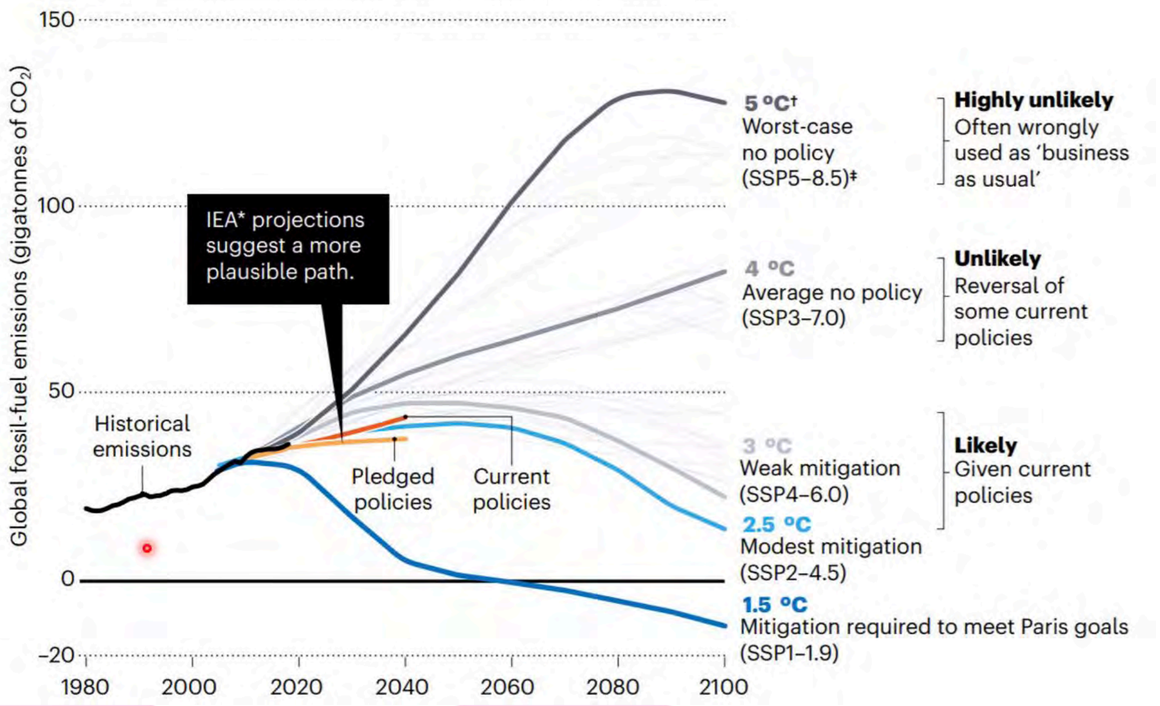
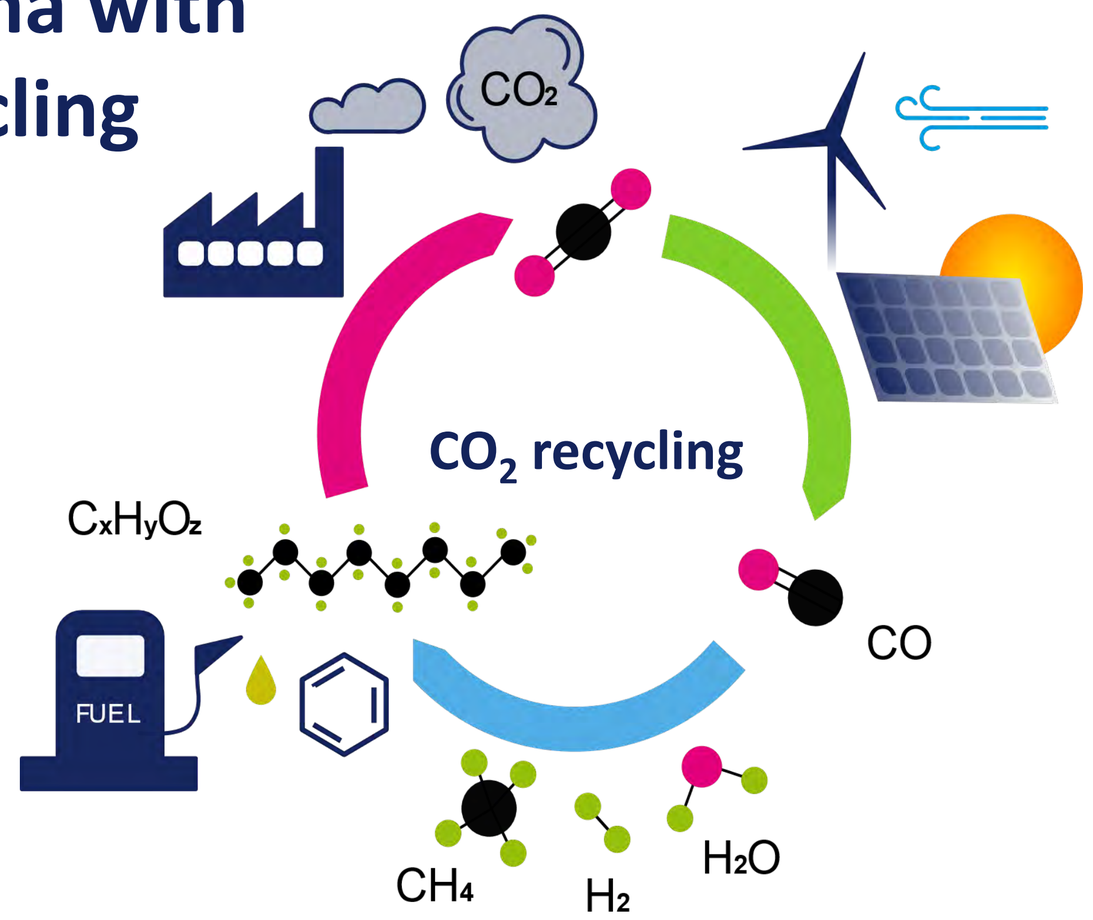
Beatrice Musig [1,2], J. Barauna [1], T. García [1], M.E. Galvez [2], M.V. Navarro [1]

[1] Instituto de Carboquimica ICB-CSIC, Zaragoza, Spain
[2] Insitut d'Alembert, CNRS UMR 7190 - Sorbonne Université, Paris, France

Synergy of non-thermal plasma with Ni/CeO_2 catalyst for CO_2 recycling

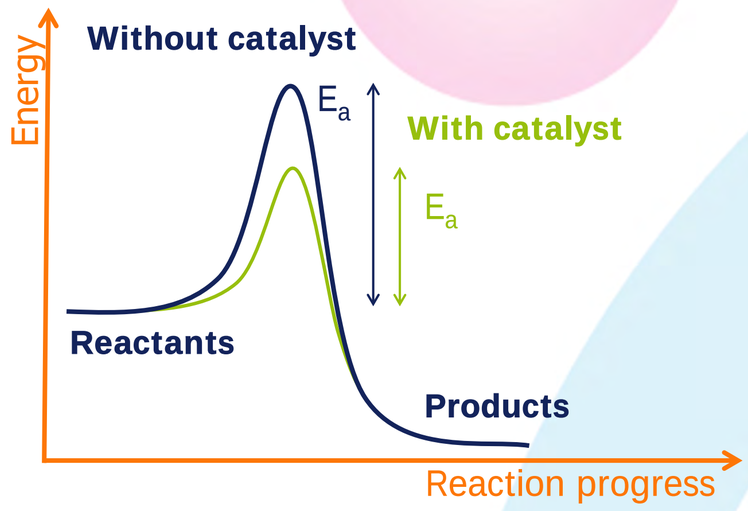


Possible mitigation scenarios and the relative predictions on emissions. Source: Hausfather et al. **Nature**, 30 January **2020**



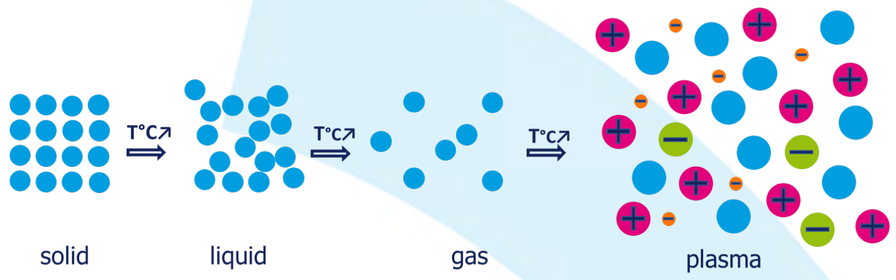
Closed carbon cycle: CO_2 capture and utilization using renewable energy sources to produce chemicals and fuels. Credits: Carolina Garcia

The use of CO_2 has great potential to complement greenhouse emission reduction strategies and to establish a sustainable and circular economy that exploits CO_2 not as an emission but as a carbon reservoir to produce value-added compounds. Innovative technologies such as non-thermal plasmas are being explored for CO_2 activation and reduction.
The combination of plasma and catalysis for the conversion of CO_2 allows the direct application of renewable electricity in an efficient way. Its application in the catalytic methanation of CO_2 takes advantage of the synergy between the ionized species in the plasma and their contact with the catalytic material to favour the reaction.



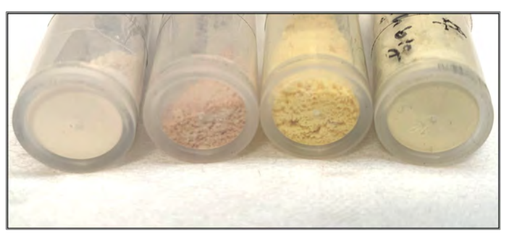
Effect of catalysts on the energy diagram profile

Plasma Catalysis



Plasma is the 4th state of matter

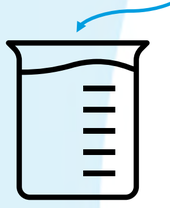
Examples of plasma in every-day life



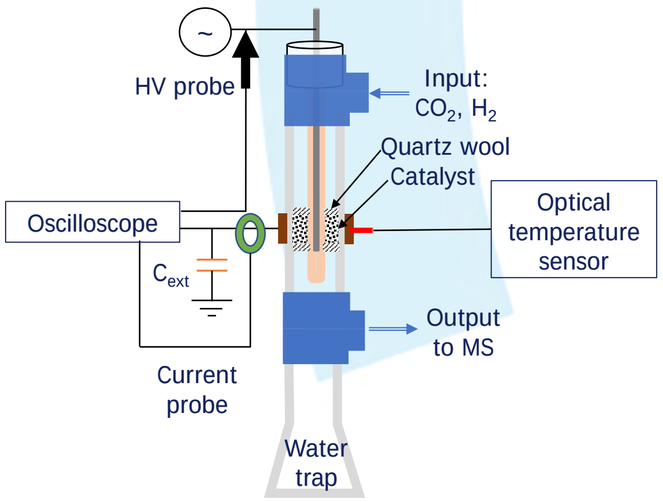
Metal oxides as supports: CeO_2 and Al_2O_3

Nickel wet impregnation

15 %wt. Ni



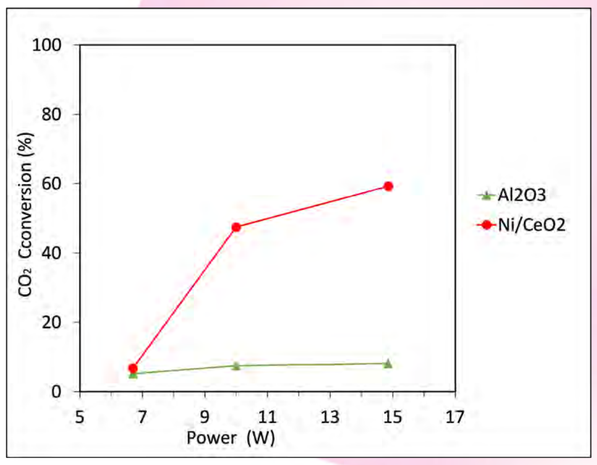
550 °C calcination + 600 °C reduction

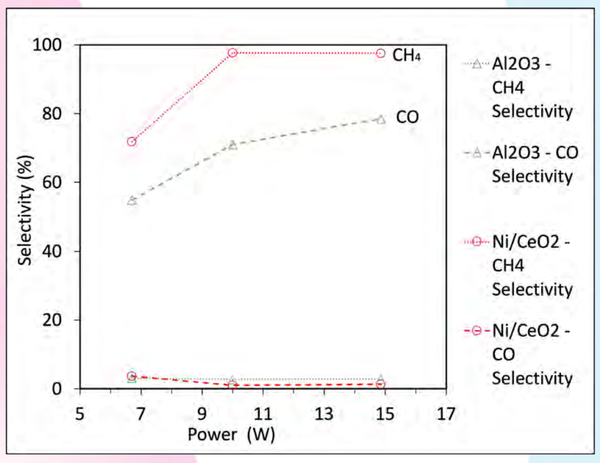


Non-termal Plasma Dielectric Barrier Discharge Reactor

- Packed bed
- AC sinusoidal signal with 27 kHz frequency and high voltage 10-20 kV

Results of CO_2 conversion and selectivity to CO and CH_4 for Al_2O_3 and Ni/CeO_2 as a function of power





Results of CO_2 conversion and selectivity to CO and CH_4 at 15 W for Al_2O_3 and CeO_2 supports compared with the catalyst with Ni active phase

	Al_2O_3	CeO_2	Ni/CeO_2
CO_2 conversion	8 %	3 %	59 %
CH_4 selectivity	3 %	5 %	98 %
CO selectivity	79 %	88 %	1 %
$T_{outside}$	84 °C	94 °C	107 °C

It is observed that high conversion and selectivity can be obtained only when the Ni containing catalyst is used compared to the negligible effect of the ceria or alumina support only.
Such results are in line with previous work carried out with other materials at comparable conditions.

Plasma is very **reactive** but not selective, and thus a catalyst is needed to improve the **selectivity**.
Plasma catalysis is used for more **energy-efficient** and selective processes.

Synergy : additional effect of combining the plasma with a catalyst, i.e., the effect of combining the plasma with the catalyst is greater than the sum of their individual effects.

Plasma-assisted CO_2 conversion:

- Advantages:
  - This process can be switched on/off easily so renewable electricity can be used
  - It can operate at mild conditions (low temperature and atmospheric pressure)
- Limitations:
  - Improvement required for energy efficiency and catalyst design
  - More collaborations between the fields of catalysis and plasma physics are necessary

➢ There is a great potential for the application of plasma towards CO_2 conversion and for Ni/CeO_2 materials to be used in plasma catalysis.

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