Energy research Centre of the Netherlands

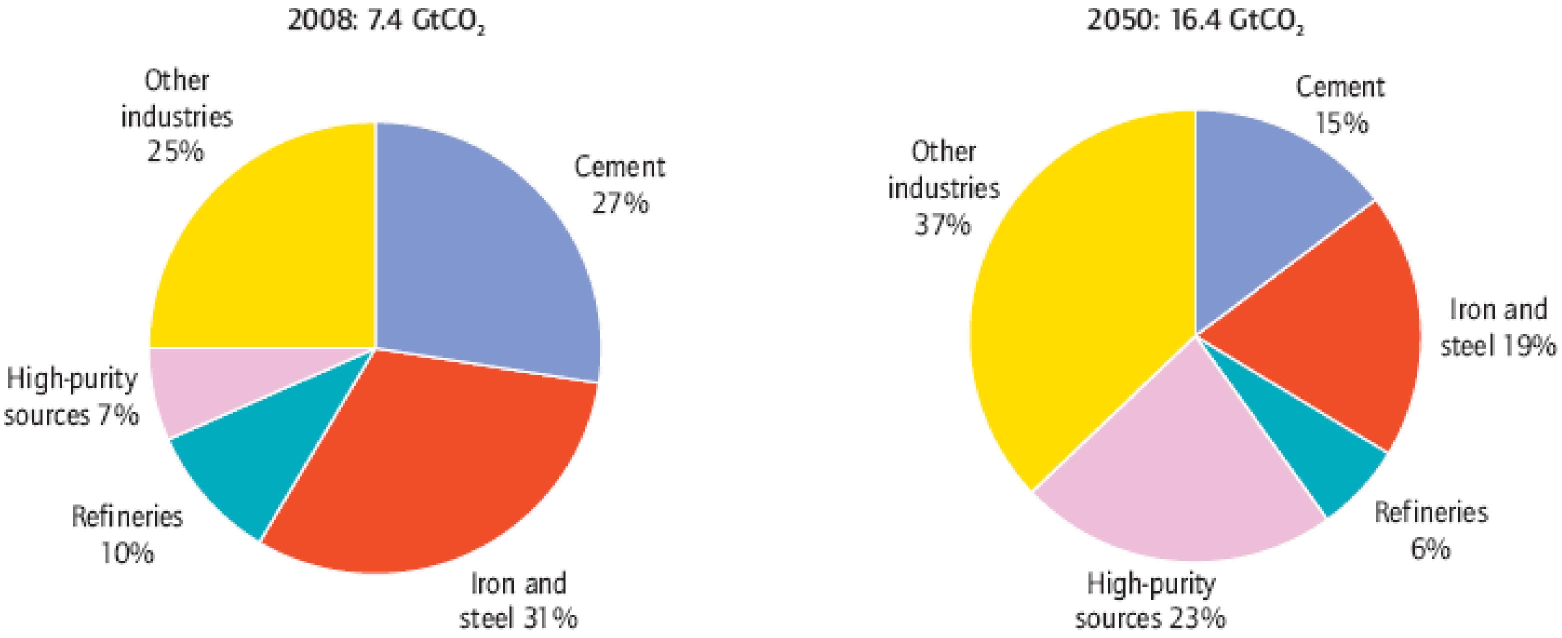
CCS in industry and niche markets

Tom Mikunda, 7th March 2012, Mexico City

Agenda

- Emissions from industry
- IEA BLUE Map Scenario
- Capture options for major industrial processes: -
    - Cement
    - Iron and steel
    - Refineries
- CCS in niche sectors
- CCS with biomass
- Costs of deployment
- Case studies
- Key messages

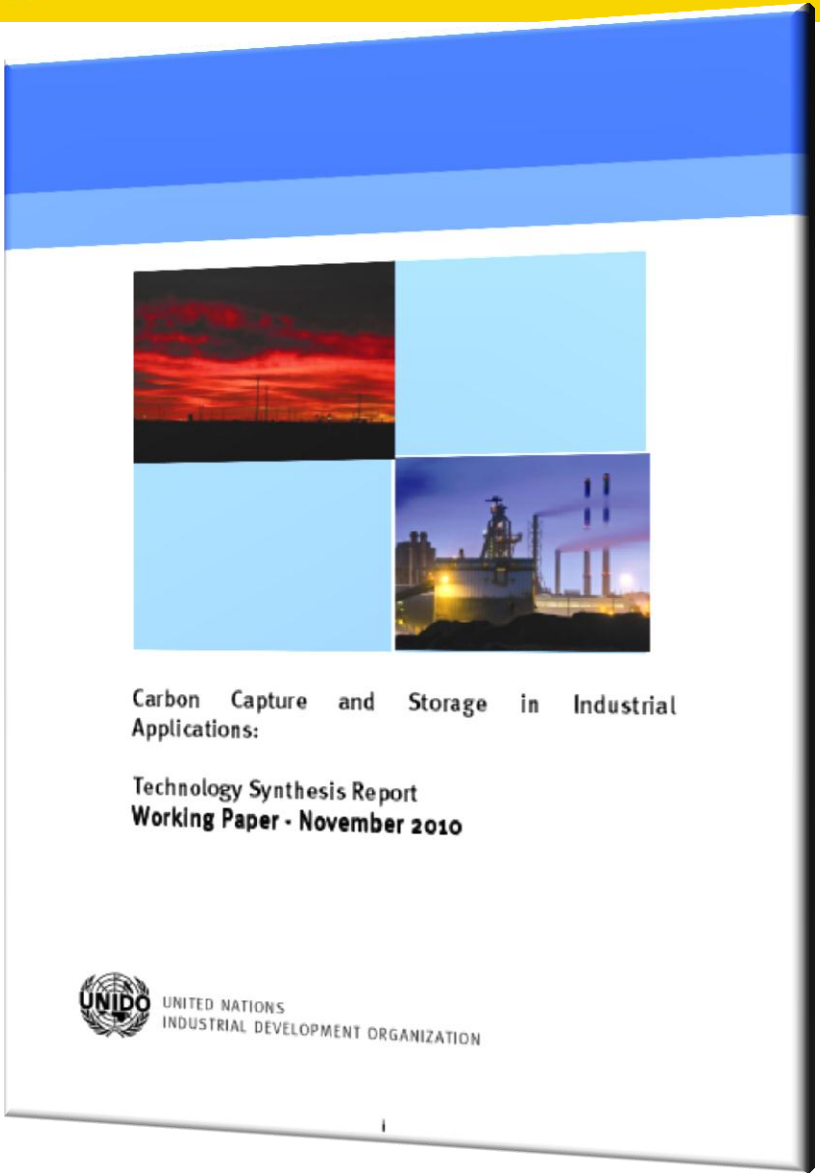
CO_2 emissions from industrial sources



- 40% of global CO_2 emissions from industry
- Emissions from industry expected to more than double by 2050

Why consider CCS for industry?

- There are few alternatives for making deep emission cuts in industries such as cement and steel production.
- Energy efficiency has a role, but many unit processes already optimised.
- Alternative materials and production processes (i.e. steel production through electrolysis) at early stages of development
- Heterogeneity of industry presents challenges and opportunities
- Early low cost opportunities for CCS deployment exist within industrial and upstream sectors ‘niche markets’



Carbon Capture and Storage in Industrial Applications:

Technology Synthesis Report
Working Paper - November 2010

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

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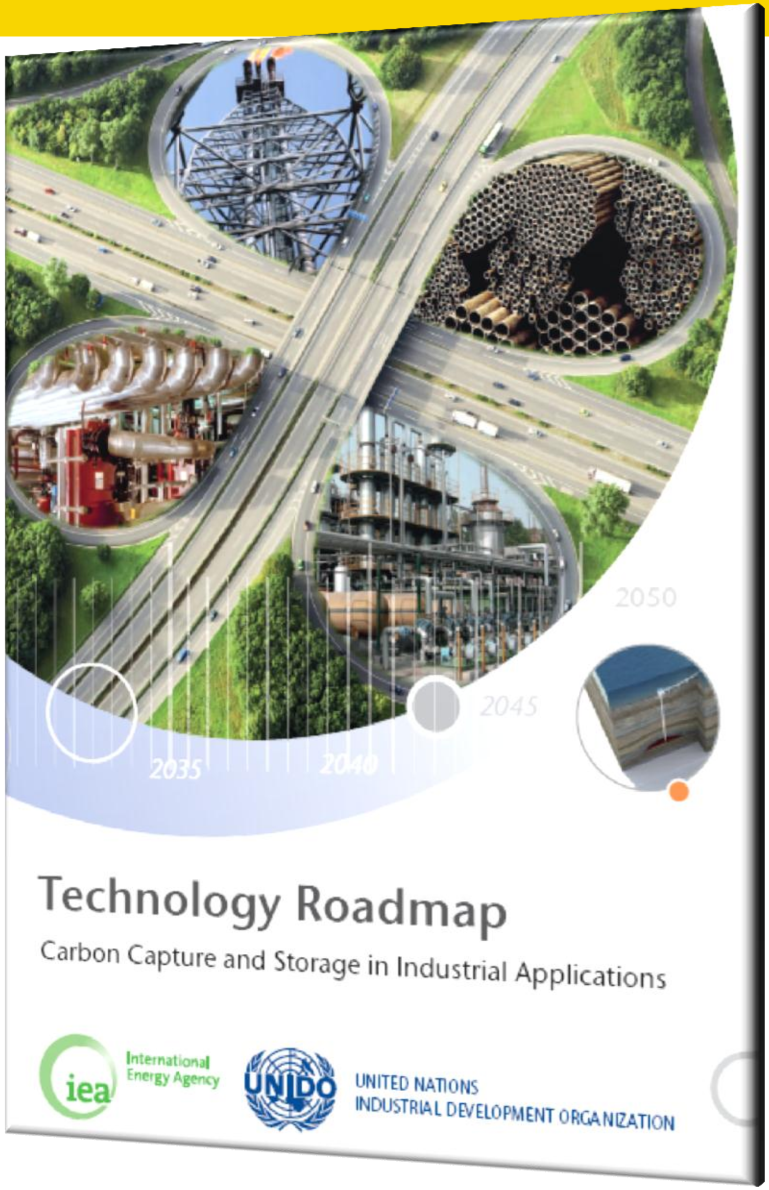

Technology Roadmap

Carbon Capture and Storage in Industrial Applications

International Energy Agency

UNITED NATIONS
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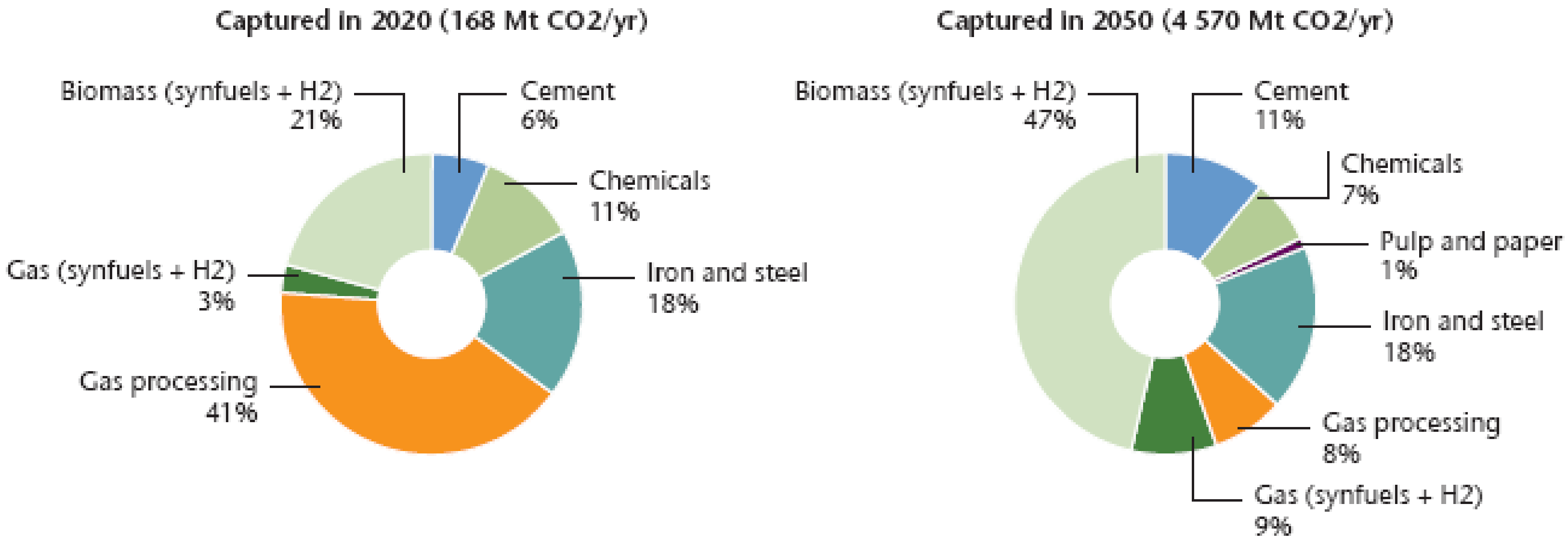
IEA ‘BLUE Map’ scenario

- By 2050, 50% reduction in annual CO_2 emissions from 2005 levels
- Bottom-up MARKAL model that uses cost optimisation to identify least cost mixes of energy technologies and fuels to meet energy demand



CO_2 reduction in the cement industry

- 30% of direct CO_2 emissions from industry globally

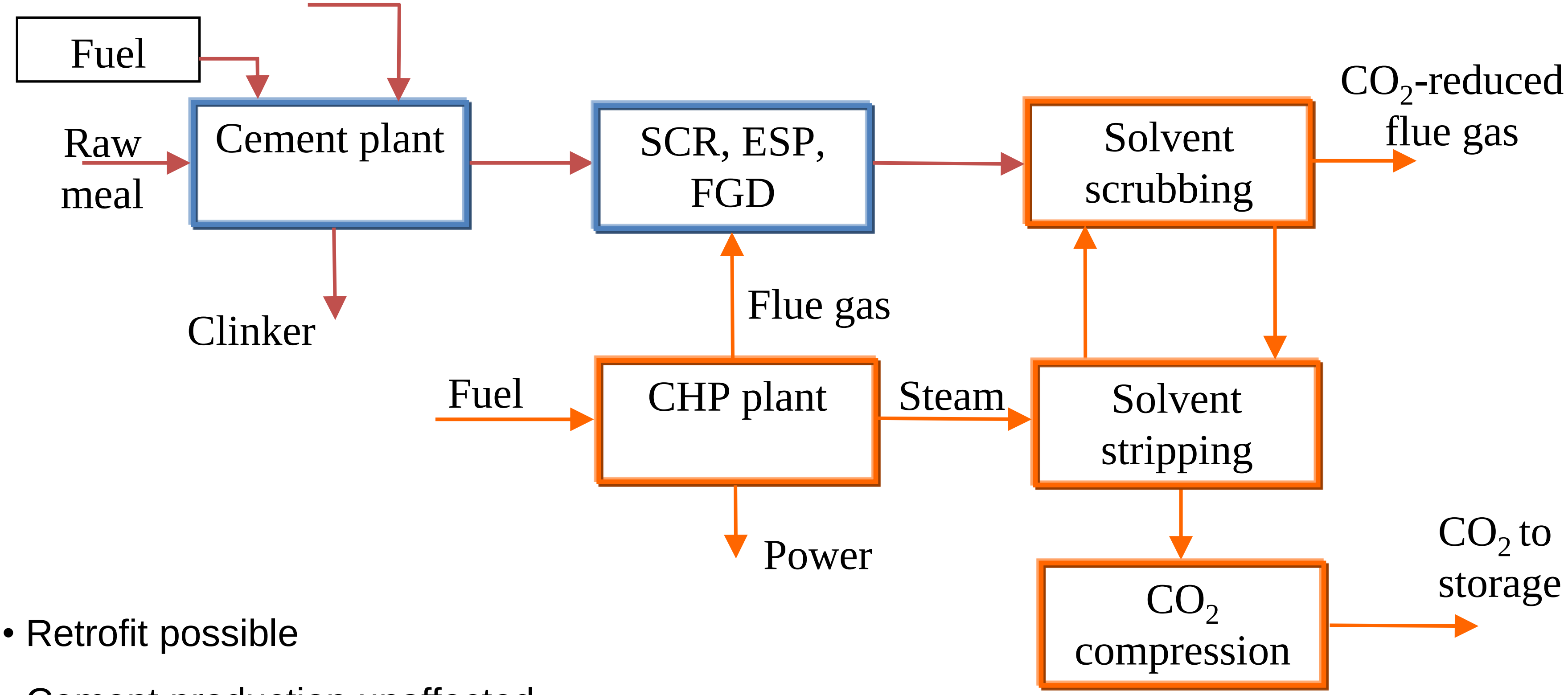
- CO_2 is produced through calcination ‘process CO_2’ (60%) and the heat requirement ‘fuel CO_2‘.

- CO_2 emissions from calcination are largely unavoidable

- Abatement options include:
    - Thermal and electrical efficiency
    - Alternative fuel use
    - Clinker substitution
    - **Carbon capture and storage**

- Both post-combustion technologies and oxyfuel can be considered

Cement – post combustion

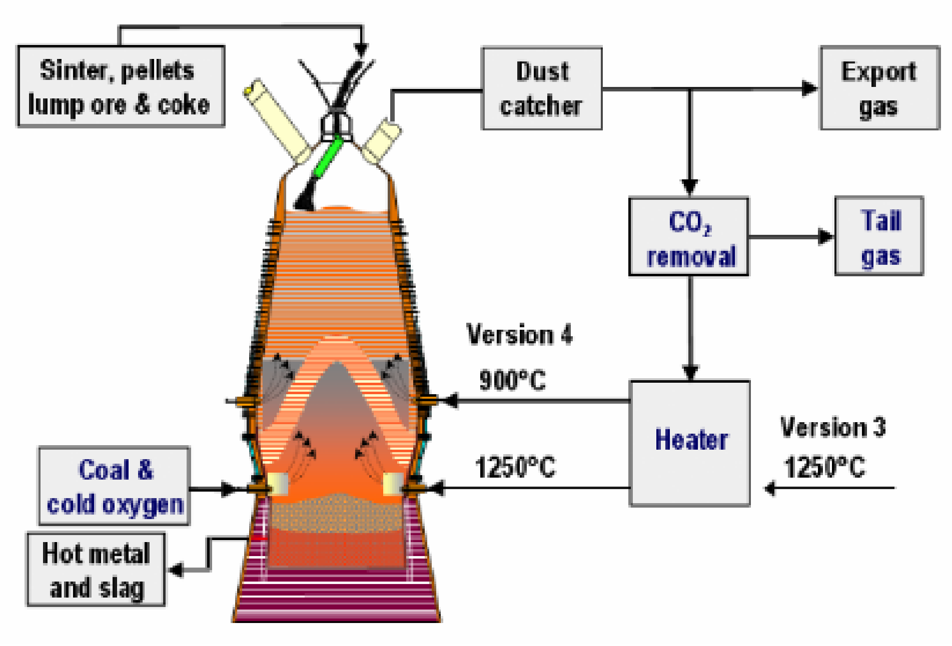


- Retrofit possible
- Cement production unaffected
- Steam needed for solvent regeneration - €50/ ton captured

CO_2 reduction in the iron and steel industry

- 19% of direct emissions from industry
- 70% of global steel production from integrated steel mills
- Between 65% and 75% of CO_2 emission from the burning of coke in the blast furnace – flue gas rich in CO and CO_2
- The use of CO_2 capture is being investigated for a number of steel production process:
  - Top gas recycling in blast furnaces
  - Direct reduced iron
  - HIsarna smelting reduction process

Top gas recycling blast furnace



- Iron ore smelted, use of coke as fuel and reductant – 65-75% emissions from BF
- Useful components – CO+H_2 can be recycled back into the furnace and reused as reducing agents, reduce use of coke.
- Process can be retrofitted
- Successfully tested at LKAB Sweden in 2007 – 2015 commercial?

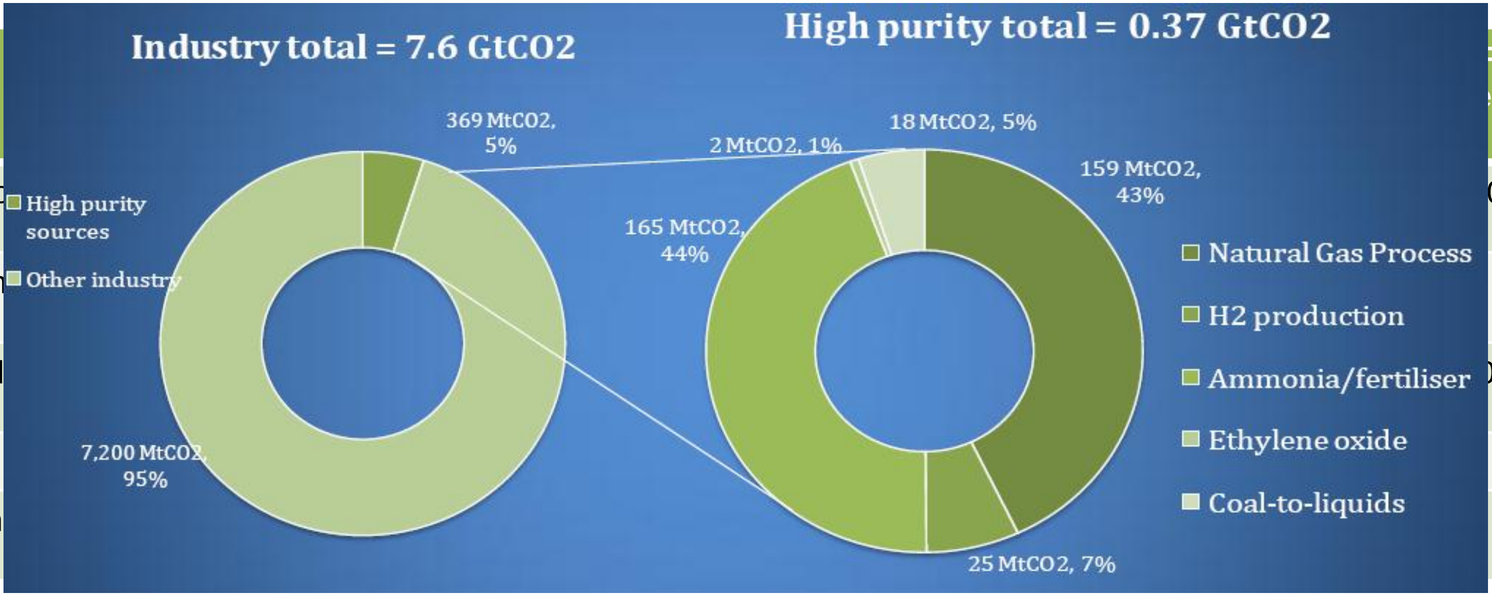
Where to capture CO_2 from refineries?

CO_2 emitter	Description	% of total refinery emissions	Concentration of CO_2 stream
Heaters and boilers	Heat required for the separation of liquid feed and to provide heat of reaction to refinery processes such as reforming and cracking Post/Pre/Oxyfuel?	30-60 %	8-10%
Utilities	CO_2 from the production of electricity and steam at a refinery. Post/Pre/Oxyfuel?	20-50%	4% (CHP Gas turbine)
Fluid catalytic cracker	Process used to upgrade a low hydrogen feed to more valuable products Post combustion of flue gases	20-35%	10-20%
Hydrogen manufacturing	For numerous processes, refineries require hydrogen. Most refineries produce this hydrogen on site. The requirements for Hydrogen increase with demands of stricter fuel quality regulation. Compression / Low cost	5-20%	90-99%

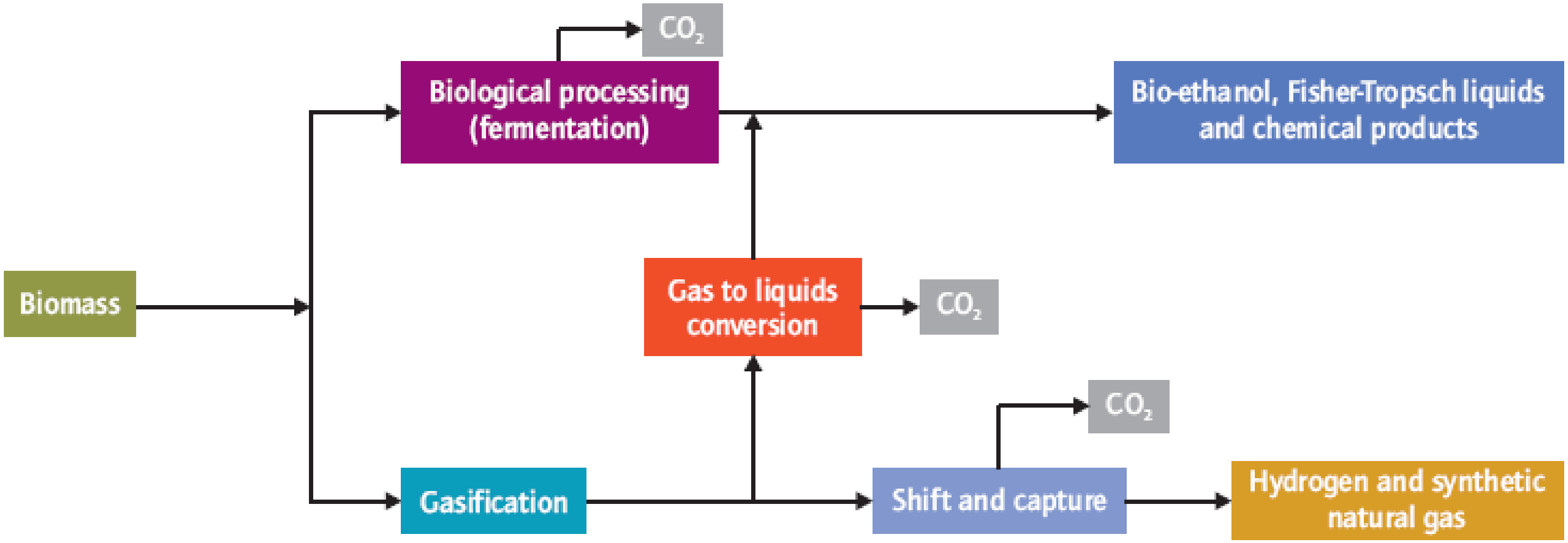
CCS in niche markets

- Carbon capture from dilute gas streams (4-14% CO_2) is the most expensive part of the CCS chain.
- The CO_2 must be concentrated to >95% in order to make transport and storage feasible
- Impurities can also be present which require gas conditioning
- There are a number of industrial process that include high-purity CO_2 offgases: -

Sector	Partial ssure (CO_2)
Gas pro	05-4.4
Ammon	0.5
H_2 prod	.3-0.5
CtL	-
Ethylen	0.2

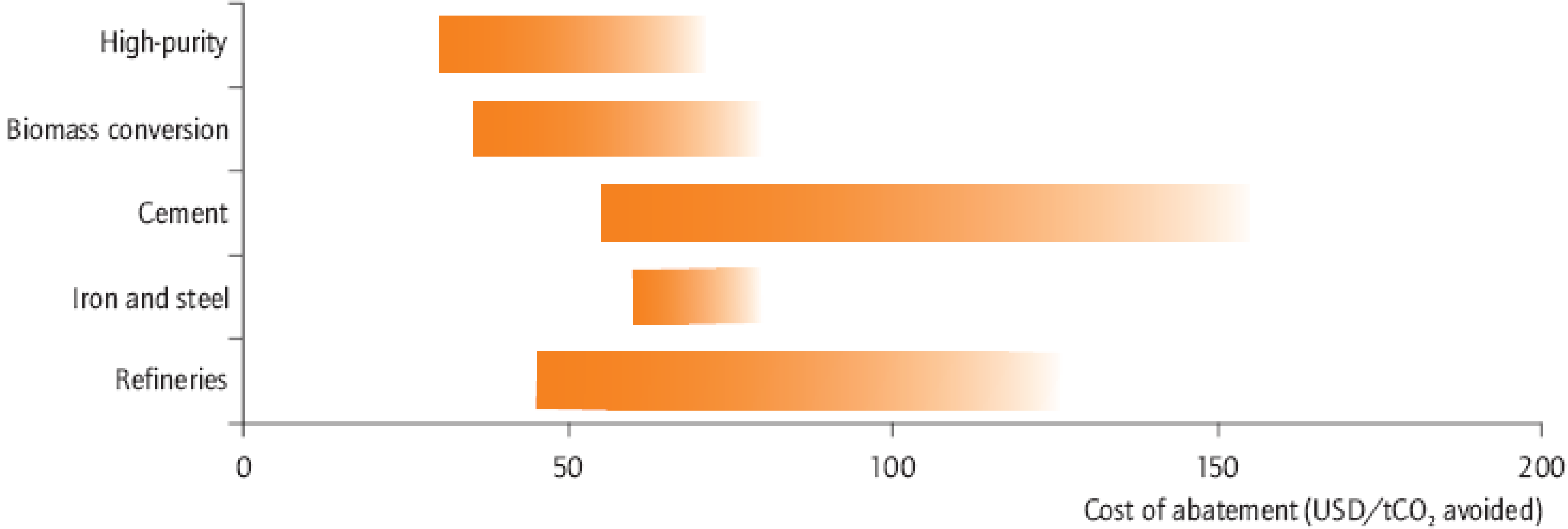


Biomass



- Fermentation of biomass to ethanol – concentrated CO_2 stream
- Biomass with CCS – negative CO_2 emissions!
- Existing biomass industry based on 1st gen unsustainable biomass – 2nd gen in development
- Demand for biomass products needs stimulating (biofuel/BioSG)
- How to credit for negative emissions?

Costs of CCS in industry



Current and potential industrial projects

- GREEN HYDROGEN – Air Liquide, Rotterdam, North Sea. Capture CO_2 from hydrogen production, shipping to mature Danish oil fields and injected for EOR. Applied for NER300 – 2016?

- IN SALAH CCS PROJECT – BP, Sonatrach, Statoil, Algeria. Capture from natural gas processing plant, storage in depleted gas reservoir. 1,2 Mt CO_2 injection per year since 2004

- ARCELORMITTAL & ULCOS – Florange, France. Post-combustion capture from blast furnace, storage in onshore saline aquifer. Applied for NER300 funding – 2015?

- EMIRATES STEEL INDUSTRIES – Abu Dhabi, UAE. Capture from steel production plant, 0.8 $MTCO_2$ per year for use in EOR. Expected operation date 2015

Key messages

- There is significant potential for CCS to reduce emissions from industry
- In some cases, CCS may be the only option decarbonize certain industrial processes
- The majority of research has focused on applying CCS to power generation, however fundamental processes are similar
- Current demonstration initiatives are industry led, knowledge (cost) sharing issues.
- High-purity ‘niche sectors’ combined with CO_2 utilization could provide the first true business cases for CCS

Thankyou

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