NZET/S6/25/18/1

Net Zero, Energy and Transport Committee
Tuesday 20 May 2025
18th Meeting, 2025 (Session 6)

Evidence session – Plans for future of Grangemouth: hydrogen aspects of the Project Willow study

1. Over two meetings in May, the Committee is taking evidence on proposals for hydrogen-related projects at the Grangemouth site, as set out in the Project Willow feasibility study.

2. The first of these, on 13 May, took a general look at the hydrogen proposals set out in the study and the wider prospects for low-carbon hydrogen fuel and products, from a panel of experts with a mixture of experience in academic research and industry.[1]

3. On 20 May the Committee will hear from two further panels: one representing Scotland's green hydrogen sector; and one representing the blue hydrogen sector or experts in that area (brief description of these terms below).

Background: Grangemouth and Project Willow

4. On 12 September 2024, Petroineos announced its plans to convert the Grangemouth refinery into a fuel import terminal. They cited declining profitability and the need for substantial new investment to keep the refinery running. Petroineos is a joint venture between PetroChina International London and the INEOS Group.

5. On 29 April 2025, it was announced that the processing of crude oil at the refinery had stopped. A reported 430 jobs were lost as a result. The refinery is part of a wider Grangemouth industrial complex employing roughly 2,000 people.

6. A £1.5m feasibility study was commissioned by Petroineos in autumn of 2024 to assess possible future uses for the Grangemouth site as a low carbon energy hub. This plan, code-named Project Willow, is jointly supported by the UK and Scottish Government. The results were published on 19 March 2025.

[1] The Committee heard from Dr Nigel Holmes: CEO of Hydrogen Scotland; Prof John Andresen: Professor in Energy Systems at Heriot-Watt University; Dr Graeme Hawker: Lecturer in Energy Systems at the University of Strathclyde and author of 'The potential for hydrogen to reduce curtailment of renewable energy in Scotland'; Dr Simon Gill: energy consultant and author of Green hydrogen in Scotland; Prof Mark Symes, leader of the Hydrogen Innovation Centre at the University of Glasgow; and Dr Jan Rosenow: Leader of the Energy Programme at the Environmental Change Institute, University of Oxford. The Official Report of the meeting will be published sometime before the 20 May meeting and available online via this link.

7. There are nine 'projects' highlighted by the Project Willow study. The Committee has decided to focus on those **(projects 6-9)** involving the use of low carbon hydrogen in some way:

    - **Project 6: Hydrogenated Esters and Fatty Acids (HEFA):** converts Scottish oil seed cover crops into Sustainable Aviation Fuel (SAF) and Renewable Diesel (RD) using low carbon hydrogen. Grangemouth currently supplies aviation fuel to Edinburgh, Glasgow, Aberdeen and Newcastle.
    - **Project 7: Fuel switching:** Replacing natural gas combustion with low carbon hydrogen. The proposed feedstocks for this hydrogen production are renewable power and water and thus, green hydrogen.
    - **Project 8: E-methanol and methanol to jet:** using low carbon hydrogen to produce methanol and convert it to Sustainable Aviation Fuel (SAF). The methanol can be used as a low carbon shipping fuel or chemical feedstock.
    - **Project 9: E-ammonia:** producing low carbon ammonia from hydrogen for shipping and chemicals. Most shipping currently uses fossil fuels including diesel, heavy/light fuel oil and liquified natural gas (LNG). In order to reduce emissions from shipping there are projections (see Project Willow report page 21) that ammonia could become the primary fuel for shipping.

8. The Scottish Government and Parliament have committed by law to make Scotland "net zero" in carbon emissions by 2045. It is widely agreed that hydrogen has a role to play as a low or no-carbon fuel in this transition to net zero, but there are differences of views as to:
    - how big a role it is likely to play compared to other energy sources;
    - how it is to be manufactured at scale (with a few known exceptions, hydrogen does not occur as a raw resource and must be processed);
    - the best applications for hydrogen fuel across different sectors, including industry, transport, heating etc.

9. These questions all form part of ongoing discussions at political level, in academic research, and within the commercial energy sector. For its part, the Scottish Government has committed to targets of 5GW hydrogen production capacity by 2030 and 25GW by 2045. It envisages doing this through:

    - Blue hydrogen: producing hydrogen using natural gas. Greenhouse gases emitted during this process are then stored at scale. This process is known as carbon capture and storage or CCS. The Committee has considered the prospects for growing the blue hydrogen sector in Scotland (in particular the Acorn Project, which would involve using depleted North Sea oil and gas reservoirs to store greenhouse gases) during its budget scrutiny, and in a "snapshot" inquiry in 2021-22;
    - Green hydrogen: producing hydrogen by electrolysis, where an electric current splits water into hydrogen and oxygen. The Committee has again considered the prospects for green hydrogen in Scotland during its budget scrutiny and as part of a short inquiry into Scotland's future energy infrastructure needs.

10. The Scottish Government's longer-term ambition is for Scotland to become a net exporter of low or no-carbon blue and green hydrogen.

Meeting on 20 May and next steps

11. On 20 May, the Committee will take evidence from two panels. The first panel is made up of representatives from Scotland's green hydrogen sector. They comprise a mix of companies, of different sizes, some based in Scotland, others international but with significant Scottish hydrogen interests:
    - Bill Ireland: CEO, Logan Energy
    - David Amos: CEO, PlusZero
    - Lewis Elder: Commercial Operations and Policy Director, Statera Energy
    - Tim Dumenil: Head of Business Development, Storegga Hydrogen
    - Mark Bradley, Hydrogen Director, Scottish Power.

12. The second panel comprises experts in blue hydrogen (and specifically the Acorn Project mentioned above), CCS and wider decarbonisation at Grangemouth:

- Nic Braley: General Manager (written submission at **Annexe A**)
- Professor Hannah Chalmers: Personal Chair of Sustainable Energy Systems, University of Edinburgh
- Professor Mercedes Maroto-Valer: Director of the Industrial Decarbonisation Research and Innovation Centre, Heriot-Watt University
- Professor Stuart Haszeldine: Professor of Carbon Capture and Storage, University of Edinburgh (written submission at **Annexe B**)

13. Panellists are likely to be asked for the overall views on the viability of the 4 hydrogen-related projects set out in Project Willow. Panel 1 witnesses will have the opportunity to express views on what industry needs from government to help the green hydrogen sector in Scotland secure a flourishing, commercially viable future and specifically what role the Grangemouth site could play in that. With Panel 2, similar questions will be asked in relation to blue hydrogen and the Acorn project, as well as Grangemouth's potential role in decarbonising industry through CCS.

14. After the evidence session, the Committee will consider the evidence it has received and possible next steps. Amongst other things, the two sessions are likely to be relevant to future scrutiny of the next draft Climate Change Plan, to be laid this autumn, setting out how the Scottish Government proposes to progress towards net zero over the next five years.

15. In considering next steps, the Committee will also take account of the work of the Economy and Fair Work Committee, which is carrying out parallel scrutiny into Project Willow and the future of Grangemouth, with a focus on the just transition. It will hear from UK and Scottish Ministers at meetings in late May and June.

Clerks to the Committee
May 2025

Annexe A - Written evidence submitted by The Acorn Project

Hydrogen aspects of the Project Willow Study
Panel 2 – blue hydrogen, CCS and wider decarbonisation at Grangemouth.

Introduction

The Scottish Cluster, with Acorn at its core, is critical to the decarbonisation of Scotland's biggest industrial and power emitters. Acorn, a CO_2 transportation and storage (T&S) system, will create a permanent storage solution for a range of diverse emitters across Scotland, who are all committed to timely and cost-effective decarbonisation.

Located at St Fergus, Aberdeenshire, Acorn will use world-class geological stores beneath the North Sea, connected to the Scottish mainland by repurposing oil and gas pipelines to safely and permanently store CO_2. These existing pipelines could transport up to 20 million tonnes per annum (Mtpa) of CO2 to the Acorn stores – double the volume of Scotland's industrial emissions in 2021 - during peak operations.

In July 2023, Acorn entered the Track-2 Cluster sequencing process for carbon capture, usage and storage, having retained Track-1 reserve status since late 2021. Throughout this period, we have continued to progress the project from a technical, engineering, planning, consenting and supply chain perspective with considerable financial support from our partners.

Enabling large-scale industrial decarbonisation

The Scottish Cluster, through connection to the Acorn T&S system, will enable clean industrial and power market development, and support the UK's position as a clean energy leader.

Most immediately, there are opportunities within the Cluster for clean hydrogen production and negative emissions technologies such as BECCS. In addition to supporting the decarbonisation of St Fergus terminal which will continue to be a key component in UK energy supply and enabling the Peterhead Carbon Capture Power Station Project to deliver dispatchable low carbon power in 2030.

Through National Gas's SCO_2T Connect Project, the Scottish Cluster will also help to secure the future of industrial hubs like Grangemouth, aligning with initiatives like Project Willow, which aims to establish a sustainable low-carbon energy hub at the site, leveraging its skilled workforce, local expertise and industrial heritage.

With 90% of Scotland's largest industrial emitters within 50km of Acorn or SCO_2T Connect infrastructure, this creates a route to rapid decarbonisation of Scotland's

major industries and hard to abate sectors, whilst protecting and creating jobs, and creating real benefits for local communities and associated supply chains.

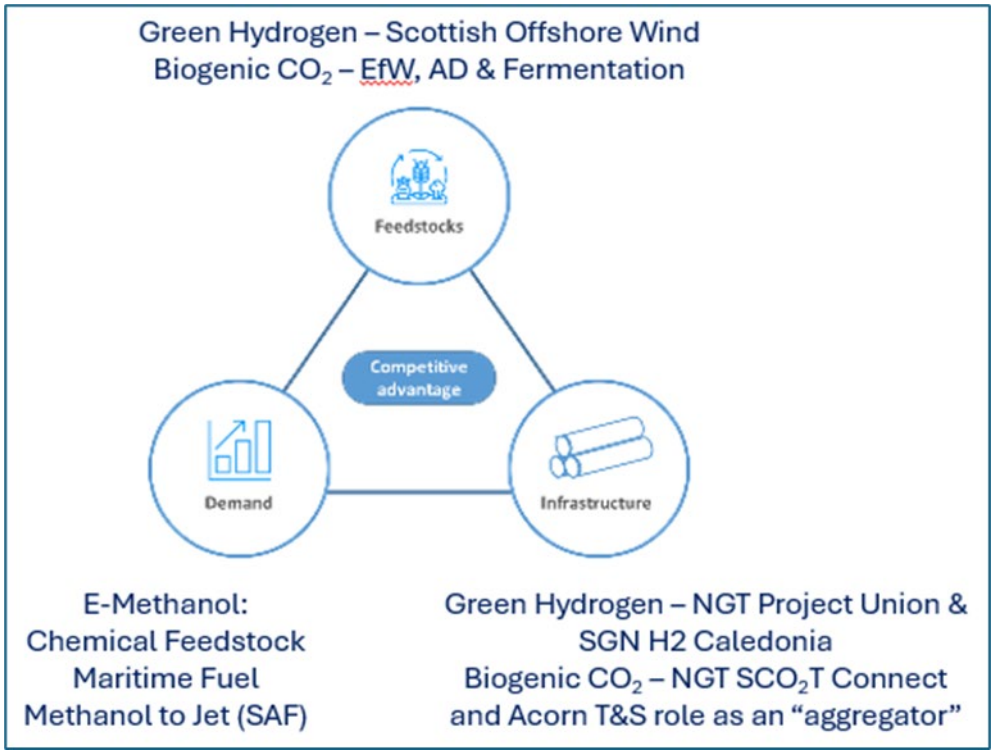
The reach of Acorn goes beyond Scotland too with the potential for non-pipeline transportation, like shipping, to move captured CO_2 to the Acorn storage sites via Peterhead Port. This would enable Acorn to support the decarbonisation of industry across the UK and even internationally.

Enabling Grangemouth transition and growth

The Scottish Cluster is uniquely positioned to deliver future growth at Grangemouth by integrating Scottish wind resource, H2 value chain, biogenic CO2 feedstocks, existing infrastructure and a skilled workforce.

Project Willow has a focus on future production of clean fuels and chemicals at Grangemouth from recycled feedstock, bio-feedstocks, biogenic CO2 and low-carbon hydrogen. There is an opportunity to leverage Scotland's wind capability to power the transition of a major industrial hub and growth across the whole of Scotland.

Acorn and SCO_2T Connect can enable transport biogenic CO2 as a feedstock for clean fuel and chemicals production, in and out of Grangemouth in a first-of-a-kind project. This also enables the decarbonisation of industrial activity via fuel switching and CCS (Fuel Switching Net Zero – blue hydrogen).



Progressing at pace

Acorn is Scotland's only CCS T&S development – Scotland needs decarbonisation, not deindustrialisation. The Scottish Cluster will mobilise construction and engineering projects, safeguard and create jobs and provide economic growth for communities. Certainty in government policy is the key enabler to drive investor confidence, jobs and support a 'Just Transition' for communities.

A 2023 report by Biggar Economics, commissioned by the Scottish Cluster, highlighted the development's economic potential[2]:

- £17.7bn contribution to UK economic output (GVA) to 2050
- 10,000 development and construction jobs and 4,000 operational jobs.
- 18,000 safeguarded jobs across the UK, that may otherwise be lost

We were pleased to see support for Track-1 carbon capture projects late last year, including the £21.7bn support package from the UK Government, and the confirmation of the Hynet North West industrial cluster in England last month. This creates important investor confidence in the sector and has enabled the UK to position itself as a future global leader in the carbon capture, transport and storage market.

We also welcome the Scottish Government's reaffirmed support for Acorn in the First Minister's recent Programme for Government announcement, reiterating the

[2]A brochure on the report, *Capturing the Economic Potential: Maximising the Positive Impact of the Scottish Cluster* can be downloaded here.

potential of £80m+ in funding for the project, dependent on UK Government Track-2 confirmation.

The Scottish Cluster partners are credible, experienced organisations including Ineos, Shell, Harbour Energy, ExxonMobil, Viridor, SSE and National Gas, who have invested significantly to develop this major project. However, to achieve the carbon emissions reductions required to meet the UK's legislated net zero targets, Track-2 projects need urgent clarity on timelines, policy, process and funding to progress further.

It is critical that Track-2 projects receive clarity from the UK government on policy, process and timelines to ensure sustained investment, including:

- Confirmation of the funding envelope for Track-2
- Collaborative development of a clear, streamlined and accelerated end-to-end process for delivery
- Insight into the parameters for the Cluster programme and emitter selection process, balancing competing priorities of affordability, value for money, delivery timescales and scale of ambition.

We continue to work closely with DESNZ and relevant government departments on progress for Track-2 ahead of the Comprehensive Spending Review.

As a sector, we must move forward at pace to seize the momentum around carbon capture for Scotland and the UK to meet its climate targets and create sustainable industries, supporting jobs and local communities.

Additional information:

- Download the Scottish Cluster: Ready to Deliver brochure here.

Annexe B - Written evidence submitted by Professor Stuart Haszeldine, University of Edinburgh

Carbon Capture and Storage and Hydrogen with project Willow

CCS

1.1) The UK Government has made a very clear commitment to Carbon Capture and Storage (CCS) construction and operation. Developing CCS to support mid-century decarbonisation is supported by modelled outputs globally from IPCC, and domestically from CCC. These both show that reaching Net Zero requires 10-20% of current emissions (ie 50-100 Million tonnes CO2 per year) to be captured at source by CCS, or re-captured after emission by GGR or DACCS (5 to 10 Million tonnes per year. The recently published 2025 “Balanced Pathway” from CCC (Committee on Climate Change) takes the recommended carbon budget 7 to 2035. The CCC models high-level costs of Transition to Net Zero to be just 0.5 to 1% of GDP, which is less than estimates during 2015 – 2020. It is claimed that investment into UK clean technology decarbonisation projects claims growth of 10% - being the fastest growing area of the economy

1.2) Practical support from UK Government has allocated £21.7Bn for 25 years to support “Track 1” clusters initially based in the clustered industrial emitters of Teesside (East Coast Cluster and Northern Endurance Partnership storage), and of Merseyside (HyNet). This is to co-fund construction of capture transport and storage infrastructure, and to pay for the price difference of a Contract for Difference method of delivery where the selling (market) price of clean electricity or captured CO2 may be less than the commercial breakeven (strike) price. Using long duration subsidy to build and create an initial market can be calculated as about £.03 per person per week, which as an energy supply or climate intervention can be considered as “low cost”

1.3) In Scotland the position of CCS is much more problematic. The capture of CO2 from dispatchable electricity generation at Peterhead with a pipeline to offshore geological storage in Goldeneye or Captain sandstone has been proposed since 2011, and stated to be ready for development since 2018. The project is supported by “The Scottish Cluster” group of investors. But progress has been held as ‘reserve’ since about 2021. Additional opportunities for CCS are now fully available in Denmark, Norway, Iceland and Netherlands, as well as globally in the USA, Canada, Indonesia. Business teams supporting The Scottish Cluster have already been downsized. Supply chain industries in Scotland need visibility of a chain of multiple CCS projects to restore confidence.

1.4) For several years the UK Government has talked about the concept of storing CO2 imported from `Europe as a “merchant” model. There are 21 sites leased for CO2 storage in the UK offshore. And there sites accepting imported `co2 for storage in `Denmark, Norway and Iceland. These sites are up to 20x oversubscribed for the

storage being developed (10-20 Mt CO2 by 2030), giving a clear signal that a new market is available to be served.

1.5) Growing the CO2 storage market rapidly, profitably and securely is within reach of UK Government, particularly for leased sites in the central North Sea most accessible from Scotland. This could use an early mover advantage where the UK has abundant studies showing suitable storage geology, import infrastructure potential though east coast and Shetland ports and a mid stream supply chain of world class offshore engineering . But to move CO2 across national boundaries outside the EU, it is necessary for the country supplying CO2 and the country receiving `co2 there has been no movement to make bilateral

1.6) CCS development needs to be clearly and immediately signalled in Scotland by the UK government. That is necessary to remove CO2 and achieve Scotland carbon budget. And is also necessary to remove CO2 from bio-refinery development at Grangemouth. With no operational CCS, there will be no economic case for any of the 9 proposals for Project Willow at Grangemouth. Lack of CCS is blocking the potential to build low carbon industries of the future.

1.7) Development of CCS current projects in UK is now progressing very rapidly Two clusters are in development, supported by UK government. £21.7bn was awarded in oct 2024 to support these `track 1 projects in construction and to support s strike price for 25 years . The recent progress of these projects provides an insight to the benefits which could be available to Scotland and the North Sea supply chain, if the Scottish Cluster and Acorn could be developed.

1.8) In Dec 2024 the East coast cluster gained `final `investment `decision (FID), and in April 2025 the Hy Net cluster around Merseyside gained FID. That was after completion of a separate trial injection of CO2 into a porous depleted and de-pressurised gas field by Poseidon project. I think thatthis was a test injection to prove he feasibility of re-using a depleted gas reservoir

1.9) Contracts to benefit UK manufacturing and industry are now being allocated. For HyNet, about £2.0 Bn is being allocated to 35 local contractors, of which £1.2Bn is for Transport and Storage. About 2,000 workers are now involved in construction. This will inject4.5 Mt CO2/yr CO2 around 2028, rising to 10.0 MtCO2/yr after 2030

1.10) The East Coast Cluster is several months ahead, and since `December 2024 has let 60 major Engineering Procurement Construction (EPC) contracts within the UK, which are now allocating sub-contracts, and intending to exceed the 50% local UK content recommended by the NSTA. This is a similar amount to the HyNet total

Hydrogen

2.1) Its hard to determine the future use of hydrogen in Scottish or global economies. There are many advantages to use hydrogen as a clean and portable fuel. Particularly in remote communities if hydrogen can be locally generated. But a large infrastructure is needed to make blue hydrogen from imported methane (which keeps Scotland and the UK dependent on imports).

2.2) Storage of hydrogen is expensive and difficult – in specially manufactured tanks or as hydrogen added to chemical vectors. If hydrogen were to be used on a national scale to replace methane for domestic heat – then huge storage is needed between seasons. From hydrogen made by electrolysis in the summer, to be stored for use as heating in the winter.

2.3) Storage can be achieved in excavated salt caverns, or can be achieved by injection into the geological porespace of depleted gas fields. But neither of these are abundant in Scotland. If hydrogen is to be used abundantly, then a national suite of storage is needed from the southern North Sea or Irish Sea salt deposits, and the southern North Sea gas fields.

Project Willow

3.1) Report largely constructed by Ineos - which means it's focused, rapid and potentially commercial.

3.2) There is an opportunity to Transition the existing workforce into similar work, but bio-oil and biomass feedstock instead of mineral oil feedstock

3.3) The projects are very expensive (because they could be real) ranging £200-900M Capex. And then will need co-venturing by UK government finance eg 30% of £3.5Bn if all the projects in the Willow report are constructed. And must also have good relations and support with Scottish Government

3.4) 6 of the 9 projects require hydrogen or direct CO2 removal. Hydrogen can be quickly and rapidly made from splitting CH4 natural gas. That will create 'waste' CO2, which needs either a large tonnage of `utilisation' - which is not yet developed. Or needs to be pipelined to storage using the Scottish Cluster Acorn project. Or CO2 needs to be collected at Grangemouth, and shipped by coastal tanker to Teesside or Humberside. But these have no planned extra input to their storage mix until maybe 2035). Or shipped to Denmark (adds large extra expense of £50 per tonne). The possible change from present 3.5 MtCO2/yr, to 6 MtCO2/yr makes this competitive as a UK industrial CO2 project for capture and re-use or storage

3.5) Project Willow is very unlikely to be commercially viable unless reliably functioning and low cost CO2 storage, and hydrogen supply are available. Paradoxically the economic case for UK investing in the Acorn project could now be argued to be very strong as it leverages new jobs into a greener future, not preserving old jobs. The current arguement of employment subsidy, can be transformed to become future income generation form already skilled workforce. That unlocks several forward -looking projects of £0.2- 1.0 Bn each, as well as employment investment to "average up' for initially 600 workers, rising to 1200 in the new bio-projects. That combination of modern bio-refining, a skilled workforce, and direct marine access is a key benefit.

3.6) But looking to the future, there will be competition. It is inevitable that the existing 6 UK refineries will downsize to 1 or 2 whilst mobility demand for petrol and diesel fuel declines as it is displaced by electric and hydrogen fuels. So key

questions in the Willow analysis of Grangemouth must also be - is this manufacturing site positioned well geographically to supply its markets for SAF and other products without excess transport cost. What if the UK refinery at Stanlow converts to SAF with a skilled workforce - but uses existing low cost pipelines to Heathrow Gatwick and Manchester airports

3.7) A second key benefit to Grangemouth is its proximity to clean electricity from offshore windfarms. If direct connection arrangements can be made - energy to power SAF manufacture, or electricity to power electrolysers to split H2O into H2 and O2 could be amongst the least cost in Europe. But even so, that low cost power at £0.06 - £0.25p/kWhr can be undercut by PV at £0.02-0.04/kW hr from Australia or China, or Mediterranean Africa. So additional investment attributes will be desirable - such as low cost feedstock, or a skilled workforce to make more complex products

3.8) It's highly probable that the plants at Mossmorran operated by Shell and Exxon will also suffer from shortage of fossil hydrocarbon supply before 2035. And the petrochemicals plant at Grangemouth will require a reliable feedstock, so is dependent on its neighbour. So the size of the employment problem at or near Grangemouth may be 1500 skilled staff not just 500. Which could be argued as a gradual scale up of green developments on the Grangemouth site, So work done now starting with Willow will be beneficial in a near future Transition.