

CCS in Europe – Current Status and Future Prospects

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The E.ON logo, consisting of the text "e-on" in white lowercase letters on a red rectangular background.

Overview

- What has been the motivation for developing CCS technologies and projects within Europe?
- What has been the outcome of European initiatives?
- Why hasn't this led to large scale demonstration?
- ...and what does the future hold for CCS in Europe

The E.ON Group: An overview

- We stand for **cleaner & better** energy and are a global, specialized provider of energy solutions.
- E.ON SE is one of Europe's largest energy companies with over 62,000 employees and a presence throughout Europe, North America, Russia, Brazil and Turkey.
- Global Business Units Include:
 - Exploration & Production
 - Generation
 - E.ON Technologies
 - Global Commodities
 - Renewables



***As an owner and operator of coal and gas fired power plant –
CCS is of direct relevance to E.ON***

European Motivation – Recognising a requirement to reduce greenhouse gas (GHG) emissions

First Kyoto Period (2008-2012): Under the Kyoto Protocol the EU-15 committed to GHG emissions reduction of 8% below 1990 levels – 16% was achieved

Second Kyoto Period (2013-2020): Further emission reductions are required over the second Kyoto period – 20% reduction – on track to achieve (22-27% expected)

EU2020 Growth Strategy: Emission reduction targets to achieve a 20% reduction of GHG emissions compared to 1990 levels – EU offers a conditional 30% reduction

2030 Climate and Energy Policy: 40% reduction in GHG emissions by 2030 (compared to 1990 levels)

2050 vision: Leaders have endorsed an emissions reduction target of 80-95% by 2050
This requires decarbonisation of Europe's power sector (93-99% GHG reduction)

European Motivation – Implementing CCS

Tools & Policy:

- EU Emissions Trading Scheme
- CCS Directive
- CCS Readiness

EU Funded Research:

Around 40 projects since 1998 (FP3 to FP7)

Demonstration:

- New Entrants Reserve
- European Energy Programme for Recovery

National initiatives (UK):

- Carbon price floor
- Emissions performance standard (450 g CO₂/kWh)

National initiatives (Norway):

- Norwegian CO₂ Tax
- Gassnova established
- Gas plants CCS ready

Initiatives in progressing the development of CCS in Europe

National initiatives (UK):

UK CCS Competition (phases 1 and 2) **£1 bn for demos**

Initiatives can work!



More than 11 million tonnes of CO₂ stored at Sleipner

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European CCS Demonstrations on Power Plant

EEPR (2009):

Janschwalde (DE)
Porto-Tolle (IT)
ROAD (NL)
Belchatow (PL)
Compostilla (ES)
Don Valley (UK)

NER 300 (2012)

Don Valley (UK)
Belchatow (PL)
Green Hydrogen (NL)
Teesside CCS (UK)
UK Oxy CCS (UK)
C.Gen North Killingholme (UK)
Porto-Tolle (IT)
ULCOS-BF (FR)
Getica (RO)
Peterhead (UK)

NER 300 (2014)

White Rose (UK)

1st UK Competition

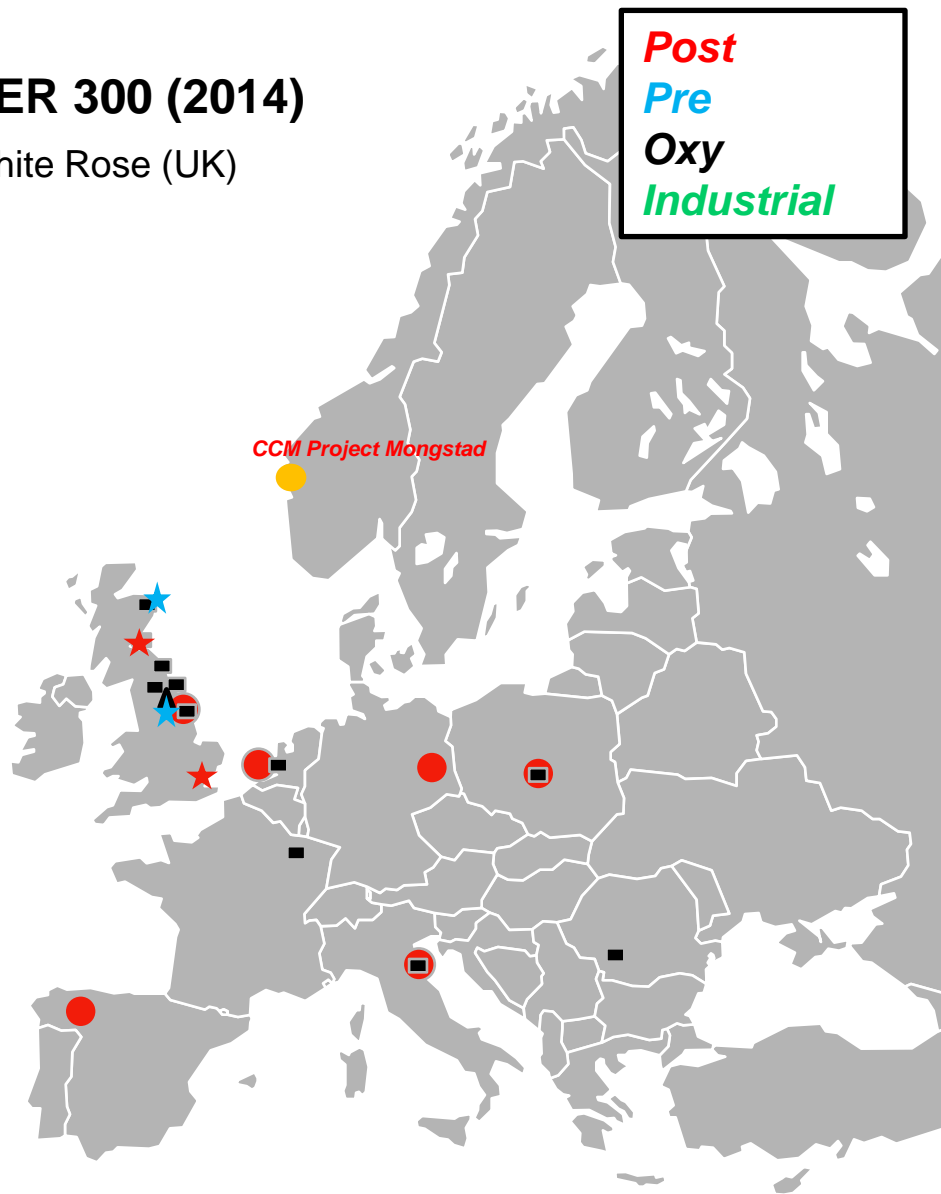
Longannet
Kingsnorth

2nd UK Competition

Peterhead
White Rose - Drax

- European Energy Programme for Recovery
- New Entrants Reserve 300 (first call)
- ▲ New Entrants Reserve 300 (second call)
- ★ UK CCS Competition (1)
- ★ UK CCS Competition (2)

Post
Pre
Oxy
Industrial



European CCS Demonstrations on Power Plant

EEPR (2009): NER 300 (2012) NER 300 (2014)

ROAD (NL)

White Rose (UK)

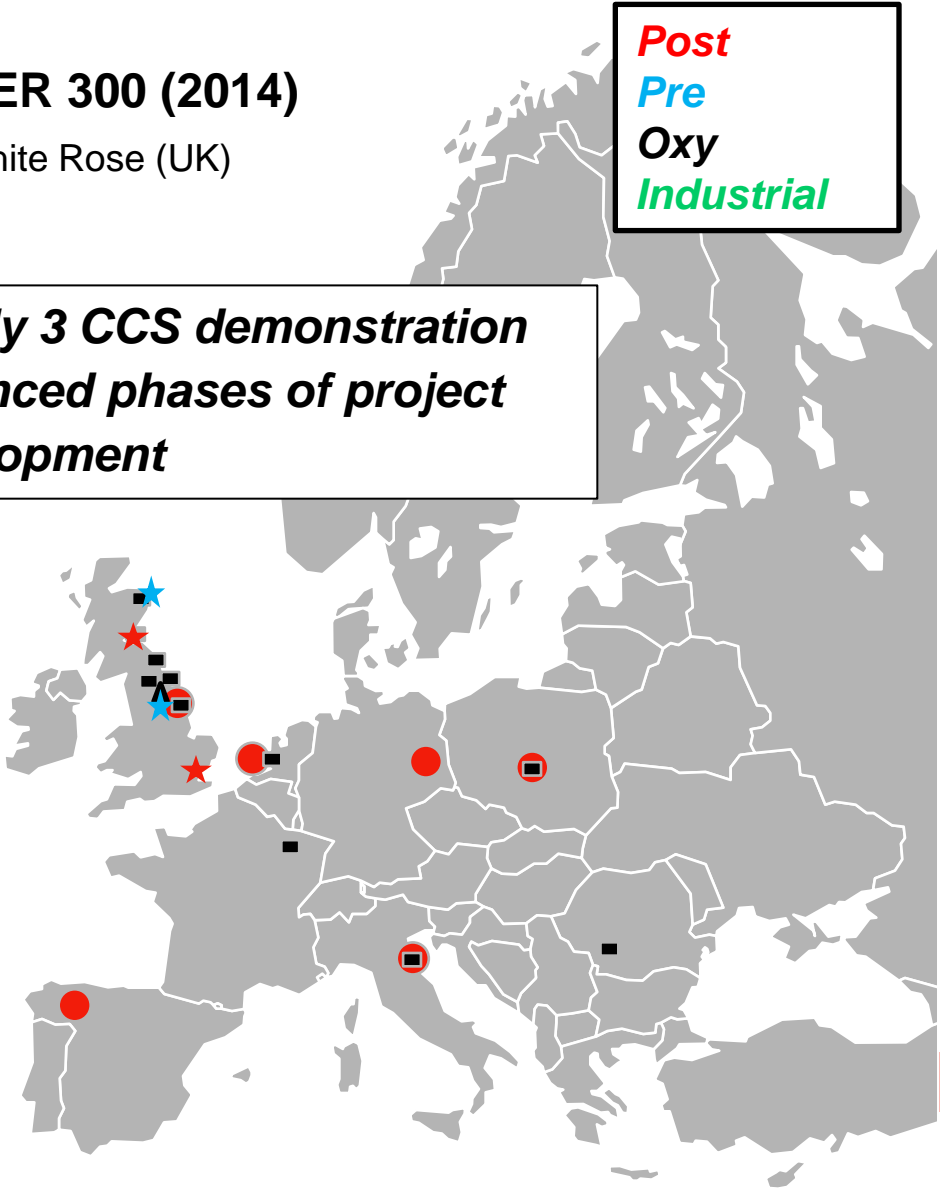
Post
Pre
Oxy
Industrial

Situation in 2015: Only 3 CCS demonstration projects in the advanced phases of project development

1st UK Competition 2nd UK Competition

Peterhead
White Rose - Drax

- European Energy Programme for Recovery
- New Entrants Reserve 300 (first call)
- ▲ New Entrants Reserve 300 (second call)
- ★ UK CCS Competition (1)
- ★ UK CCS Competition (2)



Why are projects failing to progress?

UK CCS Competition Phase 1

- Changing the rules (Killingholme)
- Economic downturn (Kingsnorth)
- Failure to agree on overall project costs and contingencies (Longannet)

EEPR Funded Projects

- Environmental permitting and public acceptance
Porto Tolle and Janschwalde
- Funding gaps and CO₂ tax
Compostilla, Porto Tolle and Belchatow



E.ON's 360 MW Killingholme Pre-Combustion CCS Project (cancelled 2007)

Lessons Learnt:

- Pilot capture plants have traditionally not focussed on addressing emissions (permitting challenges)
- Two-phase flow in pipelines and within injection wells will occur
- Considerable amount of time required to appraise storage sites (5-10 yrs)
- Modifying existing storage infrastructure (e.g. platforms) can be a challenge
- Local, regional and national government support is essential to address legal challenges

Status of the Current Demos (UK Competition)

Project: Peterhead CCS Project
Location: Aberdeenshire, Scotland
Partners: Shell UK Ltd, SSE Ltd.
Process: Retrofit (gas) post combustion capture
Scale: 1 Mtpa
Storage: Offshore depleted gas field (62 miles)
Status: FEED underway, FID expected Q4 2015



Project: White Rose CCS Project
Location: North Yorkshire, England
Partners: Alstom, Drax, BOC
Process: New Build (coal) oxyfuel combustion
Scale: 2 Mtpa
Storage: Offshore saline formation (102 miles)
Status: FEED underway, FID expected Q4 2015



Secured NER300
Funding

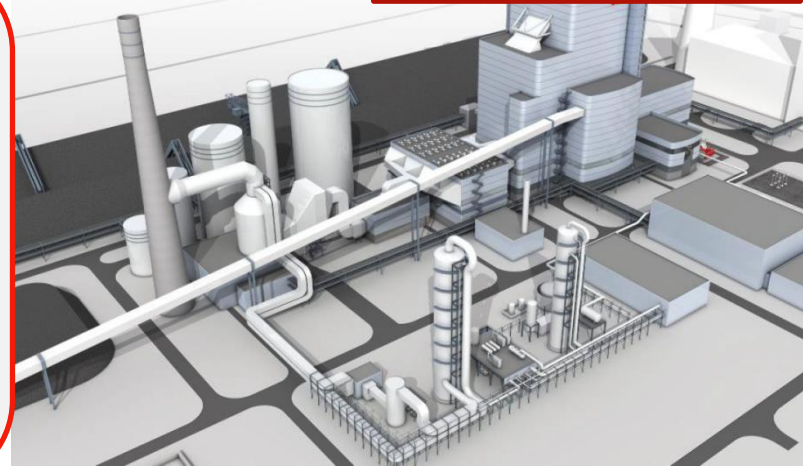
No progress expected before 2015 UK
general elections

Status of the Current Demos (EEPR)

Project: Rotterdam Opslag en Afvang Demonstratieproject (**ROAD**) CCS Project
Location: Rotterdam, Netherlands
Partners: E.ON, GDF Suez
Process: Retrofit (coal) post combustion, Fluor EFG+
Scale: 1.1 Mtpa
Storage: Offshore depleted gas field (15.5 miles)
Status: FEED + flue gas tie-ins completed. Positive FID is dependent on closing funding gap

Project: Don Valley CCS
Location: South Yorkshire, England
Partners: 2Co Energy, Samsung, BOC
Process: Pre-combustion (coal), Rectisol
Scale: 5 Mtpa
Storage: Offshore saline formation (102 miles)
Status: Negotiations in 2014 to sell the project

EEPR + €150 million
Dutch gov't funding



Not likely to
progress further

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European Pilot Plants

Development across the innovation chain has led to the advancement of first generation systems to a point at which the technology is ready for demonstration.

This is a result of:

- R&D driven by EU or government funded initiatives
- Partnerships between utilities and technology suppliers

Research Scale:

CATO (NE)
Tiller (NO)
E.ON Oxyfuel CTF (UK)
MTU

Large Generic:

Heilbronn (post)
Brindisi (post)
Esbjerg (post)
PACT (post)
Renfrew (oxy)
Schwarze Pumpe (oxy)
Buggenum (pre)
Puertollano (pre)

Partnerships

Post-CC:

Staudinger (E.ON/Siemens)
Karlshamn (E.ON/Alstom CAP)
Wilhelmshaven (E.ON/Fluor)
Niederaussen (RWE/Linde, BASF)
Ferrybridge (SSE/Doosan, HTC)
Le Havre (EDF/Alstom AA)
Aberthaw (RWE/Cansolv)
TC Mongstad (Alstom CAP/Aker)

Oxyfuel:

Compostilla (ENDESA)
Lacq (Total)

Pre-CC:

Puertollano (ELCOGAS)
Buggenum (Nuon/Vattenfall)

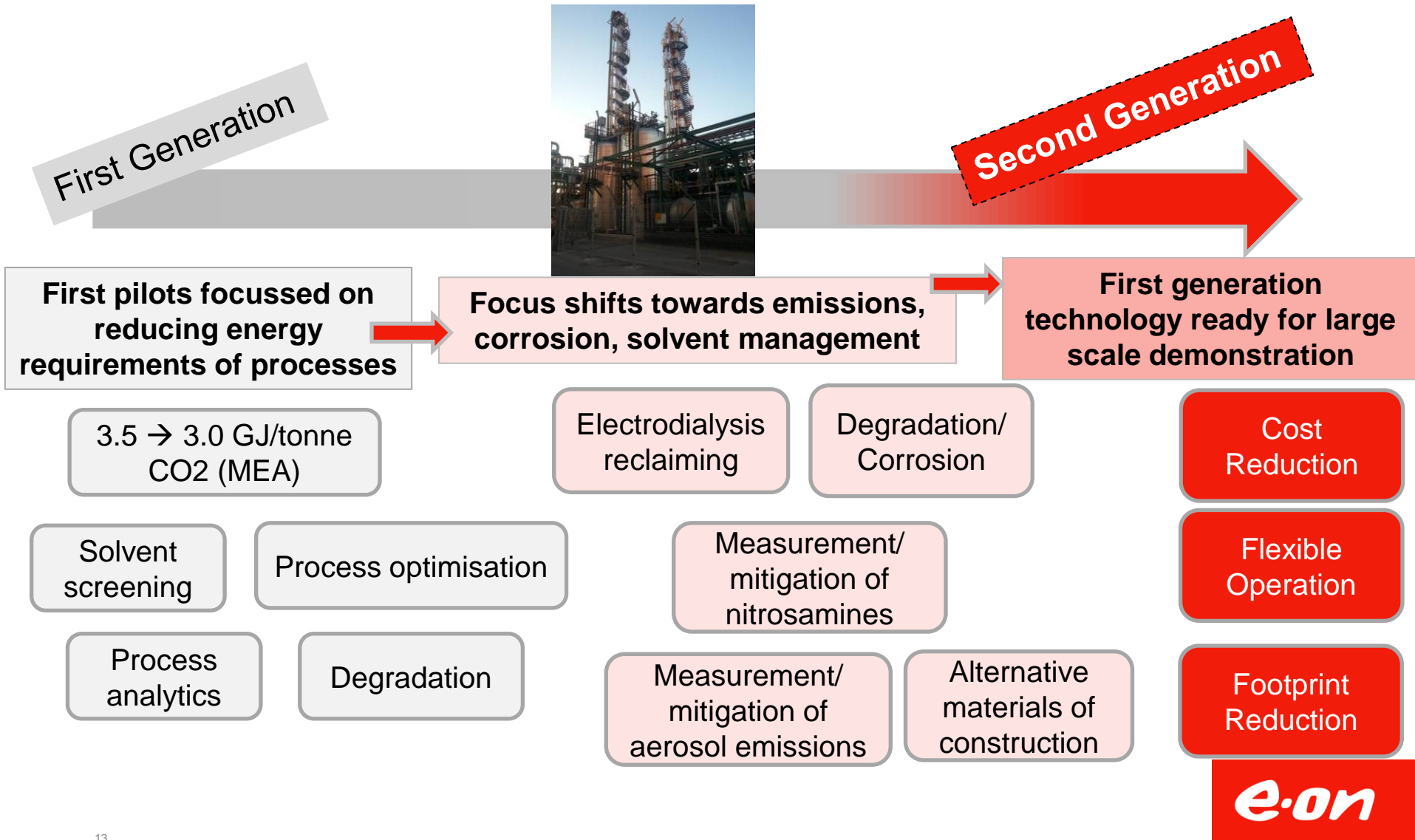
European Pilot Plants in Operation

- Consists of one amine (Aker) and one chilled ammonia plant (Alstom) – 100 ktCO₂/year
- CHP and refinery cracker gas source (3-13 % CO₂)
- 30 wt.% and 40 wt.% MEA campaigns completed
- Aker Advanced Amine and Alstom CAP campaigns completed in 2014.
- Emission reduction systems tested
- Cansolv currently testing on amine unit (CHP gas)



- 70 tpd post-combustion capture pilot
- Based on Fluor's Econamine FG+ process
- 19400 m³/h of flue gas treated from 824 MWe coal-fired unit
- Process includes intercooling and lean vapour compression
- Gained more than 5000 hours of operation
- Investigated impact of dust and SO₃ on aerosol emissions
- Evaluation of energy saving systems is underway

European Pilot Plants – Post Combustion Experience



In summary

- Europe is aiming to decarbonise its power sector – CCS provides a means of achieving this whilst maintain economic growth and energy security.
- Public acceptance, lack of decisive government action, competing incentives and the collapse of the CO₂ price have impeded the demonstration of CCS in Europe.
- Market based mechanisms such as the Emissions Trading Scheme are best suited to achieving emission reductions at least cost – but only if they currently do not work.
- Biggest hope of demonstrating full chain CCS in Europe currently lies with the UK CCS Competition
- Large pilot plant activities in Europe are reducing– 1st generation technologies are ready for deployment.
 - but what about the next generation of pilots?

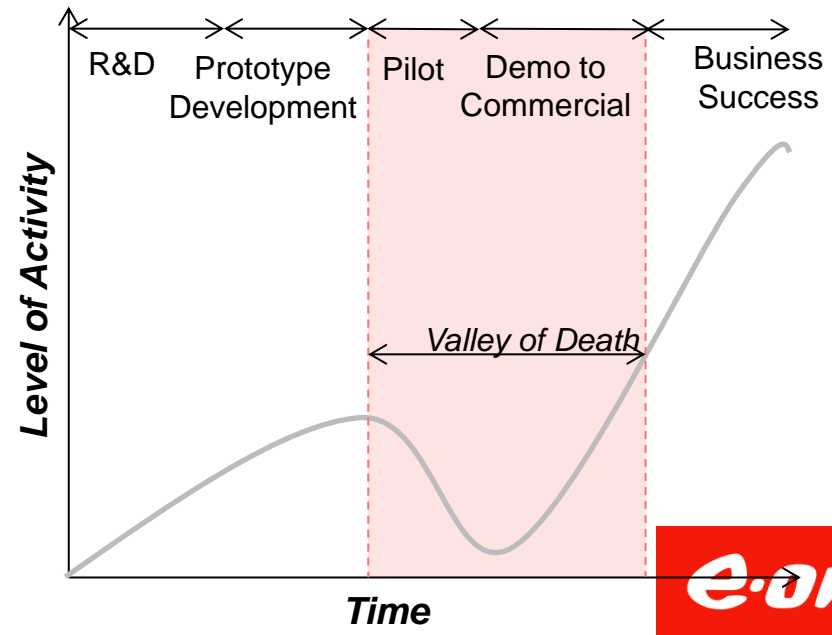
Future Prospects

- Revision of the CCS Directive within the context of 2030 and 2050 targets
- Improving the Emissions Trading Scheme
- Reconsidering a European Emissions Performance Standard
- Creation of NER300 successor, NER400, has been agreed
- National subsidies, e.g. Contracts for Differences – Feed in Tariffs

CCS is formally included in the UK Energy Act and is eligible for CfD payments anticipates 5 - 13 GW by 2030.

Fruition of the current European demos may signify that CCS in Europe is emerging from the “Valley of Death”...

...however, the correct regulatory environment and framework is required to ensure this ‘rise’ continues.



Thank You

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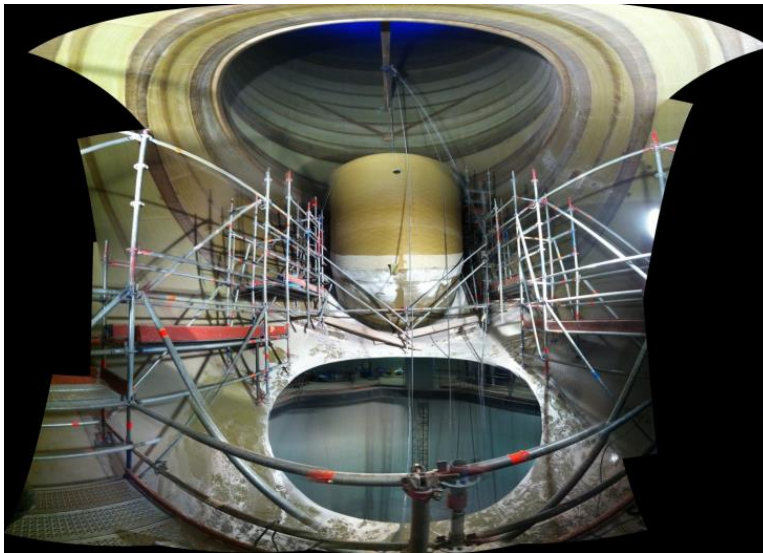
ROAD CCS: Host Power Plant (E.ON MPP3)

Output: 1070 Mwe

Efficiency: 46%

Operational: 2015

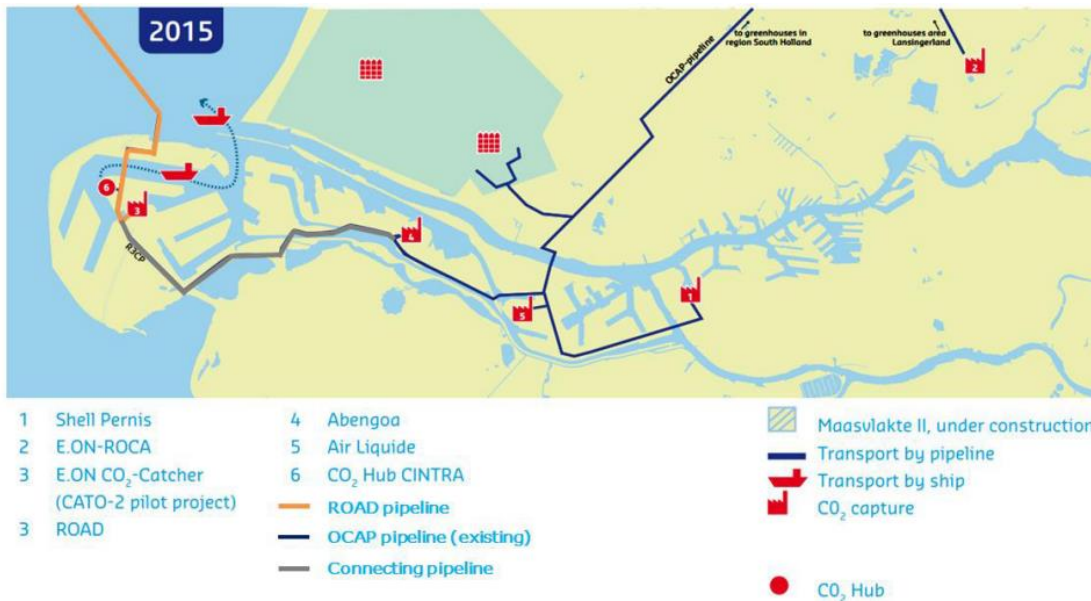
Capture Ready



Flue-gas interface construction work
has already been completed

Connecting CCS and CCUS

Rotterdam industrial area has set a target to achieve a 50% reduction in CO₂ emissions by 2025 (compared to 1990).



CCS expected to contribute 60-70% of this reduction

Proposed network will link various sources of CO₂ such as the ROAD capture plant to CO₂ sinks (e.g. greenhouses)

ROAD: CO2 Storage

- Depleted natural gas field (P18-4) will be used for CO2 storage (350 → 20 bar)
- Reservoir is 3.5 km below the sea bed
- Field is 20 km offshore
- 1.1 million tonnes per year will be stored
- Capacity is 8 million tonnes of CO2 (5 years)
- Applied for storage permit in 2010 – awarded in 2013
- Ready for CO2 injection

