

Carbon Capture & Storage

A sustainable business case?

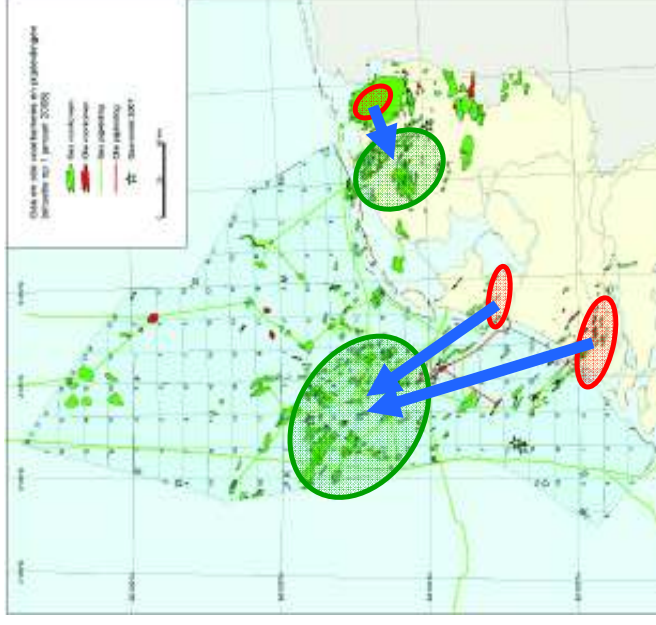
Seminar NVBK en DACE

Kosten en Waarde van
Duurzaamheid

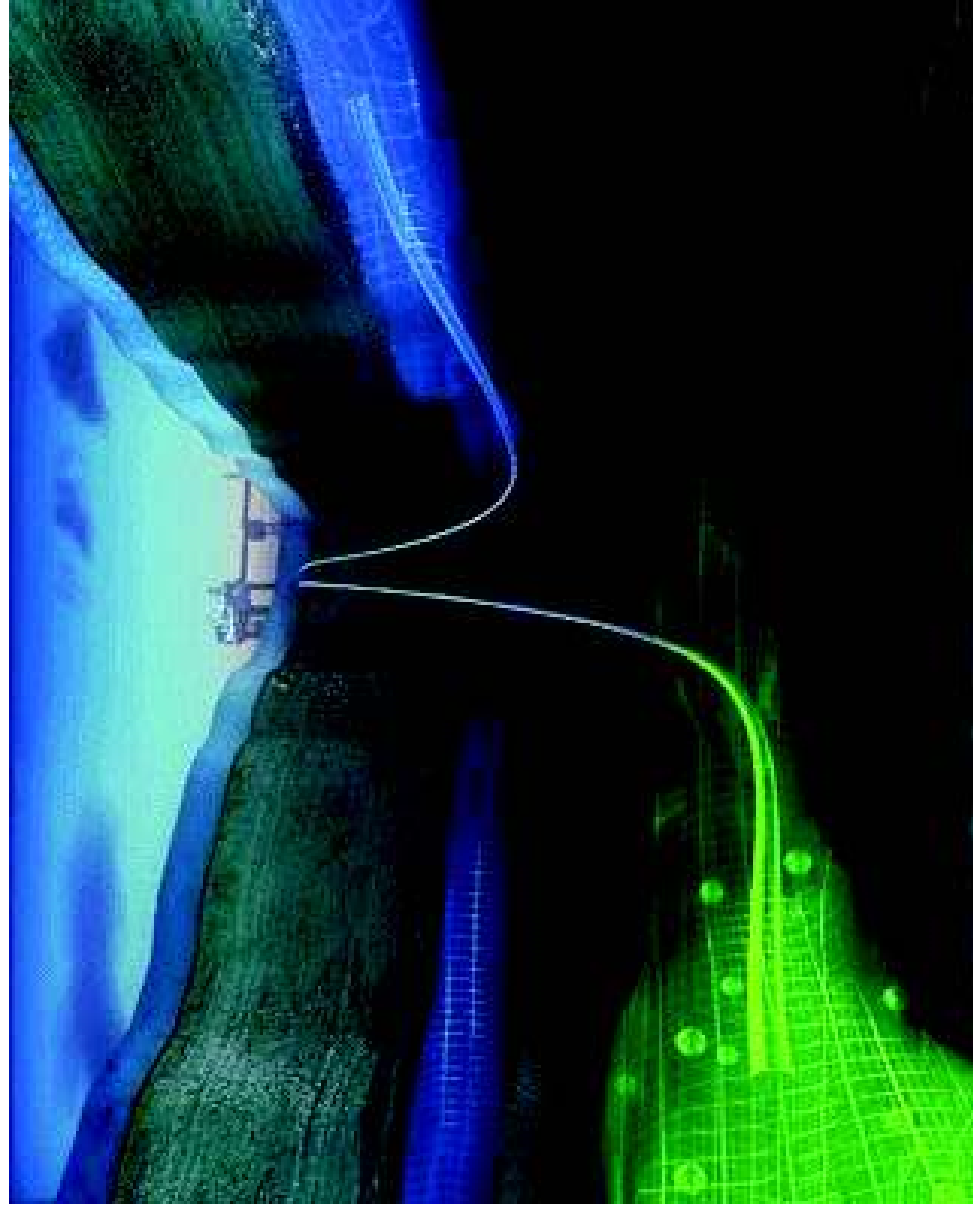


Baarn 17 September 2009

Carel Cronenberg



1. Wat is CCS?



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CCS – Carbon Capture and Storage



- CCS
 - Afvangst van CO₂ aan de bron
 - Transport
 - Opslag in de diepe ondergrond
- Overbrugging van periode tot duurzame energiehuishouding

International Panel on Climate Change (IPCC):

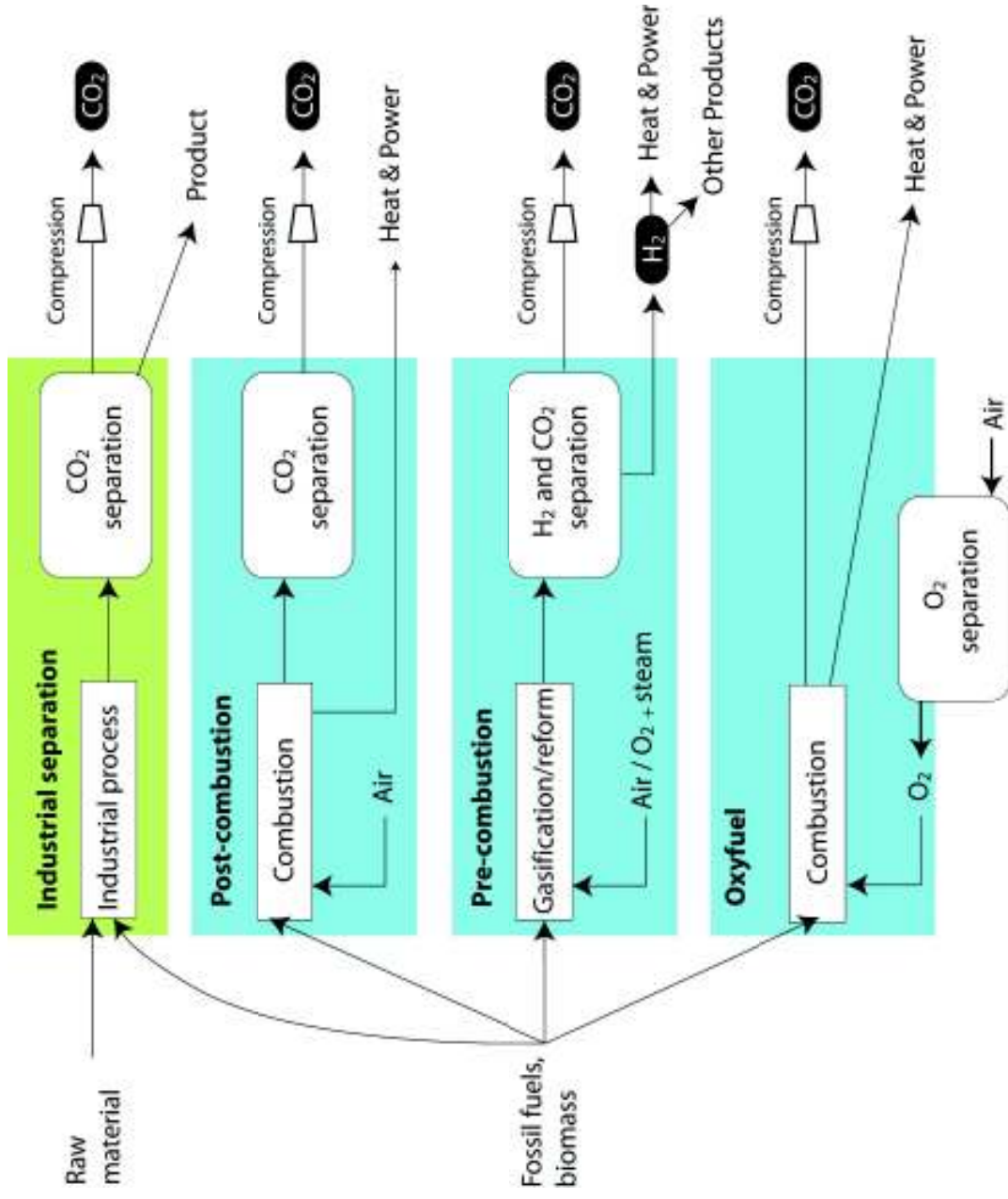
- “It is likely that the technical potential for geological storage is sufficient to **cover the high end** of the economic potential range, but for specific regions, this may not be true.”
 - “*Likely*” is a probability between 66 and 90%.

Afvangst en transport van CO₂



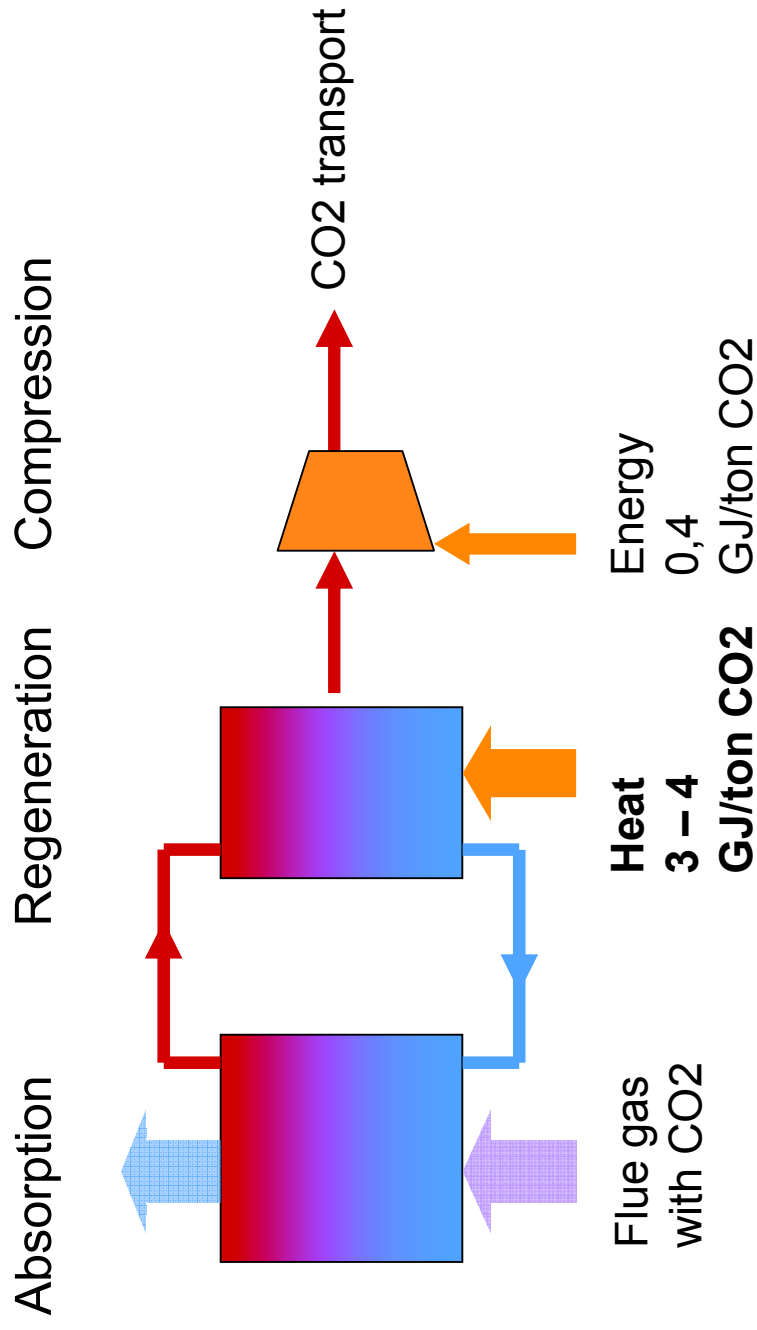
- Geschikte CO₂ bronnen voor CCS
 - Grote puntbronnen met hoge CO₂ concentraties
 - Nabij geschikte opslaglocaties
 - Bijv. E-centrales, raffinaderijen, zware chemie en metaal
- CO₂ afscheiding bij stookinstallaties
 - Post-combustion, pre-combustion en oxy-fuel
 - 80 – 90 % afvangstefficiency
- Transport
 - Pijpleiding / schip
 - Vloeibaar of gasvormig
 - Compressie aan de bron en/of op de opslaglocatie

Afvangen van CO₂





Post combustion CO2 capture



Time line



2005 -	2010 -	2015 -	2020 -
onderzoek	pilot	demo	Marktgedreven
Opslag demo's R&D Wet en regelgeving Financieringsmodellen	Pilots voor Optimalisering afvang Business case	Full scale demos gehele CCS keten Optimalisatie studies	CCS is een concurrerende techniek voor CO2 reductie CO2 transport netwerken

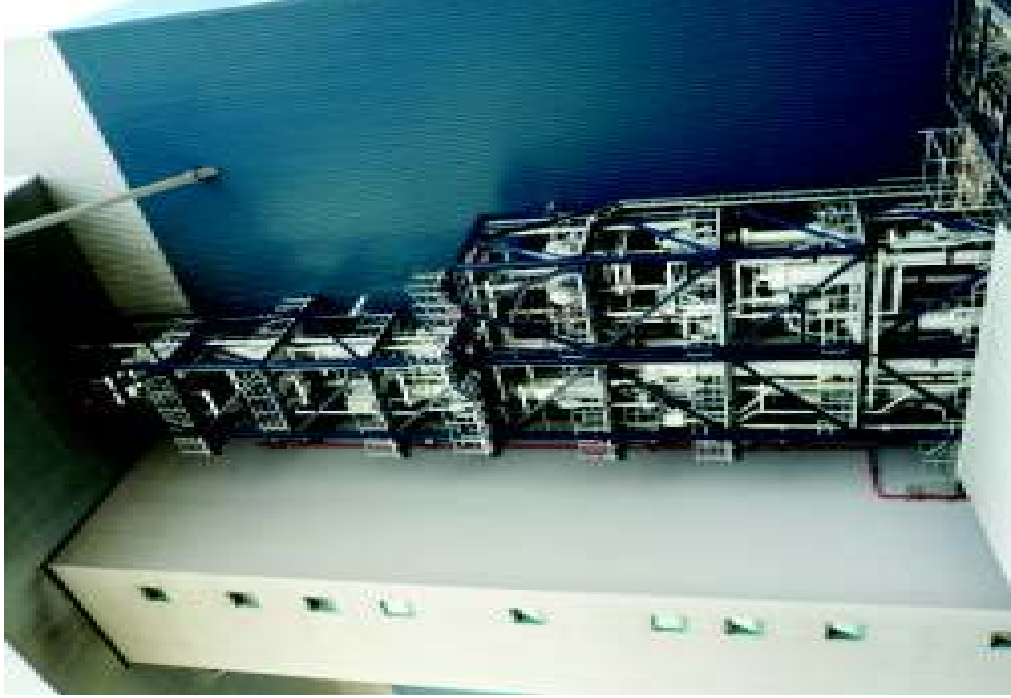
IGCC-CCS

- the capture technology ready for large-scale demonstration
- as a consequence also CO₂ storage demonstration is possible, i. e. the whole process chain can be demonstrated

CO₂ scrubbing (post combustion CCS)

- Technology not optimized for full scale
- Pilot testing needed to optimise absorption technology to lower energy demand
- Note this technology is the only capture technology for retrofit of the many conventional new-built power plants

CCS Pilot plant



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Foto's RWE, 2009

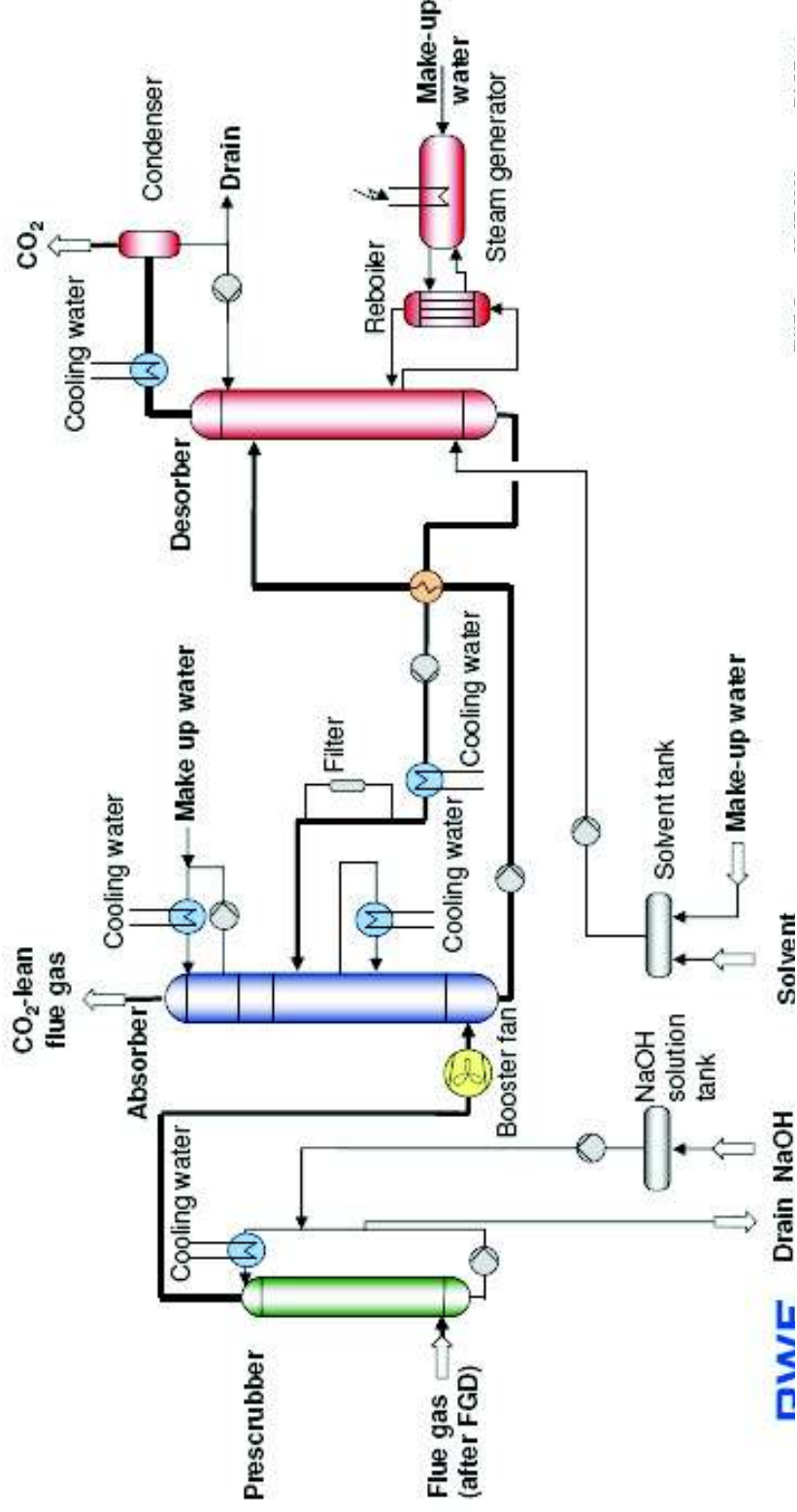
Pilot Plant Niederaussem - Basic Process



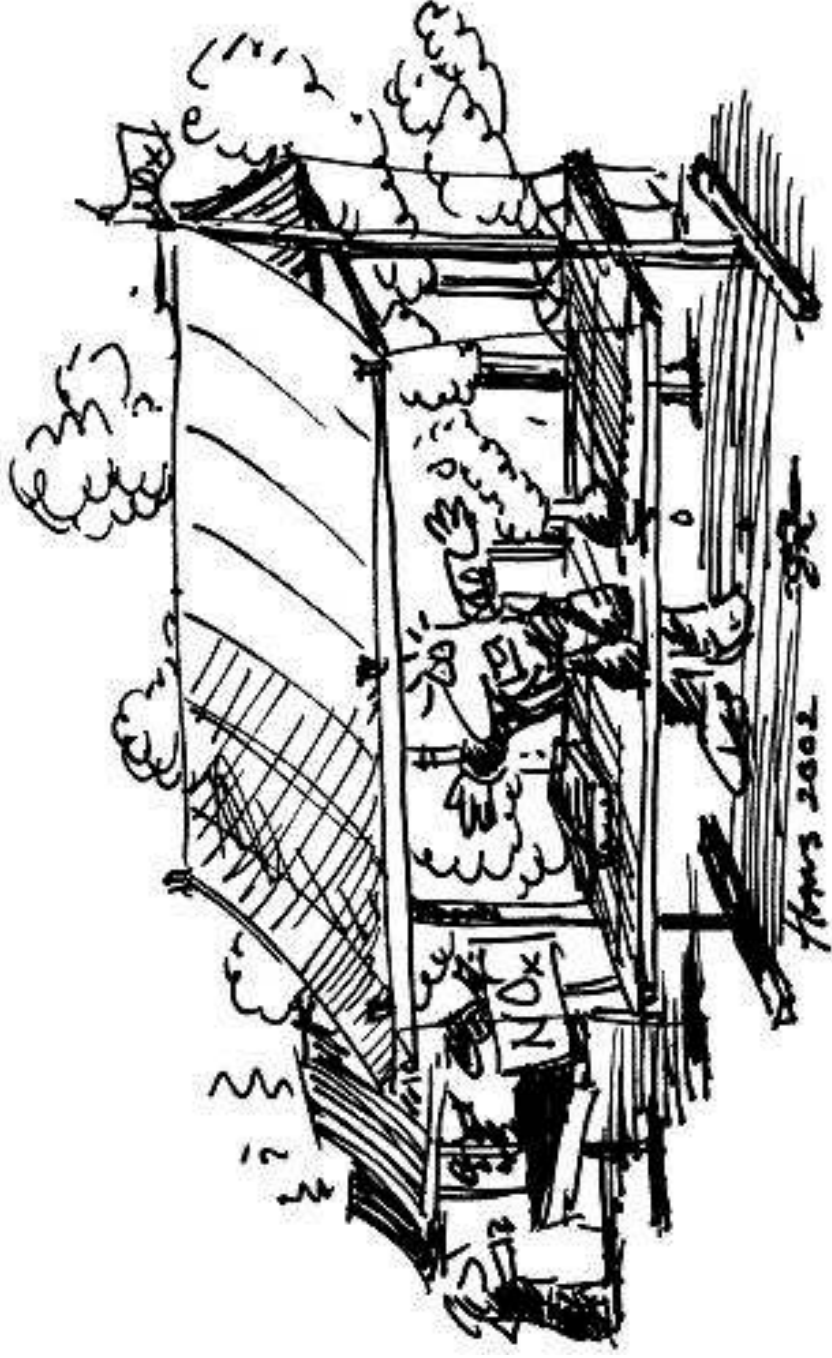
Flue gas cooling,
SO₂-pre scrubbing

CO₂-capture

Solvent regeneration



2. Wat kost CCS?



Kosten CCS



- Kostenfactoren
 - Kapitaalslasten van investeringen
 - Operationele kosten (energie en hulpstoffen)
 - Globaal 20 - 30% hogere kosten per kWh
 - 80% afvangst / 10 % transport / 10% geologische opslag

Stand der techniek 2007



Solvent: Monoethanolamine (MEA)

1100 MW coal power plant

- Flue gas flow 3 Mio. Nm³/h
- CO₂ emission 800 t/h
- Initial fill MEA 1800 t
- Refill MEA 1.3 t/h (2.4 t/h @ 200 mg/Nm³ SO₂)

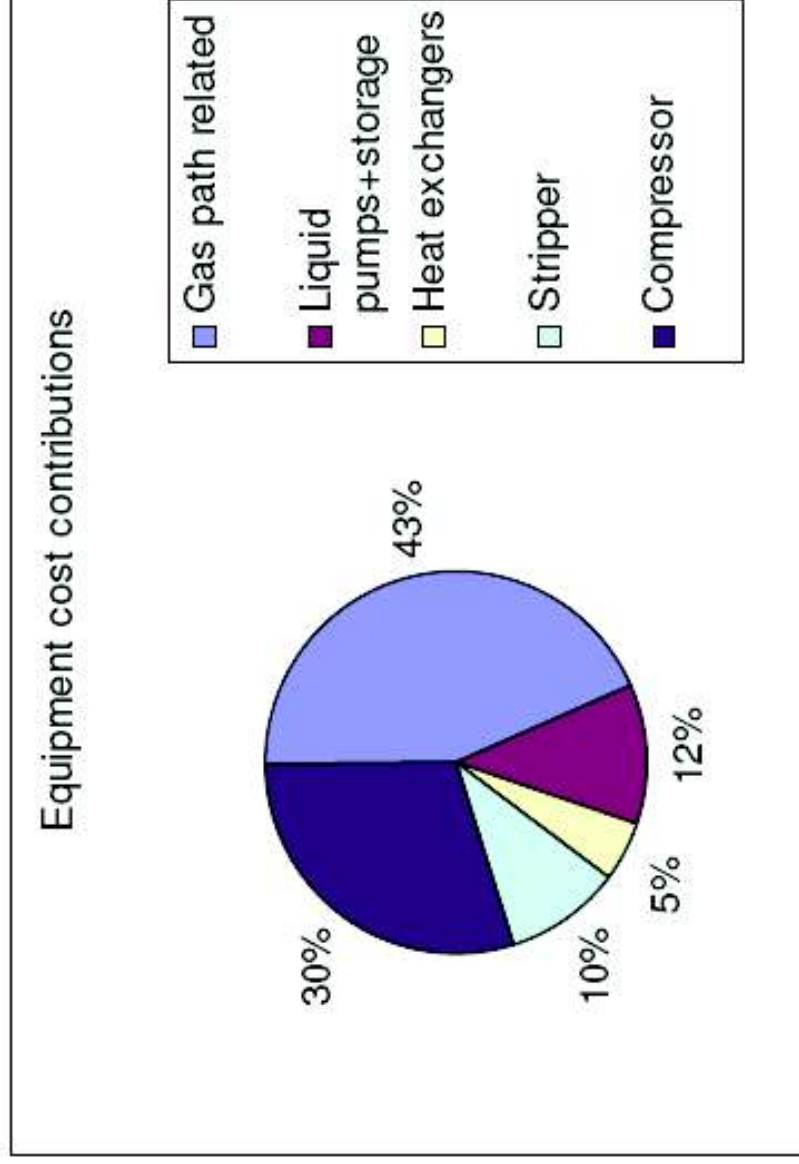
Efficiency losses 12-14 Percentage points

Cooling tower 1/3 bigger

Absorber diam 32 m (!)

Investment costs 300 - 600 Mio. €

Investeringen CO2 Capture



Abu-Zahra et. al. 2007



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Costs of CCS



Capture

Typical cost data (example)	Existing		New with CO2 capture	
Heat input	MW th	1350	1460	
Electr output	MW e	580	490	
Efficiency	%	43,0	33,6	
Investment costs	MEuro/MW	1,25	2	
CO2 emission	kg/MWh	760	40	
Cost of electricity	Euro/MWh	50	75	
Cost of CO2 avoided	Eur/ton	0	34,7	

Note these numbers are based on literature averages and used for illustration only

Development in costs



	Current costs contribution	Cost contribution by advanced process	Effected by
Investment costs			
Absorber	25 %	10 – 15 %	Compact contactor Simplified cost-optimised contactors Membrane contactors
Rest of equipment (desorber, heat exchangers)	25 %	10 – 15 %	Halving of solvent flow rate Optimised operational conditions for advanced solvents
<i>Total investment</i>	50 %	20 – 30 %	
Operational costs			
Thermal energy	25 %	10 – 15 %	Halving of energy consumption through use of advanced solvents (novel chemicals, additives with low vaporisation enthalpy) Integration of heat exchanger in desorber
Rest (cooling, electricity, chemicals)	25 %	10 – 15 %	Halving of solvent flow rate Optimised operational conditions for advanced process technologies and solvents Solvent stability improvements
<i>Total operation</i>	50 %	20 – 30 %	
Total costs	100 %	40 – 60 %	

Financiering van CCS

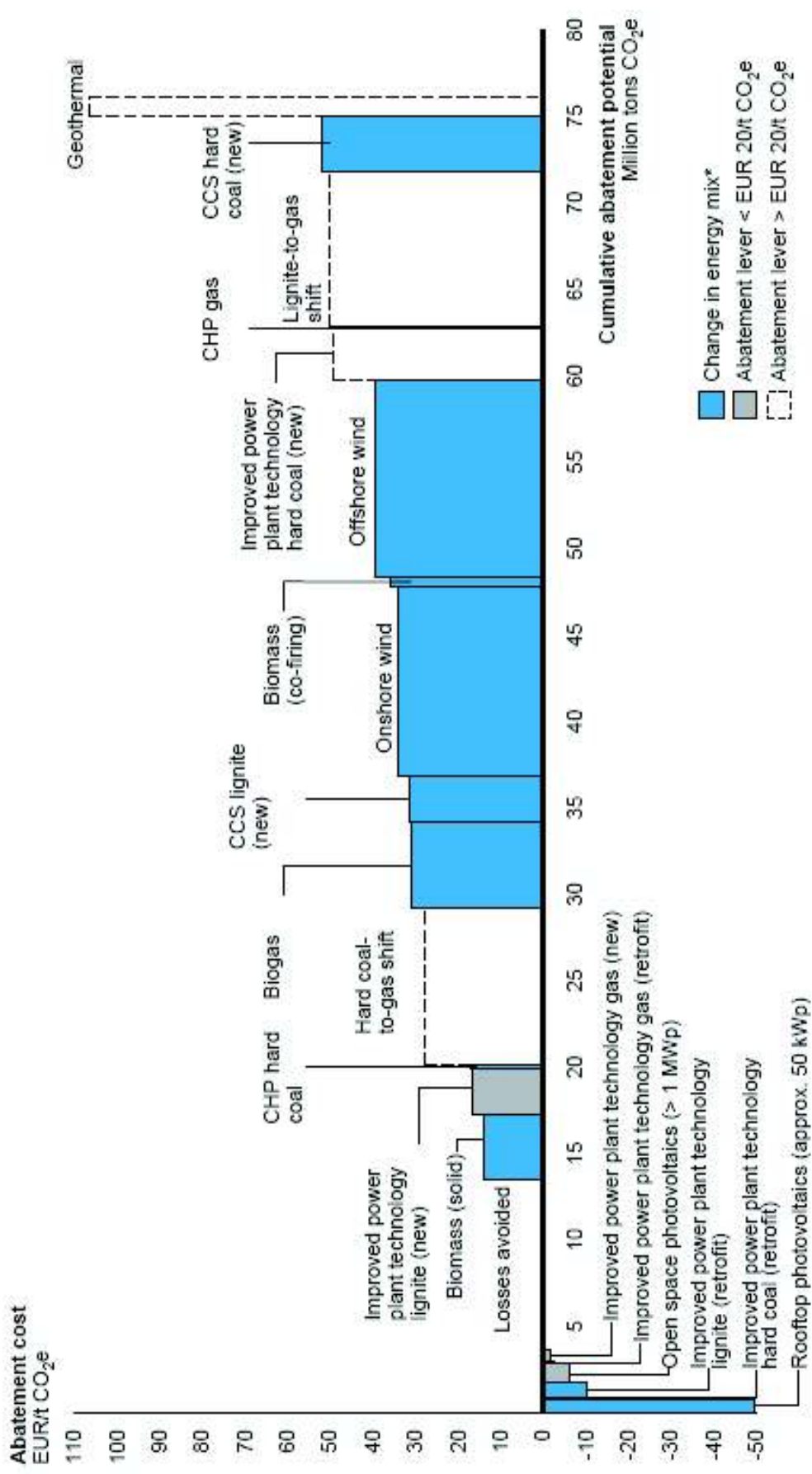


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Energy sector: Abatement cost curve in Germany, 2020*

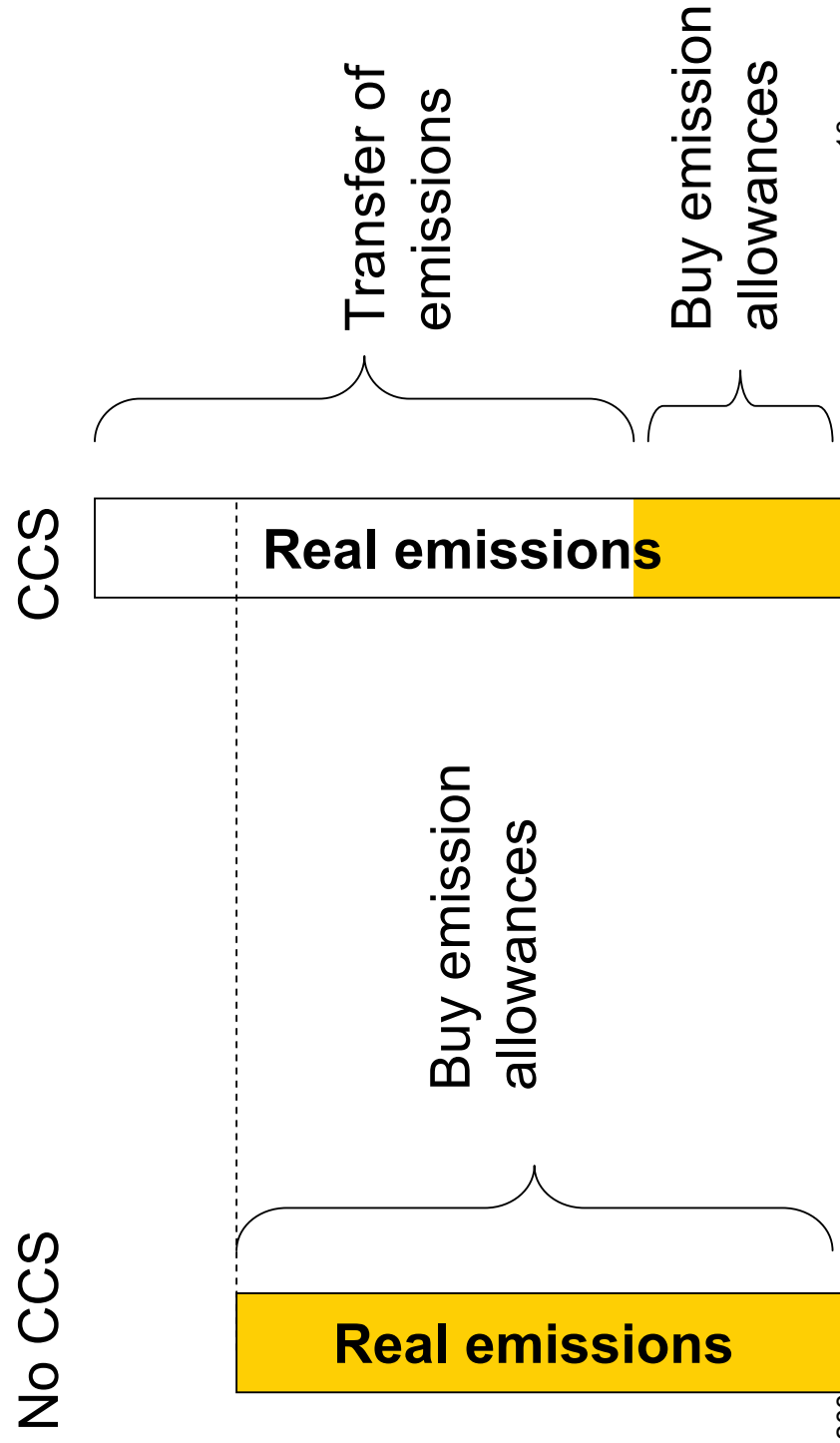
DECISION MAKER PERSPECTIVE
BASIC SCENARIO, 2020



* Maintaining exit from nuclear power and considering promotion for renewable energies (EEG)

Source: Report "Kosten und Potenziale der Vermeidung von Treibhausgasemissionen in Deutschland" by McKinsey & Company, Inc. on behalf of "BDI initiativ – Wirtschaft für Klimaschutz"

CCS and ETS



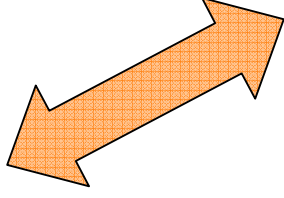
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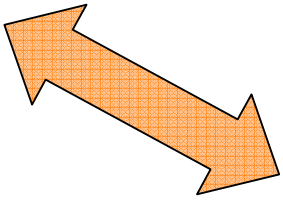
CCS business case



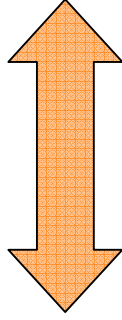
Costs of CCS



E-production costs



Cost of CO2



Cost of coal

Bekostiging CCS



- Bekostiging
 - Hogere prijzen elektriciteit en producten
 - Verrekening met emissierechten (creditering vermeden emissies)
 - Extra opbrengsten olie en gaswinning (EOR / EGR)
 - Prijsvoordeel voor schonere brandstoffen
 - Subsidies, Flagship programma

Kansen voor CCS in NL?

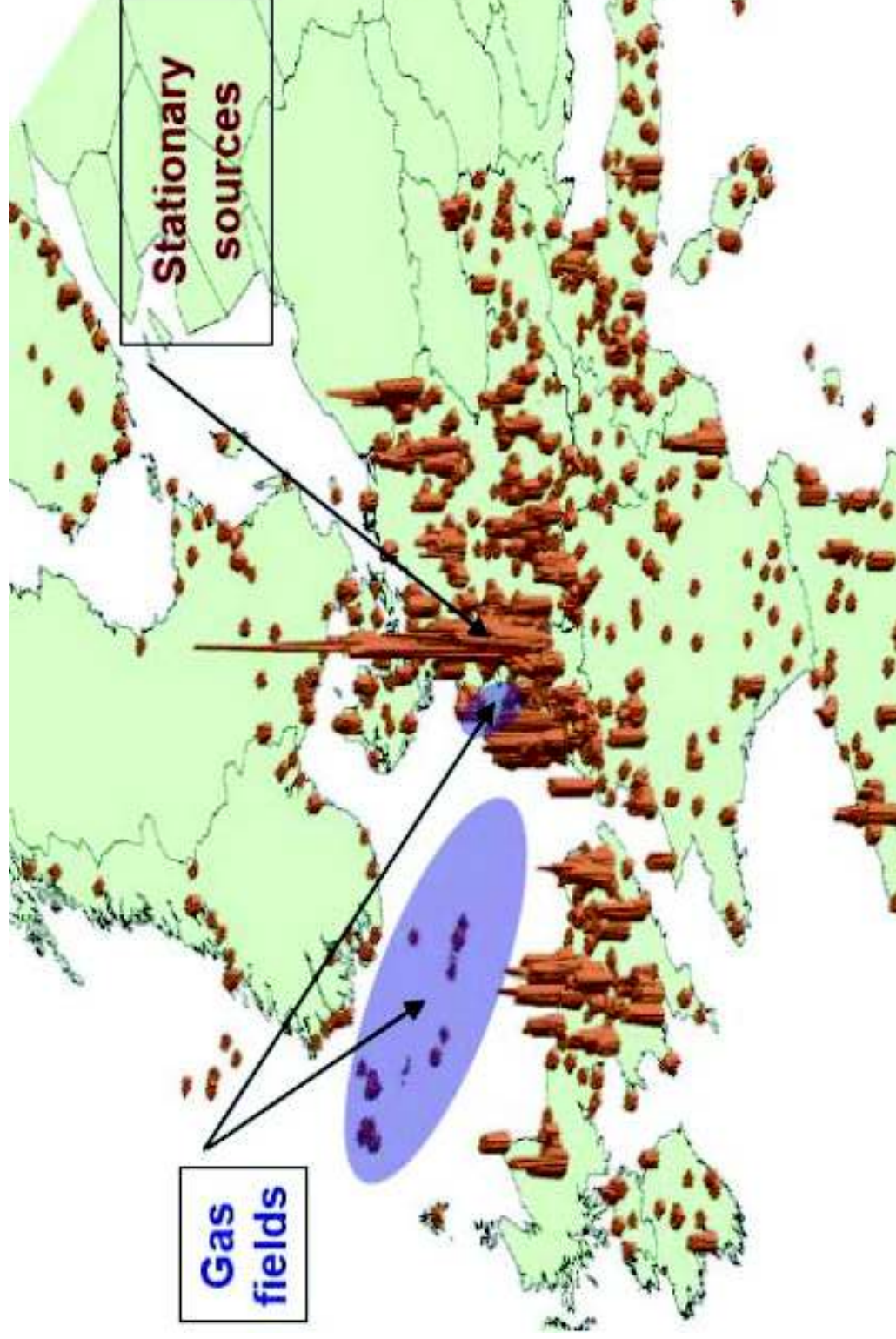


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Energy park Eemshaven

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NL is logische plek voor CCS

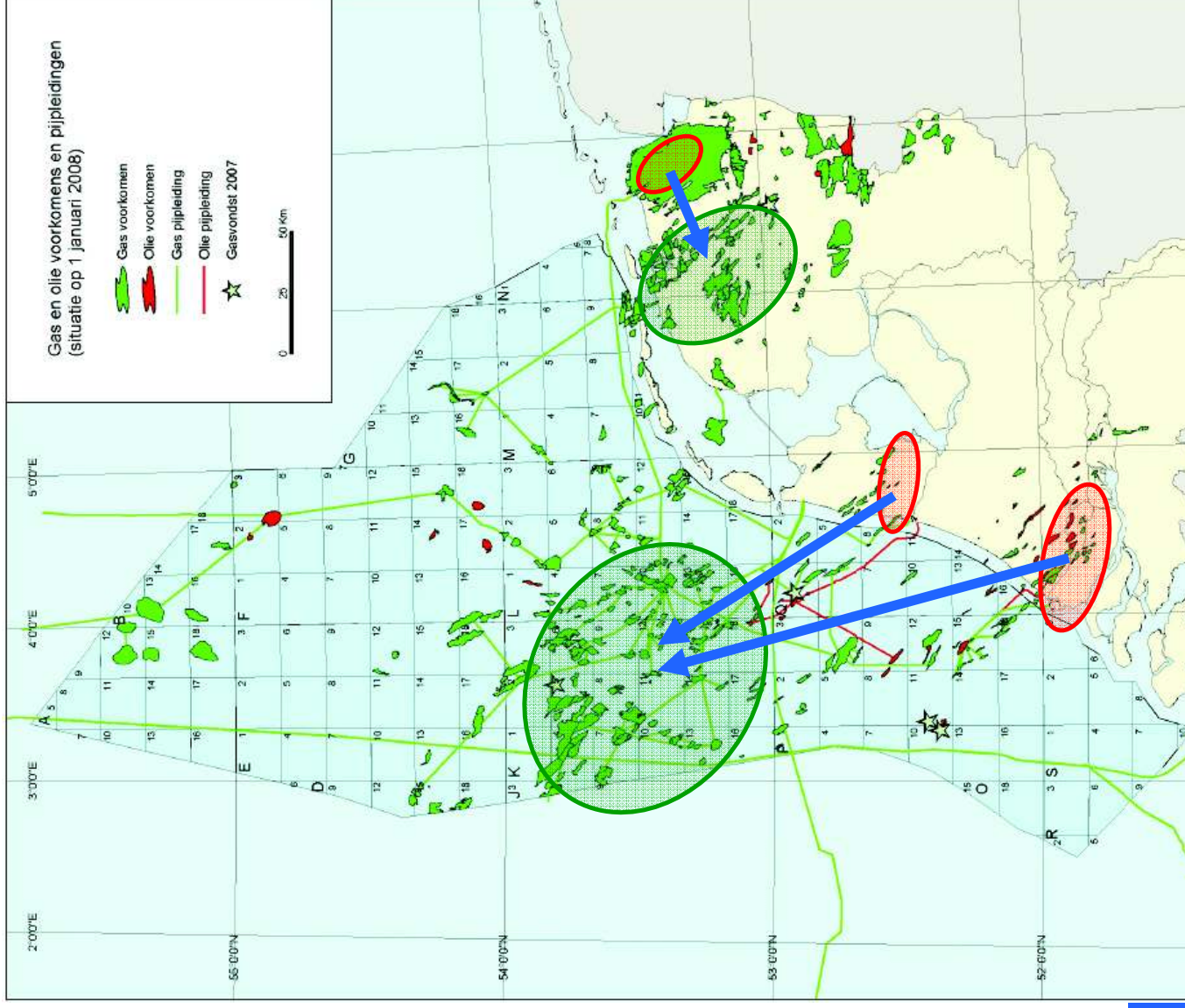


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Clustering

- Matchen
- Bronnen (centrales en industrie)
- Opslagen (lege gasvelden)
- Bestaande mijnbouwinstallaties en leidingen



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Potentieel opslag in Nederland



Lege gasvelden Groningen: > 2040 7 350 Mton Onshore: > 2020 1 600 Mton Offshore: > 2020 1 150 Mton	Overig Lege olievelden: 40 Mton Steenkoollagen: 400 Mton Aquifers: 715 Mton
Totaal kleine velden: 2 750 Mton Totaal: 10 000 Mton	Totaal overig: 1 150 Mton
Bronnen 5 nieuwe kolencentrales 2010 - 2015 (capture ready): 25 Mton CO ₂ per jaar 5 Mton CO ₂ per jaar per centrale	
Allocatie emissiehandel industriële bronnen: 100 Mton CO ₂ per jaar	
Capaciteit opvang <u>totaal theoretisch</u> Kleine velden: 100 jaar voor 5 kolencentrales / 25 jaar voor allocatie industrie Groningen: 400 jaar voor 5 kolencentrales / 100 jaar voor allocatie industrie	

Backcasting:

wat wordt de komende jaren duidelijk?



Ontwikkelingen
Barendrecht →
Kansen on-
shore? Publieke
acceptatie.

Aanname en implementatie
CCS-Directive
→ overdracht opslag locatie
aan de staat, voorwaarden
→ monitoring

Technische doorbraak
afvang technologie
→ CCS als BAT

Internationale
CO2 transport
netwerken
CO2 shipping

CCS binnen ETS
→ CO2 prijs
→ Egalisatiefonds
→ Lange termijn financiering

DHV en CCS (2007-2009)



CCS potential studies: (1) the reservoirs and their storage capacity, infectivity, and possible showstoppers. (2) The reuse of existing facilities and infrastructure for gas production. The project resulted in detailed insight in the possibilities to use offshore reservoirs for the storage of CO2 (3) possible phasing of the development of a CO2 storage infrastructure in the North Sea.

CCS feasibility and cost assessments: Feasibility study into the design and costs of an CO2 transport and storage infrastructure in the North sea.

CCS business case North Netherlands Detailed business case for large scale CO2 capture and underground storage (CCS) in depleted gas reservoirs in Groningen en Drenthe was developed

CCS policy development: Supporting the Dutch Ministry of Environment on a strategic level on CCS, directed at the monitoring and reporting of the captured and stored CO2

CCS and third party CO2 users: DHV mediates between all stakeholders involved in the Rotterdam CO2 system concerning on transfer of CO2, between participants in the European emission trading systems and third parties that are not part of this system.

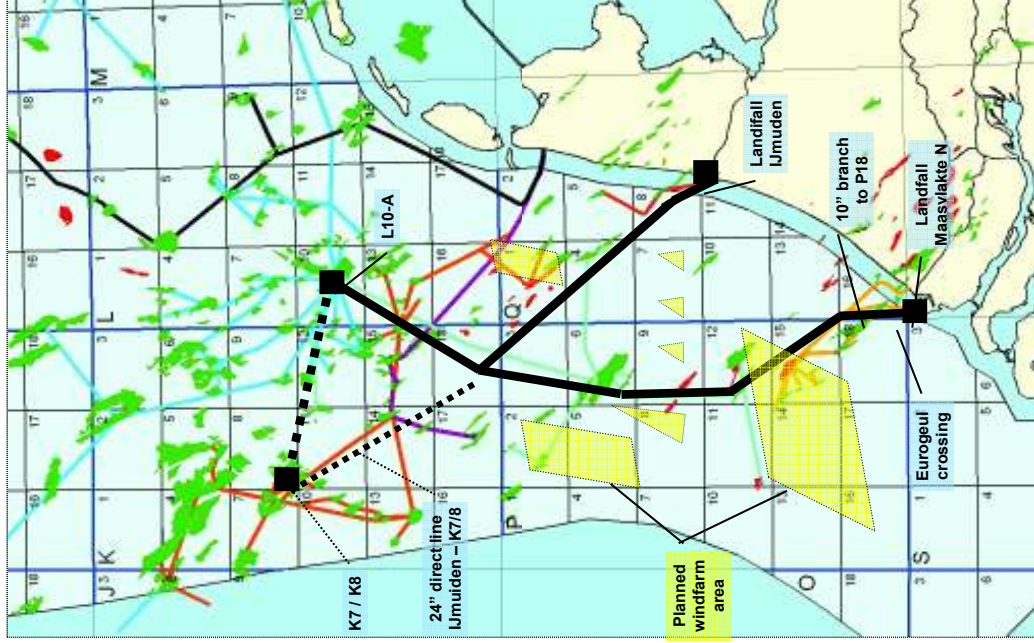
CCS and HSE support: HSE and compliance support in the further development of a CCs infrastructure in the Rotterdam area.



Environment and Sustainability
Safety and Environment - Industry

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