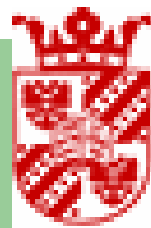


Carbon Capture and Storage



rijksuniversiteit
groningen

energy delta research centre

Catrinus J. Jepma

Scientific Director EDReC

Position of CCS

- o Given the goal of the NL Govt. (-30% GHG in 2020) CCS will be necessary as a 3rd option besides energy efficiency and renewables (excl. nuclear)
- o Certain elements of CCS tech./processes need improvement or are not (yet) considered proven technology (e.g. IGCC and certain cap. techs) or safe and reliable practice (i.e. geological- and other forms of storage)
- o Economics of CCS still unclear



CCS options

Capture

- Pre-combustion
- Post-combustion
- Oxyfuel combustion
- Industrial processes

Transport

- Pipeline
- Ship

Storage

- Geological
- Ocean
- Mineral carbonation
- Industrial uses

- o Capture; various types of membranes, chemical absorption/looping and other separation techs.
- o Transport; pipeline and ship, but also rail and truck can be considered in specific cases.
- o Geological storage; empty hydrocarbon reservoirs, EOR, EGR or ECBM, aquifers or other geological cavities such as salt domes and rock formations.

10-12 EU large pilots need to differ!



Sources and Sinks



Source: IEA-GHG: Building the Cost Curve for CO₂-storage: European sector, London, 2005

Country	Oil fields (10 ⁶ t CO ₂)	Gas fields (10 ⁶ t CO ₂)	Total capacity (10 ⁶ t CO ₂)	Annual point source (10 ⁶ t CO ₂)	Number of years storage capacity (yr)
Denmark	176	452	628	29	17
Germany	103	2.227	2.330	393	5
Netherlands	54	10.907	10.961	96	88
Norway	3.453	9.156	12.609	23	422
UK	3.005	7.451	10.456	218	37
<i>Totals</i>	6.791	30.193	36.984	218	

Source: Gestco-project, summary report november 2004.

(Note excl. Aquifers → Utsira formation; Sleipner)



Different scenario's @ different levels

- Geological storage mainly in NW-Europe, but:
- o Onshore or offshore (NIMBY and/or maritime issues)?
 - o Domestic and/or cross-border infrastructure?
 - o Pipeline and/or CO₂/LNG shipping?
 - o Regional, National, European or Global coordination for specific CCS issues?
 - o Energy Valley, Rijnmond, Werkgroep Schoon Fossiel, ETP-ZEP, OSPAR/LC, IEA-GHG R&D, Carbon Sequestration Leadership Forum, etc.



Overview of CCS projects

Statoil Sleipner

GPSP-Weyburn

GdF K12B

BP in Salah

E.ON CATO

Statoil Snohvit

CASTOR

Vattenfall Schwarze Pumpe

ENCAP

CACHET

CO2 SINK

CO2 Remove

CO2 Geonet

DYNAMIS

ENEL pilot Brindisi

Hazelwood Int. Power

Total Lacq

Naturkraft Karsto

Statoil Mongstad (ph 1)

BP-Miller

Saskpower (Airliq/B&W Canada)

E.ON IGCC

Statoil/Shell Halten CO2

BP-Carson

Hypogen

Nuon Magnum (phased build)

Statoil Mongstad (ph 2)

RWE ZEIGCC

Vattenfall Oxyfuel

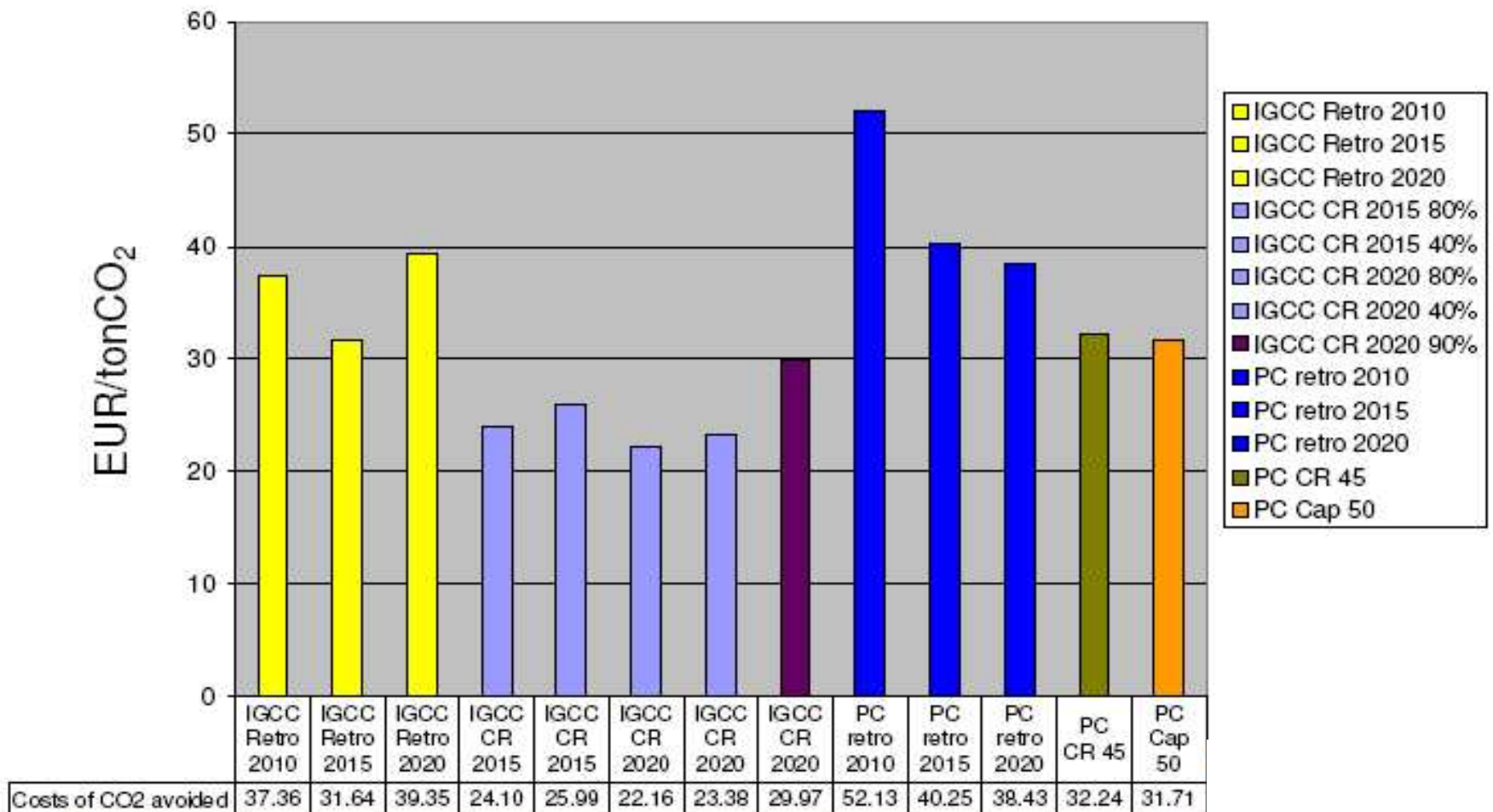
Timeframe 1996-2017

***From R&D, Planned and Operational,
on/offshore storage and for various
fuel types***

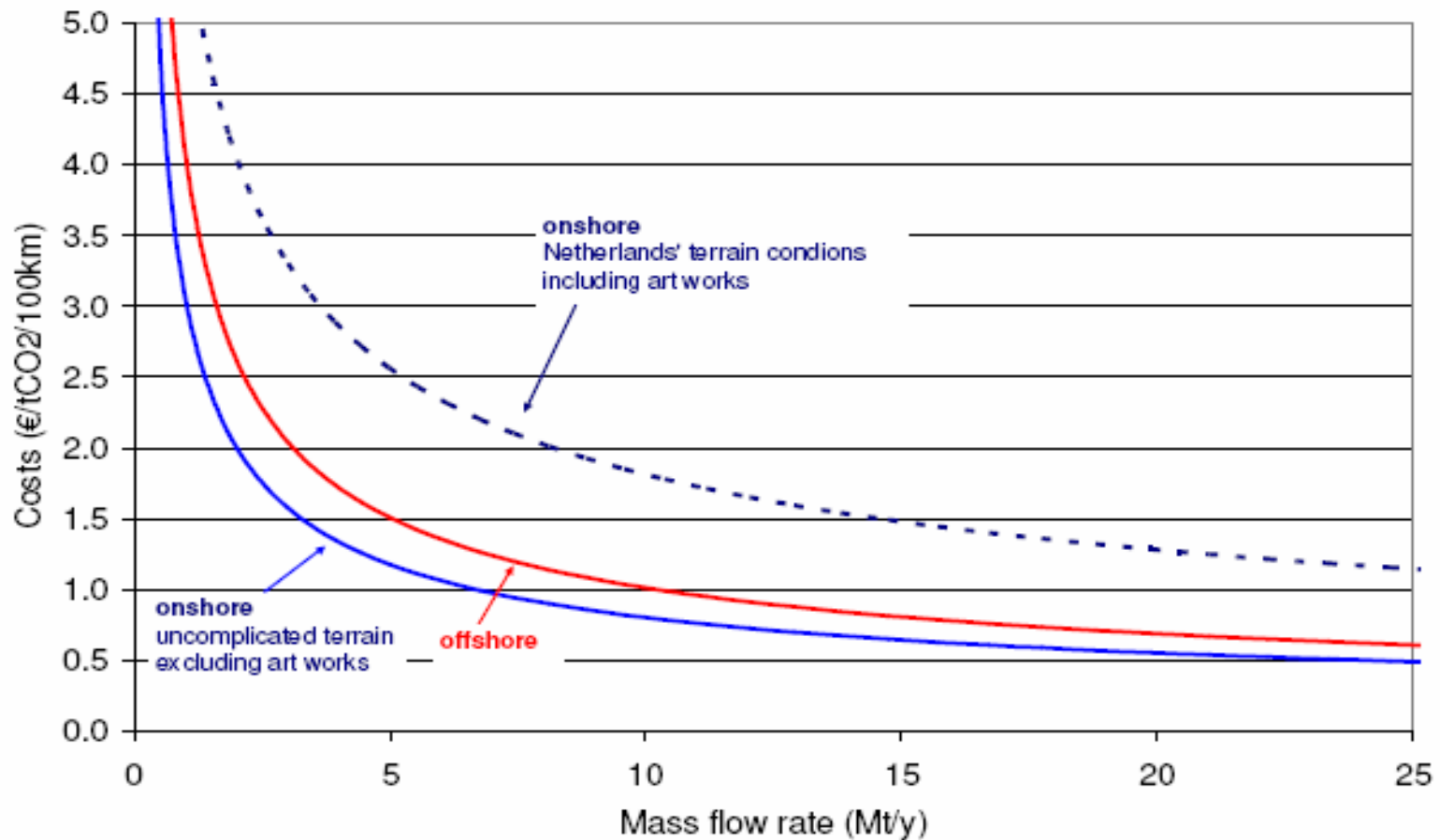
*Source: "Making large-scale carbon capture
and storage CCS work in the Netherlands",
Report a.o. commissioned by EnergieNed 2007.*



Costs of CO₂ avoided (Kema, 2006)



Costs of CO₂-pipeline transport



Source: Ecofys, 2006

Some CCS aspects

- o Permanence of storage (geological)
 - o Aquifers (open/closed formations)
 - o Empty gas field or producing gas field
 - o Permitted leakage from reservoir
 - o Temporary storage in biomass
 - o Permanent fixation by mineral carbonation
- o Incentives
 - o Crediting; EU-ETS/CDM and CCS (*may CCS installation receive additional allowances?*)
 - o Taxes and subsidy schemes
 - o Non-tariff measures (Environmental Impact Assessment and streamlining of other procedures)
 - o R&D funding/schemes)



Some CCS aspects

- o National/EU priorities/policies
 - o Competition policy in new CCS market (CCS as flagship projects to facilitate project finance)
 - o Market design (TSO similar to natural gas market?)
 - o CCS area of potential competitive advantage
 - o Capture ready (definition and legal consequences)
 - o Capture obligation and consequences in a free market
- o Technology development and innovations
 - o CO₂ shipping commercially viable
 - o Mineral fixation and/or industrial use of CO₂ competitive



Some CCS aspects

- o Rules, regulation and procedures
 - o Maritime treaties,
 - o Ownership, responsibility and liability issues related to CCS
 - o Long term liability and transfer of liability and ownership,
 - o HSE practices and standardisation for transport/storage of CO₂ and tech. and quality specs,
 - o Site operation, maintenance and abandonment procedures,
 - o Monitoring/reporting requirements

