

# Grangemouth Research Baseline Report

Final Report  
Scottish Enterprise  
06 February 2025

J3491



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### Appendix A: Review of Other Documents Relevant to Grangemouth

### Appendix B: Key Observations from Reporting on More General Cluster, Technology and Market Development Activities

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**Date:** 06 February 2025

## 1 Introduction

It is recognised that Grangemouth is a key UK manufacturing centre and a major [contributor](#) to the Scottish economy. It is, however, undergoing a period of change with, for example:

- Petroineos [announcing](#) the closure of its refinery in 2025 with transformation of the site into a fuel import terminal
- RWE [publishing](#) plans to produce green hydrogen at Grangemouth
- Falkirk council [planning](#) to develop a sustainable manufacturing campus to support emerging industrial biotechnology and carbon dioxide utilisation industries.

In response to the Petroineos announcement the Scottish and UK Governments have [announced](#) a joint investment plan for Grangemouth and the Grangemouth Future Industries Board (GFIB) continues to [work](#) to support the continued competitiveness of Grangemouth as it transitions to net zero.

It is, therefore, timely to take stock of the situation in Grangemouth, understand its current position and identify development options.

This report summarises current research on the Grangemouth industrial cluster, to enable informed decisions, identification of strategic opportunities and prioritisation of areas for further investigation. This accompanies and feeds into the main study report entitled “Industrial Cluster Best Practice Analysis”.

## 2 Approach and Methodology

Existing relevant literature on Grangemouth was collated. This included documents specific to Grangemouth and Grangemouth based companies, wider relevant Scottish and UK policy and sector documents (e.g. relating to the Just Transition, net zero and Green Freeports) and market focused information relevant to the Grangemouth company base.

Scottish Enterprise provided an initial list of publications with other, relevant publications identified and reviewed by the Optimat project team. These reports were all published within the last 5 years during which time industrial activity at Grangemouth has changed most rapidly.

The review was focused around core themes which provided a framework for the analysis. These are as follows:

- Current Infrastructure & Operations
- Economic Outlook
- Sustainability Outlook
- Social and Community Outlook
- Future Developments
- Recommendations

These themes were used for guidance purposes only and it is noted that the prominence of each varied across the reports.

The documents were split into three categories: those that were considered to be strategically important to the future of Grangemouth; those that were directly relevant to Grangemouth but had a longer term

focus or were targeted at a Scottish rather than Grangemouth level; and those that were indirectly relevant but that provided useful insights. This latter category included, for example, reports on other clusters in the UK, which were reviewed to assess cluster strategy and activities.

Analysis was undertaken to synthesise the key findings and recommendations from the reports and, subsequently, to identify common themes.

### **3 Review of Strategically Important Documents**

3 documents were identified as being of strategic importance regarding the current position and future development of Grangemouth. These are:

- Grangemouth Industrial Transition Plan, Scottish Government, 2024
- A Sustainable Just Transition for the Grangemouth Industrial Cluster, Aspect, 2024
- Project Willow, EY Parthenon, 2025

#### **3.1 Grangemouth Industrial Cluster: Draft Just Transition Plan – Scottish Government (2024)**

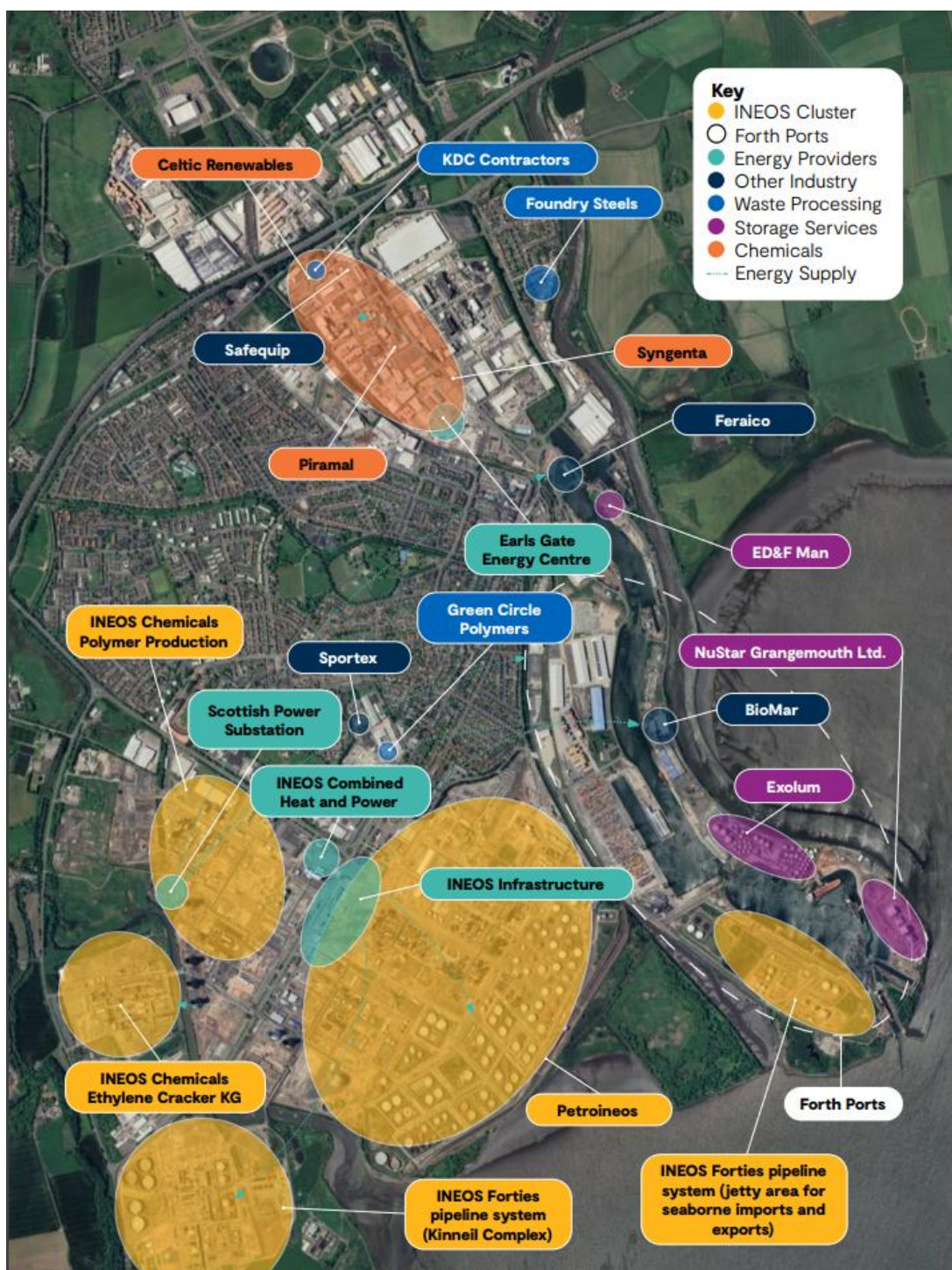
##### **3.1.1 Summary**

This report prepared by the Scottish Government highlights the importance of Grangemouth for the Scottish economy as a central base for industrial manufacturing. It sets out to identify the companies currently operating in Grangemouth and develop a Just Transition Plan to support cluster activity, community prosperity and environmental compliance. The community findings are summarised in 5 priority areas for community action: Jobs, Skills, Community Relationships, Narratives, Quality of Life. In setting out priorities, the report delivers a baseline, 2045 vision with just transition outcomes, recommendations with a proposed action plan, and an evaluation framework to monitor progress. At the time of review, this report is still in consultation.

##### **3.1.2 Key Findings and Insights**

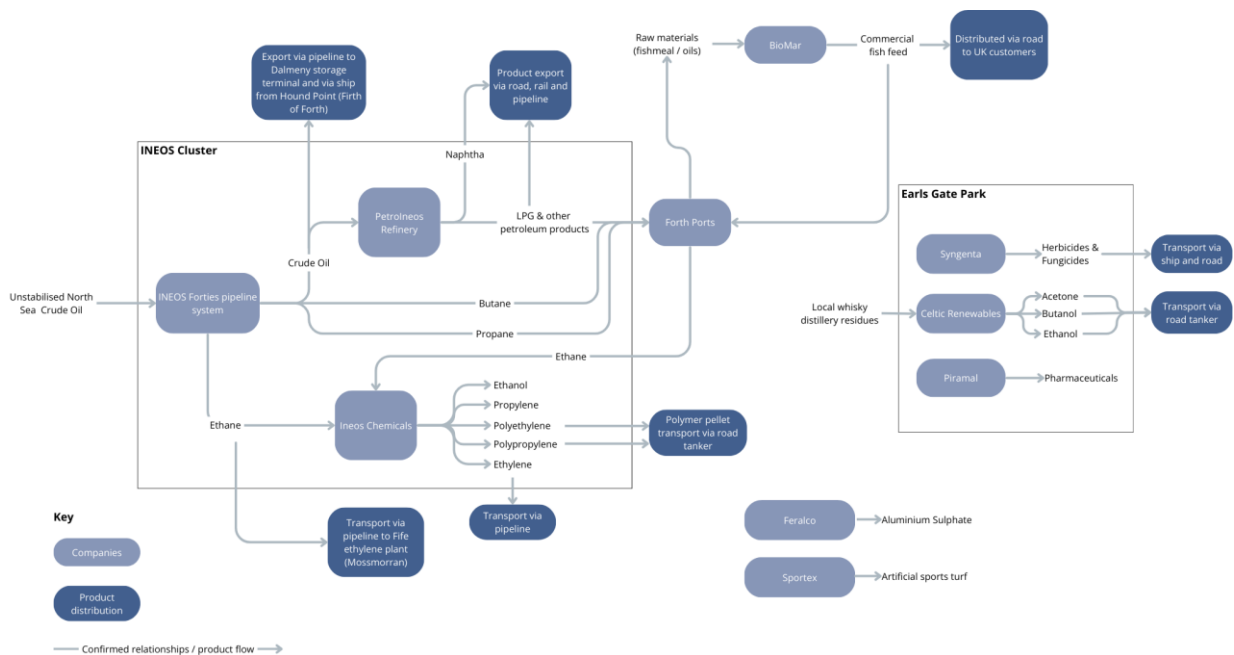
###### **Current Infrastructure and Operations**

The Grangemouth cluster now hosts only a small number of large or medium-scale operators. Despite a relatively small geographical spread, there is little to no operational cohesion or strategic intra-cluster integration. There are two separate chemicals sub-clusters as shown in Figure 1, which depicts petrochemicals focused activity at the east end of the town, dominated by INEOS and Petroineos, and fine chemicals focused activity at the west end of the town, centred in the Calachem owned and operated Earls Gate site. There is some energy and waste activity in-between. Recent developments in 2023 were cited to have had further impact on the industrial footprint of Grangemouth. These include the announcement by Fujifilm that it is closing its facilities at the Earls Gate site, Petroineos' closure of the oil refinery to be replaced by an import terminal, and Versalis announcing closure of its facility.



**Figure 1: Grangemouth Cluster Groups**

Whilst the report identifies a range of small manufacturing businesses operating in and around Grangemouth, producing a variety of products, there is very limited local supply or value chains, i.e. intra-cluster supply of products (Figure 2).



**Figure 2: Grangemouth Operations (Adapted and Updated by Optimat)**

It is difficult, therefore, to define Grangemouth as an integrated operational cluster, but rather a co-inhabited space for Scottish industrial activity. This is not to say, however, that the area lacks infrastructure and industrial assets. Central to the future of Grangemouth, and addressed in this report, is the development of a unified, strategic plan, that leverages the committed organisations' assets to increase industrial activity and to support the net zero transition of these activities.

The report also refers to the importance of Project Willow, currently being undertaken by INEOS, the UK Government, and the Scottish Government (which is discussed later in this report). This seeks to address the lack of organisational cohesion and support the development of a long-term strategy for Grangemouth, with a focus on low carbon technologies and the transition to net zero.

Further, the restructuring of the Grangemouth Future Industry Board (GFIB) to include two tiers, i.e., the Industrial Just Transition Leadership Forum and the Grangemouth Just Transition Programme Board will be responsible for oversight of the just transition plan and delivery respectively. This aims to improve representation and communication across stakeholders. Despite this, the report highlights that the large number of stakeholder voices and organisations involved at Grangemouth can be confusing and not always conducive to the development of a unified industrial vision and strategy.

## Economic

- Grangemouth is a significant economic driver in Scotland, contributing an estimated £895 million in direct, indirect and induced Gross Value Added (GVA) in 2023. It supports around 3,250 direct jobs, with additional employment in the supply chain and through induced economic activity. These high-value, skilled jobs are concentrated in the chemicals, energy, and logistics sectors, underscoring Grangemouth's role as a key hub in Scotland's industrial economy.
- The cluster exports goods both domestically (57%) and internationally (43%) with these proportions varying depending on international market fluctuations.

- The plan highlights the importance of sustainable industries such as bio-manufacturing and green hydrogen production as future growth areas.
- The purchase of feedstocks and natural gas are the highest areas of spend within the cluster. Maintaining and developing on-site infrastructure is also a major area of cost, with £ tens of millions spent each year with construction and engineering companies, many of which maintain a local presence.
- Total annual spend within the cluster equates to around £100 million per year

### **Environmental**

- Grangemouth was responsible for 7.2% of Scotland's territorial emissions (2.92MtCO<sub>2</sub>e) in 2022, making decarbonisation a critical component of its transition. This will be the baseline from which decarbonisation targets will be set and monitored.
- This report focuses on carbon capture and storage (CCS), green hydrogen, and biofuels as key technologies to reduce emissions. A major initiative, Project Willow, aims to repurpose Grangemouth's existing infrastructure to facilitate the development and deployment of low-carbon technologies, including biofuels manufacturing, and green hydrogen production.
- Carbon capture plays a pivotal role in these efforts, positioning Grangemouth as a potential future carbon capture hub for central Scotland.

### **Social**

- In 2023 there were approximately 3,250 people employed at Grangemouth, with most employees living within the immediate local area (Falkirk and West Lothian) and the vast majority on full-time hours (95% with 30+ hours per week).
- Grangemouth's community faces significant socioeconomic challenges, with high rates of income deprivation, unemployment, and limited access to public transportation. The transition plan acknowledges challenges including skills shortages and gender imbalance.
- There is a requirement for workforce reskilling and community engagement to address them.
- Skills development is a key focus, with the creation of a tailored Grangemouth Industrial Skills Program aimed at reskilling workers for new roles in the green economy. The program will focus on STEM fields and include opportunities for adult learning, youth apprenticeships, and career changes. There is a need for standardisation of accreditation to allow a pathway for workers from oil and gas to low carbon sectors.
- The transition also includes the appointment of a Community Engagement and Participation Manager to ensure local voices are heard and actively involved in shaping the future of the cluster. This is to improve community participation in the development of the town and the upskilling and employment activities to ensure a positive impact on the quality of life for residents.

### **Future Developments**

The 2045 Vision for Grangemouth was co-developed by the community, workforce representatives, academia and the Scottish Public Sector. By 2045, Grangemouth is envisioned as a net-zero industrial cluster, pivotal to Scotland's sustainable economy. Five central pillars have been proposed to guide this transformation:

1. Leveraging existing strengths in chemicals manufacturing to maintain industrial activity while lowering emissions.
2. Creating a low-carbon fuel and energy hub, supporting Scotland's energy security by building on existing renewable energy technologies and low-carbon hydrogen.
3. Becoming a CCS hub to manage industrial emissions.
4. Developing bio-manufacturing capabilities, to replace fossil fuels with bio-based alternatives for industrial processes.
5. Innovating in new industrial processes, fostering a cluster that attracts investment and supports sustainable economic growth.

### 3.1.3 Recommendations

Based on the current baseline and future vision elements of the report, recommendations were presented as action statements that consider the impacts, risks, opportunities and interdependencies for the industrial cluster. The recommendations delivered in this report are extensive and are summarised as follows:

#### Sustainability

- Develop an industry-led technical and commercial investment strategy for the Grangemouth cluster, aligned with net zero that attracts investment focused on economic, social and environmental benefit
- Create alignment and coordinated action between UK and Scottish Governments and local authorities on policy, strategy and funding
- Support and fund Project Willow as an early part of the longer-term cluster strategy, involving companies across the cluster

#### Jobs and Skills

- Establish a Grangemouth regulatory hub that can trial novel approaches to regulation.
  - This aims to use policy and regulation more effectively to support innovation whilst protecting people and the environment
  - Leverage the UK Government's Regulators' Pioneer Fund (available until March 2025) and seek additional funding routes
- Develop a series of Just Transition jobs and skills conditionalities to be applied to public funding for Grangemouth
- Establish an industrial cluster skills offer that will support the transition with a future focus and work closely with partners
- Improve coordination of existing initiatives across the Forth Valley to enhance collective opportunities
  - Forth Valley Skills Action Plan (currently under development)
  - Forth Green Freeport
  - Falkirk and Grangemouth Growth Deal

#### Finance

- Secure UK and Scottish Government funding for Project Willow and other early-stage scoping studies that will underpin the long-term strategy
- Develop and promote a comprehensive and attractive investment proposition to attract private sector investment

- Maximise the value of existing government funding (Green Freeport, Falkirk Growth Deal, Stirling and Clackmannanshire City Region Deal)

### Place and Community

- Significantly increase the visibility, pace and ambition of the Greener Grangemouth Programme (a Falkirk and Grangemouth Growth Deal funded initiative, focused on improving the town of Grangemouth through the transition to net zero, towards developing a greener, safer and more prosperous town centre) with a clear plan of realistic actions
- Define and deliver a focused, time-bound study to develop a plan to improve public transport links, connectivity and accessibility around Grangemouth
- Develop a place-based Just Transition Deal – UK and Scottish Government funded
- Define and establish best practice community engagement guidelines for partners in the Cluster Strategy, to deliver a consistent approach
- Fund a recognised Community Engagement and Participation Manager, who will act as the local community champion
- Explore the development of a local Procurement Framework that encourages and incentivises operating companies to procure goods and services from local companies

### Supply Chain Ecosystem

- Establish a supplier development programme backed by UK and Scottish governments
- Create an annual Grangemouth Industrial Decarbonisation Expo to be held in the Forth Valley area, bringing together local, national and international companies to share knowledge, technologies and solutions
- Create a specific campaign to promote the cluster strategy and opportunities by harnessing the coordinated support of trade bodies and other supply chain support organisations

### Communications

- Develop a distinctive brand identity and narrative to position the cluster with key audiences and stakeholders
- Develop and resource the delivery of a communication and marketing programme to promote the cluster – its ambition, goals, commercial opportunities, impact and benefits

## 3.2 A Sustainable Just Transition for the Grangemouth Industrial Cluster - Aspect (2024)

### 3.2.1 Summary

The report focused on future developments at Grangemouth, that were based on primary research. It builds on the Grangemouth Just Transition Vision of transforming Grangemouth into a carbon-neutral hub by 2045, focusing on five pillars: *capitalising on existing industrial strengths, developing a low carbon fuel and energy hub, becoming an important destination for carbon capture, leading in bio-manufacturing, and pioneering new industrial processes*. These are addressed through eight transition levers that cover *strategy and governance, sustainability, skills development, finance, innovation, supply chain optimisation, place development, and communication strategies*. The nature of the findings and insights are future focused and include a very large set of recommendations.

### 3.2.2 Key Findings and Insights

#### Strategy and Governance

High level findings suggest that the cluster lacks cohesion, focus and strategy.

- Industry was generally sceptical they are being adequately listened to as there is no formal, industry-led governance body responsible for the management and development of the cluster.
- The report indicated that the large number of stakeholders currently involved in various aspects of the strategic development of the Grangemouth cluster was a challenge.
  - The combination of public sector and industry can generate vested interest. Actions may be delivered more effectively with separate leadership structures.
  - The report indicated a concern from industry that there was limited industrial representation in the groups that have been set up to drive the future development of Grangemouth.
- There is a need for a long-term strategy over 'six business cycles' (30yrs) that creates a future vision for the cluster.
- The current industrial cluster was described in one interview as a 'location of stuff' where industrial activities operate in silos.
- There is a need to revisit the current (limited) organisational and governance frameworks for Grangemouth to re-focus on the development of an effective, industry-led and actionable strategy and improve communications between key stakeholders.
- The economic case for Grangemouth will require an initial 3-5 year strategy to support the implementation of basic infrastructure that will be required for future developments. This could involve potential segmentation into distinct functional sub-clusters e.g. Fuels, Chemicals and include a range of development scenarios.

#### Sustainability and Decarbonisation

- Grangemouth ultimately requires a focus on short term viability of industrial activities over wholesale decarbonisation of operations.
- The report has a strong focus on 'Project Willow', lead by INEOS, as a catalyst for the Just Transition. Whilst useful, the focus on INEOS may distract from the activities and opportunities for the rest of the cluster.
- There is a requirement for government funding to leverage private sector investment. There is a concern that existing operators will withdraw before a Just Transition can be achieved, leaving the remaining operators unable to shoulder the financial burden themselves.
- The report indicated that Government backed policy would stimulate industry operators to engage with new industrial technologies by underpinning risk and improving access to nascent markets.
  - There is particular focus on the potential to mirror economic and commercial strategies to foster innovation including, for example, streamlined planning for land redevelopment, provision of skills and investment zone status (examples cited include Aberdeen and Glasgow).
  - Other policy such as a SAF mandate would stimulate market reaction to Government strategy.

- Scottish Government strategies emphasise hydrogen production, CCUS development, biomanufacturing and plastics recycling. Whilst there is potential for all the mentioned transitional industries, a lack of clarity on specific Scottish Government policies and limited support inhibits industry's commitment to any.

### **Jobs and Skills**

- Grangemouth is well-served by local skills providers. However, there is a need to create a connected skills strategy to manage industry needs for the workforces of the future.
  - The development of a Forth Valley Skills Action Plan will be critical – working across 3 local authorities (Stirling, Clackmannanshire, Falkirk).
  - A specific skills plan for Grangemouth could support better integration of pathways for the local inhabitants.
- There is a shortage of funding in the further education sector. This relates to the specific innovation technologies and industrial applications and extends to developing specific training / upskilling for the transitional roles required by industry. Whilst much of the skills and training already being delivered are transferable, adequate and accessible mechanisms for teaching these skills must be developed.
- Transferable STEM skills remain a requirement to underpin the cross-section of engineering, life sciences and computing that will be important to support the development and implementation of new and innovative sustainable manufacturing processes in the future. This may require new programmes alongside the enhancement of existing programmes to have greater focus on emerging applications.
- The development of the necessary training and skills for the future could be championed by an industry-employer led forum to assess resources and construct a pipeline of skills support.
- Skills passports and reskilling are favoured approaches to integrate existing and new workforces into the just transition.

### **Finance**

- The devolved powers of the Scottish Government raise some challenges to the establishment of a coordinated 3-5 year financial plan. There are some misalignments in Scottish and UK Government strategies to transition industry to net zero and Scottish funding is limited in comparison to that of Westminster.
- Existing financial policies are under-funded or appear to involve significant “red tape”. For example, the Forth Greenport fiscal concessions are due to expire in 2027, limiting access to tax breaks at Grangemouth.
- Financial strategies that stimulate development were identified to require central UK Government finance to underwriting risk. When integrating new technologies this can help to avoid the “valley of death” where the technology is financially unviable until it becomes established and demonstrates operational effectiveness.
- Crucial elements for a supporting financial mechanism require integration across subsidies, taxpayer funding and SME financial aid.

## Technology and Innovation

- The companies in the Grangemouth area currently face several challenges including aging infrastructure, dependency on high-carbon processes and diverse (diffused) strategic aims. Furthermore, there needs to be substantial investment to transition to net zero as markets increasingly value (and require) sustainability. Nonetheless, there is significant potential for innovation to capture existing and emerging market opportunities.
- There are opportunities to develop a pipeline of skills that will be required for the implementation and operation of these new, green processes. This will require collaboration between industry, higher and further education and the public sector.
- The report suggests that there is hesitancy amongst industry players to engage directly with Universities and invest in the development of technologies that are at lower technology readiness levels (TRL). Leveraging of the BAPP and CDU to develop and demonstrate low carbon and net zero technologies, products and processes at industrially relevant scales will be critical for innovation.
- An innovation based transition to net zero requires a multifaceted approach focusing on strategic funding, collaborative frameworks, and learning from international best practices.
- The future vision for Grangemouth envisions a cluster where there are company interdependencies and businesses leverage one another's capabilities to enable innovation. Small hydrogen start-ups and biotech companies are seen as crucial enablers to kickstart an innovative and dynamic sustainable chemicals cluster

## Place

- Industry at Grangemouth is aware of the need to engage with the community. There is an assumption that this will be achieved through the continued existence and growth of cluster and will be a key aspect of the future strategy. Direct and indirect employment are dependent on this.
- There is, however, a disconnect between the cluster, local workers, and the wider community in Grangemouth. The cluster is not thought to serve the local community as much as it could.

## Supply Chain Ecosystem

- Grangemouth has some of the capabilities needed to build an end-to-end chemicals value chain (or others such as hydrogen/SAF).
  - An integrated ecosystem would build on existing resources and integrate novel applications including water recycling, utilising biomass as a feedstock and the use of green power.
- A comprehensive mapping of infrastructure, technology, feedstocks and markets over the next 5 years will be required to assess supply chain needs and capacity.
  - Security of supply of material, markets ready for products, maturation of technology (for investment) will also require assessment.
- The infrastructure at Grangemouth is currently adequate to support the existing businesses but there is a need to maintain existing critical assets (e.g. waste water treatment), implement new assets (e.g. green steam) and upgrade and improve infrastructure (e.g. road and rail connectivity, access to green energy, improving the connectivity of utilities between the East

and West ends of Grangemouth). This will be crucial to enable the development of an industrial cluster as companies from start-ups to large FDI projects favour the types of “plug and play” capability this would enable.

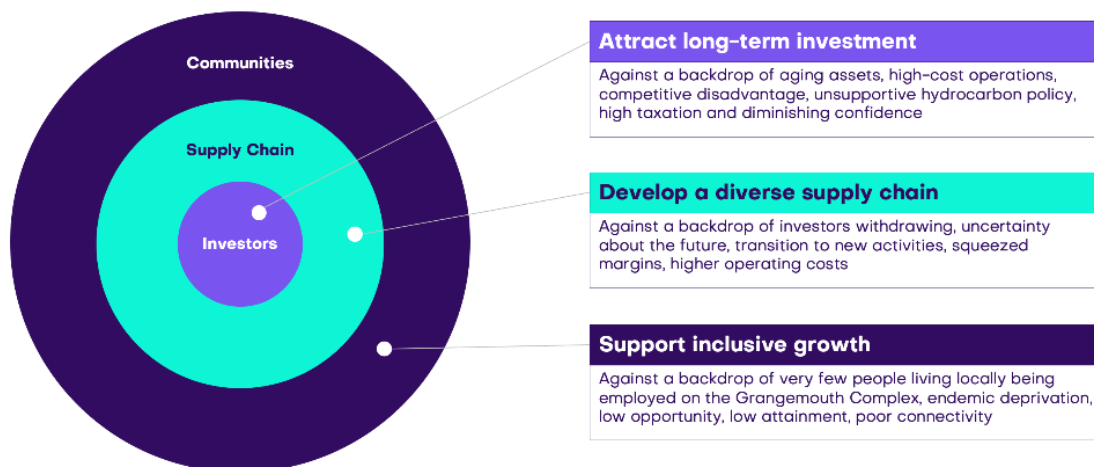
- The uncertainty surrounding the future of certain businesses and sites at Grangemouth has reduced interest in investing in transitional technologies
  - Refinery infrastructure may need to be demolished to facilitate site re-development. This would be an expensive and time-consuming process.
  - Investments in future technologies remain risky when the future of and production at Grangemouth remains uncertain.
- The report references the US Preferred scheme which provides support for SMEs to acquire new equipment, modernise facilities, and provide preferential procurement for sustainable products as a method of supporting SMEs to scale their capabilities.

### **Communication**

- The lack of collaboration and communication between companies located in Grangemouth was consistently highlighted throughout the report. Improving these was identified as a key enabler to develop a mutually beneficial strategic direction for the Grangemouth cluster. It will be important to ‘create shared ownership in the cluster’s future’.
- Grangemouth has marketable strengths (although the report does not specify what these are). It was highlighted that the narrative surrounding Grangemouth was too often bleak and negative. Many of the participants that contributed to this report were proud of and cared for the cluster and the town.
  - There must be a narrative change for Grangemouth and more positive marketing around current activity, the future potential, as well as the strong legacy in fine chemicals.
  - The Humber cluster was identified as a good example of a strong collective identity and positive marketing.
- Improved communication across and between the INEOS and Earls Gate sites at either end of Grangemouth will better facilitate this. Government will have a supporting role but, ultimately, industry should shape the communications.
- The risk of low community engagement was highlighted as businesses are more focused on ensuring their future operational and financial security. Strategic decisions should, where possible, be made public, if not consulted on.

### **3.2.3 Recommendations**

This report set out numerous recommendations, which were embedded throughout. An over-arching summary of these is shown in Figure 3.



**Figure 3: A sustainable just transition for the Grangemouth Industrial Cluster (Property of Aspect)**

### 3.3 Project Willow – INEOS, EY Parthenon and Scottish & UK Governments (2025)

#### 3.3.1 Summary

The information received from Project Willow has been limited due to the ongoing, confidential nature of the project. As a result, the analysis of this report is more limited.

Project Willow is a collaborative project between INEOS, The Scottish & UK Governments, and EY Parthenon seeking to identify, assess, and prioritise credible options for transforming the Grangemouth Industrial Cluster to one that focuses on low-carbon and sustainable products and processes. According to the last update provided, the project has completed baselining and is in the process of completing an assessment of credible projects (e.g. technology, product and market based projects) that could enable this transformation. The criteria used for this assessment are: Technical, Economic, Commercial, Regulatory, Climate/Environmental, Community, and Skills.

#### 3.3.2 Key Findings and Insights

##### Baselining

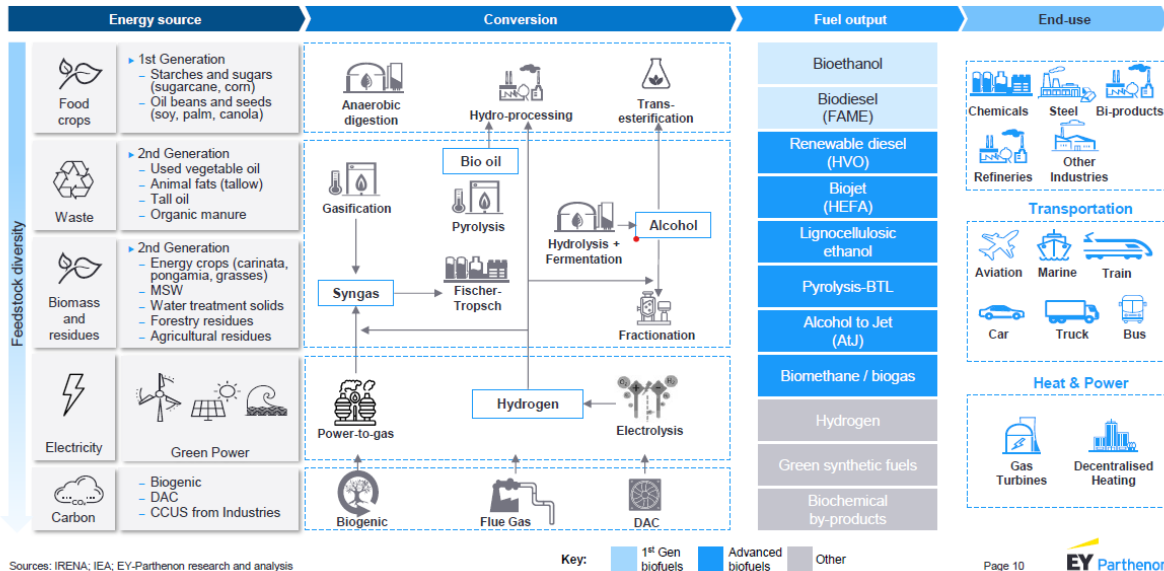
- The cluster consists of three distinct groups:
  - The (closing) Petroineos refinery
  - The wider INEOS cluster (petrochemicals, polymers & Forties Pipeline System)
  - The wider manufacturing cluster (chemicals, polymers, agrochemicals, pharmaceuticals, energy from waste, aquaculture, technical equipment & Forth Ports)
- Global energy demand is expected to grow but fossil fuels supply will remain stable. This demand is anticipated to be primarily from non-OECD countries. The difference between supply and demand is expected to be offset by improving fuel efficiency and switching to lower carbon fuels (e.g. biofuels).
  - For example, the UK's 6<sup>th</sup> carbon budget requires an acceleration of fuel efficiency and switching. The resultant demand for petroleum could decrease by 86% and gas by 75%

- There are diverse potential feedstocks and production pathways for low-carbon fuels.

#### Energy transition landscape

Diverse feedstock and pathways exist across low-carbon fuels, with a range of maturity, scalability, and competition across feedstocks, pathways, and end-uses

#### Low-carbon fuels value chain



**Figure 4: Potential feedstock pathways for Grangemouth (Property of EY Parthenon)**

- Assessment of a longlist of technologies was condensed into a shortlist of relevant technologies at TRL 5 or higher.
  - Biofuels, hydrogen production, chemicals technologies, carbon capture, power and storage, heat, E-fuels, and 3 other non-specified were selected.
- Stakeholder engagement has underpinned the research with findings as follows:
  - Shareholders and Government: clarity and confidence on what it would take to deliver the options.
  - GFIB members: input of local ideas/concerns and buy-in.
  - Technology providers: input of options and awareness of Grangemouth opportunities.
  - Potential suppliers/customers: understanding of future energy needs/feedstocks and opportunities.
  - Public sector/regulator/academia: input of relevant research and support to navigate the innovation ecosystem.
  - Investors: understanding perspectives on challenges/opportunities and organisation of investor roundtables.

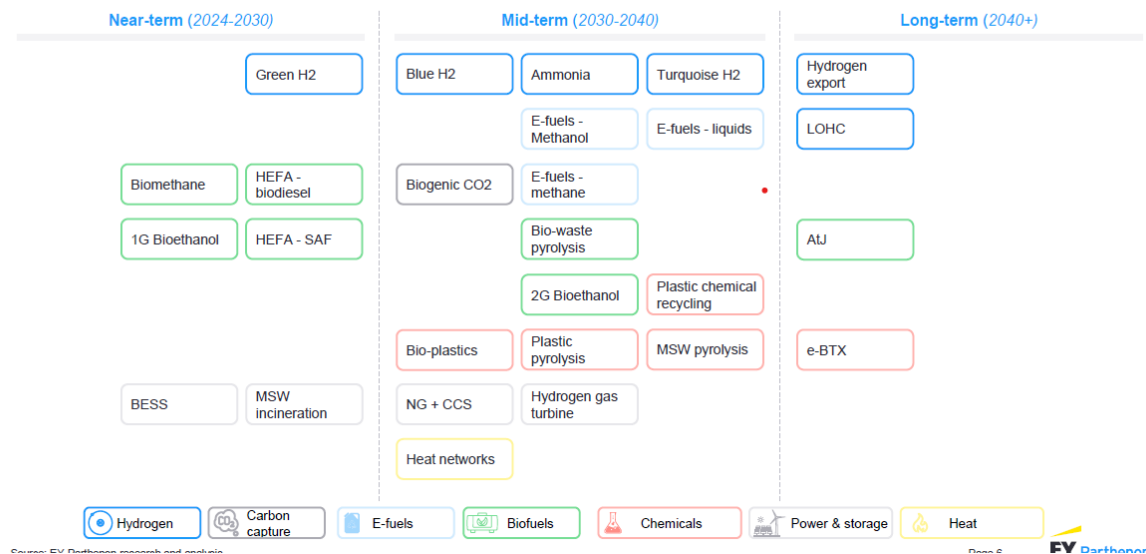
## Assessment of Shortlisted Projects

- The report suggests sequential development, over a 15 year time-frame, based on technology maturity, feedstock availability, and expected demand. This includes the development a range of associated processes with some overlap in timings for the underpinning technology sectors.

### Step 1 – Create Project Sets

The maturity of technologies, availability of feedstocks, and expected demand, lead to a natural phasing of technology options over time

#### Technology sequencing



**Figure 5: Grangemouth technology sequencing (Property of EY Parthenon)**

- Near term (2024-2030) – Hydrogen and carbon capture
  - Mid-term (2030-2040) – E-fuels, biofuels, chemicals
  - Long-term (2040+) – Power & storage and heat
- Competitive advantage could be driven in three ways:
  - Local feedstocks – limited transport costs and sufficient scale to meaningfully contribute to production
  - Local demand – targeting nascent/niche products that are constrained in the market. Integrating technology groups to create synergistic demand
  - Infrastructure – access to infrastructure that expands the available market and create assets that reduce the investment required
- Five design principles guided the proposed timing / sequence of projects:
  - Prioritise commercial-scale facilities, avoiding demonstration plants
  - Focus on local non-food feedstock sources
  - Ensure at least partially secured demand (not entirely merchant)
  - Favour circular value chains
  - Exclude export opportunities reliant on subsidies unless recoverable
- Four project sets have been identified for more detailed assessment:
  - Maximise bio-feedstocks
  - Conduit for Scottish offshore wind
  - Maximise local waste values
  - Fine chemicals production hub

A detailed impact assessment of the preferred projects is now underway that will feed into the development of a Strategic Outline Case for chosen options

### **3.3.3 Recommendations**

Due to the ongoing nature of this project, no recommendations are available.

## **4 Review of Other Documents Relevant to Grangemouth**

The following 6 documents were identified as being important to the future development of the Grangemouth cluster but are more focused on longer term, innovation focused projects that will enable the transition of Grangemouth to a cluster focused on sustainable fuels, chemicals and materials.

As such, the following review provides a summary and highlights the key recommendations from each, with a more detailed assessment provided in Appendix A.

These are:

- Business Case for the Biotechnology Accelerator Pilot Plant (BAPP), Optimat, 2023
- Business Case for the Carbon Dioxide Utilisation Centre (CDU), Optimat, 2024
- Synthetic-Sustainable Aviation Fuel (SAF) Mapping, Optimat, 2024
- Grangemouth Hydrogen Hub, Optimat, 2024
- Hydrogen Demand in Scotland: A Mapping of Industrial and Transport Applications, Element Energy, 2023
- Scottish Net Zero Roadmap (SNZR), NECCUS, 2023

### **4.1 Business Case for the Biotechnology Accelerator Pilot Plant (BAPP) – Optimat (2023)**

#### **4.1.1 Summary**

The purpose of this report is to deliver a business case to unlock £10 million in funding from the Falkirk Growth Deal to support the development of a Biotechnology Accelerator Pilot Plant (BAPP). This supports the ambition for Grangemouth to transition towards being a net zero industrial cluster. The BAPP was designed to capitalise on the growing global industrial biotechnology market and address market failures associated with companies' inability to find and secure access to pilot and scale up facilities. Development and delivery of the BAPP are detailed with potential impacts of the project included. This pilot plant was designed to be co-located with the Carbon Dioxide Utilisation (CDU) centre (following report) at a Sustainable Manufacturing Campus (SMC) in Grangemouth, supporting industry-academia knowledge transfers and stimulating innovative solutions for the transitional economy.

#### **4.1.2 Recommendations**

The BAPP will operate as part of the Sustainable Manufacturing Campus at Grangemouth focusing on demonstration, at an industrially relevant scale, of industrial biotechnology processes for the manufacture of sustainable fuels, chemicals and materials. As this report was produced to support the production of a Full Business Case for funding, no specific recommendations were made other than to

reiterate that funding of both the BAPP and CDU will enable companies to capitalise on market opportunities as industry transitions to net zero.

## **4.2 Business Case for the Carbon Dioxide Utilisation Centre (CDU) – Optimat (2024)**

### **4.2.1 Summary**

This report describes the business case for a Carbon Dioxide Utilisation Centre (CDU) to test and demonstrate technologies that convert carbon dioxide into platform chemicals or materials utilised in chemicals manufacturing, synthetic fuels and materials. The case was designed to unlock a further £10 million from the Falkirk Growth Deal and catalyse industrial application of innovative carbon capture technologies created in-situ through academic-industrial partnerships. Carbon dioxide utilisation is expected to grow as the requirement to decarbonise industry grows in response to global commitments to achieve net zero. This report provides a business case for a commercially focused research centre that will be co-located with the BAPP at the Sustainable Manufacturing Campus (SMC).

### **4.2.2 Recommendations**

The CDU will operate as part of the Sustainable Manufacturing Campus at Grangemouth and support the development of innovative industrial applications for carbon dioxide utilisation. As with the BAPP business case, this report was produced to support the production of a Full Business Case for funding and, therefore, no specific recommendations were made other than to reiterate that funding of both the BAPP and CDU will enable companies to capitalise on market opportunities as industry transitions to net zero.

## **4.3 Synthetic-Sustainable Aviation Fuel (SAF) Mapping – Optimat (2024)**

### **4.3.1 Summary**

This report critically assesses the interest in, and capability of industry, to support a SAF supply chain in Scotland that can serve the domestic and international markets. Scotland has significant potential to produce power-to-liquid fuels (e-fuels) through combining hydrogen with captured carbon to produce simple hydrocarbons that can be processed into SAF. Active development and deployment of renewable energy, green hydrogen and carbon capture utilisation and storage will result in products and processes that will enable decarbonisation of aviation. The report is not solely focused on Grangemouth but identifies the potential for the development at the cluster, building on existing industry and infrastructure, to exploit this market opportunity.

### **4.3.2 Recommendations**

Recommendations from this report are structured towards Scotland more broadly but will have implications for Grangemouth industrial activity.

- Connecting the (nascent) supply chain - if collective industrial activity is to happen, it will require an integrated approach across the supply chain. The high CAPEX costs and the alignment of the supply chain that will be required to produce SAF will require industry collaboration and cooperation.
- Bring others from outside Scotland into the network to discuss opportunities and the support they can provide - this was a theme throughout the report. Foreign direct investment (FDI) and cooperation and collaboration with international organisations will be required to enable the

transition of manufacturing processes at Grangemouth. The significant costs associated with such industrial transitions require large-scale private investment from organisations already active, or diversifying into this space. A consortia-type agreement could stimulate activity.

## **4.4 Grangemouth Hydrogen Hub – Optimat (2024)**

### **4.4.1 Summary**

This report provides a roadmap for establishing Grangemouth as a central hydrogen hub in Scotland, critical to achieving the country's 2045 net-zero goals. It highlights the strategic importance of Grangemouth in contributing 4% of the national GDP but that it remains the highest carbon-emitting cluster in Scotland. The development of a hydrogen hub at Grangemouth offers a transformative opportunity to support Scotland's low-carbon transition, leveraging the cluster's infrastructure and industrial expertise. Hydrogen offers a consistent and reliable decarbonised energy source where electrification is not sufficient. Findings centralise around the production of blue hydrogen as the primary opportunity and discuss the potential for green hydrogen should a reliable and consistent renewable energy source be secured. The report recognises Grangemouth as the focal point for Scottish fine chemicals but notes potential to pivot. By expanding geographic parameters of the Grangemouth cluster to include the extensive local value chains, it is clear that assets and opportunities can support a network of local businesses.

### **4.4.2 Recommendations**

- Enable market development through dedicated end user pull by committing to 1-2 key priorities for hydrogen use.
- Encourage collaboration through innovative public funding mechanisms: bridge the gap.
- Attract innovative companies.
- Foster innovation and collaboration, particularly encouraging major companies in the locality to collaborate.
- Capitalise on Forth Ports.
- Advocate for connectivity from Grangemouth to European infrastructure.

The key recommendations emerging from this study are to develop collaborative, simple solutions that utilise existing assets and are facilitated by public-private funding mechanisms. This will create an environment more attractive to FDI and innovation over the long-term

## **4.5 Hydrogen Demand in Scotland: A Mapping of Industrial and Transport Applications - Element Energy (2023)**

### **4.5.1 Summary**

The document focuses on mapping potential hydrogen applications in various industries across Scotland, including a deep dive into the role Grangemouth and other regions could play within Scotland's future hydrogen economy. The emphasis is on the practical applications of hydrogen and the relative TRLs of these applications in potential end-user industries. It identifies Grangemouth as a high carbon-emitting cluster with the potential to be one of Scotland's main hydrogen hubs, driving future demand.

#### 4.5.2 Recommendations

Grangemouth can be dominant player in this area if it can develop the necessary infrastructure. As a major industrial centre, it is well positioned to lead in hydrogen production, distribution, and use, especially in sectors that require high-temperature heating. The development of a local hydrogen value chain, connecting production to end-use applications, can significantly enhance Grangemouth's economic resilience and environmental impact. The cluster should market opportunities and target high TRL opportunities with further expansion as technologies and markets develop.

### 4.6 Scottish Net Zero Roadmap (SNZR) – NECCUS (2023)

#### 4.6.1 Summary

The report develops a comprehensive strategy for achieving net-zero industrial emissions by 2045 across Scotland's largest industrial emitters, which account for 75% of national CO<sub>2</sub> emissions. The roadmap includes 28 industrial sites across 11 sectors (chemicals, refining, power, cement, and more) that collectively generate £740 million in annual GVA and employ over 6,000 people. Targets include reducing emissions by 43% (from 2018 levels) by 2032 and reaching net zero by 2045. This will likely be supported by technologies like carbon capture, utilisation, and storage (CCUS), fuel switching, and renewable hydrogen. Whilst the report is focused on industrial activity more broadly in Scotland, Grangemouth emitters are identified as key stakeholders for the roadmap.

#### 4.6.2 Recommendations

The recommendations in this report were set out as a number of strategic actions, as follows:

- Prioritise integration with the Acorn Project for CO<sub>2</sub> storage.
  - The Acorn Project is a Track-2 CCS cluster that plans to develop Scotland's only advanced CO<sub>2</sub> transport and storage network, permanently storing carbon in geological storage sites under the North Sea bed.
- Advocate for early-stage funding to fast-track hydrogen and electrification technologies.
- Leverage location near Forth Ports, now a Green Freeport, for CO<sub>2</sub> shipping as an interim or complementary solution whilst permanent infrastructure develops.

## 5 Common Themes from the Literature Review

From the review of the abovementioned documents, several themes have clearly emerged, focused on that present situation at Grangemouth and future opportunities for development. These can be summarised as follows:

#### Grangemouth is a 'cluster' in a loose sense

- Grangemouth was described as a 'location of stuff' where industrial activities operate in silos. This has been further compounded by the departure of multiple companies in recent years.
- The cluster is geographically separated, around the town of Grangemouth, with INEOS operations to the East and fine chemicals / pharmaceutical manufacturing activity located in the West on the Earls Gate site.

- Grangemouth is a very small cluster with some geographically concentrated industrial activities but there is very limited collaboration and coordination between companies.

#### **Grangemouth lacks a cohesive strategy and operational governance**

- Building on the prior theme, Grangemouth currently lacks a clear cohesive strategy for development of the cluster.
- Whilst there is a group in place with responsibility for the strategic governance of the Grangemouth cluster (GFIB), repeated changes to the membership and structure of this group have inhibited progress.
- The inclusion of a wide range of voices is a positive and key principle of the Grangemouth Just Transition process to ensure that views from industry, the public sector and the local community are considered. This can, however, introduce complexities and extend timelines for the advancement of a clear or decisive strategy for Grangemouth, but mechanisms are in place to manage these.

#### **Sequencing of visions and strategy should be considered**

- Grangemouth is at a critical juncture for retaining industrial activity.
- Future visions are important to inform the long-term strategy for the cluster, but decisive action is required to develop and secure the underpinning infrastructure (e.g. waste treatment facilities) required to retain industrial activity at Grangemouth.
- The development of a sustainable cluster focused on, for example the production of low carbon fuels, chemicals and materials, as well as hydrogen offers significant opportunities. It is not always clear, however, the steps that will be required to achieve this.
- This is particularly true in the case of CCS due to the lack of clarity on progress of the Acorn Project.
  - Grangemouth would require a secure and constant offtake of the captured carbon to make the high capital investment in capture modules viable.
  - The Acorn project will provide this network. However, unclear timelines for final investment decisions has halted the progress in carbon capture integration investment at Grangemouth
- It is vital to ensure that industrial activity continues at Grangemouth, which can be achieved through small, tangible development activities that can, in turn, catalyse future opportunities, subject to market and funding conditions. This could include, for example, the construction of a utilities corridor between the industrial activities in the East and West ends of Grangemouth. A technical advisory team, working together with GFIB and industry representatives could advise on and support the implementation of such interventions

#### **Progress will benefit from simple collaborative solutions that utilise existing assets**

- There is a need for unified effort to develop collaborative solutions that benefit all parties. For example, waste treatment could become an unaffordable overhead for some companies should large organisations shut down Grangemouth operations. Alternative solutions that work for all companies should, therefore, be developed.
- Collaboration on industrial value chains such as feedstocks, transport, energy and waste management should be the focus to develop infrastructure that builds on existing assets that

have capacity to support future development and innovation. This will improve the fundamental assets that can support the creation of a diverse supply chain that is agile to market conditions

#### **Innovative methods of public-private funding will be required**

- Public sector alone will not have capacity to fund the future development of Grangemouth.
- Public funding for projects such as the CDU and BAPP will whilst hugely beneficial, will be insufficient to cover both the CAPEX and operational expenditure necessary. Furthermore, the development and implementation of a cluster strategy and management of the cluster itself cannot be financed solely by the public sector. Industry must contribute both financially and through the provision of dedicated resources.
- Innovative methods such as green bonds have repeatedly emerged as methods of sourcing critical funding.

#### **Grangemouth should continue to engage with the local community**

- There remain high levels of deprivation in the town of Grangemouth.
- Reports highlight the need to involve local communities in cluster activity and provide bi-lateral channels that foster communication, provide employment opportunities and encourage investment back into the area.
- Industrial connections to the local community can be developed through energy use, skills pathways and local green development networks (i.e. transport network).

#### **Skills development will be a requirement for Grangemouth**

- All plans for Grangemouth, both now and in the future, include a mention of skills development to address skills gaps and shortages. This will be, in part, shaped by the longer-term strategy for Grangemouth as this will inform the skills needed, e.g. industrial biotechnology, process engineering, chemical engineering, etc.
- Developing a skilled but agile workforce will, therefore, be critical to the future of Grangemouth.
- However, further development of the provision training and skills development will be necessary, particularly in STEM education. A strategy for reskilling the existing workforce such as the suggested 'skills passport' would also support skills retention.
- The cluster can be developed and promoted as an attractive place to work highlighting the focus on innovation, sustainability, relatively high wages, and the contribution to development of the local community.

#### **There is optimism about the future of Grangemouth**

- Grangemouth has a strong industrial legacy and is important to Scotland's and the UK's manufacturing industry.
- Future actions should focus on the positives about the physical and knowledge assets in the area.
- There may be the shadow left by departing organisations, but gaps also present opportunities for innovation, particularly to support a sustainable industry transition.
- Grangemouth, due to the present situation, is well positioned to develop and rapidly implement a cluster strategy if adequate support and structure is developed.

These key findings are summarised in the figure that follows.

### Grangemouth is a 'cluster' in a loose sense

- Grangemouth hosts industrial activities that operate in silos, with isolated industrial streams. The area has experienced the departure of several industrial businesses over time
- The cluster is geographically divided, with INEOS operations in the East and most other activities in the West
- While Grangemouth features geographically concentrated industrial activity, it lacks a unifying strategy and remains disjointed

### Grangemouth lacks a cohesive strategy and operational governance

- Cluster governance structures were identified but appeared overly complex due to changing consolidations and separations
- The inclusion of a wide range of voices is a positive and key principle of the Grangemouth Just Transition process but may be accompanied by some management complexities
- A unified strategic and marketable direction will be critical for Grangemouth

### Sequencing of visions and strategy should be considered

- Grangemouth is at a critical juncture for retaining industrial activity. A long-term strategy must be sequenced with short-term support for active industrial activity
- Focus on cluster futures (SAF, hydrogen, biotech) risks overlooking transitional actions
- Slow CCS progress (e.g. Acorn) highlights dependency challenges for carbon offtake
- Ensuring current industrial viability requires tangible interventions to catalyse future opportunities
- A technical industry advisory team could support such interventions

### Progress will benefit from simple collaborative solutions that utilise existing assets

- Achieving industrial viability requires collaborative solutions that benefit all stakeholders
- Waste stream management remains a challenge for Grangemouth
- Collaboration should focus on shared infrastructure requirement to develop and leverages existing assets and support innovation potential
- Foundational infrastructure can enable the conditions for a diverse and agile supply chain responsive to market needs

### Innovative methods of public-private funding will be required

- The public sector alone cannot fund Grangemouth's future development
- Projects like the CDU and BAPP offer essential components for progress
- Blended public-private funding is needed to shape strategy and attract future FDI
- Innovative funding methods, such as green bonds, have been identified as key to sourcing critical capital

### Grangemouth should continue to engage with the local community

- Grangemouth still faces high levels of deprivation
- Local communities should be involved in cluster activities through bilateral channels to foster employment opportunities and engagement with local development
- Initiatives in energy use, skills development, and local green networks (e.g., transport) can strengthen community connections

### Skills development will be a requirement for Grangemouth

- Skills development guided by the cluster's long-term strategy will be essential in addressing current and future industrial shortages at Grangemouth
- Improved skills provisions including STEM education and reskilling initiatives such as a 'skills passport' are needed
- Make Grangemouth an attractive workplace by supporting technological advancements, competitive wages, sustainable practices, and pleasant local living conditions
- Developing a skilled and agile workforce will be critical to Grangemouth's future success

### There is optimism about the future of Grangemouth

- Grangemouth has a strong industrial legacy that has been critical to Scotland and the UK
- Future actions should emphasise the area's physical and knowledge assets
- Departing organisations may leave gaps, but these create opportunities for innovation in the sustainable industry transition
- Grangemouth is well-positioned to develop and implement a clear strategy that will support the future of the cluster and town

## 6 Key Observations from Reporting on More General Cluster, Technology and Market Development Activities

A number of other reports were identified, collated and reviewed and key themes synthesised. These reports and publications are as follows:

- Economic Contributions of the Grangemouth Refinery, PwC, 2023
- The Economic Opportunities in Scotland's Net Zero and Climate Adaptation Economy, Climate Exchange, 2024
- Enabling Net Zero: A Plan for UK Industrial Cluster Decarbonisation, UKRI, 2023
- Supporting the transition to Jet Zero: Creating the UK SAF Mandate, Department for Transport, 2024
- Net Zero North West: North West Cluster Plan, UKRI, 2023
- Future Delivery of the North West Net Zero Cluster Plan, Opergy Group, 2023
- Humber Industrial Cluster Plan, UKRI, 2023
- Delivering the Vision: The Humber's Roadmap for Industrial Decarbonisation, Humber Energy Board, 2024
- Tees Valley Net Zero, BP 7 NEPIC, 2023
- A Plan for Clean Growth: South Wales Industrial Cluster Plan, UKRI, 2023
- Repowering the Black Country, UKRI, 2023
- Carbon & Cash: Funding a Circular Chemical Economy, UKRI, 2024
- Transforming Industry: Strategic Policy Insights for Scotland's Industrial Decarbonisation, IDRIC, 2024
- Exploring the Impacts of the Adopted Carbon Capture Approach to the Scottish Chemical Industry and the Wider Scottish Economy, IDRIC, 2024
- Beyond the Factory: Ten Interdisciplinary Lessons for Industrial Decarbonisation Practice and Policy, IDRIC, 2024

These were not specific to Grangemouth and, typically, covered topics such as the development and operation of clusters elsewhere in the UK; academic papers clusters and their operation and progress on the development of UK policies in relation to decarbonisation of industry and emerging low carbon markets, products and processes. The key themes identified in these reports can be summarised as followed (it is noted that some of these themes align with many of the examples of best practice identified in the "Industrial Cluster Best Practice Analysis" report that this literature review accompanies).

### Developing the Fundamentals

Industrial clusters have a few simple but essential requirements to be viable let alone attractive. Reports that focused on cluster development and operation, more generally, highlight the following key points:

- Developing efficient, consistent and clean energy supplies and managing necessary waste streams is of significant importance.
- To improve cluster activity, centralised planning and management was highlighted as a way of reducing the burden on companies and supporting public-private collaboration for the fundamental infrastructure required for cluster businesses. For Grangemouth, this could

require, for example, an energy assessment (inclusive of all sites and the town) to devise potential low-carbon solutions.

- Fuel switching for energy intensive industries has been noted as becoming increasingly necessary.
- The provision of waste management to support current as well as future activities is also critically important. Future developments to enable the transition to sustainable manufacture would require less capital and planning if this infrastructure already exists.

### **Coordinated Operational Governance and Strategy**

Effective clusters have clear governance structures that oversee the collective strategy, publish reports and case studies and create a marketable cluster identity to attract businesses and investments. Some have a dedicated, industry focused team working on the cluster strategy that interacts with key stakeholders to ensure that it continues to be relevant. This enables the development of a clear cluster identity that is representative of the ambitions of the businesses located within it. This approach does not align all business goals but drives the direction of the cluster as a result of commonalities between businesses in terms of, for example, infrastructure needs, products manufactured and certain commercial aspects.

The value is two-fold, in that, this team can coordinate the development of basic infrastructure and investment to make industrial activity easier, and by doing so, can create a unified marketable cluster that has strategic plug-in-and-play capabilities. This was most apparent with the prominence of CCUS and hydrogen, where clusters such as HyNet NW and The Viking Cluster positioned themselves as being strategically integrated into consortia bids for HAR1 and Track-1 funding.

### **Public and Private Funding Collaboration**

De-risking investments emerged as a common theme with the following mechanisms highlighted:

- Incentives, tax breaks and market regulations were all cited as methods to stimulate private funders collaborating with public funders.
- Public-private partnerships that underwrite the risk associated with large-scale developments, particularly in emerging technologies that enable the manufacture of sustainable fuels, chemicals and materials, would increase the private sector's confidence in these projects and assist in the transition to net zero.

As Grangemouth is not a recipient of HAR1 or Track-1 CCUS funding, innovative funding mechanisms that create environments suitable for industrial development that can reduce capital expenditure for future private industrial developments would be required. Complimented by the BAPP and CDU, investment can focus on developing a suitable ecosystem of industrial potential, attractive to private investment of large and small businesses.

### **Policy and Regulation**

The review of these reports indicated that policy and regulation can play a critical role in enabling and accelerating the transition to sustainable manufacturing. Scottish and UK net zero and sustainability targets are ambitious but there is limited supporting policy to drive industrial action. Reports repeatedly identified a lack of clear policy that supports and enables emerging sectors including CCUS, the hydrogen economy, and SAF. This is further complicated as most of these sectors remain the reserve of UK

Government regulation, inhibiting the development and implementation of a devolved Scottish policy that backs the genuine opportunities for Scotland.

Without focused policy, private sector investment could be inhibited, due to the high capex costs and associated risk, meaning that markets could struggle to develop. The public sector plays a vital role as the intermediary between Governments and industry, lobbying alongside industry to recommend policy reforms and inversely, support integration of policy into cluster strategy.

A number of key policy and regulatory themes were identified in the documents reviewed:

- There is a need for clarity on regulatory aspects, technology specifications (such as SAF derivative preference), timely acceptance or rejection of final investment decisions, and expedited planning and funding channels for sustainable technologies.
- Streamlined planning and permitting processes are crucial for accelerating infrastructure deployment, with targeted financial incentives like Contracts for Difference (CfDs) helping de-risk investments.
- There will, however, be a need for a skilled planning workforce that understands the technological specifications together with a policy that supports their ability to approve plans and permits for projects.
- Without policy that is focused on the potential for Scotland, securing funding for infrastructure development is likely to be more challenging.

The sustainable manufacturing campus (SMC), including the BAPP and CDU, would also benefit from a clear policy direction to underpin the strategic importance of Grangemouth as a sustainable manufacturing and innovation hub that is of national importance.

## Appendix A – Review of Other Documents Relevant to Grangemouth

### Business Case for the Biotechnology Accelerator Pilot Plant (BAPP) – Optimat (2023)

#### Key Findings and Insights

##### Strategic Case

The UK boasts strong expertise and a strategic focus on engineering biology, encompassing sectors such as medicines, therapeutics, chemicals, fuels, materials, food, and agritech. Industrial biotechnology holds significant potential to drive the production of fossil-free biofuels, bioplastics, and renewable chemicals, while also supporting waste valorisation, sustainable agriculture, and bioremediation. These advancements could play a critical role in decarbonising industrial clusters, including Grangemouth. Scotland's national strategy envisions a European-style national cluster aimed at fostering innovation in energy transition, health and life sciences, data and digital technologies, and advanced manufacturing. The report highlights an attractive market with 202 UK-based companies engaged in modern industrial biotechnology, generating an approximate turnover of £4.723 billion. The BAPP will become one of Scotland's largest industrial research facilities, operating at TRL 5-9 to support pre-pilot and pilot studies, thereby accelerating the commercialisation of technologies. Additionally, the report underscores the importance of establishing a testing facility in Scotland to reduce the need for local businesses to transport perishable bioresources over long distances. This would strengthen the region's robust SME base and facilitate the development of innovative technologies with commercial potential.

##### Services Offered and Skills Training

The BAPP proposes facilities that include:

- Innovative industrial biotechnology companies to test and demonstrate their technologies at a pre-industrial scale
- Delivery of longer term, collaborative, close to market innovation projects with R&D partners

There is also an option to provide a laboratory-based incubator facility that can accommodate a small number (four to five) start-up or early-stage companies that offers:

- Dedicated bench space in a microbiology laboratory, which is equipped with a small number of relevant equipment items
- Office space

This will, in turn, offer:

- Access to the facilities to demonstrate and test technologies, proving their operational capacity at higher TRLs
- Delivery of longer term, collaborative, close to market innovation projects with R&D partners
- Provision of 'plug and play' space for companies that do not need to use the equipment in the BAPP facility

A key capability of the BAPP will be to develop and demonstrate scaled up, industrially relevant manufacturing processes, and to devise strategies for monitoring, design, evaluation, optimisation, and scale-up of these processes through the collection and analysis of valuable data.

The report identifies the important role the BAPP will play in skills and training in key technology areas, noting fermentation science and technology to be a clear industrial biotechnology skills gap that requires addressing. Focuses proposed include:

- Upskilling and reskilling of staff
- Collaboration with Forth Valley College – a budget for relevant biotech equipment
- Potential augmented or VR enabled skills development
- Industrial scale control systems skilling in a simulation centre would be required

### **Ownership, Management and Governance**

In considering the advisory structures of Grangemouth, the operation and management of the BAPP and CDU, will have significant implication on the success of the integration. The report proposes a triad of governance including a Steering Board (stakeholders involved in the BAPP development), Scientific Advisory Board (science and technology representatives i.e. academia) and the BAPP owner/operator (assumed the same organisation). This simple governance structure is designed to foster collaboration and streamline communication to best support technological advancements.

### **Risks and Potential Impacts**

The report highlighted central risks:

- Failure to secure an appropriate site
- Availability of funding
- Escalation costs
- Failure to secure an owner / operator
- Market demand

And potential impacts

- Address a gap in innovation infrastructure (targeted demonstration and scale up)
- Enable Scottish companies to demonstrate technologies at high TRL
- Provide a national focal point for high TRL industrial biotechnology
- Enhance and accelerate commercialisation of novel manufacturing technologies
- Contribute to the development of Grangemouth as a sustainable manufacturing centre
- Support industries to make the Just Transition to Net Zero
- Direct economic impact is calculated at £3.4 million with a further indirect and induced GVA of £5.9 million and Scottish project portfolio potential of £23.2 million
- Develop capabilities that position Grangemouth and Scotland in a leading position for sustainable chemicals, fuels and materials manufacturing capability
- Demonstrate a commitment to supporting the upskilling and reskilling of people, allowing them to exploit new job opportunities in the industrial biotechnology sector and downstream sectors including chemicals, consumer products, etc.
- Catalyse the development of new value chains in Scotland and across the UK

## Business Case for the Carbon Dioxide Utilisation Centre (CDU) – Optimat (2024)

### Key Findings and Insights

#### Strategic Case

The report sets out the vast array of potential uses of carbon dioxide as a raw material. The conversion of carbon dioxide can be completed through chemical process or biological. Scottish opportunities to exploit local assets are identified as:

- Synthetic fuels – benefitting from local renewable electricity and European market demand
- Carbon nanomaterials – applications in wind turbine and battery developments
- Gas fermentation – microalgae growth techniques for aquaculture capabilities

The report includes a list of Scottish and UK companies actively engaged in carbon dioxide utilisation, along with their targeted markets. This is complemented by extensive academic research conducted across Scottish universities, which spans various TRLs and end-use markets. The strategy is framed within the broader context of localised industrial decarbonisation requirements, Scotland's national net-zero strategy, and the UK Government's targeted approach to CCUS development, all aimed at achieving these critical objectives. The just transition of the Grangemouth industrial cluster highlights the potential for expansion opportunities through the utilisation of newly available sites following the closure of the refinery. In the case of carbon dioxide utilisation (CDU), the report acknowledges significant uncertainty regarding the actual size of the CCUS market, with several factors expected to shape its future trajectory. Key developers are identified alongside a summary of high-level market demand.

- Companies developing utilisation processes
- Technology developers
- Industrial emitters
- Chemical manufacturers and users
- European industrial innovation actors
- Academic development actors

This report points to the cost differential opportunity of developing SAF and the critical role the CDU could have in supporting associated technological development. PtL or e-fuels (electrolytic hydrogen and captured carbon) is expected to be the dominant SAF production method. Successful and innovative carbon dioxide utilisation is noted to require complex supply chains, spanning several sectors. The document identifies UK wide facilities involved in carbon utilisation but emphasises the unique high TRL and demonstration potential of the CDU.

#### Services Offered and Skills Training

Services offered are described to include:

- A flexible, technology agnostic, pilot plant
- Plug in and play system capable of delivering different emission compositions
- Long continuous process runs of at least 1,000 hours
- ATEX rated, connected with existing infrastructure (RCCS, SCCS, IDRIC, Forth Valley College)
- Partnerships with Scottish universities on a campus that demonstrates circularity

A variety of emission compositions are noted to be available at Grangemouth, with emitters providing technology testing streams to the CDU. The report indicates availability of biogenic carbon from the

BAPP and low carbon hydrogen to likely be sourced from the Grangemouth cluster. Several ancillary services are expected to be required for the CDU including process control, technical support, and health and safety.

### **Ownership, Management and Governance**

In considering the complex advisory structures of Grangemouth, the operation and management of the CDU and BAPP, will have significant implication on the success of the integration. The report proposes a triad of governance including a Steering Board (stakeholders involved in the CDU development), Scientific Advisory Board (science and technology representatives i.e. academia) and the CDU owner/operator (assumed the same organisation). This simple governance structure is designed to foster collaboration and streamline communication to best support technological advancements.

### **Risks and Potential Impacts**

The CDU case sets out income derived from member projects, plug-in and play projects, contract R&D, and collaborative R&D. It sets out key risks including:

- Failure to secure an appropriate site
- Availability of funding
- Escalation costs
- Failure to secure an owner / operator
- Market demand
- Time to operate CDU

Establishment of the Grangemouth Sustainable Manufacturing Campus (CDU and BAPP) is projected to have a series of direct impacts:

- Address the infrastructure gap of demonstration and scale up of technologies for utilisation and valorisation of carbon dioxide
- Support demonstration of high TRL technologies for UK / Scottish companies
- Provide a focal point for higher TRL CDU and IB, enhancing and accelerating commercialisation of novel manufacturing technologies
- Contribute to the development of Grangemouth as a sustainable manufacturing cluster
- Support the just transition to net zero

Direct economic impacts are suggested to amount £11.63 million with a further total indirect and induced GVA impact of £5.1 million. Calculations from the report suggest a potential Scottish project portfolio of over £17.6 million stemming from this project.

Further implications of the co-location of the CDU and BAPP will

- Place Grangemouth and Scotland in a leading position for sustainable chemicals and materials manufacturing capability with cross-fertilisation of ideas
- Demonstrate a commitment to supporting the upskilling and reskilling of people, allowing them to exploit new job opportunities in the sustainable manufacturing sector and downstream sectors including chemicals, consumers products, fuels, materials, etc.
- Catalyse the development of new value chains in Scotland and across the UK
- Provide high-skilled jobs for local people and bring highly skilled and educated, well-paid people into the local community

## Synthetic-Sustainable Aviation Fuel (SAF) Mapping – Optimat (2024)

### Key Findings and Insights

#### SAF as a Decarbonisation Pathway

The aviation sector, responsible for 3.5% of total anthropogenic warming, faces a global challenge in determining the most effective path to decarbonisation. Sustainable Aviation Fuel (SAF), when blended with Conventional Aviation Fuel (CAF) at up to 50%, represents the most viable near-term solution. However, the full adoption of pure SAF will require further regulatory changes and infrastructure enhancements. By 2050, SAF is projected to dominate long-haul aviation fuel, reducing CAF to less than 20% of aviation use. Central to this transition are technologies such as Power-to-Liquid (PtL), which utilise green hydrogen and captured carbon to produce sustainable fuels.

#### Global Demand and Supply Dynamics

In 2021, SAF production met just 0.01% of global jet fuel demand, projected to increase to 7.6% by 2030 (22.5 million tonnes). The cost of SAF remains 2–4 times higher than CAF, necessitating subsidies and market incentives to drive adoption. Global SAF policies are uneven, with the US and EU leading through substantial funding and mandates.

#### Technology and Investment Needs

Developing SAF technologies requires significant capital, a 500 kt/yr plant is estimated to cost £500 million–£1 billion. Scotland’s focus on PtL technologies aligns with global trends but lacks coordinated investment. Early-stage modular demonstrator plants are proposed to de-risk larger-scale operations and support a local supply chain.

<b>Strengths</b> <ul style="list-style-type: none"> <li>• Existing Petroineos refinery</li> <li>• Industrial expertise in SAF production</li> <li>• Early off-takers (Bristow and bp)</li> <li>• Existing oil &amp; gas and aerospace engineering expertise</li> <li>• Strong aviation sector</li> <li>• Net Zero policy</li> <li>• Academic expertise (CCU, H<sub>2</sub>, biorefining)</li> <li>• SATE (Orkney)</li> </ul>	<b>Weaknesses</b> <ul style="list-style-type: none"> <li>• Fragmented supply chain/ lack of interest in parts</li> <li>• Lack of understanding amongst stakeholders</li> <li>• No incentive to adopt</li> <li>• Lack of clear UK Gov policy – mandate, incentives and investment (for plants)</li> <li>• Mixed messages from Scot Gov on decarbonising aviation</li> <li>• Feedstock – lack of clarity as to what will be available for SAF compared with other processes</li> </ul>
<b>Opportunities</b> <ul style="list-style-type: none"> <li>• Not enough SAF to meet demand</li> <li>• Renewable energy</li> <li>• Green H<sub>2</sub> – certified SAF first, P2L later</li> <li>• CCUS &amp; DAC – but needs price reduction</li> <li>• Plans for CCUS and blue hydrogen at St Fergus</li> <li>• Demand from airports and end-users</li> <li>• Clear desire for local supply chain</li> <li>• Interest from SAF producers</li> <li>• Long-term need: 2050-70(+)</li> </ul>	<b>Threats</b> <ul style="list-style-type: none"> <li>• Competition from other sectors for feedstocks (H<sub>2</sub> &amp; carbon)</li> <li>• Others in Europe (&amp; UK) moving faster</li> <li>• SAF production and use is centralised (in UK)</li> <li>• H<sub>2</sub> produced in Scotland, used elsewhere in UK</li> <li>• Certification (fuels and use in different aircraft)</li> <li>• Initial focus on long-haul may disadvantage Scotland</li> </ul>

**Figure 6 – SAF SWOT Analysis (Optimat)**

## Implications for Grangemouth

### Leveraging Existing Assets

The Petroineos refinery at Grangemouth has the potential to explore SAF production, utilising expertise in refining and emerging PtL technologies. The cluster has strong links to the Acorn Project for CCUS capabilities and potential for hydrogen hub development. The geographic location of Grangemouth is of strategic benefit for developing e-fuels that can be exported globally from the international airports of Glasgow and Edinburgh, as well as the green freeport.

### SAF Plant Development

The report proposes the potential of establishing a modular SAF plant at Grangemouth that would capitalise on existing infrastructure and proximity to renewable energy sources. This would support piloting the technology at a relatively low cost. Demonstrator projects such as at Grangemouth could attract funding and de-risk larger investments. High energy and feedstock requirements would require readily available excess renewable energy and a consistent feedstock that is not under threat to be required for another decarbonising sector or food.

### Policy and Incentive Alignment

The report sets out that aviation is reserved to Westminster which limits the potential Scottish case. With no specific SAF mandate set to be in place until 2030 and no sign of CfD support from the UK Government, the price trajectory of SAF is unclear. Consumers will likely not adopt this fuel until a policy

change occurs. The 10% blend mandate by 2030 lags more advanced countries such as the USA and the Netherlands. There lacks a clear direction on availability and preference of feedstocks for economic incentives.

### **Economic Growth**

SAF production could create high-value jobs, diversify local economic activity, and secure Scotland's position in the global SAF market. The cost of a SAF plant is expensive (between £500m-£1b). The Power to Liquid potential of Grangemouth has lower CAPEX but higher OPEX due to energy demands. It would require localised development of carbon capture and hydrogen production as feedstocks (or alternate feedstocks of HEFA, waste to fuel).

## **Grangemouth Hydrogen Hub – Optimat (2024)**

### **Key Findings and Insights**

#### **Current Hydrogen Activities**

- Grangemouth currently produces grey hydrogen (from fossil fuels without carbon capture) as a byproduct in polymer and olefin production, which is used in refining processes. Transitioning to blue hydrogen (from methane with carbon capture) or green hydrogen (from renewable electricity via electrolysis) could significantly reduce emissions
- Ongoing Projects: The INEOS Low Carbon Hydrogen Manufacturing Plant is a key planned project, integrating carbon capture technology to produce low-emission hydrogen. This project is dependent on infrastructure advancements such as the Acorn CCS project, which would store carbon emissions offshore in the North Sea
- April 2022: UK Gov announced a £240m Net zero Hydrogen Fund, with multiple other potential sources of public and private funding (CCUS Track-1/2, Electrolytic Hydrogen Allocation Rounds, Energy Entrepreneurs Fund, Industrial Decarbonisation Challenge Fund, Scotland Emerging Energy Technology Fund, Clean Growth Fund, Venture Capital, HydrogenOne Capital Growth, HyCap, Hydrogen Ventures)

#### **Mapped against Industrial Cluster Hydrogen Projects**

- HyVelocity is a cluster managed by GTI Energy on the Gulf Coast that has 48 hydrogen production plants, over 1,000 miles of pipeline, 51GW renewable energy capacity, 2.4 billion tonnes CO2 storage capacity in three hydrogen storage caverns. Funding mandate set in law to support confidence from industry.
- HYNNet North West (UK) plans encompass the entire infrastructure for blue hydrogen with plans to support green hydrogen development as renewables capacity grows.
- HEAVENN (Netherlands) hydrogen valley project includes a range of businesses and value chain aspects involved (funding up to 2.8bn EUR)

### **Key Challenges**

#### **Infrastructure Needs:**

- Significant gaps exist in hydrogen transportation, storage, and renewable energy integration.

- Insufficient grid capacity and reliance on tube trailers or dedicated pipelines for hydrogen transport pose immediate challenges.
- Seasonal variability in renewable energy availability necessitates robust storage solutions, while natural gas remains a backup energy source.

#### Policy and Funding Gaps:

- National policies, such as the Scottish Hydrogen Action Plan, outline a vision but lack consistent implementation of supporting infrastructure and funding mechanisms.
- The industry needs clearer guidelines on hydrogen production incentives and deployment priorities.
- For effective benchmarking—whether in hydrogen, CCUS, or other areas—Grangemouth's strategy must align with the development of these supply chains.
  - The existing UK hydrogen strategy is fragmented, with a preference for technologically mature projects to mitigate risks for fuel offtakers.
- Enhanced funding mechanisms are essential, as significant uncertainty persists, requiring a robust market incentive to establish a compelling commercial case.

#### Production and Sourcing Challenges:

- Consistent clean energy supply and associated infrastructure for hydrogen production remain critical challenges.
- There is potential for hydrogen production to be concentrated in the Northeast, leveraging offshore wind farms, with hydrogen transported to other regions.

#### Opportunities for Grangemouth

- **Local Decarbonisation:** Hydrogen can displace natural gas in industrial heating and heavy transport. This transition aligns with Scotland's broader goals to decarbonise logistics and establish alternative fuel market. There is opportunity alongside hydrogen to break into SAF.
- **Export Potential:** Grangemouth's strategic location near Forth Ports positions it as a potential hydrogen exporter to European markets. However, achieving this requires significant infrastructure investment and alignment with international hydrogen standards. Alternatively, Grangemouth could become a net importer and hydrogen management/distribution hub.

- **Skills:** Scotland has a strong knowledge and skills base in engineering and process industries built on the legacy of oil and gas and renewables. Skills augmentation into hydrogen should not require a significant shift if adequate support is provided such as the National Energy Skills Accelerator and an Energy Skills Passport that develops transferable skills.

Company	Primary operations	Consumer	Producer	Logistics	Notes
Celtic Renewables	Biorefinery				
Alexander Dennis	Bus manufacturing				Involved in the hydrogen activities as a manufacturer of hydrogen fuel cell buses.
INEOS	Chemicals				Announced Low Carbon Hydrogen Manufacturing plant in 2022. The timeline is under revision.
Versalis	Chemicals				Versalis to close chemical plant by April 2024.
Calchem	Chemicals				Announced the closure of the manufacturing arm in 2021.
Mossmorran NGL Plant	Chemicals				Primary interest in self-supply.
Fife Ethylene Plant	Chemicals				Primary interest in self-supply
Syngenta	Chemicals				
Piramal Healthcare	Chemicals (pharma manufacturing)				
BOC Gases	Gas distribution				Virtual pipeline
Avanti Gas Road Loading terminal	Gas distribution				
Polymer Logistics Scotland	Haulage				An opportunity to decarbonise the fleet by moving to hydrogen-powered machinery. Could become involved in hydrogen transportation via tube trailers
HWCoates	Haulage				
Malcom Logistics	Haulage				
John Mitchel	Haulage and warehousing				
Falkirk Council	Heavy fleet managers (local authority)				
Hewden	Lease of machinery				
Forth Ports	Logistics				Import and export markets.
Petroineos	Refinery				Announced the Refinery Transition Project to explore moving to primary operations as import/export site
International Timber	Timber import and distribution				
Size of opportunity			High		
			Medium		
			Low		

**Figure 7 - Grangemouth industrial cluster companies and their potential activities in the emerging hydrogen cluster (Optimat views only) (may be outdated with businesses leaving)**

## Vision

By 2045, Grangemouth aims to become a net-zero industrial hub, integrating hydrogen production, carbon capture, and storage technologies. The hub could serve domestic industries, facilitate heavy transport decarbonisation, and contribute to sustainable aviation fuels. This vision depends on strong public-private collaboration and accelerated investment in supporting infrastructure. Integration of hydrogen into Grangemouth and Scotland more broadly will require an interconnected approach from policy, businesses, skills development and community engagement.

## Hydrogen Demand in Scotland: A Mapping of Industrial and Transport Applications - Element Energy (2023)

### Key Findings and Insights

#### Hydrogen as a Decarbonisation Tool

- Hydrogen is recognised as essential for Scotland's net-zero targets, providing a potential replacement for natural gas in high-temperature industrial processes, notably in the oil and gas refining and chemicals sectors, both of which are prominent at Grangemouth. These sectors account for roughly 60% of the assessed potential hydrogen demand in Scotland

#### Grangemouth's Role as a Regional Hydrogen Hub

- Grangemouth is highlighted as one of Scotland's potential thirteen regional hydrogen hubs. As a major industrial centre, it is positioned to lead in hydrogen production, distribution, and use, especially in sectors that require high-temperature heating. The development of a local hydrogen value chain, connecting production to end-use applications, can significantly enhance Grangemouth's economic resilience and environmental impact.

#### Barriers and Opportunities

- **Barriers:** Hydrogen use faces several challenges, such as the current lack of infrastructure, high costs, and the need for technological advancements in hydrogen-compatible industrial appliances. There are also concerns about hydrogen's secure supply and safety, given its high flammability and storage requirements.
- **Opportunities:** Hydrogen offers potential economic benefits through job creation, investment, and export opportunities. Additionally, Grangemouth could leverage its existing infrastructure, including pipelines and energy production facilities, repurposing for hydrogen, reducing disruption compared to other low-carbon options.

#### Sector-Specific Insights for Grangemouth

- **Oil and Gas Refining:** The Petroineos refinery at Grangemouth, one of Scotland's highest-emitting sites, has a strong potential for hydrogen integration. It already uses hydrogen in certain refining processes but could expand its role by switching to blue or green hydrogen, depending on advancements in carbon capture and storage (CCUS) technology. It is noted that this report was written before the announcement was made by Petroineos of its intention to close the Grangemouth refinery.
- **Chemicals and Pharmaceuticals:** Grangemouth's chemical sector, including INEOS, shows high feasibility for hydrogen adoption, particularly in indirect heating processes where hydrogen can substitute natural gas. This fuel switching will support the high temperatures required for chemical production where electrification is insufficient.

#### Long-Term Potential and Economic Implications

- Grangemouth's hydrogen transition aligns with Scotland's long-term climate goals and could position the region as a leader in sustainable industrial transformation. By 2045, industrial hydrogen demand across Scotland could reach between 12.3-21.3 TWh annually, underscoring the potential for substantial hydrogen production and distribution networks centred around hubs like Grangemouth

## Scottish Net Zero Roadmap (SNZR) – NECCUS (2023)

### Key Findings and Insights

#### Technological and Infrastructure Solutions

- **CCUS:** The roadmap emphasises post-combustion carbon capture as a cornerstone technology for large emitters like Grangemouth. Amine-based solvents and calcium looping are proposed for capturing CO<sub>2</sub> from low-concentration sources.
- **Hydrogen:** A mix of blue (from methane with CCS) and green hydrogen (via electrolysis) is envisioned, with Grangemouth identified as a prime site for hydrogen production due to its existing industrial infrastructure.
- **Biomass and Negative Emissions:** Technologies such as BECCS (bioenergy with carbon capture) and direct air capture (DACCS) provide potential routes to theoretically net negative emissions.

#### Investment and Economic Impact

SNZR will require an estimated capital investment of £6–9 billion, covering CCUS infrastructure, hydrogen production, and electrification. Economic benefits include supporting 5,000 jobs annually from 2023–2045 and contributing an estimated £21 billion to Scotland’s economy over the period.

#### Pathway Scenarios

Six potential scenarios for decarbonisation are modelled, with the Infrastructure-Led Pathway identified as optimal. This pathway prioritises early adoption of CCUS through the Acorn Project in North-East Scotland. A decarbonisation of the Grangemouth sub-cluster will be a critical component of this pathway. Development of hydrogen infrastructure and CO<sub>2</sub> pipelines linking Grangemouth with regional storage will connect Grangemouth to the Acorn project through the repurposing of the existing Feeder pipeline.

#### Challenges and Risks

Dependencies on external infrastructure for CO<sub>2</sub> transport and hydrogen supply pose timing and investment risks. High costs of deploying technologies and a lack of cohesive policy incentives could hinder progress. Policies and incentives will be required to be inclusive across devolved and UK-wide systems to encourage collaborative development.

#### Implications for Grangemouth

1. **Leadership Role:** Grangemouth’s refining and chemicals sector, contributing 4% of Scotland’s GDP, will be pivotal in catalysing industrial decarbonisation. Investment in hydrogen production and CCUS infrastructure could position the cluster as a leader in low-carbon innovation.
2. **Investment Opportunities:** Grangemouth stands to benefit from £1–3 billion in hydrogen and CCUS-related projects. Public-private partnerships and green finance mechanisms (e.g. bonds) will be crucial to securing this investment.
3. **Workforce Transition:** Grangemouth’s workforce requires targeted reskilling programs for roles in hydrogen, carbon capture, and bio-manufacturing to safeguard jobs and maintain regional economic stability.

## **Appendix B – Key Observations from Reporting on More General Cluster, Technology and Market Development Activities**

### **Economic Contribution of the Grangemouth Refinery– Scottish Government and PwC (2024)**

#### **Summary of Key Findings and Insights**

The report commissioned by the Scottish Government highlights the significant economic contribution of the Grangemouth Refinery, which provided £403.6 million in Gross Value Added (GVA) in 2023, representing 0.19% of Scotland's economy. The refinery directly supports 532 jobs and contributes to 2,822 jobs across Scotland through its supply chain. Its primary expenditures are in refining, manufacturing, and energy sectors. While the refinery supports skilled labour in a region with high income deprivation, its specialised roles require targeted retraining for future transitions. Achieving a just transition will require coordinated investment and support from both UK and Scottish governments.

### **The Economic Opportunities in Scotland's Net Zero and Climate Adaptation Economy– Climate Exchange (2024)**

#### **Summary of Key Findings and Insights**

The report assesses Scotland's ability to transition to a low-carbon economy, identifying opportunities in hydrogen, carbon capture and storage (CCS), and low-carbon fuels (LCFs) as critical to achieving net-zero goals. Scotland benefits from a skilled workforce, advanced infrastructure, and natural resources like wind energy, but faces challenges such as policy misalignment, an ageing workforce, and infrastructure gaps. It emphasises the policy challenges of reserved/devolved Government powers. With the majority of energy markets reserved to the UK Government, there remains a barrier to the Scottish Government developing independent policy and regulation that supports the significant opportunities Scotland has. This inhibits funding and maintains prominent levels of risk for the development of hydrogen, CCUS and SAF. The report highlights the need for increased STEM-skilled workers, strategic partnerships with educational institutions, and private sector investment. Recommendations include expanding hydrogen and CCS infrastructure, establishing retraining programmes, and addressing regulatory and financial barriers to support long-term decarbonisation.

### **Enabling Net Zero: A plan for UK Industrial Cluster Decarbonisation – UKRI (2023)**

#### **Summary of Key Findings and Insights**

The report focuses on the development of carbon capture and storage (CCS) and low-carbon hydrogen in the UK, with a particular emphasis on the Scottish Cluster (SNZR) and its relevance to Grangemouth. The UK Government aims to establish four low-carbon clusters by 2030, with a net-zero cluster by 2040. Key challenges include gaps in STEM skills, funding barriers, and fragmented infrastructure, though there are opportunities for collaboration between industry, government, and academic institutions. Insights from UK clusters suggest the value in establishing a unified governance framework for Grangemouth, reskilling the workforce, pursuing diverse funding mechanisms, and developing shared infrastructure for hydrogen and CCS to drive decarbonisation and economic growth.

## **Supporting the Transition to Jet Zero: Creating the UK SAF Mandate - Department for Transport (2024)**

### **Summary of Key Findings and Insights**

The report outlines the UK's current Sustainable Aviation Fuel (SAF) Mandate, which aims to incorporate 10% SAF in aviation fuel by 2030 and 22% by 2040. The mandate introduces tradeable certificates, caps on certain technologies, and buy-out price mechanisms for investor certainty. SAF is seen as a key solution for decarbonising aviation and promoting industrial growth. Grangemouth, with its petrochemical infrastructure and proximity to renewable energy sources, is well-positioned for SAF production. The SAF sector could create 60,000 jobs and contribute £10 billion in GVA by 2050. SAF offers significant GHG emissions reductions and aligns with Scotland's climate goals. Recommendations include accelerating Power-to-Liquid (PtL) development, advocating for supportive policies, and fostering community engagement and workforce integration which can be achieved Grangemouth.

## **Net Zero North West: Northwest Cluster Plan – UKRI (2023)**

### **Summary of Key Findings and Insights**

The Net Zero Northwest cluster plan outlines strategies for decarbonising industrial activity, focusing on hydrogen and CCUS infrastructure. The HyNet project in the North West is a key example, with hydrogen production and CO<sub>2</sub> storage forming a scalable, integrated system. The region aims to generate £30 billion in near-term investments and create up to 660,000 green jobs in the long term. Similar opportunities exist for Grangemouth, which could benefit from integrated hydrogen and CCS infrastructure, leveraging renewable energy sources and CO<sub>2</sub> storage potential. The report highlights the importance of workforce reskilling, community involvement, and adopting a unified cross-sector collaborative governance structure. The themes of the report generally align with the future propositions for Grangemouth and provide a suitable reference.

## **Future Delivery of the North West Net Zero Cluster Plan – Opergy Group (2024)**

### **Summary of Key Findings and Insights**

The North West Net Zero Industrial Cluster report outlines strategies for advancing industrial decarbonisation through strong governance, skills development, and diversified funding sources. It recommends a Limited by Guarantee (LBG) where members pay a nominal amount to support the governance model. This promotes inclusivity and collaboration among stakeholders, which could be adopted for Grangemouth to align public and private efforts. The report highlights the need for skills programs focused on hydrogen, CCS, and bio-manufacturing, which should be implemented in partnership with local institutions. A hybrid funding model blending public, private, and green bonds is suggested, which could support Grangemouth's hydrogen and CCS projects. Key differences between the North West and Grangemouth include leadership models, economic roles (broad industrial vs refining & chemicals), and associated workforce transition needs. The report focuses on aligning governance and funding approaches, upskilling the workforce, and developing tailored investment strategies.

## **Humber Industrial Cluster Plan – UKRI (2023)**

### **Summary of Key Findings and Insights**

The Humber Industrial Cluster Plan outlines an ambitious decarbonisation strategy leveraging its industrial base, CO<sub>2</sub> storage capacity, and hydrogen infrastructure. The region benefits from extensive CCS projects, such as Zero Carbon Humber and Viking CCS, and has advanced hydrogen production and storage capabilities. With £7–10 billion in projected investments and significant job creation, Humber aims to abate up to 28 MtCO<sub>2</sub>/year and achieve net-negative emissions by 2040. Grangemouth, with similar access to North Sea CO<sub>2</sub> storage, could learn from Humber's integrated technology approach and focus on hydrogen hubs and CCS. Humber's emphasis on circular economy initiatives, workforce engagement, and governance frameworks could also serve as models for Grangemouth to enhance its sustainability efforts, stakeholder coordination, and community involvement.

## **Delivering the Vision: The Humber Roadmap for Industrial Decarbonisation – Humber Energy Board (2024)**

### **Summary of Key Findings and Insights**

The Humber Roadmap for Industrial Decarbonisation outlines a comprehensive plan to integrate hydrogen production, carbon capture, and offshore wind, with key infrastructure like the Viking CCS pipeline and the Humber Hydrogen Hub. These initiatives aim to store 15 MtCO<sub>2</sub> annually by 2035, supporting regional decarbonisation and the UK's net-zero goals. The cluster seeks £15 billion in private investment, which would create over 20,000 jobs and bolster economic resilience. Sustainability efforts focus on reducing 80% of regional CO<sub>2</sub> emissions through CCUS and renewable hydrogen projects. The Humber Energy Skills Academy addresses the workforce transition, investing in green skills development and partnering with local education providers. Governance in Humber is coordinated by the Humber Energy Board, which brings together stakeholders to align policies and investments. The cluster also plans large-scale technological deployments, such as BECCS at Drax and advanced hydrogen storage at Aldbrough, to enhance its decarbonisation efforts.

## **Tees Valley Net Zero – BP and NEPIC (2023)**

### **Summary of Key Findings and Insights**

The Tees Valley Industrial Decarbonisation Plan focuses on hydrogen production and CCUS, leveraging its deepwater port for international shipping. Key projects like the Net Zero Teesside Power Project, which aims to operate the first gas-fired power plant with carbon capture at scale, highlight the cluster's leadership in low-carbon technologies. The Northern Endurance Partnership's advanced CO<sub>2</sub> pipeline network enhances Tees Valley's decarbonisation capacity, positioning it for transformative economic growth, with £30 billion in expected investments and significant job creation through hydrogen hubs, waste-to-energy, and biofuel initiatives. Tees Valley's sustainability efforts are aimed at abating 4.9 MtCO<sub>2</sub> annually, with a strong focus on circular economy practices like plastics-to-fuel conversion. The Net Zero Skills Charter, focusing on reskilling displaced workers for green technologies, ensures a just transition, supported by public-private partnerships. Governance is coordinated by the Tees Valley Combined Authority, fostering collaboration among industrial leaders and a Net Zero Leadership Group to drive sustainable change. Future developments include hydrogen exports and scaling CO<sub>2</sub> storage capacity, aiming for 10 MtCO<sub>2</sub> annually. This approach to decarbonisation positions Tees Valley as a global leader in green technologies with a similar trunk approach to CCS technologies as Grangemouth.

## A Plan for Clean Growth: South Wales Industrial Cluster Plan – UKRI (2023)

### Summary of Key Findings and Insights

The SWIC focuses on integrating renewable hydrogen production, CCUS, and offshore wind infrastructure, supported by CO<sub>2</sub> transport through HyLine Cymru pipelines or shipping. This model aligns hydrogen production with national energy needs and supports industrial decarbonisation. SWIC's decarbonisation plans aim to attract investments of £30–40 billion, creating 113,000 jobs and fostering regional regeneration through Clean Growth Hubs. SWIC's target for net-zero emissions by 2040 includes reducing carbon emissions by 40%, aided by renewable hydrogen, CCUS, and large-scale wind energy adoption. BECCS and DACCS technologies are key to achieving negative emissions. Skills development is central to a just transition, with targeted training initiatives for workers in traditional industries, ensuring green sectors are supported. Net Zero Industry Wales (NZIW) leads governance efforts, aligning policies and driving investment, while fostering collaboration between government, industry, and communities. SWIC's innovations include floating offshore wind and sustainable aviation fuel (SAF) production, expanding its decarbonisation pathways. In comparison, Grangemouth could replicate elements of this approach, such as integrating hydrogen and CCUS with the Acorn CCS project, developing a regional skills hub, and establishing a Net Zero Industrial Board to align with national decarbonisation goals. Integrating SAF production and leveraging local expertise would position Grangemouth as a leader in decarbonisation in Scotland.

## Repowering the Black Country – UKRI (2023)

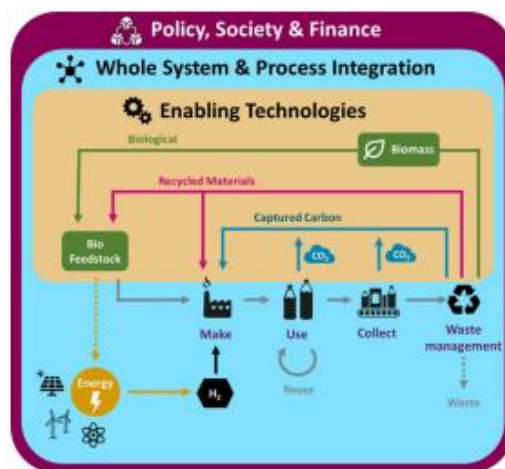
### Summary of Key Findings and Insights

The **Repowering the Black Country** initiative promotes clean economic growth in Wolverhampton, Walsall, Sandwell, and Dudley, home to over 3,000 energy-intensive manufacturing businesses. It includes tailored investment funds managed through spatial and energy planning with local authorities. A core aspect is the region's circular economy strategy, focusing on reducing resource use, reusing materials, and minimizing waste. This is supported by energy consumption and waste stream analysis, creating targeted funding mechanisms. Additionally, energy strategies are integrated with residential areas, providing local benefits like energy sharing and sustainability initiatives. The roadmap includes reconfiguring supply chains to create circular economies, improving resource use in firms, aligning with national decarbonisation scenarios, and developing zero-carbon power hubs for energy-efficient industrial heating and resource-sharing. Grangemouth could consider similar models, like regional supply chain initiatives and district energy hubs, to strengthen its decarbonisation infrastructure. The report also highlights the importance of considering industry beyond the direct geographical cluster parameters.

## Carbon & Cash: Funding a Circular Chemical Economy – UKRI (2024)

### Summary of Key Findings and Insights

This whitepaper discusses the need for a circular chemical economy and highlights key findings from policy workshops with stakeholders in academia, industry, and special interest groups. The report advocates for a systems approach to reduce waste, maintain product/material use, and regenerate natural systems, with estimates suggesting that a circular economy could create 500,000 jobs by 2030. The chemical sector, a vital part of the UK's £61 billion industrial exports, is integral to this transition, yet it relies heavily on fossil fuels for feedstocks like ethylene and propylene. The UK faces challenges in funding and scaling circular technologies due to high capital expenditure and misaligned government priorities across departments and Scottish/UK Governments. The report recommends supporting industrial clusters focused on waste utilisation, creating public research institutions with industry-academia collaboration, and redesigning carbon pricing and policies to incentivise circularity, with a particular focus on CCU. This strategy aims to overcome barriers to circularity in the chemical sector by promoting technological innovation, de-risking investments, and fostering sustainable carbon sourcing.



**Figure 8 - A Circular Chemicals Approach (UKRI)**

## Transforming Industry: Strategic Policy Insights for Scotland's Industrial Decarbonisation IDRIC Policy Synthesis Report for Scotland– IDRIC (2024)

### Summary of Key Findings and Insights

This analysis underscores Grangemouth's potential to play a leading role in Scotland's industrial decarbonisation, leveraging its existing infrastructure to drive advancements in hydrogen production, CCS, and sustainable manufacturing. Scotland is strategically positioned to lead in hydrogen, with the potential to develop hydrogen pipelines and storage for both domestic and export markets. The Acorn CCS project presents an opportunity for Grangemouth to anchor Scotland's CO<sub>2</sub> capture network, benefiting from collaboration with neighbouring industrial sites. Circular economy initiatives such as waste-to-fuel projects could complement these efforts, enhancing resource efficiency. Challenges related to workforce displacement and skills shortages, particularly in emerging technologies like hydrogen and CCS, call for regional training hubs to support workforce transitions. Streamlined planning and permitting processes are crucial for accelerating infrastructure deployment, with targeted financial incentives like Contracts for Difference (CfDs) helping de-risk investments. Economic estimates suggest industrial decarbonisation could contribute £25-30 billion to Scotland's economy by 2045, underscoring the importance of developing shared infrastructure, such as CO<sub>2</sub> transport and hydrogen pipelines, to ensure Grangemouth's role in the decarbonisation ecosystem. Recommendations include prioritising investments in hydrogen, accelerating participation in CCS projects, fostering workforce transitions, and advocating for aligned policies and financial mechanisms.

## **Exploring the impacts of the Adopted Carbon Capture Approach to the Scottish Chemical Industry and the Wider Scottish Economy– IDRIC (2024)**

### **Summary of Key Findings and Insights**

This report evaluates the economic, competitiveness, and policy implications of deploying pre- and post-combustion carbon capture technologies in Scotland's industrial sectors, with a focus on chemicals. Post-combustion CCS is less capital-intensive but has higher operational costs, increasing petrochemical product prices. Pre-combustion CCS is more capital-intensive, offers lower operational costs but also increases product prices. Grangemouth, as a major chemical hub, could use a mix of CCS technologies and collaborate with the Acorn CCS Project to reduce costs and share infrastructure. Implementing CCS could raise chemical production costs, impacting downstream industries like plastics and pharmaceuticals. This could lead to output reductions and job losses in the sector, with wider economic impacts on GDP and employment. As a significant industrial hub, Grangemouth's decarbonisation could affect Scotland's economy, making regional collaboration important for managing these challenges. Coordinated CCS adoption across the UK and Scotland could limit Scotland's GDP losses and prevent carbon leakage, helping Grangemouth retain competitiveness in export markets. Targeted subsidies could alleviate the financial burden of CCS adoption. Additionally, pre-combustion CCS is well-suited for blue hydrogen production, offering an opportunity to integrate hydrogen into Grangemouth's operations, contributing to Scotland's potential hydrogen economy. Key insights relevant to Grangemouth include integrating with the Acorn CCS Project, supporting UK-wide CCS policies, accelerating blue hydrogen production, and advocating for financial subsidies to ensure competitiveness. This report emphasises the importance of collaboration and strategic investment to overcome the challenges of CCS adoption and strengthen Grangemouth's role in Scotland's industrial decarbonisation.

## **Beyond the Factory: Ten interdisciplinary Lessons for industrial Decarbonisation Practice and Policy - IDRIC (2024)**

### **Summary of Key Findings and Insights**

The IDRIC report outlines 10 interdisciplinary lessons for industrial decarbonisation, emphasising spatial phenomena, governance, and community engagement. It identifies hydrogen, CCUS, and circular economy strategies as key to achieving net-zero, with no single solution fitting all contexts. Grangemouth's refining and chemical infrastructure is well-placed to adopt hydrogen and CCUS technologies, while emerging industrial streams like waste-to-energy can complement existing efforts. Industrial decarbonisation offers co-benefits, including job creation, community resilience, and trade advantages. Investing in decarbonisation can drive economic growth and support a just transition for the workforce. The national gap in green skills requires regional training hubs to prepare the workforce for new industrial processes. For Grangemouth this requires partnering with education providers like Falkirk College to address workforce gaps. Strong collaboration across sectors and policy innovation are vital for net-zero progress, and aligning policies between Scottish and UK governments will accelerate CCS and hydrogen project development at Grangemouth. Alternatively, a Scottish policy could backed by the UK Government could support the significant national opportunities. The report also highlights the need for equitable policy frameworks that address regional inequalities and ensure inclusive decarbonisation processes. Engaging Grangemouth's community in decarbonisation plans can build public trust and local support. Key insights for Grangemouth application include scaling hydrogen production, embedding in the Acorn CCS network, developing local training hubs, and fostering

transparent dialogue with residents. This report emphasises Grangemouth's potential to lead Scotland's industrial decarbonisation efforts through collaboration, innovation, and community engagement.



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