Acorn CCS
Developing CCU Capabilities from CCS Infrastructure

Tim Dumenil (07891 385395)
CCU Living Lab 30th January 2020

Acorn CO₂ SAPLING, project 12.2, is co-funded by the European Commission under the Connecting Europe Facility
Acorn CCS FEED is co-funded by BEIS through the Innovation Programme
A CO₂ transport and storage infrastructure business to serve decarbonised industries along the East Coast of the UK and around the North Sea Basin.

Image courtesy of North Sea Midstream Partners
Acorn CCS **unlocks** the carbon capture and storage and hydrogen infrastructure **essential** for meeting the Scottish and UK Government Net Zero targets.
Phase 1: Establishing the CCS infrastructure

- **Low capital cost start**
  Around 340,000 tonnes per year of existing CO₂ from the St Fergus gas terminal.

- **Pipeline reuse**
  More than £750 million cost savings from reuse of high capacity on and offshore pipelines.

- **World class CO₂ stores**
  Two large, well understood CO₂ stores with plenty room for growth.

Phase 2: A catalyst for clean growth

- **A major hydrogen production and CCS hub at St Fergus.**

- **An economic opportunity for the deep-water port at Peterhead to include CO₂ import facilities.**

- **A repurposed onshore pipeline to deal with Scotland’s major industrial emissions.**

- **An international CO₂ storage hub in the Central North Sea.**

“CCS is a necessity, not an option.”
Committee on Climate Change, May 2019
CO₂ from the Grangemouth cluster and beyond

90% Of Scotland’s large site emissions are within 50km of Feeder 10, a natural gas pipeline ready for reuse. An essential emission management tool for Scottish industries to meet the Net Zero 2045 target.

CO₂ import facilities at the deep-water Peterhead Port

16Mt Of CO₂ a year could be imported through Peterhead Port. Providing a CO₂ transport and storage solution for industrial clusters across the North Sea Basin.

CO₂ from H₂ production hub

35% Of all natural gas used in the UK comes onshore at St Fergus. An ideal site for a major H₂ production hub. H₂ can be fed directly into the gas grid for blending and decarbonising gas.

Phase 2 – a catalyst for clean growth
Acorn: A potential timeline

**Phase 1**
Establishing the CCS infrastructure

- **2020**: Acorn Phase 1 FID
- **2021**: St Fergus injection
- **2022**: H₂ production (340 kt/yr of CO₂)
- **2023**: First ship import (400 kt/yr of CO₂)
- **2024**: Feeder 10 (1.5 Mt/yr of CO₂)
- **2025**: Drilling of Acorn well #2
- **2026**: Drilling of Acorn well #3 & #4
- **2027**: Acorn 150 Mt Storage site “Sold Out”
- **2028**: Begin to develop Storage Site 2

**Phase 2**
A catalyst for clean growth

- **2029 & beyond**: Begin to develop Storage Site 2
Scottish Industrial Emissions

Emissions resulting from use of North Sea Gas delivered to St Fergus – five times larger than Scottish Industrial emissions.

- Petroineos Refinery
- Grangemouth CHP
- Mossmorran Ethylene
- Ineos
- Peterhead Power Stn
- RWE Markinch
- Tarmac Cement
- Acorn Hydrogen Plant
- St Fergus Gas Plant
- Feeder 10

Hydrogen Infrastructure
- Current Emissions: 9.4MT/yr
- Start at 0.5 MT/yr

Storage Resource
- Licensed Acorn Storage Site – 150MT+
- Storage Site #2 500MT+
- 3 existing re-usable offshore pipelines
- 30% of UK Storage Resource lies within 50km of this pipeline corridor

Data from SEPA 2017

Pale Blue Dot Energy Limited ©
Scottish Cluster Definition by Geography and Industry

9.5 MT per year

Hydrogen fuel switch
Start at 0.5MT/yr from huge growth potential

2017 Industrial Emissions

- 1,638,305 Petroineos Manufacturing Limited. Petroineos Manufacturing Grangemouth Refinery
- 950,295 SSE Generation Limited. SSE Gen Peterhead Power Station Peterhead
- 892,964 ExxonMobil Chemical Ltd. ExxonMobil Chemical Limited Mossmorran
- 689,035 Ineos Grangemouth CHP Ltd. Grangemouth CHP Boness Road Grangemouth
- 601,447 Tarmac Cement and Lime Limited. Tarmac Ltd Dunbar Plant E.Lothian
- 495,915 INEOS Chemicals Grangemouth Limited. INEOS Chemicals Grangemouth Ltd Grangemouth
- 472,000 RWE Markinch Limited. RWE Markinch Limited Glenrothes
- 456,931 Ineos Infrastructure (Grangemouth) Limited. INEOS Infrastructure (Grangemouth) Ltd
- 411,519 E.ON UK Plc. E.ON UK Plc Stevens Croft Power Station
- 340,828 Shell UK Limited. Shell UK Ltd St Fergus Gas Plant
- 310,885 Ineos FPS Limited. INEOS FPS Ltd Kinneil Terminal Grangemouth
- 305,919 Norbord Europe Limited. Norbord Europe Ltd Station Rd Cowie
- 278,259 UPM-Kymmene (UK) Limited. UPM-Kymmene (UK) Ltd Ayrshire
- 239,203 Total E and P UK Limited. Laggan - Tormore Shetland Gas plant
- 229,284 ENGIE FM Limited. Sullom Voe Terminal Shetland
- 197,089 Shell UK Limited. Fife NGL Plant Cowdenbeath
- 155,795 William Grant and Sons Distillers Ltd. Girvan Dist Grangestone Ind Est Girvan
- 146,155 O - I Manufacturing UK Ltd. O-I Manufacturing UK Ltd Glasshouse Loan Allo
- 144,206 Repsol Sinopec Resources UK Limited
- 123,508 Wood Group UK Limited. Sage Gas Terminal St Fergus Peterhead
- 121,887 Norbord Europe Limited. Norbord Ltd Morayhill Inverness
- 118,788 DSM Nutritional Products (UK) Ltd. DSM @ Drakemyre Chemical Works Dalry
- 112,273 EPR Scotland Limited. EPR Scotland Ltd Westfield Biomass Plant Fife

Total: 9,432,491

48,180,000

Emissions from use of gas delivered to and exported from St Fergus

Fossil Thermal Power, Biomass Thermal Power, Manufacturing, Petroleum Processing

Data from SEPA 2017
Growing CCU off CCS

- Whilst CCS is not a pre-requisite for CCU, having a CO₂ collection network for CCS, provides a useful network from which to develop and link CCU projects.

- Greater Acorn Build Out – Peterhead Port (2026): Start with 1.5Mt/yr growing to potential 16Mt/yr of CO₂ imported via ship. Good location for import/export of raw materials/finished product.

- Greater Acorn Build Out – Grangemouth (2027):
  - Scotland’s largest manufacturing region
  - Deep and broad chemical sciences knowledge base and their associated supply chains
  - 50% of the 20 largest Scottish emitters
  - Estimated capturable 3.1Mt/yr from 12 emitters within 50 miles
  - Start at 3Mt/yr. Grow to Feeder 10 capacity of 6MT/yr

- A Pale Blue Dot led consortium has secured Industrial Strategy Challenge Fund support to further progress the Grangemouth and Peterhead Port aspects of Greater Acorn.
CCU in Scotland - Open for Business

- CCS and CCU both part of Scotland’s plan
- Complementary, both major growth drivers
- CCU is not an alternative to CCS, very different scales of deployment. CCS to tackle scale of emissions, CCU to create value
- Near term demand for CO₂ is much less than the scale of emissions
- Grangemouth has largest point source CO₂ in Scotland

Providing the value case is acceptable:
- CAP:CON CCU technologies available now that offer end of pipe solutions with attractive rates of return
- Biogenic CO₂ streams, particularly from fermentation and biomethane, present the most accessible opportunity for circular solutions now.
- Proven capture units can be installed now to provide access to CO₂ but at high capex and opex that the resulting product from the CCU process will need to cover
Pale Blue Dot CCU Projects

Teesside CCU
- ICCS follow on
- 50kTpa CO₂
- CCU Demonstration

Digester CCU
- Concept Studies
- 6 and 9kTpa CO₂
- Business Case

Distillery CCU
- Concept Study
- 1 and 20kTpa CO₂
- Business Case

Biomass CHP CCU
- Concept Study
- 110kTpa CO₂
- Business Case

- Capture ready high purity sources of biogenic CO₂
- Net carbon reduction via an ‘end of pipe’ value add bolt on
CCU Products and Technologies

**Construction Materials**
- Cement and concrete
- Asphalt
- Aggregate
- Timber/super hardwood

**Fuel**
- Synthetic (methanol, butanol, natural gas, syngas, etc.)
- Micro-algae fuel
- Macro-algae fuel

**New materials**
- Carbon fiber
- Carbon nanotubes
- Fullerenes
- Graphene

**Industrial gas & fluids**
- Enhanced oil recovery
- Enhanced coal bed methane recovery
- Enhanced water recovery
- Semiconductor fabrication
- Power cycles

**Plastics**
- Polyurethane foams
- Polycarbonate (glass replacement)
- Acrylonitrile butadiene styrene
- Many more

**Agriculture & food**
- Algae-based food or animal feed
- Microbial fertilizer
- Biochar, bio-pesticides, bio-cosmetics

**Chemicals**
- Preservatives (formic acid)
- Medicinal
- Antifreeze (ethylene glycol)
- Carbon black
- Many more

Main image courtesy, The Global CO₂ Initiative
Summary

Acorn CCS on track to be UK’s first full scale CCS project

Acorn at 340kt/yr in 2024 growing into a mighty oak tree at >16Mt/yr by 2035

CCS to tackle the scale of emissions and CCU to create economic value

Biogenic sources of CO$_2$ and emissions from large industrial clusters, i.e. Grangemouth, present ideal options to develop CCU
What’s does Acorn need?

- Supply of CO₂
- Revenue Model
- Collaboration Partners
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