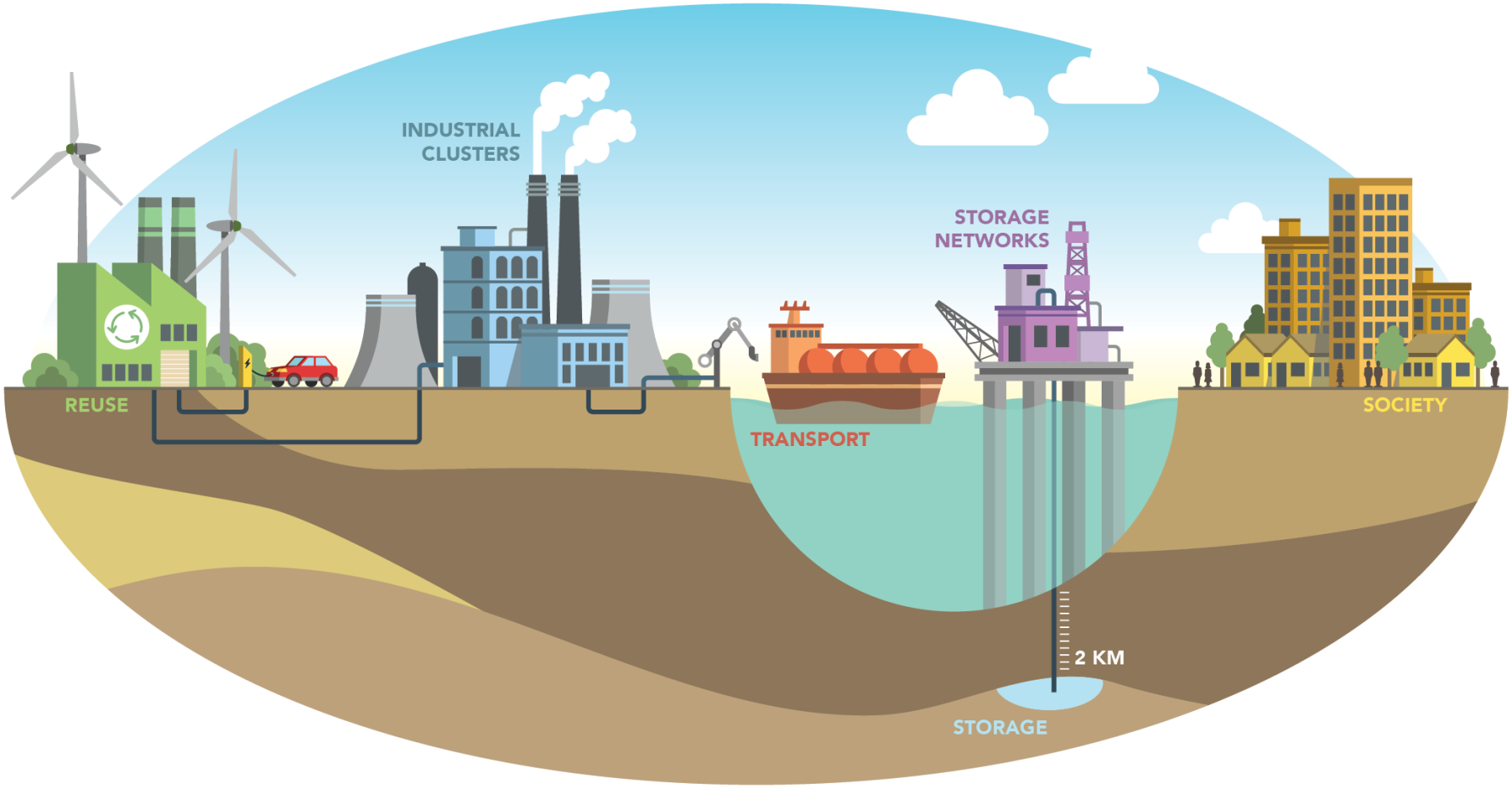
ALIGN CCUS


INDUSTRIAL CLUSTERS
STORAGE NETWORKS
REUSE
TRANSPORT
SOCIETY
2 KM
STORAGE

2nd Knowledge Sharing Workshop

ALIGN CCUS

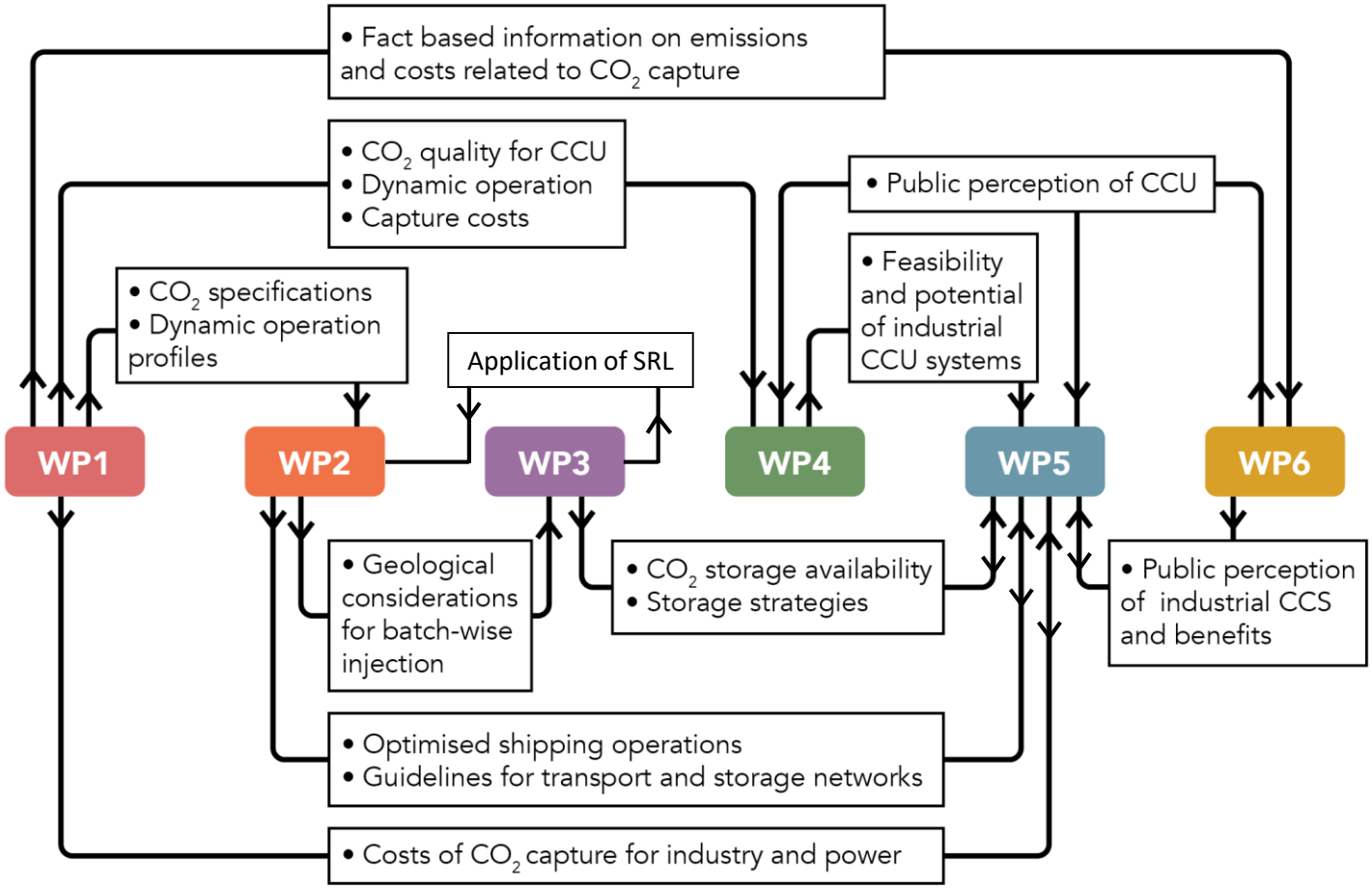
Project no 271501, ACT – Accelerating CCS technology

Peter van Os (TNO)

Coordinator

Niederaussem, Germany, November 13th 2018

Full chain integrated project



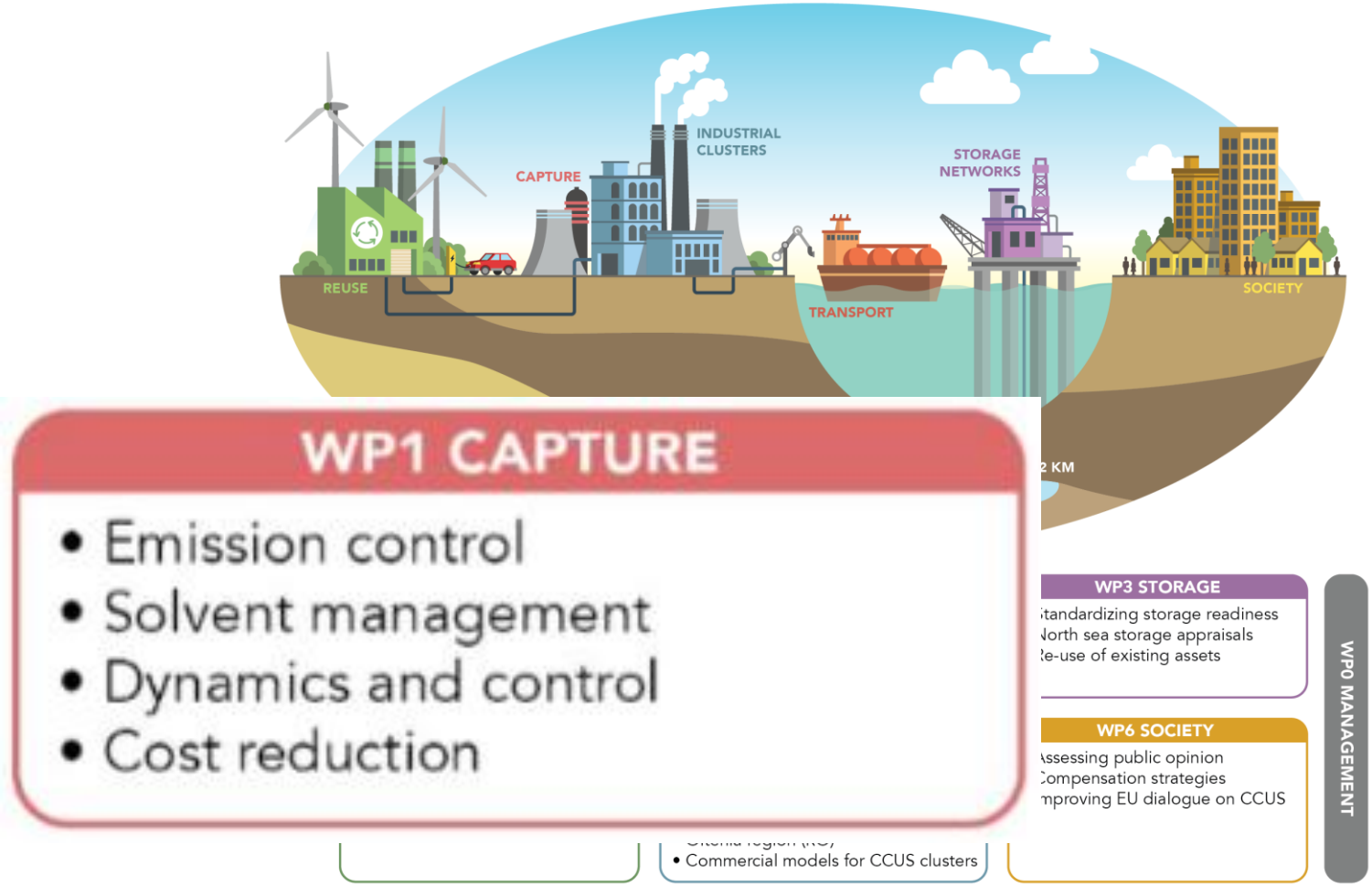
Objectives (1)

- ALIGN addresses specific issues across the CCUS chain for industrial regions in ERA-NET ACT countries, enabling large scale, cost effective implementation of CCUS by 2025. To reach the overall aim of ALIGN, the project encompasses a number of focused but interlinked objectives:
  - Capture: Enable near-term deployment of CO_2 capture by improving performance and reducing costs
  - Transport: Optimising large-scale CO_2 transport
  - Storage: Reduce uncertainty in the provision of large-scale storage networks
  - Utilisation: Establish the contribution of CCUS as an element for large-scale energy storage and conversion
  - Social acceptance: Implementing CCUS in society

Objectives (2)

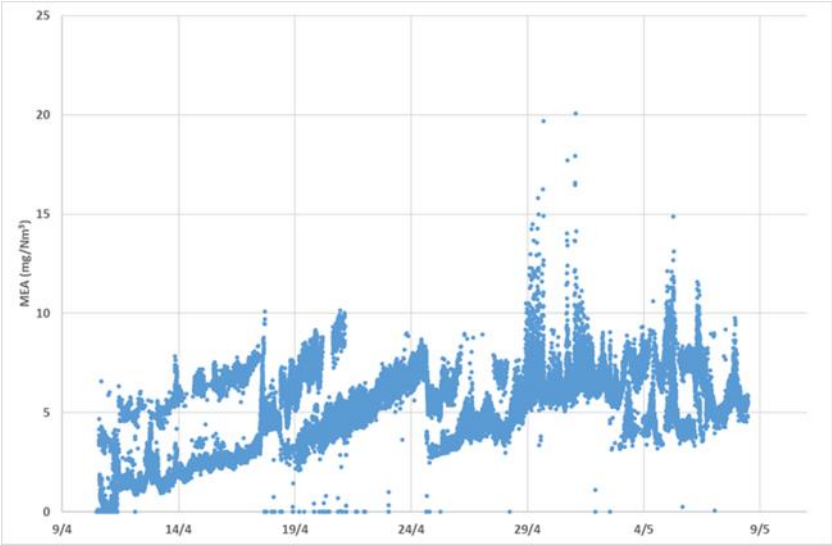
- ALIGN will combine the results from each of these objectives to deliver actionable blueprints in ERA-NET ACT countries: Teesside and Grangemouth (UK), Rotterdam (NL), North Rhine-Westphalia (DE), Grenland (NO) and Oltenia (RO, in which CCUS enables low-emission industries, through geological storage or through utilization of CO_2.

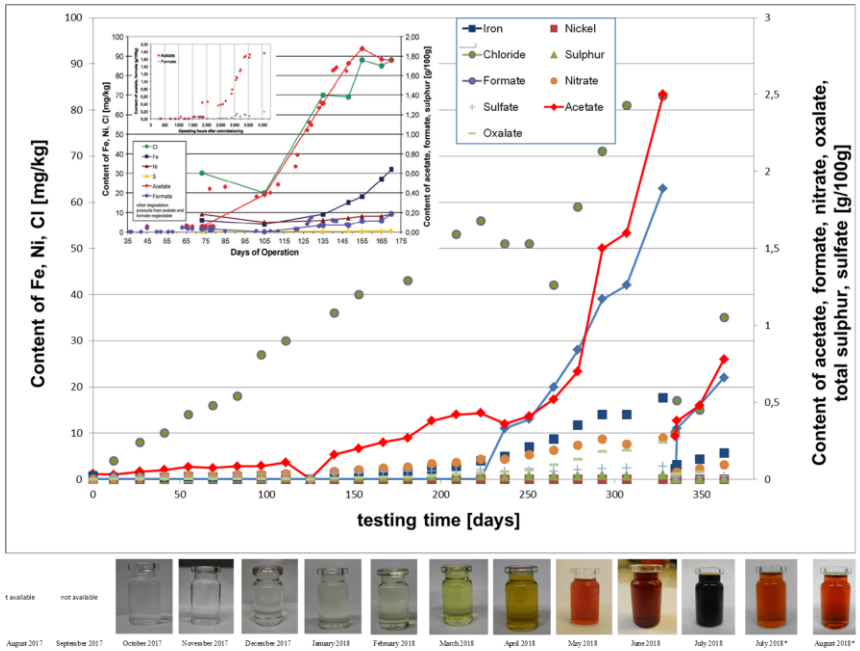
Work Packages (WP1)



WP1 Capture (SINTEF, NTNU, TNO, HWU, RWE, UoS, TCM, USN)

Testing at RWE in Niederaussem by HWU, TNO and RWE

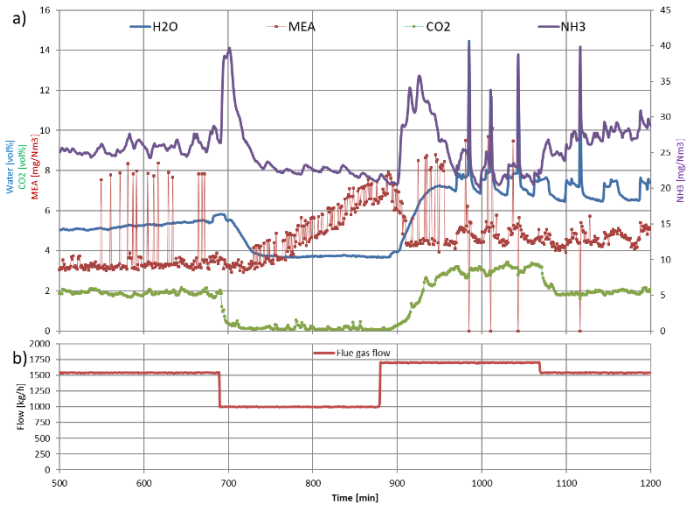




Very low emissions of MEA:
Particle measurements by HT ELPI+ confirmed that also aerosol-based emissions are irrelevant for the flue gas of a lignite-fired power plant with state of the art emission reduction technologies.

Results up to now:
Confirmation of the non-linear degradation behavior of MEA → it happens everywhere…….
Different degradation behavior compared with other pilot plants.

WP1 Capture (SINTEF, NTNU, TNO, HWU, RWE, UoS, TCM, USN)



Dynamic Testing:

Investigation of dynamic behavior of the solvent loss due to emissions in dedicated test campaigns by varying:

- Loading and temperature of lean stream
- Water wash parameters
- L/G ratios
- Absorber temperature profile (dry bed, intercooler)

A solvent degradation network model has been established to estimate the rate of solvent degradation as a function of:

- the flue gas composition
- capture plant design and
- operating conditions

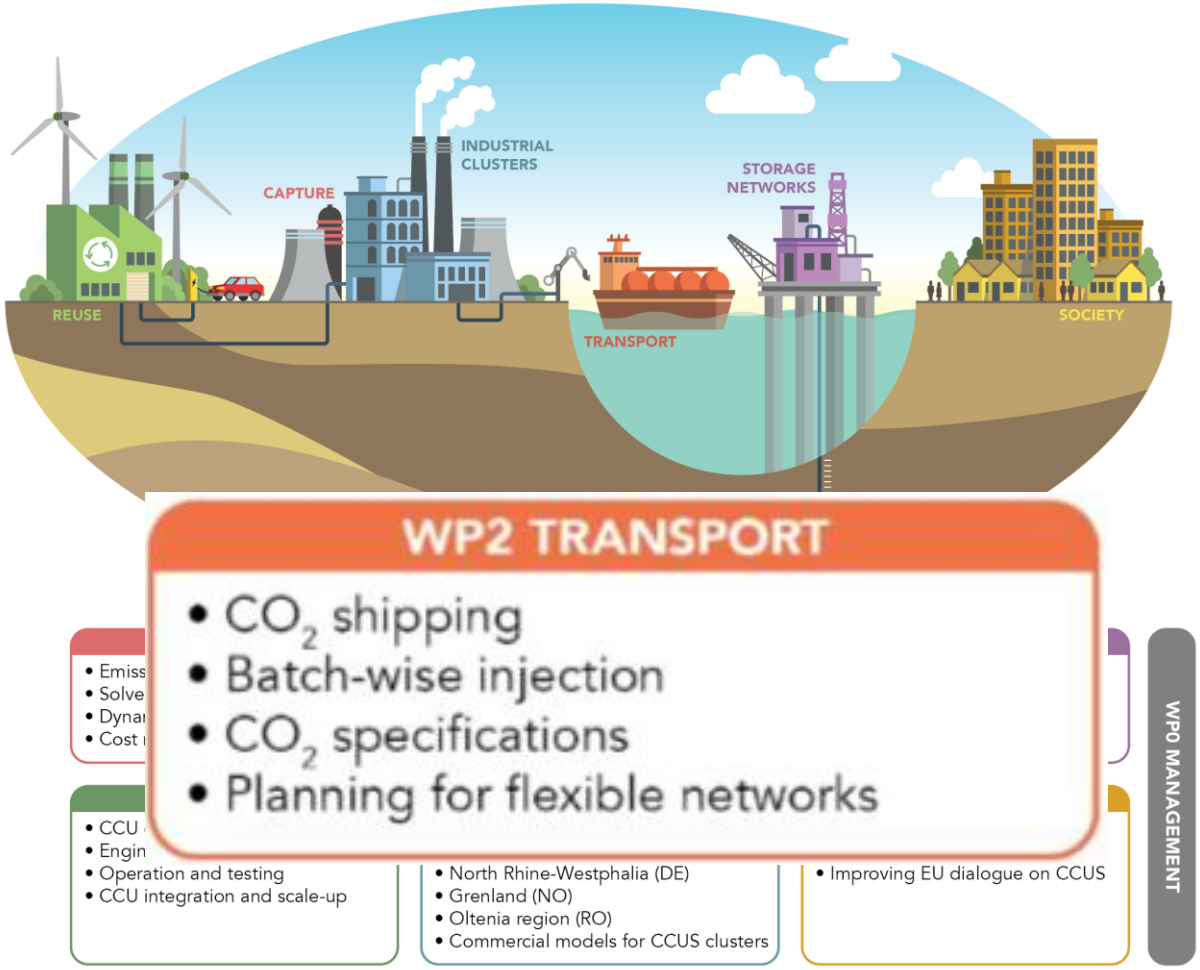
WP1 Future work

- Long term campaign at Niederaussem with CESAR-1.
- Test campaigns at TCM, Tiller and PACT.
- Emission measurements at other locations.

- Comparison <u>and understanding</u> of the results of the various test campaigns.

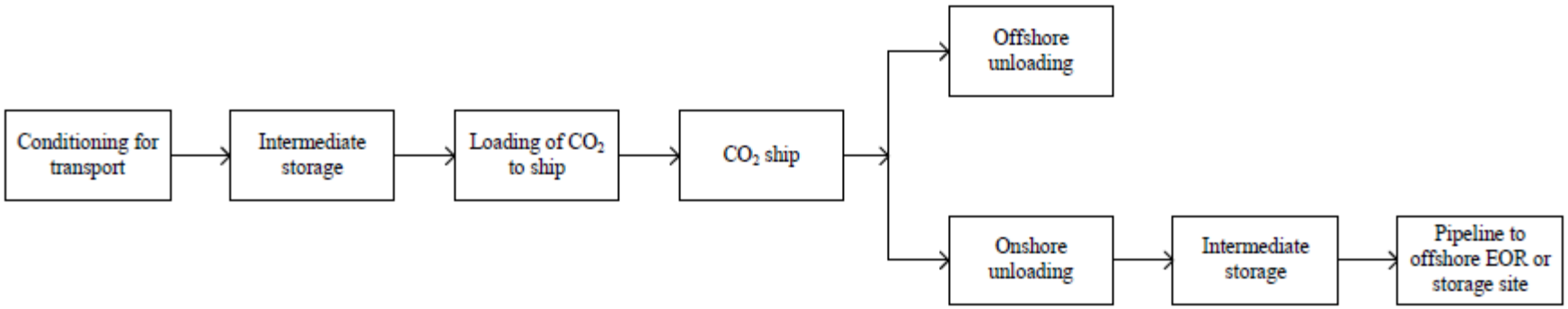
WP	Key expected results	Impacts
WP1. Capture	Complete characterisation of aerosol-based emission and demonstration of countermeasures at TRL 6/7	Validation of the performance of proposed countermeasures for aerosols at industrial scale
	Ensuring solvent consumption below 0.3kg amine/ton capture at TRL 6	Significant OPEX reduction compared with published solvent consumption and reduction of waste streams
	Guidelines for reliable and cost-efficient operation at varying feed conditions and CO_2 product requirements	Improved CO_2 capture plant design for flexible operation and niche applications.

Work Packages (WP2)



WP2 Removing technical barriers to large-scale CO_2 transport.

(**SINTEF**, ICL, TNO, IFE, TAQA)



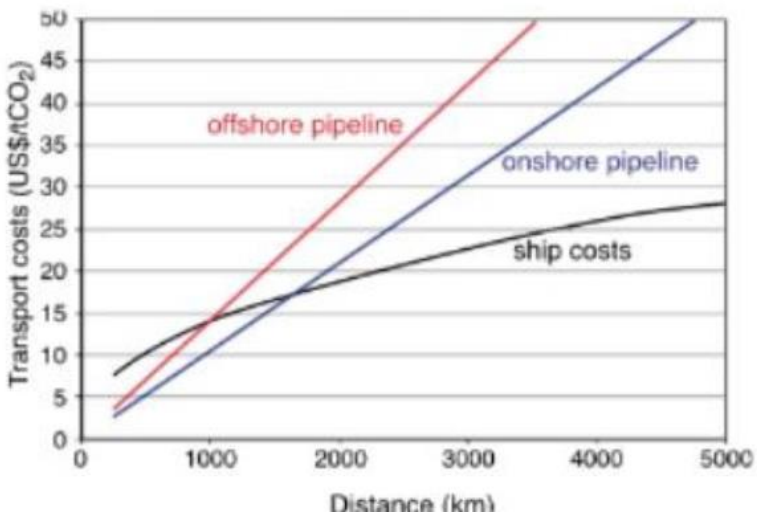


Table 1. CO_2 stream purity recommendations from literature for CO_2 storage.

Component*	CO_2 storage (NETL ,2012)	CO_2 storage (Dynamis)
CO_2	95 vol% (min)	95.5 vol% (min)
H_2O	300 ppm_{wt}	500 ppm_v
O_2	4 vol%	4 vol%
N_2	4 vol%	
Ar	4 vol%	< 4 vol%
H_2	4 vol%	
CH_4	4 vol%	4 vol%
CO	35 ppm_v	2000 ppm_v
H_2S	0.01 vol%	200 ppm_v
SO_2	100 ppm_v	100 ppm_v
NOx	100 ppm_v	100 ppm_v

WP2Removing technical barriers to large-scale CO_2 transport.

(**SINTEF**, ICL, TNO, IFE, TAQA)

Whether it is ship or pipeline that will be the most optimal transport solution is highly dependent on several parameters and thus case specific; for example:

- CO_2 volumes
- Distance from source to sink
- Lifetime of the project
- Complexity of network
    - One source to one sink
    - Several sources to one sink
    - Several sources to several sinks

WP2Removing technical barriers to large-scale CO_2 transport.

(**SINTEF**, ICL, TNO, IFE, TAQA)

Investigating a safe operating window (wrt corrosion). The test conditions have been defined, experimental plan is under development.

Test conditions

- Pressure: 15-18 bars
- Temperature: -25 to -28
- CO_2 stream composition

Comp. ppmv	Dynamis 2008	NETL* (for design)		Carbon net project 2016	Goldeneye/ Peterhead 2014 (2016)	Norwegian Fullscale project	Align I
		2012	2013				
H_2O	500	730	500	100	50	30	122
H_2S	200	100	100	100	0.5	100	130
CO	2000	35	35	900-5000	10	400	0
O_2	<40000	40000	10	20000-50000	1 (5)	10	275
SOx	100	100	100	250-2500	10	100	96
NOx	100	100	100	200-2000	10	100	69
Other							

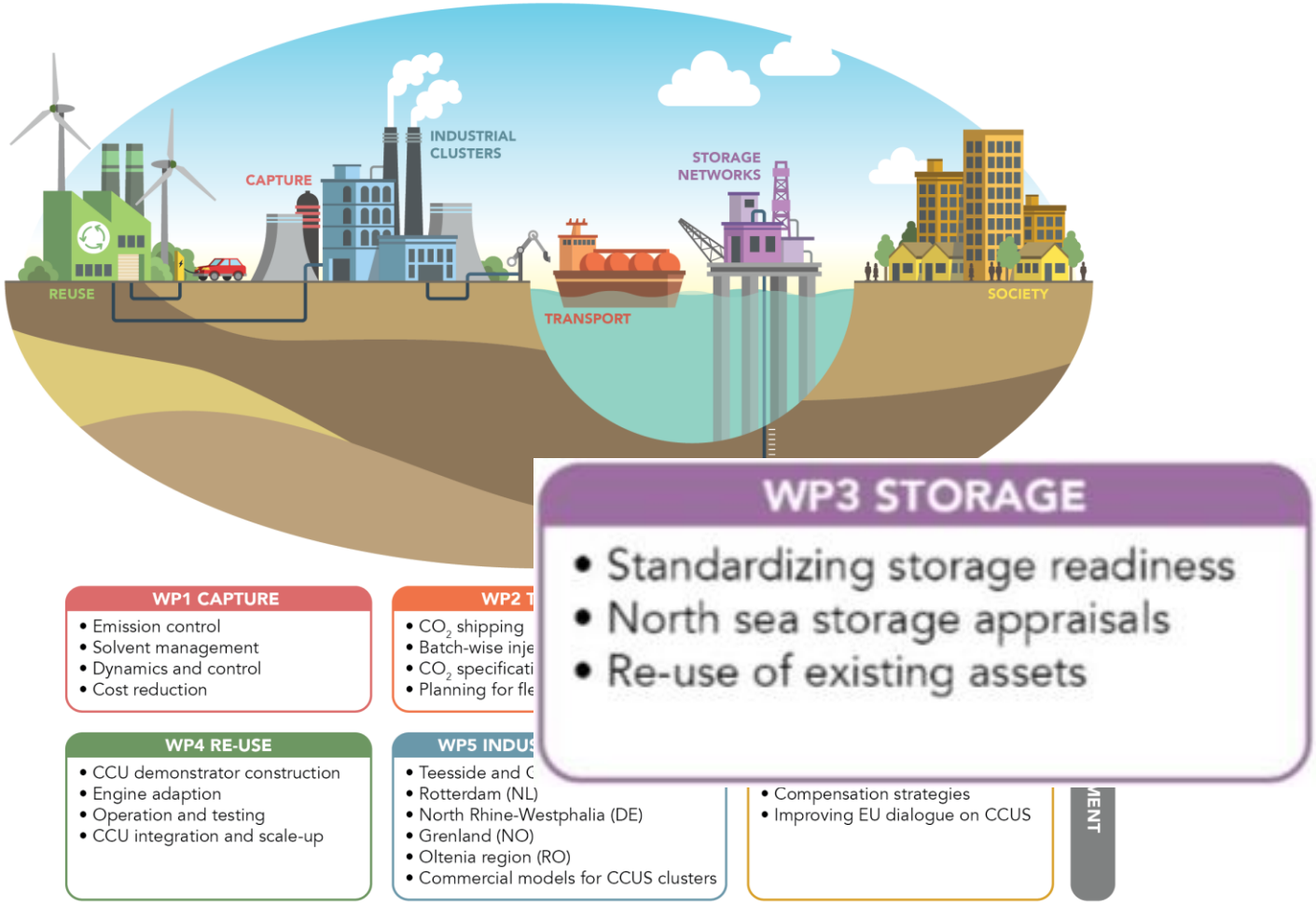
IFE

WP2 Future Work

- Investigate safe and efficient injection conditions for batch-wise injection of CO2
  - Two injection cases have been identified: a UK case and a Norwegian case
  - Possible effects in the well of injecting cold CO2 have been identified
- The work on CO2 transport networks has just started

WP	Key expected results	Impacts
WP2. Transport	Derive cost estimates and benchmarks for CO_2 shipping and offshore unloading with reduced uncertainty	Improved understanding of the business case for shipping and direct injection
	Quantification of the impacts of batch-wise injection on the integrity of the storage system	Allow operational guidelines to be developed for batch-wise injection
	CO_2 specifications expected from pilot-scale post-combustion capture systems are evaluated in dense-phase CO_2 corrosion lab	Allow the identification of an optimum balance between stream composition and transport infrastructure needs
	A real-options multi-period CCS network optimisation model including capture from power and industry, energy storage and conversion is developed	Improved cost-benefit analysis capabilities for planning full-chain CCUS projects and CCUS clusters

Work Packages (WP3)



WP3 Large-scale storage networks

(**BGS**, TNO, SINTEF PR, TAQA, TVCA, Scottish Enterprise, RUG, SDL)

- Vast potential storage capacity beneath the North Sea (fields and formations)
- Prospective industry CCS operators require:
  - increased confidence in availability
  - sufficient capacity
  - realistic costs and timing of storage provision.

- **Increase operator certainty in future storage provision**

WP3 Large-scale storage networks

(**BGS**, TNO, SINTEF, TAQA, TVCA, Scottish Enterprise, RUG, SDL)

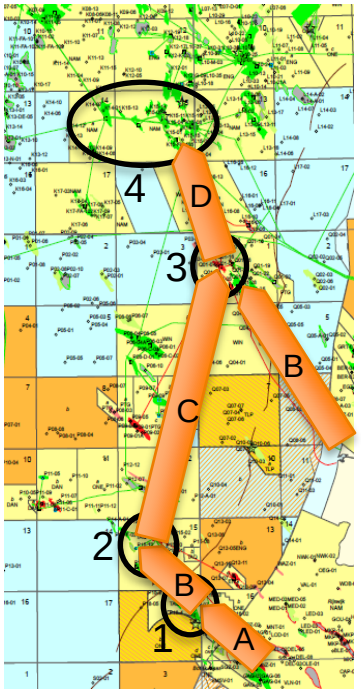
	SRL number	Description/title of SRL
	SRL 1	Country-wide (first pass) or basin-scale storage assessment
	SRL 2	Site identified in a storage atlas
Pre-feasibility study	SRL 3	Desktop study of an individual storage site & an initial project concept
	SRL 4	Validation of desktop studies & revised project concept
Feasibility study	SRL 5	Validation of site in a relevant environment
†Contingent storage resource	SRL 6	Storage site integrated as a component of a feasible project concept or as contingent resource in a portfolio of sites (national resource)
	SRL 7	Storage site recognised
Major investment decision	SRL 8	Storage site test injection in an operational environment (commissioning)
	SRL 9	Site operational

Incremental increase in understanding of the storage operation

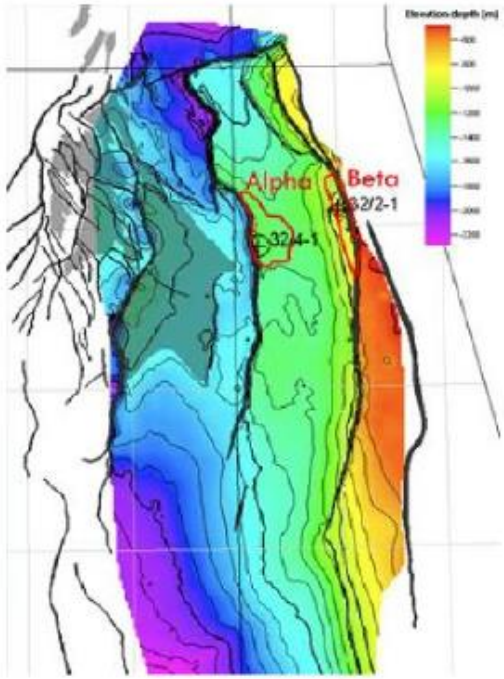
†A site at full completion of SRL 6 may remain as a contingent resource until it is required for a storage project

WP3 Large-scale storage networks

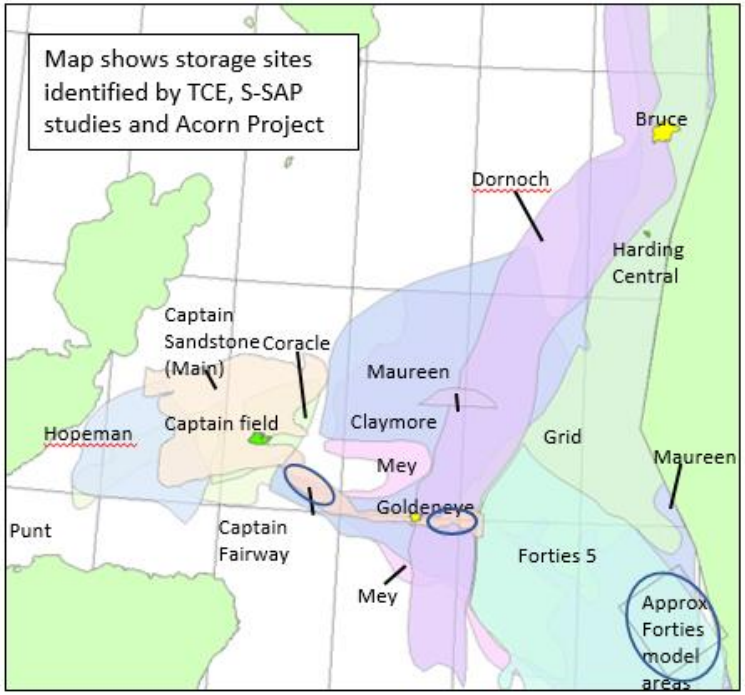
(**BGS**, TNO, SINTEF PR, TAQA, TVCA, Scottish Enterprise, RUG, SDL)



NL P18 – P15 and Q - Clusters



NO Smeaheia Area



UK Teesside and Grangemouth

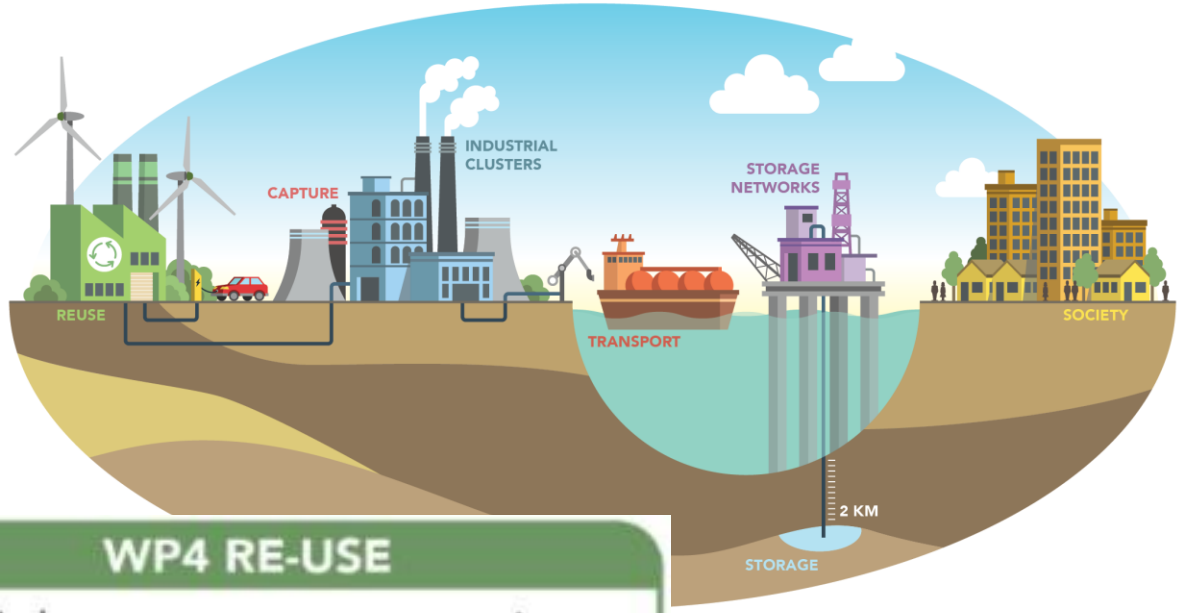
Collaboration with ACORN, PreACT, ELEGANCY

WP3 Future work

- The reuse of infrastructures for CO2 storage: first draft report submitted.
- Legal issues: A stakeholder workshop will be organized.

WP	Key expected results	Impacts
WP3. Storage	Provide a classification framework for storage readiness levels benchmarked against existing storage sites	Increased investor confidence in timeframe and resource needs for follow-on storage development.
	A portfolio of selected storage sites in the UK, Netherlands and Norway to provide certainty on storage for ALIGN clusters	Enables FIDs on transport and storage infrastructure and supporting development plans for storage roll-out.
	An asset register of existing North Sea oil and gas infrastructure and assessments of their suitability for re-use for CCUS projects	Supports decommissioning policy and regulation for transport and injection infrastructure.

Work Packages (WP4)



WP4 RE-USE

- CCU demonstrator construction
- Engine adaption
- Operation and testing
- CCU integration and scale-up

WP3 STORAGE

- Standardizing storage readiness
- North sea storage appraisals
- Re-use of existing assets

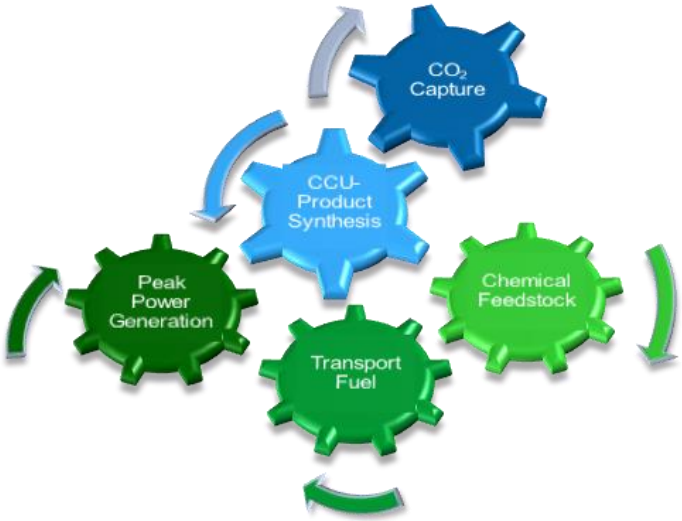
WP6 SOCIETY

- Assessing public opinion
- Compensation strategies
- Improving EU dialogue on CCUS

WP0 MANAGEMENT

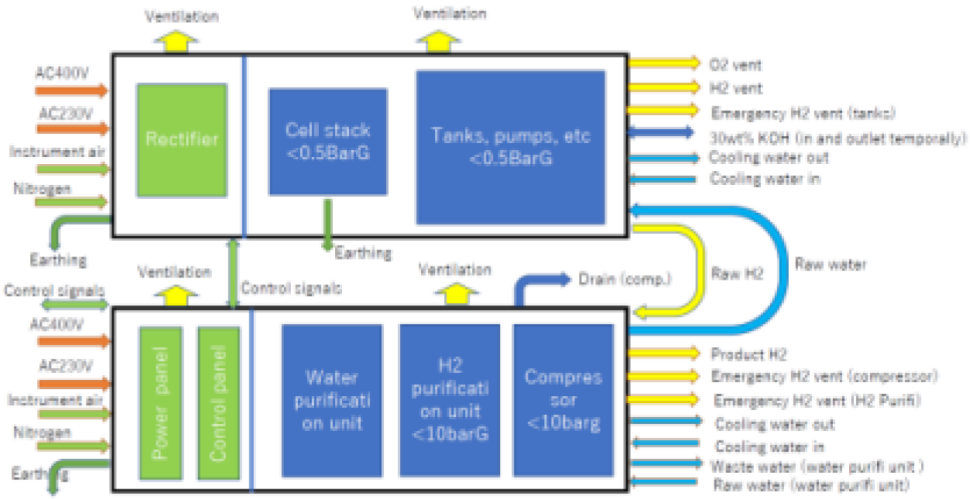
WP4 CCUS as an element for large-scale energy storage and conversion (**RWE**, MHPSE, AKEU, FEV, FZ Julich, TNO, RWTH, Deutz)

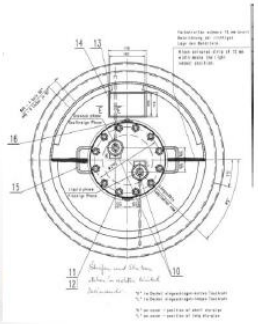
- WP4 aims at accelerating the integration of CCU applications into the energy system by:
  - Demonstrating the full CCU-chain and utilisation of CCU-products in the power and transport sectors
  - Obtaining acceptance for CCU by additional benefits: security of supply and low-emission fuels
  - Generating added value by CCUS and gain cost reduction potential by innovative technology
  - Assessing socio-economic value and benefits of CCUS

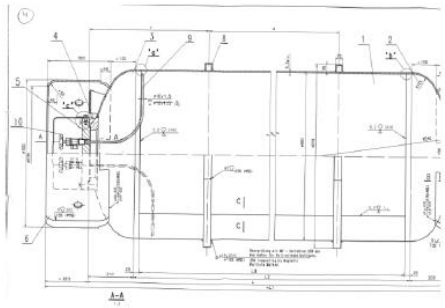


WP4 Demonstration setup

- Demonstrator design well underway.
- Engine adaption progresses as planned





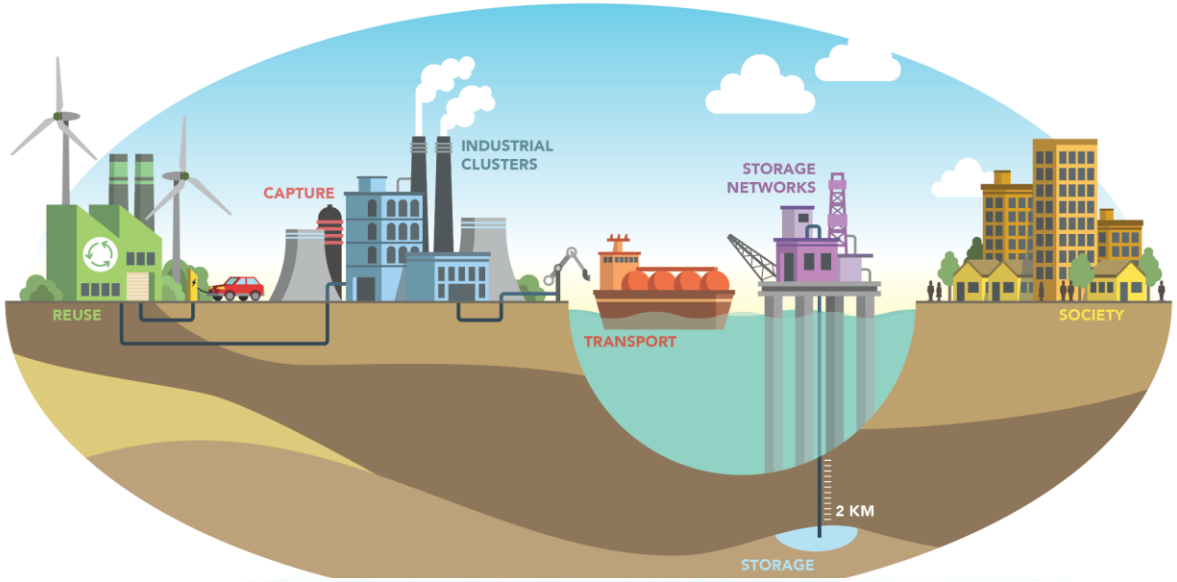


WP4 Future work

Strong focus on building the demonstrator, but work on the LCA has started, first data is received

WP	Key expected results	Impacts
WP4. Re-use	Demonstration of the full CCS/CCU chain	Proven feasibility and viability of a utilisation chain, increases public awareness and acceptance of CCS/CCU as a climate protection technology
	Understand the additional multi-sector benefits of establishing a CCUS chain producing low-emission transportation fuels	Quantifies the potential socio-economic effects of CCS/CCU beyond climate protection by intelligent coupling of the sectors energy, industry and transport.
	Techno-economic optimisation of the CCU demonstrator technology	Enhances the chance for accelerated implementation of CCU due to better economic performance.
	Quantify the environmental performance of a full CCUS chain using data derived from actual operation	Makes the advantages of CCUS transparent in comparison with other competing climate protection technologies.

Work Packages (WP5)



WP5 INDUSTRIAL CLUSTERS

- Teesside and Grangemouth (UK)
- Rotterdam (NL)
- North Rhine-Westphalia (DE)
- Grenland (NO)
- Oltenia region (RO)
- Commercial models for CCUS clusters

WP1 CAP
- Emission control
- Solvent managem
- Dynamics and co
- Cost reduction

WP4 RE
- CCU demonstrato
- Engine adaption
- Operation and te
- CCU integration a

WP0 MANAGEMENT

WP5 Targeted CCUS activities in industrial clusters (TNO, BGS, TCVA, SDL, ICL, Scottish Enterprise, Bellona, FZ Julich, SINTEF, Yara, Norcem, GeoEcomar, PicOil, CO2Club)

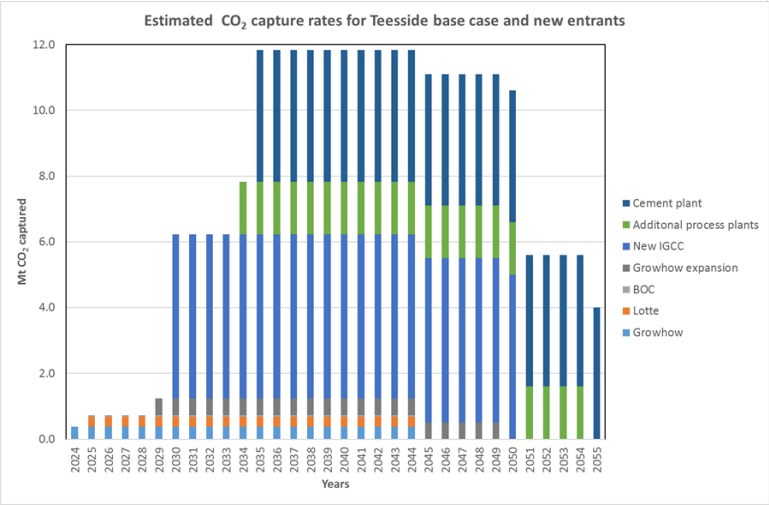
Industrial cluster/ region	Development priority in ALIGN	Existing appraised storage			Extended storage capacity to be identified in ALIGN
		Storage site	Capacity	Status	Target stores
Rotterdam (NL)	Develop plans for centralised CO_2 removal from natural gas, and increased H_2 use in power generation and industry	P18-4 Gas Field	8 Mt	Permit awarded	P18, P15 and Ijmuiden fields and sandstone formations
Teesside (UK)	Identify cost reduction opportunities through shared infrastructure / optimise transport and storage plans	Endurance structure	200 Mt	Permit ready	Depleted fields, closures in the Bunter and other sandstone formations
Grangemouth (UK)	Identify cost reduction opportunities through shared infrastructure / optimise transport and storage plans	Goldeneye Field	10-15 Mt	Permit ready	Depleted fields, closures in the Captain and other sandstone formations

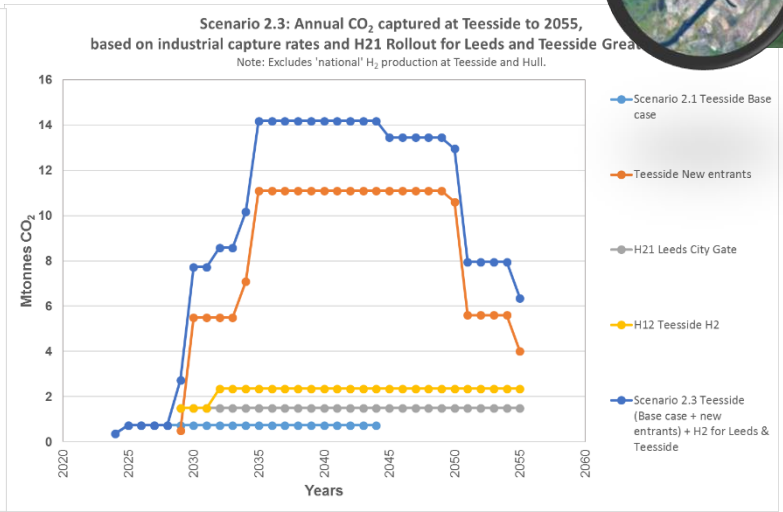
WP5 Targeted CCUS activities in industrial clusters (TNO, BGS, TCVA, SDL, ICL, Scottish Enterprise, Bellona, FZ Julich, SINTEF, Yara, Norcem, GeoEcomar, PicOil, CO2Club)

Industrial cluster/ region	Development priority in ALIGN	Existing appraised storage			Extended storage capacity to be identified in ALIGN
		Storage site	Capacity	Status	Target stores
North Rhine-Westphalia (GER)	Evaluate CCU as a multi-sector CO_2 mitigation option in the region	n/a	n/a	n/a	n/a
Grenland (NOR)	Advance engineering plans for an intermediate CO_2 surface storage facility capable of handling CO_2 from multiple sources	Smeaheia area	100 Mt	Feasibility study	Closures in the Sognefjord Sandstone and in deeper formations.
Oltenia Region (ROM)	Evaluate multi-modal CO_2 transportation routes and use in enhanced oil recovery with permanent storage	Deep saline aquifers within a 50km radius of Turceni	1.5 Mt/yr	Feasibility study	Potential storage sites in the Moesian Platform

WP5 Targeted CCUS activities in industrial clusters (TNO, BGS, TCVA, SDL, ICL, Scottish Enterprise, Bellona, FZ Julich, SINTEF, Yara, Norcem, GeoEcomar, PicOil, CO2Club)

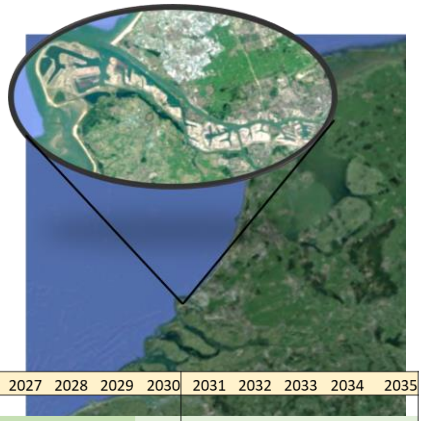
- 3 interconnecting sites covering chemicals, H_2 production, steel, gas processing, energy from waste, biomass power, and biofuels
- ~6 $MtCO_2$/yr, 6% UK industrial emissions
- €12 billion/yr / 25,000 jobs.

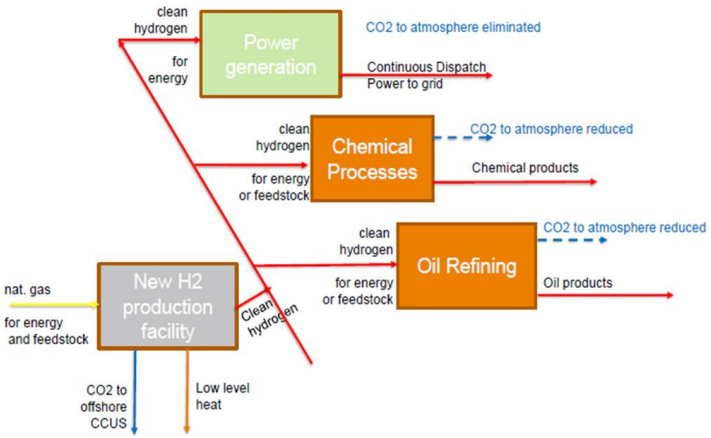




WP5 Targeted CCUS activities in industrial clusters (TNO, BGS, TCVA, SDL, ICL, Scottish Enterprise, Bellona, FZ Julich, SINTEF, Yara, Norcem, GeoEcomar, PicOil, CO2Club)

- 5 large refineries, H_2 production, (petro)chemicals (56 locations), waste-to-energy, coal and gas power generation
- ~ 30 $MtCO_2$ emitted per year
- 93,000 people directly/indirectly employed

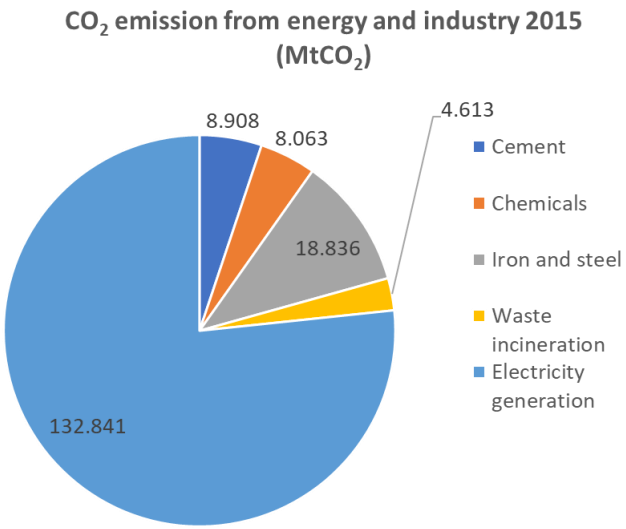


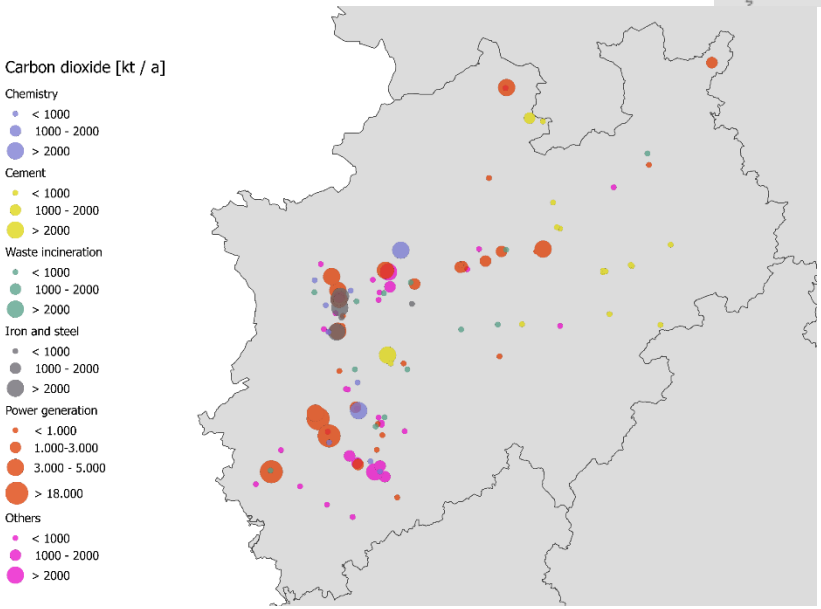


Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Available annual storage capacity (Mtpa)																
P18-a	2	2	2	2	2	2	2	2	2	2						
P18-b	1.1	1.1	1.1	1.1	1.1	1.1	1.1									
P15-a						1	1	1	1	1	1	1				
P15-b						1	1	1	1	1	1	1				
P15-c						0.7	0.7	0.7	0.7	0.7						
K15-a											3	3	3	3	3	3
K15-b															2	2
K15-c																3
K15-d																
K14-e																
K14-f																
Annual matched storage capacity (Mtpa)																
P18-a	2	2	2	2	2	2	2	2	2	2						
P18-b				0.4	0.8	1.1	1.1	1.1	1.1	1.1	1					
P15-a						0.1	0.3	0.7	0.6	1	1	1	1	1	0.3	
P15-b									0.5	0.5	1	1	1	1	1	1
P15-c											0.7	0.7	0.7	0.7	0.7	
K15-a											2	3	3	3	3	3
K15-b															2	2
K15-c																1
K15-d																
K14-e																
K14-f																
Annual matched storage capacity (Mtpa)	2	2	2	2.4	2.8	3.2	3.4	3.8	4.2	4.6	5.7	5.7	5.7	5.7	7	7
Cumulative matched storage volume (Mt)	2	4	6	8.4	11.2	14.4	17.8	21.6	25.8	30.4	36.1	41.8	47.5	53.2	60.2	67.2

WP5 Targeted CCUS activities in industrial clusters (TNO, BGS, TCVA, SDL, ICL, Scottish Enterprise, Bellona, FZ Julich, SINTEF, Yara, Norcem, GeoEcomar, PicOil, CO2Club)

- Heavily industrialised state, one-third of total German CO_2 emissions (~300 Mt/yr)
- No CO_2 storage permitted in many states
- CCU for low-carbon transport fuels
- LCA on climate impact of CCU ongoing



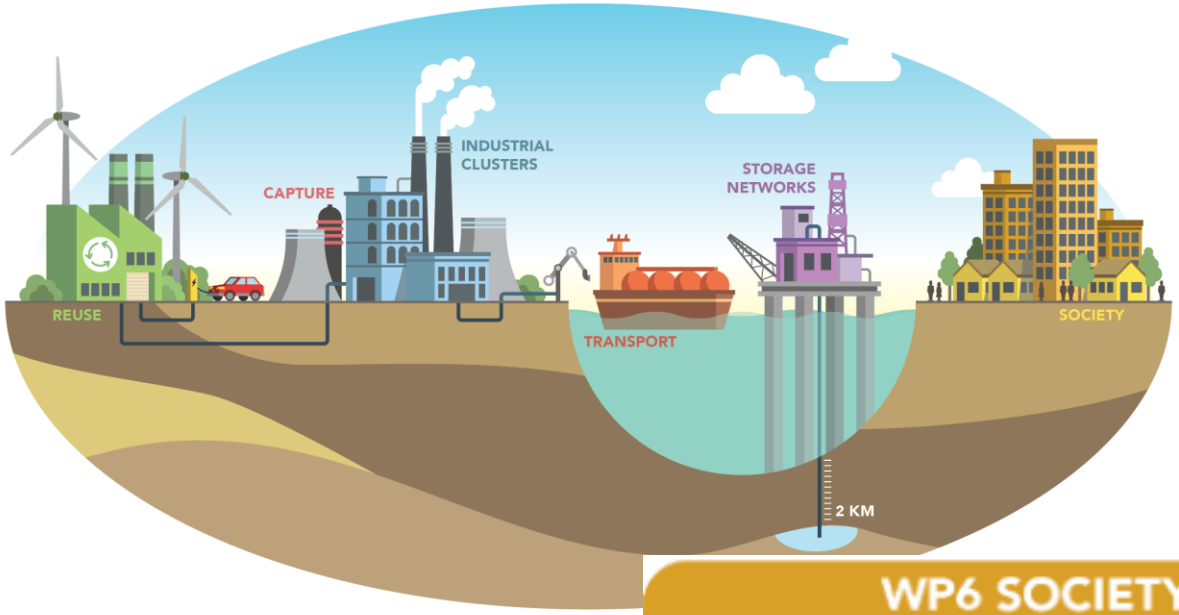


WP5 Future Work

- Include the other industrial areas.
- Take this results and the results from the other work packages and other (ACT) project to develop the actionable blueprints for decarbonisation.

WP	Key expected results	Impacts
WP5. Industrial clusters	Provide a set of actionable development plans for targeted CCUS activities in 6 key industrial clusters across the EU	Supports national and regional governments in decision-making for industrial decarbonisation strategies
	Develop commercial models for embryonic CO_2 cluster infrastructure using results from pilot-testing and optimisation modelling completed in ALIGN	Greater clarity on the expected investment requirements and benefits for public and private actors

Work Packages (WP6)



WP1 CAPTURE
- Emission control
- Solvent management
- Dynamics and control
- Cost reduction

WP2 TRANSP
- CO_2 shipping
- Batch-wise injection
- CO_2 specifications
- Planning for flexible ne

WP4 RE-USE
- CCU demonstrator construction
- Engine adaption
- Operation and testing
- CCU integration and scale-up

WP5 INDUSTRIAL C
- Teesside and Grangem
- Rotterdam (NL)
- North Rhine-Westphalia
- Grenland (NO)
- Oltenia region (RO)
- Commercial models for

WP6 SOCIETY
- Assessing public opinion
- Compensation strategies
- Improving EU dialogue on CCUS

WP6 Implementing CCUS in Society

(**LU**, UEDIN, ECN, FZ Julich, Bellona, NUPSPA)

- Coordination with other (ACT/H2020) research programs (**ELEGANCY, ACORN, ECOBASE, ENOS**)
- Seek cooperation on national level: PORTHOS (Port of Rotterdam CO2 Transport Hub & Offshore Storage)
- Informed representative polling in UK & NL: General public (proximity to industrial areas; place attachment, industry attitudes), Questionnaire & information in preparation

WP6 Implementing CCUS in Society

(**LU**, UEDIN, ECN, FZ Julich, Bellona, NUPSPA)

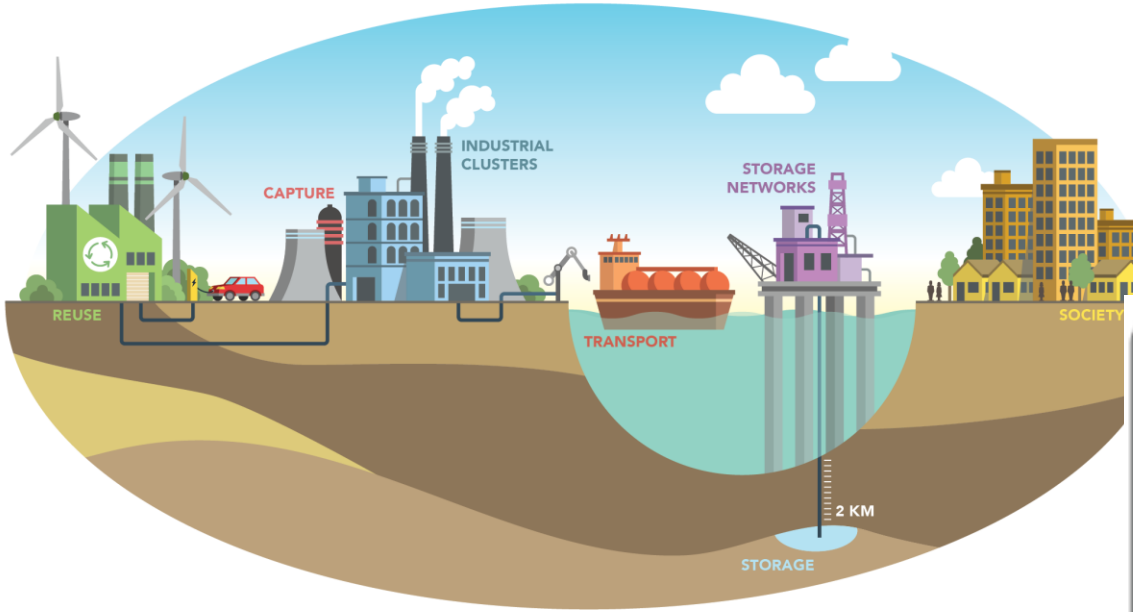
- Compensation schemes in different countries
  - desk-based review on compensation practices for subsurface activities, energy and infrastructure developments in EU and non-EU countries (review of scientific literature, projects, practices and policies): finalized, journal article in preparation.
- Identification of best practices and knowledge gaps (consultation/participation, compensation)
  - ~30 semi structured interviews with (non)CCUS stakeholders in NL, UK and RO. Interview protocol finalized: interviews October-December 2018, preliminary results expected in spring 2019
- Testing the effectiveness of compensation schemes
  - quantitative studies in NL, UK and RO to close knowledge gaps: study with students data collection finalized in April 2018; new (pilot) studies scheduled for spring 2019.

WP6 Future Work

- Stakeholder perceptions in different European countries
- Creating and testing new core messages

WP	Key expected results	Impacts
WP6. Society	Understanding of public and stakeholder perception concerning CCUS projects in industrial applications, including CO_2 utilisation	Provides tools for making site selection decisions and developing effective consultation and communication strategies
	Evidence-based insight in best practices regarding the use of compensation schemes for CCUS projects	The identified success factors and pitfalls support project developers and national governments in designing effective compensation strategies
	Development and testing of new communication materials for CCUS	Provides strategic elements for a dialogue with society about the need and necessity of CCUS

Work Packages (WP0)



WP1 CAPTURE
- Emission control
- Solvent management
- Dynamics and control
- Cost reduction

WP2 TRANSPORT
- CO_2 shipping
- Batch-wise injection
- CO_2 specifications
- Planning for flexible networks

WP3 STORAGE
- Standardizing storage readiness
- North sea storage appraisals
- Re-use of existing assets

WP4 RE-USE
- CCU demonstrator construction
- Engine adaption
- Operation and testing
- CCU integration and scale-up

WP5 INDUSTRIAL CLUSTERS
- Teesside and Grangemouth (UK)
- Rotterdam (NL)
- North Rhine-Westphalia (DE)
- Grenland (NO)
- Oltenia region (RO)
- Commercial models for CCUS clusters

WP6 SOCIETY
- Assessing public opinion
- Compensation strategies
- Improving EU dialogue on CCUS

WP0 MANAGEMENT

WP0 Management

(**TNO**, SINTEF, BGS, LU, NUPSPA, UEDIN-SCCS)

- Project management
  - No major deviations. Some (short) delays in reporting and shifts of milestones. All logically explainable without impact on overall progress.

WP0 Dissemination

(**TNO**, UEDIN-SCCS)

Twitter:

182 Followers
July 2.141 Impressions
August: 15.300 Impressions
September: 2.922 Impressions
October: 10.500 Impressions

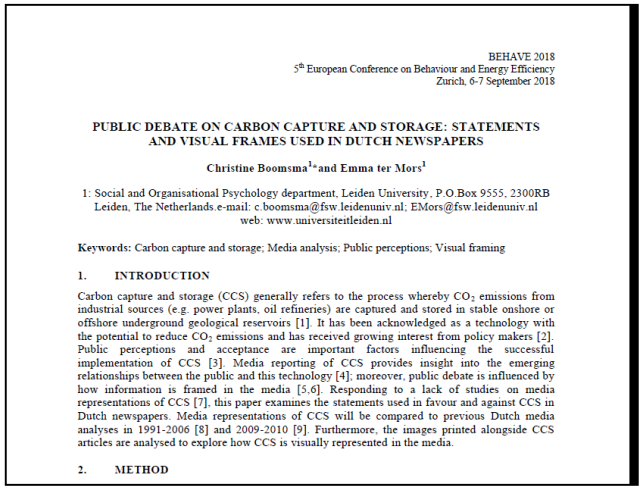
YouTube channel: 67 watches

Webinars

ALIGN-CCUS: Accelerating low-carbon industrial growth through CCUS
40 external participants
CCUS as an element for large-scale energy storage and conversion
29 external participants

WP0 Dissemination

(**TNO**, UEDIN-SCCS)



BEHAVE 2018
5th European Conference on Behaviour and Energy Efficiency
Zurich, 6-7 September 2018

PUBLIC DEBATE ON CARBON CAPTURE AND STORAGE: STATEMENTS AND VISUAL FRAMES USED IN DUTCH NEWSPAPERS

Christine Boomsma[1]*and Emma ter Mors[1]

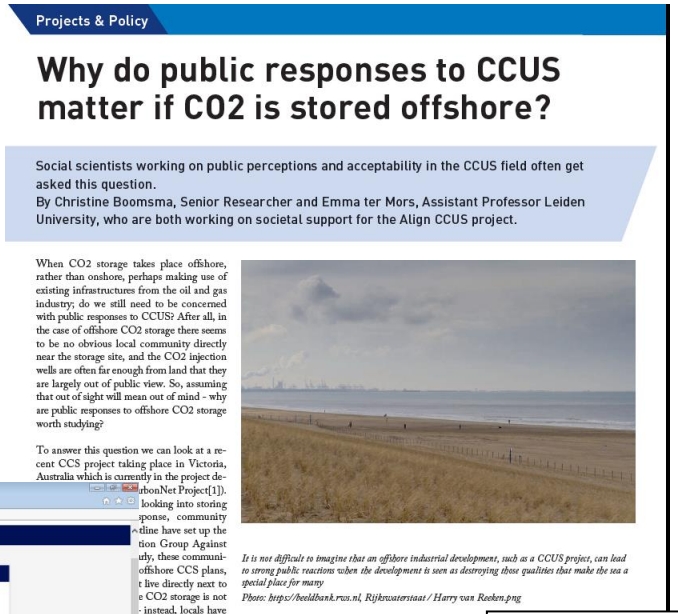
1: Social and Organisational Psychology department, Leiden University, P.O.Box 9555, 2300RB Leiden, The Netherlands.e-mail: c.boomsma@fsw.leidenuniv.nl; EMors@fsw.leidenuniv.nl
web: www.universiteitleiden.nl

Keywords: Carbon capture and storage; Media analysis; Public perceptions; Visual framing

1. INTRODUCTION

Carbon capture and storage (CCS) generally refers to the process whereby CO_2 emissions from industrial sources (e.g. power plants, oil refineries) are captured and stored in stable onshore or offshore underground geological reservoirs [1]. It has been acknowledged as a technology with the potential to reduce CO_2 emissions and has received growing interest from policy makers [2]. Public perceptions and acceptance are important factors influencing the successful implementation of CCS [3]. Media reporting of CCS provides insight into the emerging relationships between the public and this technology [4]; moreover, public debate is influenced by how information is framed in the media [5,6]. Responding to a lack of studies on media representations of CCS [7], this paper examines the statements used in favour and against CCS in Dutch newspapers. Media representations of CCS will be compared to previous Dutch media analyses in 1991-2006 [8] and 2009-2010 [9]. Furthermore, the images printed alongside CCS articles are analysed to explore how CCS is visually represented in the media.

2. METHOD



Projects & Policy

Why do public responses to CCUS matter if CO2 is stored offshore?

Social scientists working on public perceptions and acceptability in the CCUS field often get asked this question.
By Christine Boomsma, Senior Researcher and Emma ter Mors, Assistant Professor Leiden University, who are both working on societal support for the Align CCUS project.

When CO2 storage takes place offshore, rather than onshore, perhaps making use of existing infrastructures from the oil and gas industry; do we still need to be concerned with public responses to CCUS? After all, in the case of offshore CO2 storage there seems to be no obvious local community directly near the storage site, and the CO2 injection wells are often far enough from land that they are largely out of public view. So, assuming that out of sight will mean out of mind - why are public responses to offshore CO2 storage worth studying?

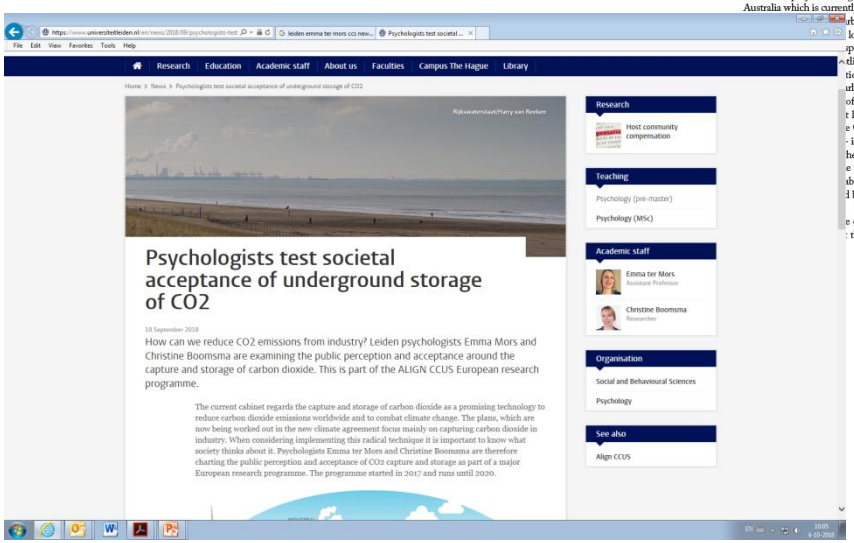
To answer this question we can look at a recent CCS project taking place in Victoria, Australia which is currently in the project de- ...arbonNet Project[1]). ...looking into storing ...sponse, community ...tline have set up the ...tion Group Against ...uly, these communi- ...offshore CCS plans, ...t live directly next to ...e CO2 storage is not ... instead, locals have ...he effects that CO2 ...e 'pristine' environ- ...about the level of in- ...d by the government.

...e of public responses ... there is evidence to

It is not difficult to imagine that an offshore industrial development, such as a CCUS project, can lead to strong public reactions when the development is seen as destroying those qualities that make the sea a special place for many
Photo: https://beeldbank.rws.nl, Rijkswaterstaat / Harry van Reeken.png

There is no evidence for an universal preference for offshore developments over onshore developments[4]

among th... regions w... age optio...



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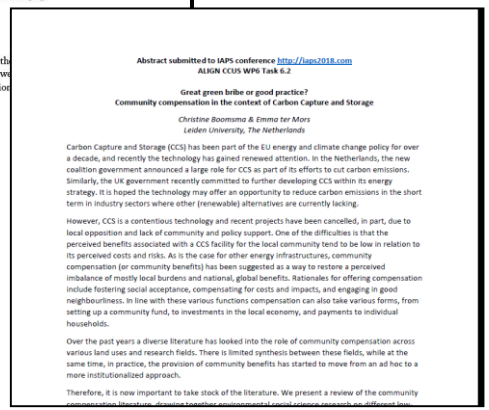
Psychologists test societal acceptance of underground storage of CO2

18 September 2018

How can we reduce CO2 emissions from industry? Leiden psychologists Emma Mors and Christine Boomsma are examining the public perception and acceptance around the capture and storage of carbon dioxide. This is part of the ALIGN CCUS European research programme.

The current cabinet regards the capture and storage of carbon dioxide as a promising technology to reduce carbon dioxide emissions worldwide and to combat climate change. The plans, which are now being worked out in the new climate agreement focus mainly on capturing carbon dioxide in industry. When considering implementing this radical technique it is important to know what society thinks about it. Psychologists Emma ter Mors and Christine Boomsma are therefore charting the public perception and acceptance of CO2 capture and storage as part of a major European research programme. The programme started in 2017 and runs until 2020.

Research: Host community compensation
Teaching: Psychology (pre-master), Psychology (MSc)
Academic staff: Emma ter Mors, Assistant Professor; Christine Boomsma, Researcher
Organisation: Social and Behavioural Sciences, Psychology
See also: Align CCUS



Abstract submitted to IAPS conference http://iaps2018.com
ALIGN CCUS WP6 Task 6.2

Great green bribe or good practice?
Community compensation in the context of Carbon Capture and Storage

Christine Boomsma & Emma ter Mors
Leiden University, The Netherlands

Carbon Capture and Storage (CCS) has been part of the EU energy and climate change policy for over a decade, and recently the technology has gained renewed attention. In the Netherlands, the new coalition government announced a large role for CCS as part of its efforts to cut carbon emissions. Similarly, the UK government recently committed to further developing CCS within its energy strategy. It is hoped the technology may offer an opportunity to reduce carbon emissions in the short term in industry sectors where other (renewable) alternatives are currently lacking.

However, CCS is a contentious technology and recent projects have been cancelled, in part, due to local opposition and lack of community and policy support. One of the difficulties is that the perceived benefits associated with a CCS facility for the local community tend to be low in relation to its perceived costs and risks. As is the case for other energy infrastructures, community compensation (or community benefits) has been suggested as a way to restore a perceived imbalance of mostly local burdens and national, global benefits. Rationales for offering compensation include fostering social acceptance, compensating for costs and impacts, and engaging in good neighbourliness. In line with these various functions compensation can also take various forms, from setting up a community fund, to investments in the local economy, and payments to individual households.

Over the past years a diverse literature has looked into the role of community compensation across various land uses and research fields. There is limited synthesis between these fields, while at the same time, in practice, the provision of community benefits has started to move from an ad hoc to a more institutionalized approach.

Therefore, it is now important to take stock of the literature. We present a review of the community

WP0 Management and Dissemination

(**TNO**, UEDIN-SCCS)

ghgt-14

14th International Conference on Greenhouse Gas Control Technologies

October 21 - 25 2018

Melbourne Convention Centre - Melbourne, Australia

Oral presentation

Session 7E - Electro- and Thermochemical Conversions

Oct 24, 2018

9:10 AM - 10:50 AM

Eureka 2

ghgt-14

14th International Conference on Greenhouse Gas Control Technologies, GHGT-14

21st -25th October 2018, Melbourne, Australia

Demonstrating the CCU-chain and sector coupling as part of ALIGN-CCUS – Dimethyl ether from CO_2 as chemical energy storage, fuel and feedstock for industries

Peter Moser[a]*, Georg Wiechers[a], Sandra Schmidt[a], Knut Stahl[a], Muhammad Majid[b], Sven Bosser[b], Arthur Heberle[b], Hiroshi Kakihara[c], Mutsuhiro Maruyama[c], Ralf Peters[d], Stefan Weiske[d], Petra Zapp[d], Stefanie Troy[d], Bastian Lehrheuer[e], Marcel Neumann[e], Sharareh Schaub[f], Jaap Vente[g], Jean-Pierre Pieterse[g], Jurriaan Boon[g], Earl Goetheer[g]

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[b]Mitsubishi Hitachi Power Systems Europe GmbH, Schiffbauerstraße 38, 47059 Duisburg, Germany
[c]Asahi Kasei Europe GmbH, An Seestern 4, 40547 Düsseldorf, Germany
[d]Forschungszentrum Jülich GmbH, IEK-3 and IEK-STE, 52425 Jülich, Germany
[e]VKA, RWTH Aachen University, Forckenbeckstraße 4, 52074 Aachen, Germany
[f]KEY Europe GmbH, Neuenhofstraße 181, 52078 Aachen, Germany
[g]TNO, Leeghwaterstraat 44, 2628 CA Delft, The Netherlands

Abstract

In the ALIGN-CCUS project a full CCU-chain will be demonstrated as an element for large-scale energy storage together with CO_2 conversion and CCU-fuel usage as a promising blue print for sector coupling. The demonstration comprises: amine-based CO_2 post-combustion capture, liquefaction and storage processes at the lignite fired power plant at Niederaussem (liquefied CO_2 processes 16.5 bar(a) - 17.5 bar(a), temperature -28.5 °C), an alkaline water-electrolyser unit (140 kW_{el}, specific power consumption 4.5 kWh/m_n^3 H_2 at 1.0 A/cm²), to split water into hydrogen and oxygen, and an one-step methanol/dimethyl ether (DME) synthesis unit (approx. 50 kg DME/day from 180 kg CO_2/day). A diesel engine of a stationary power generator (240 kW_{el}) will be adapted to the use of DME to demonstrate peak and back-up power production in the energy sector. Additionally a passenger car will be modified for the utilization of synthetic dimethyl ether (DME$_s$), a diesel substitute for the transport sector that could be produced out of the CCU here chemically methanol and DME. Based on real data from the demonstration plant the integration costs and environmental benefits of the CCU-chain technology are evaluated and optimized by a techno-economic-ecological assessment. A promising optimization measure for the synthesis process is the in-situ removal of water in the reversed water-gas shift reaction to increase efficiency and yield. For the application of DME as a fuel for peak- and back-up power production an optimized concept for the integration of the power generator into the existing power plant infrastructure will be developed.

Keywords: CCU, sector coupling, dimethyl ether, DME, synthetic dimethyl ether, DME_s, chemical energy storage

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E-mail address: peter.moser@rwe.com

50. KRAFTWERKSTECHNISCHES KOLLOQUIUM

VORANKÜNDIGUNG 2018

23. und 24. Oktober 2018
Internationales Congress Center Dresden
Ostra-Ufer 2 | 01067 Dresden | www.kraftwerkskolloquium.de

Schirmherrschaft
Martin Dulig, Sächsischer Staatsminister für Wirtschaft, Arbeit und Verkehr und stellvertretender Ministerpräsident

Wissenschaftliche Leitung
Professor Dr.-Ing. Michael Beckmann, Technische Universität Dresden
Professor Dr.-Ing. habil. Antonio Hurtado, Technische Universität Dresden

Beirat
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Dipl.-Ing. Rainer Block, TÜV SÜD Division Industry Service, München
Dipl.-Ing. Britta Dassler, Quarzy GmbH & Co. KG, Burgwedel
Dipl.-Verwaltungswirt (FH) Erich Fritz, SACHSA Sanierungsverwaltungs- und -verwertungsgesellschaft mbH, Freiberg
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Hans-Joachim Polk, VKU AG, Vorstand Infrastruktur/Technik, Leipzig
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Professor Dr. Thomas Thiemann, Siemens AG, Mülheim an der Ruhr
Professor Dr. Andrea Vertlieb, ar – Andrea Vertlieb Rechtsanwälte, Berlin
Dipl.-Ing. (FH) Roland Zepeck, IBO International Business Development, Freising

TECHNISCHE UNIVERSITÄT DRESDEN

Oral presentation

Tuesday, 23rd October 2018

Conference room 2/3
System Integration I
Session Chair: Professor Dr.-Ing. habil. Klaus Görner, Universität Duisburg-Essen, Essen

04.10 pm Novel ancillary services: extended island operation capability using thermal power plants
Dr.-Ing. Gunnar Lübning, Florian Wenzel, M.Eng., Dipl.-Ing. Dietmar Hanke, Dipl.-Ech. techn. Hans Melkow, Lausitz Energie Kraftwerke AG, Cottbus

04.45 pm Flexibilization of a natural gas power plant by integration of methanol synthesis
Dipl.-Ing. Florian Mellenbruch, Mike Dressler, M.Sc., Dr.-Ing. Gerd Oeljeklaus, Prof. Dr.-Ing. habil. Klaus Görner, Universität Duisburg-Essen, Essen

05.10 pm Boundary conditions for power-to-MeOH applied on flexible power consumption process, battery, grid-connected system
Dipl.-Ing. (FH), Dipl.-Ok. Christian Schwalbe, Robert Hensel, Stan Wanik, Ibe Engineering Leipzig GmbH

05.45 pm ALIGN-CCUS: Diesel fuel substitute DME from separated CO_2 from the Niederaussem power plant
Dr. rer. nat. Peter Moser, Dipl.-Ing. Georg Wiechers, Dr.-Ing. Sandra Schmidt, Dipl.-Ing. Knut Stahl, RWE Power AG, Essen | Dr.-Ing. Muhammad Majid, Dr.-Ing. Arthur Heberle, Mitsubishi Hitachi Power Systems Europe GmbH, Duisburg
Hiroshi Kakihara, M.Sc., Dr. rer. nat. Mutsuhiro Maruyama, Asahi Kasei Europe GmbH, Düsseldorf
Prof. Dr.-Ing. Ralf Peters, Stefan Weiske, M.Sc., Dr.-Ing. Petra Zapp, Dr.-Ing. Stefanie Troy, Forschungszentrum Jülich GmbH
Marcel Neumann, M.Sc., Dipl.-Ing. Bastian Lehrheuer, VKA, RWTH Aachen
Dr.-Ing. Sharareh Schaub, Dr.-Ing. Thorsten Schnorbus, KEY Europe GmbH, Aachen

06.15 pm End of lecture

ALIGN-CCUS: Dieselersatztreibstoff DME aus abgetrenntem CO_2 des Kraftwerks Niederaußem

ALIGN-CCUS: Dieselersatztreibstoff DME aus abgetrenntem CO_2 des Kraftwerks Niederaußem

Peter Moser, Georg Wiechers, Sandra Schmidt, Knut Stahl, Muhammad Majid, Arthur Heberle, Hiroshi Kakihara, Shinji Hasegawa, Mutsuhiro Maruyama, Ralf Peters, Stefan Weiske, Petra Zapp, Stefanie Troy, Marcel Neumann, Bastian Lehrheuer, Sharareh Schaub und Thorsten Schnorbus

1. Einleitung

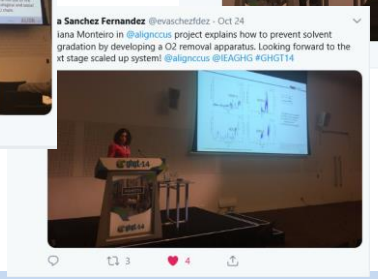
Das europäisch und national geförderte ALIGN-CCUS-Projekt vereint 31 Forschungsinstitute und Industrieunternehmen aus fünf Ländern mit dem gemeinsamen Ziel, den schnellen und kosteneffektiven Einsatz von CO_2-Abscheidung, -Nutzung und -Speicherung zu unterstützen.

1

WP0 Dissemination

(**TNO**, UEDIN-SCCS)

#	Abstract	Oral / Poster
1	Van Os P, Kvamsdal H, Haugen HA, Akhurst M, Moser P, Mikunda T, ter Mors E, ALIGN CCUS: an ERA ACT project on the full CCUS chain to accelerate implementation of decarbonisation in industrial areas *(ALIGN-CCUS, overall)*	Poster
2	Akhurst M, Bentham M, Kirk K, Neele F, Grimstad, A-A, Steps to achieve storage readiness for European industrial CO_2 source clusters, ALIGN-CCUS (*ALIGN-CCUS WP3.1)*	Oral
3	Neele F, Gittins C, Wildenborg T, Mikunda T, Initiating large-scale storage in the Netherlands offshore (*ALIGN-CCUS WP3.2)*	Oral
4	Mikunda T, Neele F, Akhurst M, Pearce J, Skagestad R, Morgenthaler S, Sava CS, Maver M, Targeted CCUS R&D activities in industrial clusters (*ALIGN-CCUS WP5)*	Oral
5	Juliana Monteiro, Isabella Stellwag, Martin Mohana, Arjen Huizinga, Purvil Khakharia, Peter van Os, Earl Goetheer, De-oxygenation as countermeasure for the reduction of oxidative degradation of CO_2 capture solvents	Oral
6	Purvil Khakharia, Arjen Huizinga, Henk Trap, Juliana Monteiro, Earl Goetheer, Lab scale investigation on the formation of aerosol nuclei by a Wet Electrostatic Precipitator in the presence of SO_3 in a gas stream	Poster
7	Purvil Khakharia, Shreyas Harsha, Arjen Huizinga, Juliana Monteiro, Earl Goetheer, In-situ experimental investigation on the growth of aerosols along the absorption column in PCCC	Oral
8	Julia Barrio, Susana Garcia, M. Mercedes Maroto-Valer, Earl Goetheer, Purvil Khakharia, Juliana Garcia Moretz-Sohn Monteiro, Peter Moser, Georg Wiechers and Eva Sanchez Fernandez, Impact of transient operation on amine emissions at the Niederaussem capture plant.	Poster
9	Peter Moser, Georg Wiechers, Sandra Schmidt, Knut Stahl, Muhammad Majid, Sven Bosser, Arthur Heberle, Hiroshi Kakihira, Mutsuhiro Maruyama, Ralf Peters, Stefan Weiske, Petra Zapp, Stefanie Troy, Bastian Lehrheuer, Benedikt Heuser, Thorsten Schnorbus, Jaap Vente, Jean-Pierre Pieterse, Earl Goetheer, Demonstrating the CCU-Chain and Sector Coupling as Part of ALIGN-CCUS - Dimethylether from CO_2 as chemical Energy Storage, Fuel and Feedstock for Industries	Oral
10	Peter Moser, Georg Wiechers, Sandra Schmidt, Reinhold Elsen, Earl Goetheer, Purvil Khakharia, Juliana Garcia Moretz-Sohn Monteiro, Klaus-Joachim Jens, Kjell-Arne Solli, Eva Sanchez Fernandez, Susana Garcia, Mercedes Maroto-Valer, Julia Barrio, Hanne Marie Kvamsdal MEA consumption – ALIGN-CCUS: Comparative long-term testing to answer the open questions	Poster
11	Ardi Hartono, Hammad Majeed, Andrew Tobiessen, Hallvard F Svendsen and Hanna K Knuutila. Aerosol growth in an absorber for a post combustion CO2 capture using the 2-Amino-2-methyl-1-propanol/ Piperazine (CESAR 1) solvent	Poster
12	Kjell-Arne Solli, Lars Erik Øi Electrochemical Corrosion Measurements of MEA aqueous solutions at elevated temperatures	Oral



WP0 Dissemination

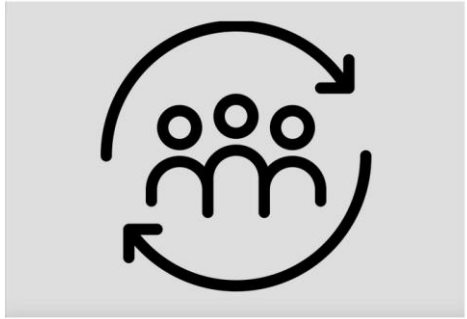
(**TNO**, UEDIN-SCCS)

26 JUN

VIDEO: Capturing a low-carbon future – behind the scenes at PACT

14 MAY

BLOG: Pooling European learning and expertise to protect our atmosphere



By Dr Maxine Akhurst

Maxine Akhurst is a research geoscientist at British Geological Survey (BGS) in Edinburgh and leader of CO2 storage research in the ALIGN-CCUS project. She recently hosted the second technical meeting for the project at the BGS offices in Edinburgh.

29 AUG

Expert interview: Could legal issues prevent North sea oil & gas infrastructure being reused for CO2 storage?

Interview with Joris Gazendam LL.M (left) of Groningen Centre of Energy Law, University of Groningen. Main photo: Kjetil Alsvik/Equinor

By Tom Mikunda, TNO

15 AUG

BLOG: Why do public responses to CCUS matter if CO2 is stored offshore?

By Christine Boomsma, Senior Researcher, WP 6 (Task 6.2 Lead) and Emma ter Mors, Assistant Professor, WP6 Lead, both Leiden University

28 MAR

ALIGN innovation: can methanol-based synthetic fuels drive an energy revolution?

Interview with Prof. Dr. Ralf Peters (left), Head Fuel Processing and Systems, Forschungszentrum Jülich.

By Tom Mikunda, TNO

#ENERGY ENERGY SYSTEMS

ELEGANCY collaboration with ALIGN-CCUS 'sister' Accelerating CCS Technologies (ACT) project

BY SINTEF
AUGUST 21, 2018

COMMENTS
0

Guestblogger: Maxine Akhurst, British Geological Survey, lead of UK case study, ELEGANCY

ALIGN CCUS Outreach

www.alignccus.eu

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ALIGN-CCUS

Acknowledgements

ACT ALIGN CCUS Project No 271501

This project has received funding from RVO (NL), FZJ/PtJ (DE), Gassnova (NO), UEFISCDI (RO), BEIS (UK) and is cofunded by the European Commission under the Horizon 2020 programme ACT, Grant Agreement No 691712

www.alignccus.eu