Decarbonising industry through industrial clusters: lessons from international experience

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Introduction

This briefing presents the key findings of a rapid evidence assessment on international experiences in industrial cluster decarbonisation. It is based on a review of the available technical, policy and grey literature on the development of low carbon industrial clusters internationally. The focus is on the enabling conditions for cluster decarbonisation: the surrounding socio-economic context, the configuration of sectors and technologies, the choice of policy and business models, and the governance structures which characterise front-runner industrial cluster decarbonisation initiatives.

Overview

Industrial decarbonisation

Energy intensive industry is a significant contributor to greenhouse gas emissions, producing over a quarter of the global total (IEA, 2021). The sector incorporates numerous industries and activities, including the manufacture and production of metals and minerals, chemicals, food and drink, paper and pulp, ceramics and glass. What unites these different groups is the relatively high carbon intensity of their processes. Emissions stem from two main sources: combustion emissions, often emitted during the generation of high-temperature process heat, and process emissions, released as a by-product of the manufacturing process.

A number of different options are available to decarbonise industry, but they are at different levels of technology readiness, and the best choices depend on the sector in question and the available infrastructure. Material and energy efficiency measures can reduce the demand for energy inputs, whilst low carbon electricity and hydrogen can replace fossil fuels in many cases. Finally any residual combustion emissions and those from the production process can be substantially removed by carbon capture, use and storage (Bataille et al., 2018).

Industrial Clusters

Energy intensive industry often collocates in particular places with good access to supply chains and supporting infrastructure. In the UK, industry generates 16% of national greenhouse gas emissions and over half of these originate from six industrial clusters located around the coast (HM Government, 2021). The decarbonisation of industrial clusters is of critical importance to the UK's ambitions of cutting greenhouse gas emissions to net zero by 2050.

Initiatives are also underway elsewhere. Governments across the EU, North America and Australasia are providing funding for demonstration projects to reduce carbon emissions from energy intensive industrial clusters.

Despite these promising developments, the decarbonisation of energy intensive industry faces a number of barriers. These include not only the immature status of some key technologies, but also a lack of clarity around business models and funding, and the need for harmonised policy and standards. As work on industrial decarbonisation moves from feasibility into implementation, understanding the factors that have contributed to the success of existing cluster decarbonisation initiatives offers lessons on the challenges and opportunities for other industrial areas seeking to reduce emissions.

Findings

Context is key

Industrial clusters are all unique, evolving in response to local conditions - often over a period of decades. However the clusters emerging as front-runners in industrial decarbonisation share certain key elements which are difficult for other places to replicate.

- **Proximity to large quantities of renewable energy**. Low carbon electricity will be necessary to enable direct electrification, indirect electrification using green hydrogen, and to support blue hydrogen and carbon capture and storage (e.g., for separation processes and compression). Clusters with access to large scale solar and wind-generated electricity possess a significant advantage.
- **Proximity to sinks.** These can be geological storage sites for carbon capture and storage or opportunities for sharing heat with nearby industrial or domestic facilities. In either case, proximity reduces transport costs.
- **Proximity to ports**. Ports provide a natural focus point for energy intensive industry, which often locate in their vicinity. They often have existing hydrogen production and storage for refineries. They act as logistical hubs for flows of industrial materials and wastes, providing opportunities for circular economy initiatives, and access to a future global hydrogen supply chain.

Cluster organisations must lead their members but also engage their stakeholders

Industrial decarbonisation infrastructure, such as shared transport and storage facilities for carbon capture and storage and hydrogen pipelines, are expensive. Demonstration projects require government financial support. This means cluster organisations need to be able to operate and influence across administrative boundaries and between governance scales if they are to obtain funding.

- Strong cluster leadership is a key element of success, but there is no ideal form of cluster governance. Configurations and membership vary according to country, technology field, local context, age of the cluster and cluster focus.
- For long-term projects, such as those involving carbon capture and storage, consistency of governance arrangements appears more important than the specifics of their configuration.

Strong networks support innovation but too strong a technology focus may obscure the importance of these linkages

Strong networks and linkages between cluster members and to supporting regional institutions support tacit knowledge exchange and the development of innovative approaches. The industrial clusters leading on decarbonisation often have these networks in place. Not all industrial clusters can be assumed to have similar capacity.

Policy and business models for hydrogen and carbon capture and storage are policy and business models for industrial cluster decarbonisation, and vice versa

Current industrial cluster decarbonisation initiatives focus on the deployment of carbon capture and storage, with hydrogen posited as a future secondary revenue stream to support commercial operation. This model of decarbonisation privileges investment into large coastal clusters with access to low carbon electricity.

- Cluster initiatives prioritising deployment of electrification and material and energy efficiency measures are less well established , but these interventions have the potential to deliver decarbonisation in places where carbon capture and storage is not economically viable.
- Synergistic CCUS, hydrogen, electrification and district waste heat reuse cluster initiatives (e.g., small and medium industry using steam methane reformation and CCUS waste heat to make steam using heat pumps) to maximise the input and output value chain and business proposition are possible, but these possibilities are little discussed and planned for within the literature reviewed.

When it comes to initiating action on carbon capture and storage, the amount of carbon dioxide emitted appears to be more important than the sectors involved

Not all industrial sectors are equally suitable for carbon capture and storage but at the initiation stage the presence of a high-emitting industrial source to appears more important to kick-starting work than the presence of a particular sector.

- Integration of different sectors into a joint carbon capture transportation and storage system will present a key challenge and may influence where it is possible to install carbon capture and storage. As yet, cluster decarbonisation initiatives have not had to address this issue.

Implications

- Technology choice is shaping which clusters are emerging as front-runners in industrial decarbonisation. It is not clear how transferrable their experiences will be to clusters that don't have their geographical advantages and institutional capacity
- The focus on carbon capture and hydrogen tends to obscure questions about the integration of these technologies with other decarbonisation interventions, e.g. material efficiency & electrification. Further attention is needed to understand how electrification and material and energy efficiency could deliver cluster decarbonisation
- A technology focus tends to ignore the local and regional social, historical and political factors which are important elements of cluster success, particularly in the area of innovation. The front-runner clusters may already possess these attributes, but future policy for cluster decarbonisation will need to consider how to build capacity in these areas, in addition to technical skills.
- Clusters evolve. This means the management of industrial decarbonisation will be an ongoing process, and must be designed to be flexible and robust to unanticipated changes from the start. Policy-makers and clusters organisations will need to ensure that decarbonisation technologies and clusters evolve in concert so that one does not become a barrier to the other.

About the project

The *learning from international experience in decarbonising industrial clusters* project aims to identify and disseminate lessons and best practice from the international experience of clyster decarbonisation. It forms part of the work of the UK Industrial Decarbonisation Research and Innovation Centre (IDRIC), a £20 million programme of work supported by UKRI which aims to deliver research taking a whole systems approach to accelerating industrial decarbonisation.

The findings in this document are drawn from a rapid evidence assessment of 124 documents on international experiences of industrial cluster decarbonisation.

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References

BATAILLE, C., ÅHMAN, M., NEUHOFF, K., NILSSON, L. J., FISCHEDICK, M., LECHTENBÖHMER, S., SOLANO-RODRIQUEZ, B., DENIS-RYAN, A., STIEBERT, S., WAISMAN, H., SARTOR, O. & RAHBAR, S. 2018. A review of technology and policy deep decarbonization pathway options for making energy-intensive industry production consistent with the Paris Agreement. *Journal of Cleaner Production,* 187**,** 960-973.

HM GOVERNMENT. 2021. *Industrial Decarbonisation Strategy* [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/970149/6.7279_BEIS_CP399_Industrial_Decarbonisation_Strategy_FINAL_PRINT_FULL_NO_BLEED.pdf [Accessed 11 August 2022].

IEA. 2021. *Tracking Industry 2021* [Online]. Paris. Available: https://www.iea.org/reports/tracking-industry-2021 [Accessed 1 December 2021].