Webinar 3:
The Cork Cluster study

REALISE CCUS

26 April 2022

Welcome and project overview

Inna Kim, SINTEF

Agenda

- ❑ Welcome and project overview - Inna Kim, SINTEF
- ❑ Summary of the Cork Cluster report, Paul Murphy, Ervia
- ❑ An exploration of approaches to public engagement, Paola Velasco-Herrejón, University College Cork
- ❑ Panel Q&A

REALISE project (05.2021-10.2023)

CO_2 capture with 2nd gen. solvents

- Mobile pilot on-site refinery
- Stationary pilot

Solvent management technologies

- Avoid solvent loss
- Emissions control

CO_2 transport, conversion and storage

- CO_2 liquefaction
- CO_2 conversion
- CO_2 storage

Socio-political context

- EPE program
- CCUS readiness

CCUS business cases: Irland, China, S. Korea

Dissemination and knowledge sharing

Partners

biobe Expertise in plastics | Bord Gáis Energy | CYBERNETICA | equinor | 敦华石油 DUNHUA OIL

IRVING | NTNU | PENTAIR UNION ENGINEERING | POLITECNICO MILANO 1863 | SCCS

ervia | ESB Energy for generations | Tsinghua University | UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

SINTEF | TNO innovation for life | SK innovation

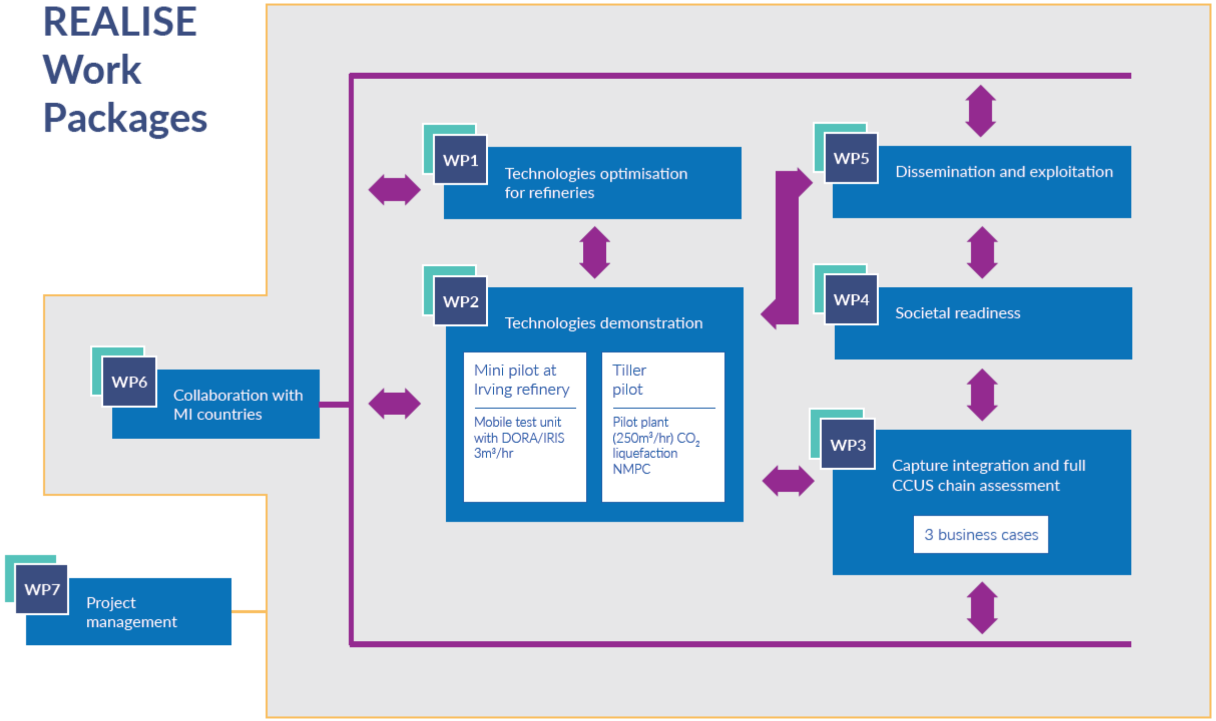
Advisory Board

Concawe | petroineos REFINING AND TRADING | GLOBAL CCS INSTITUTE

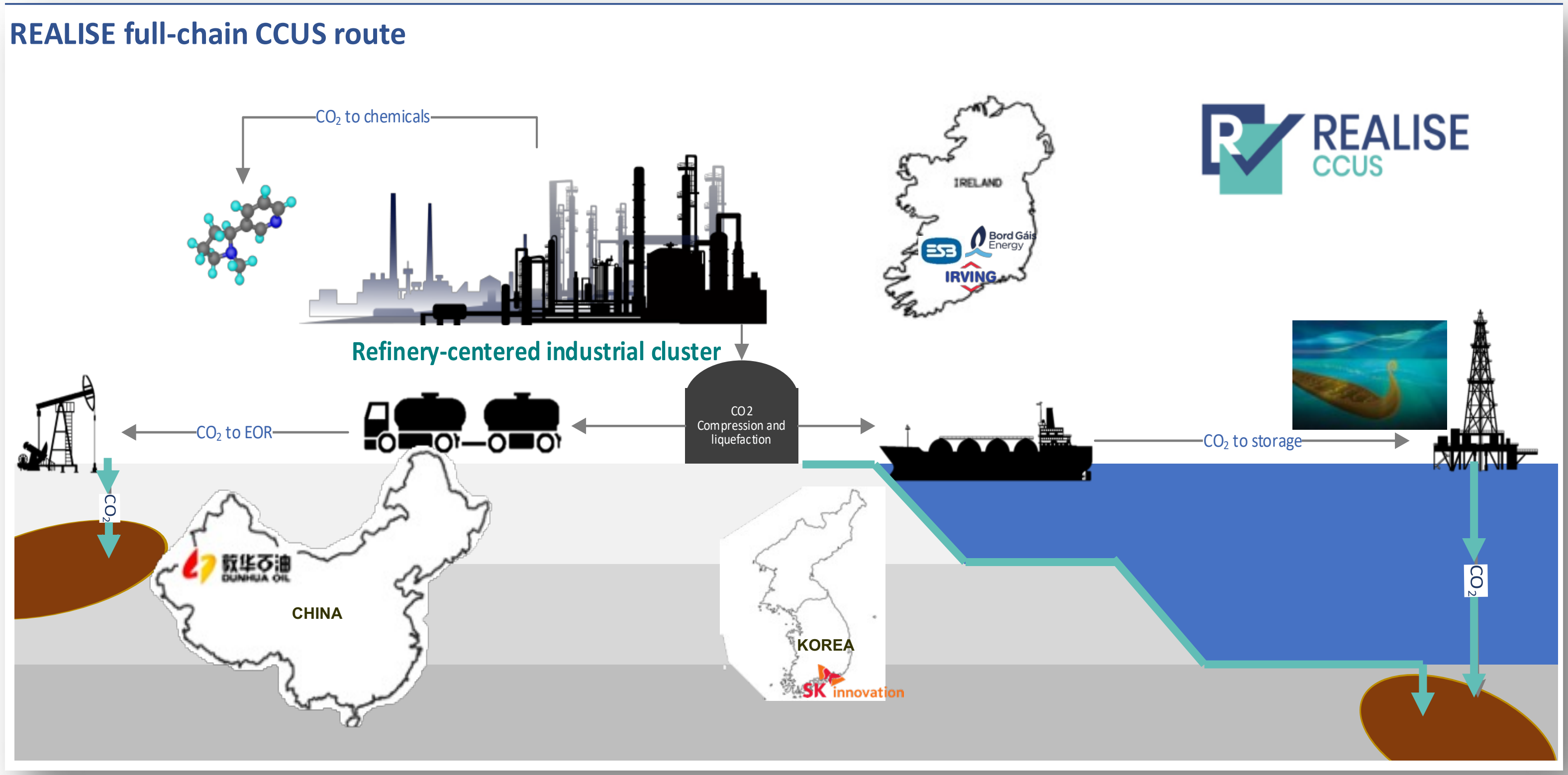
CO2 TECHNOLOGY CENTRE MONGSTAD | SARAS | Science Foundation Ireland sfi For what's next

REALISE Objectives

- ✓ Decrease energy demand of CO_2 capture by 30%
- ✓ Maximize use of solvent by reducing losses of solvent components by 80%
- ✓ Decrease Capex by 15% using plastics
- ✓ Lower capture cost by at least 30% by coupling of the facilities with the power sector
- ✓ Provide guidance for the choice of CO_2 capture scenarios at different refineries using an open-access simulation tool



Case studies in REALISE



REALISE Cork Cluster Study

Paul Murphy

Webinar | Cork, Ireland | 26th April 2022, 12.00GMT

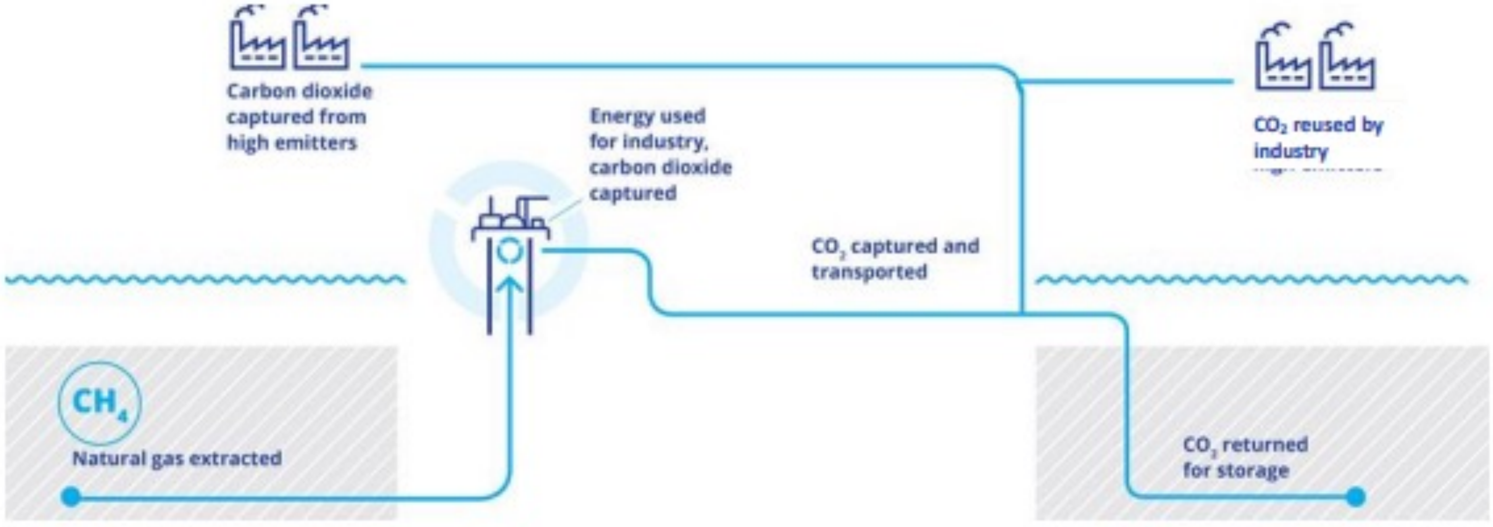
Summary of findings from Cork Cluster Study Report

1. What is CCUS?
2. Cluster
3. Indigenous storage and export of CO_2 options
4. Cost benefit study

Context

- Caveat
  - Please note this presentation is discussing the findings of a report submitted in October 2021
  - There have been significant increases in materials, capex construction costs and gas prices since then

1. What is Carbon Capture, Utilisation and Storage (CCUS)?



2. Cork Cluster

- Cork is the second largest city of Ireland with a population in excess of 300,000
- The city is contained within the county of Cork which has a population of just over 540,000 and an area of 7,500 km²
- It contains Cork Harbour, the second largest natural harbour in the world after Sydney, Australia
- The city of Cork is surrounded by several plants either in the pharmaceutical, distilleries or in the food ingredients sector

Cork Cluster

1D2O0379 Photo: Peter Barrow, Tel: 0872-559638 15th February 2013,

- 3 Largest emitters of carbon dioxide in Cork
- The depleted Kinsale Head Gas Field is located within 50 kms of the oil refinery and power plant cluster
- Potential future additional large emitter in Indaver incinerator

Irving Oil Whitegate Refinery

FACTS & FIGURES

CRUDE CAPACITY UP TO
75,000
barrels per day

PRODUCTS & PRODUCTION

GASOLINE CAPACITY UP TO
20,000
barrels per day

DISTILLATE CAPACITY UP TO
30,000
barrels per day

Products

- Propane
- Butane
- E5 Gasoline
- BOB Gasoline
- B7 Diesel
- B0 Diesel
- Off-road Diesel
- Gas oil
- Kerosene

ESB Aghada Generation Station

BGE Whitegate Generation Station

435 MW
Commissioned 2010

445 MW

Commissioned 2010

Assumption for new Combined Cycle Gas Turbine (CCGT) Power Stations

Commissioned 2030

Min generation – Open Cycle 33%

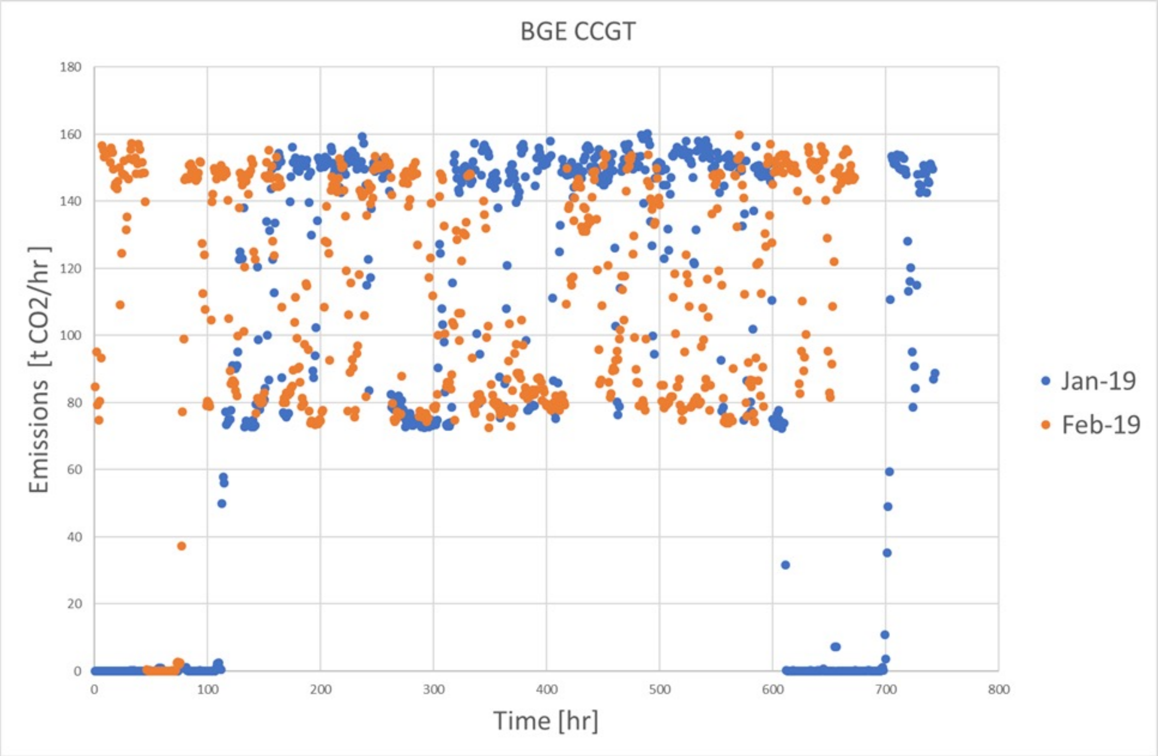
1.08Mtpa - Load Factor 55% - Base Case

Load Factor 74% - High Scenario

1.6Mtpa at 92% load factor (full load)

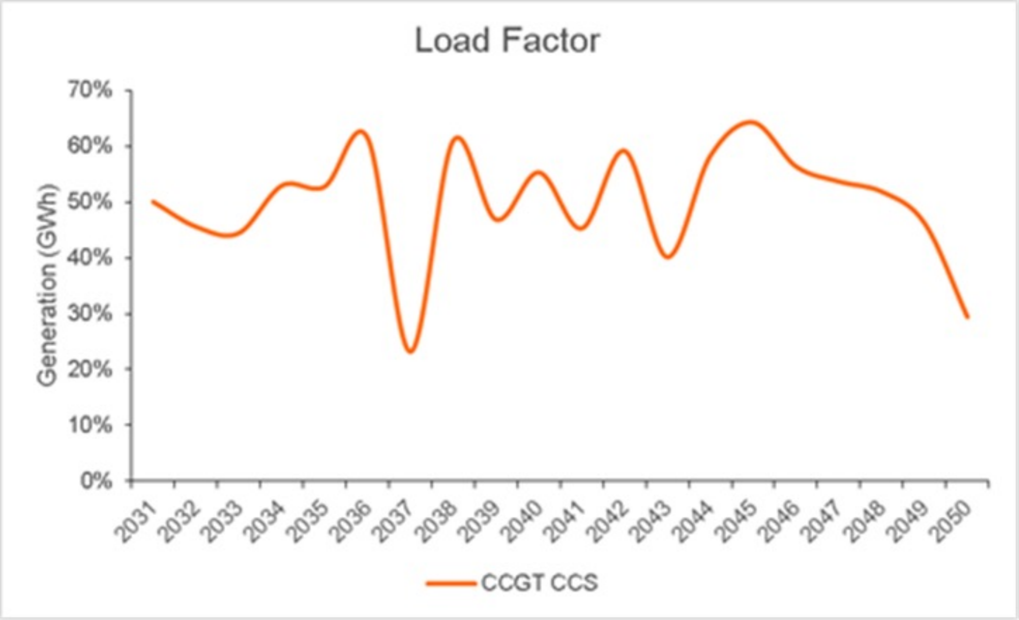
GE 7HA.02	
CC Net Output (MW)	502
CC Net Heat Rate (Btu/kWh, LHV)	5,531
CC Net Heat Rate (kJ/kWh, LHV)	5,835
CC Net Efficiency (%, LHV)	61.7%
Plant Turndown – Minimum Load (%)	47%
Ramp Rate (MW/min)	51
Startup Time (Hot, Minutes)	<31

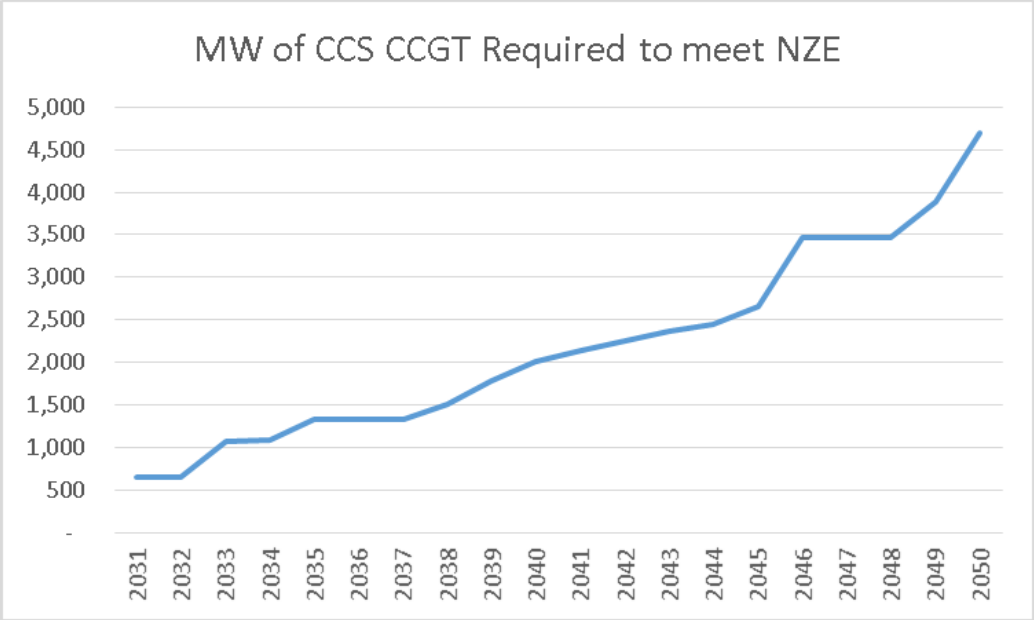
BGE Whitegate Generation Station – Variable output example



- Hourly data of CO_2 emission of the Whitegate CCGT for January and February of 2019
- Emission level ranges from zero to a maximum of about 160 t/hr

CCS CCGT Power Station Load Factor





Source: Baringa (2020), the Role for CCUS in Ireland Net-Zero Electricity Capacity

Cluster Output

Base Case Scenario	Net Export to Grid (GWh pa)	CO_2 Generated (MTPA)	CO_2 Captured (MTPA)	CO_2 Emitted (MTPA)	Availability	Annual Load Factor	CO_2 Capture Rate
Aghada Power Plant	2,731	1.08	0.97	0.11	92%	55%	90%
Whitegate Power Plant	2,731	1.08	0.97	0.11	92%	55%	90%
Irving Oil Whitegate Refinery	-	0.32	0.29	0.03	96%	96%	90%
Total for Scenario	5,462	2.48	2.23	0.25			

3. Indigenous Storage and Export option

Components Considered in the Cluster Study

- Compression
- Conditioning
- Liquefaction
- Interim Storage
- Shipping
- Indigenous Field
- Pipelines

High Level Configuration

Site		Aghada	Whitegate	Whitegate*
Application		Main CO_2 Compressor	Main CO_2 Compressor	Recirculation
Type		Integral Geared Horizontal Split	Integral Geared Horizontal Split	Integral Geared Horizontal Split
No. of Stages		4	4	4
Mass flow	Kg/h	189,773	222,264	187,245
Suction Pressure	Bara	1.7	1.7	6.9
Discharge Pressure	Bara	35	35	35
Power	kW	12,295	14,425	5,709
Isothermal efficiency	%	78.4	75.2	82.3
Motor size	kW	14,400	16,500	6,900
Foot print	mm	18900x16500	18900x16500	15410x9625

- Liquefaction and intermediate storage of the CO_2 at a single site
- CO_2 from Aghada Power Station transported by pipeline in gas phase
- The pipeline pressure is fixed at 35 bara, (aligned indigenous storage via Inch Gas Terminal)
- Drying done at each location -density of compressed and dried CO_2 for pipeline transport is 72 kg/m^3

*The main compressor will compress the CO_2 from both plant and refinery, the recirculation compressor recompresses flash gas from the 35 bar liquid to 7 bar storage pressure

Expected CO_2 inlet quality

Comparing the inlet specification and the target requirement

- Gap on the water, oxygen and nitrogen content – indicates purification of the CO_2 needed
- Rest of the impurities – within acceptable level

(Based on literature data from capture plant campaigns at Technology Center Mongstad (TCM) using MonoEthanolAmine (MEA). The final impurity profile for the HiperCap solvent is not available at this stage in the Realise project. When this data is made available, it might be concluded that further purification to remove e.g. NOx is needed.)

Johnsen, K. et al (2019), CO2 Product Quality: Assessment of the Range and Level of Impurities in the CO2 product Stream from MEA Testing at Technology Centre Mongstad (TCM)

Compound	Concentration	Rationale
CO_2	Balance	
N_2	500	ppm-V/V
O_2	50	ppm-V/V
Aldehydes	5	ppm-V/V
NOx	<10	ppm-V/V
NH_3	<5	ppm-V/V
SO_2	0	ppm-V/V
Water	Saturated at 40 C and 1.7 bara	

Compression of CO_2

- Allow for more efficient transportation,
- More efficient purification of the CO_2,
- Allow for liquefaction of the CO_2 before intermediate storage and export to permanent storage.
- Liquefy the gaseous CO_2 - reduce the electrical load (refrigeration).
- Avoiding the formation of CO_2 solids upon cooling the gas.

Plant & Parameters	Capture Plant	Compression/ Conditioning	Liquefaction Plant	Intermediate CO_2 storage	Ship Vessel	Inch Terminal
Inlet Temperature, Pressure	>100°C, 1.05 bara	40°C, 1.7 bara	40°C, ~35 bara	-52°C, 7 bara	-52°C, 7 bara	5°C, ~35 bara
Outlet Temperature, Pressure	40°C, 1.7 bara	40°C, 35 bara	-52°C, 7 bara	-52°C, 7 bara	N/A	N/A

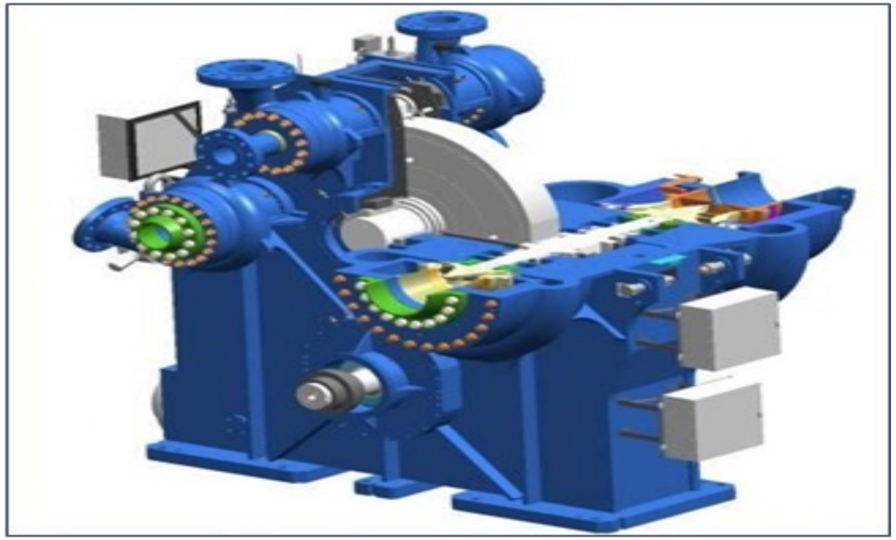
Compressors

- Traditionally reciprocating compressors or oil lubricated screw compressors have been used for compression of CO_2 upstream of liquefaction,
    - **However** both these technologies do not meet the volumetric capacities
    - Therefore, centrifugal compressors were considered.
- Centrifugal compressors hold further advantages compared to reciprocating compressors
    - Higher efficiency
    - Higher reliability and
    - Higher meantime between overhauls
- Two types of centrifugal compressor were considered
    - multi shaft integral geared and
    - single shaft inline compressors

(axial compressors were briefly considered, but the limitations on the outlet pressure for this type rules them out.)

Integral Geared Compressor

Due to the higher degree of flexibility, high efficiency and low investment cost, integral geared compressors were considered.

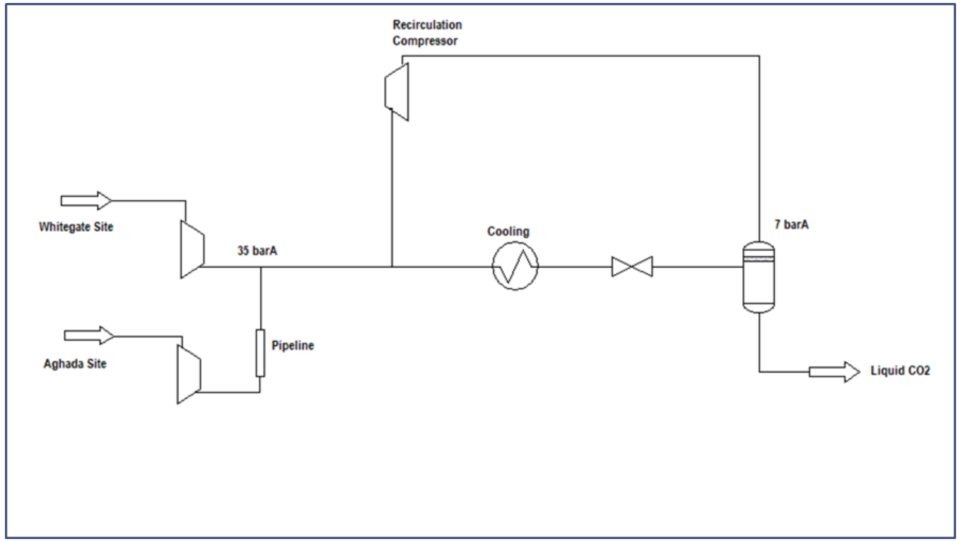


- Better performance at part load,
- Higher reliability,
- Lower power demand especially with many stages,
- Smaller motor size with less implication to general electrical system and
- Very high pressure is achievable.

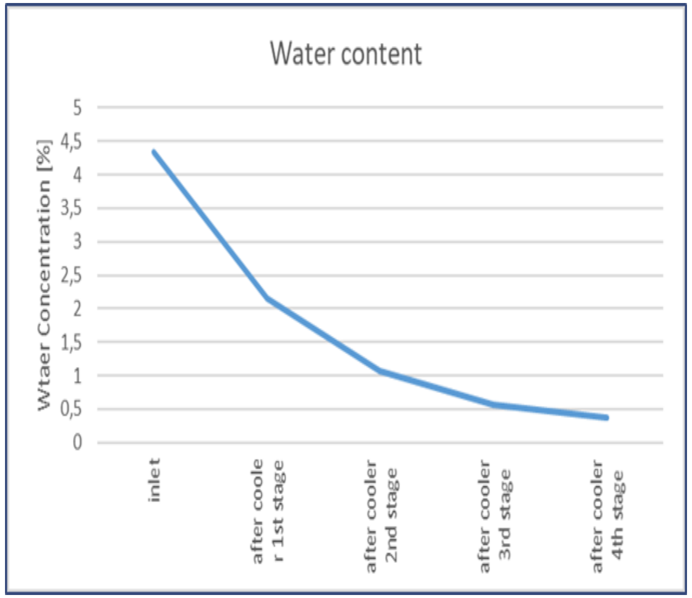
Compressor Configuration

- 3 CO_2 compressor packages needed for 2 sites:
- 1 compressor package at each to 35 bara
- One recirculation compressor that will compress:
  - balance gas from storage tank (displaced when filling tanks with liquid),
  - Evaporation from storage tank created by heat ingress from ambient and
  - The flash gas formed when letting down the pressure from pipeline pressure to the 7 bara that is the intermediate storage pressure.

- Possible turn down to about 70 % capacity with little power penalty, below that bypass operation is needed
- If further flexibility is forecasted to be needed two or three packages in parallel are required



Drying

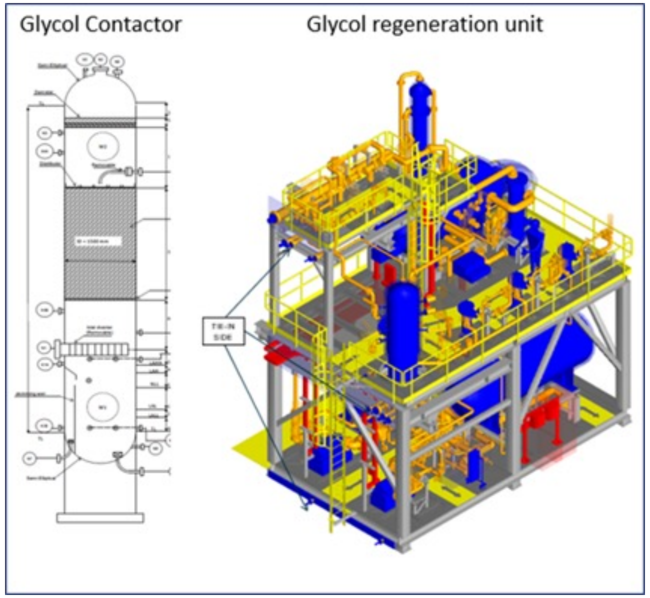


Drying - Avoid formation of hydrates - Avoid corrosion in downstream equipment made from steel.

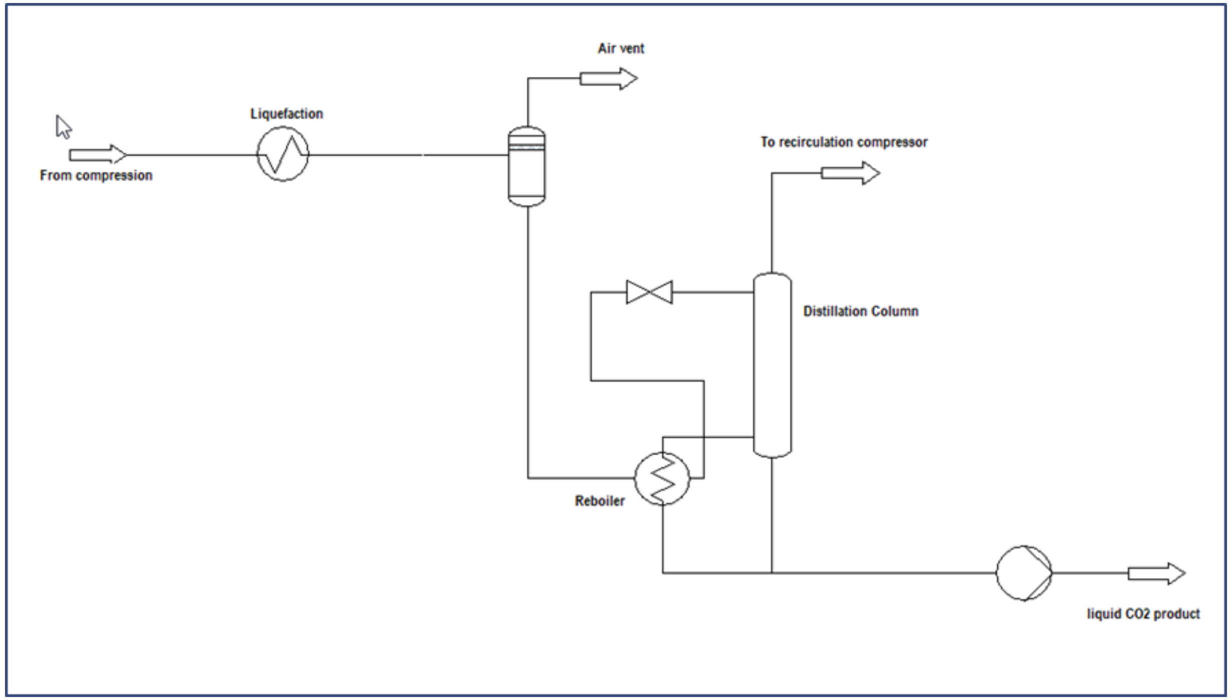
Balance - Corrosion of pipelines and joints due to carbonic acid, or mechanical damage from hydrates. increase drying costs unnecessarily.

Compression facilitates purification of the CO_2 both drying and removal of trace impurities.

- Adsorption or
- **Absorption** – Preferred
    - Low pressure steam as heating.
    - Lower electrical load.
    - Lower heat demand.



Low Temperature Distillation



- Single site – remove nitrogen and oxygen
- 7 bara* (lower than storage pressure)- corresponding to a CO_2 dew point of -49 °C.
- Heat - supplied by sub cooling the liquid stream from condenser (35 bara/-4 °C)
- Oxygen and nitrogen removed by stripping - compounds separation factors of ~60 and ~80 at 7 bara respectively
- Packing height of 4 meters

*Noting distillation could also be performed at 15 bara as intermediate step

Liquefaction for intermediate storage and export

- In Northern Lights Phase 1 - medium pressure 15 bara.
- Future phases that Northern Lights - medium or low pressure.
- Low pressure transport of CO_2 - about 7 bara – appears to be more cost effective for long distance transportation by sea, (not as mature)

External Refrigeration - similar to conventional refrigeration cycles where the heat of evaporation is:

- Removed from the CO_2 by evaporation of a refrigerant,
- Elevated to a higher temperature by a refrigerant compressor and
- Removed from the refrigeration loop by condensing the refrigerant by cooling with air or water.

Internal Refrigeration – use Joule Thompson effect, where expansion of gas result in cooling of the gas, allowing for partial condensation, separation of gas and liquid and recompression of the remaining gas fraction.

- Slightly higher Opex and Capex:
    - Pressure 70 bara to achieve a significant liquid faction upon expanding.
    - More complex compression.

Utility Consumption compression, purification and liquefaction

Whitegate site

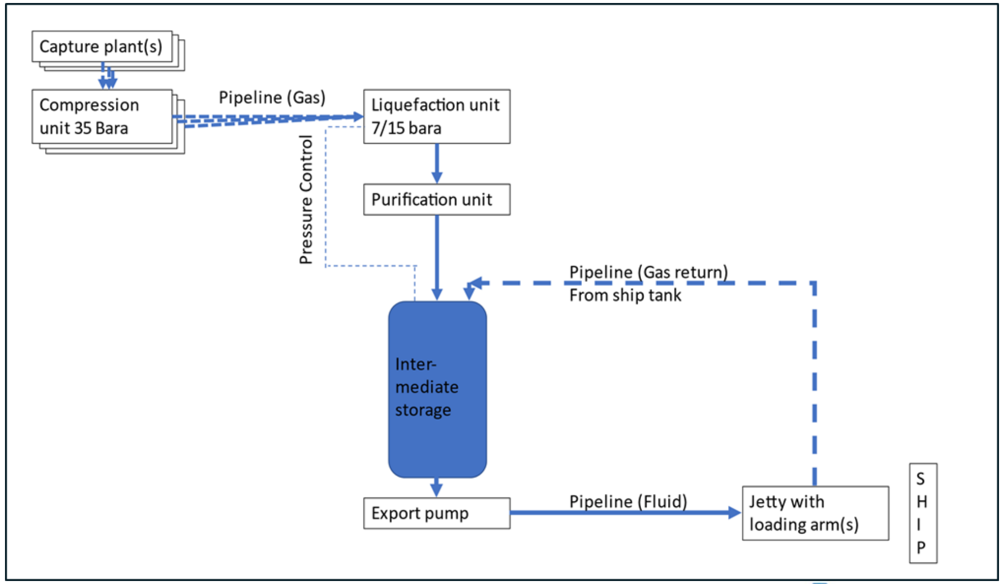
Utility	Part	Unit	Amount
Power	Supply	kV	10
	Motor & Heater capacity installed	MW	35.6
	Consumption	MW	31.012
Cooling water	Temperature	°C	30
	Consumption Whitegate Site	MW	28.05
Air cooling	Demand Whitegate Site (ref. Condenser)	MW	52.1
Steam	Consumption Whitegate site	MW	0.66

Aghada site

Utility	Part	Unit	Amount
Power	Supply	kV	10
	Motor & Heater capacity installed	MW	14.87
	Consumption	MW	12.765
Cooling water	Temperature	°C	30
	Consumption Aghada Site	MW	17.0
Air cooling		MW	
Steam	Consumption Aghada site	MW	0.59

Intermediate Storage

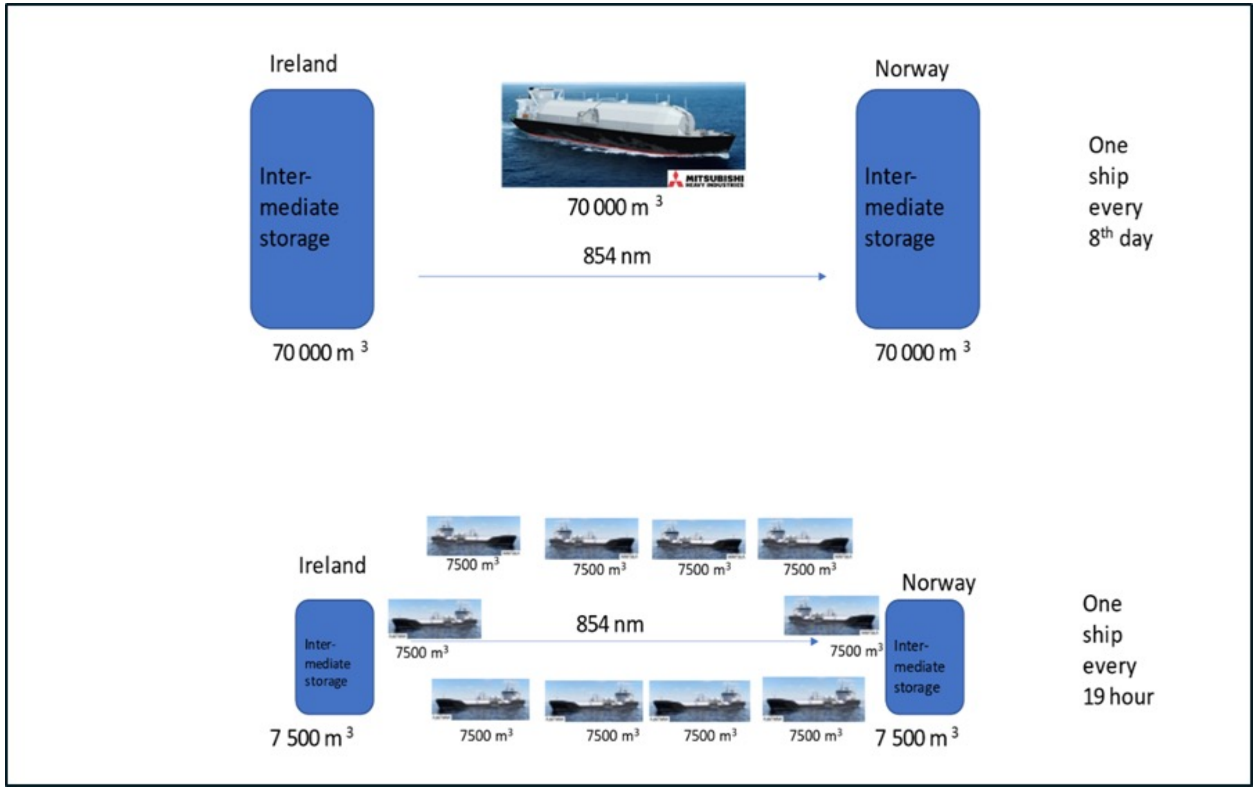
- Bullet Tanks
- Stainless Steel
- Spherical
- Floating Production Storage and Offloading



Jetty requirements

- Extend jetty head – shared trestle
- Built in 1959
- Jetty trestle 720 m long
- Jetty head 70 m long (370 including mooring dolphins)
- Accommodate the insulated piping system and pipes for the vapour return
- 2 loading arms for the liquid CO_2
- 1unloading arm for the vapour CO_2
- 1 common spare
- Control and instrumentation system.

Shipping



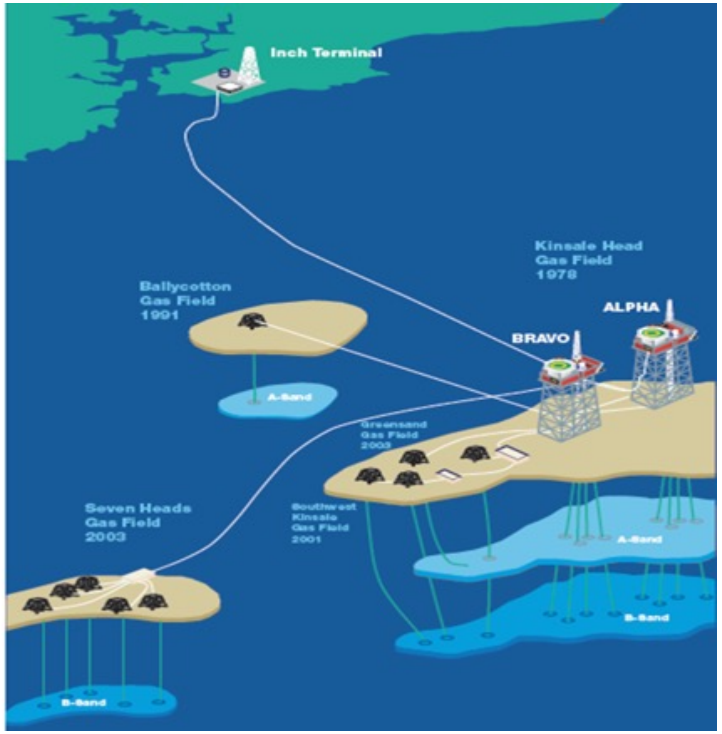
Low pressure (7 bara and -50 °C)

- Shipping distance & Volume
- Effect of heel & vapour density 94.5%
- 7500 m^3 x 0.945 x 1155 kg/ m^3 = 8,200 tonnes.

Medium pressure (15 bara and -28 °C)

- Higher TRL – used in food grade industries
- Weight of tank 185% higher
- Heel 92.5%
- 7,500 m^3 x 0.925 x 1040 kg/ m^3 = 7,200 tonnes

Indigenous Kinsale Head Gas Field - depleted



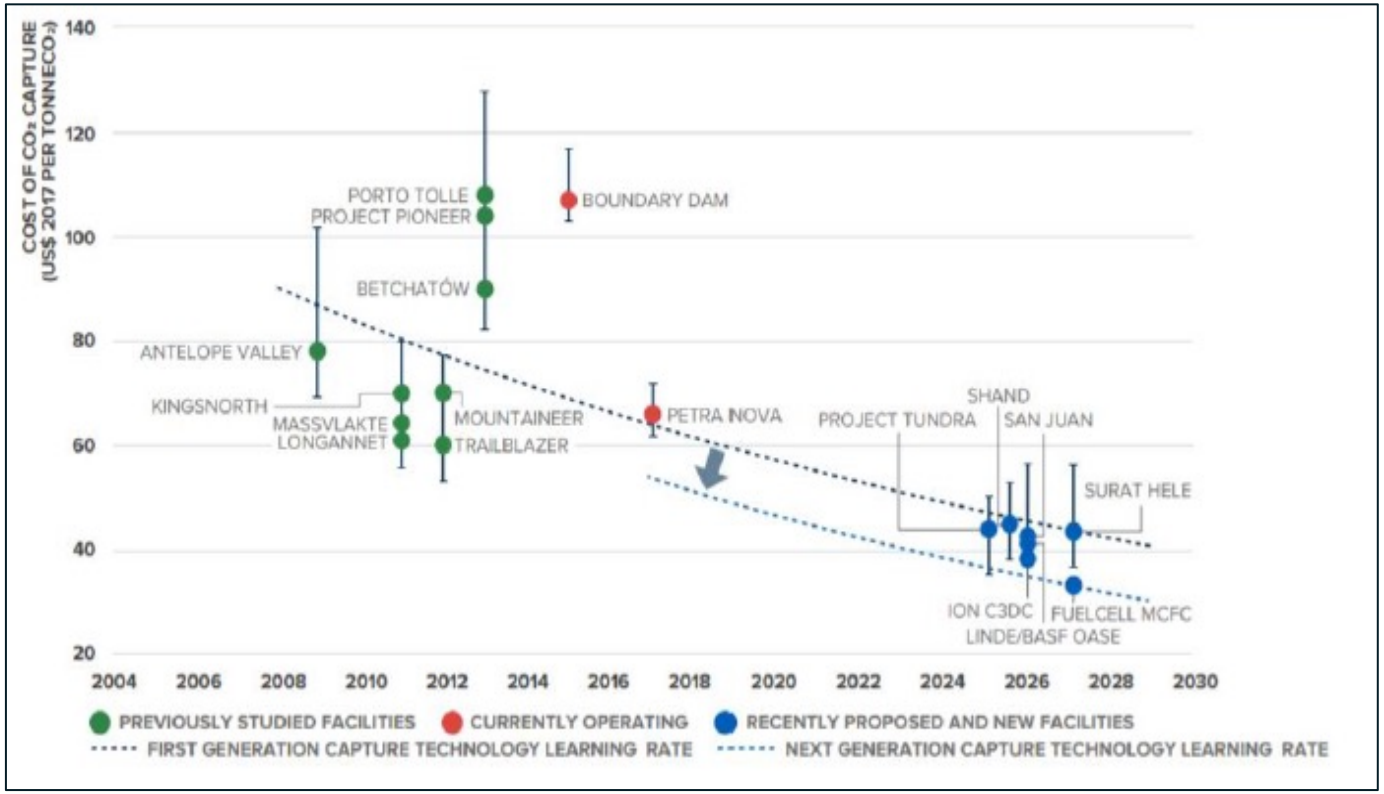
- 300 Mt CO_2 storage
- Decommissioning currently (partially complete)
- Potential to reuse
    - 50 km pipeline from Inch Terminal to field
    - 10 km of pipeline from Inch Terminal to Whitegate

Indigenous – Gas Phase

- Maximum flow rate of about 40 kg/s
- 3 wells (2 platforms), (80 kg/s about 2.5 Mtpa 50% spare capacity).
- Minimum flow rate for the wells about 30 kg/s each
- Low flow - single well or lower pipeline pressure
- Half available storage capacity for operating in gas phase.
- 2.23 Mtpa - more than 50 years
- To avoid frequent shut-ins there are 4 options:
  - line pack (better with gas),
  - buffer storage, about 40,000 m^3 (liquefied CO_2) would be needed to provide a flow rate of 30 kg/s for a duration of 400 hrs, which is a large amount of storage so possibly the other options are better
  - changing pressure in the transport pipeline or
  - using wells with different operational windows.

4. Cost Benefit Analysis

CCS Cost Reducing



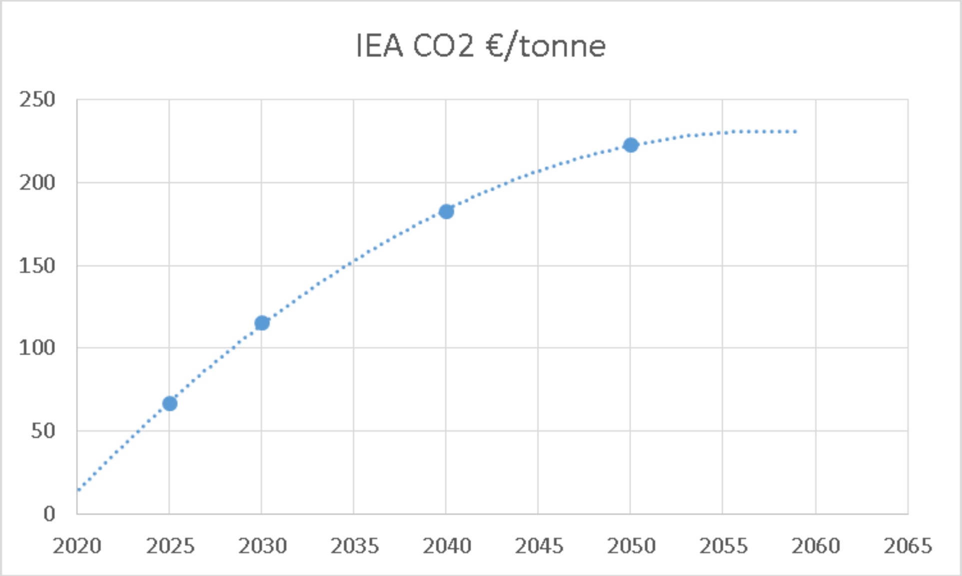
- > $100/tonne - Boundary Dam facility
- $65/tonne - Petra Nova facility, 3 year later
- $43/tonne - facilities due to come in to operations in 2024-28.
- $33/tonne - New technologies at pilot-plant scale promise capture costs around

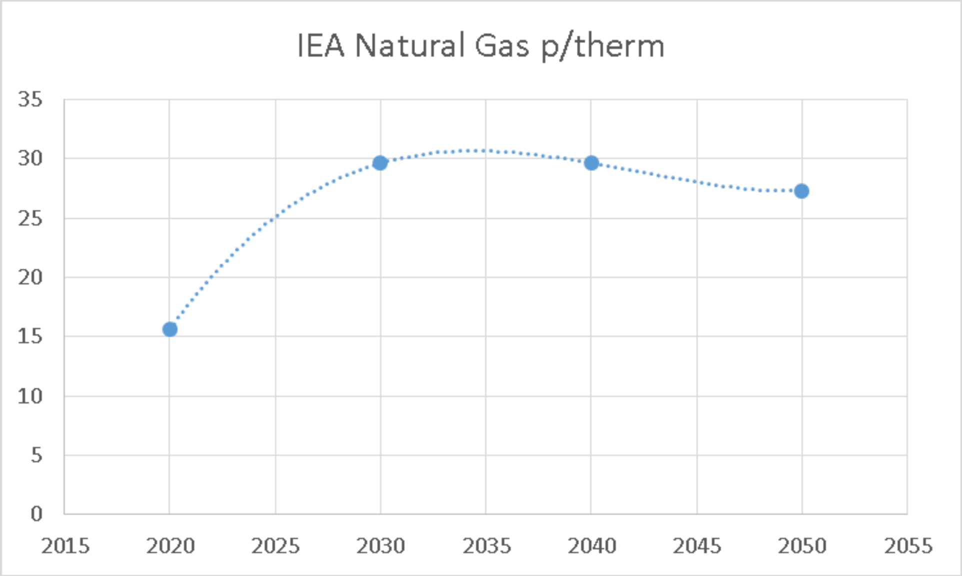
Assumptions/Inputs

- Target internal rate of return of 3.4%
- Insurance and local tax 2% of Capex
- Working Capital 5% of product level
- Debt/Equity ratio 70/30
- Straight line depreciation over 25 years
- Input costs - Public domain data from Wood CCS Benchmarking Project for BEIS - Cansolv NOAK unit

- Base Case
- 2.48Mtpa CO_2 produced
- 2.23Mtpa CO_2 Captured
- 4 years in development
- 4 years in construction
- Gas phase injection
- Liquid phase export
- All new infrastructure

Forward Price Curves (IEA)





Source: IEA (2021), Net Zero by 2050: A roadmap for the global energy sector

Capex

Capital Item (Export)	€m	%
Power Island	668.3	37.5%
Capture	383.5	21.5%
Compression	44.4	2.5%
Utilities	67.7	3.8%
Transport	11.0	0.6%
Liquefaction, Storage & Loading	105.0	5.9%
Owners Costs	196.4	11.0%
Contingency	288.0	16.2%
IDC	18.0	1.0%
Total (Real)	1,782.2	100.0%
Total CO_2 Captured	2.2MTpa	

Capital Item (indigenous)	€m	%
Power Island	668.3	30.0%
Capture	383.5	17.2%
Compression	44.4	2.0%
Utilities	67.7	3.0%
Transport	98.7	4.4%
Storage	338.4	15.2%
Owners	238.1	10.7%
Contingency	360.2	16.2%
IDC	25.7	1.2%
Total (Real)	2,225	100.0%
Total CO_2 Captured	2.2MTpa	

Opex

Avg Operating Costs Export (€m - Real based on 2034)	Low Load Factor	Base Case Load Factor	High Load Factor
Fixed Costs	70.3	70.3	70.3
Variable Costs	159.5	217.2	269.5
Of which:			
Chemical & Catalysts	4.7	6.4	8.0
Transport and Storage	63.5	88.5	109.8
Natural Gas	89.3	119.3	147.7
Others	2.0	3.0	4.0
Total Costs	229.8	287.5	339.8

Avg Operating Costs (Indigenous) (€m - Real based on 2040)	Low Load Factor	Base Case Load Factor	High Load Factor
Fixed Costs	78.6	78.6	78.6
Variable Costs	96.0	128.9	159.8
Of which:			
Chemical & Catalysts	4.7	6.4	8.0
Transport and Storage (Shipping and Receiving)	0.0	0.0	0.0
Natural Gas	89.3	119.3	147.7
Others	2.0	3.2	4.1
Total Costs	174.6	207.5m	238.4

Comparative Levelised Cost of Electricity

Levelised Cost of Electricity (Export)	Low Load Factor	Base Case Results	High Load Factor
LCOE (€/MWh)	112.30	88.8	75.10
LCOE for Un-Abated Plant (CCGT) (€/MWh)	123.80	108.6	99.40
Incremental cost of CCUS (€/MWh)	11.50	19.80	24.30
Expressed in percentage terms	9%	18%	24%
Levelised Cost of Abatement (€/tonne CO_2 captured)	126.70	113.40	106.50

Levelised Cost of Electricity (Indigenous)	Low Load Factor	Base Case Results	High Load Factor
LCOE (€/MWh)	101.20	76.50	62.70
LCOE for Un-Abated Plant (CCGT) (€/MWh)	123.80	108.60	99.40
Incremental cost of CCUS (€/MWh)	22.6	32.10	36.7
Expressed in percentage terms	18%	30%	37%
Levelised Cost of Abatement (€/tonne CO_2 captured)	103.20	84.10	74.3

Experts agree that CCUS is a necessity not an option

IPCC — Intergovernmental Panel on Climate Change

CCUS is critical to achieving climate targets
138% higher costs without CCUS

EirGrid

Eirgrid's Tomorrow's Energy Scenarios: CCUS is deployed in two of the three scenarios.
Climate objectives are only met in the scenario which deploy CCUS

iea — International Energy Agency

Without CCUS transformation of power sector….
$3.5 trillion more expensive

Committee on Climate Change

The UK Committee on Climate Change's Net-Zero report (May 2019) states…
"CCUS is a necessity not an option"

An exploration of approaches to public engagement

Dr Paola Velasco Herrejón , University College Cork @PaolaVelascoH

REALISE CCUS webinar 3:
The Cork Cluster study

Online

26 April 2022

Background

- ❑ Postdoctoral researcher at the Cleaner Production Promotion Unit, University College Cork Ireland.
- ❑ Engaged research on the theme of *Society, Sustainability and Energy.*
- ❑ Focus on people’s relationship with the energy system.

Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

cppu – cleaner production promotion unit

www.ucc.ie/cppu
@ucc_cppu

Socio-political considerations within REALISE

- The technical and geological aspects of a CCS project are of course the primary focus of the planning and implementation phases.
- However, REALISE recognizes the importance of understanding (and appreciating) the social context of prospective CCS projects.
- Specific package of work which seeks to develop and in-depth understanding of the societal, socio-political and commercial contexts of CCS deployment.

Socio-political dimensions of decarbonization

- Deployment of major infrastructure needed to realise the required decarbonisation transition can only be successful with social acceptance.
- This means acceptance by the public generally (of the technology), but also, and critically acceptance by the community which will play host to the infrastructure.
- However, the strong public opposition faced by many projects threatens to significantly slow down this transition.

Dunphy, N. P., Revez, A., Gaffney, C., & Lennon, B. (2017). Intersectional Analysis of Perceptions and Attitudes Towards Energy Technologies. Deliverable 3.3 of the ENTRUST H2020 project. https://doi.org/10.5281/zenodo.3479301

Why engage with the public?

- Effective public engagement can help identify project risks, improve project design, and establish ways to resolve communities’ concerns about the project.

Dunphy N.P., Lennon, B., Quinlivan, L., Velasco Herrejon, P., Curran, R. (2021). Critical review of Education and Public Engagement initiatives. Deliverable 4.1 of the REALISE Horizon 2020 project.

What is public engagement?

- Public engagement is the process through which a project developer or a regulator builds and maintains constructive relationships with communities by involving them in a timely and transparent manner over the life of a project.

Dunphy N.P., Lennon, B., Quinlivan, L., Velasco Herrejon, P., Curran, R. (2021). Critical review of Education and Public Engagement initiatives. Deliverable 4.1 of the REALISE Horizon 2020 project.

Principles for effective public engagement

1. Understand the local community context

- ❑ Assess community dynamics and your historical presence.
- ❑ Weigh participatory engagement.

Dunphy N.P., Lennon, B., Quinlivan, L., Velasco Herrejon, P., Curran, R. (2021). Critical review of Education and Public Engagement initiatives. Deliverable 4.1 of the REALISE Horizon 2020 project.

Dunphy N.P., Velasco Herrejon, P., Lennon, B. (2021). Review of Education and Public Engagement Programmes. Deliverable 7.2 of the SafeWAVE EMFF project.

Principles for effective public engagement

2. Exchange Information about the Project

- ❑ Engage early and develop a relationship with the community.
- ❑ Answer questions.
- ❑ Seek input and provide information openly and transparently.

Dunphy N.P., Lennon, B., Quinlivan, L., Velasco Herrejon, P., Curran, R. (2021). Critical review of Education and Public Engagement initiatives. Deliverable 4.1 of the REALISE Horizon 2020 project.

Dunphy N.P., Velasco Herrejon, P., Lennon, B. (2021). Review of Education and Public Engagement Programmes. Deliverable 7.2 of the SafeWAVE EMFF project.

Principles for effective public engagement

3. Identify Appropriate Level of Engagement

- ❑ Foster two-way engagement.
- ❑ Consult and negotiate with communities.
- ❑ Address concerns.
- ❑ Convey feasible level of engagement.

Dunphy N.P., Lennon, B., Quinlivan, L., Velasco Herrejon, P., Curran, R. (2021). Critical review of Education and Public Engagement initiatives. Deliverable 4.1 of the REALISE Horizon 2020 project.

Dwyer, J., & Bidwell, D. (2019). Chains of trust: Energy justice, public engagement, and the first offshore wind farm in the United States. Energy Research and Social Science, 47(January), 166– 176. https://doi.org/10.1016/j.erss.2018.08.019

Principles for effective public engagement

4. Discuss Risks and Benefits of Project

- ❑ Answer questions.
- ❑ Discuss with community risks, benefits, uncertainties, and mitigation and contingency plans.
- ❑ Consider benefit sharing schemes.

Dunphy N.P., Lennon, B., Quinlivan, L., Velasco Herrejon, P., Curran, R. (2021). Critical review of Education and Public Engagement initiatives. Deliverable 4.1 of the REALISE Horizon 2020 project.

Dunphy N.P., Velasco Herrejon, P., Lennon, B. (2021). Review of Education and Public Engagement Programmes. Deliverable 7.2 of the SafeWAVE EMFF project.

Principles for effective public engagement

5. Continue Engagement through Time

- ❑Engage community at each step of project schedule.
- ❑Consider informal, long-term relationship to ease stewardship transition.

Dunphy N.P., Lennon, B., Quinlivan, L., Velasco Herrejon, P., Curran, R. (2021). Critical review of Education and Public Engagement initiatives. Deliverable 4.1 of the REALISE Horizon 2020 project.

Dunphy N.P., Velasco Herrejon, P., Lennon, B. (2021). Review of Education and Public Engagement Programmes. Deliverable 7.2 of the SafeWAVE EMFF project.

Final thought …

"Engagement techniques that focus on community concerns – and which are transparent, realistic and honest in what they can deliver – fall into my category of good practice and ones that don't fall into my bad practice category."

- Cast study informant

www.ucc.ie/cppu

@ucc_cppu

Dunphy N.P., Velasco Herrejon, P., Lennon, B. (2021). Review of Education and Public Engagement Programmes. Deliverable 7.2 of the SafeWAVE EMFF project.

Thank you for listening

Presenter

Inna Kim, SINTEF

Paul Murphy, ERVIA

Paola Velasco Herrejón, University College Cork

Project

@realise-ccus

www.realiseccus.eu

info@realiseccus.eu

Acknowledgements

biobe Expertise in plastics
Bord Gáis Energy
CYBERNETICA
equinor
敦华石油 DUNHUA OIL
ervia
ESB Energy for generations
IRVING
NTNU
PENTAIR UNION ENGINEERING
POLITECNICO MILANO 1863
SCCS
SINTEF
TNO innovation for life
Tsinghua University
UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh
The University of Edinburgh

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 884266