CCS Research in the Netherlands

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Outline

- Relevance of CCS for the Netherlands
- Current state of CCS R&D
- TEOTWAWKI
- Future Options for CCS

Key Indicators

- Availability (clustered) large CO2 point sources (> 60%)
- Large storage capacity (1500 Mt in gas fields, excl. Slochteren and aquifers)
- Relatively short transport distances
- Extensive knowledge of gas and CCS (technology, infrastructure etc.)
- Long academic tradition (research since 1990; > 25 master programs that include CCS)
- Serious business interests and commitment of relevant parties

CCS Implementation Plan (2009)

- Phase 1 (done): Research and small experiments (CATO)
- Phase 2 (on-going): Additional Research (CATO-2) and small demonstrations
- Phase 3 (planned): Large demonstrations (2015-2020)
- Phase 4 (anticipated): Commercial deployment (2020 -)

Timeline

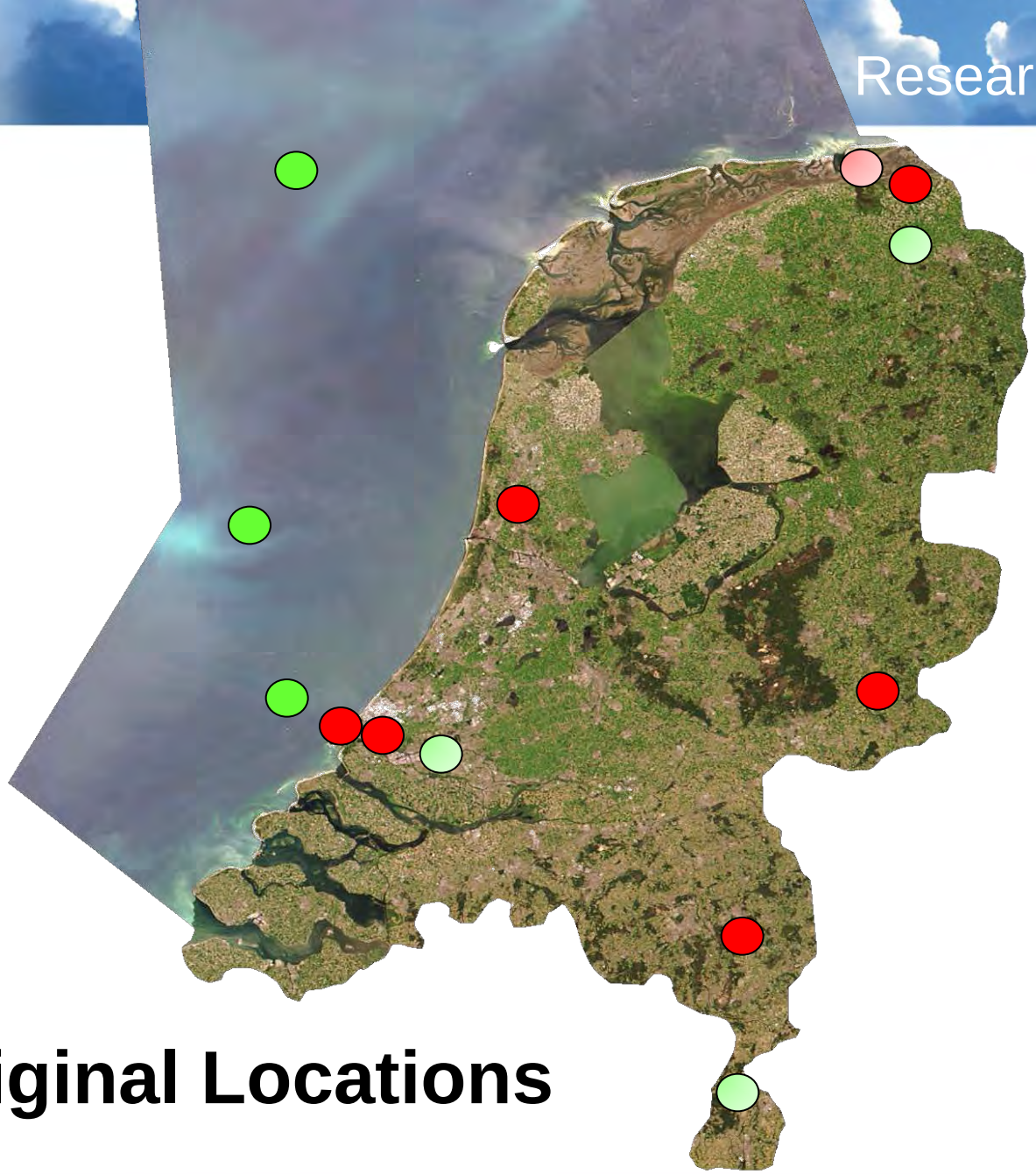
- Starting ~1990 CCS research was executed in a number of dedicated (mono-disciplinary) National and European R&D projects

- As of 2004, National research was conducted in programs CATO and CATO2, covering the full CCS chain and addressing both fundamental and applied topics

CATO In a Glance

- Applied and Fundamental research
- Demand driven & flexible program
- > 100 M€ (50% government)
- Duration 2004-2014
- > 40 Partners from industry, SME, university, NGO
- > 2000 papers and deliverables
- > 60 Work packages
- > 50 PhD thesis
- Scope: Complete CCS Chain

	SP	Sub-Programs
	0	Coordination, dissemination, cooperation
	1	Capture
	2	Transport and chain integration
	3	Storage & monitoring
	4	Regulation and safety
	5	Public perception



Original Locations

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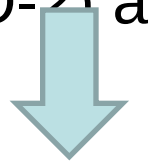
The end of the world as we know it



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- International political climate
  - The political momentum has gone. Climate change was commonly considered among the main challenges facing the world. Nowadays, the financial and economic crisis has taken pole position in political decision making.
  - Many demonstration projects have been cancelled or delayed due to e.g., legal (Germany, Italy) and financial (Poland) issues.
  - Funding for CCS is not sufficient (partially due to low ETS prices)
  - Game changer: shale gas Shale gas is used as a less carbon intensive fuel than coal, and it plays a role in energy security issues in Europe. The attention of policy makers is shifting from CCS to shale gas, which is already a commercially viable option.
  - Only a few countries are investing heavily in large-scale CCS projects (basically those countries that have fossil fuel interests).

- Dutch political climate
  - Barendrecht discontinued
  - Onshore Storage postponed
  - NER-300 CCS Demo canceled
  - ROAD awaiting FID
  - Research Funds strongly reduced

- Locations
  - K12B storage pilot still active
  - Post-combustion capture pilot still active
  - Pre-combustion capture pilot completed
  - On-shore storage pilots (Chemelot and Barendrecht) canceled
- Funding
  - CCS now part of “Topsectors for Innovation”
  - As of 2015 government funding reduced from 6 M€/year to ~2M€/year
  - Additional budget pending FID ROAD
  - Strong focus on Re-use

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CCS Implementation Plan (2014)

- "Energy Treaty" (2013) between major stakeholders (Government, Industry, Unions, NGO's …)
  - Includes CCS
  - No "hard" commitments
- CCS vision document to be completed fall 2014
  - Two scenario's
    - "ROAD"
    - "MOTHBALLING"
- Future for ROAD still uncertain

CCS R&D beyond 2014

CATO-3: CCUS SUB-PROGRAMME ELEMENTS			
Work Programme Theme	**Discovery**	**Development**	**Deployment**
WP1: CO_2 capture	Fundamental research to reduce capture costs, aimed at: ➢ chemical looping ➢ advanced and novel absorption concepts ➢ advanced pre-combustion capture	Development of 3rd generation capture technology focused on: ➢ gas-fired power plants ➢ robust, high performance/low cost coal-fired generation ➢ chemical industry and refineries ➢ iron and steel plants	Facilitation of the ROAD project: ➢ plant/project optimisation ➢ demonstration plant extension ➢ operational technical support
WP2: CO_2 utilisation	Opportunities for CO_2 reuse through research focused on: ➢ biological conversion and bio-refineries ➢ mineralisation ➢ chemical conversion ➢ fuels from renewables combined with CO_2	Development opportunities for: ➢ enhanced hydrocarbon production ➢ bio/chemical conversion of CO_2 ➢ multi-fuel/multi-product facilities	Enhanced hydrocarbon recovery (EHR) deployment: ➢ CO_2 enhanced gas recovery ➢ CO_2 enhanced oil recovery and monitoring. Enabler of large share of variable renewables
WP3: Storage (aquifer and depleted reservoirs), verification, monitoring and safety	Improving storage economics by fundamental research on: ➢ combining CO_2 storage with underground coal gasification (UCG) and enhanced coal bed methane (ECBM) ➢ CO_2 usage in deep geothermal energy production	Development of safe and reliable storage opportunities including: ➢ proving up the Q1 aquifer ➢ investigation of near depleted gas fields ➢ strategies for combining EHR and storage ➢ development of MMV approaches for Dutch application	Deployment opportunities including: ➢ facilitation of the ROAD project storage ➢ field tests in depleting oil and gas fields and aquifers (linkages to WP2)
WP4: Transport and CCUS chain integration	Integrating CCUS in the energy sector by improving the understanding of: ➢ interfaces/interactions across the whole chain ➢ optimising the transport network ➢ integration of power plants, CO_2 use and renewables	Solutions for full chain design including: ➢ 'future proofing' to enable subsequent 3rd party access ➢ increasing tolerance around CO_2 purity ➢ accounting for CCUS plant operating and grid flexibility	Address technical issues associated with: ➢ injection from fixed platforms and/or ships (eg K12-B pilot) ➢ interconnectivity issues between chains ➢ ship based transport
WP5: Policy, legal and regulatory frameworks	Advancing policy considerations for CCUS through work on policy/legal/regulatory drivers as they effect The Netherlands in relation to: ➢ policy and regulatory options for CO_2 use and to address storage liability pressures ➢ the development of policy levers to assist with CCUS deployment and project financing including the EU ETS and other options (ie feed-in tariffs, emissions performance standards); and inputs into EC policy considerations (ie 2015 CCS Directive evaluation) ➢ options for 'light-handed' regulatory regimes to facilitate EHR; permitting guidelines for high pressure CO_2 pipelines; Dutch input into ISO standardisation development ➢ trans-boundary movement regulatory issues; unitisation; and transnational storage issues		
WP6: Public Outreach, communications and awareness	Development of: ➢ best practice guidance in relation to the practical engagement with local communities and development of communication strategies ➢ continued monitoring of public awareness, knowledge and perception ➢ evidence based communication strategies and organisational/non-technical learning tools ➢ benefit sharing tools and understanding the importance of local preferences/conditions		

CCS R&D beyond 2014: Scope

- **CO2 capture** - 2nd and 3rd generation capture technology; industrial applications & Gas
- **Utilisation** – improving the business case for CCUS through CO2 use and enabling large scale implementation of variable sustainable energy sources through storage of electricity in chemicals and fuels
- **Storage, verification, monitoring and (long term) safety** – with emphasis on monitoring, measurement and verification; aquifers and depleted oil/gas reservoirs

CCS R&D beyond 2014: Scope

- **Transport and CCUS chain integration** – common user infrastructure; full CCUS chain integration and scale up
- **Policy, legal and regulatory frameworks** – EU and national policy frameworks; regulatory issues; trans-boundary CO2 transport
- **Public Outreach, communications and awareness** – community acceptance; CCUS safety