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Cork CCUS CEF Pre-FEED Study

GATHERING, LIQUEFACTION, TEMPORARY STORAGE AND SHIPPING OF CAPTURED CO_2

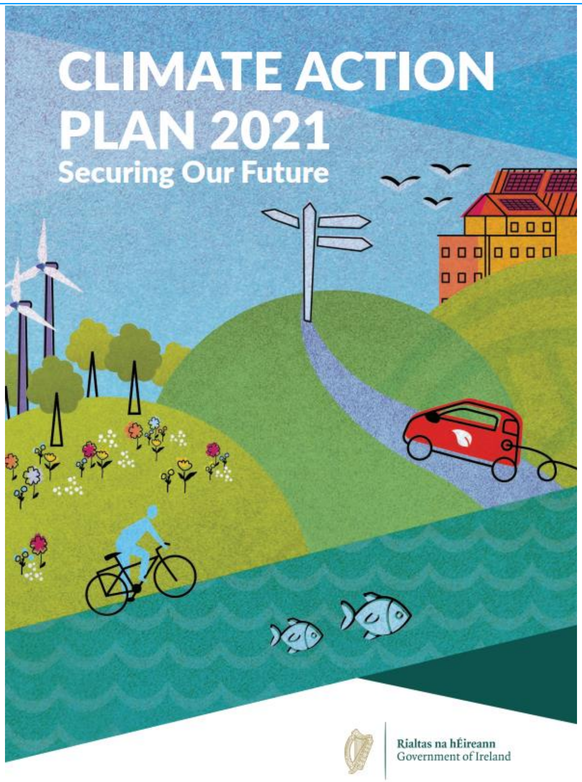
Presented by:
Gearóid Fitzgerald, Ervia

Document Reference: MDE1234-RPS-07-XX-RP-Z-0001 Global CCS Institute

Project Background

- Ireland's Climate Action Plan objectives
  - Reducing CO_2 emissions by 50% by 2030
  - Achieving net zero CO_2 emissions by 2050
  - Potential role for Carbon Capture & Storage (CCS)

- Action 126: *'Examine… the feasibility of… Carbon Capture and Storage'*
  - Emitter clusters identified in Cork and Dublin
  - Potential Carbon Sinks identified
    - Cork (former Kinsale Head Gas Field)
    - Norway (Northern Lights Project)



Carbon Capture and Storage

Action 33: Establishment of a Steering Group to examine and oversee the feasibility of the utilisation of CCS in Ireland, and report to the Standing Committee on Climate Action as appropriate			
Steps Necessary for Delivery	**Timeline by Quarter**	**Lead**	**Other Key Stakeholders**
Establish Steering Group	Q2 2019	DCCAE	
Agree appropriate research investment by Ervia/Gas Networks Ireland in CCS feasibility	Q3 2019	DCCAE	DHPLG, CCS Steering Group
Monitor progress of Ervia proposal in Cork	Q2 2020	DCCAE	
Draft necessary legislation and regulatory regime if CCS research is positive	Q3 2020	DCCAE	

Climate action plan 2019

Action	126	Examine and oversee the feasibility of the utilisation of Carbon Capture and Storage in Ireland			
Steps Necessary for Delivery		Proposed Output	Timeline	Lead	Key Stakeholders
Establish a framework for analysis of the potential for CCS deployment for Ireland including assessment of the environmental, technical, and financial factors		A framework for analysis of CCS potential for Ireland, including feasibility in electricity and cement sectors	Q4 2022	DECC	EPA, SEAI, DETE

Climate action plan 2021

CCS Feasibility Study

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2018

- Start of CCS Feasibility study
- Initiation of technical studies
- Offshore infrastructure assessment
- Full chain cost estimations

XODUS

wood.

2019

- Start of Gov't cross dept CCS Steering group
- MOU signed with Equinor
- PCI status granted
- Electricity Market Modelling
- Storage risk assessment

Northern Lights

Baringa

2020

- Deep Kinsale reworking
- First report to the steering group
- Abandoned well head studies
- ARUP study of the onshore infrastructure
- Financial modelling

ARUP

CGG

2021

- CEF funding secured for CO_2 transport
- H2020 Funding Realise CCS Demo
- Completion of final CCS Assessment report to Dept WG
- CEF Pre-FEED Study commences

REALISE CCUS

HR Wallingford

2022

- Carbon captured at Irving Oil refinery
- Completion of the CEF Pre-FEED study
- Presentations at the Global CCS Institute, CCSA (UK) & Cork events

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2021 CCS Feasibility Study- Key Conclusions

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Environmental - Modelling

- 2050 climate targets need CO_2 Removal
- Potential to reduce Ireland's emissions by 6 to 16.6 $MtCO_2$ per annum
- Monitoring and assessment of the CO_2 to ensure permanent geological storage is the responsibility of the host country where the store is located
- The export of CO_2 is a viable option for Ireland to develop CCS

Technical & Financial Feasibility

- Capture (post- and pre-combustion), transport (by pipeline and ship) and storage of CO_2 (in saline aquifers) commercially deployed
- Existing ISO standards & guidance documents,
- Stores available to accept CO_2 in the mid 2020's
- Current CCS developers believe that the risks could all be adequately mitigated
- On enhanced LCOE basis CCS is viable
- Abatement costs are comparable to other decarbonisation options

Regulation – IE/EU

- A framework for CCS in Ireland was developed
- Export of CO_2 avoids long-term liability for the State with the export storage option.
- There have been significant CCS developments at Member State level (BE, DK, NL, FR,PL,SE, GE & GR)
- Norway, the UK and Iceland have all stated that they will be available to import CO_2 from European countries.

Pre-FEED Study Objectives

Mission Statement

Develop a detailed costing of CO_2 transportation infrastructure to inform CCS policy

- CO_2 gathering network
- Central Processing Facility including liquefaction, temporary storage, regasification
- Ship loading facilities for CO_2 export and import

Cork (1.25MMtpa CO_2)

1. BGE Whitegate Power Station
2. Irving Oil Whitegate Refinery
3. ESB Aghada Power Station

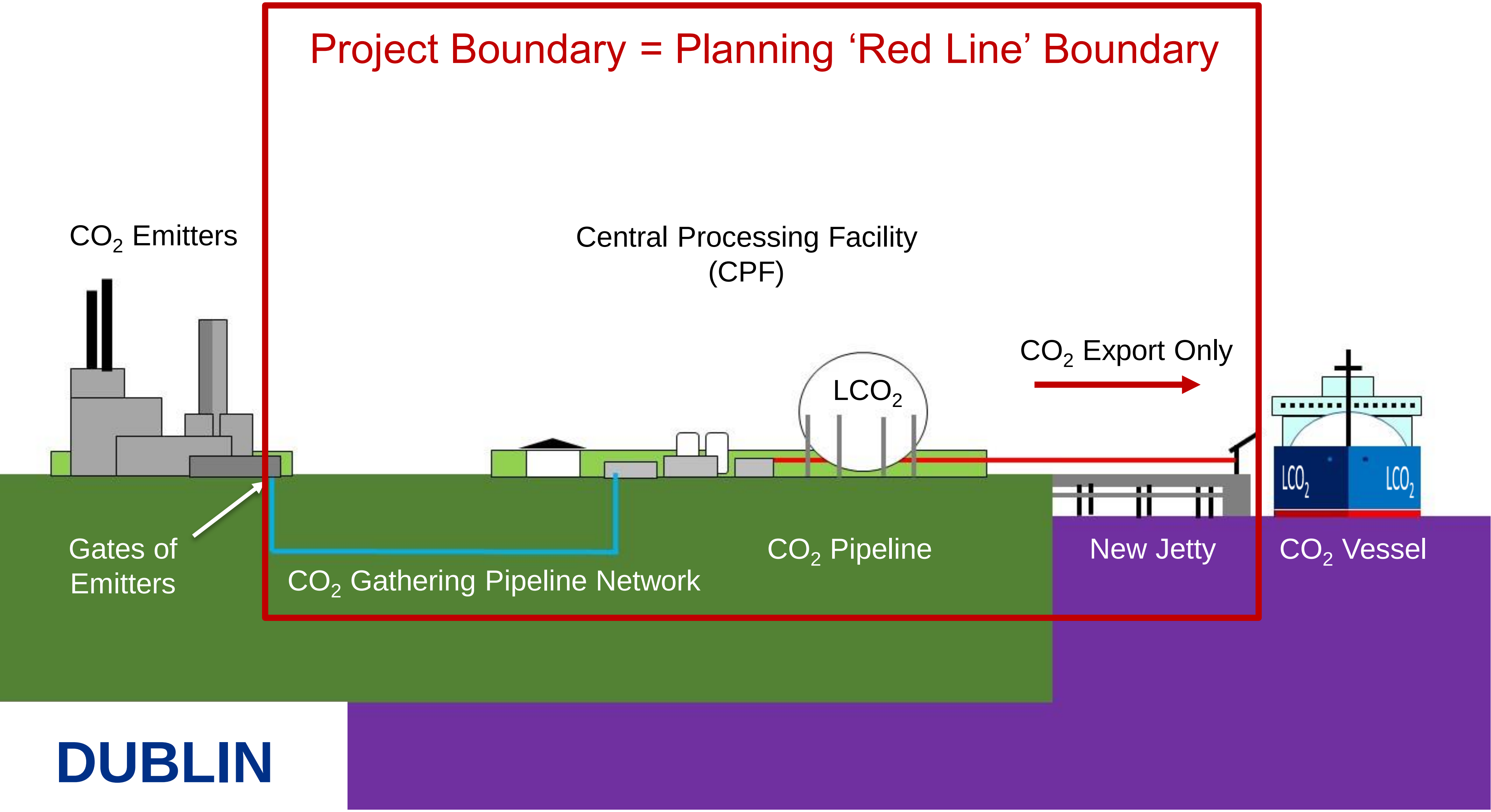
Dublin (1.75MMtpa CO_2)

1. ESB Dublin Bay Power Station
2. Covanta Dublin Waste to Energy (WTE) Plant
3. ESB Poolbeg Power Station

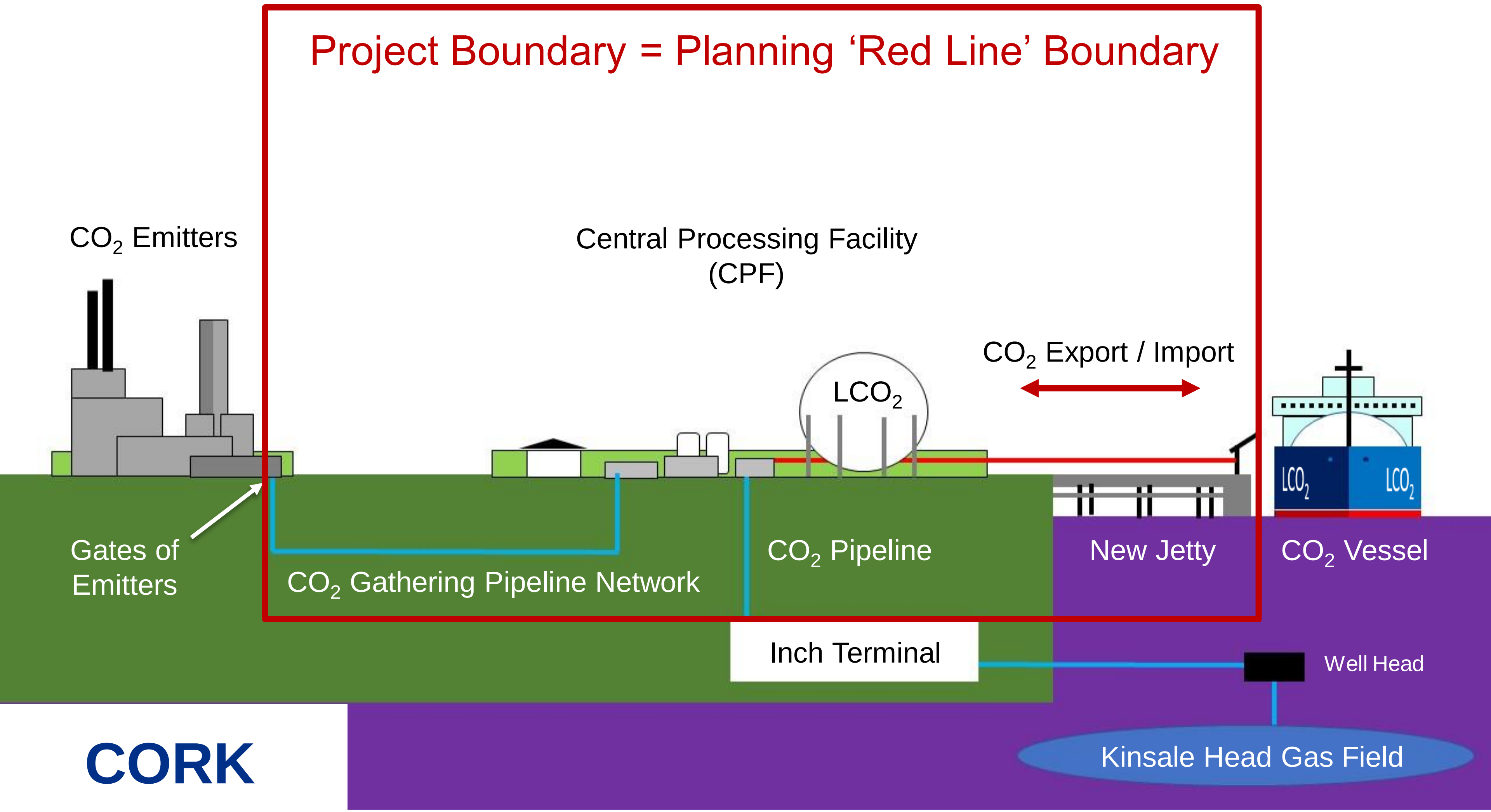
~ 5% of Irish CO_2 Emissions

- Process Engineering – PFD, MSD, P&ID, Datasheets, Equipment list, etc.
- Develop safety processes (HAZID, HAZOP, HIRA, Gas Dispersion studies)
- Produce a well defined design basis for FEED
- AACE Class 4 Cost Estimate for CAPEX
- OPEX Estimate

Carbon Transportation and Storage



Carbon Transportation and Storage



Pre-FEED Methodology

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~320 documents

Detailed Project Brief

Study Basis

Shipping Studies

Philosophy Documents (36 docs)
Process & Utilities Design Basis,
Process Control & Safeguarding,
Pipeline Design, Material Selection,
HSSE, Operations & Maintenance,
Process Safety Design Basis,
Stakeholder Management
Legislative & Environmental Approvals

CO_2 Gathering Network (52 docs)
Pipeline alignments
Flow Assurance & Hydraulic Analysis
Proximity / Safety separation

Process Engineering (160 docs)
12 Process Flow Diagrams (PFD)
10 Utility Flow Diagrams (UFD)
12 Process Safety Flow Diagrams (PSFD)
19 Material Selection Diagrams (MSD)
28 Piping & Instrumentation Diagrams (P&ID)
40 Process Datasheets
Single Line Diagrams (SLD)
Input / Output List

Plant Design (54 docs)
Plot Layout with Storage, Civil, Structural,
Architectural, Drainage, and Electrical Design
Developed 3D Models for facilities
Preliminary Design of Jetties & Marine

FEED Basis of Design

Safety Processes (12 docs)
HAZID / HAZOP / HIRA
Gas Dispersion

Project Execution Plan
Procurement Strategy
Contracting Strategy
Construction & Logistics Strategy
Programme / Schedule

Risk & Opportunities Register

AACE Class 4 Estimate
Work Breakdown Structure (WBS)
Equipment Vendor Quotations
Bulk Material Take-Offs & Pricing
Indirect Costs (e.g. Const. Eqp. Etc.)
Contingency Analysis

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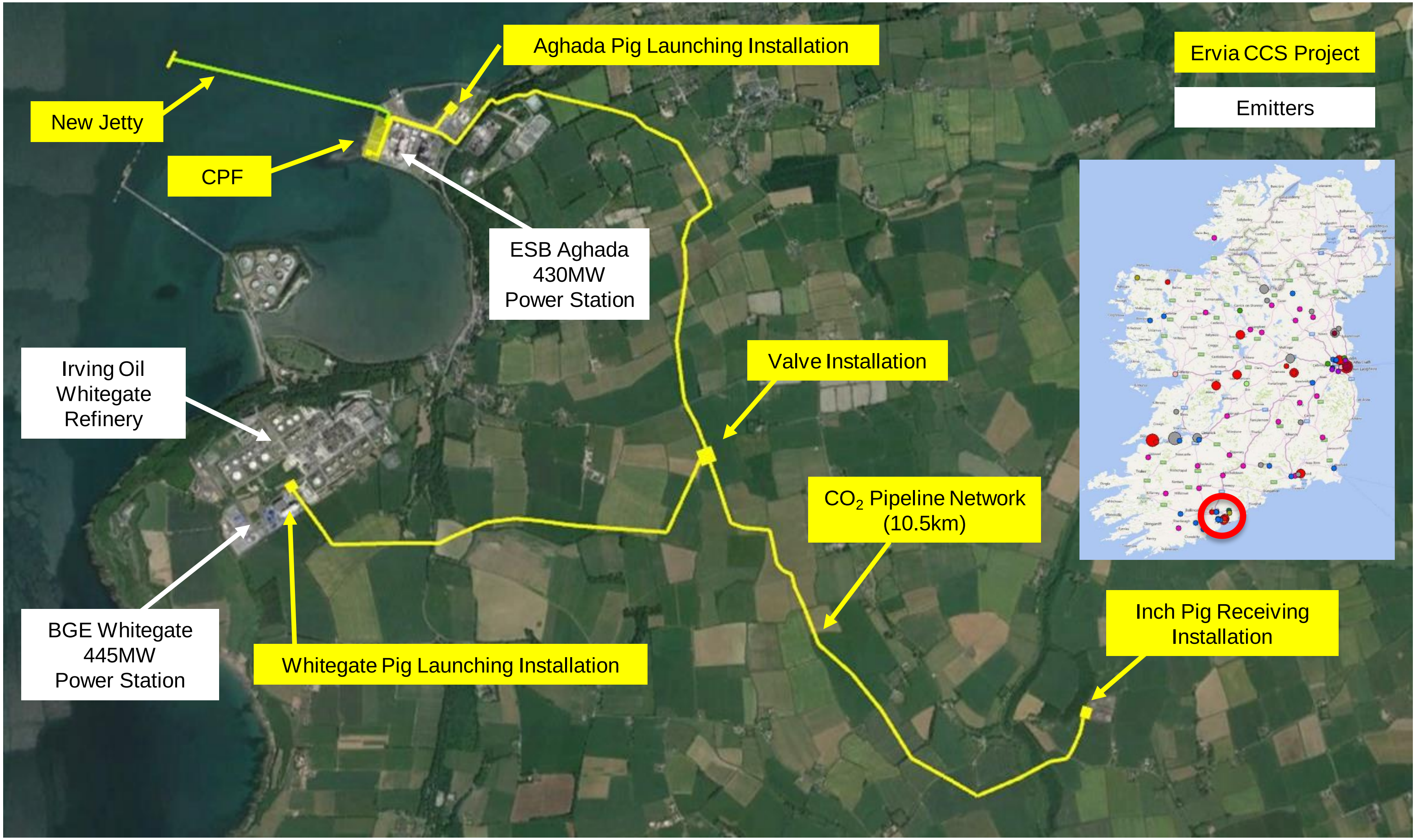
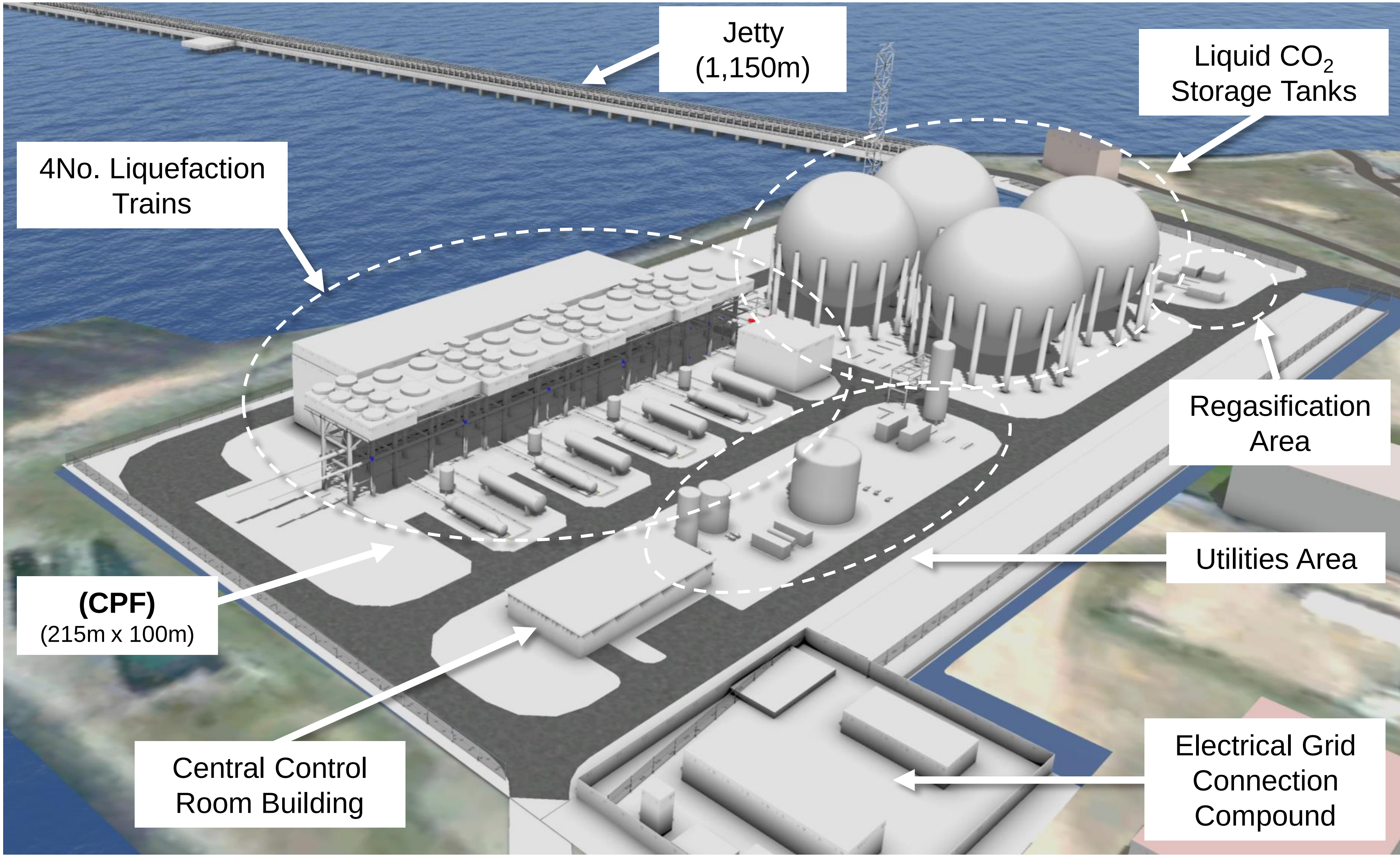
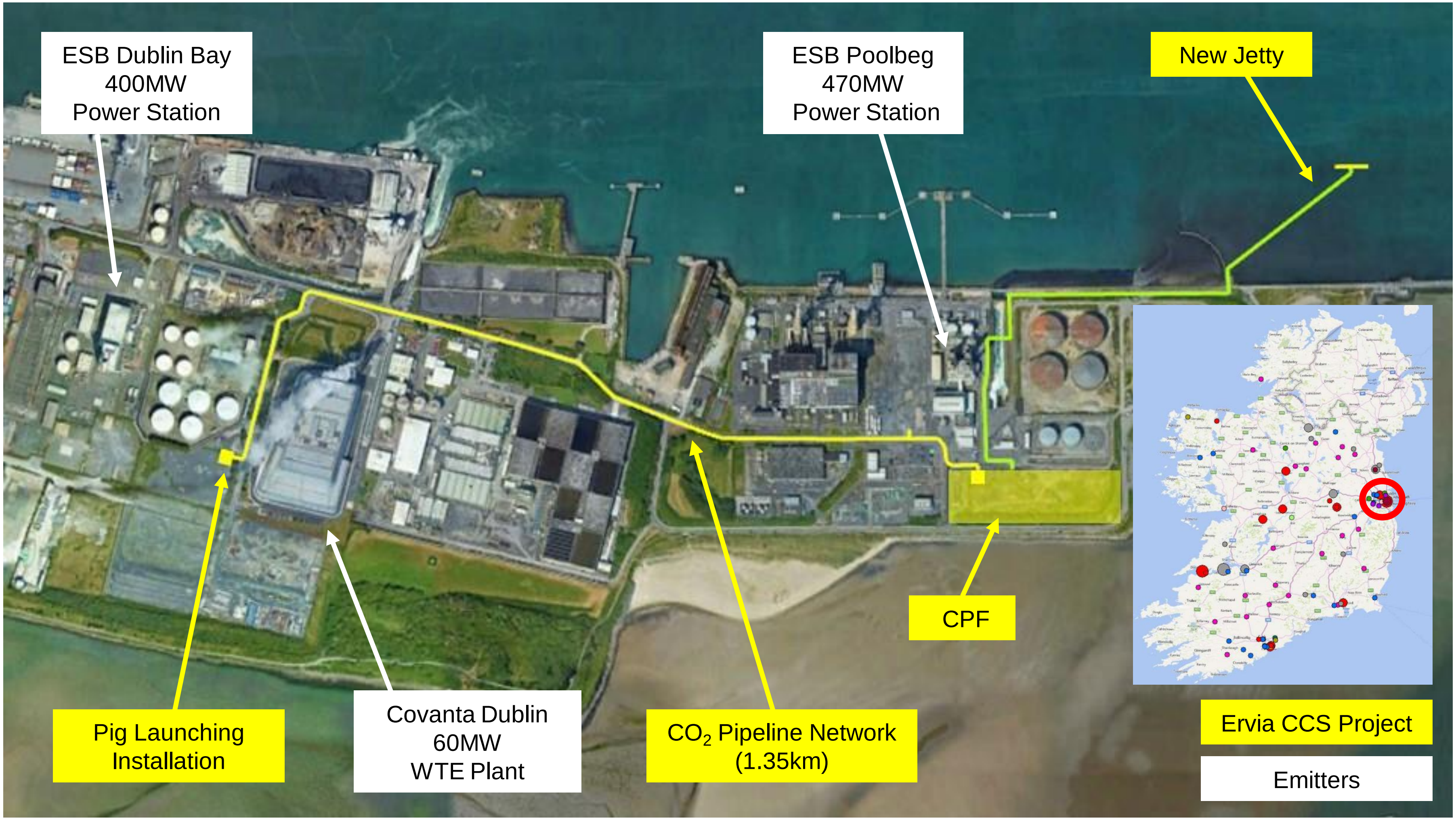
Cork CO_2 Gathering Network



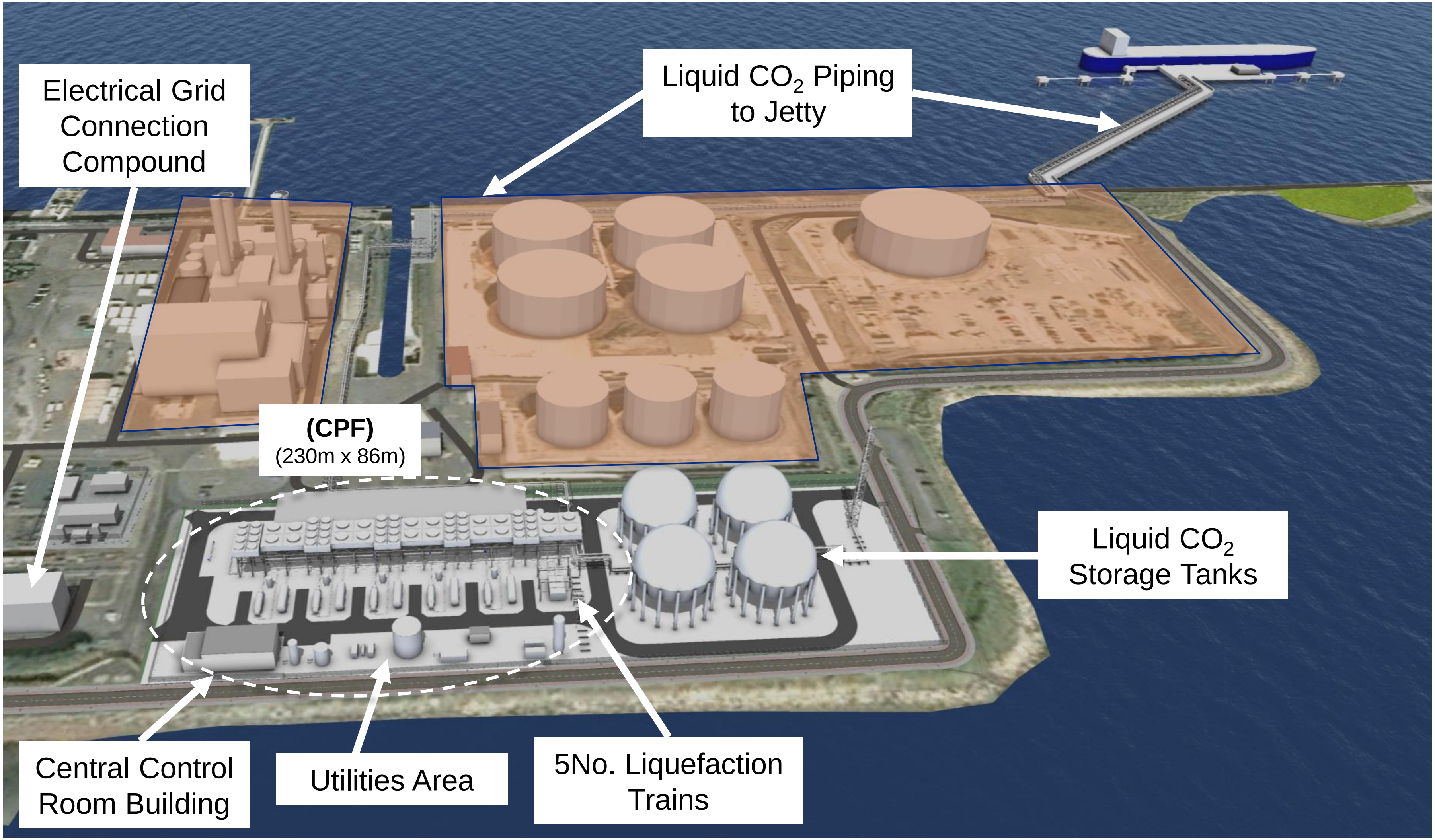
Central Processing Facility – Cork



Dublin CO_2 Gathering Network



Potential Plant Location – Dublin



CO_2 Shipping Study

CO_2 Conditions

- Medium Pressure conditions (14bar to 20bar / -30ºC to -19.5ºC)
- Northern Lights Project Specification
- Compatible with LPG carriers

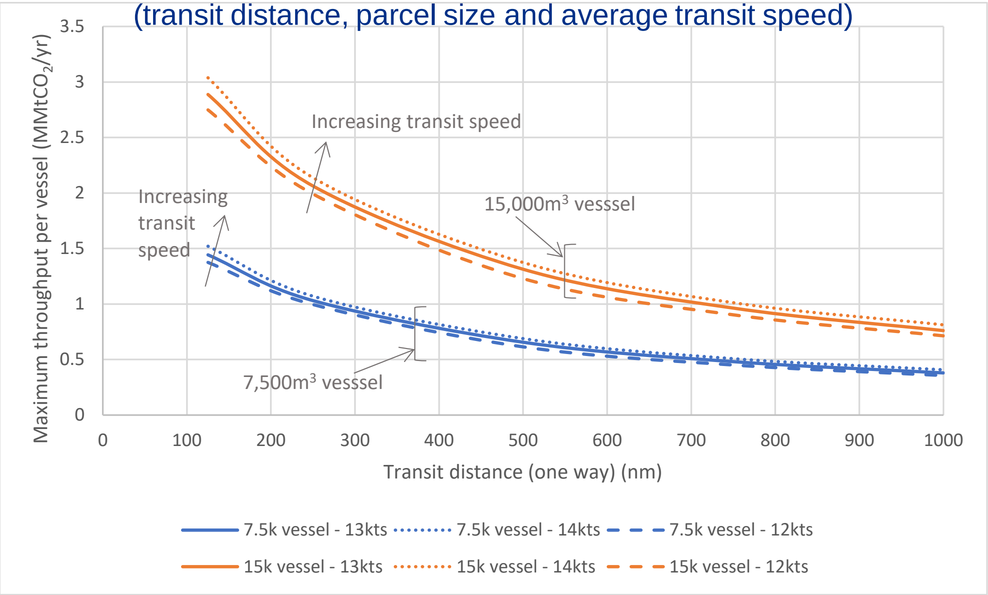
Vessel size

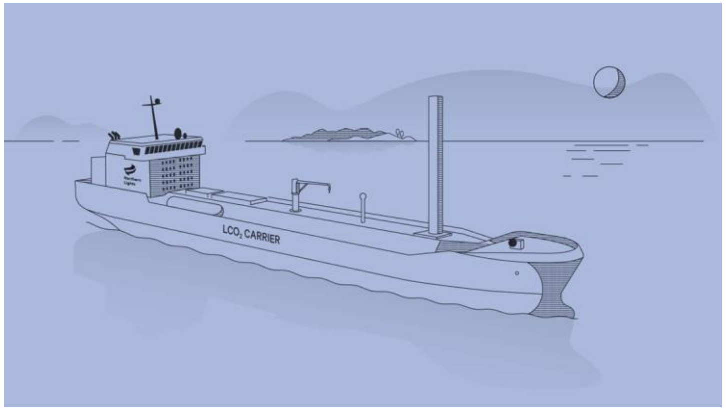
- 7,500m^3 x 4No. Vessels per facility
- Voyages per year:
  - Cork: 152 (900nm to Kollsnes)
  - Dublin: 212 (750nm to Kollsnes)
- Determines storage capacity requirements:
  - Cork: Vessel + 3 days production = 26,050m^3
  - Dublin: Vessel + 3 days production = 29,700m^3
- Future consideration: 15,000m^3 vessels (2 per facility)

Port Locations

- Cork and Dublin suitable for envisaged vessel sizes

Annual throughput capacity for a single vessel
(transit distance, parcel size and average transit speed)





Northern Lights CO_2 Vessel (7,500m^3)

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CO_2 Temporary Storage

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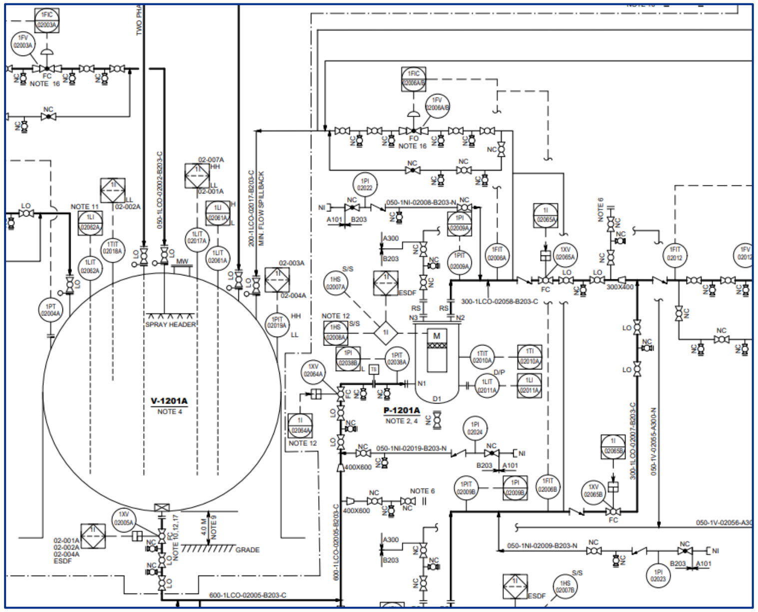


Storage Options

- Spheres
  - Larger capacity : 4 Spheres equated to 53 Bullets
  - More economical as storage needs increases, reduces footprint
  - Sphere option reduces piping, valving, and simplifies control system
  - Sphere option reduces risk of leaks and/or equipment failure

- Horizontal Vessels / Vertical Vessels (Bullets)
  - Economical (shop fabricated) suitable for smaller volumes
  - Size limitations driven by economics (i.e. steel thickness)

Jetty Design

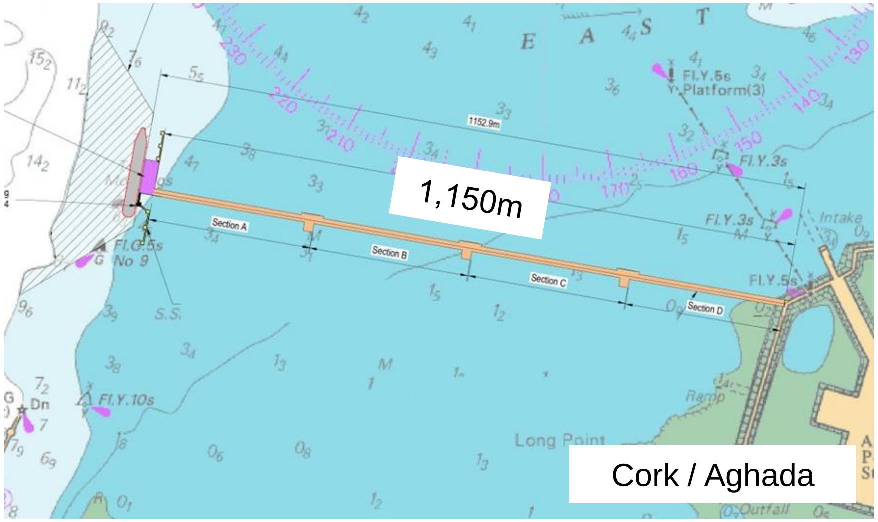
- New Jetties required:

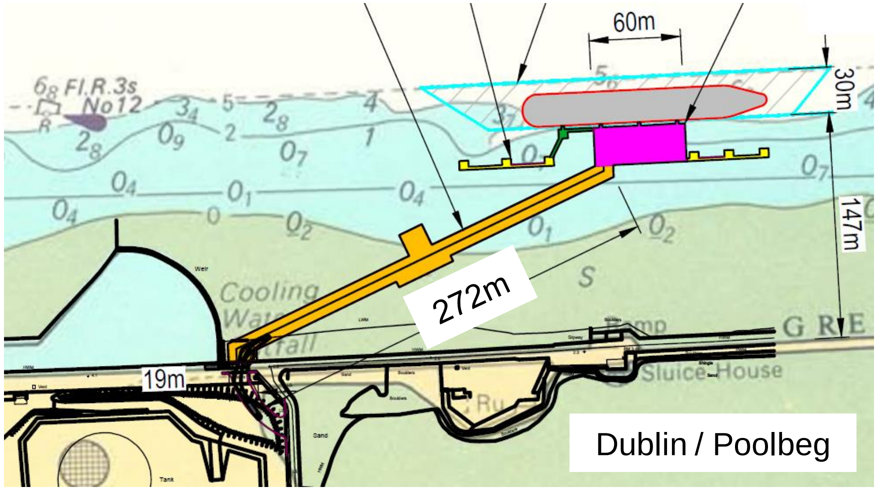
  Cork – Whitegate oil jetty cannot accommodate CCS project

  Dublin – Existing jetties will be removed for 3FM Project. New oil berth for NORA planned for Poolbeg
- Safe vessel access at all stages of tide without obstructing other marine traffic
- Dredge to -10m Chart Datum
- Jetty Lengths:

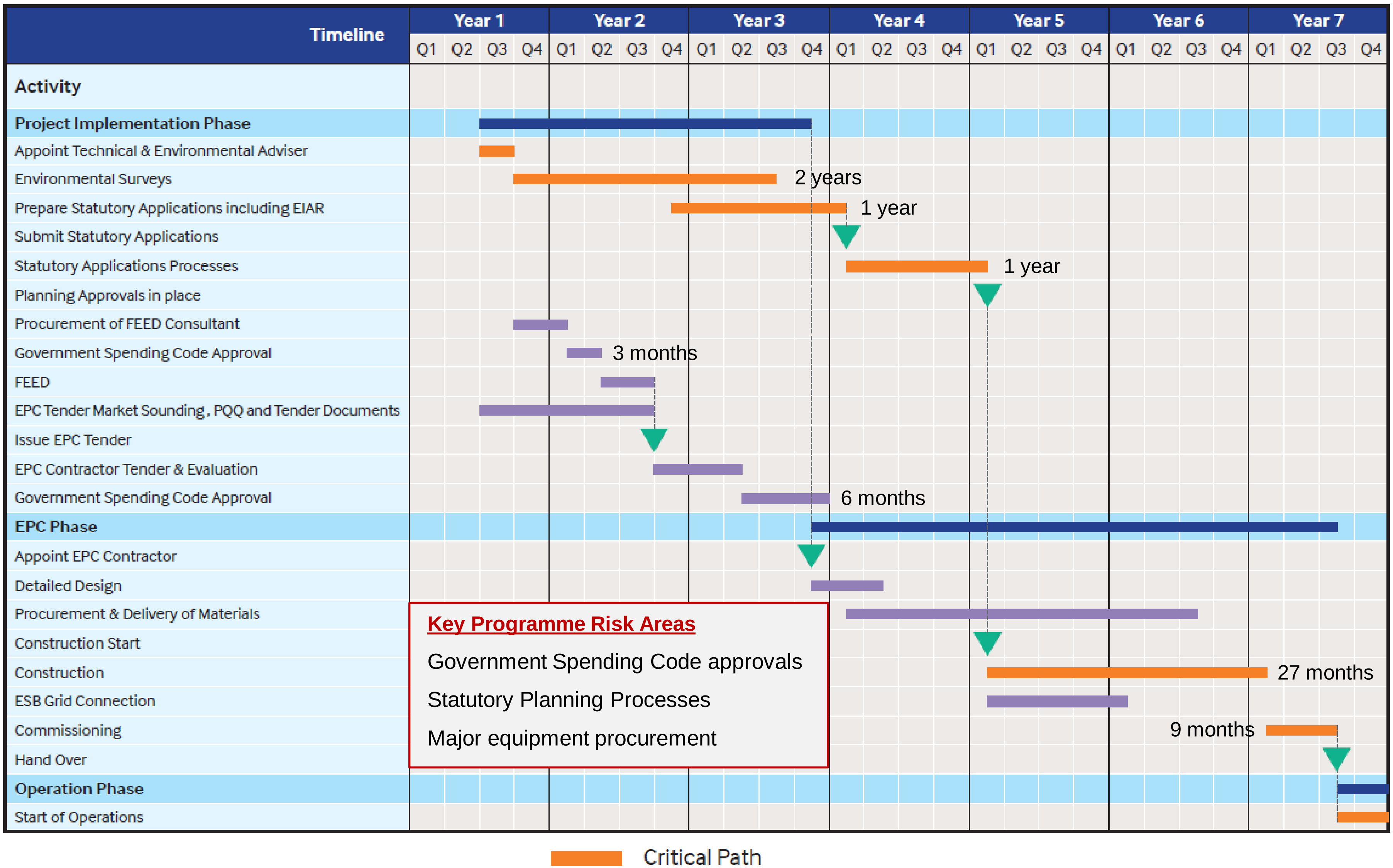
  Cork: Approximately 1,150m

  Dublin: Approximately 280m
- Design loading for 15,000m^3 vessels
- Steel piled construction with reinforced concrete decks





Indicative Project Schedule



Cost Estimates – CAPEX Methodology

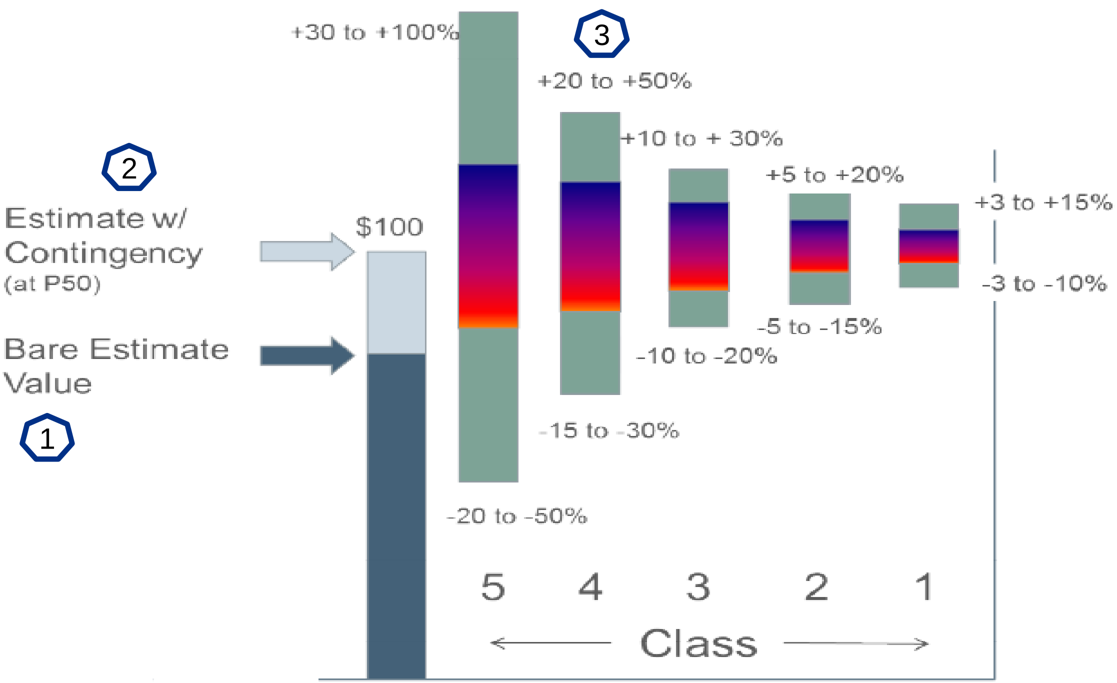
AACE Class 4 estimate was developed considering the following elements:

- Vendor pricing for mechanical equipment based on process data sheets
- Material Take-Off (MTO) quantities based on conceptual 3D model
- Reference to recent historical and local pricing for bulk materials and labour
- EPC costs with consideration of:
  - Traffic & logistics
  - Temporary construction facilities
  - Professional Services (i.e. Engineering, Procurement and Project Controls during EPC)
  - Construction services and equipment (tools etc.)
  - Commissioning and start-up costs
- Other Costs (Contingencies, spare parts etc.)

- CAPEX exclusions are; abnormal subsurface conditions, unexpected underground demolition, remediation of contaminated soils, cost of electrical grid connections and owner's costs (e.g. cost of land purchase, permitting costs, environmental studies, environmental impact assessments and financing costs etc.).
- Current global pricing volatility and global supply chain disruptions has meant that future escalation cannot be priced at this time and is also excluded.

AACE Class 4 Cost Estimate Accuracy

Key Equipment Costs	Direct Costs	Indirect Costs	Other Project Costs
Compressors Pumps Spheres Tanks Air coolers	Bulk materials *(Steel, Pipe, etc.)* Installation costs *(Labour, scaffolding, insulation, painting)* Subcontract costs	Temporary Facilities Construction Equipment, Tools & Supplies Field Engineering Start-up labour & material Traffic & Logistics	Professional services *(Engineering, Procurement, Project Controls)* Warranty Fee Contingency



AACE Estimate Development

1. The Bare Estimate Value must fully consider the items listed in the above table.
2. 20% contingency has been used for this project based on a project contingency assessment.
3. The +/- value shown represents the typical percentage variation of actual costs from the cost estimate after the application of contingency for each Class of AACE estimate.

Cost Estimates – Location Summary Comparison

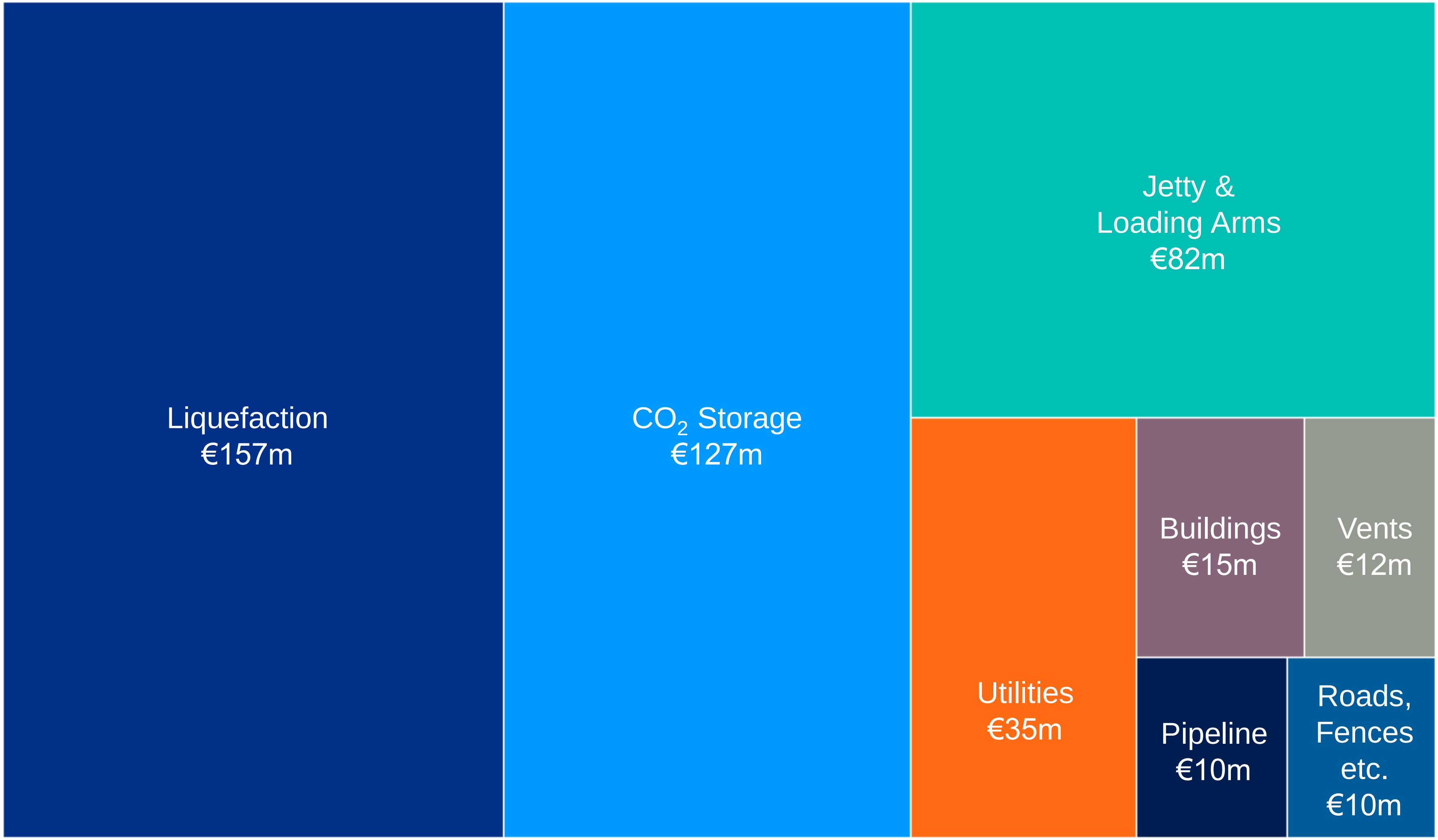
Description	Cork	Dublin
Plant Capacity	1.25MMtpa	1.75MMtpa
No. Liquefaction Trains	4	5
Minimum Flow Rate	0.125 MMtpa	0.25 MMtpa
Regasification	0.5 MMtpa	No
Length of CO_2 Gathering Network	10.5km	1.35km
No. Pipeline Installations	4	1
Liquid CO_2 Storage Capacity	3 spheres 26,050m^3	3 spheres 29,700m^3
Length of Jetty	1,150m	280m
CAPEX	**€510 m**	**€450 m**
OPEX*	***€40 m/a***	***€41 m/a***

** 50% of OPEX cost is from electricity consumption, this is currently a highly unstable variable*

Class 4 Cost Estimate – Cork

Total CAPEX : €510 m

Class 4 Cost Estimate – Dublin



Total CAPEX : €450 m

CAPEX Sensitivity Analysis

Class 5 Estimated Costs for Flowrate Sensitivity:

Scenario	Cork CAPEX	Dublin CAPEX
Base Case	**€510 m**	**€450 m**
Increase Flowrate by 50%	€687m (+35%)	€630m (+40%)
Increase Flowrate by 100%	€792m (+56%)	€736m (+64%)
Decrease Flow rate by 50%	€428m (-16%)	€365m (-19%)

Pre-FEED Study – Key Findings

- The comprehensive project scope led to greater detail and cost accuracy:
  - Detailed P&IDs were more developed than for a typical Pre-FEED
  - A preliminary HAZOP at this Pre-FEED stage pushed the definition of the project
  - Shipping studies were essential to optimising overall project configuration
  - Modelling of CO_2 gathering network resulted in optimised configuration for Cork
  - Vendor pricing was obtained for all major equipment before February 2022
- Other key factors which led to greater accuracy of Class 4 cost estimate included:
  - EPC contractor expertise and access to vendors
  - Local knowledge and expertise of similar infrastructure in Ireland
  - Development of 3D model for material quantities etc.
- Value engineering opportunities identified included:
  - Further consideration of vessel sizes and onshore storage requirements
  - Potential for shared marine facilities

Pre-FEED Study – Conclusions

- The study has resulted in a detailed understanding of the transportation & storage aspects of CCS and the associated costs in Ireland
- The AACE Class 4 cost estimates for Cork and Dublin were developed rigorously and accurately reflect (normal) ‘real world’ conditions
- This infrastructure is technically feasible for both locations
- If the projects were to be progressed, development would take at least 7 years
- If progressed, stakeholder engagement and statutory approvals will be critical to timely project delivery
- This Pre-FEED study will inform CCS policy
- The legislative context for CCS in Ireland must be developed
- Many aspects of this study are transferrable to potential CCS projects

Go raibh maith agaibh!

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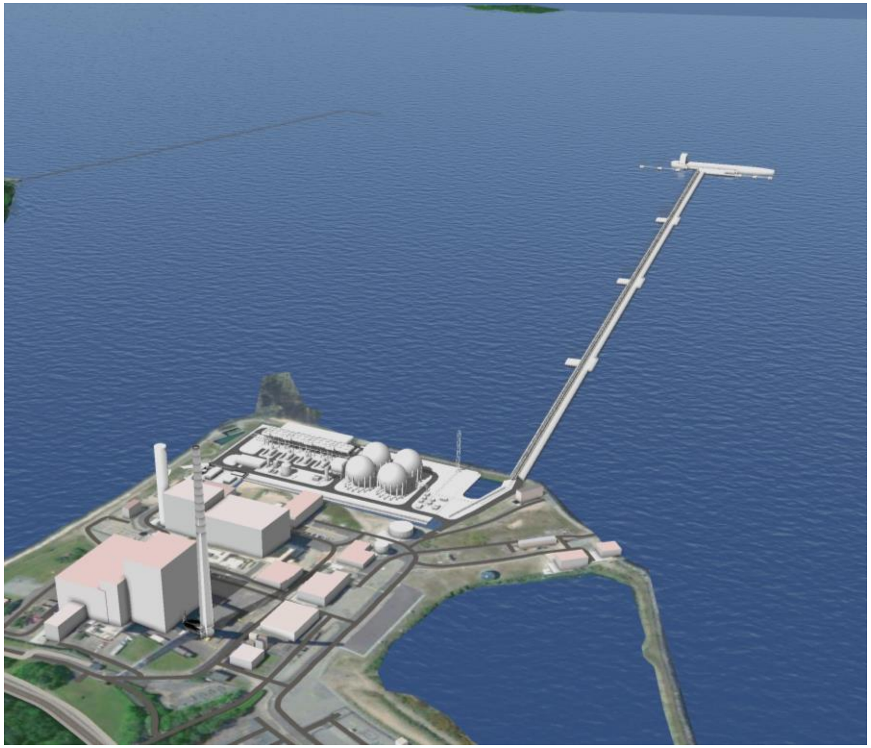
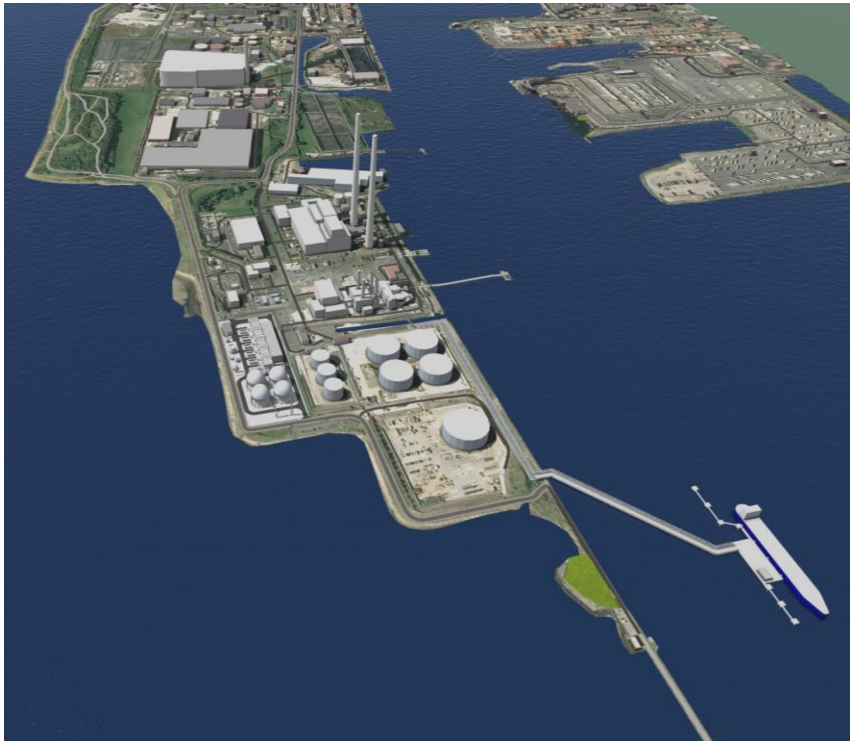


Ervia CCS Project - Cork



Ervia CCS Project - Dublin

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