



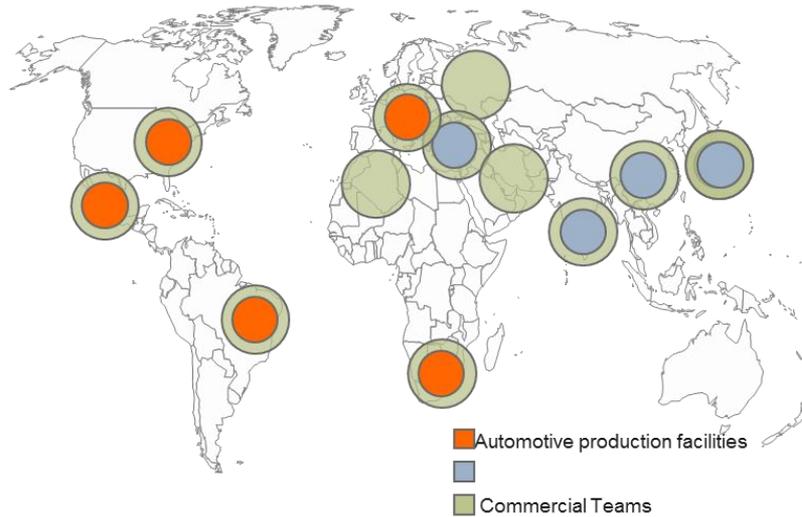
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ArcelorMittal : possible pathways towards
THE LOW EMISSION PLAN(T)

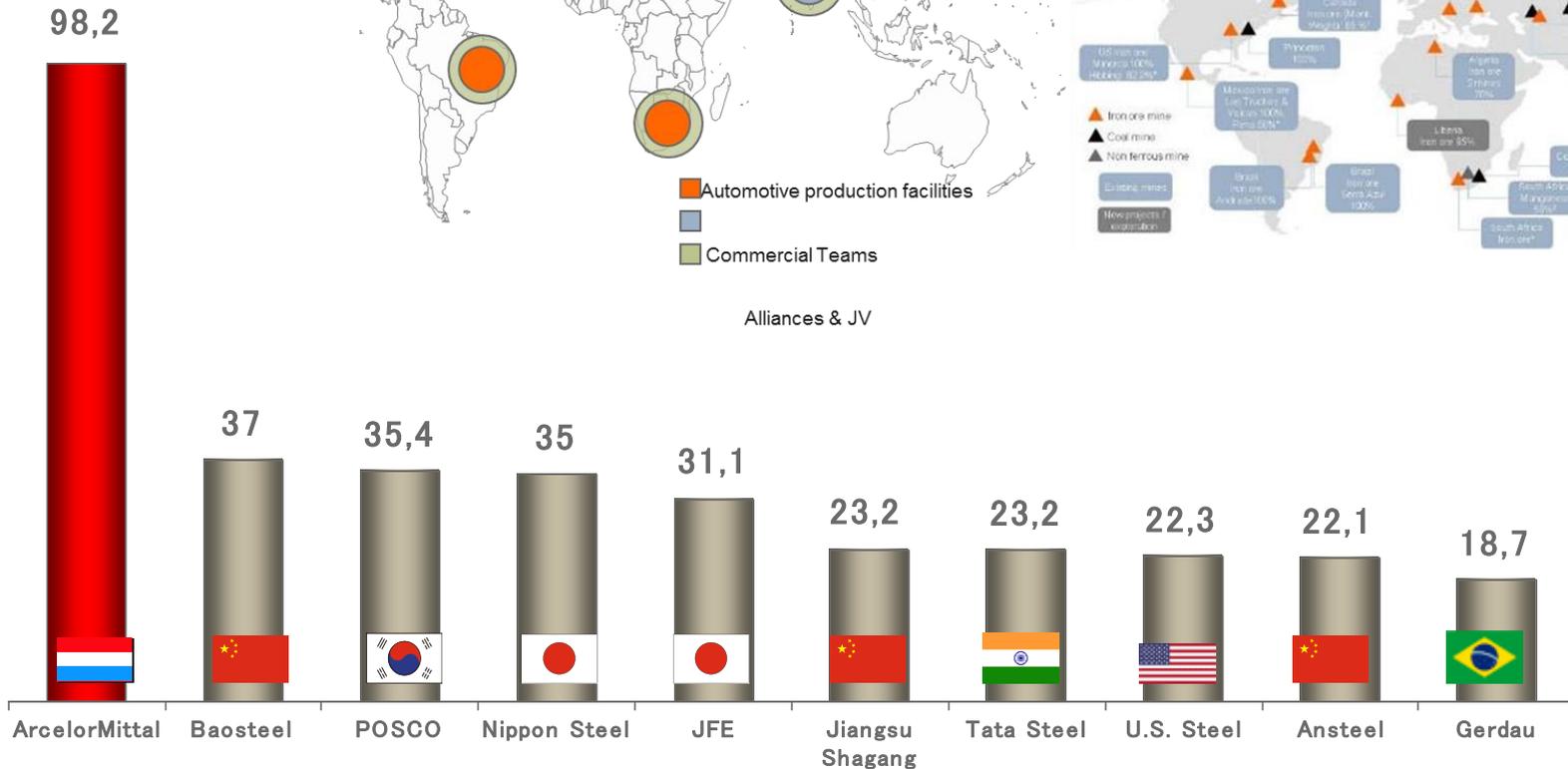
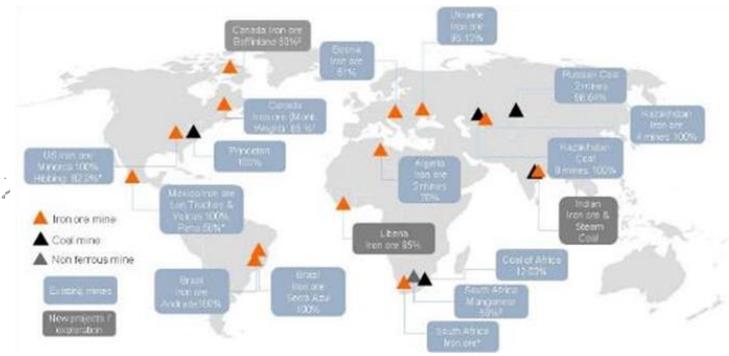
July 2018

Largest steel producers (in mt crude steel)

ArcelorMittal's industrial network



Mining business portfolio



* Source: Worldsteel

Group Management



Lakshmi N. MITTAL
 President of the Board
 and
 Chief Executive Officer (CEO)
 Health and Safety



Aditya MITTAL
 Chief Financial Officer (CFO)
 Europe, Investor Relations,
 Communication

CTO
David CLARKE



Group Executive Committee



Lakshmi Mittal
 Président-directeur général

Aditya Mittal
 Directeur financier groupe,
 DG ArcelorMittal Europe



Les vices-présidents exécutifs

Brian Aranha
 Stratégie de la technologie,
 de la R&D et du secteur
 automobile au niveau mondial



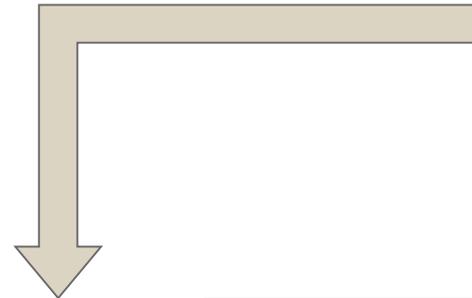
Jefferson de Paula
 DG ArcelorMittal Amérique
 du Sud Produits longs



Geert van Poelvoorde
 ArcelorMittal Europe
 Produits plats



Simon Wandke
 DG ArcelorMittal Mines



LIS* Eric De Coninck
 Wim Van Der Stricht
 Jean Borlée



**Enabling
 Technology
 Deployment**
**Carl
 De Marié**



LIS team = low impact
 steel making



Agenda :

1. European history of steelmaking
2. Others are still at the very beginning of this history
3. What can Europe afford ?
4. Low emission principles
 - a) Gas separation
 - b) CO re-use by chemical industry
 - c) CO₂-H₂-chemistry : new technologies
 - d) CO₂ sale
 - e) CO₂ storage
5. Some political issues

The challenge of the steel industry = C-footprint reduction

Conventional steel making = blast furnaces (BF) Electrical steel making = electric arc furnaces (EAF)

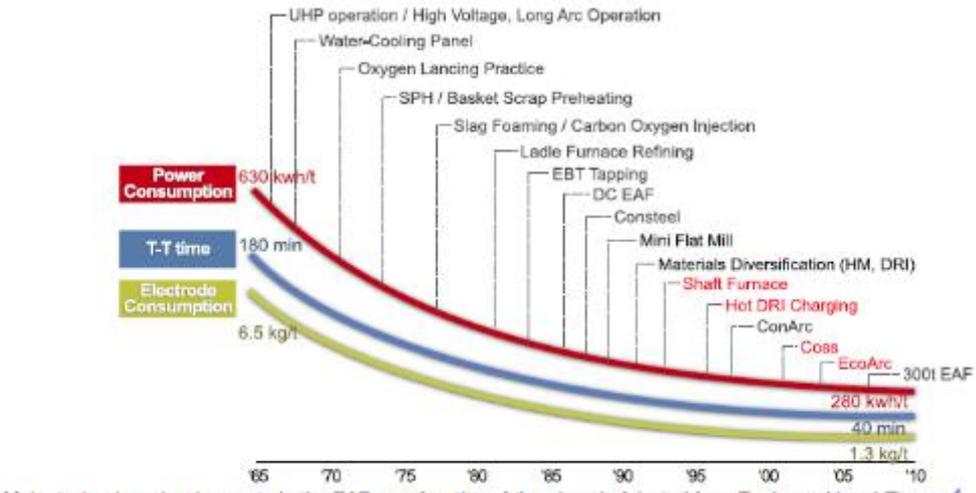
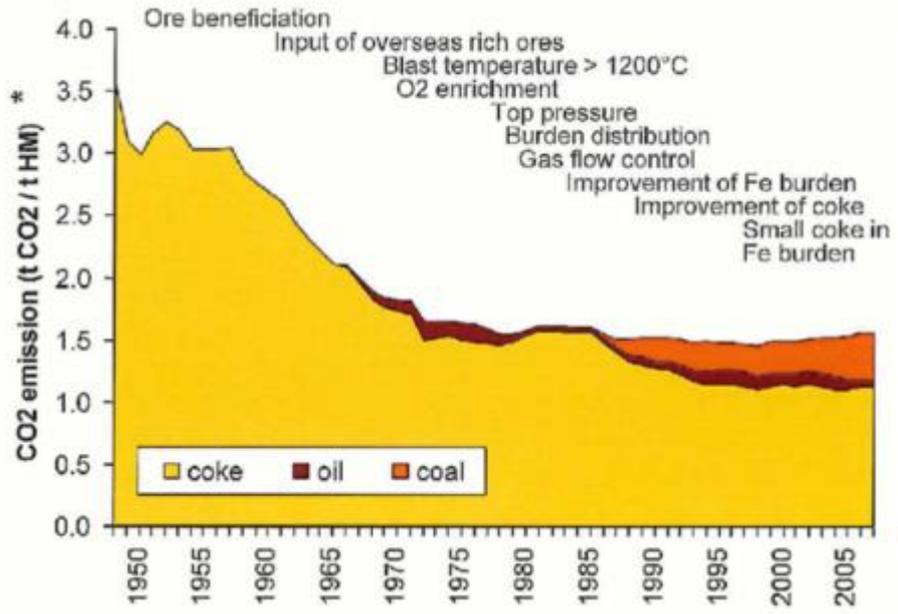
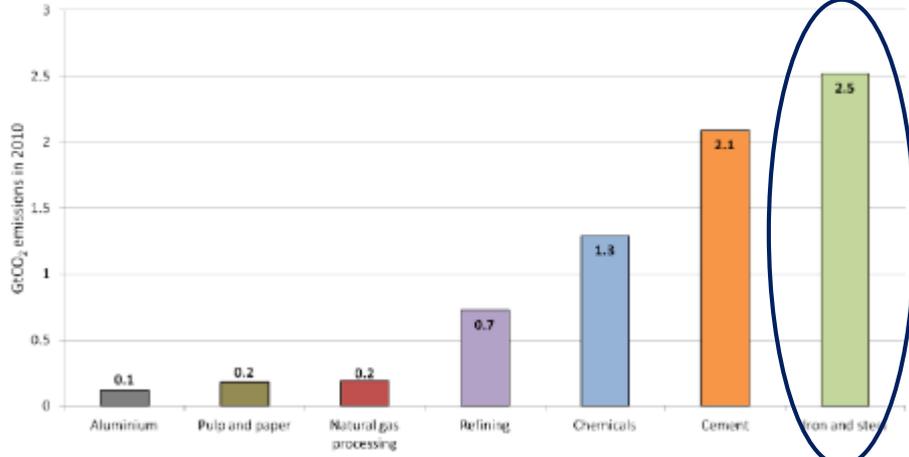


Figure 1. Global emissions from the seven most CO₂-intense industrial sectors in the IEA Energy Technology Perspectives (ETP) analysis



1,6 billion tons of steel in 2014
(1,691.2 in 2017)

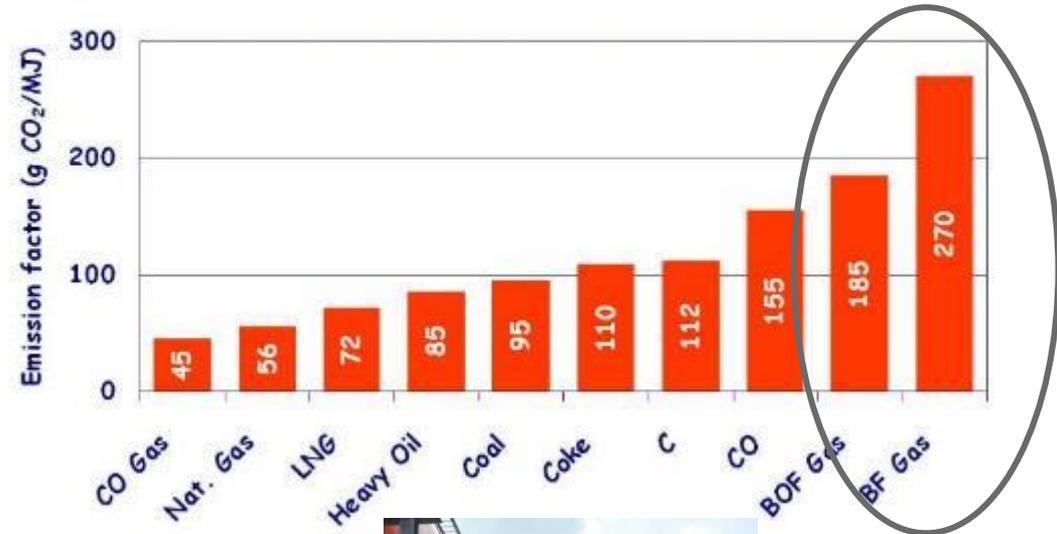
30% of industrial CO₂-emissions.
6,7% of anthropogenic CO₂-emissions

They are amongst the highest of industries....

Power generation is a very common practice, but not the answer to the CO₂ problem



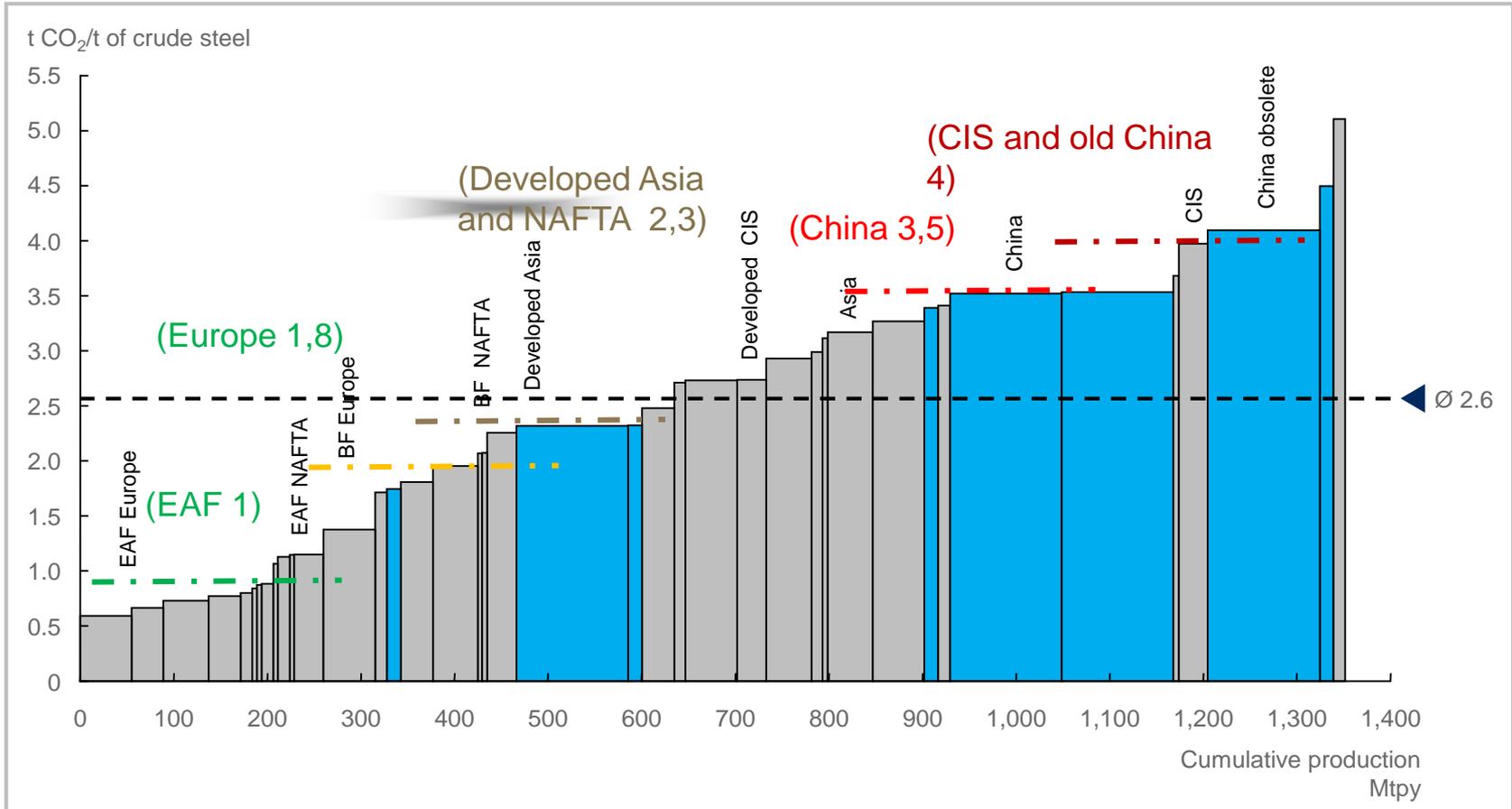
CO₂ emission factor for some fuels





C-footprint reduction : the main emitters are not located in Europe !!!

China/India
Other

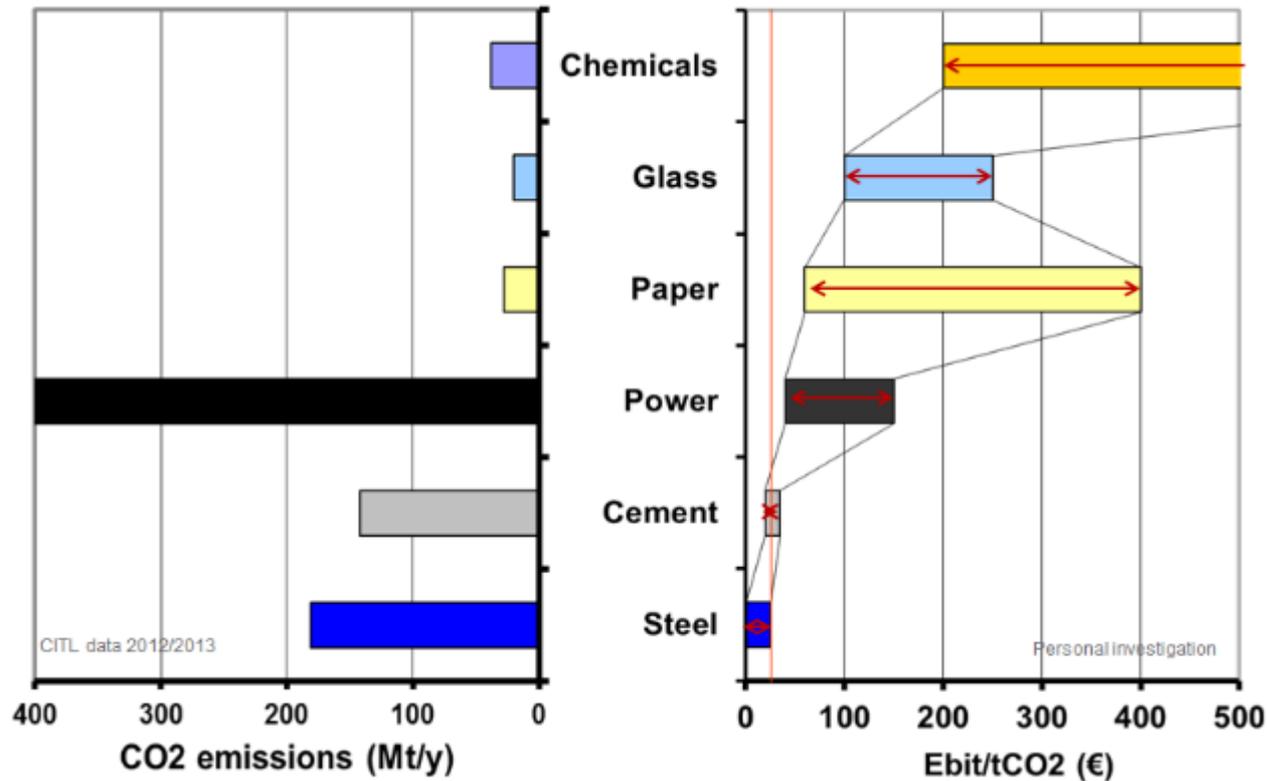


global CO₂ curve

How much can Europe afford ???



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Carbon is a reactant agent for steel production, not an energy source !
 $2C + O_2 \rightarrow CO + FeO \rightarrow Fe + CO_2$ $CO_2 + C \rightarrow 2 CO$

You can not lower the CO₂ emission from the steel industry by installing one more windmill...

ETS is made for power generation, not for chemical processes.

The Low Emission Plant principles



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Technical principles :

- Half of the steel mill gases is CO, which is burnt for power production. By not burning the CO a lot of CO₂ is avoided. This CO can be used for fuel and chemical production.
- The lack of electricity on the grid, can be compensated by the production of RENEWABLE electricity. This is the major lever to reduce the CO₂ emissions
- By separating the CO from the CO₂, pure CO₂ is available for re-use or storage.

CORESVM

CarbOn-monoxide RE-use through industrial SYMBiosis between steel and chemical industries

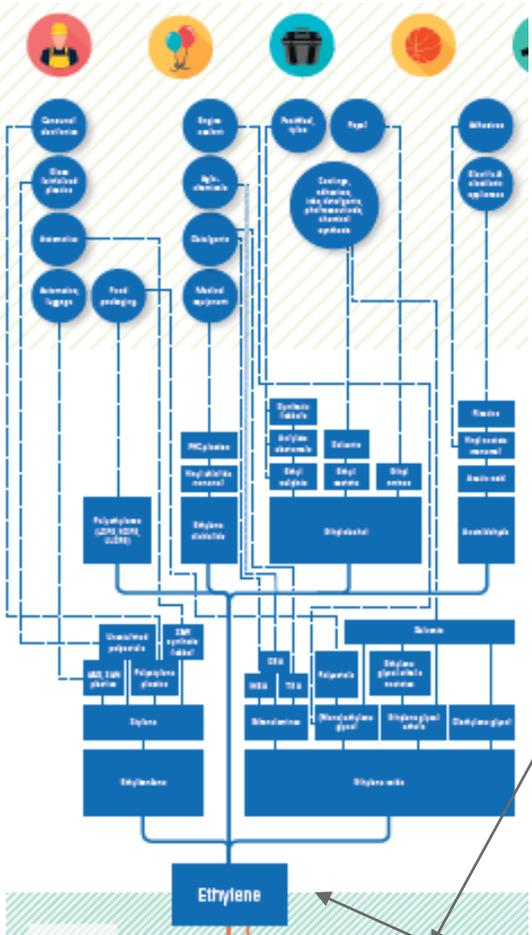
SCALING UP A EUROPEAN CO-RECYCLING SCENARIO:
Here we take a closer look at the implications of CO recycling from steel mills under an optimistic scenario. European demand for methanol and ethanol, as well as a small share of the demand for fuels (0,1%) can be met by recycling 77% of Europe's steel mill waste gases into products.



Institute for Sustainable Process Technology

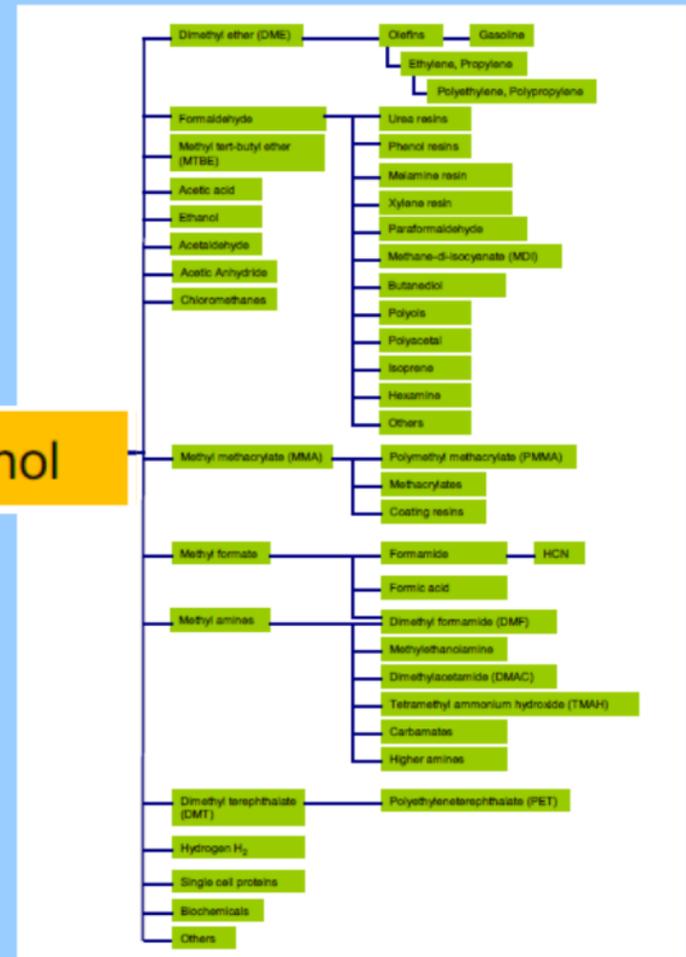
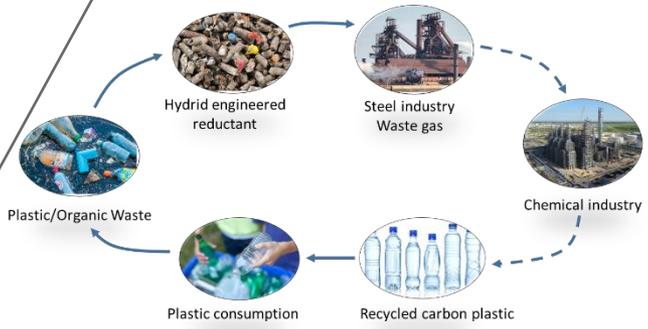
The Low Emission Plant principles

CDA = carbon dioxide avoidance
 CDU = CCU = carbon (di)oxide re-use
 CDS = CCS = carbon dioxide storage



CO, CO₂

Methanol



14/07/2018

Ethanol

Confidential

The steel mill of the future will still produce gasses



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Steel mill gases contain
CO/CO₂/H₂/N₂

- BF Gas : 62 %
- BOF Gas : 10%
- CO Gas : 28%

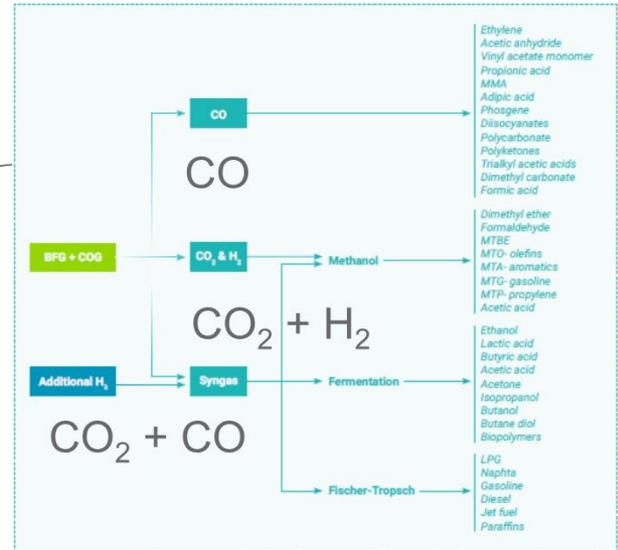
52% of the gas energy replaces natural gas in the plant

Power plant : 48%



14/07/201

Gas separation



- O₂ : is a valuable byproduct
- H₂ : valuable gas agent to combine with carbon gases
- N₂ : sale

Steel mill available waste heat = 500 MW

The steel mill of the future will provide the single gas components



Steel mill gases
CO/CO₂/H₂/N₂



DMEA Solvents



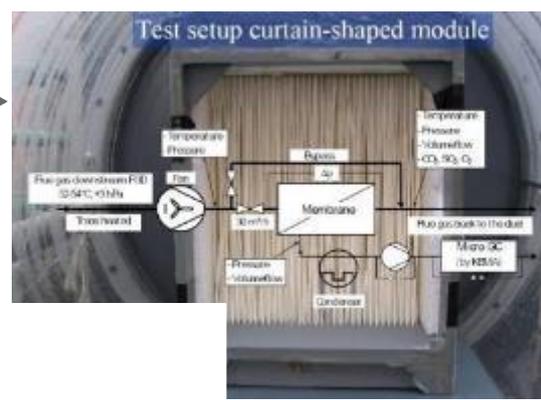
(V)PSA



AM Saldanha Works VPSA



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MEMBRANE

The steel mill of the future will sell CO

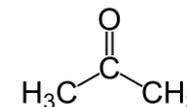
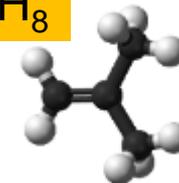
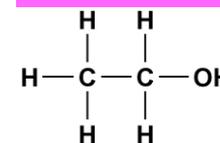


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Valorisation of steel mill CO

Sale to chemical industry
Conversion into valuable hydrocarbons



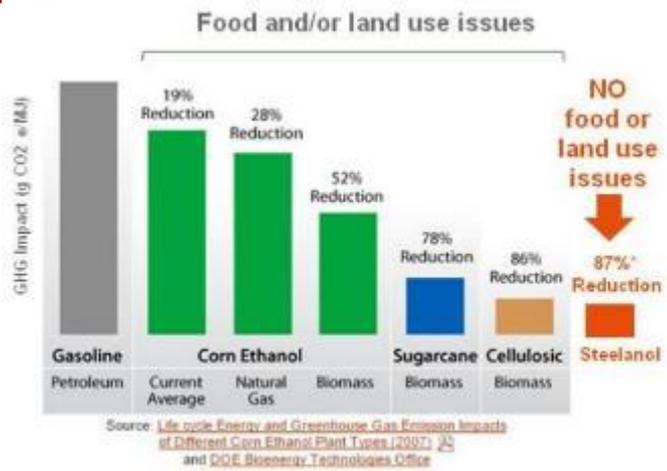
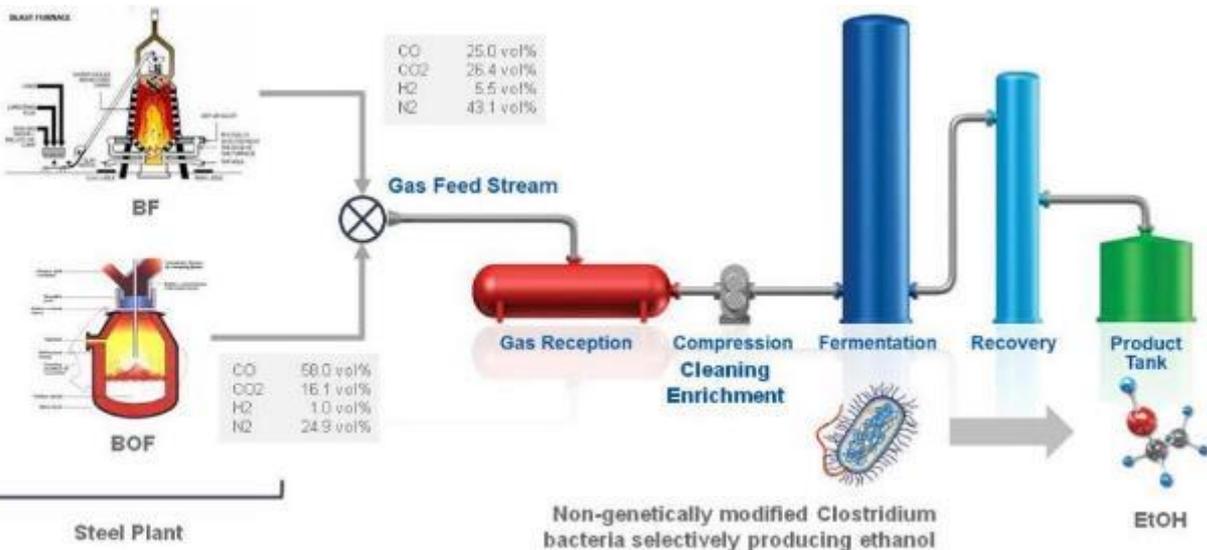
H₂- sources =

- Coke Oven gas
- H₂ surplus from chemical partner
- Electrolysis

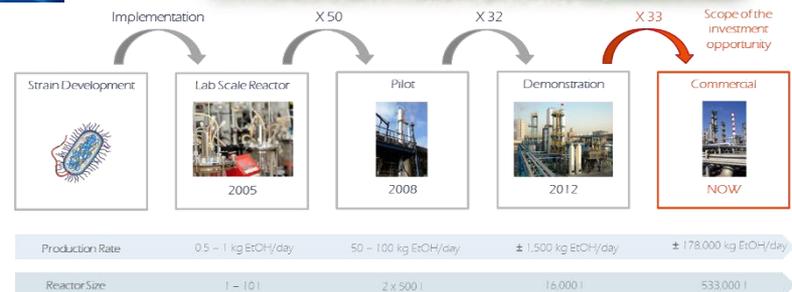


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The steel mill of the future will sell CO



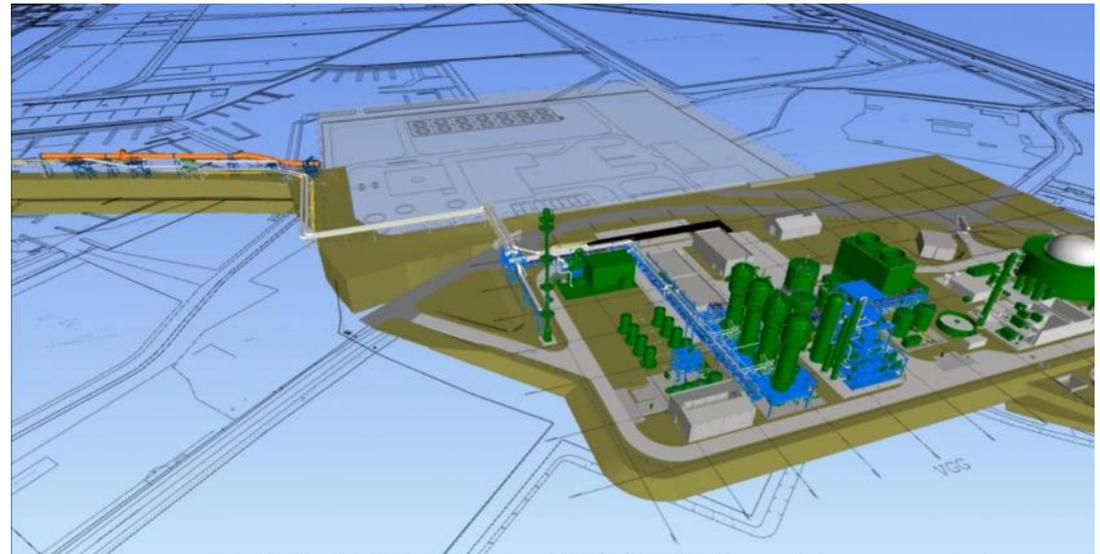
Potential of 300 kton EtOH/year = 380 MI/year = over 700 kT/y of CO₂ savings



The steel mill of the future will sell CO



The Gent Ethanol plant



The steel mill of the future will sell CO₂ - derivatives



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Valorisation of steel mill CO₂

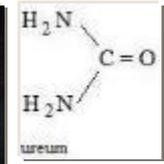
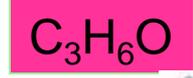
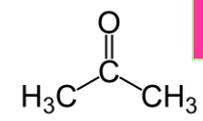
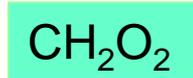
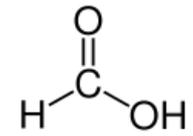
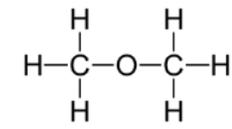
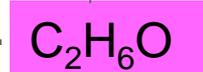
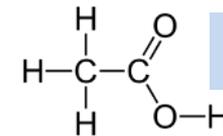
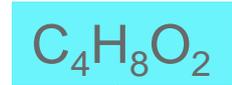
Fuels - chemicals



Raw CO₂

H₂- sources =

- Coke Oven gas
- H₂ surplus from chemical partner
- Electrolysis



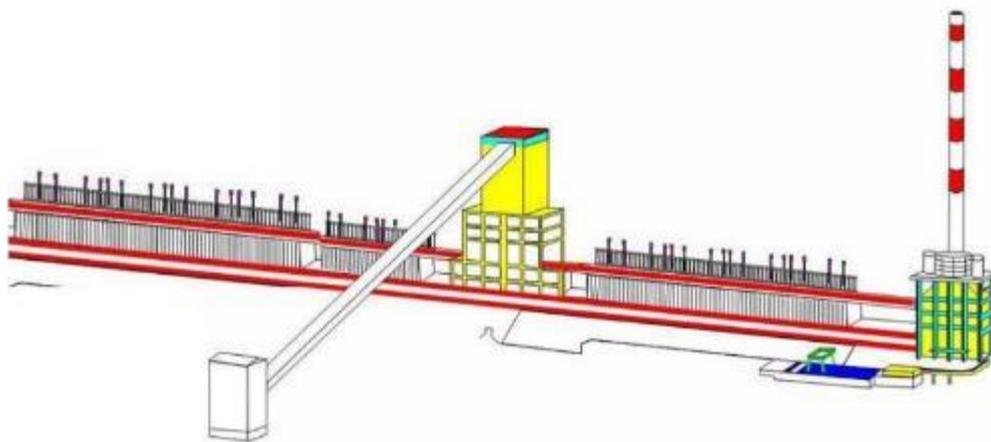
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The steel mill of the future will need more H₂ - gas



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25 – 50 kT/y of coke oven gas



Supply from
neighbouring chemical,
chlorine electrolysis
plant : 25 – 50 kT/y



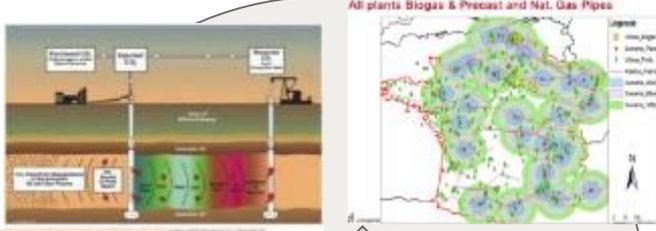
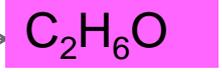
5 – 10 kT/y by electrolysis or rSOEC



The steel mill of the future will sell CO₂



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Sale of the CO₂ (industrial gas supplier, green houses, EOR ...)



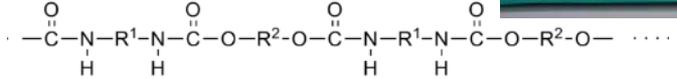
Carbonation minerals – slags - ..



Photo 1: overview of the rotating batch autoclave

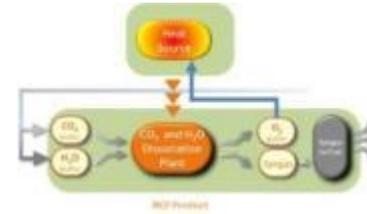


Polyurethane

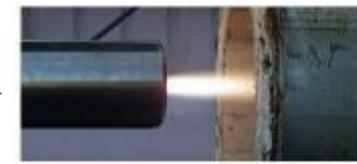


Raw CO₂

Valorisation of steel mill CO₂



CO₂ high temperature electrolysis with renewable electricity



CO₂ reforming in plasma torches with renewable electricity

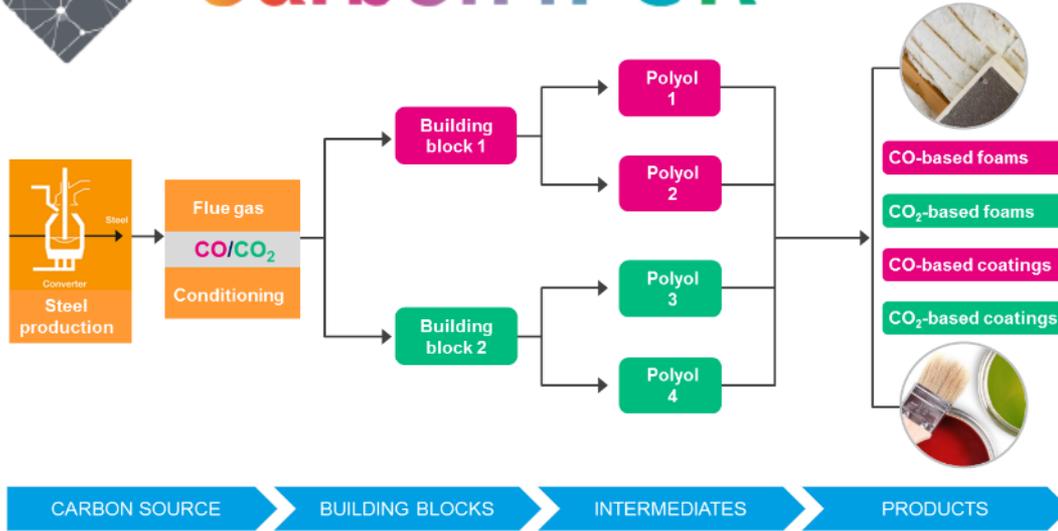
Figure 1: plasma torches of a 2 MW torch



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Carbon4PUR

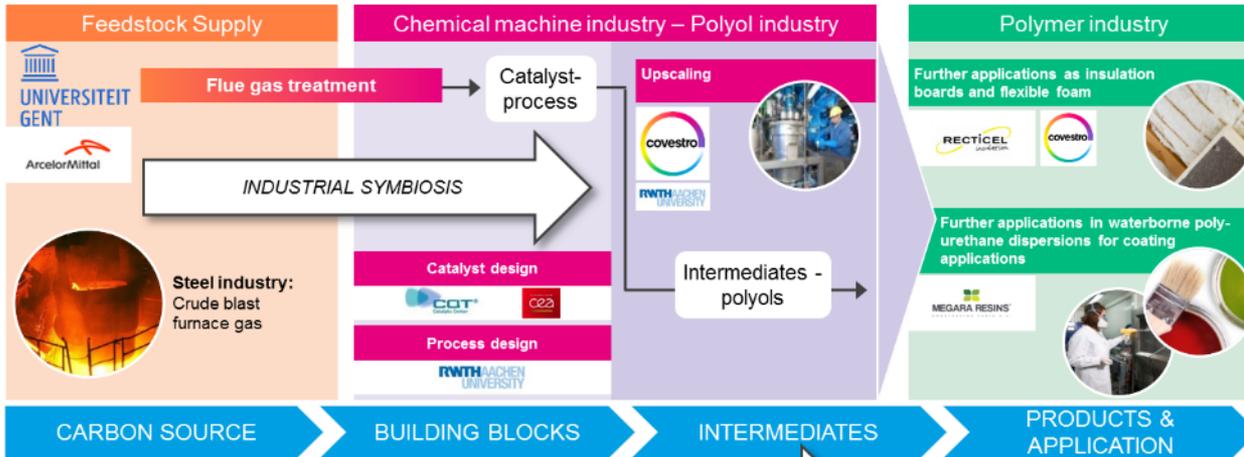


SPIRE

Sustainable Process Industry through Resource and Energy Efficiency



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The steel mill of the future may have a legal problem ... and no market for its products

RED 2 : 2020 - 2030

Recycled Carbon Fuels

Many of these products will cost more than the fossil products

1. The LCA-methodology has to be defined and accepted in a delegated act. The minimum threshold of GHG reduction is not yet fixed (renewable electricity privilege for electrical cars to be expected)
2. Member states can decide themselves if they allow Recycled Carbon Fuels in the energy mix for transport
3. The CO2 taxes for re-used carbon will not be eliminated (ETS)

The promotion of recycled carbon fuels can also contribute towards the policy objectives of energy diversification and transport decarbonisation when they fulfil the appropriate minimum greenhouse gas savings threshold. It is therefore appropriate to include those fuels in the obligation on fuel suppliers, whilst giving Member States the option not to consider these fuels in the obligation if they do not wish to do so. Since those fuels are of non-renewable nature, they should not be counted towards the overall EU-target for energy from renewable sources.

EUROPEAN COMMISSION



greenhouse gas emission savings from renewable liquid and gaseous transport fuels of non-biological origin and recycled carbon fuels, which shall ensure that no credit for avoided emissions be given for carbon dioxide whose capture already received an emission credit under other legal provisions.

The steel mill of the future Conclusions :



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1. A quick increase of renewable electricity capacity in the EU is to be installed
2. A clear and unambiguous LIFE CYCLE ASSESSMENT methodology is necessary (DG Energy : start 2018)
3. This will allow us to calculate the real CO₂ abatement potential of the new technologies, and rank them for support measures
4. This will determine a CO₂ support price to deploy new technologies
5. This will create new industries, jobs, .. and make Europe less depending from energy from other continents (gas, oil, coal,)
6. As as result the EU will have cleaner air to breathe



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The steel mill of the future Storage is not its core business .. so the authorities have to bear this responsibility...

- Still too many uncertainties : a lot more R&D is required
- Manage the social attitude towards CCS, too many bad examples already

Norway abandons Mongstad carbon capture plans

20 September 2013 Last updated at 18:10 GMT



Dutch officials stop Shell's CO₂ storage project
Ministry officials insist facility is safe, but bow to local opposition to the Barendrecht pipeline and gas reservoir.

By Agence France-Presse , Thu, Nov 04 2010 at 2:28 PM



Vattenfall Stops EUR1.5B Investment In German CCS Plant

Date: 06 Dec 2011; Source: [Wall Street Journal](#)

Vattenfall abandons Jaenschwalde Project in Germany



DEUTSCHLAND CCS-TECHNIK OHNE CHANCE

Ecofys: CO₂-opslag niet essentieel voor klimaatdoelen

Österreich verbietet CO₂-Speicherung

The Zero Emission plant....

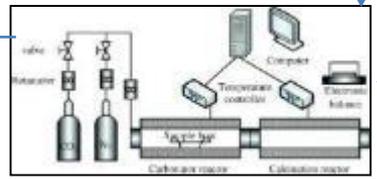
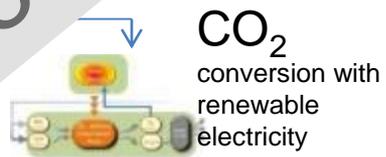
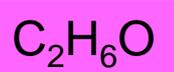
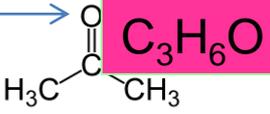
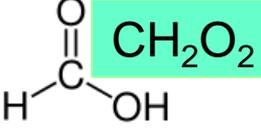
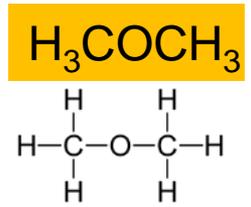
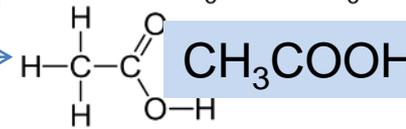
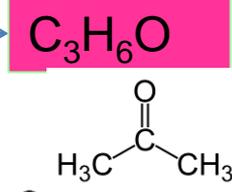
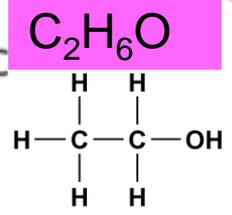
Clean H₂
From COG,
electrolysis or excess
from chemical industry

Sale to chemical industry



Steel mill
gases
CO/CO₂/H₂

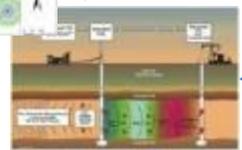
Clean CO/H₂



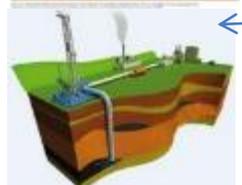
EOR



CSS



Sale to gas
industry



Public pipe

Thank you for your attention

14/07/2018