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Imagining a net-zero Teesside: actors, networks, and expectations in industrial decarbonisation megaprojects

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Abstract

Decarbonising industrial clusters is critical to achieving the UK's net-zero industrial strategy. This study focuses on Teesside, an industrial cluster in Northeast England, analysing its transition through the framework of the Sociology of Expectations (SoE). The research investigates the role of public and private stakeholders in driving decarbonisation efforts, concentrating on a limited set of technologies and large-scale megaprojects, especially carbon capture, hydrogen production, CO_2 and hydrogen transport. The study highlights the challenges of deploying these first-of-a-kind technologies, which are not yet commercially viable in the UK. Our analysis identifies both opportunities and significant risks in Teesside's approach, particularly the potential over-reliance on a narrow range of technologies. The findings raise concerns about the assumed reductions in costs and carbon emissions, questioning the feasibility of scaling these technologies for long-term industrial sustainability. The main implication is that, should the technologies currently favoured by incumbent industry fail to perform, the expectations could play a double and contradictory role in net-zero transitions—by both motivating actors to legitimise decarbonisation technologies, yet blinding others to the significant challenges that lie ahead.

1. Introduction

Industrial regions in the United Kingdom (UK) are important for the national and local economy, employing 1.5 million people across steel, oil refining, chemical, and other energy-intensive industries, and worth £320 billion in goods and services (UKRI, 2021). Yet industrial clusters are also a major source for the UK's greenhouse gas emissions (GHGs), cumulatively generating nearly 32 metric tons of carbon dioxide equivalent ($MtCO_2e$) annually (HM Government 2021, BEIS 2022a). To revive declining industries, and to meet GHG reductions by 2050, the UK has earmarked substantial public funds—worth billions of pounds in the coming years—to drive industrial decarbonisation across its industrial clusters (Devine-Wright 2022, Sovacool *et al* 2023a).

Of the five largest industrial clusters, Teesside has arguably the most diverse industrial history—spanning cement, chemicals, fertilisers, metals, oil refining, pharmaceuticals, petrochemicals, and steel. At its peak in the 1960s, the chemical and metals industries alone supplied 63,700 jobs (Chapman 2005). Notwithstanding this industrial diversity and history, its industrial base underwent a steep and steady decline beginning in the late 1970s (Geels 2022). The decline is mainly attributed to the collapse of the petrochemical industry—specifically ICI (Imperial Chemicals Industries)—the privatisation and decline of British Steel in 1999, and the closure of three oil refineries in 2009 (Geels 2022). In conjunction, its industrial emissions have declined precipitously in the last decade—now at 3.8 $MtCO_2e$ from a peak of 6.2 $MtCO_2e$ in 1980 (HM Government 2021). Despite this decline in emissions, today it is the fifth highest GHG emitting industrial cluster within the UK.

Consistent with government's Levelling Up Agenda, and owing to its strategic infrastructural and locational assets, Teesside has been deemed a 'Super Place,' primed for reorientation for the net-zero economy (Devine-Wright 2022). Moreover, Teesside was recently one of eight ports to be designated a UK Freeport—which means it now has simplified customs procedures and tax relief until 2031 (IFS 2023). Furthermore, it has convenient access to proposed offshore CO_2 storage sites in the North Sea, and the presence of many multinational corporations (MNCs), which are capable of deploying vast resources to novel decarbonisation projects.

Understanding the progression of industrial projects requires examining agency and selectivity, particularly for 'first-of-a-kind' decarbonisation initiatives (Hassink *et al* 2019, Sovacool and Geels 2021, Blažek and Květoň 2023). The formation of technological frames and narratives, which shape industrial path development, necessitates examination of the agency of local firms and actors (Binz and Gong 2022, Miörner 2022, Benner 2024). In addition, social alliances are constructed through technologies, grant varying degrees of agency to different actors, and often benefit incumbent firms (Bijker and Law 1994, Borup *et al* 2006, Heidenreich and Mattes 2012). Technological expectations—which are often embedded in texts, materials, and actions—shape future possibilities (Latour 1999, Whyte and Davies 2021, Baumgartinger-Seiringer 2022, Turnheim 2022). The Sociology of Expectations (SoE) is useful in analysing shared visions among actors that drive industrial renewal, highlighting legitimation processes for new technologies and the roles of coordinating actors, including firms and governments (Suchman 1995, Van Lente 1993, 2012, Nilsen *et al* 2023).

Our research addresses the critical question: How are various socio-technological configurations for industrial decarbonisation being driven and framed by actors, and why? We tackle this by focusing on the Teesside industrial cluster, a vital case for understanding the dynamics of industrial decarbonisation in practice and implementation. First, we present key background information on Teesside's industrial landscape. Next, we conduct a social network analysis to map the influential actors shaping Teesside's ongoing and planned decarbonisation projects. Drawing on extensive expert interview data (N = 65), we explore how technological expectations and framings influence Teesside's industrial transition. Finally, we apply the Sociology of Expectations (SoE) to evaluate instances of 'new regional industrial path development' (Hassink *et al* 2019), particularly in response to emerging 'place-based' industrial policies (Devine-Wright 2022, Beer *et al* 2020). This multi-faceted approach enables the study to shed light on the effect of local firm, policies, and assets which are, if working in unison, capable of driving innovation and transformation in a globally significant industrial region.

The paper is structured as follows: the next section provides a background and theoretical underpinning. We then introduce the methodology and data collection. The main section uses expert interview data to draw out the features of Teesside's industrial decarbonisation path renewal processes. We close with a short discussion of technological expectations within Teesside.

2. Background, literature, and theoretical underpinning

The Industrial Decarbonisation Challenge, the Cluster Sequencing for Carbon Capture, Usage and Storage (CCUS) deployment, and the Industrial Clusters Mission are among the major central government-led policies supporting industrial decarbonisation in the UK. Catalysed by these interrelated policy mechanisms, both public and private actors are coming together to begin building out net-zero industrial clusters (Griffiths *et al* 2023, HM Government 2021). Immediately below we outline the merits of co-location for both industrial decarbonisation infrastructure and strategic reorientation of industry, and close section 2 with a deeper discussion of SoE within this setting.

2.1. Industrial composition, co-location, and net-zero technologies

Low-carbon industrial projects are in vogue as policymakers attempt to bridge climatic goals (e.g., net-zero emissions targets) with industrial renewal. Maintaining essential industries—including ceramics, steel, iron, and mining—has important ramifications for the wider economy and, in parallel, these industries are critical to the low-carbon technology supply chains and innovations (Greig *et al* 2023, Rattle and Taylor 2023, Sovacool *et al* 2023b, Ogwumike *et al* 2024, Oh and Al-Juaied 2024, Sovacool *et al* 2024b, Sovaccol *et al* 2024c).

During times of great disruption in industrial regions, the co-location of firms and industries can be highly beneficial (Geels 2018, Labory and Bianchi 2021). Co-location is also cited as critical to net-zero project development—especially for CCUS and new large-scale industrial hydrogen applications (i.e., 'megaprojects') (Miller *et al* 2017, Sovacool *et al* 2022, Sovacool *et al* 2024a, 2024b). Recent developments in the Merseyside and the Humber—two of the largest clusters in terms of GHGs and economic output—have demonstrated the positive effects of collaboration among co-located actors, especially for industrial-scale hydrogen and CCUS projects in England (Geels *et al* 2023, Sovacool *et al* 2023a), with similar benefits of co-location for potential CCS projects in Scotland (Swennenhuis *et al* 2020). Outside the UK, in Norway, co-location has also proven instrumental in the initial phases of its Northern Lights carbon storage project (Furre *et al* 2019).

Incumbent firms in the UK have played a significant role in industrial decarbonisation efforts, especially those currently in the oil and gas industry (BP, Equinor, Shell, TotalEnergies). However, research highlights the dual nature of these actors: they can drive change but also hinder low-carbon transitions (Lee and Hess 2019). For instance, Kronsell *et al* (2019) demonstrate that potential change agents often promote technologies aligned with incumbent interests, as seen in Sweden's industrial decarbonisation transition. Similarly, Gordon *et al* (2022) examine the motivations of incumbents in the emerging clean hydrogen economy, emphasising the role of public-private partnerships that co-evolve alongside technological advancements from incumbent players. Using a Social Construction of Technology perspective, Sovacool *et al* (2023a) show that decarbonisation projects in the Humber— the UK's largest GHG-emitting cluster—are increasingly influenced by powerful incumbents, potentially leading to future contestation over technologies like CCUS and hydrogen (BEIS 2022b).

2.2. Strategic re-orientation for industrial decarbonisation

The decarbonisation of industrial clusters requires a strategic reorientation that emphasises learning, monitoring, and experimentation by local actors who can harness internal knowledge flows (Binz *et al* 2014, Molina-Morales and Martínez-Cháfer 2016, Geels 2022). Despite some advantages of a geographically concentrated industrial area, industrial clusters exhibit limited adaptability, making it challenging to incorporate costly low-carbon technologies (Hassink 2010, Stephens 2015).

The role of project promoters is therefore critical in legitimising new technologies (Van Lente 2012, Greig *et al* 2023), especially within industrial clusters where existing infrastructure, sunk costs, and competing interests create integration challenges (Comi and Whyte 2018). Proposed solutions to large-scale socio-technical challenges, such as emissions reduction and job creation, can guide the development of innovative technologies when supported by shared visions (Dosi 1982, Rip and Kemp 1998). Such visions are, however, often promoted by influential actors with overly optimistic assumptions about emerging technologies (Berkhout, 2006). In turn, this can lead to 'shared fantasies,' resulting in conflict rather than consensus under competitive pressures (Sovacool and Hess 2017, Kriechbaum *et al* 2021).

2.3. Sociology of expectations (SoE) for industrial decarbonisation

The Sociology of Expectations (SoE) has been applied in previous research to explain technological legitimation, coordination, and development (Suchman 1995, Van Lente 1993, 2012). Borup *et al* (2006) argue that SoE is grounded in what is 'possible in the future,' where the legitimation of emerging technologies helps secure funding and governmental support. SoE is particularly effective in analysing infrastructural projects that involve novel technologies (Van Lente 1993, Van Lente and Bakker 2010, Kriechbaum *et al* 2021).

Technological expectations do more than describe future realities, they actively shape and create them (Van Lente 2012). As such, new social orders can emerge based on collective future projections (Van Lente and Rip 1998). Yet, cognitive biases may distort these visions, posing risks for decarbonisation technologies like CCUS and hydrogen (Arranz 2016). The promise of new technologies often leads to inflated expectations, which can result in early enthusiasm followed by later disappointment when initial promises fall short (Borup *et al* 2006). Expectations can, therefore, create a dilemma when technological legitimation solidifies before a technology's performance is fully understood (Bakker 2010).

When technologies do not live up to initial expectations, they are said to be at the trough of a 'hype-cycle' which, if it meets a second major trough, has gone through a 'promise-disappointment' cycle (Bakker 2010). These cycles are usually the result of technologies becoming integrated in sociotechnical configurations before performance is fully known (Rip and Kemp, 1998) (*see* figure 1). Indeed, promise-disappointment cycles are identified in myriad studies on hydrogen technologies (van Lente and Bakker 2010, Bakker *et al* 2011), fuel cells (Ruef and Markard 2010, Konrad *et al* 2012), smart meters (Hielscher and Kivimaa 2019), carbon capture and storage (Hansson and Bryngelsson 2009, Torvanger and Meadowcroft 2011, Arranz 2015, Arranz 2016), and other related industrial decarbonisation technologies (Melton *et al* 2016).

3. Research methods and data collection

We selected the Teesside industrial cluster for several reasons. First, the cluster has undergone significant industrial restructuring in the last half century, demonstrating its ability to transition industrial operations (Chapman 2005, Warren 2018). Second, in terms of decarbonisation, the region includes a diversity of industrial emitters spanning steel, cement, energy, petrochemicals, fertilisers, energy production, and pharmaceuticals. Third, Teesside is a geographically well-defined industrial cluster (Gough and Mander 2022). Its net-zero plans, fourth, already include seven massive decarbonisation projects—e.g., large-scale carbon capture and storage, and new blue hydrogen production facilities (BEIS 2022b, Geels *et al* 2023). Finally, considering the above, Teesside is also deemed a 'Super Place'—a region primed for industrial cluster renewal by capitalising on 'emissions reduction in ways that are considered fair and acceptable by local communities (Devine-Wright 2022: 1).

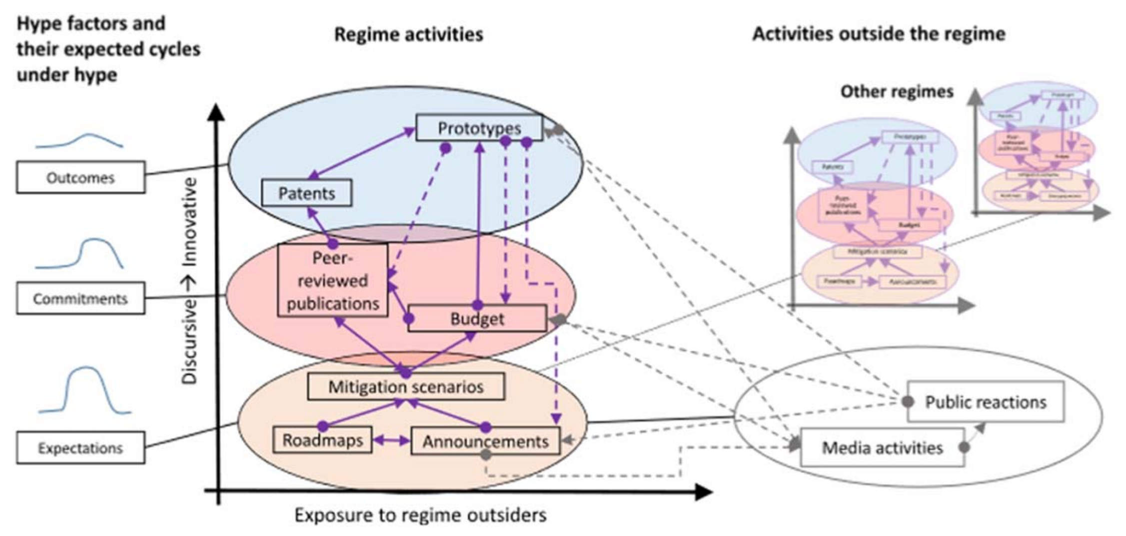

Figure 1. Visualising expectations and sociotechnical discourses. Source: Arranz (2016). Reprinted from Arranz (2016), Copyright (2016) with permission from Elsevier.

3.1. Mixed methods research design

To investigate Teesside's industrial decarbonisation cluster, we used multiple data-collection and analysis methods. We extracted and transformed three types of original data: (1) expert interviews and site visits (2) clustering of key actors, projects, and relationships, (3) and, machine-aided content analysis of relevant policy documents for industrial decarbonisation in the UK.

3.2. Interviews, industrial sites, and public documents

The authors conducted 65 semi-structured expert interviews, which lasted between 30 and 70 min, from October 2022 to February 2023. Interviews were recorded and then fully transcribed using a professional transcription service (see appendix B). To protect the anonymity of respondents, interviewees were given a generic respondent number, and each provided signed consent prior to the interview (see appendix B1). In addition, the researchers visited six industrial sites in Teesside and Redcar (see appendices B1, B2, and B3). Finally, we analysed a large corpus of publicly available reports, internal planning documents, trade-journals, and policy documents relevant to the UK's industrial decarbonisation mission. To enhance our analysis, we uploaded these documents into Provalis Wordstat® textual mining software to isolate key themes and related data such as project cost estimates, partners, and other networks.

3.3. Visualising clusters via pre clustering relational analysis

To map the key actors and relationships involved in Teesside's decarbonisation projects (see appendix E1 and appendix F1), we developed an interactive network—the Teesside Industrial Cluster Network (TICN). This network was constructed using social network research methods (Bathelt *et al* 2004, Latour 2007, Stephens and Sandberg 2020), particularly those supporting project development (Chinowsky *et al* 2008). The TICN highlights the actors, activities, and understandings that shape clustering within a regional context (Weller and Tierney 2018, Stephens and Sandberg 2020). To build the TICN, we first identified the major decarbonisation projects, then added key actors (organisations and firms), decarbonisation technologies, and public financial support mechanisms linked to these projects (*see* figure 2 and appendix D1).

Seven large-scale decarbonisation projects have been announced for Teesside (BEIS 2022b, Geels *et al* 2023), shown in purple in figure 2, with greater detail in appendix E. In line with the Sociology of Expectations (SoE), the high initial expectations for these technologies have helped to legitimise investments from both public and private sectors (Van Lente 2012). Most of these projects focus on CCUS and blue hydrogen, the latter produced from methane with carbon capture, aligning with the UK government's top-down selection of technologies. The government has committed over £21 billion to CCUS (Reuters 2024) (see appendix A1 for public funding details). However, these technologies have yet to be widely tested and deployed in the UK, posing significant risks (Arranz 2016, Melton *et al* 2016, Rattle and Taylor 2022). These points are further explored using interview data in the next section.

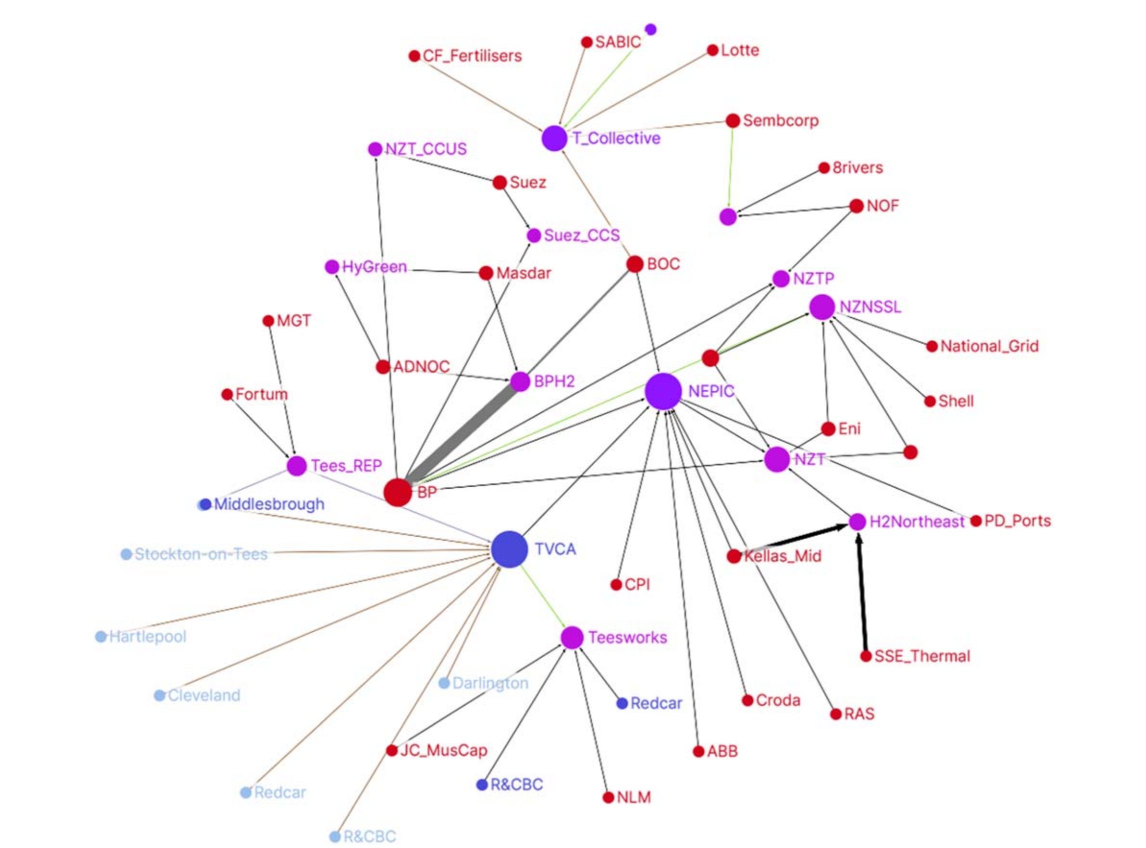

Figure 2. The teesside industrial cluster network (TICN). Source: Author's compilation of open-source data, using Graph Commons (www.graphcommons.com). The coding for the network nodes is as follows: (1) Megaprojects are pink, (2) Networks are purple, (3) Firms are red; (4) Local Councils are light blue, (4) Local authorities are blue. For more details on the nodes, see appendix E and F. The interactive TICN map is located here: https://graphcommons.com/graphs/b5d8923c-c0b6-4972-9d62-e91b073281eb.

4. Expectations for industrial decarbonisation in Teesside

Having introduced the decarbonisation projects and core actors in Teesside, here we undertake deeper analysis by applying SoE to our expert interview data. The results are organised by four key themes: umbrella organisations and orchestrators (4.1), shared local visions (4.2), industry-led narratives and framing (4.3), and, place-based expectations for industrial decarbonisation (4.4). Section 4.5 provides a synthesis of the findings.

4.1. Umbrella organisations and orchestrators

We begin our expert interview analysis with a discussion of the actors and projects identified in the TICN above, with the exception of companies. Most central among these are the Tees Valley Combined Authority (TVCA) and the Northeast of England Process Industry Cluster (NEPIC). R43 highlighted that the former operates under the specific remit to 'improve the economic conditions in the Tees Valley.' From the outset the TDC and TVCA 'had an agenda, through the local authority, and through local businesses there, to reindustrialise parts of Teesside where they'd lost a lot of industry' (R20). The purpose is to keep constituents informed and to enable 'learning between companies […] facing a lot of the same challenges […] learning from each other' (R63). Indeed, as articulated by R63, meetings arranged by these organisations provide a venue for led firms to voice challenges: 'Have you thought about X? Have you thought about Y?' It does help in terms of collaboration, learning from each other, avoiding repeating the same mistakes between companies;' in addition, R63 added that both umbrella actors are 'trying [to] get people talking. Even just get them sharing some of the challenges that they're having.'

Furthermore, as explained by R20, 'Teesside has a very strong background in pushing through the public sector to deliver' (R20). For instance, the Tees Development Corporation (TDC) and TVCA spearheaded the Teesworks Project, which emerged well ahead of central government's cluster competitions. The Project sought to rejuvenate industrial hinterland in Redcar with the purpose to attract decarbonisation megaprojects: 'all the buildings, all the blast furnaces and so on are pretty much gone now […] sold to the new industries like the Net-zero Teesside Power' (R43). The Tees Valley mayor and the TVCA have, moreover, been working in lockstep 'to raise the prospects for the region' (R58). These collaborations have also led to synergies between local and central government, and between companies and research organisations, which are positively impacting activities on the ground, as explained by R58:

'In terms of policy development, obviously some activity is feeding in from the universities [...] and the 'Levelling Up' agenda and policies associated with that [...] [such as the] 'Just Transition' agenda' (R58). Nevertheless, matters have come to a head in the Teesworks project, as project partners claim the Mayor's plans could lead to the public missing out on rent revenues up to £550 million in the coming decade (Williams 2024).

4.2. Shared local visions

The health and wellbeing of local communities emerged as a key factor in Teesside's decarbonisation efforts, which were largely driven by bottom-up momentum. As R20 noted, the primary concern was emissions, with local residents expressing a strong desire for cleaner industries and improved welfare: 'We just don't want dirty industries anymore.' Local politicians also played a significant role in this momentum, leading to a collective decision to commit resources and support decarbonisation initiatives (R05).

Although projects align with the government's current cluster programme, positioning Teesside to secure future funding (R15), the challenge was to ensure that new collaborations can reduce risks. Collaborations, while often seen as beneficial for reducing risk through diversification, can have drawbacks for regional firms. R01 emphasized the risks of overreliance on external partnerships, stating that 'collaboration is a two-edged sword' in an insular system. R28 highlighted the missed opportunity to involve local actors earlier in the development phase to ensure a smoother transition into operational roles (R28). The likelihood of local opposition derailing projects is, moreover, much lower in comparison to other clusters (R05, R28). Furthermore, some respondents anticipated positive economic impacts from the net-zero transition, citing increased demand for local labour, particularly in construction and skilled trades (R15, R28).

Despite this grassroots support, therefore, some elements connected to the institutional constraints of central government have introduced uncertainty. For instance, while local government actors are actively fostering collaboration, assuming that decarbonisation technologies will soon be deployed, several respondents noted that central government cluster competitions are not always well-suited to regional needs (R01, R15, R58, R62). Additionally, the political landscape is unstable, with frequent changes impacting long-term planning (R15). Concerns were also raised about the potential for a 'boom and bust' cycle after project completion, with little focus on long-term workforce planning.

4.3. Industry-led narratives and framing

A distinctive feature of Teesside is the early commitment of private companies to decarbonisation (R15, R43, R58, R62), with many taking the initiative to solve problems independently without relying on state intervention (R20). The presence of numerous multinational firms in Teesside means that successful decarbonisation projects could serve as models for industrial clusters in other regions and countries (R43, R63). Teesside's largest industrial emitters have already united under the Net-Zero Tees Valley Cluster Plan, involving ten major companies contributing CO_2 to the Net-Zero Teesside initiative, alongside 44 other firms (R43).

Since 2020, BP, Aker Solutions, and SSE Thermal Group have led a consortium at the core of Net-Zero Teesside (NZT), a key player in the Teesside Industrial Cluster Network (TICN). The stated aim of NZT is to deliver power and carbon capture projects (R15). Among these multinational firms, BP is emerging as a dominant force in CCUS and hydrogen project development, spearheading both NZT and the H2 Teesside hydrogen project (R43). However, BP's dominance introduces risks. Delays in BP's megaprojects could hinder other cluster initiatives and projects. For instance, blue hydrogen projects cannot go forward until BP's CCUS projects (including capture and transport) are fully operational (R05, R06). Despite this, R05 expressed confidence in BP's projects due to strong public backing, noting that BP's carbon capture project in Teesside is the only one unequivocally supported by the government (R05).

The competitive structure of the government's cluster competitions, moreover, has led some firms to proceed cautiously with collaborations. However, this competition has also strained the pool of skilled workers. As R63 pointed out, 'the only thing most of them are competing for is people,' underscoring the delicate balance between competition and collaboration within the cluster. This point was reinforced by R62, who explained that firms are aware of the challenges of government-driven competition, in addition to the challenge to secure contractors for similar decarbonisation projects. In addition, R58 highlighted that while competition can be beneficial, it is crucial not to exclude any players in the race to decarbonise. R62, representing a large firm, acknowledged that carbon capture and storage was the only viable solution within the required timeframe, leading to their involvement in the Teesside Collective Project.

4.4. Place-based expectations for industrial decarbonisation

Teesside's industrial foundations were originally built around two major sectors: chemicals and steel. Respondents emphasised that the region's industrial restructuring might draw from this historical industrial expertise (R43, R58). Plans to reinvent these sectors and repurpose vintage infrastructure are already underway (R20). As R43 noted, 'businesses that were partitioned off still exist, and the pipeline corridors between them still exist.' Despite the decline of the steel industry, existing infrastructure—such as electrical connections, land, and services—remains viable and is being repurposed for new industrial uses (R43). Other respondents also highlighted the region's robust technological and infrastructural assets, including seven energy-from-waste processing plants operated within three cluster sites (R37).

These assets provide a means for experimentation and innovation in CCUS and hydrogen technologies, although carbon capture remains relatively new in comparison to hydrogen (R20). As a designated 'Super Place' (Devine-Wright 2022), Teesside is expected to play a key role in helping other parts of the UK decarbonise, as articulated by R43: 'There are things done on Teesside that don't emit a lot of CO_2 locally but help the rest of the UK decarbonise.' Teesside's geographical concentration of industries further enhances its capacity for CO_2 abatement, giving the cluster a competitive edge over other UK clusters vying for the same public funds (R38).

The region's tight-knit geographical agglomeration of companies, indeed, emerged as a key factor for its early success in securing funding. Teesside's industrial cluster is more physically concentrated than other UK clusters, where the concept of clustering is more of a political or business idea rather than a physical reality (R43). The presence of multinational corporations and its recently awarded Freeport status are expected to engender further scope for innovatiton and export of decarbonisation technologies.

Teesside's proximity to the harbour enables efficient transportation for industrial operations, with pipelines expected to transport CO_2 for storage in the Endurance saline aquifer (R28, R15, R42, R43). The existing pipeline network across Teesside could also be leveraged for CO_2 transport from many different industrial emitters (R05). Last, Teesside stands out in its approach to emissions reduction, as it is the only UK cluster addressing all Scope 1, 2, and 3 emissions—targeting not just direct emissions but also those from electricity and the supply chain (R43). This ambitious strategy positions Teesside as a leader in comprehensive, place-based industrial decarbonisation.

4.5. Synthesis: technological expectations in Teesside

The Sociology of Expectations (SoE) encompasses not only technological but also temporal and spatial dimensions influenced by advocates, promoters, and agenda-setters (van Lente 1993, van Lente 2012, Hydle 2015). In the concluding part of section 4, we leverage SoE to elucidate the redirection of Teesside's industrial pathways (Binz *et al* 2014, Hydle 2015)—both emergent and expected.

Respondents indicated that, in contrast to other clusters, Teesside is unlikely to decrease its methane imports, which means that it makes much sense to developed blue hydrogen facilities there (R06, R22). As one respondent noted, 'Ultimately, methane could potentially stop going into the Northwest, but it's unlikely to stop going into Teesside' (R22). Consequently, Teesside's hydrogen initiatives rely heavily on blue rather than green hydrogen (R49). Other respondents arguded that blue hydrogen's performance expectations are particularly risky, however: 'Producing blue hydrogen requires doubling your gas supply to stockpile sufficient quantities, and this has not been adequately addressed' (R49).

This blue hydrogen situation highlights the complexities surrounding technological expectations. Although the central government frames blue hydrogen as a crucial solution for decarbonisation, this stance may warrant re-evaluation. Howarth and Jacobson (2021) suggest that blue hydrogen might failt to reduce overall GHGs, and could potentially lead to an increase in emissions when accounting for full lifecycle impacts. Beyond emissions reductions, economic risks were also flagged 'by making blue hydrogen you need to double your gas supply to raise a big stock for that blue hydrogen, and that has not been talked about properly at all' (R49). Therefore, should Teesside's decarbonisation transition continue to rest on CCUS and blue hydrogen, the eventual success of balances on the gap between technological expectations and actual performance—measured by both cost and emissions. These risks and technological unknowns underscore the pressing need for learning, experimentation, collaboration, and innovation for decarbonisation technologies (Hansson and Bryngelsson 2009, Meadowcroft and Langhelle 2009).

With respect to the co-location of industrial assets, the extensive network of existing pipelines—which includes gas, water, and steam lines—are viewed as critical emerging industrial decarbonisation projects (R05). While Teesside's industrial heritage and the proximity of numerous firms position it well for learning and experimentation in CCUS and hydrogen technologies (R43)—and these locational advantages suggest substantial emissions mitigation potential (Parfomak *et al* 2007)—the specifics of how to repurpose existing infrastructural assets, particularly the pipeline network, remain uncertain (R42, R58, R05).

Several respondents expressed confidence that decarbonisation initiatives would progress irrespective of government funding (R08, R20, R43). This optimism stems from an inherent collaborative framework supported by existing infrastructure, enabling cost reductions in deploying pipelines for hydrogen and other utilities (R08). However, scepticism remains regarding the capacity of private actors to independently advance these initiatives, primarily due to economic viability concerns and the need for governmental support (R49). One respondent noted that transitioning from natural gas to processed alternatives and capturing CO_2 for resale is economically challenging (R63). As such, the performance of decarbonisation technologies and the expectations surrounding these projects may need to be moderated as the development of low-carbon technologies may not align with initial performance predictions.

Critics assert that these technologies are still in their infancy, and uncertainties regarding future costs could jeopardize large-scale initiatives (Boswell 2022, R05, R49). In similar vein, industrial decarbonisation is contingent on the effective performance of the associated technologies (McLaughlin *et al* 2023, Turner *et al* 2023). Transparent communication of costs and timelines is vital for the success of decarbonisation megaprojects (Bathelt *et al* 2004, Sovacool and Geels 2021, Sovacool *et al* 2023a). Ultimately, the successful implementation of industrial decarbonisation faces dual challenges: cost management and the effectiveness of emissions reduction efforts.

5. Discussion and conclusion

In this study, we constructed a network of actors within Teesside's industrial cluster, currently the site of ongoing efforts to implement net-zero industrial megaprojects, where we also conducted interviews. We then applied the Sociology of Expectations (SoE) framework to analyse the region's decarbonisation projects and constituent actors. While we identified instances where vintage industrial infrastructure, and the agglomeration of industrial firms, might provide fertile grounds for industrial decarbonisation, several uncertainties persist. First, we observed a divergence between local public actors and central government plans, which could potentially delay future projects, aligning with previous research (Torvanger and Meadowcroft 2011, Lee and Hess 2019, Baumgartinger-Seiringer 2022). Second, this divergence fosters contestation and competition over future visions (Geels 2004, Borup *et al* 2006, Van Lente *et al* 2013). And third, while policy actors can frame potential technological solutions, addressing technological risks introduces new decision-making challenges based on the expectations environment (Borup *et al* 2006, Voß *et al* 2009, Ungureanu *et al* 2019).

Specifically, our site visits and interviews revealed that several multinational firms are actively shaping technological narratives in Teesside. While sensible given the immense costs of decarbonisation megaprojects, such engagement nevertheless carries risks: although large firms stand to gain reputational benefits from successful decarbonisation, failures in initial projects could hinder progress on subsequent initiatives. Additionally, the discourse remains centred around CCUS and blue hydrogen technologies, which have yet to achieve commercial success in the UK.

The findings also prompt reflection on their implications for other industrial clusters and evolving geopolitical contexts. For instance, in Scotland, INEOS is the largest emitter and may soon receive substantial public subsidies. However, if these subsidies lead to minimal emissions reductions, they could undermine the Levelling Up Agenda and negatively impact civil society's view of climate-aligned industrial policies in the UK and beyond. In the US, for example, significant tax breaks and subsidies for heavy emitters may lead to local backlash if carbon capture projects are abandoned due to political changes (Herman 2024). Moreover, while Norway is often lauded for its advanced industrial decarbonisation efforts, recent research indicates that the CO_2 captured in its flagship projects are only a fraction of initially hyped expectations during project development (Geoengineering Monitor 2024).

What do our findings imply for the future expectations of industrial decarbonisation technologies within the SoE framework? First, as the UK begins to deploy these technologies, project costs remain largely uncertain. This uncertainty is heightened by the risk that the central government may retract promised funding, as seen in 2007 and 2013. Recent funding withdrawals from the Humber industrial decarbonisation cluster underscore these concerns. Consequently, the expectations surrounding these technologies carry inherent risks, with technological hype-cycles and patterns of promise and disappointment already evident in similar initiatives (Bakker 2010, Konrad *et al* 2012, van Lente *et al* 2013, Arranz 2016). In this way, expectations play a double and contradictory role in net-zero transitions: they can motivate actors and create effective frames for legitimating decarbonisation but at the same time they may blind key actors to some of the fundamental challenges involved.

Acknowledgments

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Data availability statement

The data cannot be made publicly available upon publication because they contain sensitive personal information. The data that support the findings of this study are available upon reasonable request from the authors.

Appendix A . UK industrial decarbonisation funding

Table A1. Industrial decarbonisation funding provided by the UK Government.

Policy/Fund	Type of mechanism	Detail	Total £
Carbon Capture and Storage (CCS) Infrastructure	Subsidies for infrastructure	For establishing CCS at 2 sites, the first by the mid-2020s, the second by 2030. Announced in 2020 Budget.	£1b
Carbon Capture and Utilisation Demonstration (CCUD) innovation programme	Subsidies for infrastructure	To demonstrate CCUS at several key industrial sites in the UK, and 'accelerate cost reductions of about 20%–45% in carbon capture technology', 'to encourage a project pipeline of follow-on CCU projects that will help less mature, but more novel technology to be demonstrated at scale', to develop understanding of CCUS tech cost and performance and to de-risk the technology. Phase 3 closed in September 2019.	£20m
CCUS Innovation Programme	Subsidies for infrastructure	Grant funding for technologies reducing the costs of Carbon Capture Utilisation and Storage (CCUS) deployment.	
Energy Innovation Programme	Subsidies for infrastructure	£505m budget spread over 6 themes (smart systems, £70m, built environment, £90m, industrial decarbonisation and CCUS, £100m, nuclear innovation, £180m, renewables innovation, £15m, energy entrepreneurship and green finance, £50m.	£505m
Industrial Clusters Mission	Subsidies for infrastructure	Financed by the Industrial Strategy Challenge Fund (£170m public investment).	£170
Low Carbon Hydrogen Production Fund	Subsidies for infrastructure	A £90m fund constituted of £70m for 2 large scale low carbon hydrogen production plants (Merseyside, Aberdeen). 'A third project will develop technology to harness offshore wind off the Grimsby coast to power electrolysis and produce hydrogen.' £20m is assigned to household smart energy projects.)	£90m
Low Carbon Hydrogen Supply Competition	Subsidies for infrastructure	'The £33 million Low Carbon Hydrogen Supply competition aimed to accelerate the development of low carbon bulk hydrogen supply solutions in the above sectors. Aimed at projects at a technology readiness level (TRL) of 4 to 7, which could result in lower capital or operating costs when compared to Steam Methane Reformation with Carbon Capture & Storage (SMR+CCS), or improve the carbon capture rates at a comparable cost.' Closed competition.	£33m
Boosting access for SMEs to energy efficiency	Subsidies for performance	Innovation competition funding of £6m to enable small and medium-sized enterprises (SMEs) to take up energy efficiency measures.	£6m
Industrial Energy Efficiency Accelerator	Subsidies for performance	'The IEEA programme aims to increase the number of innovative energy efficiency technologies available to British industry to help reduce energy consumption and cut carbon emissions…designed to strengthen the global competitiveness of UK industry in sectors including manufacturing, waste processing and data centres. The Accelerator seeks industry-specific solutions which are close to commercialisation by leveraging private sector investment and strengthening UK supply chains to reduce energy costs for UK industry.'	£13m
Industrial Energy Transformation Fund	Subsidies for performance	For capital investment in energy efficiency (EE) and deep decarbonisation (DD) (specifically not for operational expenditures). Companies are to propose the specific technologies. Supports the deployment of EE and DD technology, demonstration at scale, mature EE technologies, DD technologies (CCS, fuel switching, material efficiency) which are not necessarily as mature, Feasibility and Front-End Engineering and Design (FEED) studies […], capacity building (to provide technical expertise for feasibility studies and deployment). Delivered in the form of competitive grants. The fund is targeted towards projects 'that would not happen without Government support.'	£315m
Industrial Heat Recovery Support	Subsidies for performance	Supporting 'investment in heat recovery technologies.' Successful applicants are partially funded for a proposed project. Applies to England and Wales. The total funding available is worth £18m, and 'allocated through a competitive process' and against scoring criteria. Three possible 'entry points' are available for funding: feasibility studies/preliminary engineering, preliminary engineering (where the applicant has undertaken an independent feasibility study); detailed design and delivery.	£18m

Table A1. (Continued.)

Policy/Fund	Type of mechanism	Detail	Total £
Clean Growth Equity Fund	Subsidies for innovation	'Aims to speed up the deployment of innovative clean technologies that reduce greenhouse gas emissions, by making direct investments in companies seeking to commercialise promising technologies. […] The new £40 million Fund combines a £20 million investment from BEIS alongside £20 million from a private sector investor CCLA, a UK institutional investor with an environmental social governance agenda. The Fund has ambitions to reach £100 million and CGIM [Clean Growth Investment Management LLP] is now seeking additional investment from other private sector investors.'	£40
Clean Steel Fund	Subsidies for innovation	£250m fund to enable the sector to implement new technologies/processes towards achieving net-zero. Also, to 'maximise longevity and resilience in the UK steel sector by building on longstanding expertise and skills and harnessing clean growth opportunities.' Designed in conjunction with the Low Carbon Hydrogen Production Fund (worth £100m).	£250m
Industrial Fuel Switching Competition	Subsidies for innovation	Phased funding to support research, feasibility studies and investment in low carbon fuel switching processes and technologies. Closed competition.	
Industrial Strategy Challenge Fund (ISCF)	Subsidies for innovation	Part of the £4.7bn total research and development investment under the Industrial Strategy (over 4 years). Structured by the 4 'grand challenge areas'. The 'Industrial Decarbonisation' programme is the relevant challenge here, at £170m in value, with an expectation of industry match funding of up to £261m.	£170m
Transforming Foundation Industries	Subsidies for innovation	Competition funding under the Industrial Strategy Challenge Fund, worth £5m for innovation projects in the foundation industries. The 'Government is prepared to invest up to £66m in this challenge.'	£66m
Contracts for Difference (CfDs, large scale generation)	Funding for low-carbon energy supply	Low carbon/renewable electricity generation incentive, replacing the Renewable Obligation Certificates (ROCs) phased out from 2017. Capacity allocated through an auction system. Renewable energy generation deployment (over 5 MW). Eligible technologies include onshore/offshore wind, solar PV, geothermal, hydropower, tidal/wave power, landfill gas, sewage gas, anaerobic digestion, biogas/biomass, CHP. 'Developers are paid a flat (indexed) rate for the electricity they produce over a 15-year period, , the difference between the 'strike price' (a price for electricity reflecting the cost of investing in a particular low carbon technology) and the 'reference price' (a measure of the average market price for electricity in the GB market).'	
Energy Intensive Industry Exemption Scheme	Funding for low-carbon energy supply	Eligible energy-intensive companies can be compensated for the costs of renewable energy schemes in the UK, namely up to 85% of the costs of Contracts for Difference (CfDs), the Renewables Obligation (RO), and small-scale feed-in tariffs (in N. Ireland). The Autumn statement (2015) announced the move from compensation to exemption - this applied to charges from RO/Feed in Tariffs from 2017, and from CfDs from 2016.	
Heat Networks Investment Project	Funding for low-carbon energy supply	Provision of £320m capital funding to 'gap fund' heat network projects (applicable to England and Wales). Intended to support 200 projects via grants/loans.	£320m
Non-domestic Renewable Heat Incentive	Funding for low-carbon energy supply	Installations are given quarterly payments over 20 years according to the amount of heat they generate. Designed to enhance confidence in investing in renewable heat technology.	
TOTAL FUNDING AVAILABLE			£3016m

Source: adopted from Garvey and Taylor, 2020).

Appendix B. Interview and site visit data

Interviews focused on five themes.

1. Technology implementation, experimentation, and knowledge
2. Policy, governance, and management
3. Benefits and risks
4. Business strategy, incumbency, and disruption

5. Equity and vulnerability (civil society).

In addition, two research team members visited 6 sites across Teesside which involved naturalistic observation and face-to-face conversations with project participants.

1. Teesworks: Sea-Ah Turbine Manufacturer Site
2. Teesworks: British Steel Corp
3. Teesworks: BOC
4. Teesworks Freeport / Harbour
5. Wilton International
6. Teesside Region (Cleveland, Redcar, Middlesbrough)

Table B1. Expert interview respondents, affiliation, and date of interview.

Respondent	Affiliation	Type	Date
R01	Manchester University	Academia	17.09.22
R02	NECCUS	Industry: trade group	22.09.22
R03	NECCUS	Industry: trade group	22.09.22
R04	Energy Transition Advisor Limited, Storegga	Industry	06.10.22
R05	Herriot-Watt Uni.	Academia	05.10.22
R06	Kellas Midstream	Industry	05.10.22
R07	BGS	Policy-Research-Academia	10.10.22
R08	Lanzatech	Industry	10.10.22
R09	Stanford University	Academia	05.10.22
R10	North Sea Transition Authority	Policy	14.10.22
R11	Wales West Utilities	Industry	21.0.22
R12	SBH4	Industry	24.10.22
R13	ECITB	Trade	24.10.22
R14	Carbon8	Industry	24.10.22
R15	Aker Solutions	Industry	25.10.22
R16	TuvSud	Policy-Research	25.10.22
R17	UCL	Academia	28.10.22
R18	BGS	Policy-Research	27.10.22
R19	ICL, Just Transition Scotland	Academia	26.10.22
R20	SWIC/Industry Wales, Baxter360	Industry	27.10.22
R21	hydrogen centre / Uni S. Wales	Academia	28.10.22
R22	CT Energy, Southeast Water UK, CPH2, Nuclear Decommissioning Authority, Cadent Gas Ltd.	Industry	27.10.22
R23	Tarmac	Industry	28.10.22
R24	University of Strathclyde	Academia	28.10.22
R25	University of Strathclyde	Academia	31.10.22
R26	Plansea	Industry	31.10.22
R27	Manchester Uni.	Academia	31.10.22
R28	Aker Solutions	Industry	24.10.22
R29	Carbon Trust	Policy	03.11.22
R30	Storegga	Industry	03.11.22
R31	Renewables hydrogen alliance	Policy	09.11.22
R32	Just Transitions Committee, Uni. Bath	Academia	09.11.22
R33	Airhive	Industry	10.11.22
R34	Engaging Next Gen. Industry, Fuel Change	Trade	10.11.22
R35	University of Aberdeen	Academia	28.10.22
R36	Reliagen, Association of Renewable Energy and Clean Technology, BioSci	Industry	10.11.22
R37	Suez Group	Industry	11.11.22
R38	Shell	Industry	11.11.22
R39	green alliance		
	Policy	09.11.22	
R40	SCCS	Policy	14.11.22
R41	Vale	Industry	31.01.23

Table B1. (Continued.)

Respond-ent	Affiliation	Type	Date
R42	Storegga (Pale Blue Dot)	Industry	14.11.22
R43	Tees Valley CA, CER Technologies, Ltd.	Local authorities	08.11.22
R44	ENSUS UK Ltd., NEPIC	Trade	15.11.22
R45	Innovate UK (Enterprise Services at Heriot-Watt)	Policy-Research	16.11.22
R46	VNZS, VItaBio Group	Industry	07.11.22
R47	Oxford	Academia	16.11.22
R48	British Geological Survey	Policy-Research	18.11.22
R49	Edinburgh University	Academia	18.11.22
R50	Honeywell	Industry	18.11.22
R51	Sheffield University	Academia	18.11.22
R52	BEIS (NZBI - Clean Heat)	Policy	15.11.22
R53	Low Carbon Contracts Company	Policy-Industry	24.11.22
R54	Shell	Industry	25.11.22
R55	Intercontinental Energy, Everything About Hydrogen, Hydrogen Council, Sustainable Energy Council	Industry	25.11.22
R56	Scottish Parliament	Policy	02.12.22
R57	British Geological Survey	Academic/Research/Industry	06.12.22
R58	Durham University	Academia	09.12.22
R59	retired British Steel	Industry	16.12.22
R60	Helmholtz Centre, RIFS-Potsdam	Academia	
R61	BEIS	Policy	07.12.22
R62	Kellas Midstream (NEPIC)	Industry	22.12.22
R63	Sembcorp Energy UK (Wilton Int.)	Industry	11.01.23
R64	RWE	Industry	15.12.22
R65	Protium Green Solutions, Everything About Hydrogen (UK Hydrogen & Fuel Cell Association)	Industry	19.01.23

**** - joint interview (NECCUS).

+note: we conducted interviews across three of the UK's industrial clusters (Scotland, South Wales, and Teesside). Although some of the respondents above were not working specifically within the Teesside cluster, all respondents provided insight into, at minimum, the UK's industrial cluster mission, related policies, or technologies. We therefore include all respondents here.

Figure B1. BOC industrial site, Teesworks complex.

Figure B2. Vintage Pipelines in Teesworks.

Figure B3. View of old industrial plants with wind energy in the background.

Appendix C. History of teesside's industrial cluster (1940–2006)

Teesside has a well-established history of industrial organisation and collaboration since the dawn of the UK's industrial revolution (Teesplan 1969, Warren 2018). Oil became part of local industry in the 1960s, with North Tees transporting raw materials through pipelines used by chemical firms (Chapman 2005). The steel industry was in private hands from the 1930s through the 1960s, when 14 firms were amalgamated and nationalised under the British Steel Corporation (the Iron and Steel Act). At its peak in the 1960s the chemical and metals industries supplied 33,100 and 30,600 jobs, respectively (Chapman 2005). Finally, in 1988, Thatcher's government re-privatised the chemical industry, with significant ramifications for industry in Teesside which reverberate up to the present day (Geels 2022).

While the unfortunate de-industrialisation of Teesside continued until the mid-2000s, a cluster renewal fomented in 2007. It was the first industrial cluster to plan for a regional CCS network—indeed, the Teesside Low Carbon Project was one of the final four in the UK Commercialisation Competition. In 2015, the Tees Valley City deal secured funding for new industrial infrastructure in Teesside, marking another point of renewal for the area.

In the same year of the Tees Valley City deal, the central government introduced *the Industrial Decarbonisation and Energy Efficiency Roadmaps*, followed in 2017 by seven *Action Plans* jointly developed with industry. These policy developments prepared the ground for the 2017 *Clean Growth Strategy*, which focused on alleviating the burden of decarbonisation for heavy industries, including public funds for fuel switching and CCUS projects. With a renewed focus on funding the decarbonisation of industrial regions, *the Industrial Strategy Challenge Fund* (ISCF), in 2018, committed £170 million to *Clean Growth and Transforming Construction* with £250 million expected to come from private sector. The central government's *Industrial Energy Transformation Fund* (IETF), to the tune of £315 million (from 2021–2025), provides capital grants for the deployment of energy efficiency, deep decarbonisation, and fuel switching.

Already having experimented with CCS since 2007, and still home to many of the world's highest GHG emitting MNCs, Teesside then recognised that it could rebuild industry with net-zero technologies at heart, banking on publicly available financial support (Gough and Mander 2022). Implementation of these funds is guided by the government's cluster sequencing 'competition', with two of five clusters selected at the end of 2021 (the Humber and Merseyside), wherein Teesside went forward as part of the Norther Endurance Partnership (NEP) with the former. The NEP will build out the infrastructure needed to transport CO_2 from across the Humber and Teesside to an offshore storage facility in the Southern North Sea (Sovacool *et al* 2022).

Teesside's net zero cluster

According to the Prime Minister's *Ten Point Plan for a Green Industrial Revolution* (2020), at least two low-carbon industrial clusters should be fully operational by 2027, with one achieving net-zero emissions by 2030. Teesside aims to become this cluster (Sutherland *et al* 2022). A total of 20 proposals were shortlisted for Phase 2 cluster sequencing (as of August 2022), with seven in Teesside, including: two Power CCUS projects (Whitetail Clean Energy and Net-zero Teesside Power); two hydrogen projects (BP H2 Teesside and H2 Northeast), and three industrial carbon capture (ICC) projects (CF Fertilisers CCS, Tees Valley Energy Recovery Facility Project, Teesside Hydrogen CO_2 capture) (BEIS 2022b). (see historical background appendix C).

While CCUS and hydrogen technologies dominated Teesside's initial cluster plans, given the preponderance of firms, each with substantial demands for energy and carbon sequestration, renewable energy projects and new cycle gas turbine (CCGT) power stations fitted with CCS (considered 'low-carbon' energy) are also on the table. Furthermore, it expects to produce 1.8 GW of zero-carbon power from hydrogen. Finally, Teesside boasts an international element, including its recently awarded Freeport status, and also considering its carbon and hydrogen infrastructure set to connect with Scotland, Belgium, Norway, the Netherlands, and Germany (Gough and Mander 2022).

Appendix D. Teesside's greenhouse gas emissions

Source: Author's rendition of BEIS GHG data. Emissions are concentrated in Redcar and Cleveland. Darlington averaging about 150, Middlesbrough gone down a lot. In tonnes of CO' equivalent, total industry emissions Teesside (2005–2020).

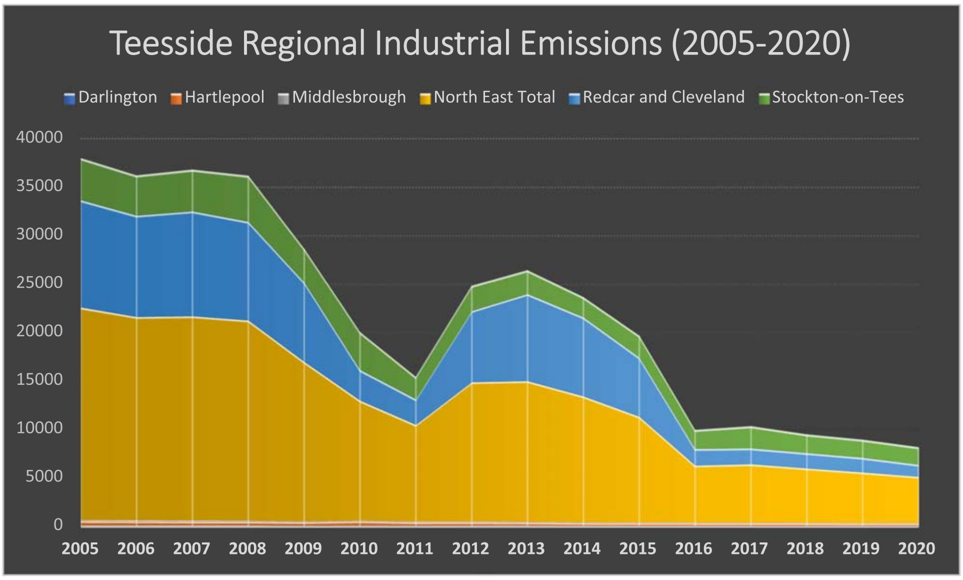

Figure D1. Teesside's industrial emissions, by local council.

Table D1. Emissions from publicly traded firms with operations in Teesside and participating in at least one industrial decarbonisation project.

Firm	Carbon to Revs. (millions $)	Scope 1 emissions (tonnes of CO-2e)	Scope 2 emissions (tonnes of CO-2e)	Scope 3 emissions (tonnes of CO-2e)	Total emissions (tonnes of CO-2e)
ADNOC	26	150,626	21,060	129,566	N/A
Aker Solutions	6	20,834	10,003	10,831	3,181
Balfour Beaty	25	240,781	199,002	41,779	N/A
BP	226	35,600,000	33,200,000	2,400,000	303,600,000
ENI	470	40,890,000	40,080,000	810,000	196,500,000
Equinor	136	12,100,000	12,000,000	100,000	252,810,000
GE	24	1,810,000	740,000	1,070,000	505,000,000
National Grid	52	981,000	30,000	951,000	432,000
Sembcorp Energy	4528	26,166,200	25,936,300	229,900	8,878,400
Shell	264	69,000,000	60,000,000	9,000,000	1,299,000,000
Total Energies	192	35,374,000	33,300,000	2,074,000	391,154,000
Lotte	495	5,574,266	3,623,926	1,950,340	N/A

Source: Eikon Refinitiv, excel add-in. Represents firm-level emissions reported under the UK's Climate Act. Emissions reported are from Teesside and other operations.

Appendix E. Teesside decarbonisation projects

Table E1. Teesside's net-zero decarbonisation projects.

Project	Technology	Lead Partner/ others	Funding/Network/other notes
Sofia wind farm	Offshore Wind	RWE	Sofia offshore wind farm: led by RWE, plans to be the largest in the world powering 1.2 million homes with 1.4GW of energy. The Decarbonisation Innovation Special Interest Group will integrate into the Tees Valley Cluster plan, identifying challenges and providing solutions via the Cluster Plan Industrial Advisory Group.
Whitetail clean energy		Sembcorp	Whitetail: Led by Sembcorp Energy UK, with 8 Rivers Capital and NZTP, it aims to be the UK's first Net-zero power station producing 300 MW, storing emissions from methane in the North Sea
Suez recycling CCUS	CCUS	Suez and BP	SUEZ first announced plans to develop a commercial scale carbon capture plant at its Tees Valley (Lines 1 and 2) facility at Teesside in November 2020 after signing a memorandum of understanding with bp. The original project envisaged capturing the carbon dioxide from the facility's flue gas emissions and transporting this to a geological storage site beneath the North Sea.
H2NorthEast	Hydrogen (blue)	Kellas Midstream	H2NorthEast is a strategic initiative to build a 1GW facility producing low carbon, blue hydrogen utilising UK North Sea natural gas that is already processed at the existing CATS Terminal. Over 95% of the CO2 produced will be captured and transported offshore for storage using infrastructure developed by the Northern Endurance Partnership. H2 NorthEast is being developed in response to customer demand and is in line with the UK government's strategy to create a hydrogen economy and would contribute 20% of the government's target of 5GW of blue hydrogen capacity by 2030
BPH2 teesside	Hydrogen Energy Production	BP (BOC, ADNOC, Masdar)	An FID on the project is expected in early 2024. The facility is expected to commence operations with a 500MW hydrogen production capacity by 2027 or earlier. Integrated with carbon capture technologies, the H2 Teesside facility will utilise the NEP infrastructure to export and store up to 2Mt of CO_2 a year. bp's world-scale hydrogen project that aims to produce 1GW of blue hydrogen starting in 2027, capturing and sending for storage up to two million tonnes of carbon dioxide p/a through the NEP. (*Shortlisted for Phase II). ADNOC and Masdar (UAE). The electricity generation with post-combustion carbon capture Partnership comprises bp, Eni, Equinor and Total, with bp leading as operator. NZT Power will be responsible for the Proposed Development in so far as it relates to the construction, operation, and eventual decommissioning of the Electricity Generating Station together with its carbon capture plant (both within the scope of the DCO Application). 1.2.5 The CO_2 gathering network, CO_2 compression and onshore section of CO_2 export pipeline Partnership comprises bp, Eni, Equinor, National Grid, Shell and Total, with bp leading as operator.

Table E1. (Continued.)

Project	Technology	Lead Partner/ others	Funding/Network/other notes
Net-zero teesside power (NZTP)			Net-zero Teesside Power's carbon capture, utilisation and storage (CCUS) project is a world first for a new gas-fired power station with a built-in process to capture and pump waste CO_2 into a North Sea abandoned gas field cluster. *Shortlisted for Phase 2 Sequencing funds. NZNS Storage will be responsible for the Proposed Development in so far as it relates to the construction, operation and eventual decommissioning of the equipment required for the high-pressure compression of CO_2 from the electricity generating station and industrial emitters via the CO_2 gathering network and the onshore section of the CO_2 export pipeline (these are all within the scope of the DCO Application). 1.2.6 NZNS Storage will also be responsible for the offshore elements of NZT, comprising the offshore section of the CO_2 export pipeline (below Mean Low Water Springs ('MLWS')) to a suitable offshore geological CO_2 storage site under the North Sea, CO2 injection wells and associated infrastructure. The offshore elements of NZT (with the exception of the gas and CO_2 pipeline crossings of the River Tees and the water outfall from the electricity generating station) do not form part of the DCO Application (Balfour Beaty, £1 billion with BP)
Net-zero teesside (NZT)	CCGT with CCS	BP and Equinor	gas-fired, 840 MW. Integrated with carbon capture technology. Will comprise the hub project of the Net-zero Teesside cluster and supply flexible, low carbon electricity to power up to 1.3 million homes. The CO_2 emissions from the NZT Power facility will be exported and stored by the Northern Endurance Partnership. NZT Power will be responsible for the Proposed Development in so far as it relates to the construction, operation and decommissioning of the electricity generating station together with the equipment required for the capture of its CO_2 emissions. 2.1.8 BP, ENI, Equinor and Total share all the costs and liabilities incurred in relation to the Proposed Development. NZT is being promoted by Net-zero Teesside Power Limited ('NZT Power') and Net-zero North Sea Storage Limited ('NZNS Storage'). NZT Power and NZNS Storage (together the Applicants for the purposes of the DCO Application) have been incorporated on behalf of bp as operator of the two Partnerships. a CO_2 gathering network (including connections under the tidal River Tees) to collect and transport the captured CO_2 from industrial emitters to a CO_2 compressor station (the industrial emitters using the gathering network will be responsible for consenting their own carbon capture plant and connections to the gathering network), • a high-pressure CO_2 compressor station to receive and compress the captured CO_2 from the electricity generating station and gathering network before it is transported offshore, and • a dense phase CO_2 export pipeline for the onward transport of the captured and compressed CO_2 to the Endurance saline aquifer under the North Sea.
CF Fertilisers Billingham Ammonia CCS*			(*Shortlisted for Phase II, but 'halting amonia production because of market, Aug. 2022).
HyGreen Teesside			The HyGreen Teesside project aims to produce 60 megawatt electrical input of hydrogen at start-up in 2025 before increasing to 500 megawatt electrical input by 2030. . Energy companies ADNOC and Masdar will support bp's H2Teesside and HyGreen Teesside ambitions.
Northern Endurance			Connects Teesside and ZCH offshore carbon store
TV ERF	Tees Valley Energy Recovery Facility		(*Shortlisted for Phase II)
Tees renewable energy plant	MGTeesside		Tees at Teesport in Redcar and Cleveland, North East England. The plant will operate alongside other renewable energy units and industrial processes operating in the Northeast of England Process Industry Cluster (NEPIC)
Tees valley hydrogen innovation project (TVHIP)	Hydrogen		Financially supported through the European Regional Development Fund (ERDF), the project offers a minimum of 12 h of fully-funded support to eligible SMEs. . European Regional Development Fund (ERDF)

Table E1. (Continued.)

Project	Technology	Lead Partner/ others	Funding/Network/other notes
Tees works		TVCA	The largest UK Freeport, exclusive sustainable, low-carbon industrial zone (TVCA, South Tees Development Corporation, and Redcar & Cleveland Borough Council). South Tees Site Company Limited, set up with STDC and BEIS in 2016, then fully aquired by former in 2020). The TVCA and the Mayor's Group owns the South Tees Development Corporation, which has oversees Teesworks. South Tees Dev Corp: The South Tees Development Corporation Group comprises South Tees Development Corporation (STDC), and its wholly owned subsidiary companies South Tees Developments Limited and South Tees Site Company Limited (STSC) which was acquired 08 October 2020. 1,420 acres of land on the former Redcar steelworks site has been acquired by the South Tees Development Corporation after Tees Valley Mayor Ben Houchen formally signed off the deal today (21 February). Since it was launched by the Prime Minister in August 2017, the South Tees Development Corporation has already seen more than 100 enquiries from around the world, with a potential first-phase investment pipeline of £10billion, as it aims to create 20,000 jobs over the next two decades. South Tees Development Corporation and Group - Annual Financial Statements 2020/21 Narrative Report Introduction Welcome to the South Tees Development Corporation and Group's Annual statement of Accounts for 2020/21 which have been prepared in accordance with the Code of Practice on Local Authority Accounting in the United Kingdom 2020/21. The South Tees Development Corporation Group comprises South Tees Development Corporation (STDC), and its wholly owned subsidiary companies South Tees Developments Limited and South Tees Site Company Limited (STSC) which was acquired 08 October 2020

Source: government documents.

Appendix F. Teesside industrial cluster network (TICN)

Table F1. TIC network nodes.

Number	Type	Name	Code
1	Network	Teesside Collective	T_Collective
2	Megaproject	Net Zero Teesside Power	NZTP
3	Megaproject	Teesworks	Teesworks
4	Megaproject	Blue Hydrogen Northeast	H2Northeast
5	Megaproject	Green HyGreen	HyGreen
6	Megaproject	BP Blue Hydrogen	BPH2
7	Megaproject	Suez Carbon Capture	Suez_CCS
8	Megaproject	Net Zero Teesside CCUS	NZT_CCUS
9	Megaproject	Whitetail Clean Energy	Whitetail_clean
10	Council	Darlington Council	Darlington
11	Council	Hartlepool Council	Hartlepool
12	Council	Middlesbrough Council	Middlesbrough
13	Council	Redcar Council	Redcar
14	Council	Cleveland Council	Cleveland

Table F1. (Continued.)

Number	Type	Name	Code
15	Council	Set Zero Tees-side Tees	Stockton-on-Tees
16	Firm	Fortum Firm	Fortum
17	Firm	BP Firm	BP
18	Firm	Eni Firm	Eni
19	Firm	Equinor Firm	Equinor
20	Firm	Total Firm	Total
21	Firm	BP Firm	BP
22	Firm	Eni Firm	Eni
23	Firm	Equinor Firm	Equinor
24	Firm	Net Zero Tees-side Grid	National_Grid
25	Firm	Shell Firm	Shell
26	Firm	Total Firm	Total
27	Firm	Equinor Firm	Equinor
28	Firm	BP Firm	BP
29	Firm	NOF Firm	NOF
30	Firm	Sembcorp Firm	Sembcorp
31	Firm	8rivers Firm	8rivers
32	Firm	NOF Firm	NOF
33	Firm	BP Firm	BP
34	Firm	Jet Zero Tees-side MusCap	JC_MusCap
35	Firm	NLM Firm	NLM
36	Network	TVCA Network	TVCA
37	Authority	Ret Zero Tees-side R&CBC	R&CBC
38	Firm	BP Firm	BP
39	Firm	Suez Firm	Suez
40	Firm	ADNOC Firm	ADNOC
41	Firm	Masdar Firm	Masdar
42	Firm	ADNOC Firm	ADNOC
43	Firm	Masdar Firm	Masdar
44	Firm	BP Firm	BP
45	Firm	Cet Zero Tees-side Fertilisers	CF_Fertilisers
46	Firm	Lotte Firm	Lotte
47	Firm	SABIC Firm	SABIC
48	Firm	Sembcorp Firm	Sembcorp
49	Firm	CPI Firm	CPI
50	Firm	Croda Firm	Croda
51	Megaproject	Tet Zero Tees-side REP	Tees_REP
52	Firm	Ket Zero Tees-side Mid	Kellas_Mid
53	Firm	Set Zero Tees-side Thermal	SSE_Thermal
54	Firm	MGT Firm	MGT
55	Firm	BOC Firm	BOC
56	Firm	Pet Zero Tees-side Ports	PD_Ports
57	Firm	ABB Firm	ABB
58	Firm	RAS Firm	RAS

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References

Arranz A M 2015 Carbon capture and storage: frames and blind spots *Energy Policy* **82** 249–59

Arranz A M 2016 Hype among low-carbon technologies: carbon capture and storage in comparison *Global Environ. Change* **41** 124–41

Bakker S, Van Lente H and Meeus M 2011 Arenas of expectations for hydrogen technologies *Technol. Forecast. Soc. Change* **78** 152–62

Bakker S 2010 The car industry and the blow-out of the hydrogen hype *Energy Policy* **38** 6540–4

Bathelt H, Malmberg A and Maskell P 2004 Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation *Progress in Human Geography* **28** 31–56

Baumgartinger-Seiringer S 2022 The role of powerful incumbent firms: shaping regional industrial path development through change and maintenance agency *Regional Studies, Regional Science* **9** 390–408

Beer A, McKenzie F, Blažek J, Sotarauta M and Ayres S 2020 *Every Place Matters: Towards Effective Place-based Policy* (Routledge)

BEIS 2022a Hydrogen transport and storage infrastructure A consultation on business model designs, regulatory arrangements, strategic planning and the role of blending Closing date: 22 November 2022

BEIS 2022b Cluster sequencing Phase-2: shortlisted projects (power CCUS, hydrogen and ICC), August 2022 URL: https://gov.uk/government/publications/cluster-sequencing-phase-2-eligible-projects-power-ccus-hydrogen-and-icc/cluster-sequencing-phase-2-shortlisted-projects-power-ccus-hydrogen-and-icc-august-2022 Accessed March 15, 2023.

Benner M 2024 System-level agency and its many shades: path development in a multidimensional innovation system *Regional Studies* **58** 238–51

Bijker W E and Law J (ed) 1994 *Shaping Technology/Building Society: Studies in Sociotechnical Change* (MIT press)

Binz C and Gong H 2022 Legitimation dynamics in industrial path development: new-to-the-world versus new-to-the-region industries *Regional Studies* **56** 605–18

Binz C, Truffer B and Coenen L 2014 Why space matters in technological innovation systems—mapping global knowledge dynamics of membrane bioreactor technology *Research Policy* **43** 138–55

Blažek J and Květoň V 2023 Towards an integrated framework of agency in regional development: the case of old industrial regions *Regional Studies* **57** 1482–97

Borup M, Brown N, Konrad K and Van Lente H 2006 The sociology of expectations in science and technology *Technology Analysis & Strategic Management* **18** 285–98

Boswell A 2022 *The Net Zero Teesside Project Planning Examination* 2021–2

Chapman K 2005 From ‘growth centre’ to ‘cluster’: restructuring, regional development, and the Teesside chemical industry *Environment and Planning A* **37** 597–615

Chinowsky P, Diekmann J and Galotti V 2008 Social network model of construction *Journal of Construction Engineering and Management* **134** 804–12

Comi A and Whyte J 2018 Future making and visual artefacts: an ethnographic study of a design project *Organization Studies* **39** 1055–83

Devine-Wright P 2022 Decarbonisation of industrial clusters: a place-based research agenda *Energy Research & Social Science* **91** 102725

Dosi G 1982 Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change *Research Policy* **11** 147–62

Furre A K, Meneguolo R, Ringrose P and Kassold S 2019 Building confidence in CCS: from sleipner to the northern lights project *First Break* **37** 81–7

Geels F W 2004 From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory *Research policy* **33** 897–920

Geels F W 2018 Disruption and low-carbon system transformation: progress and new challenges in socio-technical transitions research and the multi-level perspective *Energy Research & Social Science* **37** 224–31

Geels F W 2022 Conflicts between economic and low-carbon reorientation processes: insights from a contextual analysis of evolving company strategies in the United Kingdom petrochemical industry (1970–2021) *Energy Research & Social Science* **91** 102729

Geels F W, Sovacool B K and Iskandarova M 2023 The socio-technical dynamics of net-zero industrial megaprojects: outside-in and inside-out analyses of the Humber industrial cluster *Energy Research & Social Science* **98** 103003

Geoengineering Monitor 2024 Over-promising and under-delivering for half a century: CCS is still a risky and unproven technology 18 January 18 2024. URL: https://geoengineeringmonitor.org/geo-map-ccs-jan-2023 Last accessed: 12 October 2024

Gordon J A, Balta-Ozkan N and Nabavi S A 2022 Homes of the future: unpacking public perceptions to power the domestic hydrogen transition *Renew. Sustain. Energy Rev.* **164** 112481

Gough C and Mander S 2022 CCS industrial clusters: building a social license to operate *Int. J. Greenhouse Gas Control* **119** 103713

Greig C, Keto D, Hobart S, Finch B and Winkler R 2023 Speeding up risk capital allocation to deliver net-zero ambitions *Joule* **7** 239–43

Griffiths S, Sovacool B K, Del Rio D D F, Foley A M, Bazilian M D, Kim J and Uratani J M 2023 Decarbonizing the cement and concrete industry: a systematic review of socio-technical systems, technological innovations, and policy options *Renewable and Sustainable Energy Reviews* **180** 113291

Hansson A and Bryngelsson M 2009 Expert opinions on carbon dioxide capture and storage—a framing of uncertainties and possibilities. *Energy Policy* **37** 2273–82

Hassink R 2010 Locked in decline? On the role of regional lock-ins in old industrial areas *The Handbook of Evolutionary Economic Geography* **450**

Hassink R, Isaksen A and Trippl M 2019 Towards a comprehensive understanding of new regional industrial path development *Regional Studies* **53** 1636–45

Heidenreich M and Mattes J 2012 Regional embeddedness of multinational companies and their limits. A typology *Innovation and Institutional Embeddedness of Multinational Companies* 29–58

Herman K S 2024 Biden’s climate agenda: the most ambitious ever, or overlooking key technological bottlenecks? *Sustainable Futures* **7** 100209

Howarth R W and Jacobson M Z 2021 How green is blue hydrogen? *Energy Science & Engineering* **9** 1676–87

Hielscher S and Kivimaa P 2019 Governance through expectations: examining the long-term policy relevance of smart meters in the United Kingdom *Futures* **109** 153–69

HM Government 2021 *Industrial Decarbonisation Strategy (CP 399). London* https://assets.publishing.service.gov.uk/media/6051cd04e90e07527f645f1e/Industrial_Decarbonisation_Strategy_March_2021.pdf. Accessed: 6 July 2024

Hydle K M 2015 Temporal and spatial dimensions of strategizing *Organization Studies* **36** 643–63

IFS 2023 *Freeports: What are they? What do we know? And what will we know? The Institute for Fiscal Studies (IFS).* (Stuart Adam and David Phillips) 10 March 2023. URL: https://ifs.org.uk/publications/freeports-what-are-they-what-do-we-know-and-what-will-we-know. Last accessed: 16 October 2024
Konrad K, Markard J, Ruef A and Truffer B 2012 Strategic responses to fuel cell hype and disappointment *Technol. Forecast. Soc. Change* **79** 1084–98
Kriechbaum M, Posch A and Hauswiesner A 2021 Hype cycles during socio-technical transitions: the dynamics of collective expectations about renewable energy in Germany *Research Policy* **50** 104262
Kronsell A, Khan J and Hildingsson R 2019 Actor relations in climate policymaking: Governing decarbonisation in a corporatist green state *Environmental Policy and Governance* **29** 399–408
Labory S and Bianchi P 2021 Regional industrial policy in times of big disruption: building dynamic capabilities in regions *Regional Studies* **55** 1829–38
Latour B 1999 On recalling ANT *The Sociological Review* **47** 15–25
Latour B 2007 *Reassembling the Social: An Introduction to Actor-Network-Theory.* (Oup Oxford)
Lee D and Hess D J 2019 Incumbent resistance and the solar transition: changing opportunity structures and framing strategies *Environmental Innovation and Societal Transitions* **33** 183–95
McLaughlin H, Littlefield A A, Menefee M, Kinzer A, Hull T, Sovacool B K and Griffiths S 2023 Carbon capture utilization and storage in review: sociotechnical implications for a carbon reliant world *Renew. Sustain. Energy Rev.* **177** 113215
Meadowcroft J and Langhelle O 2009 The politics and policy of CCS: the uncertain road ahead. *Caching the Carbon: The Politics and Policy of Carbon Capture and Storage* Chap 11 p 267
Melton N, Axsen J and Sperling D 2016 Moving beyond alternative fuel hype to decarbonise transportation *Nat. Energy* **1** 1–10
Miller R, Lessard D R and Sakhrani V 2017 Megaprojects as games of innovation *The Oxford Handbook of Megaproject Management* 217–23
Miörner J 2022 Contextualizing agency in new path development: how system selectivity shapes regional reconfiguration capacity *Regional Studies* **56** 592–604
Molina-Morales F X and Martínez-Cháfer L 2016 Cluster firms: you'll never walk alone *Regional Studies* **50** 877–93
Nilsen T, Grillitsch M and Hauge A 2023 Varieties of periphery and local agency in regional development *Regional Studies* **57** 749–62
Ogwumike C, Akponeware A, Oyewole A, Dawood H, Pinedo-Cuenca R, Ling-Chin J and Dawood N 2024 Transitioning or tinkering at a net-zero economy? Introducing an assessment framework for industrial cluster decarbonisation in the United Kingdom *Energy Research & Social Science* **110** 103459
Oh S and Al-Juaied M 2024 Decarbonizing industrial hubs and clusters: towards an integrated framework of green industrial policies *Energy Research & Social Science* **118** 103777
Parfomak P W, Folger P and Vann A 2007 *Carbon Dioxide (CO_2) Pipelines for Carbon Sequestration: Emerging Policy Issues* (Congressional Research Service, Library of Congress)
Rattle I and Taylor P 2022 Decarbonising industry through industrial clusters: lessons from international experience (IDRIC) *University of Leeds* 12 September 2022
Rattle I and Taylor P G 2023 Factors driving the decarbonisation of industrial clusters: a rapid evidence assessment of international experience *Energy Research & Social Science* **105** 103265
Reuters 2024 Britain promises up to $28.5 bln for carbon capture projects. Susanna Twidale 4 October, 2024 https://reuters.com/sustainability/climate-energy/britain-promises-up-217-billion-pounds-cleaner-energy-2024-10-03/
Ruef A and Markard J 2010 What happens after a hype? How changing expectations affected innovation activities in the case of stationary fuel cells *Technology Analysis & Strategic Management* **22** 317–38
Sovacool B K and Geels F W 2021 Megaprojects: Examining their governance and sociotechnical transitions dynamics *Environmental Innovation and Societal Transitions* **41** 89–92
Sovacool B K, Geels F W and Iskandarova M 2022 Industrial clusters for deep decarbonisation *Science* **378** 601–4
Sovacool B K, Herman K S, Iskandarova M and Hall J K 2024b Oh Yes! Net-Zero': sociotechnical capabilities and regional innovation systems for British industrial decarbonization *Environmental Innovation and Societal Transitions* **51** 100852
Sovacool B K and Hess D J 2017 Ordering theories: typologies and conceptual frameworks for sociotechnical change *Social Studies of Science* **47** 703–50
Sovacool B K, Iskandarova M and Geels F W 2023a Bigger than government': exploring the social construction and contestation of net-zero industrial megaprojects in England. *Technol. Forecast. Soc. Change* **188** 122332
Sovacool B K, Iskandarova M and Geels F W 2024c Leading the post-industrial revolution? Policy windows, issue linkage and decarbonization dynamics in the UK's net-zero strategy (2010–2022) *Industrial and Corporate Change* dtae015 (https://doi.org/10.1093/icc/dtae015)
Sovacool B K, Iskandarova M and Hall J 2023b Industrializing theories: a thematic analysis of conceptual frameworks and typologies for industrial sociotechnical change in a low-carbon future *Energy Research & Social Science* **97** 102954
Sovacool B K, Del Rio D F, Herman K, Iskandarova M, Uratani J M and Griffiths S 2024a Reconfiguring European industry for net-zero: a qualitative review of hydrogen and carbon capture utilization and storage benefits and implementation challenges *Energy Environ. Sci.* (https://doi.org/10.1039/D3EE03270A)
Stephens A M and Sandberg J 2020 How the practice of clustering shapes cluster emergence *Regional Studies* **54** 596–609
Stephens J C 2015 Carbon capture and storage: a controversial climate mitigation approach *The International Spectator* **50** 74–84
Suchman M C 1995 Managing legitimacy: strategic and institutional approaches *Academy of Management Review* **20** 571–610
Sutherland F, Lawrance D, Legrand P and Wraith E 2022 Seismic monitoring for subsurface uncertainties at the Endurance CO_2 store *The Leading Edge* **41** 253–8
Swennenhuis F, Mabon L, Flach T A and De Coninck H 2020 What role for CCS in delivering just transitions? An evaluation in the North Sea region *Int. J. Greenhouse Gas Control* **94** 102903
Torvanger A and Meadowcroft J 2011 The political economy of technology support: Making decisions about carbon capture and storage and low carbon energy technologies *Global Environ. Change* **21** 303–12
Teesplan 1969 *Teesside Survey and Plan* Vol 1 (HMSO)
Turner K, Katris A, Karim Zanhouo A, Corbett H and Race J 2023 The potential economic value of increasing scottish CO_2 transport and storage capacity to service overseas export demand
Turnheim B 2022 Destabilisation, decline and phase-out in transitions research *Technologies in Decline* 43–77
Ungureanu P, Bertolotti F, Mattarelli E and Bellesia F 2019 Making matters worse by trying to make them better? Exploring vicious circles of decision in hybrid partnerships *Organization Studies* **40** 1331–59
Van Lente H 1993 Promising technology *The Dynamics of Expectations in Technological Developments*

Van Lente H 2012 Navigating foresight in a sea of expectations: lessons from the sociology of expectations *Technology Analysis & Strategic Management* **24** 769–82
Van Lente H and Bakker S 2010 Competing expectations: the case of hydrogen storage technologies *Technology Analysis & Strategic Management* **22** 693–709
Van Lente H and Rip A 1998 Expectations in technological developments: an example of prospective structures to be filled in by agency *De Gruyter Studies in Organization* 203–30
Van Lente H, Spitters C and Peine A 2013 Comparing technological hype cycles: towards a theory *Technol. Forecast. Soc. Change* **80** 1615–28
Voß J P, Smith A and Grin J 2009 Designing long-term policy: rethinking transition management *Policy Sci.* **42** 275–302
Warren J 2018 Industrial teesside's biography *In Industrial Teesside, Lives and Legacies* 51–86 (Palgrave Macmillan)
Weller S and Tierney J 2018 Evidence in the networked governance of regional decarbonisation: a critical appraisal *Australian Journal of Public Administration* **77** 280–93
Whyte J and Davies A 2021 Reframing systems integration: a process perspective on projects *Project Management Journal* **52** 237–49
Williams J 2024 Two founders of Teesworks regeneration project hit out at mayor Houchen *Financial Times* 26 April 2024. URL: https://on.ft.com/4c1Aov2