of H_2O and solid C

$$CH_4 \rightarrow 2H_2+C$$