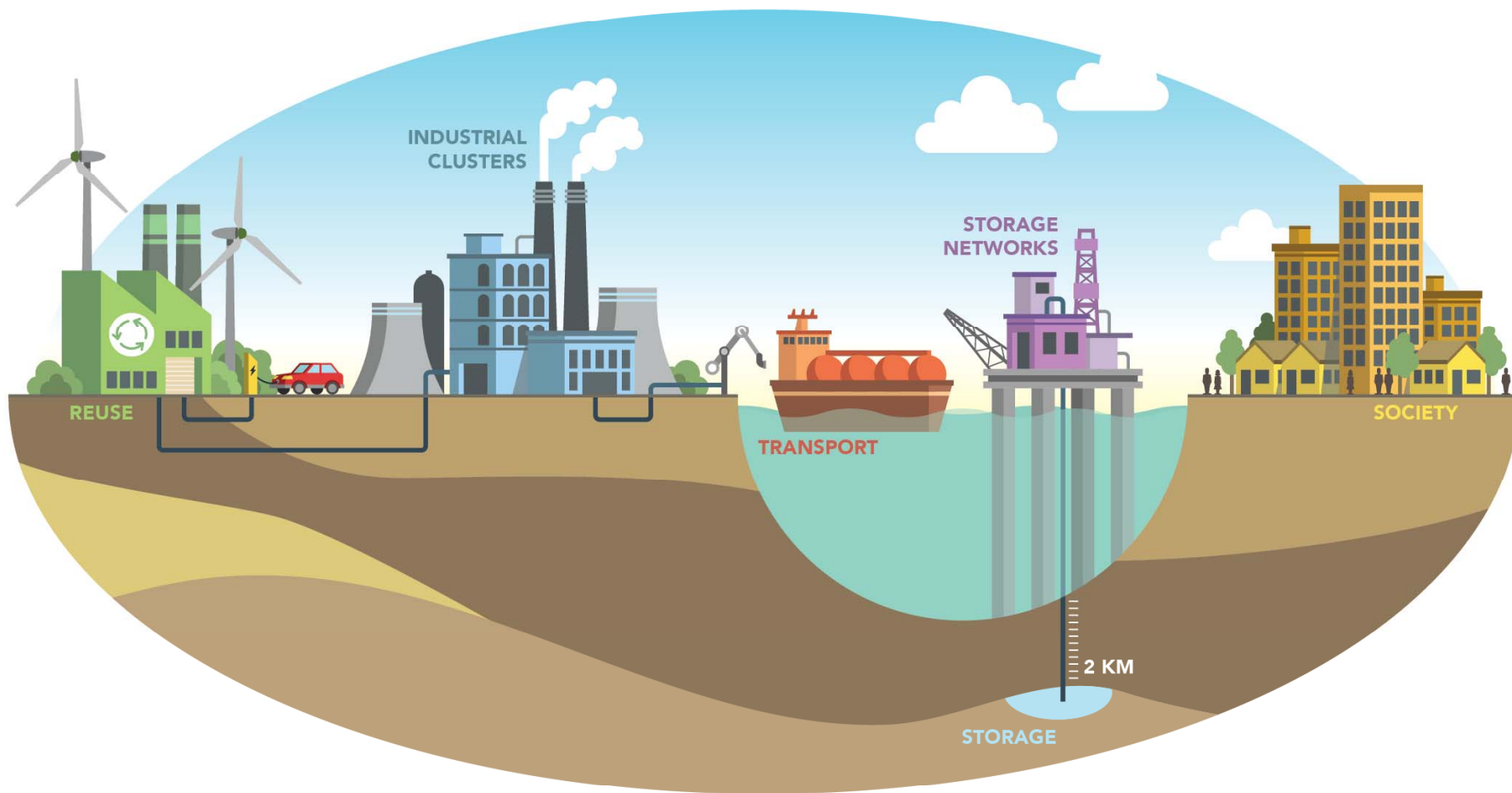


ALIGN ← CCUS



Carbon
Sequestration
Leadership
Forum



Peter van Os, TNO, Project Coordinator

Presentation at CSLF meeting by Constantin Sava, GeoEcoMar, Romania, Project Partner

ALIGN CCUS

Accelerating Low Carbon Industrial Growth through CCUS 'ALIGN-CCUS'

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 CO₂ capture by improving performance and reducing costs
 - **Transport:** Optimising large-scale CO₂ 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

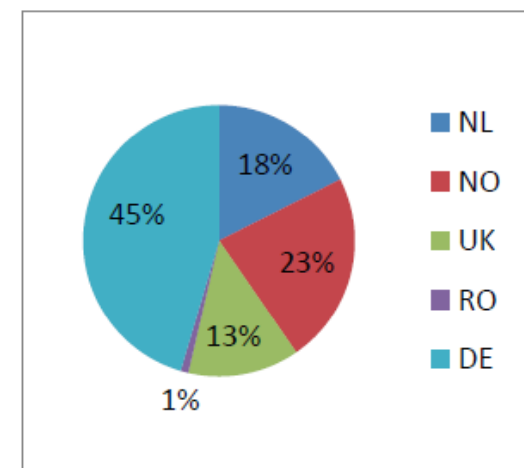
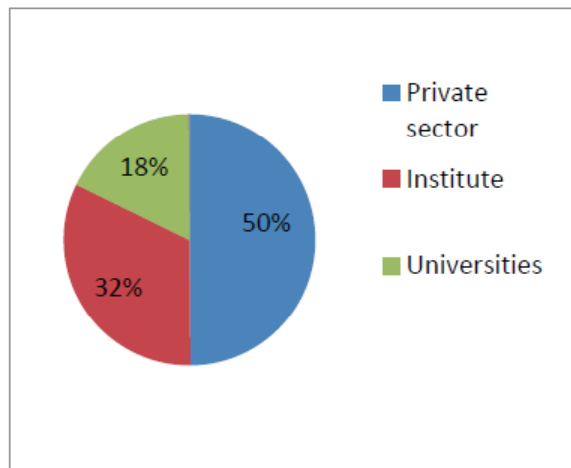
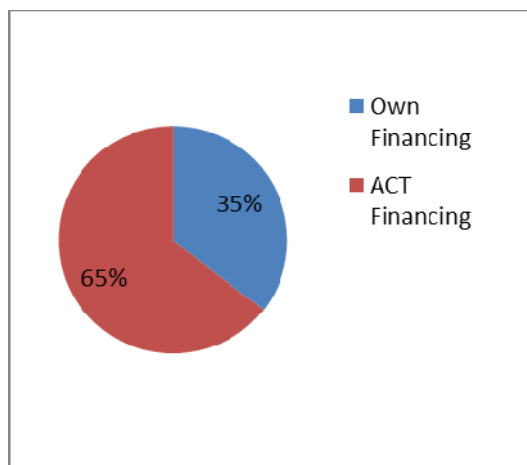
Objectives (2)

- 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 CO₂).



Key Figures

- 31 partners in the project from Germany, Norway, Romania, United Kingdom, The Netherlands
- ~23 Million Euro project budget, ~15 Million Funding
- September 1st 2017 until September 1st 2020
- Budget division as below



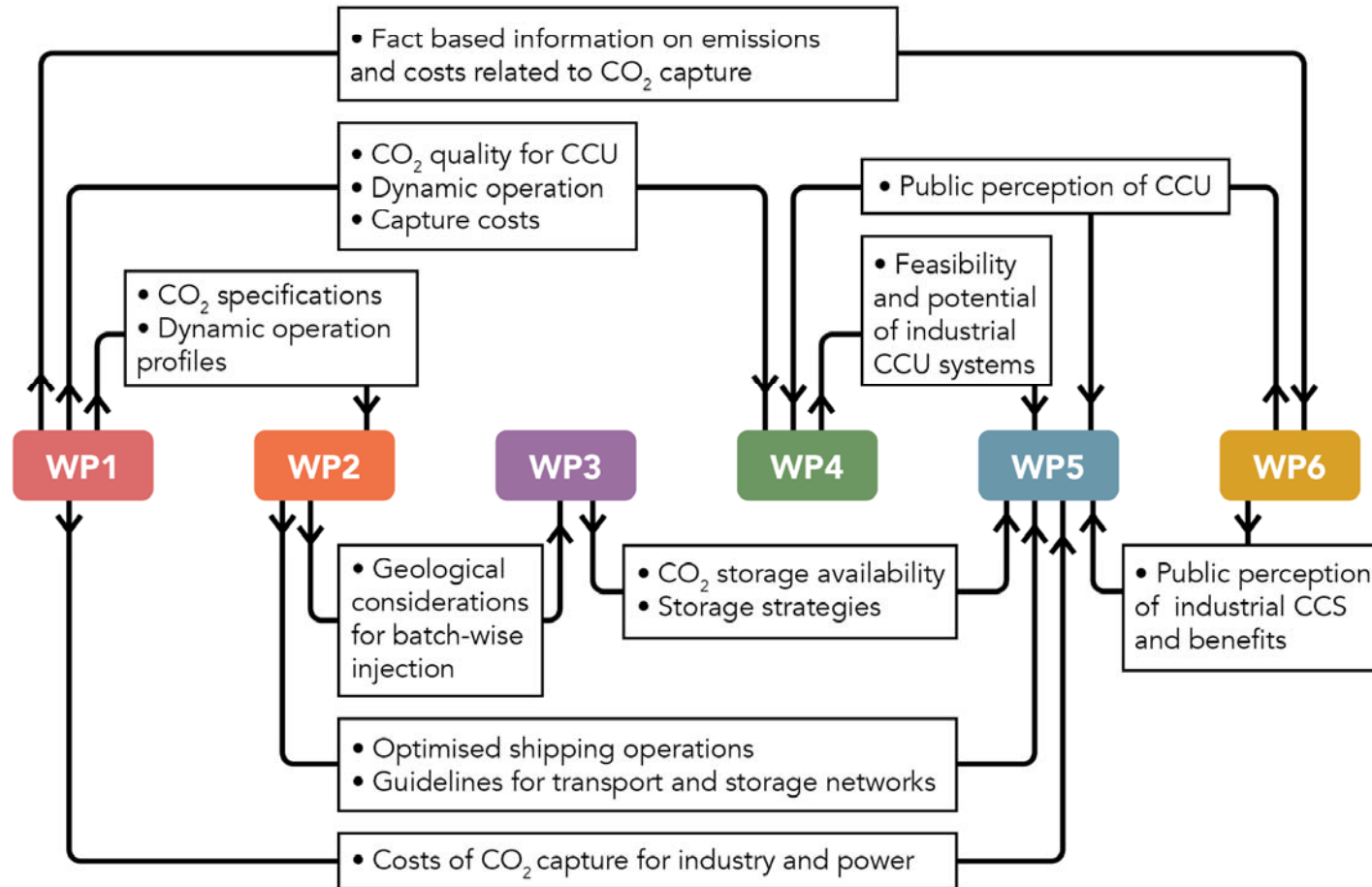
ALIGN CCUS

- Testing at world-class research facilities
- Multidisciplinary research teams
- Exceptional industrial commitment
- Demonstration of FOAK full-CCU chain
- Accessible and inclusive dissemination plan
- Links to Industry (IAG) and Australia (CSIRO)

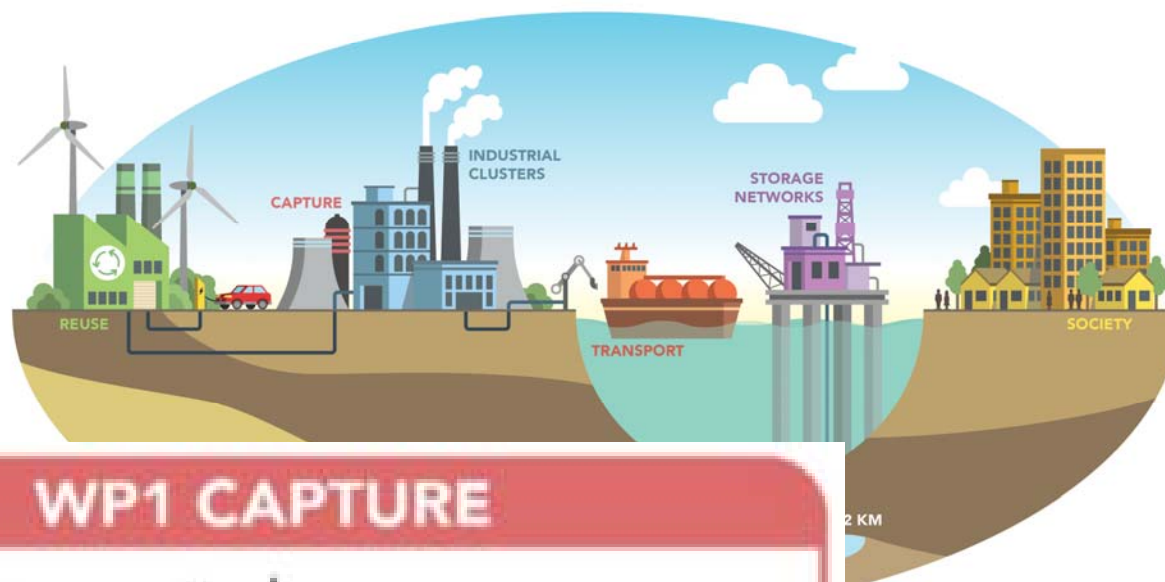
Project partners

Name	Short name	Country
Nederlandse Organisatie voor toegepast natuurwetenschappelijk Onderzoek TNO, the Coordinator	TNO or the Coordinator	The Netherlands
Name	Short name	Country
Stifelsen SINTEF by its institute Materials and Chemistry (WP1 coordinator)	SINTEF M&C	Norway
Tel-Tek (WP2 coordinator)	Tel-Tek	Norway
Natural Environment Research Council, as represented by the British Geological Survey (WP3 coordinator)	BGS	United Kingdom
RWE Generation (WP4 coordinator)	RWE	Germany
University of Leiden (WP6 coordinator)	UL	The Netherlands
Asahi Kasei Europe GmbH	AKAEU	Germany
Bellona	BELLONA	Norway
CO2 Club Association	CO2CA	Romania
Energy Research Centre of the Netherlands	ECN	The Netherlands
FEV Europe GmbH	FEV	Germany
Forschungszentrum Juelich GmbH	Jeulich	Germany
GeoEcomar	GeoEcomar	Romania
Heriot-Watt University	HWU	United Kingdom
Institute for Energy Technology, IFE	IFE	Norway
Imperial College of Science Technology and Medicine	ICL	United Kingdom
Mitsubishi Hitachi Power Systems Europe GmbH	MHPS	Germany
NORCEM AS / Heidelberg Cement	NORCEM	Norway
Norwegian University of Science and Technology	NTNU	Norway
National University of Political Studies & Public Administration	SNSPA	Romania
PicOil Info Consult	PicOil	Romania
Rijksuniversiteit Groningen	RUG	The Netherlands
RWTH Aachen University for its Institute for Combustion Engines represented by the Rector or a person commissioned thereby, Templergraben 55, 52062 Aachen, Germany	RWTH	Germany
Scottish Enterprise as an agency of The Scottish Government	SEP	United Kingdom
SINTEF Petroleum AS	SINTEF PR	Norway
TAQA Energy B.V.	TAQA	The Netherlands
Technology Centre Mongstad	TCM	Norway
Tees Valley Combined Authority	TVCA	United Kingdom
University of Edinburgh	UnivEdin	United Kingdom
University of Sheffield	UnivShef	United Kingdom
Yara International ASA	YARA	Norway

Well integrated



Work Packages (WP1)



WP1 CAPTURE

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

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

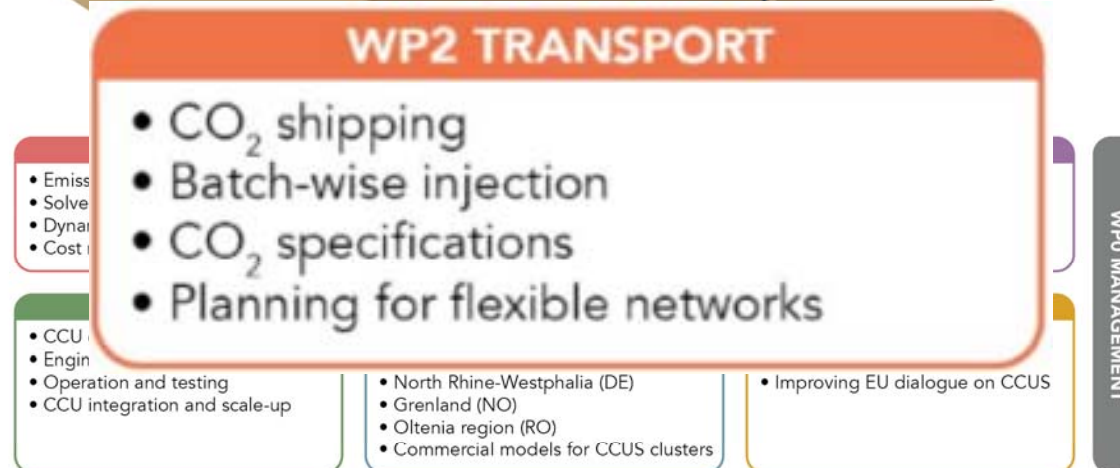
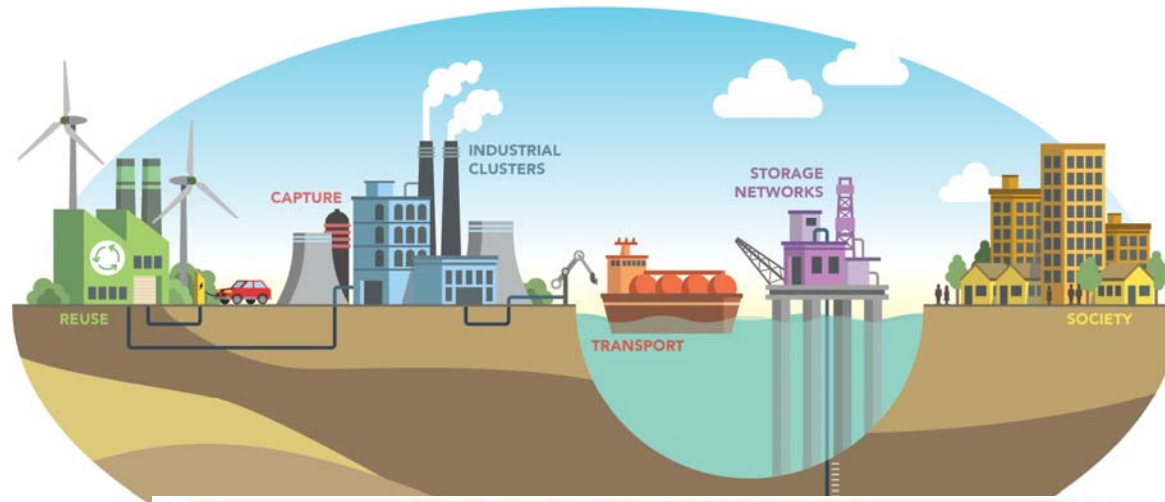
WPO MANAGEMENT

Commercial models for CCUS clusters

WP1 Key expected results

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.

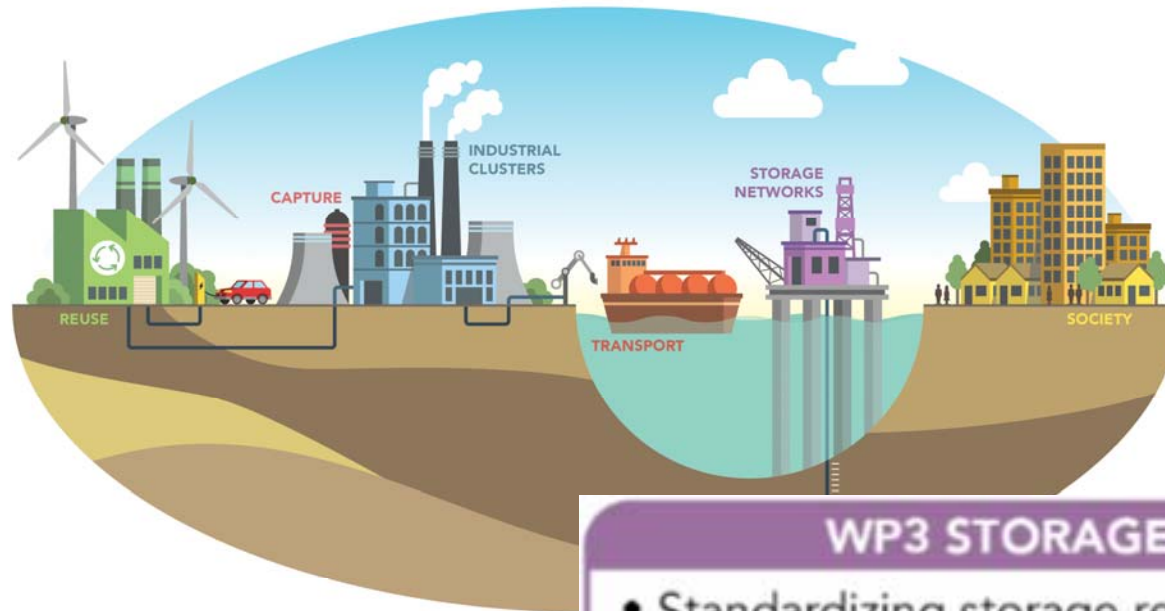
Work Packages (WP2)



WP2 Key expected results

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)



WP1 CAPTURE

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

WP2 TRANSPORT

- CO₂ shipping
- Batch-wise injection
- CO₂ specifications
- Planning for fleet

WP4 RE-USE

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

WP5 INDUSTRIAL CLUSTERS

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

WP3 STORAGE

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

WP6 POLICY AND REGULATION

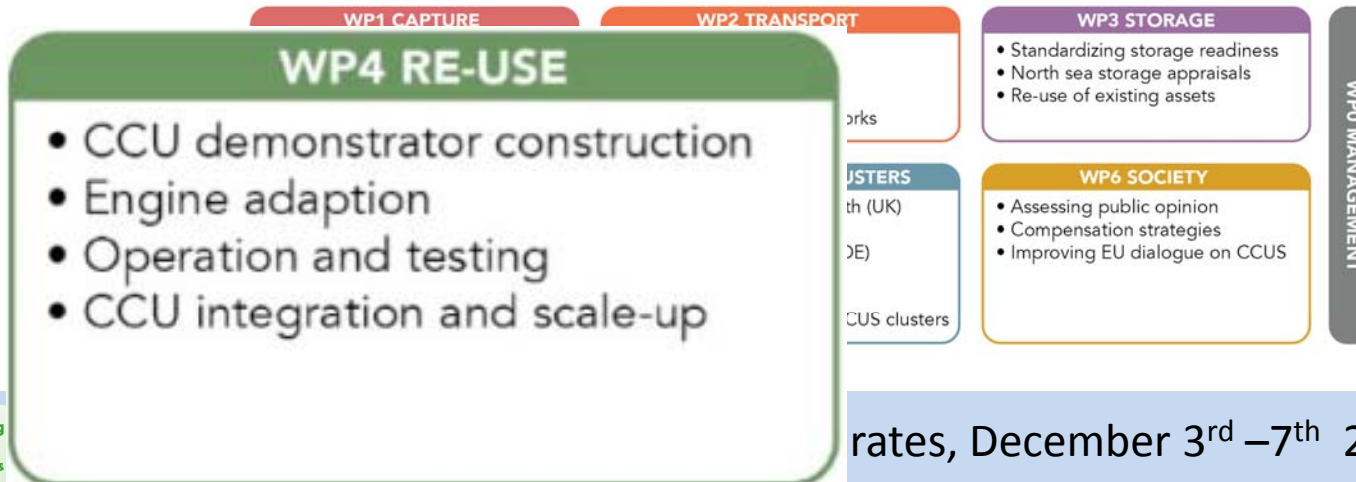
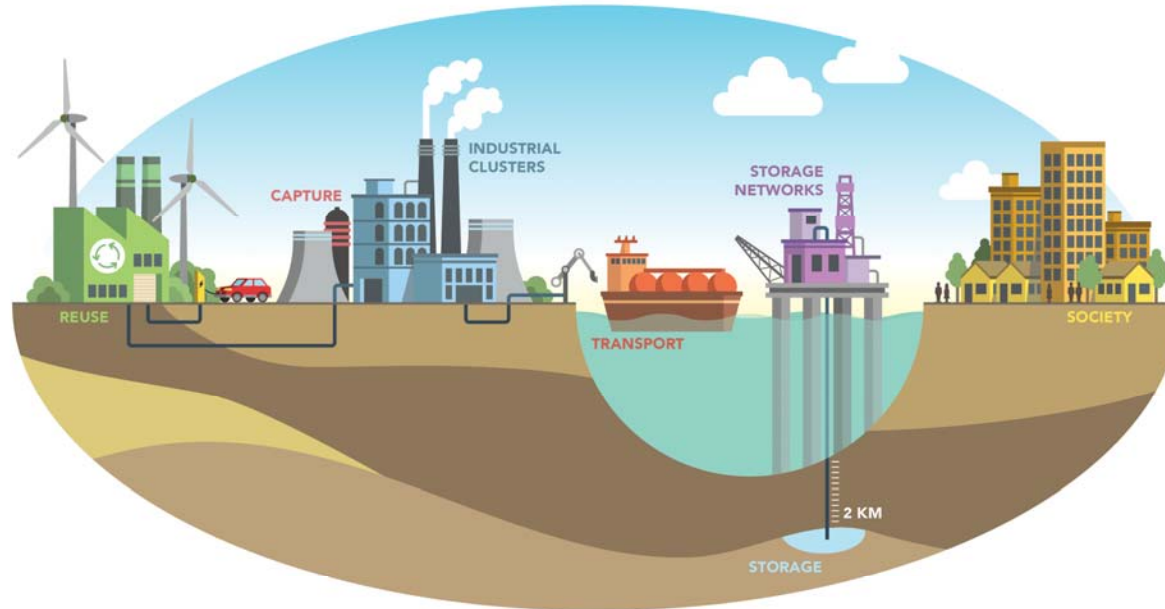
- Compensation strategies
- Improving EU dialogue on CCUS

MENT

WP3 Key expected results

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.

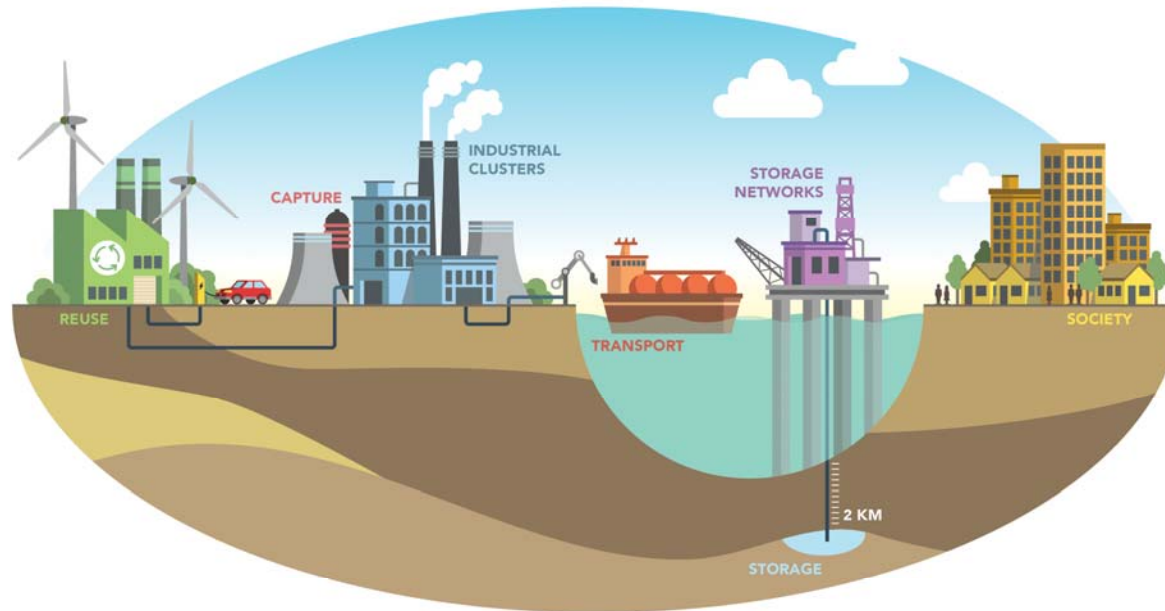
Work Packages (WP4)



WP4 Key expected results

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.

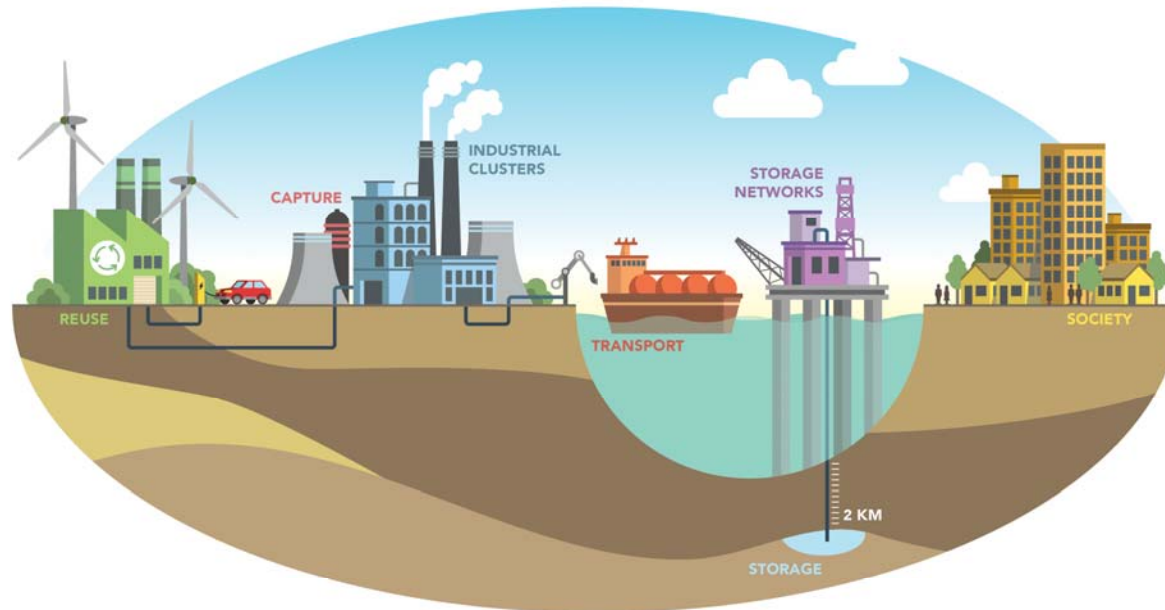
Work Packages (WP5)



WP5 Key expected results

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

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

- WP2 TRANSPORT**
- CO₂ shipping
 - Batch-wise injection
 - CO₂ specifications
 - Planning for flexible

- WP5 INDUSTRIAL**
- Teesside and Grand
 - Rotterdam (NL)
 - North Rhine-Westphalia
 - Grenland (NO)
 - Oltenia region (RO)
 - Commercial model

- WP3 STORAGE**

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

WP6 Key expected results

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

ALIGN CCUS Outreach



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ALIGN-CCUS

Acknowledgements

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