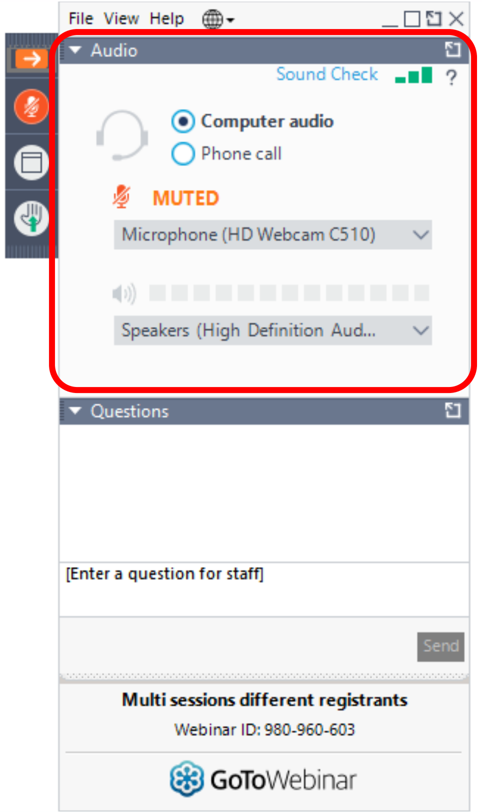
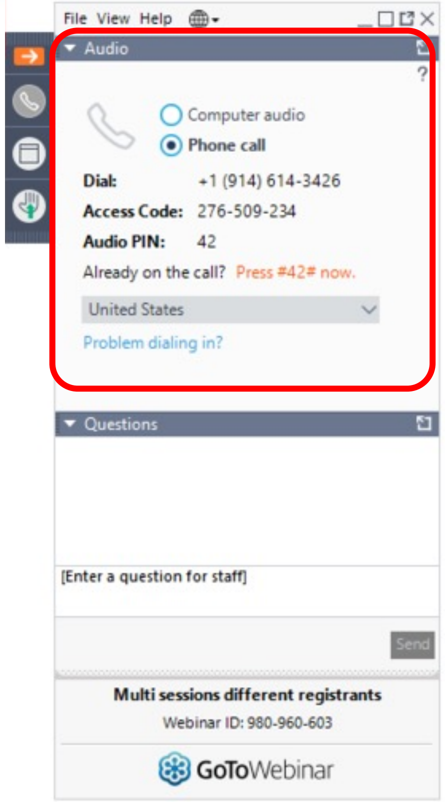
Webinar 1: Enabling full-chain CCUS for refineries through clusters-based strategies

REALISE CCUS

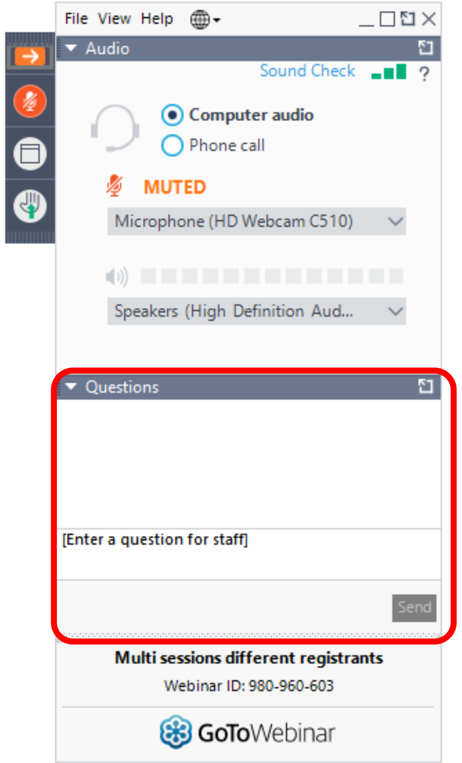
27 April 2021

Audio options

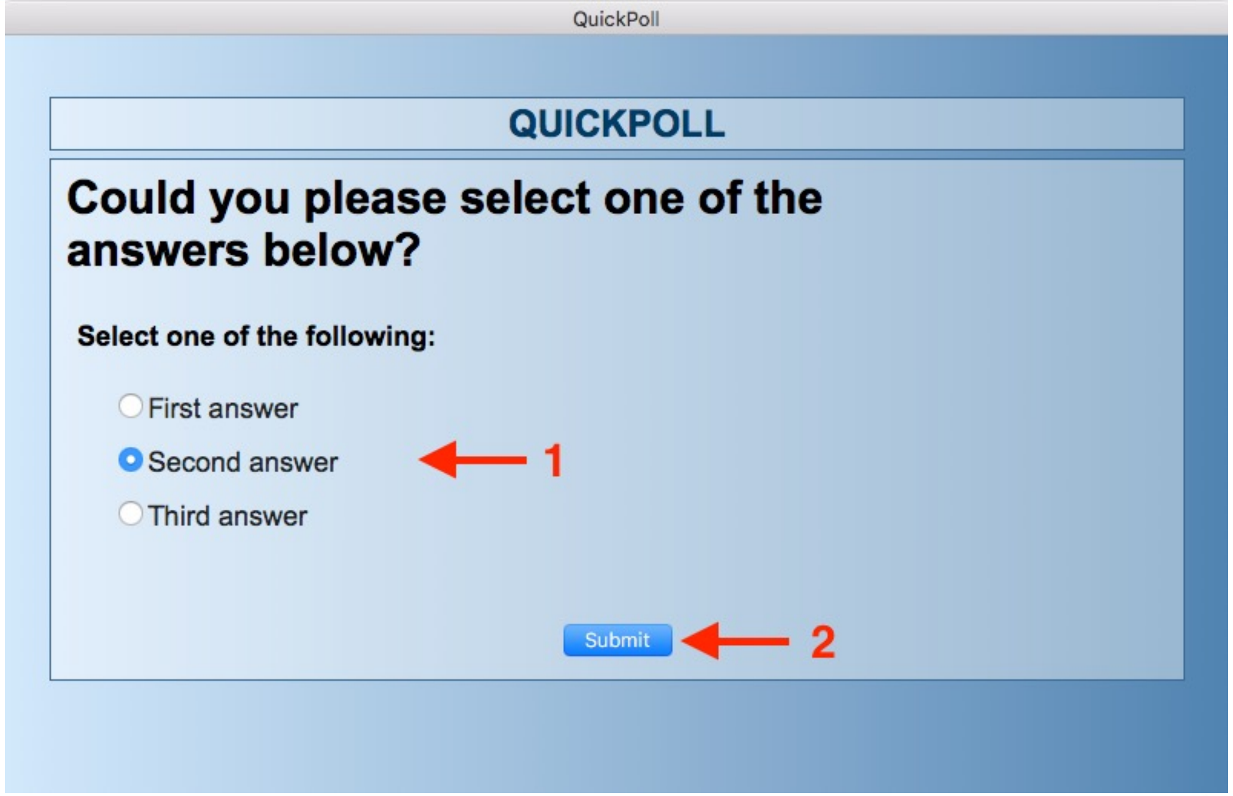




Participating in the webinar – Q&A



Participating in the webinar – Live Poll



Demonstrating a refinery-adapted cluster-integrated strategy to enable full-chain CCUS implementation - REALISE

REALISE CCUS

Inna Kim, SINTEF

Webinar #1 | **Trondheim, Norway** | **27 April 2021**

Webinar outline

- REALISE overview

Inna Kim, SINTEF

- Optimising and validating technologies for refineries

Solrun J. Vevelstad, SINTEF

- Demonstrating pilot-scale CO2 capture

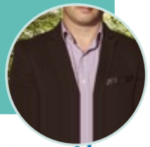
Juliana Monteiro, TNO

- Assessing potential for CCUS at oil refineries

Pádraig Fleming, Ervia

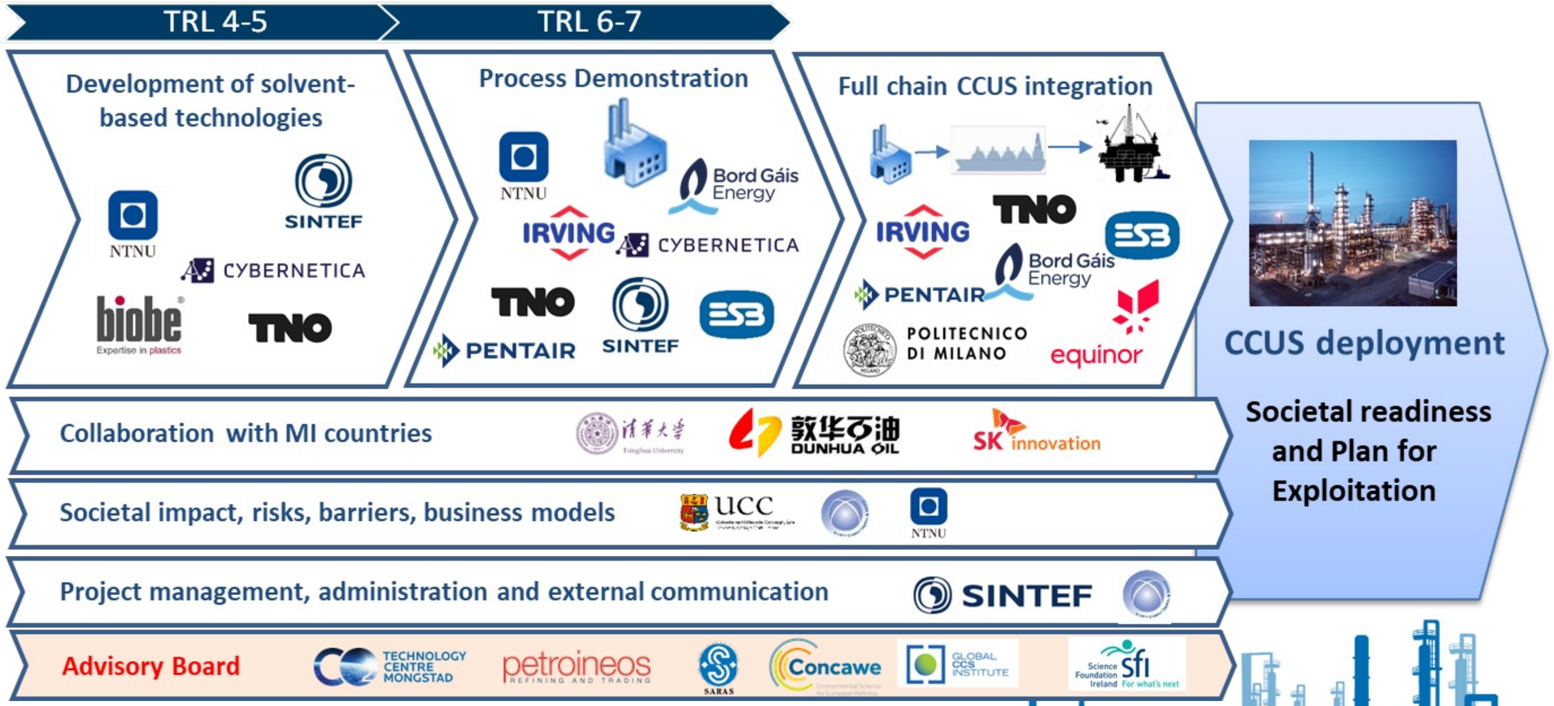
- Social, political and commercial context for CCS deployment

Niall Dunphy, UCC



REALISE overview

- Project period: 05.2020 - 04.2023
- Project partners:
  - 14 EU partners
  - 2 partners in China
  - 1 partner in S. Korea
- Project budget: 7 MEuro



REALISE objectives

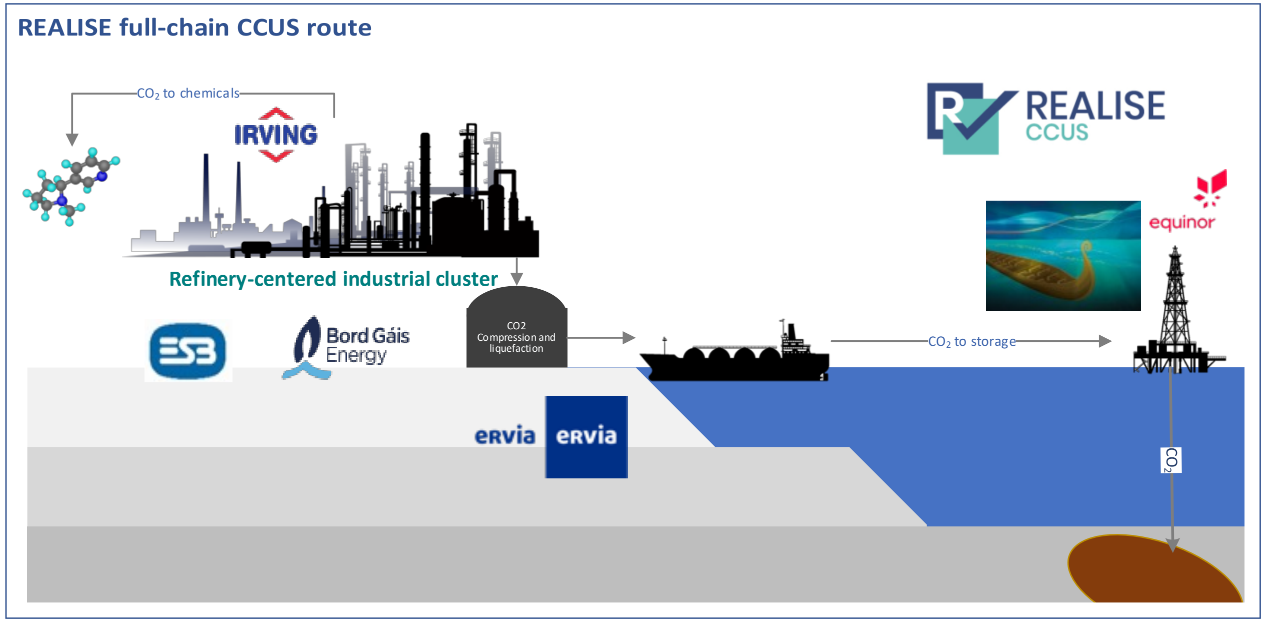
Reduction of GHG emissions

Increase of cost- and implementation- effectiveness

- Using low-energy HS-3 solvent ➔ decrease of the energy demand of CO_2 capture by 30%
- Maximization of performance thanks to efficient solvent management ➔ active component losses decreased by >80%
- Use of plastic equipment ➔ lower CO_2 capital costs by 15%
- Coupling of available facilities with the power sector ➔ lower the capture costs by at least 30%
- Safe, flexible and guided-choice regarding CO_2 capture scenarios thanks to an open-access simulation tool

CCUS business cases: Ireland

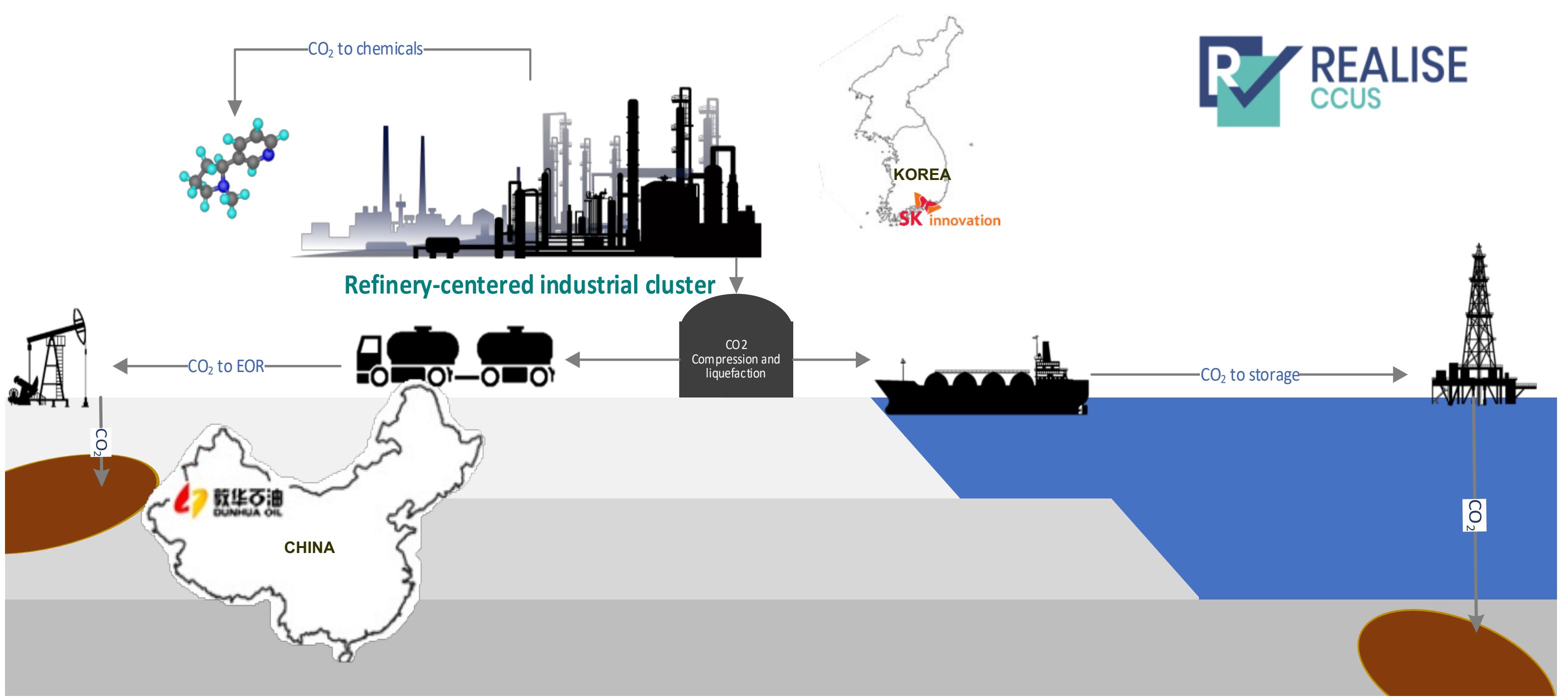
200 kTPA CO2 refinery + 2MTPA CO2 power stations
Ship transport (e.g. Northern Lights), pipeline transport to depleated gas reservoir
Education and Public Engagement Program & CCS readiness index



Phase 1 of Northern Lights
(https://ccsnorway.com/wp-content/uploads/sites/6/2020/07/Plan-for-long-term-use-of-the-Northern-Lights-infrastructure-1.pdf)

CCUS business cases: China and South Korea

REALISE full-chain CCUS route



China:
- in operation: 100 kTPA CO2 refinery truck transport to EOR
- plan: 400 kTPA and pipeline transport

Korea:
- 7.2 MTPA CO2 refinery complex
- Pipeline transport to depleated gas reservoir or ship to other country

Thank you for listening

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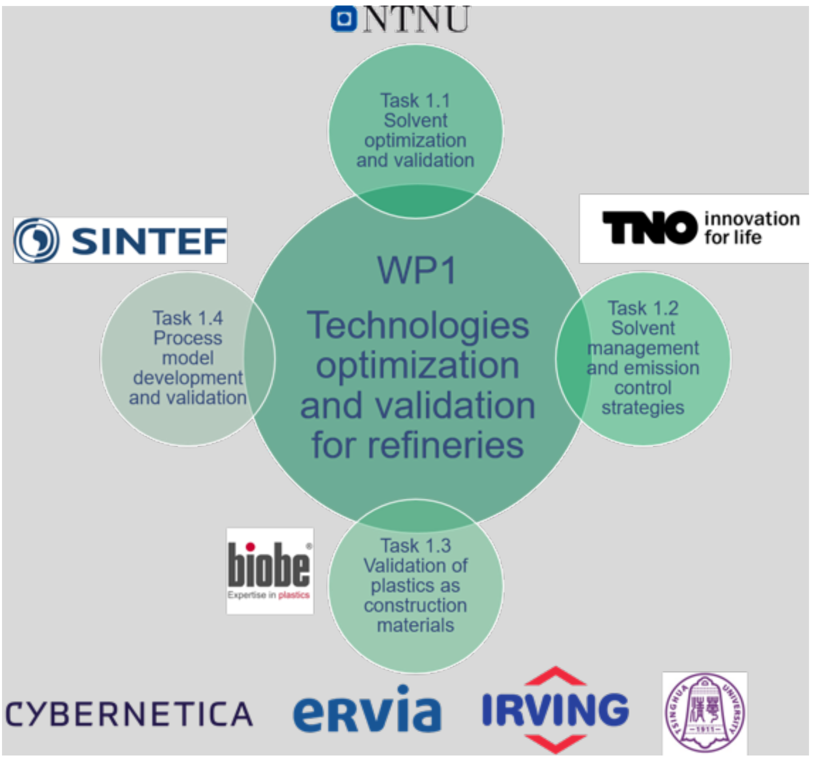
WP1: Technologies optimisation and validation for refineries

Solrun Johanne Vevelstad, SINTEF

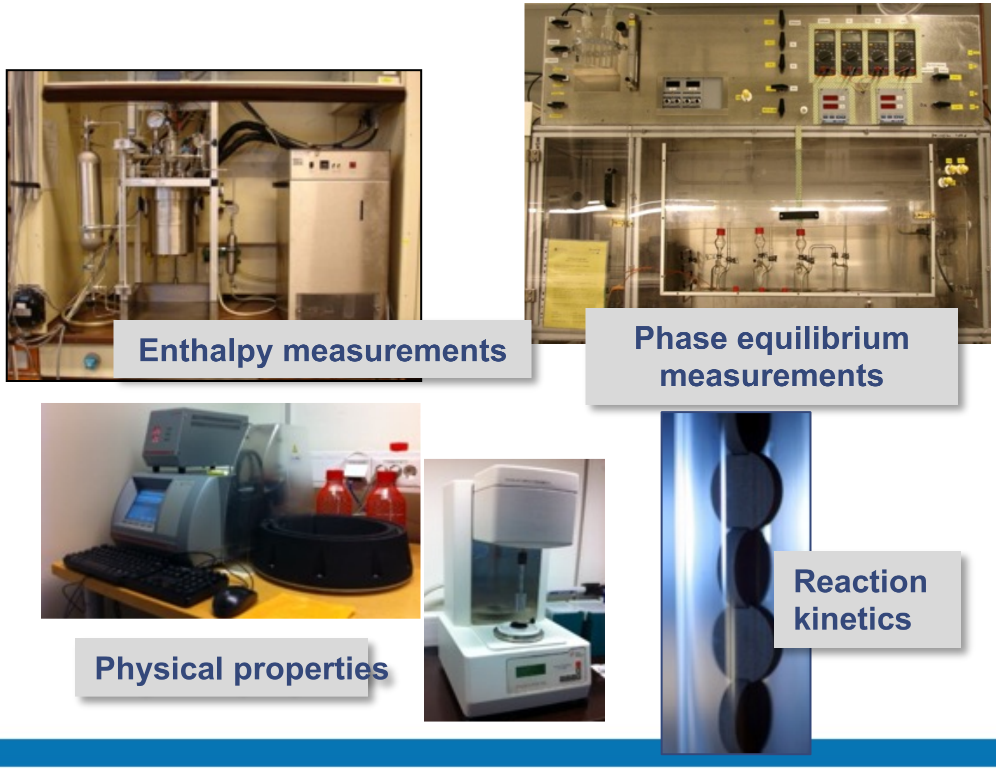
Webinar | **Trondheim, Norway** | **27-04-2021**

WP1 Objective

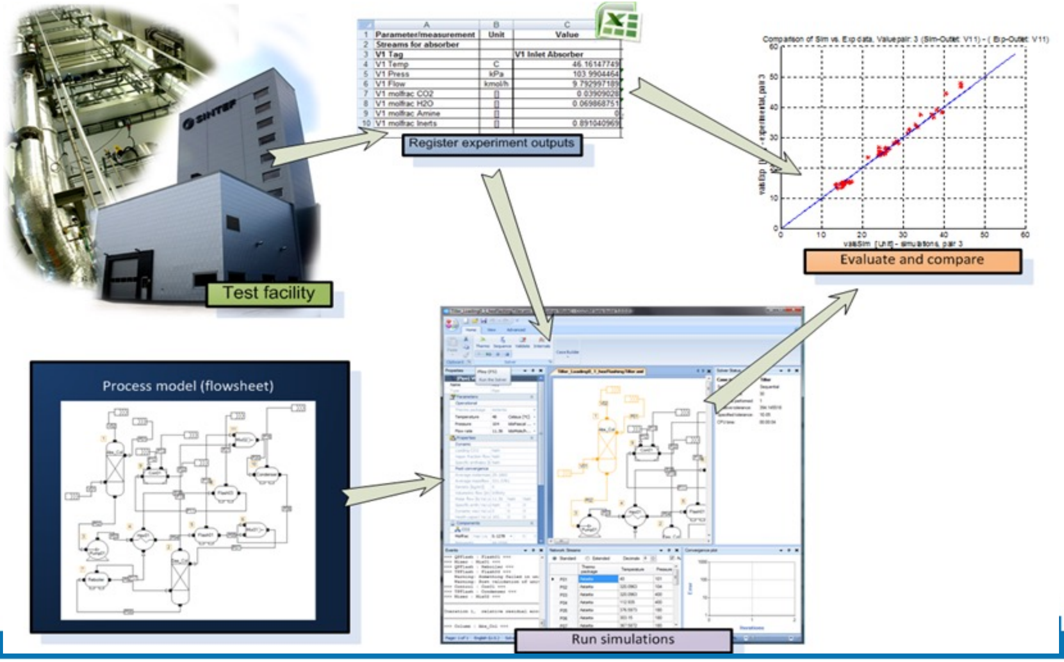
Optimise the solvent performance with respect to **energy usage and solvent stability**, including devising a **solvent management strategy** for pilot demonstration



Solvent optimisation and validation

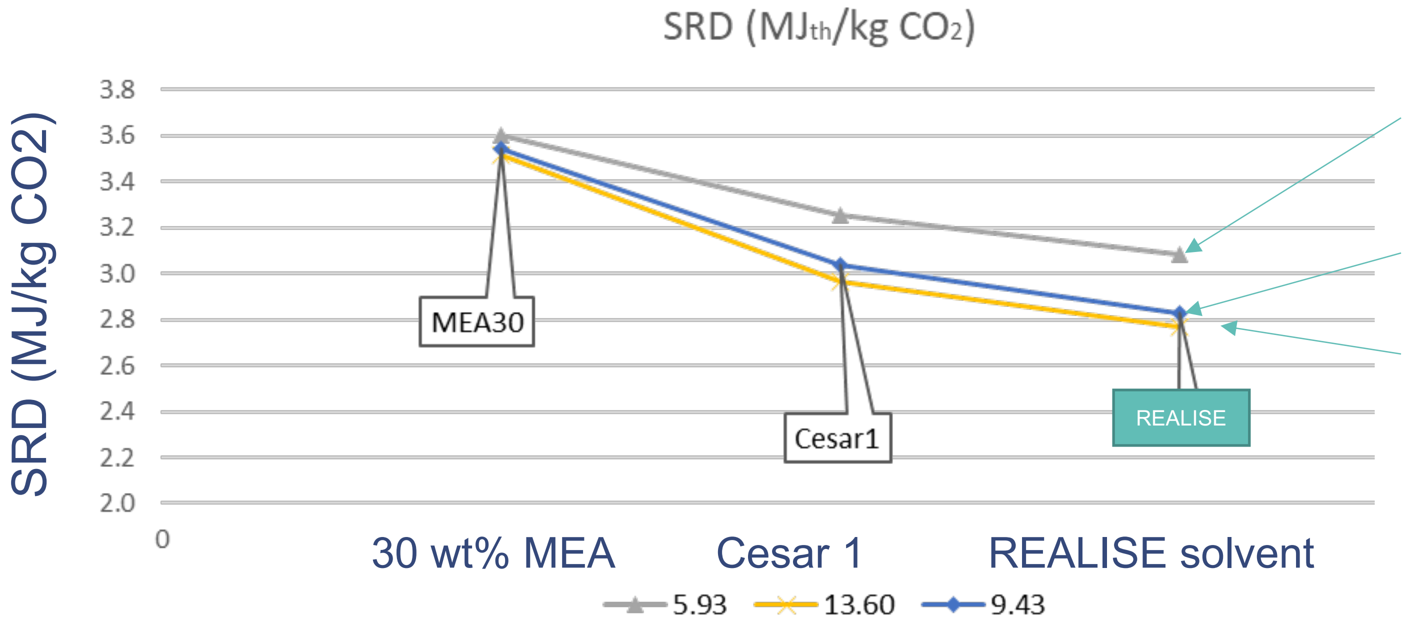


Thermodynamic and kinetic models as basis for process simulation



Test cases for different flue gas sources to be used in REALISE demonstration campaign

Preliminary simulation results



CO_2 content in flue gas:

5.93 vol%

13.6 vol%

9.43 vol%

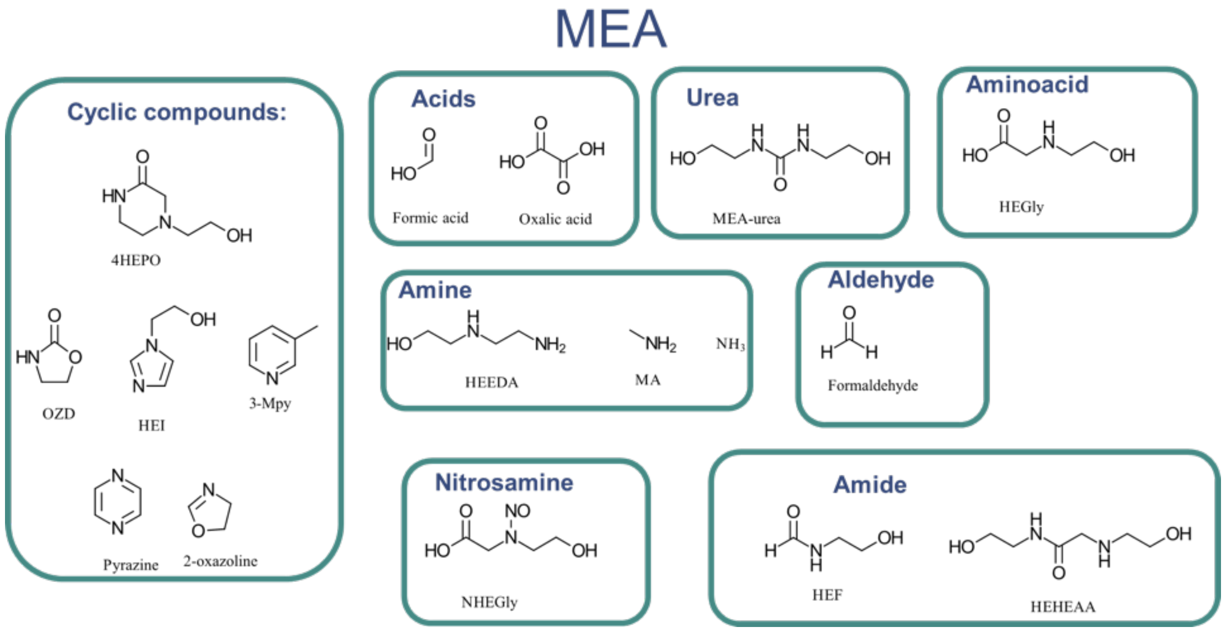
Solvent stability and solvent management strategies

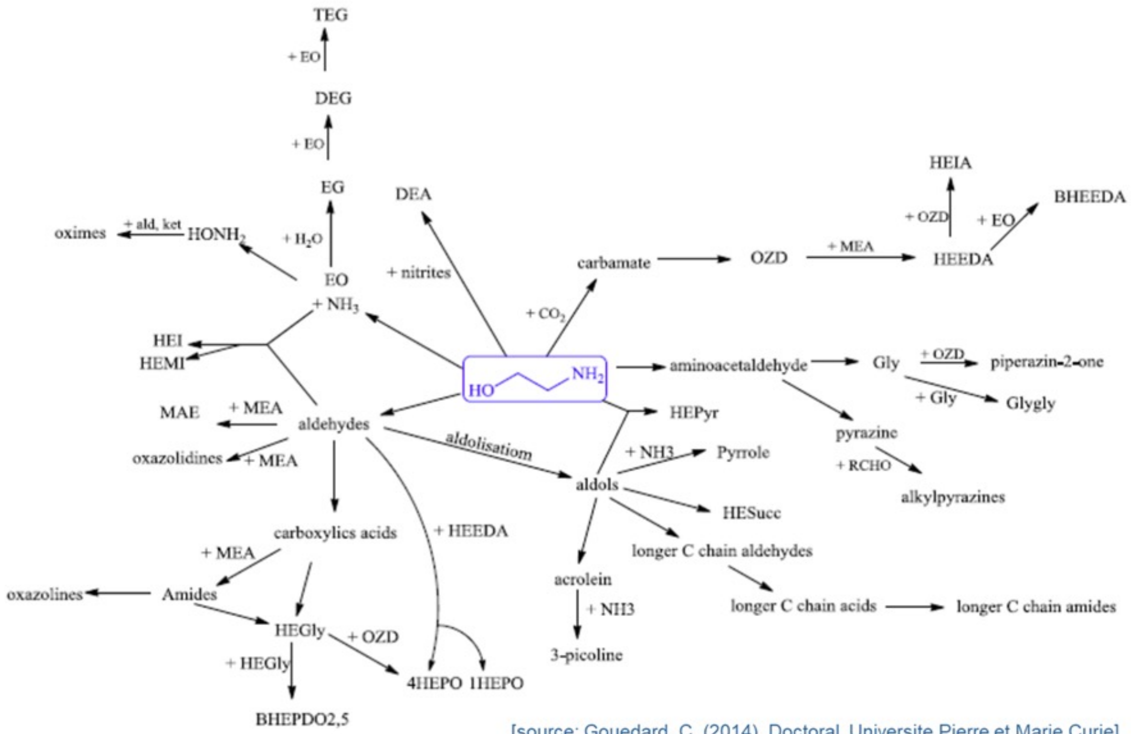
- Technology based on chemical reaction

- Solvent deterioration leads to
  - Loss of capture effiency
  - Operational issues
    - Fouling, foaming, corrosion
  - Environmental and health aspects through emission or spill

} Increased cost

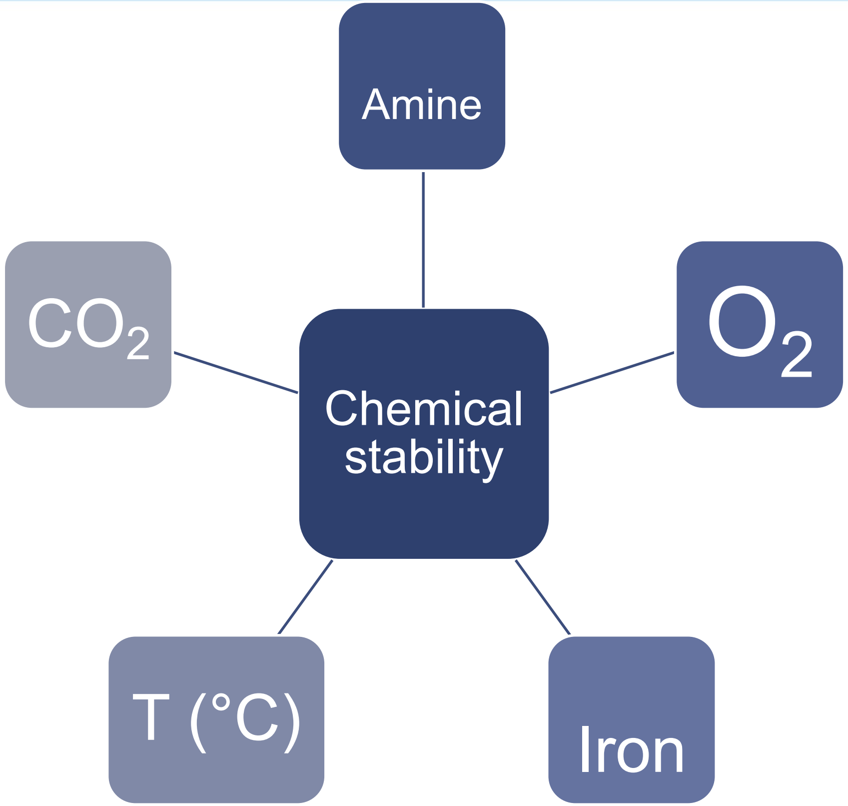
Solvent stability





[source: Gouedard, C. (2014). Doctoral, Université Pierre et Marie Curie]

Solvent management strategies

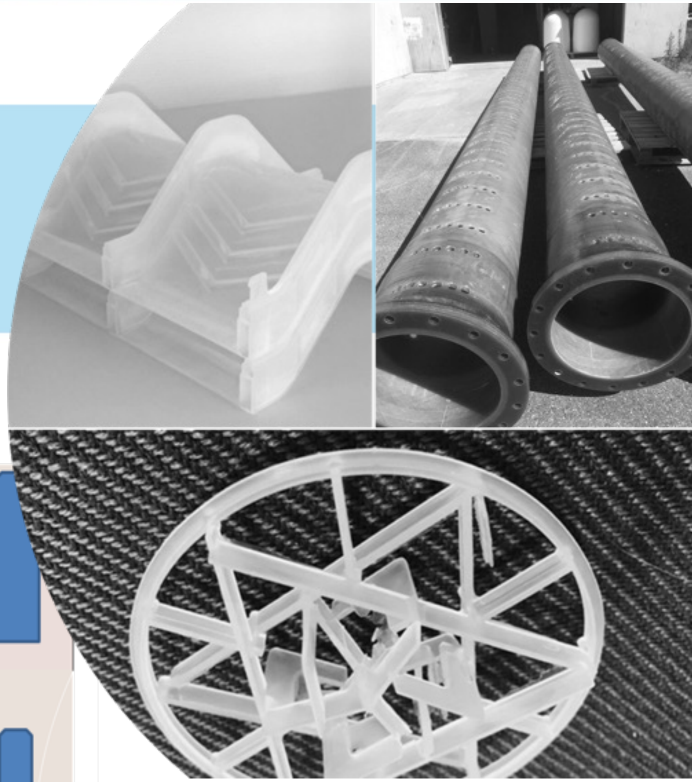


HS3 solvent (developed in HiPerCap and optimized in REALISE)

Dissolved oxygen removal apparatus (DORA)

Iron removal, material selection

Validation of plastic as construction material



- Possible use of plastics:
  - Column internals (structured or random packing)
  - Pipelines
  - Storage vessels
- Tests in REALISE:
  - Materials screening based on long term exposure of plastics til REALISE solvent
  - Tests of the selected material with the degraded solvent

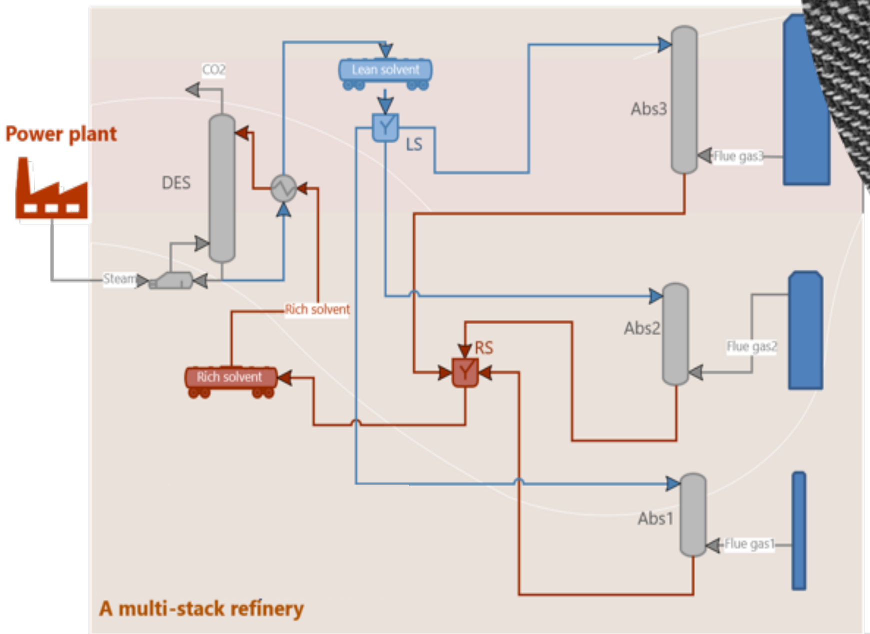
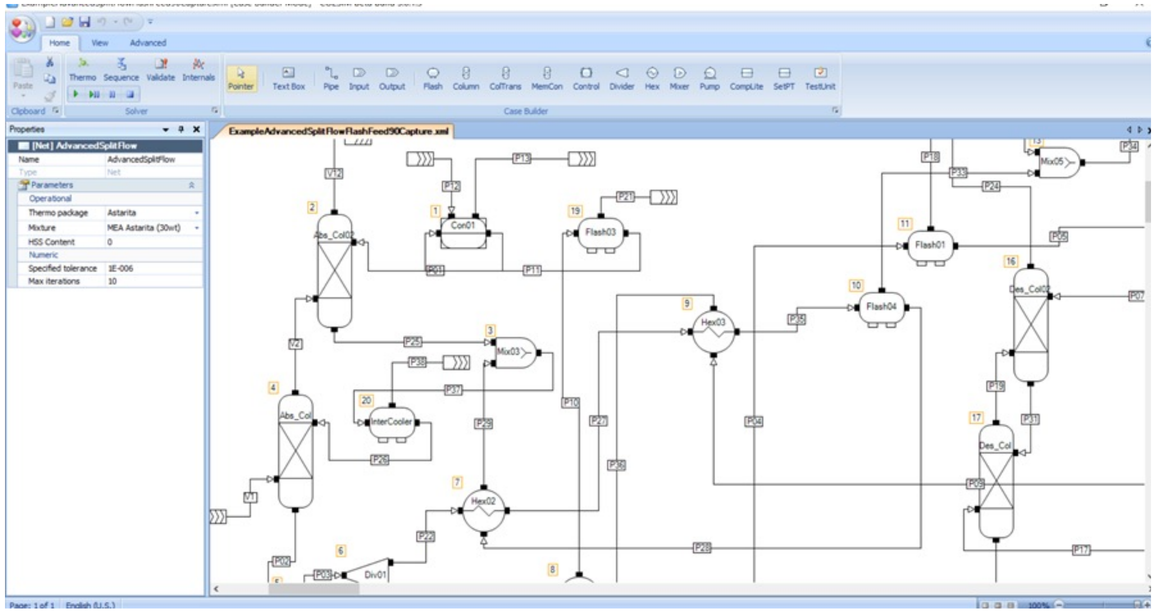
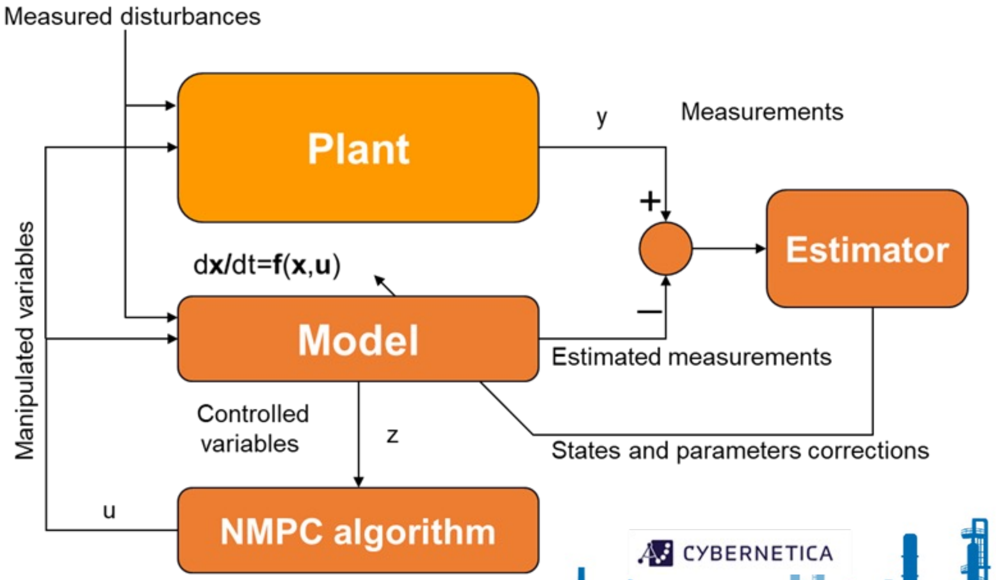


Image source: www.biobe.no

Process model development and validation



Nonlinear Model Predictive Control (NMPC)



Summary

Optimized solvent as input to demonstration in WP2

Solvent management strategies as input to WP2

Process simulations as input to WP3 and TEA

Thank you for listening

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WP2. Technologies demonstration

Juliana Monteiro, PhD (TNO)

Webinar #1 | **Delft, The Netherlands** | **27.05.2021**

WP2 Objective

To demonstrate CO_2 capture from refinery flue gases using HS-3 solvent

Demonstration Campaigns

2 pilots:

- TNO miniplant → mobile system, 20L
- SINTEF Tiller plant → 600L

HS-3 solvent at Whitegate refinery

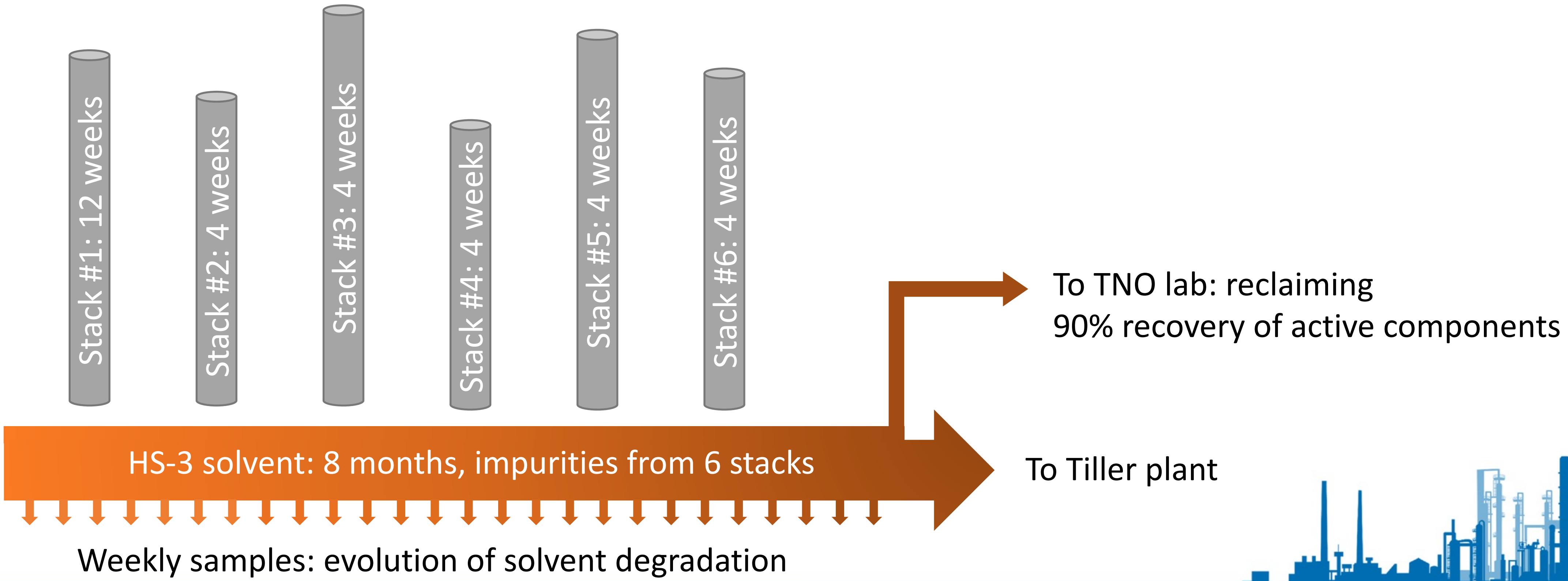
- 8 months campaign (2021-2022)
- 6 stacks (12 weeks + 5* 4 weeks)
  - ➢ CO_2 content: 4.0 – 10.5 vol%
  - ➢ NOx: 100 – 200 mg/Nm^3
  - ➢ SOx: <6.7 – 20.4 mg/Nm^3 (option to remove)
  - ➢ Dust: < 0.8 – 4.7 mg/Nm^3 (option to remove)

TNO's Miniplant

ATEX containers

2nd floor

CO_2 capture with HS-3 solvent at Whitegate refinery



Tiller pilot

HS-3 solvent at Tiller

- Mimic reclaimed solvent: degraded (20L) + fresh (600L)
- 12 weeks of operation
- Demonstrate low energy demand
- Monitor: degradation, emissions (absorber, stripper)
- CO_2 compression and liquefaction → CO_2 quality for shipping
- Bring HS-3 to TRL7

WP2 Outcome

- Receives input from WP1 (solvent formulation, operational window)
- Returns key information on solvent performance:
    - ✓ Energy requirement
    - ✓ Optimal operational parameters
    - ✓ Solvent stability
    - ✓ Degradation and emission management strategy
    - ✓ CAPEX and OPEX of CO_2 capture → for WP3 models

Novel, open solvent at TRL7

Thank you for listening

Presenters

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Work Package 3

Pádraig Fleming

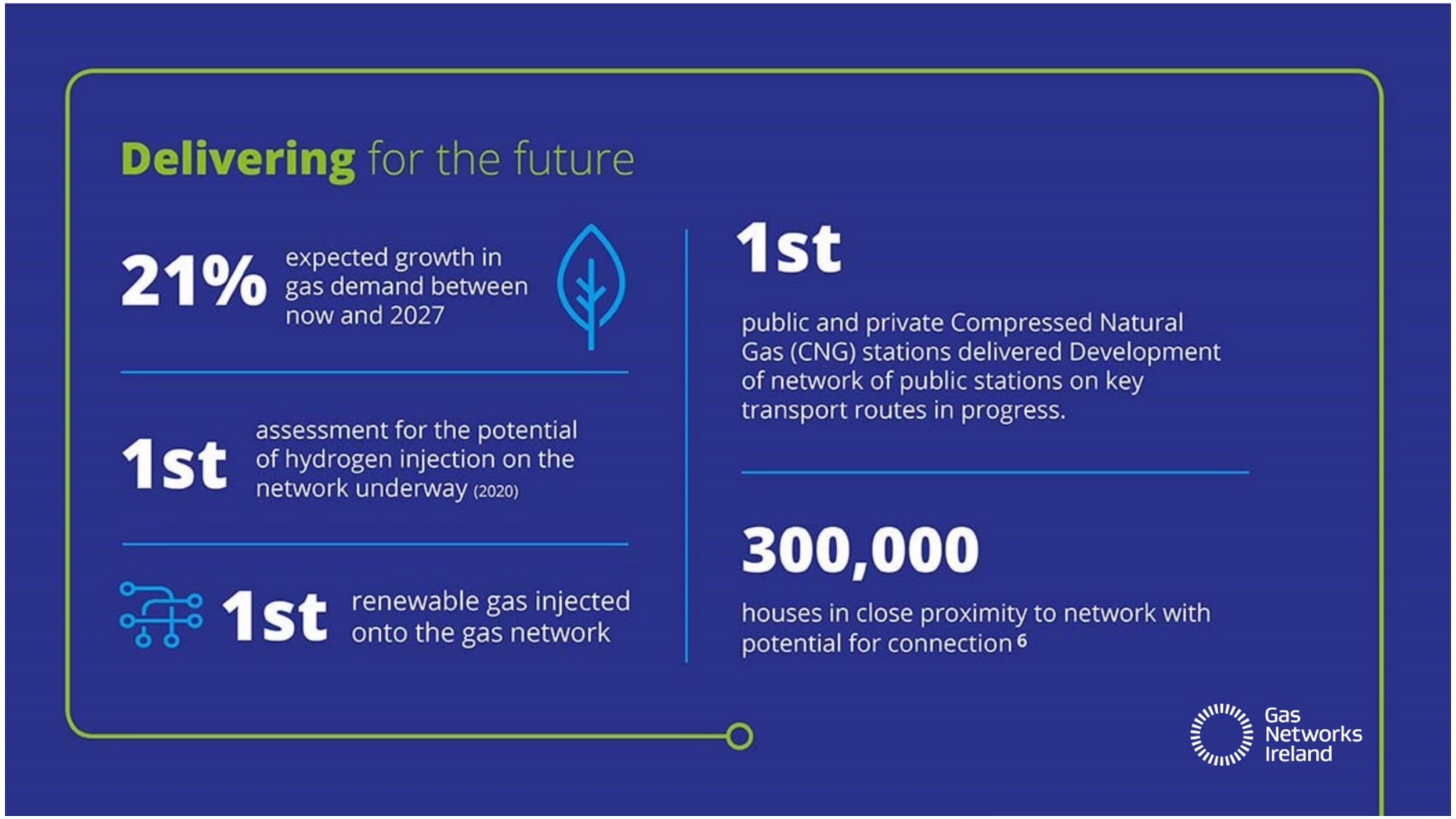
REALISE CCUS

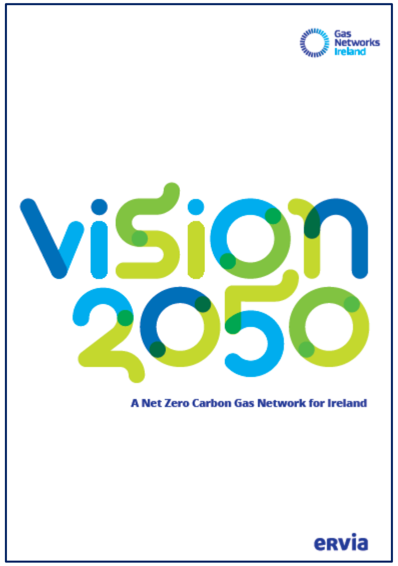
Webinar **Ireland** **27th April 2021**

Agenda

- Er[illegible]
- W[illegible]
- T[illegible]3.1–3.5

Ervia/Gas Networks Ireland – committed to net zero by 2050



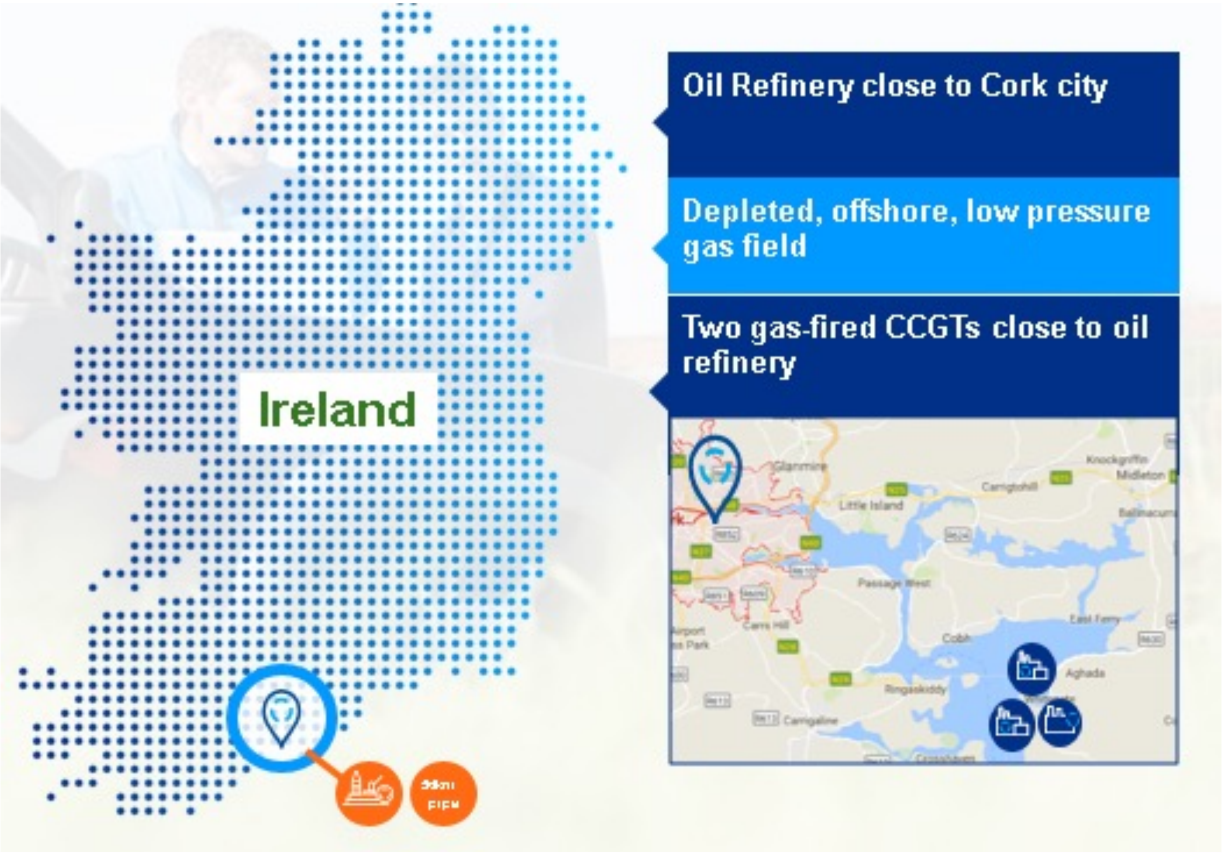


Work Package 3 – Undertake a real-world assessment of the potential for CCUS at an oil refinery which is part of a large CCUS Cluster

Coordinated by Ervia

Contributors

Work Package 3 – Undertake a real-world assessment of the potential for CCUS at an oil refinery which is part of a large CCUS Cluster



Undertake a real-world assessment of the potential for CCUS at an oil refinery which is part of a large CCUS Cluster

- Economically feasible percentage of carbon capture at an oil refinery;
- Potential process implications of post combustion carbon capture from stacks;
- Plot size and source of associated utilities and auxiliaries for reference locations;
- Potential cost and operational efficiencies achievable from cluster approach;
- Transportation, utilisation and storage options required for industrial clusters;
- Appropriate storage options for the identified CCUS clusters, and;
- Build an open access simulation tool that can be used to design CO_2 capture units for refineries of different complexities.

Tasks

3.1 Optimal integration and Techno-Economic Assessment of CO2 capture plant in refinery

3.2 CO_2 capture tool for refineries

3.3 Cluster transportation of CO_2 and storage

3.4 CO_2 utilisation assessment

3.5 Report

Task 3.1 Optimal integration and Techno-Economic Assessment of CO_2 capture plant in refinery

M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36

Assess (using various capture rates)

- Economically feasible capture rate –taking account of steam available
- Plot size including utilities & auxiliaries
- Cost effective source of utility cluster
- How will Non-linear Model Predictive Controls based control system will reduce operating cost

Ervia

POLIMI
Pentair
Ervia
Irving
ESB
BGE
Cybernetica
Biobe

Task 3.2 CO_2 capture tool for refineries

M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36

Develop tool from simulation model in WP1 (fast running model in Python)

- A beta-version of the tool developed for the REALISE partners for tests
- Taking partner's suggestions improve to Version 1.0
- Released, in combination with a workshop involving members of Industry Club
- Taking Industry Club feedback produce final tool (V2.0),
- Make available for download through the REALISE webpage.

Ervia

TNO
NTNU

Task 3.3 Cluster transportation of CO_2 and storage

M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36

Cluster transport study will be assessed

- CO_2 transport by pipelines and ships
- Potential for repurposing existing pipelines and other appropriate infrastructure.
- Potential for expanding the cluster will be evaluated.
- CO_2 compression and conditioning technology for CO_2 lean and dense phases
- Ship transportation
- Hubs for intermediate storage CO_2 from various sources + closer to the storage site
- Assessment of requirements for a jetty or dock

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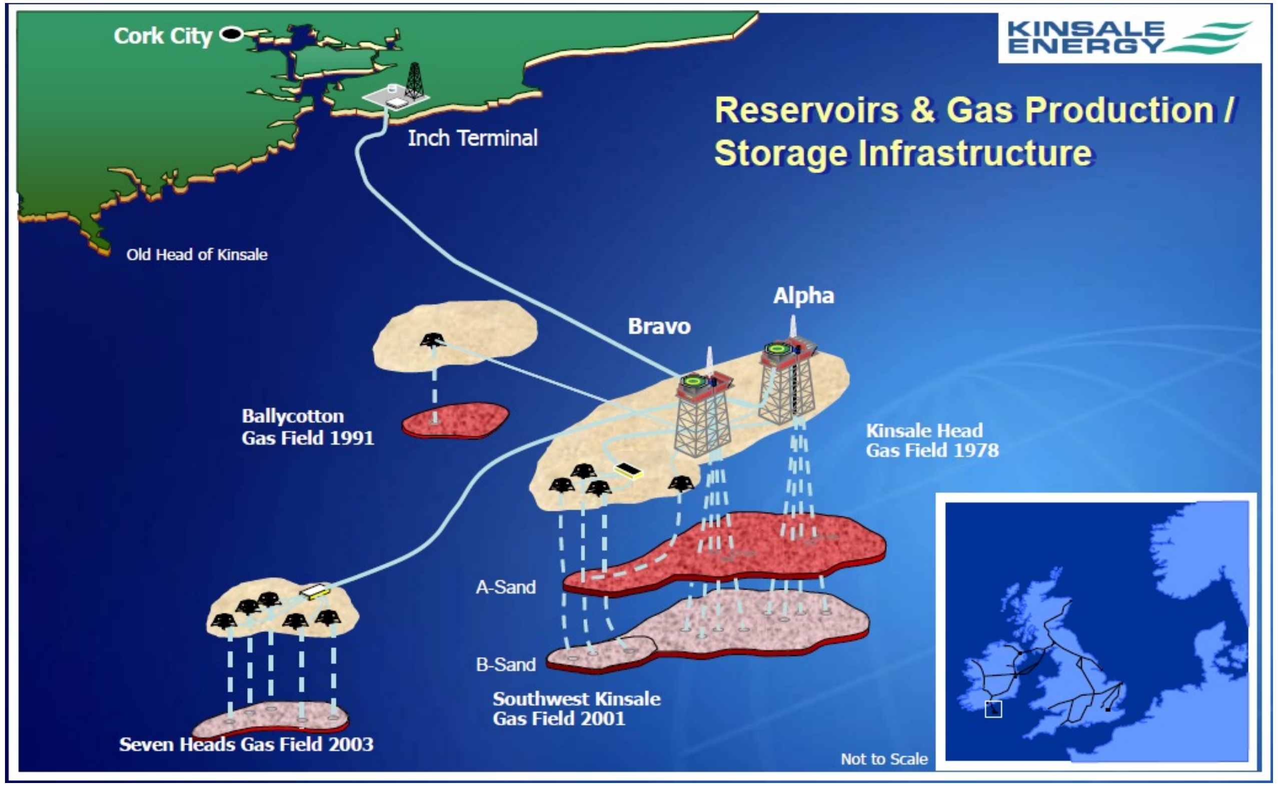
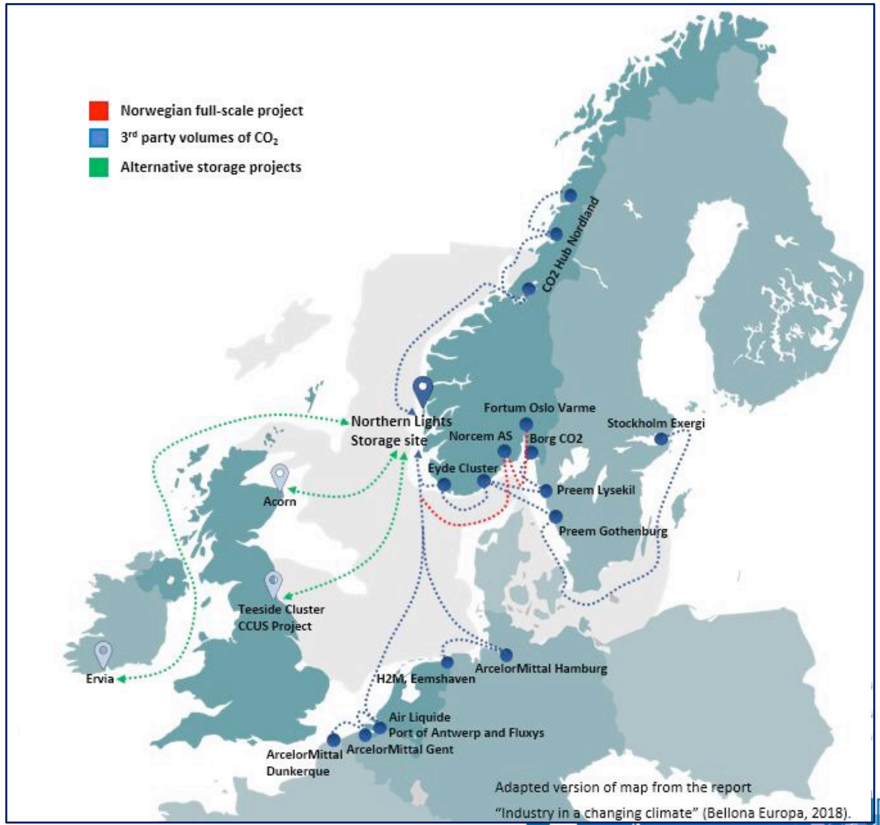
TNO
Equinor
SINTEF
ESB
BGE

Task 3.3 Cluster transportation of CO_2 and storage

M1 M2 M3 M4 M5 M6 M7 M8 M9 M10 M11 M12 M13 M14 M15 M16 M17 M18 M19 M20 M21 M22 M23 M24 M25 M26 M27 M28 M29 M30 M31 M32 M33 M34 M35 M36





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Task 3.4 CO_2 utilisation assessment

M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36

Potential to increase the demand of CO_2 by displacing other process and working gases such as in the refrigeration and energy storage sectors.

- Review of the existing suppliers of CO_2 in cluster location.
- Desktop research study of the existing CO_2 market.
- Model the impact on the market that introducing a large source of CO_2 would have on the commodity price of CO_2.
- Evaluate the techno-economic impact of CO_2 utilisation in the full CCUS chain and decide to which extent utilisation should be included in the chain for each cluster.
- Research the potential for increases in CO_2 demand for alternative uses.

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Irving
TNO

Task 3.5 Report

M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36

Draft report consolidating the results of the business cases in Europe, including capture, utilization, transport, storage and societal readiness results for the Cork cluster (Ireland) and SARAS (Italy).

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Thank you for listening

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Social, political and commercial context for CCS deployment – WP4

Dr Niall Dunphy, University College Cork

REALISE CCUS

REALISE Webinar 1 | **Cork, Ireland** | **27 April 2021**

T4.1 Education and public engagement best practice

M1-9

– The deployment of the major infrastructure (such as CCS) needed for the required energy and industrial transition, can only be realised with societal acceptance.

– Cognisant of the importance of societal acceptability and social acceptance this initial task was concerned with understanding successful civic engagement.

– It comprised a critical review of education and public engagement associated with large energy and related infrastructure.

T4.1 Education and public engagement best practice

M1-9

– Information on selected case studies was gathered through a literature view combined with interviews of key informants.

– The methods used for EPE in each of the cases was identified, key challenges faced by such programmes identified, and best practices documented.

– The knowledge developed in this task and presented in this report will feed into the development of an Educational and Public Engagement programme within Task 4.2.

T4.2 Social acceptability, societal impact

M10-28

– Building on the developed knowledge, this task involves designing an Education and Public Engagement programme with input from community stakeholders.

– This programme will be informed by just transition concepts and leverage the experiences of the case studies in the critical review from T4.1.

T4.2 Social acceptability, societal impact

M10-28

Perceptions of fairness play a crucial role in determining the social acceptability of infrastructure projects.

– Procedural justice: the way in which the process is structured and implemented.

– Distributional justice: how benefits and ills of the project are distributed.

– Recognition justice: acknowledgement, recognition and respect.

T4.2 Social acceptability, societal impact

M10-28

- The approach will take an intersectional approach, considering the socio-demographic specificities of the relevant communities, including for example: gender; economic privilege; and life stage.
- During the design of the programme, key elements will be trialled to evaluate effectiveness, to identify areas of potential improvement, and to ascertain transferability of the programme.

T4.3 Socio-political context analysis

M9-24

T4.3 seeks to capture the socio-political lessons from CCS projects, the conditions and policies that enabled success, and assess their implications for CCS at EU refineries. The aim is to

– identify and analyse socio-political lessons from unsuccessful CSS projects;

– characterise key enablers of CCS facilities; and

– identify perquisites for successful deployment.

T4.3 Socio-political context analysis

M9-24

– For each case study, the CCS readiness index (CCS-RI) will be determined.

– This will be achieved by adapting the methodology of the CCS-RI, developed by GCSSI to monitor the progress of CCS on a country level.

– The resultant report (D4.3) will present an analysis of socio-political considerations of CCS deployment. (including but not limited to policy, legal and storage resource barriers)

T4.4 Industrial context analysis

M1-36

– A transnational Industry Club has been established to develop an understanding of the industrial and commercial context of CCS.

– This is an external body to the project and acts as a forum which will provide expert knowledge, and economic insight to the project, while also serving as a means of disseminating information to these key players.

– This Industry Club, animated by UEDIN, and contributed to, and facilitated by, all partners, comprise members throughout the value chain.

T4.4 Industrial context analysis

M1-36

– contribute to plan the commercial deployment of capture technologies in refineries;

– ensure the technology is acceptable for the industry and is technologically & economically viable;

– contribute to the elaboration of a shared vision of CCS development in relevant regions;

– support the elaboration of a business model for carbon capture in refineries;

– attend regional stakeholder engagement events;

– facilitate dissemination amongst industrial sector and advise on exploitation.

T4.5 Public outreach activities and life-long learning

M7-36

The REALISE consortium aims to actively contribute to increase societal readiness by improving public acceptance though outreach activities. These activities, led by NTNU but involving all partners, will include

– **Seminars** for municipalities, refineries and other local industry providing information on demonstration activities, safety, risks and outcomes

– **Youth Dissemination** *e.g.,* mini seminars for students, guest lectures, summer schools;

– **Research based learning activities** in partner universities: research challenges to different courses and will educate masters level students at all partner universities.

T4.6 Synthesis report on societal readiness

M29-36

– This final task comprises a synthesis of the earlier tasks to draw broad-based conclusions on the societal readiness of the REALISE CCUS approach.

– In the process, drawing on both quantitative and qualitative evidence from the earlier tasks, we will work to identify and characterise the societal, political, and socio-economic barriers to CCS.

– This analysis will be used to inform the development of a suite of recommendations for policy and regulatory changes to address the various identified barriers.

Thank you for listening

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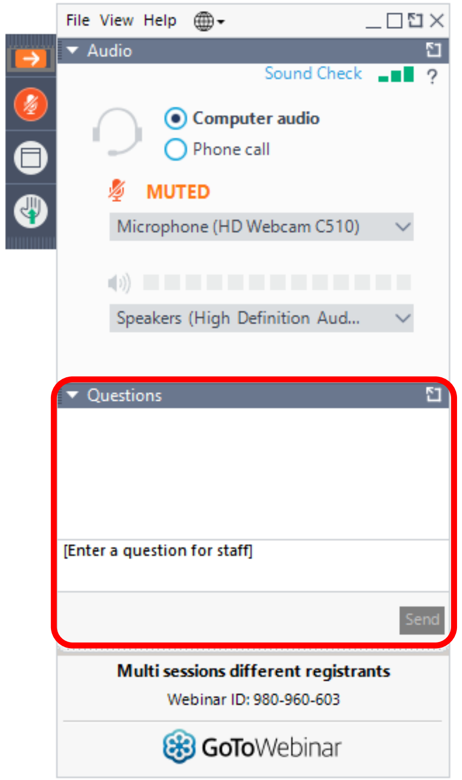
Q&A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Acknowledgements

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Expertise in plastics

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Coláiste na hOllscoile Corcaigh

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