

CO₂ Capture in the Steel Industry

Capture & Geological Storage of CO₂,

3rd International Colloquium

5-6 November 2009

JP. Birat



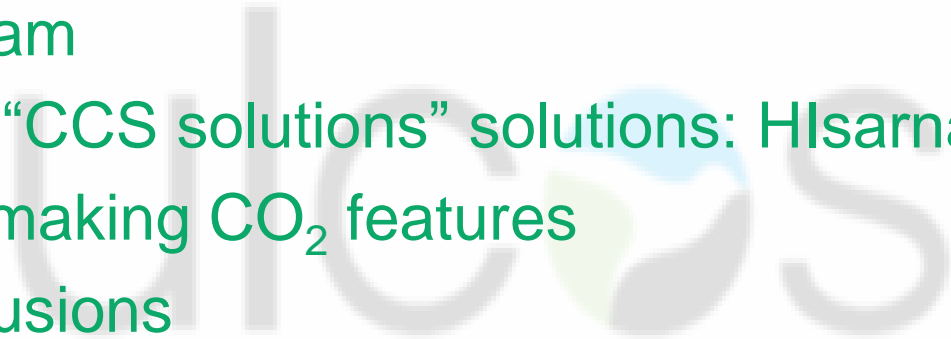
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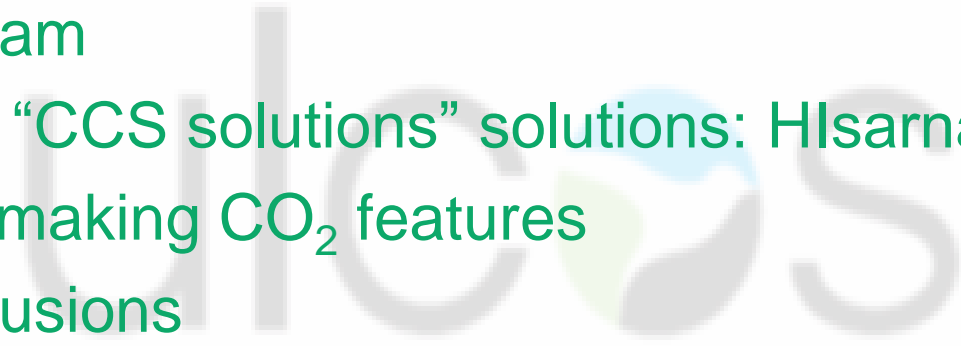
Menu

- Steel
- solutions and role of CCS in the solutions: ULCOS
- Top Gas Recycling Blast Furnace & the ULCOS II program
- other “CCS solutions” solutions: HIsarna & ULCORED
- Steelmaking CO₂ features
- conclusions



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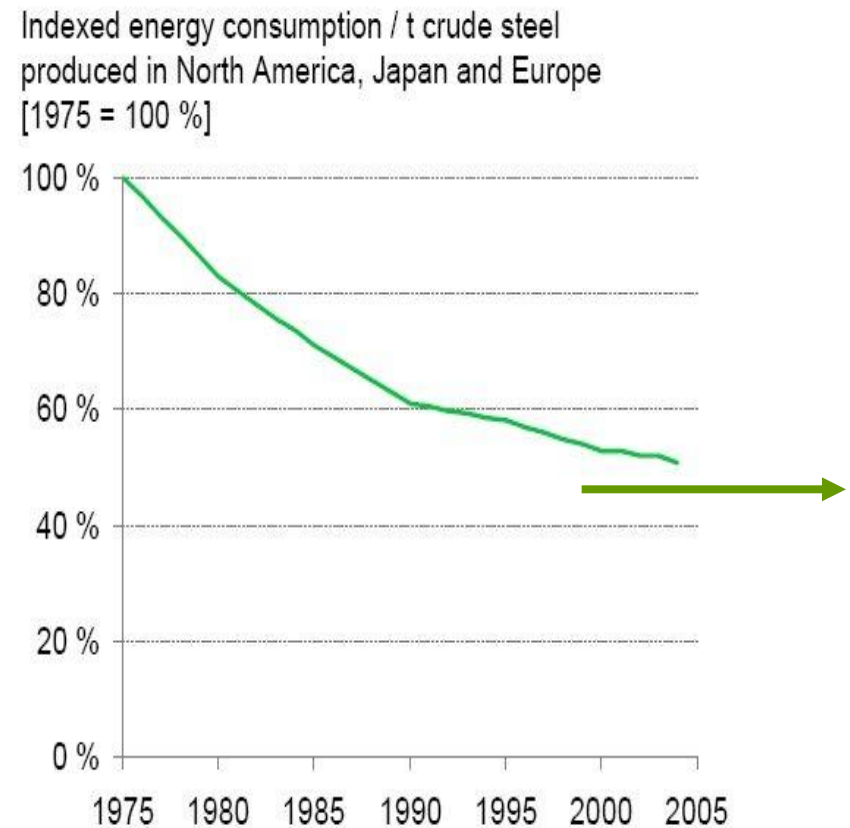
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Background on Steel & Steelmaking...

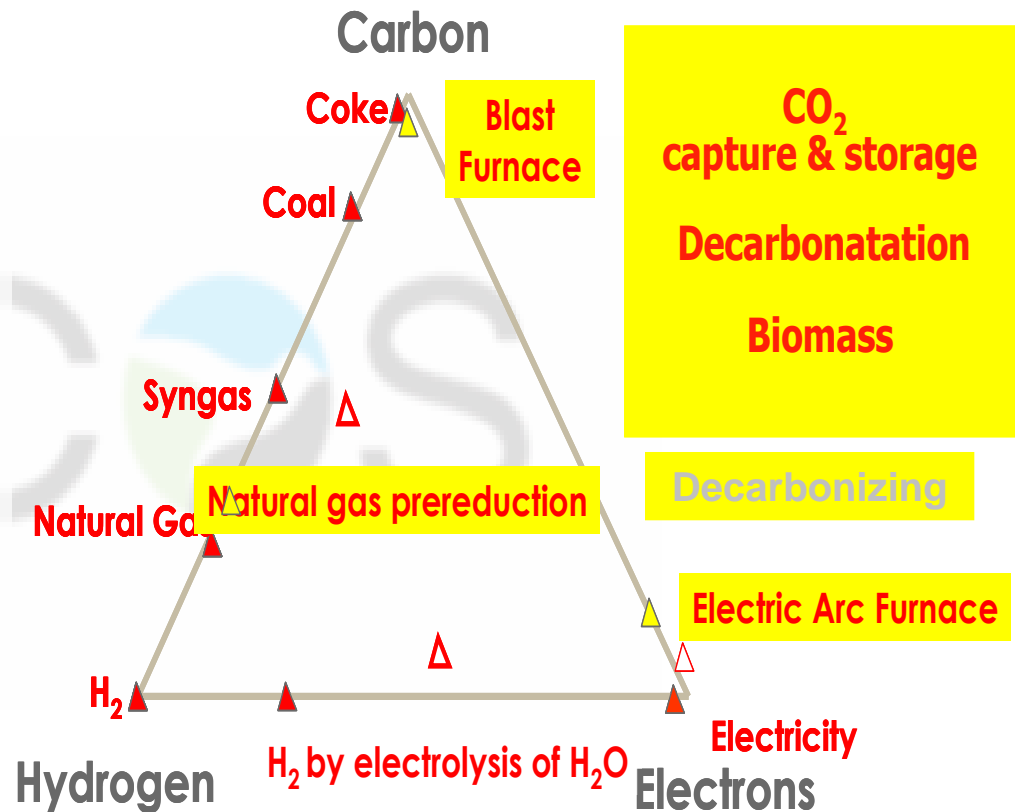
- **Steel demand** strong (2008: 1,329.7 Mt) and **to remain strong** even in carbon-constrained, long-term scenarios (doubling by 2050): steel = key to world & society's well being in any economic model!
- Steel from **1^{ary}** (2 t of CO₂/t_{steel}, 60-70%) or **2^{ary} raw materials** (0.3-0.6 t, 40-30%)
- **recycling** fully internalized in the steel business: high recycling rates (85%)
- **energy conservation** cut consumption by 50% over last 30 years – similar CO₂ cuts; **further cuts small in the EU!**

The average energy consumption per tonne of crude steel 1975 – 2005¹⁸



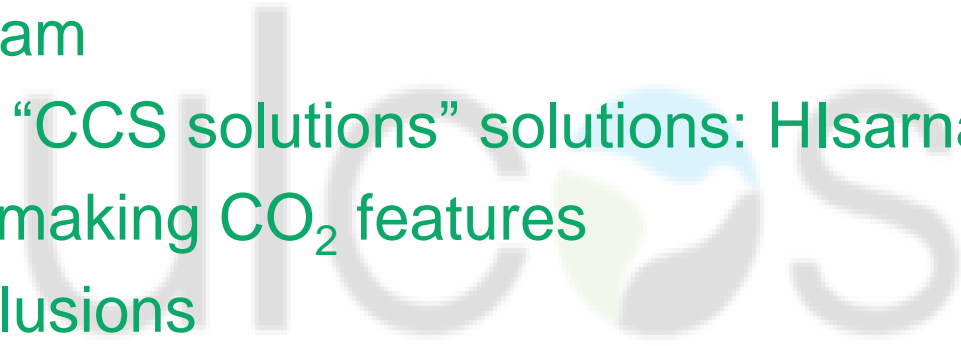
Background... a bit more!

- 1^{ary} route uses coke and coal, 2^{ary} route electricity and some coal (DR: natural gas)
- Steel needs exergy rather than energy (=coal not simply burned into CO₂!): carbon is mainly a reducing agent, not just a fuel!
- Steel rather different from the power or other energy-intensive industries: specific context, needs, technologies and solutions to climate change mitigation!!!
- this is also true of CCS!



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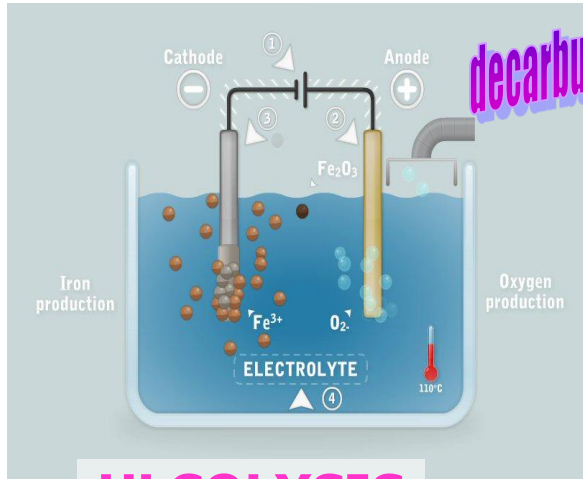
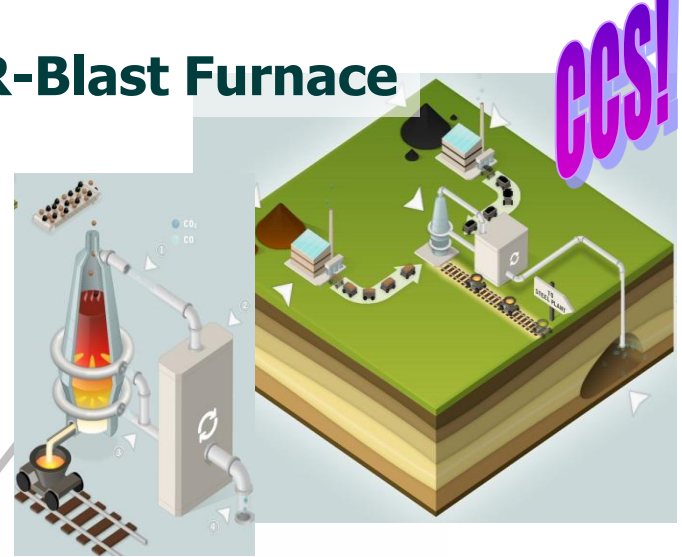
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- Ultra Low CO₂ Steelmaking ULCOS





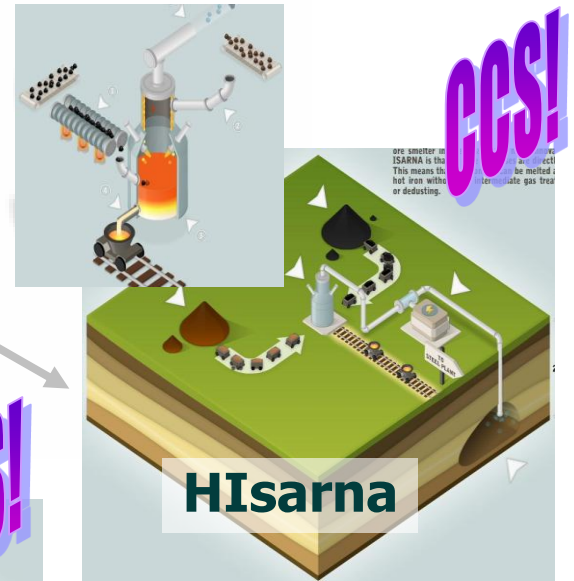
Biomass-based steel production

TGR-Blast Furnace



decarburizing

ulcos



**ULCOLYSIS
ULCOWIN**

Hydrogen



decarburizing

ULCORED



HIsarna



ArcelorMittal

Shown here is the year of launching the 1st demonstrator.
It will take roughly 5 years to validate its technology
and commercial implementation would follow up within 5 more years.

ULCOWIN,
ULCOLYSIS

post-carbon

the age of demonstrators

Hlsarna

2030

2020

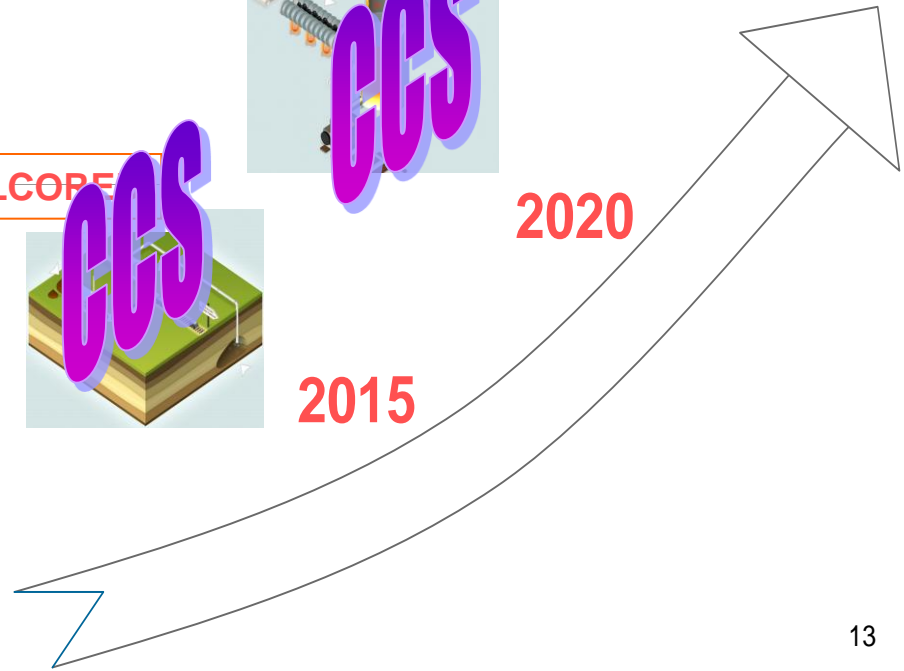
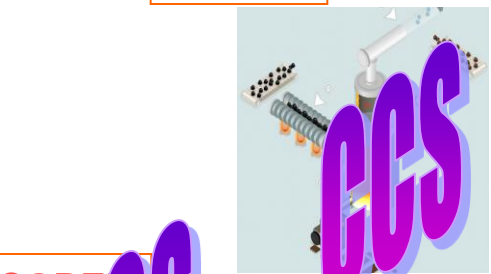
ULGOPE

2015

TGR-BF with CCS



2010



13

Governance & more...

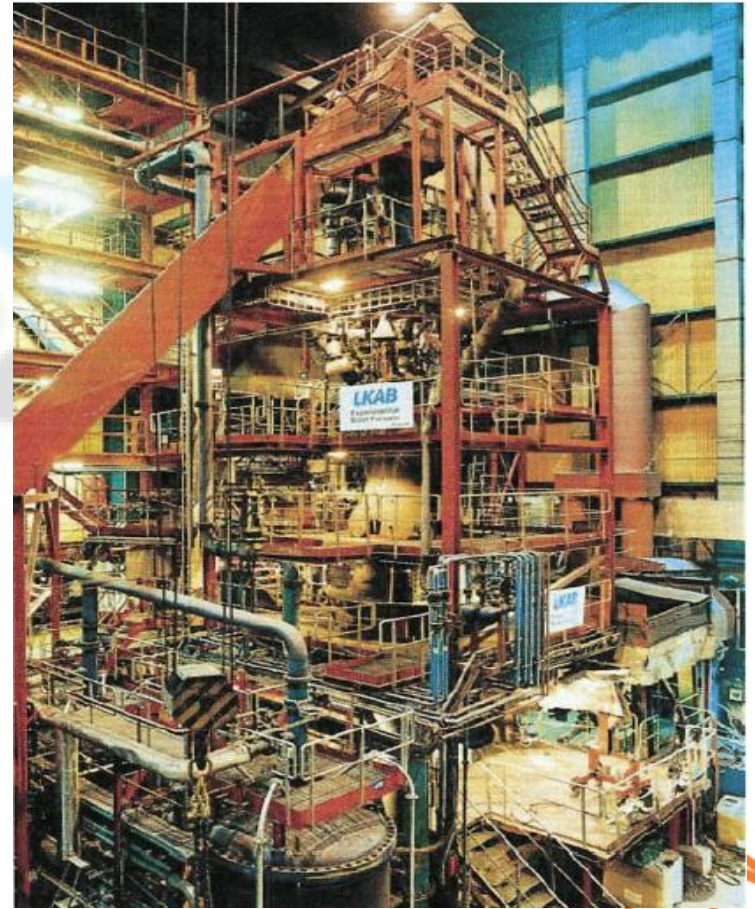
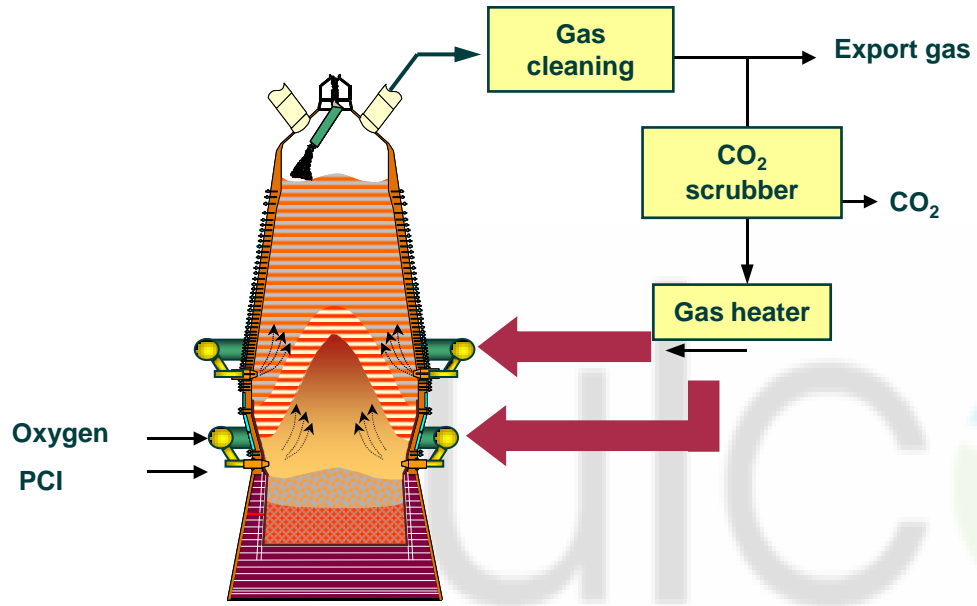
- the program is run by a core group made of most of the Western European Integrated Steel Producers
- the consortium has sorted out, among a long list of potential technologies (80), the final short list which is based on the source of energy used (coke, coal, natural gas, electricity, charcoal/biomass and hydrogen)
- intellectual property is shared on an equal basis by all the core group members
- all the ULCOS technologies selected in the short list are breakthrough technologies
- in addition to achieving the F2 target on CO₂ emissions, all solutions also cut energy consumption & some of them achieve a higher productivity. They are not just plug-in, end-of-pipe solutions!

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ULCOS – TGRBF (Top-Gas Recycling Blast Furnace)



Paris, 5-6 November 2009



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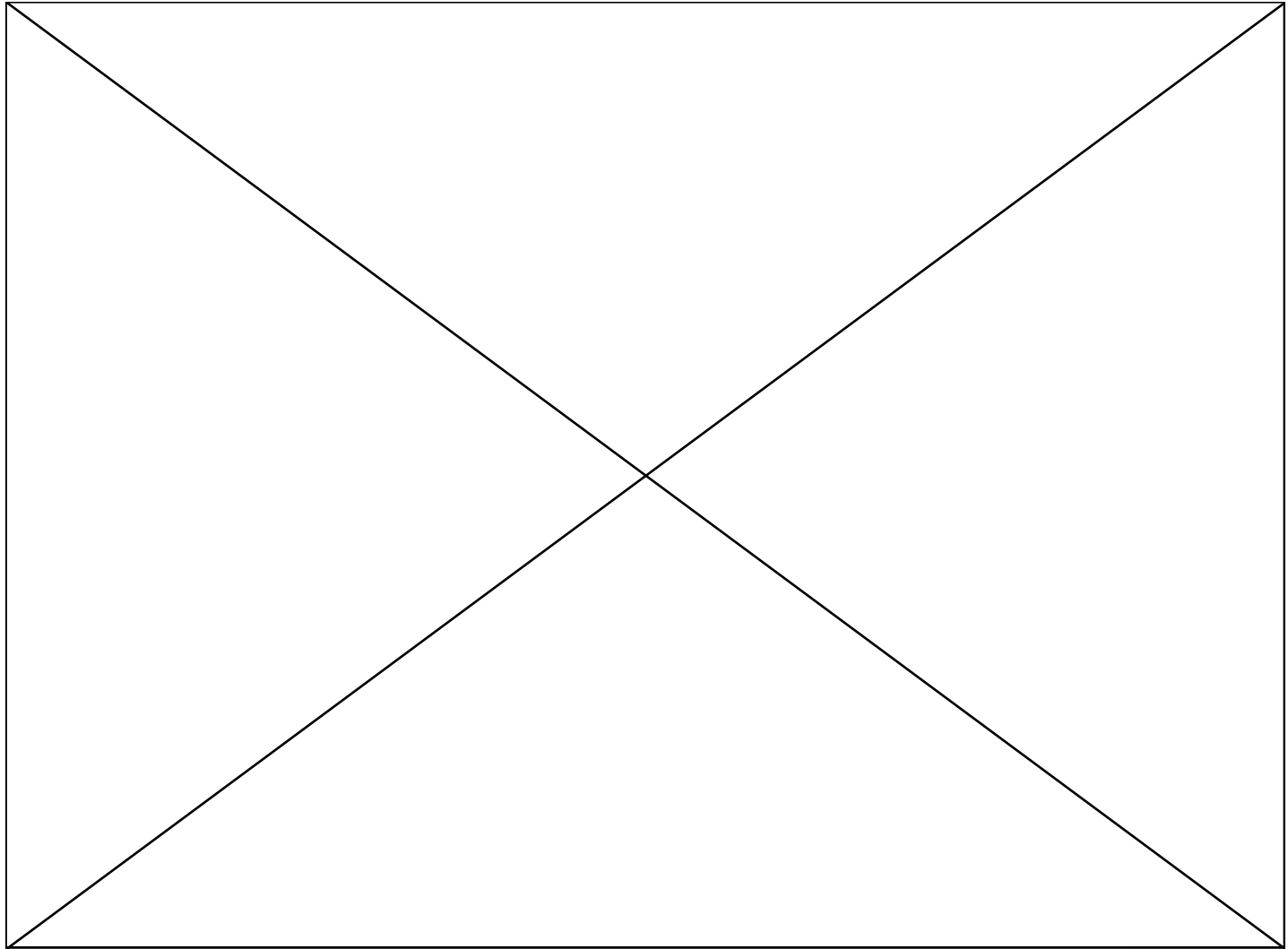


- ULCOS II Program, launched 3-2009:
 - **Pilot Plant** in AM-Eisenhüttenstadt, 2012-2013
 - CO₂ capture only with PSA, O₂ operation and gas recycling
 - **Demo-plant** in AM-Florange, 2014-2016
 - CO₂ capture and storage (2016) using PSA + CPU
 - with the support of a consortium of Steel producers including most of the European BF producers
 - financing expected from national and regional governments (F, G, L, etc.) and from the CCS demonstration fund.
 - total budget: 500-550 M€.

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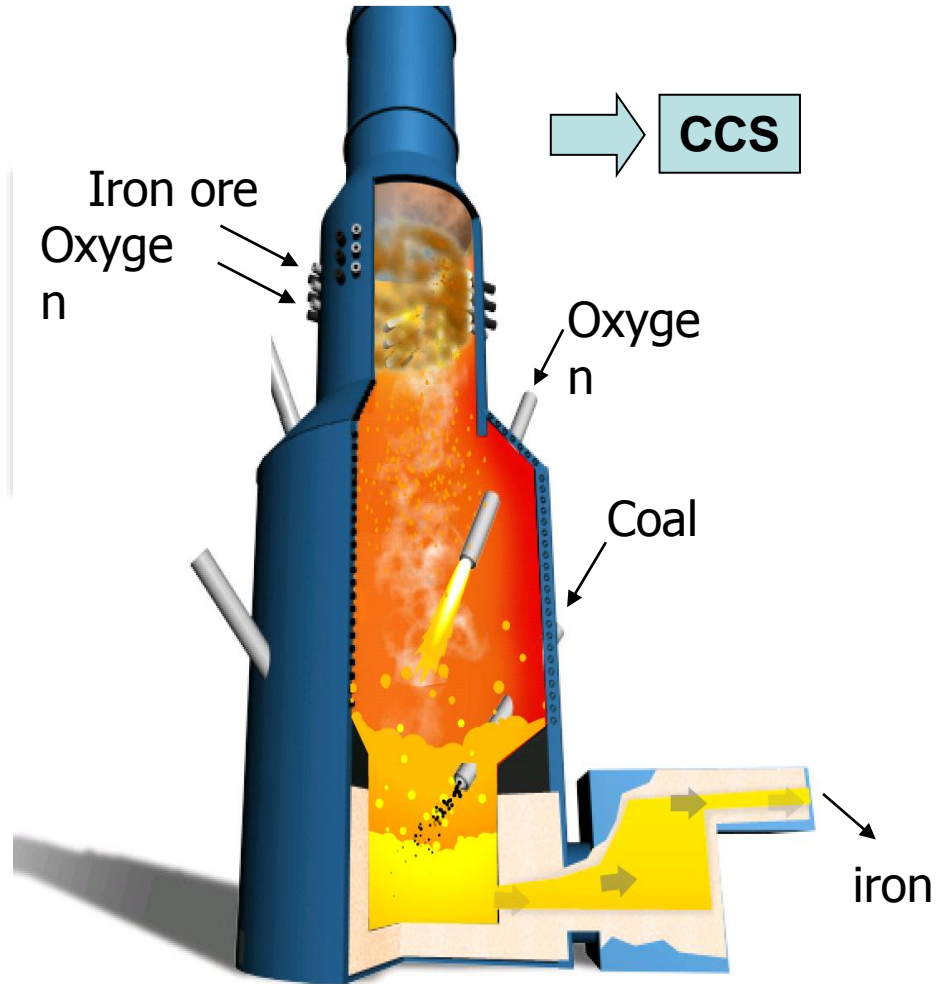
Hisarna Process



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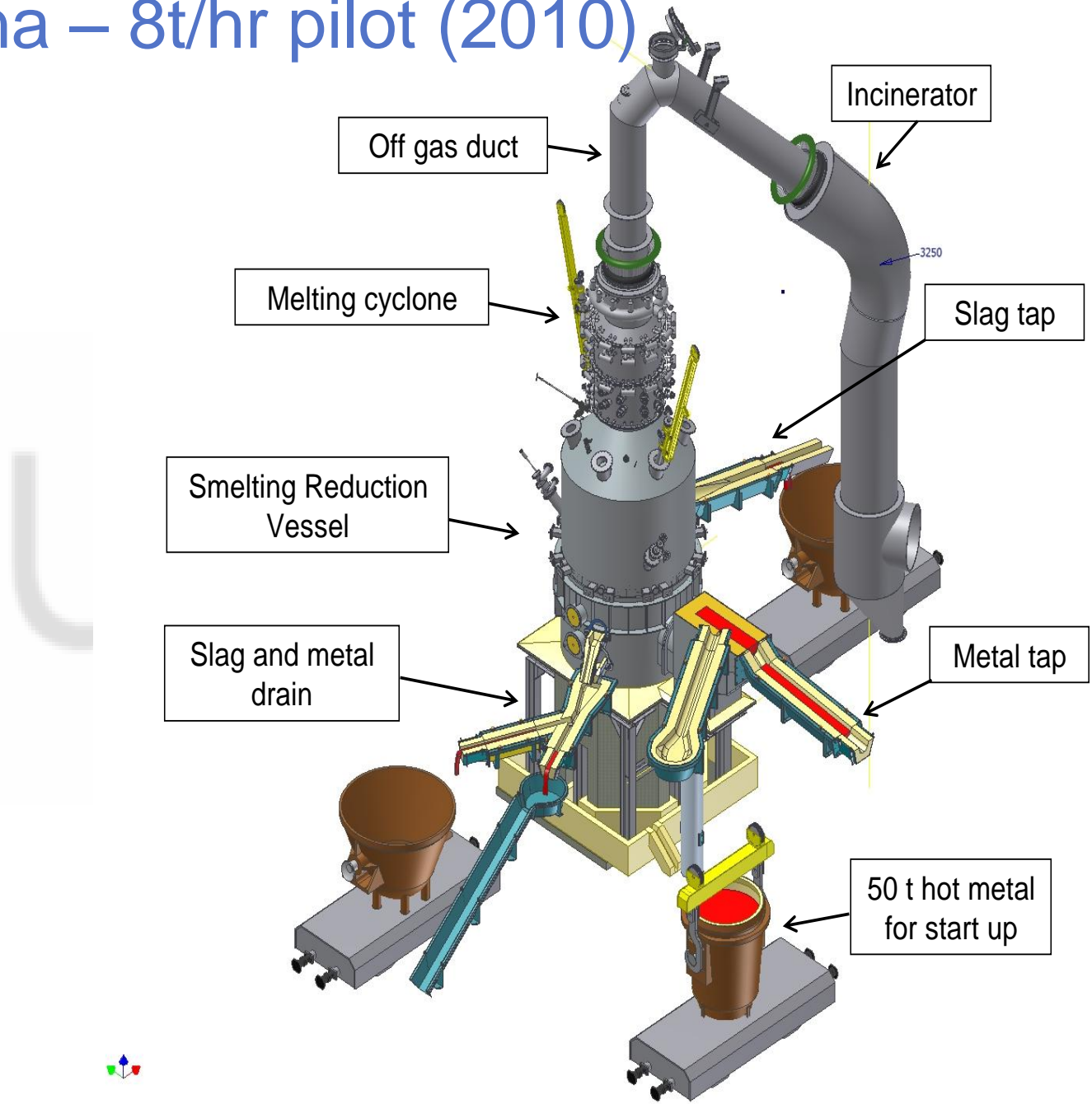
Smelting Reduction: HIsarna

HIsarna



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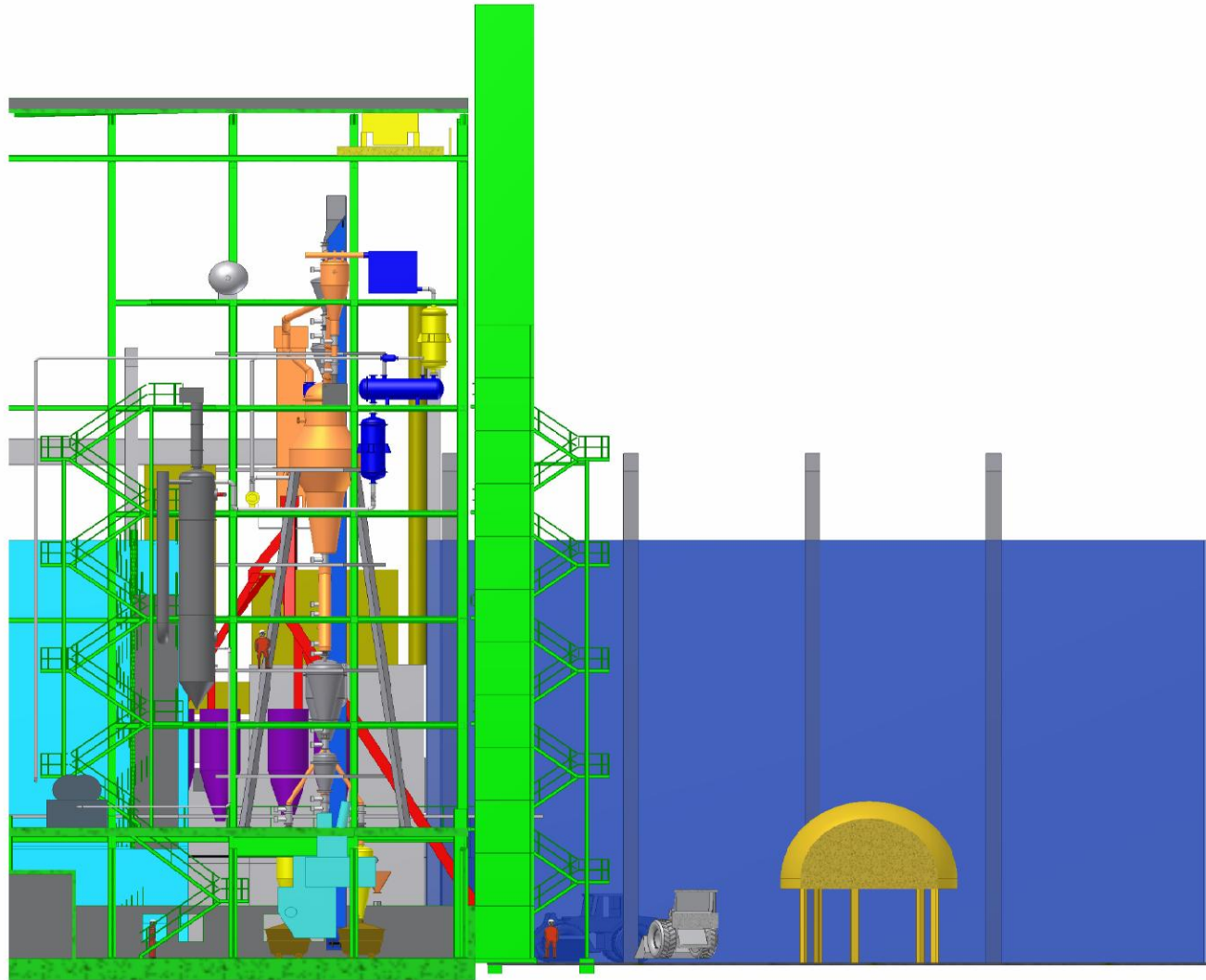
Hisarna – 8t/hr pilot (2010)



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EDRP – ULCORED pilot (2011)



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Electrolysis of iron ore (ULCOWIN)

- Iron sample (ULCOWIN-Maizières)
- Laboratory Pilot (ULCOWIN-Maizières)



solution for the post-carbon world

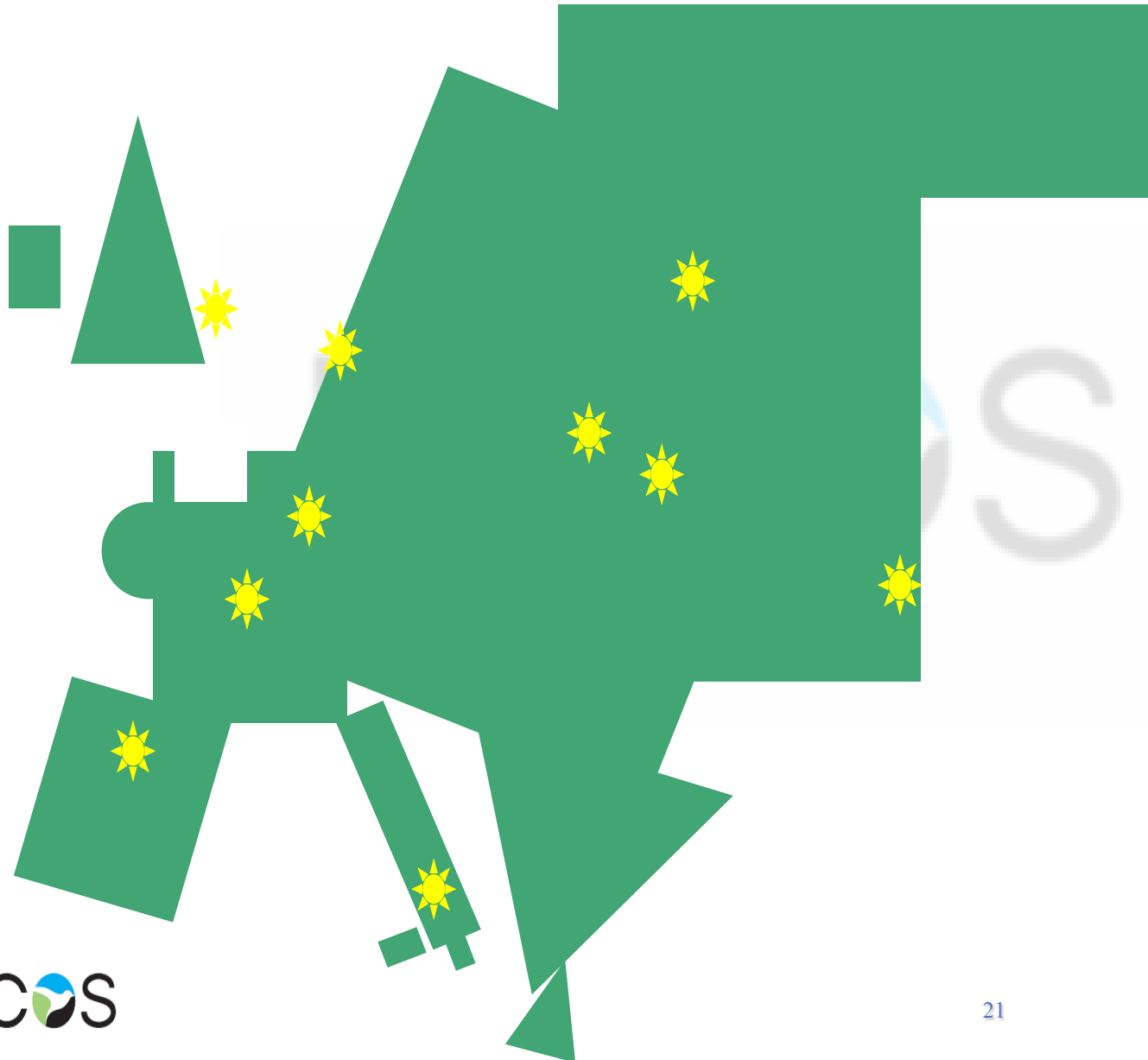
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CCS – Steel's specific needs

- **CCS for Steel:** *neither pre- nor post-combustion, nor oxyfuel* but **oxyreduction and in-process capture**
- 1 steel mill: 5 Mt/y for 50 years = 250 Mt_{steel} + 500 Mt_{CO₂} (potential) + regional non-steel emitters
 - need of fairly **large size reservoirs!** 20 reservoirs in the EU today.
- **CO₂ stream:**
 - CO₂ concentration: **20 to 40%** for the BF, **80%** for HIsarna prior to capture
 - physisorption technologies (**PSA** or **VPSA**) cheaper in that case than chemisorption (amines)
 - if CO stream recycled, purity of CO determines purity of CO₂ stream sent to storage; but later fine tuning is possible (**CPU**)
- **Storage**
 - type of reservoir a matter of local conditions
 - largest potential is in **deep saline aquifers**

CCS: the sunflower model



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Conclusions...

- what **role for CCS** and for how long?
 - a **bridging technology**?
 - a sustainable technology for some sectors (steel) until, in the very long term, a closed-loop, recycling society can take over and mitigate emissions.
- cutting CO₂ emissions of the Steel industry is under way, in a **pro-active and bold approach** at R&D and demonstrator levels, but it needs time, money, a realistic regulatory framework, stakeholder engagement and some luck to match the expectations of the planet
- **Steel has specific needs and has developed a specific approach, both from the standpoint of technology and governance**
- I surmise that all the other players in the area have exactly the same constraints!

Thank you!



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