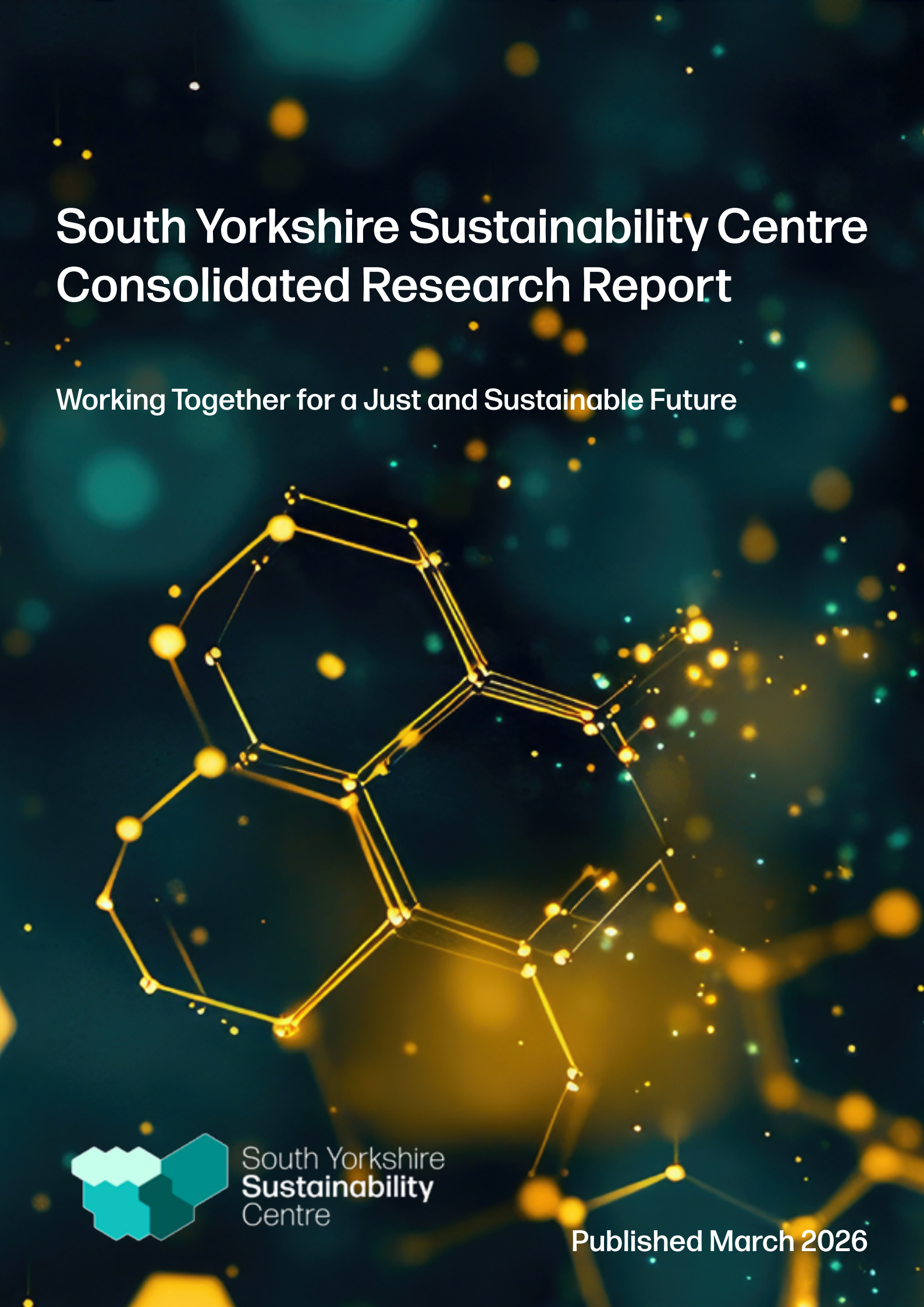
South Yorkshire Sustainability Centre Consolidated Research Report

Working Together for a Just and Sustainable Future



South Yorkshire Sustainability Centre

Published March 2026

Acknowledgements

The South Yorkshire Sustainability Centre is funded by the Research England Develpment Fund.

Our focus is on working collaboratively to identify and respond to regional sustainability challenges through research that is rooted in South Yorkshire.

We would like to thank our core partners for their continued support: South Yorkshire Mayoral Combined Authority, The University of Sheffield and Sheffield Hallam University.

Additionally we would like to thank the four South Yorkshire local authorities for their continued involvement with the centre: Barnsley Metropolitan Borough Council, City of Doncaster Council, Rotherham Metropolitan Borough Council and Sheffield City Council.

We believe the partnerships, collaboration and knowledge exchange we have built and fostered have contributed robust, data driven and evidence-based solutions to the region's sustainability challenges.

The South Yorkshire Sustainability Centre Consolidated Research Report is published by the South Yorkshire Sustainability Centre and and features confributions from academics and researchers from the University of Sheffield and Sheffield Hallam University.

With thanks to the SYSC central team:
Prof. Rachael Rothman, Sylvia Moffatt, Jess Thomas, Emily Williams, Simon Archer, Dr Meg Lewis, Nicola Ross and Alexander Fletcher.

Prof. Rachael Rothman welcomes attendees to the SYSC Summit, January 2026.

Rachael Orr from Climate Outreach delivers a keynote speech to the SYSC Summit, January 2026.

Foreword

Professor Rachael Rothman

As Academic Director for the South Yorkshire Sustainability Centre, I am incredibly proud of what we have all achieved together.

This report is the culmination of four years of hard work. However, the publication of this report is not the end and there is so much more that we could and should do together.

I am very excited to present this report showcasing the breadth and depth of the findings of the South Yorkshire Sustainability Centre. It seems like only yesterday, and yet also a lifetime ago, that we first started planning the Centre and asking how we could work together better across South Yorkshire to tackle the challenge of net-zero. What a lot we have achieved together since then.

We secured £5m funding from the Research England Development Fund in March 2022 to pilot a partnership model that aimed to **build stronger working relationships between the region's universities and public, private and third sector organisations.** The grant allowed us to establish a partnership that includes the two regional universities, the South Yorkshire Mayoral Combined Authority (SYMCA) and the four local authorities.

The core mission was to find successful mechanisms for co-producing interdisciplinary, place-based research that responds to real-life challenges in South Yorkshire. The goal was to produce research outputs that have real-world utility and can support regional actors to achieve their own strategic objectives. Whilst the South Yorkshire Sustainability Centre (SYSC) was focussed on supporting the region to **accelerate a just transition to net-zero**, the intention was always that the model and learnings could be applied to any challenge area such as public health or economic growth.

The funding enabled the delivery of a **large portfolio of sustainability research projects that were structured into the intersecting themes and work packages** shown in figure 1. Through these projects, we have been developing our transdisciplinary and collaborative practice whilst also seeking to deliver research findings that could tangibly support and enable South Yorkshire to **find decarbonisation pathways that are faster, fairer and supported by evidence that is rooted in place.**

The grant also provided £300k of flexible funding, which was generously matched by £600k from the South Yorkshire Mayoral Combined Authority. These **flexible funds enabled SYSC to be responsive** to the opportunities that were being identified through our interactions with partners, leading to exciting outputs such as the development of a soil carbon testing facility that will be used to support regional nature recovery, a collaborative demonstrator with the City of Doncaster Council analysing the indoor air quality impacts of retrofit, and the installation of a home heating demonstrator in the Gleadless Valley in collaboration with Sheffield City Council, Daikin and E.ON.

Such interdisciplinary and, moreover, transdisciplinary research is often not easy and we have learnt a lot over the past four years about how to successfully work together. **Facilitation of interactions and good communication between partners have been vital.**

This report comprises collections of policy briefs that distil key findings of our research portfolio. The report is structured so that our partners can engage selectively with the content; **each thematic chapter provides a summary of the centre's research as well as relevant policy analysis.** Following the summary, there are case studies that outline individual project findings as well as their scalability and regional relevance. Finally, for those wanting more granularity, each case study links to full findings and published research papers.

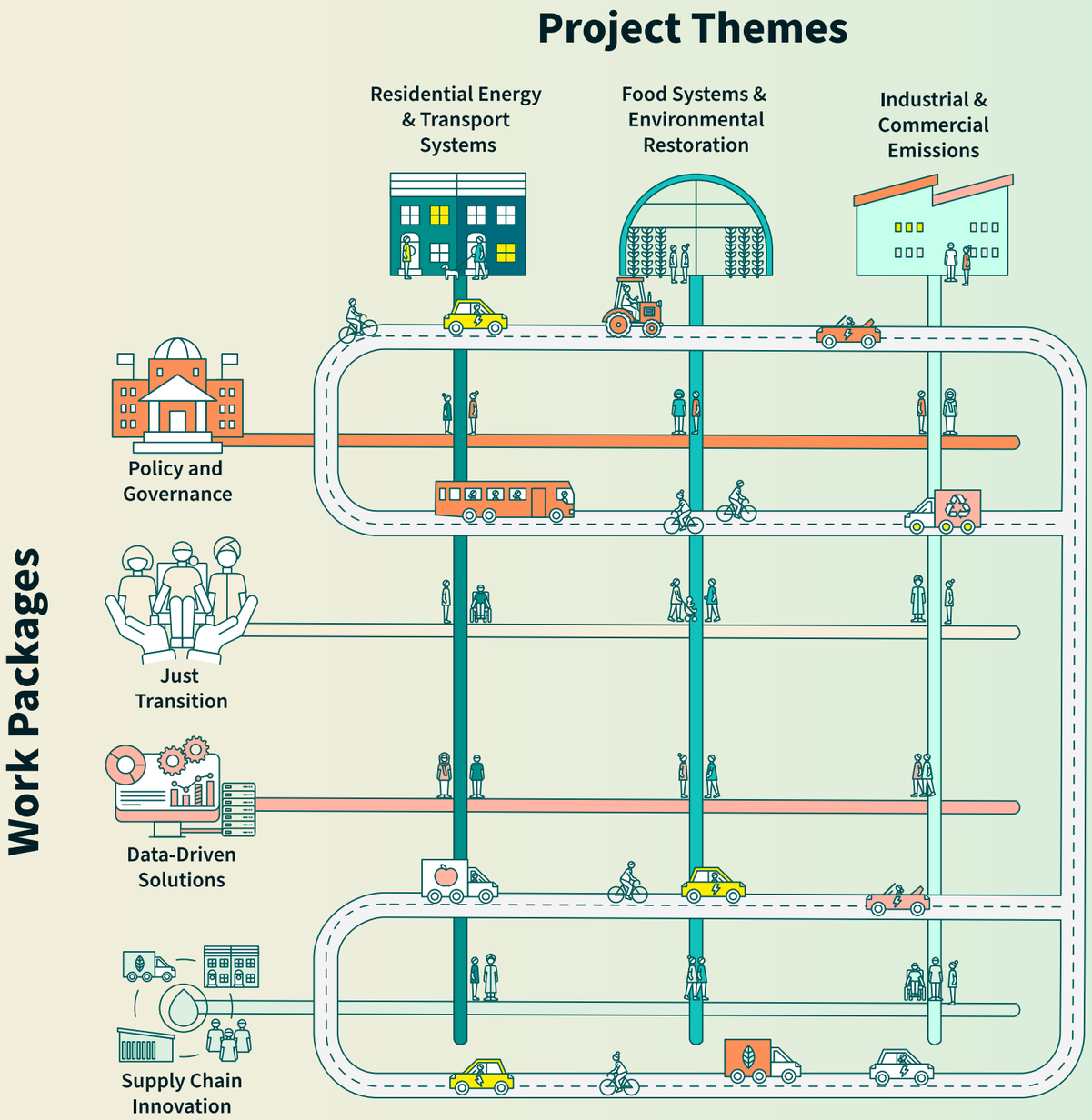


Figure 1: SYSC's organisational matrix showing the intersecting themes and work packages.

As I reflect on the last four years, I can't help but feel that the need for collaboration is even greater than when we submitted the SYSC bid. The world has grown significantly more volatile and uncertain since 2021 and net-zero goals can at times feel under threat. It is clear that the external environment has shifted and that we need to frame our research, and any future research projects, in terms that align with the policy environment; **this means talking about decarbonisation in terms of its co-benefits** i.e. affordable, warm homes, clean air, resilient businesses, healthy neighbourhoods, food security, good, green jobs etc.

I am also heartened by many significant leaps forward that have been made; the Great British Energy Act 2025 received Royal Ascent in May 2025, helping to establish Great British Energy as a publicly owned and operationally independent energy company with a mission to 'drive clean power deployment[1]; and the Warm Homes Plan, published early in 2026, sets clear commitment to ensure warm, safe and low-carbon homes to be the future of Britain.

South Yorkshire is also named as one of the advanced manufacturing clusters[2] in the UK's Modern Industrial Strategy. Furthermore, the Strategy recognised South Yorkshire's Investment Zone for growing the region's clean energy ecosystem[3]. The region's commitment to clean energy and green growth is further reflected in South Yorkshire Mayoral Combined Authority's Local Growth Plan vision, which focuses on these 'real sector strengths' of South Yorkshire[4].

Together we can seize these opportunities and build on the momentum provided by the central, regional and local government to design, test and implement effective interventions in South Yorkshire.

As Academic Director for the South Yorkshire Sustainability Centre, **I am incredibly proud of what we have all achieved together**. This report is the culmination of years of hard work. However, the publication of this report is not the end and there is so much more that we could and should do together. Whilst this report signals the end of the Research England period of funding, it is by no means the end of SYSC. And so I challenge readers, as they move through the report, to reflect on where research could support your own vital work and to reach out to SYSC. It is only through cross-sectoral collaboration that we can make a difference and **build a sustainable future together.**

How to use this Document

The 244 pages of this consolidated report contain the full breadth of our research portfolio, representing the findings across 34 projects delivered between 2021-2026. It has been divided into six thematic sections. Each section contains an in-depth overview of the challenges the region faces along with the SYSC research response. This is followed by recommendations for regional policy makers. Finally, each section then contains a series of detailed case study reports from our individual research projects.

The structure of this report mirrors the SYSC research themes, which were designed to respond to the challenges posed by South Yorkshire's highest emitting but most difficult to decarbonise sectors. While it is divided into six separate themes each section draws on interdisciplinary research representing the challenges as they are faced at a systemic level.

I hope you enjoy reading report and finding out more about what we have been doing. Do get in touch with us if you have ideas of how we can work together in future.

1 DESNZ (2025) Great British Energy Act 2025: factsheet.
2 UK Government (2025) The UK's Modern Industrial Strategy. Advanced Manufacturing Sector Plan.
3 UK Government (2025) The UK's Modern Industrial Strategy. Clean Energy Industries Sector Plan.
4 SYMCA (2025) South Yorkshire's Growth Plan. South Yorkshire's Vision for Business Growth and Greater Opportunity 2025-2035.

Executive Summary

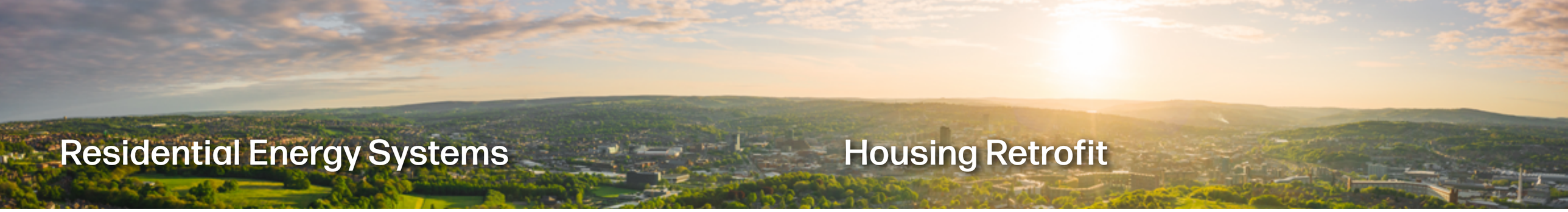
The research compiled in this report highlights the extent to which climate and environmental action is fundamentally a public health imperative. Our internal and external environment increasingly poses a risk to human health. Moreover, whilst action is often framed as too expensive, the climate crisis poses significant economic risks to households and businesses, which will increase in severity as we move closer towards 2 degrees heating above pre-industrial levels. This has been made plain in a recent report by the University of Exeter and the Carbon Tracker, Recalibrating Climate Risk.

However, as this body of research shows, climate action contains significant economic, social and environmental opportunities. With increasing devolution, there is unprecedented opportunity for regional action, ensuring that change responds to place and benefits the people of South Yorkshire. The combined recommendations in this report demonstrate that, to harness these opportunities at a regional level, we urgently need to collaborate across sectors and disciplines, build trust, and channel targeted funding towards activities that could accelerate the transition to more sustainable forms of operating such as participatory engagement, trials, pilots and demonstrators, professional networks and working groups.

Any green transition must also be a just transition if we want to achieve improvements in public health and regional prosperity. Taken together, our just transition research has demonstrated that justice and inclusion are not an add-on to the already urgent list of tasks to be delivered in South Yorkshire but can provide an approach and set of values that underpin climate action and drive meaningful change. These changes rely on adopting new ways of working with citizens, communities, businesses and workers, which underpin our recommendations.

The sections that follow give a brief overview of our research findings, which are outlined in more detail in the thematic chapters laid out in the table of contents. Within the chapters, you'll also find the policy recommendations that have emerged from the evidence.

We hope you take something useful from this report and urge you to get in touch with us at sysustainabilitycentre@sheffield.ac.uk if you want to discuss our findings in more detail, or have an exciting idea for more research.



Residential Energy Systems

SYSC's regional energy model shows that the increasing load from Heat Pumps and Electric Vehicle deployments will cause overload at 50% of both primary and secondary substations by 2050, requiring upgrades at a cost of £940 per customer.

Implementation of network-level smart controls could reduce the proportion of overloaded substations by 2050 from 50% to 35%, and defer the requirement to upgrade in other cases. This would reduce the required investment in grid upgrades by around £300 per household.

Domestic thermal storage could also help to relieve grid pressure by charging energy stores during off-peak periods and supplying homes with electricity during peak demand. Installing a 10 kWh thermal energy store into 1 million of the UK's estimated 30 million homes could provide up to 10 GWh of thermal storage alone. Current SYSC research is exploring whether storage and control technologies can also bring the cost of heating in line or below that of a gas boiler.

The SYSC Home Energy Survey has found that 46% of South Yorkshire residents surveyed did not have and did not want solar panels, 57% did not have and did not want heat pumps and 27% answered that they did not have and did not want smart heating controls.

Resistance to heat pumps correlated with income, indicating a perception that heat pumps are more expensive than gas boilers. Attitudes towards district heat networks (DHNs), were more positive.

The survey also indicates that the respondents' opinion of climate change is not a significant driver of domestic energy use; most energy saving action is motivated by a need or desire to reduce costs. The respondents said that their decision to join a DHN would be mostly influenced by cost savings (65%) and reliability (42%), with only 25% saying that they would join a DHN because it is better for the environment and only 13% would join to help reach the net-zero.

However, 75-86% of respondents were concerned that the UK wasn't investing enough in alternative energy sources quickly enough, that power cuts would become more frequent, and that the UK was becoming dependent on energy from other countries.

Community energy could stimulate public acceptance towards low carbon energy technologies and also provide a mechanism for keeping wealth in the region. This is demonstrated by the fact that 40% of Energise Barnsley investors are located in Yorkshire.

Housing Retrofit

SYSC research indicates that if South Yorkshire is to prioritise carbon reduction and align with the 1.5 °C net-zero climate target, its existing housing stock - approximately 609,000 homes, including around 480,000 houses and bungalows - would need to be retrofitted at a substantial pace.

Specifically, meeting the 2050 net-zero target would require the retrofit of approximately 19,200 houses and bungalows per year, rising to around 32,000 annually to achieve the more ambitious regional 2040 net-zero target.

To maximise carbon savings, homes with higher operational energy demands - larger pre-1920s homes - should be prioritised. In South Yorkshire there are 46,000 homes that are both above 100m^2 and constructed pre-1919.

A typical semi-detached house emitting ~2.5 tonnes/year of operation carbon for heating, would require 5.7 tonnes of embodied carbon for a whole-house retrofit leading to a carbon payback period of 2.28 years with the average payback periods being around 2-4 years.

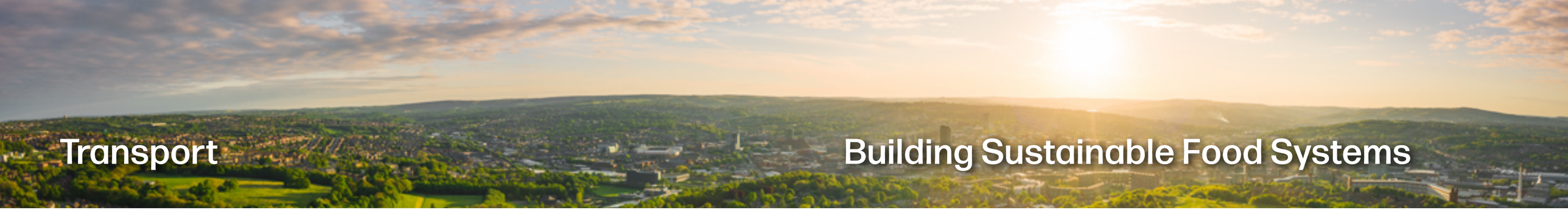
To avoid energy bill hikes, whole-house retrofit, including fabric insulation measures and replacing fossil fuel heating systems is the best option, ensuring highest carbon and cost savings. If whole-house retrofit is unfeasible due to high upfront costs, a fabric-first approach would yield more favourable economic and carbon savings results compared to a systems-first approach (electrification of home heating via heat pumps with no fabric alterations), which would result in high energy bills due to electricity being more expensive than natural gas.

4% of South Yorkshire homes in dense urban areas could benefit from being connected to a district heating network (DHN). DHNs utilising waste heat from industry and energy-from-waste is projected to save 3.5% of annual regional heating costs and reduce annual emissions by around 45,000 tCO_2.

Prior to connecting to a DHN, certain retrofit measures, such as loft insulation and cavity wall insulation would be cost effective and help to reduce energy costs.

Effective ventilation, passive or mechanical, is a key part of good retrofit - essential for ensuring indoor air quality and preventing overheating in future temperature rises scenarios.

Over 88% of respondents to our Home Energy Survey said that they set their thermostat to 18°C or higher, with 16.1% saying that they set it to 22°C or more. If energy bills decrease with increased efficiency, residents may just increase the thermostat, increasing the operational emissions. By increasing the heating set point from 18°C to 20°C, the average annual heating demands of existing homes could increase from 14,500 kWh/a to 21,500 kWh/a, a 48% increase.



Transport

In South Yorkshire, 2023 roadside monitoring in parts of Rotherham recorded peak annual average NO_2 concentrations of over 60 µg/m^3, which is more than six times the World Health Organization (WHO) guideline of 10 µg/m^3. Re-routing vehicle traffic using a pollution-optimal traffic assignment model (TA) can reduce congestion and achieve a 21% reduction in Sheffield-wide NO_2 concentrations, reducing the number of roads exceeding WHO recommended limits from 37% to 30%, whilst only increasing average journey time by ~20 seconds.

Traditional transport models often assume that travel time and monetary cost are the only determinants of modal choice. In reality, a range of factors such as comfort, convenience, safety, and reliability are equally influential. SYSC is developing a decision-support tool that models the complex dynamics between factors that determine people's transport choices. The tool will enable identification of specific roads and routes where current conditions and traffic patterns already create a high probability for people to choose walking or cycling over driving.

SYSC's e-cargo cycle research found a high economic feasibility in South Yorkshire's urban centres, in some cases across areas as large as 80 km^2, with average CO_2e emission reductions of 10.8 kg per delivery route. At scale, replacing one diesel van with an e-cargo bike performing three routes per working day would save around 8.2 tCO_2e per year.

Another SYSC's project assessed regional job accessibility using the current public transport network of South Yorkshire, taking 'communities' as populations within lower-layer super-output areas (LSOAs). It found that age is the most important predictor of transport affordability, with younger people struggling to meet their transport bills significantly more than older people. Across South Yorkshire, 32% of the total Barnsley region, 38% of the total Doncaster region, 35% of the total of Rotherham and 44% of the Sheffield region are likely to struggle to pay for transport.

Significant disparities emerge between those who rely on public transport and those with access to private vehicles. This is particularly true for those who don't live near high demand routes and/or work during 'off-peak' hours, often in low paid sectors such as warehouses and hospitals. The analysis shows that accessibility of employment sites via public transport drops significantly during these shift-change windows.

Building Sustainable Food Systems

Sheffield Hallam University's Advanced Food Innovation Centre (AFIC) places the value of South Yorkshire's local food and drink manufacturing industry at around £434 million, with roughly 170 businesses and about 9,000 jobs tied to food and drink production. Including agriculture, catering, retail and wholesale, the total "agri-food" sector accounts for £1.58 billion in economic output and 68,500 jobs in the region, representing 11.6% of all jobs.

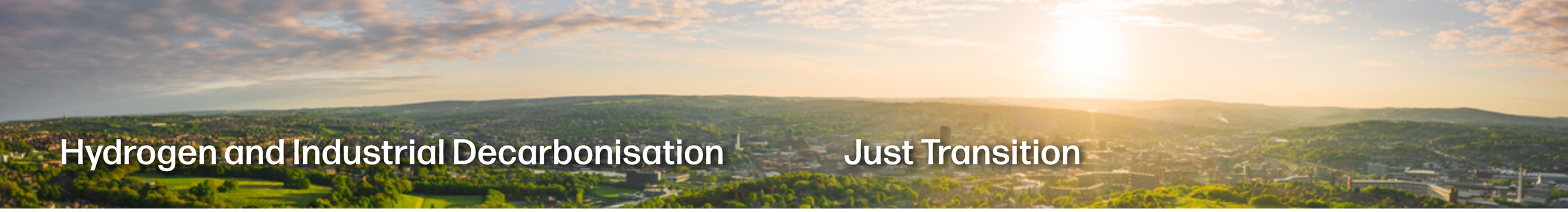
An SYSC study of 12 food manufacturers in South Yorkshire, representing 7.05% of the industry population, found that the annual total consumption of energy of all 12 businesses was 34.63 GWh. This amounts to 7.15 tCO_2e of operational emissions per year assuming that electricity generation follows the same grid energy mix contributions as the entirety of the Yorkshire region.

The emerging findings of our research project evaluating South Yorkshire's soil health suggest that regardless of land use, denser soils tend to store less carbon and that carbon decreases with depth, displaying declines in soil organic carbon (SOC) between surface soils (uppermost 10 cm) and lower depths – which is a typical pattern even in healthy soils. However, this decline was less obvious on land that is under conservation land management and on one site the total organic carbon stocks were greater than the UK national average.

The research also highlighted the vulnerability of surface soils to disturbances and compaction associated with unmanaged grazing, noting the importance of incorporating soil health assessments into grazing regimes for the mitigation of substantial carbon losses. With grazing farms being a predominant type in Yorkshire and the Humber, this is particularly relevant for the region.

We also found that remaining financially viable is the most pressing concern amongst farmers and, whilst many are willing to take some land out of production to participate in nature recovery schemes, to access funding and to support nature restoration, many felt driven to do this because of unstable markets for farm produce. Farmers and land managers need stable funding sources that support financial viability alongside pro-environmental interventions as well as support from trusted people and organisations to access and manage grants.

The South Yorkshire Food Network feasibility project surveyed 56 local businesses, policymakers and civil society organisations from all four local authorities in the South Yorkshire region to gauge regional need for the South Yorkshire Food Network. The survey demonstrated strong support, with high levels of perceived value, openness to change and depth of commitment. Survey respondents emphasised that any network would need to: have transparent governance and accountability, focus on practical outcomes and actionable objectives, add value to local initiatives, avoiding duplication. This vision was shared across all geographies and sectors.



Hydrogen and Industrial Decarbonisation

The steel industry in South Yorkshire has undergone significant change over the last 40-50 years. In 1971, 140,000 people were employed in the steel industry in Sheffield alone, accounting for half of all the city's jobs. In 1987 this number fell to 57,000 and continued to decline with only 15,000 remaining employed by the steel industry in the region by 2024.

Industry and manufacturing decarbonisation, especially of heat-intensive industries such as steel, ceramics and glass making, presents a substantial challenge that requires collaboration between local authorities, industry and academia to overcome. SYSC convened the Industry Decarbonisation Roundtables with key stakeholders and partners across the region - including SYMCA, Forgemasters, Marcegaglia, Ardagh Glass, Aggregate Industries, Chesterfield Special Cylinders, E.On, Cadent and others - to hold open discussions about key challenges and barriers to decarbonisation. These discussions revealed that the two most realistic pathways to decarbonisation are seen as electrification, followed by hydrogen. The main challenges to widespread hydrogen adoption were identified as the lack of clear, long term policy steer from the national government, high risk and operational and capital costs of hydrogen, hydrogen supply uncertainties, readily available volumes of hydrogen in the region and further large scale feasibility studies required.

SYSC research to ascertain hydrogen economy readiness benchmarked the hydrogen economy maturity of the UK against other G20 nations. The study found the UK to be one of the frontrunners, together with the US and China in hydrogen economy maturity. For the UK – and particularly regions such as South Yorkshire seeking to embed themselves in the hydrogen economy – this benchmarking provides insight into the country's competitive positioning relative to other G20 members

Although South Yorkshire is not within a hydrogen cluster at the moment, it is well connected to two large emerging hydrogen clusters at the Tees Valley and Hull, whilst also holding 0.37 GW (enough to produce ~1944GWh annually) hydrogen production capacity (albeit currently restricted by grid headroom availability). Still, SYSC's State of Hydrogen in South Yorkshire Report identified that the real strengths of the region and its leadership potential lies in hydrogen research, hydrogen use demonstrators and manufacturing for the hydrogen supply chain.

Another study utilised the regional optimisation model AENi to understand where hydrogen clusters could be established to achieve a cost optimal scale-up of hydrogen supply in South Yorkshire. The study considered 21 energy, heat and emission intense manufacturing companies of varying sizes in South Yorkshire. Although just an initial modeling exercise that requires further in-depth collaboration with partners, the project's findings show that a hydrogen network for industrial sites is likely feasible using existing electrical grid connections.

Successful hydrogen deployment depends not only on technical feasibility, but on societal and institutional readiness. Acceptance of hydrogen storage and distribution across different stakeholder groups within the region is broadly positive but strongly conditioned by perceptions of safety and risk. Across all stakeholder groups, safety emerged as the dominant determinant of acceptance with positive responses to enhanced monitoring and transparency. More than 80% of public respondents indicated that additional monitoring systems would increase their comfort with hydrogen storage and distribution. This suggests that visible, data-driven safety mechanisms can materially improve acceptance.

Just Transition

A just transition seeks to ensure that addressing the ecological emergency does not exacerbate existing inequalities, and instead seeks to reduce inequality through embedding inclusivity and equity within sustainability actions. This means supporting marginalised communities and sharing the benefits of transitions. It also requires recognition of the needs of current and future generations, for instance through providing space for youth participation as key stakeholders in a just transition.

Just transition is multi-faceted, requiring focus on fair distribution of costs and benefits, recognition of different identities, cultures and needs, and ensuring inclusive procedures for decision-making.

As well as practical challenges, there are cultural barriers to achieving a just transition, such as established ways of life: the daily rhythms and routines built around ways of heating homes, doing business, work, leisure and travel. These norms vary across generations and different households, reflecting complex emotional and behavioural responses towards what feels normal and acceptable for different people

South Yorkshire has already undergone significant change over the last 40 years, with the industrial change experienced during the 1980s and 90s being particularly difficult on some of the communities within the region. Tens of thousands of jobs were lost in the mining and manufacturing sectors. Today 20% of local areas in South Yorkshire are in the top 10% most deprived in England.

The region's industrial legacy also creates new challenges. Over 15% of workers in Yorkshire and Humber will need to reskill or find alternative employment as fossil fuel industries are being phased out and replaced by renewable energy sources. Recent research puts parts of the region among those most vulnerable to the economic implications of transition in the UK.

The transition to a low carbon economy also brings economic opportunities. For instance, clean energy has been identified as a key opportunity area for the region. Effective mechanisms will be required to ensure that the wealth created by such opportunities can be harnessed to provide opportunities to those that most need them, and to capture value for the region to invest in collective goods and services.

Residential Energy Systems

Challenge

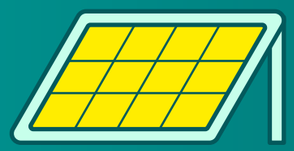
According to the National Audit Office, in 2021, the UK's 28 million homes accounted for 18% of all UK greenhouse gas emissions (GHGs)[1]. Most of those emissions derive from burning natural gas which is still used for heating and hot water in 86% of UK homes[2], with 90% of households having mains gas as the primary source of heating in South Yorkshire[3]. In the recently published Warm Homes Plan, the government aims to accelerate decarbonisation of home heating by tripling the number of solar panels by 2030 as well as increasing heat pump installation delivery to over 450,000 per year[4].

However, the vision of an electrified future for home heating is complicated by an electricity grid being under strain. Without significant reinforcement of the current national grid capacity, the nation-wide rollout of heat pumps and electric vehicles (EVs) will produce acute pressures for the grid. Whilst a typical house currently contributes 1 - 2 kW to peak demands, a heat pump by itself contributes around 2 kW, and a residential EV charger contributes around 1 kW. This leaves significant demand that needs to be met by South Yorkshire's electricity grid. However, SYSC's regional energy model shows that this increasing load from heat pumps and EV deployments will cause overload at 50% of both primary and secondary substations by 2050, requiring upgrades at a cost of £940 per customer.

There are also risks associated with the supply of electricity generated by renewable energy sources. The variability of solar and wind generation introduces fluctuations that complicate the integration of the power generated into the grid, which challenges system resilience. Even if the supply is secured, every kWh still carries high embedded impacts arising from manufacturing, raw materials extraction, and installation of renewable energy generators. Improvements in technology maturity are needed to reduce these impacts, such as the anticipated improvements in the efficiency of photo-voltaic cells for solar panels.

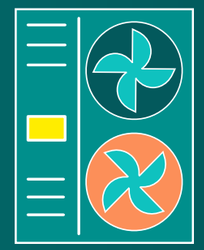
1 NAO (2024) Decarbonising home heating.
2 https://www.energy-uk.org.uk/fuelling-the-future/the-role-of-gas-heating-in-homes/
3 Carrick, J.and Wood, M. 2024. 'Consumption Habits: A report into household energy use in South Yorkshire'.
4 UK Government (2026) Warm Homes Plan.

The government aims to accelerate the decarbonisation of home heating



Triple the number of solar panels by **2030**

Increase heat pump installation delivery to over **450,000 p/a**

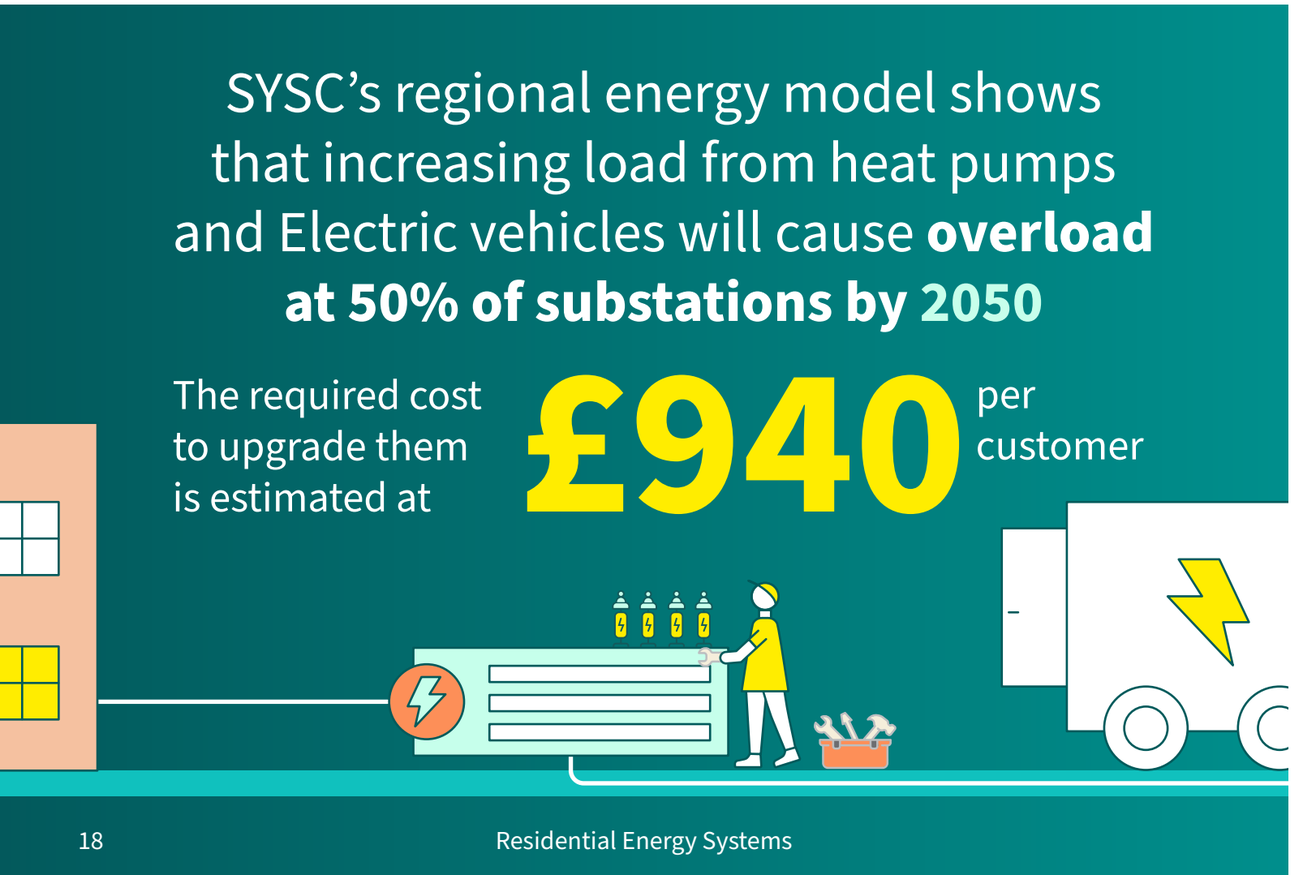


It is important to reduce overall energy consumption alongside any efficiency gains. In 2008, UK homes were kept, on average, 5 degrees warmer than they were in 1970[5]. Over 88% of respondents to the SYSC Household Energy Survey said that they set their thermostat to 18 degrees or higher, with 16.1% saying that they set it to 22 degrees or more. The same survey also found that, in South Yorkshire (as is elsewhere), energy use increased with income[6]. This may produce practical challenges as well as questions of equity as demand in more affluent parts of the city could cause surging grid pressure during peak hours.

Yet, we cannot expect all households to reduce their energy consumption to the same level due to differing needs; there is an issue of simultaneous overconsumption and underconsumption in the UK, with underconsumption being a particular issue in South Yorkshire. Fuel poverty within the region ranges from 14% (Rotherham, Sheffield) to 16% (Barnsley, Doncaster), according to 2023 data published by DESNZ[7].

Lastly, there is also a question of public acceptance of low-carbon home heating technologies. The SYSC Home Energy Survey has found that 46% of SY residents surveyed did not have and did not want solar panels, 57% answered that they did not have and did not want heat pumps and 27% answered that they did not have and did not want smart heating controls. Resistance to heat pumps was also correlated with income, indicating a perception that heat pumps are more expensive than gas boilers. Attitudes towards district heat networks (DHNs), however, were more positive once information about DHNs was given. The survey also indicates that the respondents' opinion of climate change is not a significant driver of domestic energy use; most energy saving action is motivated by a need or desire to reduce costs. The respondents said that their decision to join a DHN would be mostly influenced by cost savings (65%) and reliability (42%), with only 25% saying that they would join a DHN because it is better for the environment and only 13% would join to help reach the net-zero.

5 UK Government (2011) Great Britain's housing energy fact file.
6 Carrick, J.and Wood, M. 2024. 'Consumption Habits: A report into household energy use in South Yorkshire'. Sheffield: University of Sheffield, p.6.
7 DESZN (2025) Sub-regional fuel poverty in England, 2025 report (2023 data). Interactive map.



SYSC Research Response

SYSC research aimed to address these significant technical, social and economic challenges to support and enable the delivery of a fair and effective low carbon heating transition in South Yorkshire.

Our research showed that, without flexibility measures, ~50% of both primary and secondary substations in the region will require upgrade by 2050. We estimated that the cost of carrying out these upgrades stood at a staggering £940 per customer. Furthermore, SYSC research found that time-of-use tariffs (TOUTs) by themselves would be insufficient to alleviate distribution grid issues. Although they can accomplish savings to emissions and energy costs, large spikes in demand will still arise, and can actually increase in magnitude if consumers all respond simultaneously to off-peak price incentives.

SYSC explored other technological options, such as smart grid controls and domestic thermal storage as ways to enhance grid flexibility and alleviate increasing pressure. We found that smart grid controls, which can coordinate all heat pumps and EV chargers on a network, can reduce demand peaks for residential areas by around 21%. Implementing network-level smart controls could reduce the proportion of overloaded substations by 2050 from 50% to 35%, and defer the requirement to upgrade in other cases. This would reduce the required investment in grid upgrades by around £300 per household. Smart controls were found to be the most effective for EV chargers, which offer the greatest flexibility, whilst heat pumps can be left under full user control and still retain ~80% of the cost benefits, provided EV charging is under smart control.

Increased opportunity to charge EVs at work could further even out EV charging demand, cutting peaks by an additional 5%, for an additional saving in grid upgrade costs of around £65 per household.

Domestic thermal storage could also help to relieve grid pressure by charging energy stores during off-peak periods and supplying homes with electricity during peak demand. These storage options can be deployed in various ways, for example to address space heating (SH) or domestic hot water (DHW) needs within an individual dwelling, or to provide additional flexibility within communal heating loops. Local storage systems could have significant benefits across the network, avoiding grid constraints during periods of peak electrical demand. Although more research and optimisation is needed, initial findings show that thermal stores could be suitable for direct use for either domestic

hot water or low temperature space heating. The potential is significant; installing a 10kWh thermal energy store into 1 million of the UK's estimated 30M homes could provide up to 10GWh of thermal storage alone.

Whilst electrification will be the dominant form of heat decarbonisation nationally and in South Yorkshire, heat networks remain part of the optimal future energy mix solutions. The Warm Homes Plan sets the ambitious government target to more than double the amount of heat demand met via heat networks in England to 7% by 2035, with the expectation that they'll provide a fifth of all heat by 2050[8].

SYSC projects also explored the economic viability and decarbonisation potential for district heat networks and their expansion within South Yorkshire. The research found that, for 4% of South Yorkshire's housing stock, connection to a district heat network was economically viable. Viability depended on housing density and proximity to high demand customers such as hospitals and schools.

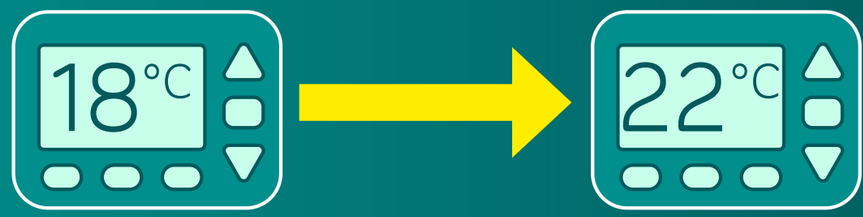
Researchers also applied different models of DHN development to the case study of Sheffield to understand how different policy approaches ('Profit-driven', 'Social Maximising' and 'Social-Leaning') might play out in terms of continuous network expansion and profitability. They found that a sustained growth trajectory was only possible under the Social-Leaning strategy, which describes centralised planning policies that balance commercial interest with social good. Network expansion under this strategy occurs in multiple phases over the 25-year simulation, enabling the development of larger, more integrated networks that connect a broader range of urban areas, achieving both the highest linear heat density (21,352 kWh/m/year) and the highest cumulative profit (£17.8M)

We also investigated the economic viability and achievable carbon reductions of different heat sources for the DHNs, such as waste heat and minewater. Utilising waste heat from industry and energy-from-waste is projected to save around 3.5% on the annualised cost of heating for the region, versus the scenario with pure electrification. Utilising these heat sources could also reduce annual emissions by around 45,000 tCO_2, or 3% of the total with electrification. Development of minewater sources was not found to be cost-optimal in this study with energy prices around 1.5p/kWh more expensive than electrification resulting in a rise of circa £200 per annum for a typical house. Minewater sources could enable further cuts to emissions provided efficiency is high but this has not yet been demonstrated.

8 UK Government (2026) Warm Homes Plan.

Over 88% of respondents to the SYSC Household Energy Survey said that they **set their thermostat to 18 degrees or higher.**

16.1% saying that they set it to 22 degrees or more



88% **16%**

of household energy survey respondents

Where dwellings are connected to heat networks, certain fabric retrofit measures are also recommended to implement beforehand. These recommended measures are loft insulation and cavity wall insulation. These measures reduce energy peak loads which leads to network savings of ~10%, as well as reduced energy costs. Floor insulation and solid wall insulation were found to be borderline cost-effective (cost of installation vs. operational savings and DHN infrastructure savings).

The current costs of running low-carbon energy systems are linked to electricity tariffs, the price of which is largely dictated by wholesale gas prices rather than the true cost of delivering electricity. This means that space heating using an Air-Source Heat Pump (ASHP) without other interventions - for example, fabric retrofit, thermal storage or use of TOUTs - can be higher than the cost of heating the same space with a gas boiler. This is a key barrier to increasing the uptake of ASHPs in the UK and in South Yorkshire. Thermal storage has the potential to deliver reduced operating costs for ASHPs without the costs and disruption associated with deep fabric retrofit.

The housing retrofit section of this report provides more information and covers the benefits, including carbon and energy cost savings of retrofit.

Just Another Transition

Although the task ahead might seem overwhelmingly complex, heating transitions are far from novel and have occurred more frequently within living memory than at any other point in human history[9]. While the primary goal of the current transition is to reduce greenhouse gas emissions from buildings, it is not the first time heating practices have been altered for environmental and public health reasons. For example, shifts away from coal toward cleaner burning fuels, such as natural gas, were largely driven by the need to improve air quality. History provides a rich body of experience that can inform today's move towards sustainable domestic heating systems. The JustHeat project explored

9 Ambrose, A., and Davies, K. (2024), Was the Past More Sustainable? Keeping Warm.

District Heat Networks

Modelling shows that District Heat Networks can connect up to **4%** of South Yorkshire's housing stock

Over a 25 year period they can also...

deliver up to
£17.8 m
in profit

reduce the region's emissions by around
45,000 tco_2

the challenges faced by communities with strong historical ties to fuels now being phased out. These fuels often shaped the very development of communities, with dominant industries like mining providing employment, housing, fuel and leisure, and creating lasting loyalties long after their decline.

The project highlighted key themes that can help us understand how we might build consent for contemporary heating transitions. Firstly, comfort and homeliness were central to how people used heat. Secondly, households layered heat sources (e.g. gas, electric, heaters, log burners) to maintain flexibility and security during periods of financial or supply uncertainty. The SYSC's Household Energy Survey also found that 29% of the respondents said they used an alternative source of heating with 80% reporting that they did so to save on the cost of their primary source of heating. Finally, place-based identities count, particularly in former coalfield communities where coal symbolised pride, work, security and belonging.

The JustHeat project also uncovered narratives amongst participants which suggested that trust in the state regarding energy interventions has traditionally been high in Sweden, compared to the UK[10]. At a regional level, the Household Energy Survey also found that 69.4% of respondents scored their confidence in local councils as a source of information about energy savings between 1 and 4, with 1 representing no confidence and 7 a lot of confidence. Confidence rates were no better for either the Department for Energy Security and Net Zero (DESNZ) or the South Yorkshire Mayoral Combined Authority. Recommendations from family and friends were also more likely to influence respondents' decision to join a heat network than recommendations from an energy supplier, Ofgem or their local council.

This lack of trust in established bodies was reflected in broader concerns about the energy transition, with the majority of respondents (75%-86%) also concerned that the UK wasn't investing enough in alternative energy sources quickly enough, that power cuts would become more frequent, and that the UK was becoming dependent on energy from other countries.

One of the mechanisms that could help to address these barriers to low-carbon heating transitions and earn social acceptance is community energy schemes.

Community energy is broadly defined as a project that includes some degree of community involvement in a sustainable energy activities, i.e. an activity that results in reducing emissions from energy use, either by green energy supply (replacing fossil fuelled energy with renewable energy) or reducing energy demand (e.g. installing energy efficiency measures).

SYSC research found that community energy schemes provide economic benefits for individuals as well as the region. Since 2004, the UK has been a net importer of natural gas[11]. Community energy could provide a mechanism for keeping wealth in the region, as demonstrated by the fact that 40% of Energise Barnsley investors are located in Yorkshire. Community energy schemes can also reduce residents' bills alongside the payment of community dividends.

Community groups can also provide mutual support and advice on how a healthy and sustainable 'bricolage' approach can improve thermal comfort, experience and resilience. There are some great examples of community led initiatives, which don't often reach the biggest energy users (more affluent households) but are engaging sensitively with more vulnerable households that would benefit most from the support. For example, the Upper Don Community Energy Groups' Community Warming Project.

Community energy could also act as a positive interface for political representatives and the civil service to build trust with South Yorkshire residents. Initiatives such as the Sheffield Energy Hub show how community energy can broaden engagement by linking private, public, and third-sector organisations.

Finally, to increase social acceptance and willingness to transition away from fossil fuels, the promotion and marketing of co-benefits, such as better health and more resilient, cheaper home heating systems should not be underestimated. SYSC research into twentieth century energy transitions shows how the public sector led the marketing of the transition from coal to gas by selling the considerable benefits to housewives (i.e. reduced workload), delivering a programme that converted 40 million appliances in 14 million households in just 8 years between 1969 and 1977.

There are of course differences between the post-war and contemporary context; in the post-war period, the public was more accepting or used to centralised control, governments could more easily control messaging and the gas transition offered a more tangible difference to lives such as whole-house heating or instant heating. However, there are also similarities: change was stimulated by public health and environmental concerns, the thermal experience changed, the transition increased energy bills for some, and, although heavily subsidised (70% from national and local authority schemes), incurred costs for the homeowner.

10 Ambrose, A. and Palm, J. (forthcoming) Cheap and warm vs cold and expensive: the very different histories of home heating in Sweden and the UK, Insights - The Conversation

11 UK Department for Energy Security and Net Zero (2025) Digest of United Kingdom Energy Statistics.

Residential Energy Systems Recommendations for Regional Policymakers

1. Local policymakers should **implement heat zoning policies to provide the certainty and scale needed to de-risk the development of district heating networks in deprived areas**, and to create the conditions for strong network growth, securing more connections and higher profits.

   i. Heat Network Zoning and the Alignment of Profit and Equity in District Heat Networks.

2. Local authorities, in partnership with Distribution Network Operators, should **pilot smart grid technologies in South Yorkshire's residential areas** to better understand their potential to help mitigate future grid overload.

   i. Demand Flexibility to Support the Electrification of Heat and Transport.

3. Local policymakers should **support cross-sectoral partnerships that can deliver regional innovation (including demonstrators) in smart storage and control electrified heating systems, alongside retrofit**, in order to demonstrate cost competitiveness with gas boilers and to expedite the availability of smart storage and control systems in the home.

   i. Novel Storage and Control Technologies for Decarbonisation of Domestic Heat.

4. To help address anticipated grid overload as the deployment of heat pumps and electric vehicles (EV) gain pace, **local policymakers should collaborate with energy suppliers and employers to develop a workplace EV charging offer** that could reduce peak demand in residential areas.

   i. Novel Storage and Control Technologies for Decarbonisation of Domestic Heat.

5. **Local policymakers should pursue a fabric-first approach to the heating transition so that heat pumps are only installed in thermally efficient buildings**, helping residents to maintain warm homes at affordable costs. This is essential for building public consent and tackling fuel poverty.

6. **Local policymakers should prioritise community ownership to build trust with residents and generate greater buy-in for electrified heat and electric vehicles (EV).** Community energy schemes provide a feeling of ownership, whilst also providing energy security and helping to lower the bills, which could increase the appeal of electric heating and electric vehicles. The evidence shows that community energy projects and groups can also build more positive relationships between communities and local authorities.

   i. Enabling Community Energy in South Yorkshire.

7. In recognition of the multiple benefits provided by community energy (beyond MWh generated), and in anticipation of central government investment such as the Local Power Plan, local policymakers should provide **long-term, consistent, financial and coordination support to community energy groups**. This should include taking responsibility for convening diverse actors from across the region via connected energy hubs (i.e. the Sheffield Energy Hub) and actively targeting the expansion of community energy schemes in the region.

   i. Enabling Community Energy in South Yorkshire.

8. Research shows that local histories, needs and conditions shape the way in which energy policy lands in practice. In collaboration with community organisations and research partners, **local policymakers should adopt a localised, tailored approach to developing Local Area Energy Plans and Regional Energy Strategic Plans**. See Just Transition Recommendations for Regional Policymakers for details on a proposed Living Transitions Programme.

   i. Towards a Faster, Fairer and more Popular Transition to Clean Heat in South Yorkshire.

9. **Local policymakers should prioritise the retrofit of off-gas-grid homes to support a fair and accelerated transition** for those communities that were left behind during the transition to gas. Prioritising those previously left behind is not only just but may also provide 'quick wins' as these communities are more likely to see a transition to electrified heat as an improvement.

Further Research Opportunities

Flexibility measures: Further research or trials should assess the impact of flexibility measures on energy costs and the energy market, as well as the network. Flexibility measures are also not without cost, so a full cost-benefit analysis is recommended.

Demand flexibility: Peer-to-peer (P2P) trading of power can incentivise the adoption of EV chargers and heat pumps with photovoltaic generation; trials and studies that combine smart controls with an element of P2P could analyse: the physical and digital infrastructure needed, the real-world effects on demand profiles, and real-world human behaviour, including ease of recruitment.

District heat networks: To better understand whether retrofitting prior to connecting a home to a heat network is economically viable, more real-world data collection is needed on thermal comfort, and the rebound effect following building fabric improvements.

Heat zoning planning: Future work could develop the existing analysis by incorporating additional real-world complexities, including multiple competing operators, evolving technology costs, fuel price volatility, and adaptive consumer preferences.

Community energy: More research should be conducted into inclusive models of participation and methods for capturing the wider impacts of community energy.

Retrofit

Challenge

In 2023, 1.6 Mt CO2e[1] of annual territorial greenhouse gas emissions were from domestic gas and electricity consumption in South Yorkshire. This was 25% of the total regional emissions in 2023. The Climate Change Committee (CCC), the government's advisory body, said the UK will not meet its emissions targets "without near complete decarbonisation of the housing stock[2]".

The government confirmed their commitment to the Future Homes and Buildings Standards to ensure that new homes have low-carbon heating, high levels of energy efficiency and solar panels by default[3]. However, considering that 80% of 2050's housing stock is already built[4], and that demolition is a better whole-life carbon option for only a very small subset of stock[5], there is an urgent need for housing retrofit on a national and regional scale to help to reduce household bills, cut carbon emissions, improve energy security and improve energy efficiency.

Currently, the energy efficiency of a dwelling is determined using the Standard Assessment Procedure (SAP), where energy consumption of the property is first estimated, then multiplied by the costs of energy and then divided by the property's floor area to give an energy cost factor per m2. Finally, this factor is converted to a scale from 1-100, where 1 is the least energy efficient and 100 indicates that the property has zero energy needs/costs. This scale is further divided into 7 bands (A-G), where A is given to the most efficient (92 and higher) and G to the least efficient (between 1 and 20) properties. These ratings are then used for the Energy Performance Certificate (EPC) rating accordingly[6].

The scale of the challenge is significant - 60% of homes in the UK are below an EPC band C. The combined average SAP score for South Yorkshire is 64.75, placing the region in Band D. Moreover, the current EPC assessment criteria is likely to become more stringent from mid-late 2026, with the new Home Energy Model, which is due to replace SAP[7]. Currently, EPC ratings are attached to energy costs from which energy efficiency is assumed. New standards will focus on establishing actual thermal and energy efficiency by assessing: fabric performance (insulation, draught-proofing, glazing standards), the efficiency of heating systems, smart readiness i.e. the use of smart meters and battery storage.

Retrofit is not solely a decarbonisation measure. There is a strong link between poor energy efficiency and the presence of damp and mould in homes. A 2007 meta-analysis showed a 30-50% increase in the likelihood of poor respiratory health for people living in homes with signs of dampness or mould[8]. In 2019, the presence of damp and/or mould in English residences was estimated to be associated with approximately 5,000 cases of asthma and ~8,500 lower respiratory infections among children and adults[9]. In South Yorkshire, around half of the SYSC's Household Energy Survey respondents said they had mould, mildew or damp in at least one room.

1 1 Mt = 1 000 000 tonnes
2 House of Commons Library (2024) Housing and Net Zero. Research Briefing.
3 UK Government (2026) Warm Homes Plan.
4 House of Commons (2025) Energy security and Net Zero Committee. Retrofitting homes for net zero.
5 Abbey, D., Arbabi, H. and Densley Tingley, D. (2025) Parametric contribution of building form to whole-life carbon decision-making. Royal Society Open Science, 12(7).
6 House of Commons Library (2025) Energy efficiency of UK homes.
7 Department for Energy Security and Net Zero (2025) Home Energy Model: replacement for the Standard Assessment Procedure (SAP). Consultation Outcome.
8 UK Centre for Moisture in Buildings (2019) Health and Moisture in Buildings.
9 GOV.UK. (2023). Understanding and addressing the health risks of damp and mould in the home.

The government's Department for Energy Security and Net Zero research programme 'Climate services for a Net Zero resilient world' found that a full fabric building retrofit (including wall and loft insulation, and double glazing with trickle vents) improved the consistency of indoor temperatures and reduced the presence of mould. Furthermore, the report calculated that these improvements would result in an increase of 12 Quality Adjusted Life Years (QUALYs) per 10,000 population, and a saving of around £0.3 billion to the NHS[10].

Retrofit is also a significant economic growth opportunity. The 2021 Heat and Buildings Strategy estimates that the transition to low-carbon buildings could add £6 billion Gross Value Added (GVA) and support 175,000 skilled jobs by 2030 and 240,000 skilled green jobs by 2035[11]. These estimates are also supported by more recent evidence. In February 2025, CBI Economics and Energy and Climate Intelligence Unit published The Future is Green: The economic opportunities brought by the UK's net zero economy report. The report found that the net zero sector grew 10.1% between 2023 and 2024, generating £83.1 billion in GVA, with each full time role generating 38% more in economic value than the average UK full time job[12].

One of SYSC's projects explored the opportunities and implications of pursuing Modern Methods of Construction (MMC) as a delivery system for regional retrofit. There is significant opportunity for growth in this sector; South Yorkshire has a strong array of MMC providers, 28 within 50 miles of Sheffield City region[13]. There are also existing commitments within the region to become leaders in MMC, and MMC forms a part of Sheffield's Housing Growth delivery plan (2025-2030).

There are clear advantages of MMC over traditional retrofit practice; more work is indoors, increasing productivity and improving working conditions; work places were found to be more inclusive environments for women; the required skillset tended towards generalist, problem solving skills, allowing entry from a more diverse range of careers; the shift to factory work means it's easier to positively manage the working environment and gives employees consistent commutes.

However, MMC does also risk creating repetitive, low paid work very different from the varied work that exists in parts of the construction sector. Factory work does also imply centralisation of functions, jobs are not located locally, with factory locations being based on transport links.

Overall, MMC retrofit may be easier for those outside of the construction sector to join, which is likely to be a significant benefit considering that, in the UK alone, 66,000 additional tradespeople per year are required to deliver retrofit at the pace and scale needed to meet decarbonisation goals[14].

10 Symonds, P. et al (2025) Health impacts of net-zero housing in England.
11 HM Government (2021) Heat and Buildings Strategy.
12 Energy and Climate Intelligence Unit (2025) The Future is Green: The economic opportunities brought by the UK's net zero economy.
13 Arcadis et al. (2020,) Sheffield City Region: Modern Methods of Construction (MMC) Audit: Eco System and Opportunity in the City-Region, p. 32.
14 PwC (2022), Green skills as an enabler of UK retrofit. Deep dive research report. PwC, p. 15

The scale of the challenge is significant

60%
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The combined average SAP score for South Yorkshire is **64.75**

This places the region in **Band D**

If made attractive, these new jobs could create an opportunity for previously excluded groups to enter the sector[15, 16, 17] and to enjoy improved working conditions compared to traditional construction.

Along with the opportunities to bolster economic growth and create good jobs, retrofit helps alleviate fuel poverty. Improving building fabric energy efficiency reduces heat loss and thus reduces energy needed for heating, and associated energy bills. Most homes in England use gas central heating (86%), while 9% rely on other fossil fuels[18], all of which have seen significant price increases in recent years due to volatile markets and geopolitical instability. The Office for National Statistics reported that 41% of their 2024 survey respondents claiming it was very or somewhat difficult for them to afford energy bills[19]. In South Yorkshire, a SYSC Household Energy Survey found 26% of respondents in the 12 months up to January 2024 claim it was extremely or somewhat difficult to pay their home heating bills[20].

Lastly, as global temperatures rise, maximum summer air temperatures in South Yorkshire could increase by up to +7.6 C (change from the baseline period 1981-2000) by the 2080s in high emissions scenarios[21]. With 2025 being the third warmest year in UK, and all top 5 warmest years on record happening within the last decade[22], our homes will need to adapt as the risk of overheating will

15 Macrorie, R. et al. (2024), 'Support Place-Based and Inclusive Supply Chain, Employment and Skills Strategies for Housing-Energy Retrofit', in A. Crowther et al. (eds) Strengthening European Energy Policy. Cham: Springer Nature Switzerland, pp. 73–85.
16 Littig, B. (2017), 'Good Green Jobs for Whom?', in S. MacGregor (ed.) Routledge handbook of gender and environment. London New York: Routledge (Routledge international handbooks), pp. 318–330.
17 CITB and Eunomia (2021), Building Skills for Net Zero. Industry insights and analysis. CITB, p. 193.
18 HM Government (2021) Heat and Buildings Strategy.
19 ONS(2024) Cost of living insights:energy.
20 J.Carrick and M.Wood (2024) Consumption Habits - A report into household energy use in South Yorkshire.
21 https://www.ukclimateresilience.org/wp-content/uploads/2020/12/sheffield-city-pack_august-2022.pdf
22 Carbon Brief (2026) Met Office: A review of the UK's climate in 2025.

A 2007 analysis showed a **30-50% increase** in the likelihood of **poor respiratory health** for people living in **homes with signs of dampness or mould.**

In 2019, the **presence of damp and/or mould in English residences** was estimated to be associated with approximately **5,000 cases of asthma** and **8,500 lower respiratory infections** among children and adults

become increasingly more likely.

Retrofitting South Yorkshire's Housing Stock

SYSC research indicates that if South Yorkshire is to prioritise carbon reduction and align with the 1.5 °C net-zero climate target, its existing housing stock—approximately 609,000 homes, including around 480,000 houses and bungalows—would need to be retrofitted at a substantial pace. Specifically, meeting the 2050 net-zero target would require the retrofit of approximately 19,200 houses and bungalows per year, rising to around 32,000 annually to achieve the more ambitious regional net-zero target by 2040.

To maximise carbon savings, homes with higher operational energy demands, e.g. larger pre-1920s homes, should be prioritised. Using the Verisk GPS database, there are about 46,000 homes in South Yorkshire that are both above 100m2 and constructed pre-1919.

Moreover, how retrofit is designed and implemented matters enormously from an economic, social and environmental perspective. A system-first approach - where fossil fuelled heating systems (gas boilers) are replaced with electrified heating systems (such a heat pump(HP)) - would deliver a 73% operational emissions reduction but would result, on average, in 10% higher energy bills. Although heat pumps are 3.5 times more energy efficient than gas boilers, the electricity tariff is 3.9 times higher than the gas tariff (2025 prices). This approach could further exacerbate already high fuel poverty levels; 15% of South Yorkshire households live in fuel poverty according to Office For National Statistics 2023 data[23], which is unevenly distributed across the region and significantly higher in communities facing multiple disadvantages.

Our research confirms that the highest savings in both operational carbon emissions (96%) and energy bills (85%, heating temperature setpoint of 20°C) would be achieved with whole house retrofit deployment. Whole house retrofit is defined as replacing the central gas heating system with heat pumps and installing all insulation measures (wall, roof, floor) as well as high performance windows, as recommended in the UK's Building Regulations.

If whole-house retrofit is unfeasible due to the upfront investment needed, then a fabric-first (installing insulation measures, such as external, internal, cavity wall, roof insulation, triple glazed windows, etc.) approach should, in the immediate term, be prioritised over a system-first approach (replacing gas heating with heat pumps only), as it would result in higher operational emissions reductions (85%), reduce bills and make homes warmer. There will however be a tipping point before 2040 when the electricity grid is sufficiently decarbonised that systems retrofit results in the lowest whole life carbon solution, due to the additional materials being used in fabric retrofit and their embodied impacts.

Retrofit is a critical element of building a reliable and efficient low carbon energy system, but every kWh saved still carries environmental costs arising from manufacturing, raw materials extraction, transportation, installation and maintenance of the retrofit materials and systems.

SYSC research has calculated that for a typical semi-detached house emitting ~ 2.5 tonnes/year of operation carbon for heating, 5.7 tonnes of embodied carbon investment is needed to achieve a whole-house retrofit leading to a carbon payback period of 2.28 years with the average payback periods being around 2 - 4 years.

Decarbonisation of the grid would lower the embodied carbon investment of retrofit materials further. If heat pumps were deployed and all fossil fuel electricity generation was replaced, the majority of Scope 2 emissions associated with heating the home would be mitigated. However, with the government ramping up heat pump deployment, setting an installation target of over 450,000 heat pumps per year by 2030[24], and Northern Powergrid expecting the number of heat pumps in South Yorkshire to increase from around 10,000 now to 360,000 by 2050[25], the environmental impact of these technologies needs to be better understood. According to the Heat Pump Association, in 2024, based on UK sales data, the most popular type of heat pumps were air source heat pumps, specifically air to water systems (~83% of total UK sales[26]), which work with traditional radiators or underfloor heating. These types of heat pumps are preferred due to their comparatively low cost and ease of installation. SYSC life cycle assessments of different heat pumps - air-source (ASHP), ground-source (GSHP), water-source (WSHP) and hydrogen-source (HSHP) - show that air-source heat pumps currently show the highest overall environmental impacts, particularly in relation to global warming potential, ozone depletion, and ecotoxicity. An SYSC study conducted environmental impact forecasting against the UK net-zero targets, which revealed that ASHP are likely to achieve the largest carbon emission reduction over time (97% by 2050), while GSHP, WSHP, and HSHP are expected to reduce by 94%, 95%, and 59%, respectively. Across all technologies, key environmental hotspots include the use of copper and steel, refrigerant leakage, and the reliance on fossil-based electricity in manufacturing.

Furthermore, the deployment of heat pumps

23 ONS(2025) Sub-regional fuel poverty data 2025 (2023 data).

24 UK Government (2026) Warm Homes Plan.
25 Northern Powergrid (2025), Northern Powergrid DFES Local Authority Level.
26 HPA (n.d) Annual Heat Pump Sales UK.

into thermally inefficient homes risks electricity supply issues, grid overload and increased consumer energy bills that would increase fuel poverty rates. Fabric retrofit is needed to help reduce carbon emissions in the interim (until full grid decarbonisation is achieved) but also to help manage peak demand spikes and to control the costs of space and water heating for the consumer.

The heating source type is also relevant when considering fabric-first retrofit measures. A SYSC study considered whether properties should be retrofitted prior to connection to a district heat network. It found that a certain amount of retrofit interventions proved to be cost effective (cost of installation vs. operational savings and District Heat Network (DHN) infrastructure savings) for homes connected to district heat networks - loft insulation, glazing upgrade and cavity wall insulation reduce network load by 10% and energy bills, assuming thermostat temperatures were not increased. However, floor and solid wall insulation were borderline cost effective. It is important to note that these measures would still reduce heat loss and so could be considered an important intervention for alleviating fuel poverty; this recommendation is the result of an economic analysis only.

Measures to reduce bills and make homes warmer should also be prioritised in lower income households i.e. relatively cheap and easy, fabric first measures, such as draft excluders and loft insulation. For example, the Upper Don Community Energy group's 'Community Warming' project[27] provides free energy efficiency measures such as draught excluders and door curtains to people in fuel poverty and/or with ill health associated with cold and damp homes.

Retrofit, Overheating and Indoor Air Quality

Improving building fabric energy efficiency by adding insulation and establishing an airtight envelope could make a building more vulnerable to overheating and could trap indoor air pollutants, if retrofit interventions do not integrate the necessary passive and active ventilation measures or if ventilation is not installed correctly. Poorly executed retrofit can also increase the risk of damp and mould, reducing indoor air quality.

Our research found that without adding mechanical ventilation and cooling bedroom spaces, pre-and post-retrofit housing archetypes exceed various building standards' overheating thresholds for 2050 projected weather conditions[28]. Reversible heat pumpss, which could provide both heating and cooling, would be an option to reduce peak temperatures, particularly in vulnerable households.

27 Upper Don Community Energy group's 'Community Warming' project https://www.udcommunityenergy.co.uk/cwp.html

28 University of Exeter (2025) PROMETHEUS: Probabilistic Future Weather Research Project.

The Office for National Statistics reported **41%** of their 2024 survey respondents claimed it was **very or somewhat difficult for them to afford energy bills**

In South Yorkshire, an SYSC Household Energy Survey found **26%** of respondents in the 12 months up to January 2024 claimed it **extremely or somewhat difficult to pay home heating bills**

Fabric retrofit also helps protect buildings from overheating and reduce grid demand. Homes with system-only retrofit or existing fabric construction are vulnerable to extreme summer temperatures and thus higher peak cooling loads, e.g. average of 31.2 kWh/day in 2050 weather. Fabric retrofit reduces this to 15.9 kWh/day.

However, fabric retrofit reduces background ventilation, which impacts temperature, humidity, CO2, particulate matter, volatile organic compounds and formaldehyde levels within homes. Most rooms in post-retrofit archetypes experience above the recommended indoor CO2 concentration levels (500ppm above outdoor) in cooler seasons. More research is being conducted in partnership with Doncaster City Council through a SYSC & Grantham Centre funded project that seeks to understand the health impacts that come with energy efficiency improvements, positive or negative.

Additional passive ventilation, e.g. trickle vents in windows, or mechanical ventilation, potentially with heat recovery, is recommended as part of retrofit measures in order to improve indoor air quality and help manage internal temperatures during hot weather.

The Rebound Effect

Real-world energy use and carbon savings from post-retrofit homes could significantly diverge from theoretical models due to occupant behaviour and individuals' comfort needs. The rebound effect describes an increase in occupant energy consumption as a result of increased efficiency and decreased costs.

An SYSC study explored the sensitivity of operational carbon emissions and energy costs to changes to heating and cooling temperature set points. The results show that by increasing the heating set point from 18°C to 20°C, the average annual heating demands of existing homes could increase from 14,500 kWh/a to 21,500 kWh/a, a 48% increase.

Over 88% of respondents to our survey said that they set their thermostat to 18 degrees or higher, with 16.1% saying that they set it to 22 degrees or more . If energy bills decrease with increased efficiency, residents may just increase the thermostat, increasing operational emissions (compared to SYSC modelling) and causing a greater risk of grid overload, particularly in affluent areas.

Therefore, we recommend a retrofit policy that integrates behaviour change design for energy consumption (e.g., education and reward programs), user engagement strategies, and provides necessary information about retrofit sensitivities in different archetypes.

Retrofit Recommendations for Regional Policymakers

1. In order to **maximise carbon** savings from retrofit programmes in an environment where both finances and grid capacity is constrained, **local authorities should prioritise the retrofit of larger, pre-1920 properties (over 100m2), and the associated engagement with able-to-pay groups.**

   i. South Yorkshire's Path to Net-Zero: A Case Study on Decarbonising Regional Housing Stock.

2. **Working with local providers, a whole house retrofit approach (fabric and system) should be taken to best manage peak electricity demand periods** (avoiding substation overload) and to control the costs of space and water heating for consumers. This will also reduce operational carbon emissions until the grid is fully decarbonised.

3. In parallel with retrofit deployments, **local policymakers should support the deployment of relatively cheap and easy measures to low income households that could reduce bills and make homes warmer.** Measures could include draft excluders and loft insulation, delivered in partnership with Community Energy groups.

4. Regional retrofit initiatives must ensure that all retrofit designs include adequate ventilation (passive or active) to ensure good indoor air quality, and to avoid exacerbating existing health inequalities. **Local authorities should continue to collaborate with universities to understand and model the health risks and necessary mitigations to ensure safe retrofit.**

   i. Retrofit for a Healthy Building in a Warming World.

5. Local authorities should work with partners to produce **seasonal public education campaigns that support communities to become more resilient to extreme heat** by promoting summertime ventilation practices and relatively cheap adaptations such as external shutters.

   i. Retrofit for a Healthy Building in a Warming World.

Further Research Opportunities

Heat pump supply chains: Future research should extend life cycle analysis to include recycling and end-of-life pathways, alongside socioeconomic modelling of job creation. A comparative cost–benefit analysis of reshoring versus importing under different grid scenarios would also provide valuable guidance for investment and policy decisions.

Retrofit work pathways: Further research could compare findings on work implications for Modern Methods of Construction (MMC) with other retrofit pathways, for example, retrofit delivered by large incumbent organisations such as energy companies, community-led retrofit and SME led retrofit.

Retrofit deployment: Following on from the Let Zero project, more research is needed to understand the drivers, barriers and opportunities for other user groups such as 'able-to-pay' or homeowners that would need financial support.

Public consent: More research is needed in South Yorkshire to better understand the barriers and resistance to adoption of retrofit measures and develop strategies to unlock public consent for retrofit action in the region, particularly in local authority properties that might be prioritised for retrofit.





Transport

Challenge

Domestic transport rose from 16% to 29% of UK territorial emissions, from 1990 to 2023, and has been the single biggest source of the UK's territorial emissions since 2014[1]. Provisional statistics for 2024 put transport at 30% of total emissions[2], a rise of 1% on 2023[3].

Reliance on private cars generates high levels of congestion, contributes significantly to regional greenhouse gas (GHG) emissions, and worsens air quality. In the UK, 68% of roadside NO_2 concentrations in 2023 originated from NO_x emissions from exhaust pipes[4]. In South Yorkshire, 2023 roadside monitoring in parts of Rotherham recorded peak annual average NO_2 concentrations of over 60 µg/m^3, which is more than six times the World Health Organization (WHO) guideline of 10 µg/m^3. Additionally, Sheffield City Council estimates that road transport in Sheffield is the *"most-significant overall single contributor"* to NO_2 emissions, citing around a 30% share of NO_x from motor vehicles[5].

Although the transition to electric vehicles (EV) will mitigate tail-pipe emissions, indirect emissions associated with car manufacture and the current grid energy mix will still occur. Electric vehicles still produce particulate matter pollution from tyres and brakes, affecting local air quality and ecosystems. Moreover, the carbon payback takes significant time. Life-Cycle-Analysis (cradle-to-grave) of battery EVs (BEVs) concluded that a medium-size car would need to be driven for 70,000 km before embodied and operational emissions fall below those of a vehicle with an internal-combustion-engine[6]. Given that Sports Utility Vehicles (SUVs), which are larger than a medium car, represented 71% of new electric vehicle registrations (an increase since 2021 of 28%)[7], the carbon payback will be even more delayed.

The 'autobesity' trend has social and practical implications as well as environmental. SUVs cause more road damage, more congestion, increase parking pressure, and pose significant safety risks to those who walk, wheel and cycle[8]. More generally, the requirement for on-street EV charging facilities may directly conflict with space for active travel lanes and bike/e-cargo cycle storage, not to mention adding demand that could cause grid overloading during peak times. Furthermore, the uptake of EVs could exacerbate social and economic inequalities. Considering the relatively high cost of an EV, and the need for a space for plug-in charging, they are more likely to be purchased by higher income households with off-road parking. The benefits of EVs are therefore unevenly distributed, whereas the costs of upgrading the electricity network to cope with the additional demand will be added to everyone's bills.

This shows that the reliance on private cars and conventional delivery vehicles, particularly in dense, urban environments needs to be reduced. However, the number of licensed vehicles in the UK is rising; in December 2024, there were 2,605,000 vehicles registered for the first time, an increase of 3% from the year before[9]. South

1 Department for Transport (2025) Greenhouse gas emissions from transport in 2023.
2 DESNZ (2024) 2024 UK Provisional Greenhouse Gas Emissions.
3 Department for Transport (2025) Greenhouse gas emissions from transport in 2023.
4 DEFRA (2025) Emissions of air pollutants in the uk – nitrogen oxides (nox).
5 Ivings, S., King, J.A., Roocroft, A., Ortiz, P., Willis, T., Martin, M.V., Arbabi, H. and Punzo, G. (2025) Origin–destination specific traffic emissions and data-driven NO2 pollution-optimal routing in urban environments. Environmental Modelling & Software, p.106813.
6 Styring, P., Duckworth, E.L. and Platt, E.G. (2021). Synthetic Fuels in a Transport Transition: Fuels to Prevent a Transport Underclass. Frontiers in Energy Research, 9.
7 Transport Environment (2025) UK's SUV Surge is Driving Up Road Risk and Costs - will HM Treasury Act?
8 Ibid.
9 Department for Transport (2025) Vehicle licensing statistics, United Kingdom: 2024.

Yorkshire's population is also due to rise from 1.4 million in 2025 to over 1.55 million by 2043[10], which could potentially increase the number of cars and congestion, particularly around urban centres.

This growing pressure on South Yorkshire's roads could be relieved by modal shifts for short distance journeys to minimise traffic congestion and improve air quality. Growing population density should also be seen as an opportunity to increase the use and economic viability, of public and active transport, and its infrastructure, in Sheffield, Rotherham, Barnsley and Doncaster. In line with national trends, South Yorkshire's population is also ageing, which only increases the need for efficient and reliable public transport. The Leeds Observatory data predicts that the number of 70-84 year olds (data not available over 84) will increase from 149,998 (2018) to 211,889 (2043)[11].

However, there are significant challenges to achieving modal shifts. A SYSC study on the recent history of transport in the UK, discussed how 'motornormativity' (a concept developed by Ian Walker and colleagues[12]) emerged from specific post-war policy choices that entrenched car use in the built environment. This trajectory was not always certain. In the 1930s, the Ministry of Transport sought the creation of around 500 miles of cycle paths alongside road building, inspired by the cycle lanes being created alongside new roads in the Netherlands. During this period, more miles were cycled than driven, although this was reversed by 1950 and the gap has widened ever since. It is worth noting that Amsterdam's trajectory has been famously different and the gap has widened. While Amsterdam opposed the vision of streets existing mainly for cars[13], the same did not happen in the rest of the world, Britain included[14].

Motornormativity has in many ways locked systems into car use. Research conducted in 2023, explored cycling experiences over the life course of a group of Sheffield based cyclists. The results showed that one of the key changes over the

10 Leeds Observatory (n.d.) Population projections.
11 Ibid.
12 https://doi.org/10.1504/IJENVH.2023.135446
13 BICYCLE DUTCH (2019) The battle for the Ferdinand Bolstraat.
14 Reid, C. (2017). How the Dutch Really Got Their Cycleways. Bike Boom. Island Press, Washington, DC.

Transport Emissions

Domestic transport has been the ***single biggest source*** of the UK's territorial emissions since **2014**

Percentage of transport in UK territorial emissions

16% in 1990 → **29%** in 2023

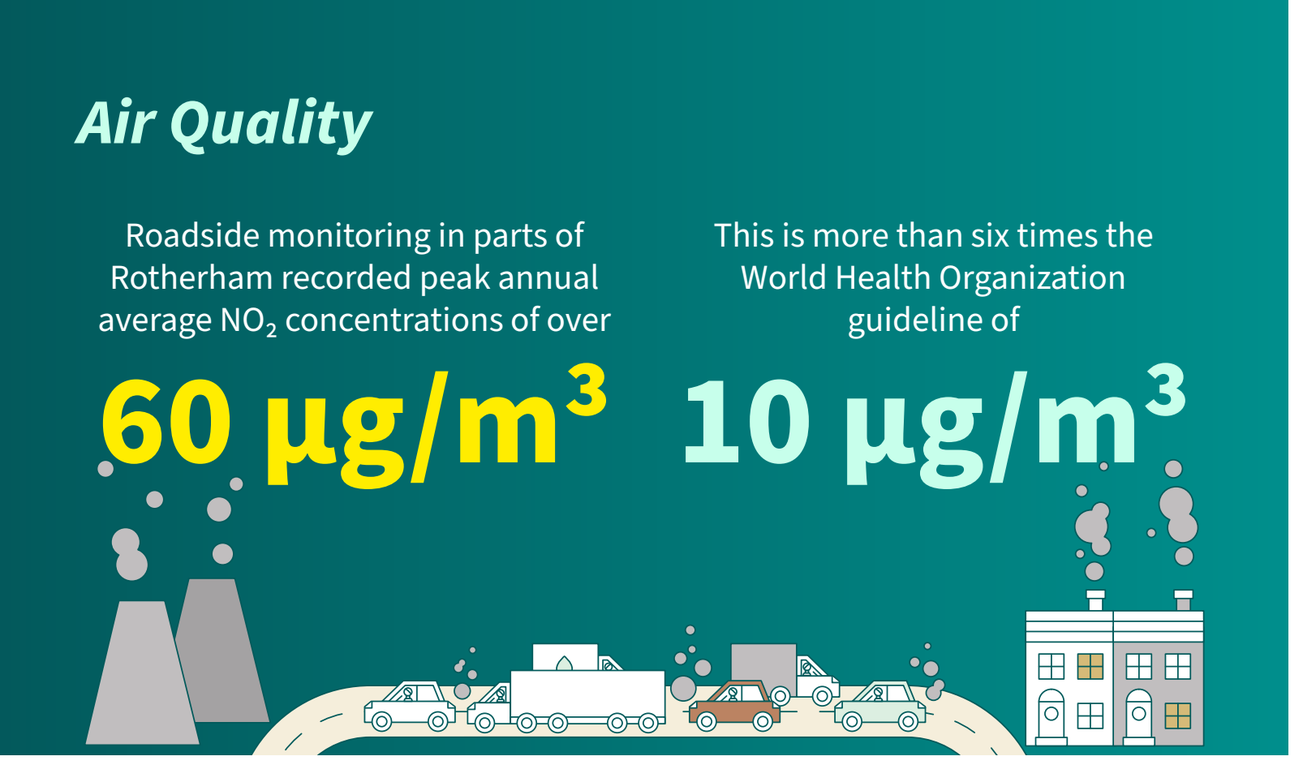
Provisional statistics for 2024 show a rise of 1% to 30% total emissions

1% in 2024

past decades was a perception that safety was worsening. Bigger vehicles, driving faster, and at times more aggressively, have contributed to a difficult environment for cyclists (and pedestrians) to navigate[15]. This perception is supported by the statistics. Whilst the proportion of fatalities for car drivers is declining (from 52% in 2004 to 45% in 2023), it is rising for pedestrians (from 21% in 2004 to 25% in 2023) and pedal cyclists (from 21% in 2004 to 25% in 2023)[16].

Furthermore, the congestion and street parking in city centres presents challenges for running reliable bus services[17]. Mobility and safety are also key to creating a vibrant local economy. Transport for the North (TfTN) attributes the 25% gulf in Gross Value Added (GVA) between the North and other areas of England to *"sub-optimal transport links and underinvestment in transport"*[18]. Accessible public transportation is at the heart of equitable societies; residents having equal opportunity to travel when, where, and how they want, at affordable costs. Moreover, high quality, high connectivity transport networks support regional development and regional economic growth. To determine how accessible and affordable the current public transport (PT) system is in South Yorkshire, SYSC assessed regional job accessibility using the current PT network of South Yorkshire, taking 'communities' as populations within lower-layer super-output areas (LSOAs).

15 Parkes, S. and Rafalowicz-Campbell, M. (in preparation) Cycling past and present: an oral histories approach in Sheffield, UK.
16 Ibid.
17 Sheffield City Council (2024) Connecting Sheffield: Abbeydale Road and Ecclesall Road.
18 Transport for the North (2019) Northern Powerhouse: Independent Economic Review Core Messages.



The study extracted three key metrics: (1) how many direct routes exist between all pairs of LSOAs; (2) modelled time spent travelling; and (3) minimum number of changes required to assess accessibility. It merged this analysis with SYSC's Energy Decadence project survey which provided five key outputs for this study: (1) age; (2) working status; (3) income; (4) education level, and; (5) whether or not respondents are struggling to pay for their transport bills.

We found that age was the most important predictor of transport affordability; younger people struggle to meet their transport bills significantly more than older people. Across South Yorkshire, our modelling predicted 32% of the total Barnsley region, 38% of the total Doncaster region, 35% of the total of Rotherham and 44% of the Sheffield region were struggling to pay for transport.

We also found that significant disparities emerge between those who rely on public transport and those with access to private vehicles. This is particularly true for those who don't live near high demand routes and/or work during 'off-peak' hours, often in low paid sectors such as warehouses and hospitals. The analysis shows that accessibility drops significantly during these shift-change windows.

Whilst public transport plays an important role in reducing GHG emissions and congestion as well as providing equitable access to workplaces, increasing active travel could play a significant role in improving public health (life expectancy for men and women in South Yorkshire is two years lower than the national average for England[19]), which also drives productivity. Still, care must be taken in the way that policies are designed to avoid a further entrenchment of motor-normativity and existing inequalities. For instance, a push to implement on-street EV charging infrastructure could affect pavement accessibility[20], hindering the government's targets for 50% of all the journeys to be completed via active travel methods such as walking, wheeling or cycling by 2030[21].

There is a need to uphold the rights of those who walk, run and wheel otherwise a 'green' EV policy may inadvertently entrench car use further. However, the EV transition also presents opportunities for community energy groups to co-own EV charging points so that financial benefits are retained locally, offsetting potential negative impacts and fostering a sense of local ownership.

19 NHS South Yorkshire (2025) A review of the health of South Yorkshire's population.
20 Possible (2023) Electric vehicle charging rollout poses growing threat to walking and wheeling targets and disabled access, warn charities.
21 Active Travel England (n.d.) About us.

Response

SYSC's research asked how we might build a more sustainable and equitable transport system that supports a thriving economy, society and environment. Whilst it is clear that private cars and vans will play a continued role in the transport systems of the future, it is only with fewer cars on the road, driving fewer miles, that we can deliver significant improvements in reducing carbon emissions whilst improving air quality, journey times and journey experiences.

The core question is how to facilitate modal shifts to active travel or public transport for a proportion of journeys. Traditional transport models often assume that travel time and monetary cost are the only determinants of modal choice[22]. In reality, a range of factors such as comfort, convenience, safety, and reliability are equally influential. Public transport users consider wait times and proximity to bus stops; active travel users are sensitive to hills, weather, and the availability of safe cycle routes.

SYSC is developing a decision-support tool that models the complex dynamics between factors that determine people's transport choices. The project seeks to understand the relationship between the enjoyability of a journey and the priority placed on the duration of the journey. The hypothesis posits that when a person's experience of moving is higher quality, they place a lower priority on time taken (within reason). An increasing positive experience of different travel modes helps broaden a person's alternative modal choice and increases the likelihood that they will select an alternative form of transport to the private vehicle.

Using the tool, it will be possible to pinpoint specific roads and routes where current conditions and traffic patterns already create a high probability that people will choose walking or cycling over driving. This shows us where the shift away from cars is already most likely to happen based on the real-world behaviour of the traffic network. Once the tool has been optimised, the project team will produce a series of scenarios tailored to regional priorities, such as:

- Shifting commuting trips from cars to public transport through service frequency improvements.

22 McFadden, D. (1974), 'The measurement of urban travel demand'. In: A. A. P. D. Hensher and P. R. Stopher (eds.), Behavioural Travel Demand Modelling. Lexington Books, pp. 279–318

- Designing active travel corridors between key employment centres and residential areas.

- Testing the impacts of low-traffic zones or car-free city centre policies.

There is also a need to explore opportunities for modal shifts from commercial delivery vans. SYSC funded interdisciplinary research to investigate the technical viability for e-cargo cycle deliveries across South Yorkshire as well as the socio-economic barriers to their adoption.

A modelling exercise found that there is great potential for e-cargo cycles to replace a significant proportion of last-mile deliveries in South Yorkshire's urban areas, especially where there is a high density of businesses and housing. Feasibility was found to be particularly high in Barnsley and Rotherham; across the areas of 80 km_2, e-cargo cycles still take less time than vans, despite making a mean of 5.9 and 6.2 subtours (between which more packages are picked up from the depot). In Sheffield, e-cargo cycles outperformed vans no matter the number of stops when the delivery area was 16km2 or less. In Doncaster, feasibility is high for e-cargo cycles up to 12 stops but is always outperformed by a van after 26 stops. This is due to lower business density and faster arterial routes that favour vans.

Whilst the modelling demonstrated strong potential for e-cargo cycle deployment, the accompanying qualitative research found significant challenges such as business resistance to change, the safety and security of both riders and e-cargo cycles, as well as a lack of local authority resources to support the transition. However, a clear role for local government emerged, alongside continued commitment to invest in cycling infrastructure; supporting the normalisation of e-cargo cycles through trials and their incorporation into internal fleets , with one interviewee noting *"People are not going to start seeing this as an alternative unless they start seeing them"*.

The combined study shows that there are strong use cases for Small and Medium-sized Enterprises (SMEs) and for certain delivery types (i.e. small parcels, groceries, medicines, documents). There could be additional value for those positioning themselves as sustainable businesses to their customers. Larger companies may also find value in partial adoption, with e-cargo cycles complementing vans for some types of deliveries.

Equitable Transport

Transport for the North attributes the **25% gulf in Gross Value Added** between the North and other areas of England to **"sub-optimal transport links and underinvestment in transport"**

Across South Yorkshire, our modelling predicted that

32% of Barnsley residents

35% of Rotherham residents

38% of Doncaster residents

44% of Sheffield residents

were struggling to pay for transport

This could reduce congestion pressure and improve air quality in dense urban areas.

Whilst some journeys can and should be shifted to alternative modes of transport, motorised vehicles will remain a significant part of the transport system. Therefore, policy and technical innovation is needed to temper the social and environmental costs associated with private and commercial motorised vehicles.

Researchers at The University of Sheffield found that re-routing vehicle traffic using a pollution-optimal traffic assignment model (TA) can reduce congestion and achieve a 21% reduction in Sheffield-wide NO_2 concentrations, reducing the number of roads exceeding WHO recommended limits from 37% to 30%. Traffic re-assignment could also reduce the number of roads exceeding 20µg/m3 - a level associated with elevated long-term health risks[23] - from 8% to 5%. Moreover, these gains are not accompanied by significant time penalties for drivers - the average increase in journey times is just ~20 seconds showing that health and environmental benefits don't need to come at the cost of major inconvenience.

Regional traffic policies may be implemented to encourage drivers to take the pollution-optimal routings. However, the transition to EVs will present new air pollution challenges; Particulate matter (PM) 10 and 2.5 from road, brake and tyre wear will increase due to the increased weight of EVs (compared to conventional vehicles) caused by large batteries[24], although advances in regenerative braking may eventually reduce pollution[25].

23 WHO (2021) WHO Global Air Quality Guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide, World Health Organization, Geneva.
24 Parkes, S. and Rafalowicz-Campbell, M. (in preparation) Cycling past and present: an oral histories approach in Sheffield, UK.
25 Liu, Y., Chen, H., Gao, J., Li, Y., Dave, K., Chen, J., Federici, M. and Perricone, G. (2021). Comparative analysis of non-exhaust airborne particles from electric and internal combustion engine vehicles. Journal of Hazardous Materials, 420(126626), p.126626.

Transport Recommendations for Regional Policymakers

1. Working in collaboration with researchers, businesses and communities, local policymakers should include **communication and engagement campaigns that actively tackle 'motor-normativity'** in their delivery plans for promoting public and active transport. This should include creating **explicit statements of the benefits of multi-modal transport** in order to build public understanding of, and acceptance for, the need for change.

2. Planning departments should **change their focus from the optimisation of the flow of vehicles to the flow of people**, to give greater priority to alternative modes of transport that could deliver a more sustainable transport system, as well as a better experience for South Yorkshire's residents.

3. Acknowledging that transport-related economic and social exclusion limits regional growth ambitions, **local policymakers should use the transition to public control of buses by 2027 to implement an equity-based approach to service provision (in contrast to demand-driven models). This should occur alongside the introduction of a simplified distance-based fare structure** that eliminates the financial penalty of transferring between services.

   i. South Yorkshire's Public Transport Network and Distributive justice: Which Communities Face Poor Job Opportunities?

2. SYSC research has shown high feasibility for e-cargo cycles to replace last-mile deliveries in South Yorkshire's urban centres. **Local policymakers should work collaboratively with potential local providers** (such as a Different Gear, Evoloce or Russell's Bicycle Shed (all Sheffield based)) **to create a coherent, resourced, South-Yorkshire-wide e-cargo cycles scheme** that provides: a try-before-you-buy fleet, business change support, and support accessing subsidies and grants. In parallel, investment is needed in infrastructure such as sufficiently wide, segregated lanes, strategically placed distribution hubs and parking and storage facilities.

   i. Modelling the Impact of e-cargo Bikes for Last Mile Deliveries in South Yorkshire.

   ii. E-cargo Cycle Schemes: Lessons for Policy Design.

3. Regional transport planners should **include air quality as a design factor when developing local traffic policies** (i.e. speed limits or traffic light timings) as pollution optimal routing could reduce NO2 concentrations on major roads without significant increases to journey times (~20 seconds).

   i. Improving Air Quality: Re-Routing Sheffield's Commuting Cars Could Reduce City-Wide NO2 Concentrations by 21%.

Further Research Opportunities

The impact of EV charging infrastructure on urban spaces and accessibility, particularly conflict with walking, wheeling and cycling.

Factors influencing EV adoption beyond charging infrastructure - such as cost, range anxiety, vehicle choice, sensory (i.e. sound and feel of a petrol or diesel engine).

Best practices for integrating active travel, public transport, and EV use.

Effectiveness of various nudging techniques to promote sustainable transport.

The impact of urban planning and policy on travel behaviour and mode shift.

Research to understand the potential for regional policies to accelerate EV adoption.





Building Sustainable Food Systems

The Challenge

It is estimated that the climate impact of the food system is such that, even if fossil fuel emissions were eliminated immediately, a business-as-usual food sector would put the target of restricting global warming to 1.5°C, or even 2°C, out of reach[1].

Unless there are major reductions to the climate impact of the global food system, including large scale decarbonisation and landscape restoration, we are unlikely to meet the central goal of the Paris Agreement in 'holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C'[2]. The Intergovernmental Panel on Climate Change (IPCC) predicts that even if warming is restricted to 1.5°C, it would be enough to destabilise whole ecosystems and impact weather patterns[3]. This calls for urgent action from all actors across the global food system to work together to limit the impacts of global temperature rises on climate and nature systems while preparing to adapt to coming weather uncertainties to build resilient food and nature systems fit for the future.

At the South Yorkshire Sustainability Centre (SYSC), our response to the food system emergency has been two-fold; to think globally - within the sustainable development framework laid out by the UN[4] - and to work locally with partners to build knowledge and capacity within our region around how to make South Yorkshire's food system, and the landscape it resides in, more sustainable.

South Yorkshire's Natural and Food System Landscape

The Natural Capital Solutions (NCS) report states that South Yorkshire covers 1,552 km^2 area and has a diversity of habitats within its boundary, but is dominated by improved grassland in the west and arable land in the east (44%)[5], with lowland areas around Doncaster and Barnsley supporting much of the farming activity. Although data for the South Yorkshire region only is not publicly available, according to OS MasterMap data for South Yorkshire, the area of agricultural land is 79,269 hectares (ha). South Yorkshire is included in the Yorkshire and the Humber geographical area for the Department for Environment, Food and Rural Affairs (DEFRA) agricultural statistics, which state that in 2024 the average farm size in the Yorkshire and the Humber region was about 91 ha, slightly above the English average of 87 ha. Around 26% of farms are 100 ha or larger, with most of the agricultural land area contained in these larger holdings. Smaller farms (less than 20 ha) are less prevalent by area, though more common in number. The predominant farm types were grazing livestock (41%) and cereal (20%) and the region's total income from farming was £582 million, with the average income per farm of £50,700 (a 43% decrease from the previous year)[6].

Whilst regional agriculture contributes to the rural economy through food production and related employment, South Yorkshire's food and drink manufacturing sector is an equally important

1 Clark, M.A., Domingo, N.G.G., Colgan, K., Thakrar, S.K., Tilman, D., Lynch, J., Azevedo, I.L. and Hill, J.D. (2020). Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. Science, [online] 370(6517), pp.705–708.
2 UNFCCC (2015). Paris Agreement. United Nations.
3 IPCC (2018). Summary for Policymakers — Global Warming of 1.5°C. IPCC.
4 UNSDG (2019) UNITED NATIONS SUSTAINABLE DEVELOPMENT COOPERATION FRAMEWORK.
5 NCS (2021) South Yorkshire natural capital and biodiversity mapping.
6 DEFRA (2025) Agricultural facts: Yorkshire and the Humber region.

part of the regional food system. A report carried out on behalf of Sheffield Hallam Advanced Food Innovation Centre (AFIC) places the value of the local food and drink manufacturing industry at around £434 million, with roughly 170 businesses and about 9,000 jobs tied to food and drink production. Including agriculture, catering, retail and wholesale, the total "agri-food" sector accounts for £1.58 billion in economic output and 68,500 jobs in South Yorkshire. This represents 11.6% of all jobs[7]. The report also found the productivity of food and drink manufacturing workers matches that of key targeted sectors like advanced manufacturing and digital at approximately £65,000 per worker[8].

Furthermore, local universities including centres like Sheffield Hallam's AFIC are actively working on sustainable processing, efficiency improvements, and innovation in food manufacturing. There are also emerging efforts in controlled environment agriculture (CEA), vertical farming or glasshouse technologies, alongside urban agriculture and community growing which could enhance local production capacity, improve local food security[9], whilst also promoting sustainable land use. Collaboration between universities, urban growers and councils aims to support nature-friendly food production and strengthen local supply chains[10].

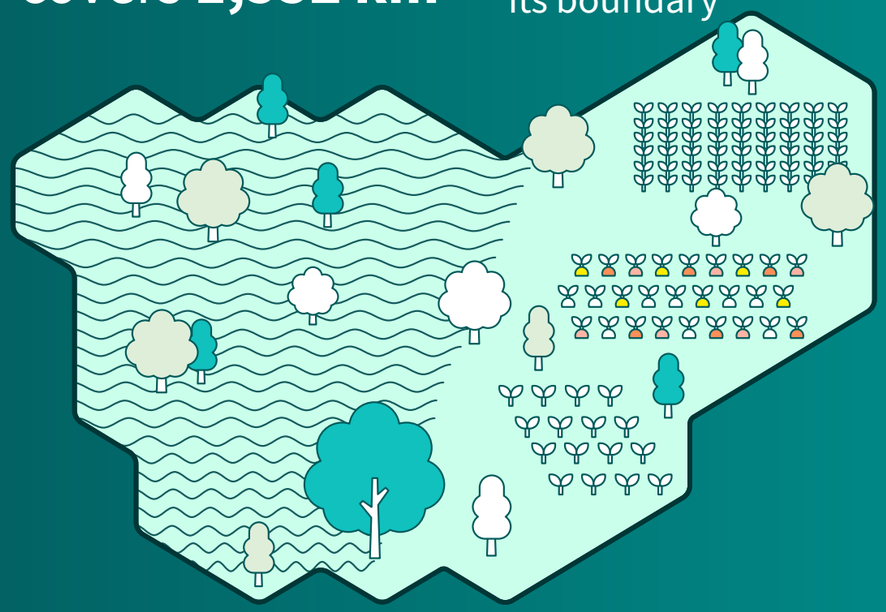
Overarching Challenges

The 2023 State of Nature report found the UK to be of the most nature-depleted countries on Earth, with significant nature and biodiversity degradation resulting in vast declines of many species of birds, plants, and insects that are crucial for keeping our habitats and ecosystems healthy[11]. According to the Green Finance Institute's analysis, the deterioration of the natural environment in the UK could lead to an estimated 12% reduction to Gross Domestic Product (GDP) in the years ahead - larger than the hit to GDP from the global financial crisis or Covid-19[12].

Outside of biodiversity loss, the UK is also facing significant soil degradation. Soils are the largest terrestrial carbon reservoirs and provide fundamental ecosystem services, including the provision of food and habitats and the regulation of water and climate[13, 14]. Soil organic matter (SOM) is a fundamental component of soils and a major determinant of soil health, containing stores of carbon and nitrogen bound together with other mineral nutrients. Soil organic carbon (SOC) makes up about 40-60% of SOM, and strongly influences the physical, chemical and biological structure and function of soils[15, 16]. The UK Centre for Ecology and Hydrology's Countryside Survey found an 11% increase in SOC on arable and horticulture land between 1978 and 2007[17]. Completed in 2007, the survey did not find an overall SOC decrease due to increase of woodland areas and improved grassland soils[18], however, the survey comprised of relatively small soil sampling (1,197 plots within 256 1km squares in 1978, 1,098 plots within 256 squares in 1998 and 2,614 plots within 591 squares

7 Food and Drink Technology (2023) South Yorkshire's hidden gem: food and drink manufacturing sector valued at £434m, reveals report.
8 Sheffield Hallam University (2023) South Yorkshire's 'overlooked' food and drink manufacturing sector worth £434m – new report.
9 South Yorkshire Sustainability Centre (n.d.) Establish South Yorkshire green infrastructure to enable delivery of the net-zero food system roadmap.
10 The University of Sheffield. (2023) South Yorkshire Sustainability Centre Launch.
11 State of Nature (2023) STATE OF NATURE 2023.

12 Green Finance Institute (2025) Assessing the Materiality of Nature-Related Financial Risks for the UK.
13 Harden, J.W., Sanderman, J. and Hugelius, G. (2017). Soils and the Carbon Cycle. International Encyclopedia of Geography, Wiley, pp.1–14.
14 Haygarth, P.M. and Ritz, K. (2009) The future of soils and land use in the UK: Soil systems for the provision of land-based ecosystem services. Land Use Policy, 26(1), pp.S187–S197.
15 Lal, R. (2016). Soil health and carbon management. Food and Energy Security, 5(4)
16 Lal, R. (2025). Soil organic matter: The heart of soil health. Journal of Soil and Water Conservation, 80(4), pp.320–326.
17 ONS (2022) Habitat extent and condition, natural capital.
18 UKCEH (2007) Soils in UKCEH Countryside Survey.



in 2007[19]) and used the Loss on Ignition (LOI) method which can estimate, but not measure, exact organic matter content. According to the Environment Agency, in 2010 soil degradation was calculated to cost £1.2 billion every year[20]. Since then to 2020, land used for organic farming, which helps to promote and restore soil health, decreased by 32%[21].

In South Yorkshire, the NCS evaluation of 91% of the region, found the majority (~57%) of the region's natural habitats to be in poor condition, due to the predominance of arable and improved grassland habitat and the extent of domestic gardens and amenity grasslands. The ecosystem services provided by the South Yorkshire's natural capital were carbon storage and sequestration, air purification, noise, local climate, water flow and water quality regulation, food production, timber production, recreation and accessible nature, with the demand focussed in the urban centres of Sheffield, Barnsley, Rotherham and Doncaster. The value of these services was estimated to be £550 million per annum, with air quality regulation (£237 million annually), recreation (£188 million annually), and physical health (£68 million annually) being particularly large. Despite this, the region is overall a net emitter of carbon at 105,300 tCO_2e per year at a cost of £8 million annually[22].

Furthermore, South Yorkshire faces the same soil degradation issues as has been observed nationally. Natural England Agricultural Land Classification (ALC), which maps agricultural land and assesses its fertility according to multiple factors, such as texture, structure, depth and chemical composition, shows that although a lot of South Yorkshire's agricultural land falls into 'good' to 'moderate' condition, there are big parcels of land rated as 'poor' or 'very poor' condition[23]. It is also important to mention, that the ALC methodology has its limitations, e.g. it only assesses the levels of soil inorganic carbon (SIC) in terms of calcium carbonate and does not measure or take into consideration SOC, thw importance of which was described previously[24].

19 UKCEH (2007) Countryside Survey: Soils report from 2007.
20 Environment Agency (2023). Summary of the state of the environment: soil.
21 ONS (2022) Habitat extent and condition, natural capital.
22 NCS (2021) South Yorkshire natural capital and biodiversity mapping.
23 Natural England (2010) Agricultural Land Classification Yorkshire and The Humber - ALC003.
24 DEFRA (2025) Agricultural Land Classification of England and Wales. Guidelines for grading the quality of agricultural land

The value of the local food and drink manufacturing industry in South Yorkshire is estimated at **£434m**

9,000 jobs and **170 businesses** are tied to food and drink production in South Yorkshire

In South Yorkshire, including agriculture, catering, retail and wholesale, the **total "agri-food" sector** accounts for

£1.58bn in economic output and **68,500 jobs**

This represents **11.6%** of all jobs

SYSC Research Response

The SYSC has worked to identify ways of addressing these challenges whilst also making the regional food system better for the people of South Yorkshire. Using local knowledge and local partnerships, our projects have a regional focus, but can offer perspectives with national relevance, with implications for local, regional and national strategies and policies.

As described previously, currently there is a very limited understanding and insufficient data on soil health nationally, with the Environment Agency claiming that more investment is needed to monitor soils effectively[25]. To address this knowledge gap in South Yorkshire, a SYSC research project is sampling and analysing soils from sites under agricultural and conservation land management to generate better insights into how different land uses influence soil carbon storage across distinct carbon pools. Across South Yorkshire farms, soils were collected from arable, long-term arable, mixed arable-pasture, long-term pasture and woodland sites, with some sites being sampled at different depths. Carbon content and bulk density of soils from both agricultural and conservation settings were measured, and SOC, black carbon and total organic carbon stocks calculated. Whilst this research project and result analysis is still ongoing, the emerging findings suggest that regardless of land use, the denser soils tend to store less carbon and that carbon decreases with depth, displaying declines in SOC between surface soils (uppermost 10 cm) and lower depths – which is a typical pattern even in healthy soils. However, this decline was less obvious on land that is under conservation land management and on one site the total organic carbon stocks were greater than the UK national average.

The research also highlights the vulnerability of surface soils to disturbances and compaction associated with unmanaged grazing, noting the importance of incorporating soil health assessments into grazing regimes for the mitigation of substantial carbon losses. With grazing farms being the predominant type in Yorkshire and the Humber, this is particularly relevant for South Yorkshire.

However, placing land under management plans, requires resources, knowledge and skills that may be inaccessible to some farmers. Whilst there is commitment in legislation to support new environmental management via the Agricultural Act (2020) and Environment Act (2021), there is

25 Environment Agency (2023). Summary of the state of the environment: soil.

Ecosystem Services in South Yorkshire

~57% of South Yorkshire's natural habitats are in poor condition

The value of ecosystem services is estimated to be £550m per annum

£237m/a
Air quality regulation

£188m/a
Recreation

£68m/a
Physical health

Despite all this, the region is a **net emitter of carbon** at **105,300** tCO_2e/a

considerable uncertainty about how policy and legislation will translate into a tangible funding regime. Although current government grants to increase productivity and manage land to benefit the environment exist via different funding streams of environmental land management (ELM) scheme, these can also be difficult to navigate and require time and know-how to apply for and administrate successfully.

Another SYSC project explored nature recovery farming in South Yorkshire, by interviewing people working in land management and farming in South Yorkshire and the Peak District National Park about their experiences of navigating the current funding and policy landscape. The research found that remaining financially viable is the most pressing concern amongst farmers and whilst many are willing to take some land out of production in order to access funding and support nature restoration, many felt driven to do this because of unstable markets for farm produce. Farmers and land managers need stable funding sources that support financial viability alongside pro-environmental interventions as well as support from trusted people and organisations to access and manage grants so that they can carry out the day to day work of producing food and ecosystem services for the region. Whilst collaboration is welcomed, there is also wariness about it leading to a loss of control over land, and decision making being transferred to the collective.

The importance of agency, the ability to participate in decision making and accessible support was also evident in SYSC research that focused specifically on micro and small scale growers in the region. The project conducted fieldwork in rural and peri-urban areas around South Yorkshire to understand the decarbonisation journeys for small growers and asked how these pathways could be designed so that they were fair-for-all. The research found that there was a need for greater inclusion in sustainability and decarbonisation policy and regulatory frameworks. Study participants noted their distinct characteristics which brought specific challenges 'due to their size'. Growers made an urgent call for a greater focus on the ways they operate, as well as on the vital role they play at ensuring a more sustainable agri-food system, and supporting the local economy.

Food Production and Manufacturing

Nature, agriculture and farming is where our food system often begins, but food production and manufacturing forms another branch of this system and has a set of its own unique challenges. South Yorkshire is a hub for food production and manufacturing, with 170 businesses including bakeries, breweries, ready-meal producers, distilleries and others. Along with its economic significance, the sector causes negative environmental impacts, with the most frequently reported impacts being high greenhouse gas (GHG) emissions and high water and energy consumption. On a national level, approximately 30.31 TWh of energy is used each year to support the industry[26]. However, this data is aggregated from multiple manufacturers of different size and type of manufacturing and lacks specificity that would help to address decarbonisation and resource efficiency challenges in South Yorkshire, especially in terms of small and medium-sized enterprises (SMEs), that form a large part of the region's economic landscape.

To properly target funding and interventions and to understand where energy, water, and emissions arise in day-to-day operations, regional policymakers and support programs require actual site-level data. This is urgently needed because SMEs are under immediate pressure to reduce expenses and emissions, but they frequently lack the information and standards necessary to support workable solutions. To address this gap in data, SYSC collected and analysed the environmental impact of products from 12 different food and drink manufacturing facilities in South Yorkshire (11 of them being SMEs), including annual energy use, water consumption, and carbon emissions. Out of approximately 170 food and drink manufacturing businesses, this study covered 7.05% of the industry population. The study found that the annual total consumption of energy of all 12 businesses was 34.63 GWh, the majority of which (32. 51 GWh) attributed to the one large manufacturer, with the remaining

26 DEFRA (2025) Food Statistics in your pocket.

contribution coming from a diverse group of SME manufacturers with lower, yet still significant, energy demands. This amounts to 7.15 tCO_2e of operational emissions per year, assuming that electricity generation follows the same grid energy mix contributions as the entirety of the Yorkshire region, as currently there is no South Yorkshire specific dataset - a limitation that the study discovered. The study also discovered a higher than the UK average reliance on natural gas in the overall energy consumption of the 12 study participants - this has important implications, as gas-fired equipment typically consumes more energy than electric alternatives. Although gas-fired equipment heats rapidly, it is generally less efficient and is associated with greater heat losses. Energy efficiency could also be improved by replacing gas-powered boilers, ovens, stoves, and steamers with renewable energy sources or by implementing heat recovery on dryers, wastewater steam, refrigeration systems, and ovens. The greater emphasis on natural gas in South Yorkshire is likely related to the kind of businesses operating and the age of the appliances. Many sites are still reliant on gas-fired systems because they were historically the most affordable option. Simultaneously, limited budget and practical concerns about switching to electric alternatives cause gas to remain the key energy resource in daily operations in this region.

The study also collected and analysed the data and energy performance from the three study participants that already implemented various measures to decarbonise and improve environmental performance, such as solar PV, aerobic food waste disposal system and a combined heat and power system, with the results described in the “From Data to Impact: Quantifying Environmental Footprint and Transforming Sustainability in South Yorkshire’s Food and Drink Manufacturing Industry” case study.

The study highlighted the importance of local, site-specific data collection and analysis, as well as barriers, such as reluctance of businesses to participate in research. There is a long-term opportunity to shift the culture and behaviour of food and drink manufacturers towards renewable resource use and energy efficiency. During SYSC’s research, many SMEs rejected participating because they were unconvinced of the benefits, lacked awareness of energy-saving opportunities, and faced practical barriers, including limited expertise, insufficient time, and a lack of internal capacity or resources to collect data and undertake energy-efficiency tasks. By actively engaging with the industrial community and continuing to collect data to encourage energy efficiency, this work prompts factories to check in on their energy and encourages integrating decarbonisation into supply chains, which can shift cultural assumptions about sustainability in food production.

The Case for a South Yorkshire Food Network

The key question is how can the region tackle these challenges whilst also benefitting from the opportunities available in a way that is fair for all of the region’s residents? It is clear that the food system is highly complex, nature recovery and conservation, farming and food production and manufacturing, health, education, economy and social wellbeing are intertwined. Trying to detangle and address only one of these strands risks incurring damage to others and thus a unified, holistic approach is needed.

Despite the vital work of local food partnerships in each of the four local authorities, South Yorkshire currently lacks a unified regional food network that brings together large-scale producers, small businesses, and community groups, allowing them to speak with a common voice on key issues of mutual concern.

SYSC’s South Yorkshire Food Network feasibility project aimed to address these issues whilst building on previous work on public procurement in Sheffield, that showed how the city’s ‘anchor institutions’ such as hospitals, schools and colleges could improve the health and sustainability of the food they serve to the public by increasing their purchasing from local small- and medium-sized producers.

The South Yorkshire Food Network feasibility project explored the idea of extending this work to a regional scale, evaluating the prospects of establishing a regional food network that could bring together key food system actors from across South Yorkshire. The study included a survey of 56 local businesses, policymakers and civil society organizations from all four local authorities in the South Yorkshire region. The survey demonstrated strong support for a regional food network, with high levels of perceived value, openness to change and depth of commitment. This vision was shared across all geographies and sectors.

While confirming their strong support for this initiative, participants expressed the importance of transparent governance and accountability, focusing on practical outcomes and actionable objectives. Respondents wanted a function that added value to local initiatives and avoided duplicating what already exists, emphasising that there should be a clarity of purpose with a focus on tangible benefits.

This multi-partner approach is ambitious and challenging, it is difficult to build coherent shared goals and objectives with tangible outputs and outcomes where partners have different competing priorities, pressures and resources available. However, another SYSC project, the Urban Agriculture Task Force (UATF), demonstrates how this can be achieved and the value it could have for

the region. The Task Force, which initially focused on the Gleadless Valley ward, and then the wider South Sheffield Local Area, aimed to contribute to a food system that is both socially just and environmentally sustainable, while demonstrating methods that can be replicated elsewhere in the region.

A core feature of the UATF's approach has been to work across nested governance structures: beginning at neighbourhood level, and building outward to wards, Local Area Committees, the local authority, regional networks, and national campaigns. This has allowed the UATF to develop a grounded understanding of local issues, identify systemic gaps, and design interventions that can be strategically scaled.

The UATF has also prioritised a multidisciplinary and multi-partner approach, combining practical farming, landscape design, education, research, and policy advocacy. By connecting community groups, public institutions, and academic research, the UATF has acted as a connector and enabler, bringing coherence to a fragmented food system and working towards the shared goal of a sustainable, fairer, and more accessible food system.

The UATF work programme revolved around 3 clusters:

1. **Developing a layered approach to urban horticulture, linking research, policy advocacy, infrastructure reuse, and hands-on design.** This involved mapping Sheffield's existing growing spaces, assessing socio-economic dynamics, and identifying new opportunities for food-growing using Geographical Information Systems (GIS); contributing to the national Right to Grow campaign, led by Incredible Edible; responding to the Sheffield Local Plan consultation noting equitable food access as a core component of good landscape design and management policy; supporting the Growing and Composting Working Group and playing a key role in helping the social enterprise Food Works to secure the lease for Norton Nurseries - the only large-scale glasshouse site in Sheffield and thus helping to bring underutilised infrastructure back into productive use.

2. **Focusing on education, training, and the cultivation of food system literacy across age groups and professions.** The UATF hosted a month-long Social Accountability Placement for four medical students from the University of Sheffield; worked with Year 6 SEN pupils from Woodlands Primary School on a bespoke farm-based education programme; members of the UATF have become approved practitioners to the national Climate Ambassadors scheme which connects climate and environmental sustainability volunteers with nurseries, schools and colleges across the UK.

3. **Connecting urban neighbourhoods with peri-urban farms, demonstrating the value of a joined-up landscape approach.** The UATF has contributed extensively to the Gleadless Valley regeneration programme, advocating for the integration of agroecological urbanism and nature-based solutions as well as supporting smaller interventions such as a raised herb and wildflower bed at the Gaunt Shopping Precinct in Sheffield.

By working through nested governance structures, the UATF has shown how local initiatives can inform ward-level, city-level, regional, and even national strategies. This offers a practical alternative to "bigger is better" models, and aligns the findings of international research on food system transformation.

Taken together, the projects featured in the case studies supporting this Building Sustainable Food Systems narrative provide a vision for the future. The UATF demonstrates concrete and scalable steps to support this vision for the region - where communities in rural, peri-urban and urban spaces are happy, prosperous and healthy. Everyone has access to food sufficient for nourishment and personal taste, with excess food redistributed rather than wasted. The whole regional food system is decarbonised, from on-farm production to distribution to food processing and manufacturing.

A vibrant, robust and sustainable local food economy is flourishing, attracting inward investment from innovative green businesses. A sustainable regional food system is helping to regenerate the landscape, working together with nature, and bringing benefits to human health and wellbeing for every resident in South Yorkshire.

Building Sustainable Food Systems Recommendations for Regional Policymakers

1. Local policymakers should use the delivery of the Local Nature Recovery Strategy to allocate funding for a **'One-Stop-Shop', delivered through trusted partners, for farmers and growers that aims to enable successful engagement with nature friendly farming grants and subsidies.** SYSC research shows that practical support is needed to access and administer grants that reward environmental action, as well as advice, knowledge sharing and advocacy to support farmers and growers maintain financial viability alongside environmental action i.e. supporting new entrants into the sector through the creative use of land leasing and tenancies.

   i. Nature Recovery Farming: Supporting Regional Landscape Scale Resilience.

2. Local policymakers should recognise the importance of soil health, as well as other ecosystem services, for building landscape scale resilience and regional prosperity in South Yorkshire. **As part of the Local Nature Recovery Strategy delivery, local policymakers should initiate a South Yorkshire Resilient Landscapes programme that aims to build resilience through nature recovery** by bringing together key regional stakeholders through research, knowledge sharing events and collaborative projects. This should include coordination with existing alliances such as Connected by Water.

   i. Soil Carbon Storage Across South Yorkshire: Understanding Soil Carbon Stocks Across Pools in the Context of Agricultural and Conservation Land Management.

3. **Support electrification and efficiency in the food processing and manufacturing industry:** Policymakers should consider ways of providing financial and business change support to food processors and manufacturers to replace gas-powered equipment (boilers, ovens, steamers) with renewable energy sources or implement heat recovery systems on dryers and refrigeration units.

4. **Local policymakers should commit resources to set-up and service a South Yorkshire regional food network** that aims to establish a "common voice" for the regional food system, providing a space for innovation, confronting shared challenges (i.e. funding and policy gaps), knowledge exchange and mutual support. Research on horticultural SMEs suggests that sub-groups could be effective in addressing specific needs of different types of actors within the network.

   i. South Yorkshire Food Network Feasibility Study.

5. **Local authorities should adopt a "Right to Grow" model,** replacing a permissions-based with a rights-based model for land access. This would allow community groups to apply for licenses to utilise underused council assets for food production (e.g. land, glasshouses, public spaces).

   i. Urban Agriculture Task Force: Building a Just and Sustainable Food System in Sheffield.

6. Public sector landowners should **support peri-urban agroecological clusters to establish viable businesses** by providing secure land tenure, providing or facilitating investment in infrastructure, and supporting the set-up of public procurement contracts.

   i. Urban Agriculture Task Force: Building a Just and Sustainable Food System in Sheffield.

7. **Integrate food into regional health strategies, recognising the critical role it plays in public health:** Embed food-growing and food education initiatives into broader health, climate, and greenspace strategies to address health inequalities in deprived areas such as the Gleadless Valley.

   i. Urban Agriculture Task Force: Building a Just and Sustainable Food System in Sheffield.

Further Research Opportunities

Sustainable agriculture: Further research could consider how we can effectively incentivise and compensate farmers and land managers to deliver valuable ecosystem services such as biodiversity restoration, natural flood management, and carbon storage.

Landscape Resilience: Collaborative research is needed to determine how landscape scale resilience can be effectively monitored and evaluated, which should include exploration of the metrics and indicators that would satisfy the demands of environmental, social and economic resilience for our region.

Landscape Resilience: Collaborative research needed to determine how effective collaboration can be fostered between different actors within the farming and land management sector in order to deliver regional landscape resilience.

Soil health: More research is needed to determine how quickly organic carbon stocks in disturbed/compacted soil recover through restorative measures i.e. through well-managed conservation grazing or appropriate agricultural management practices.

Soil health: Further research could explore how effective conservation grazing is at enhancing and maintaining high-quality soil organic carbon stocks in South Yorkshire grasslands.

Food Processing & Manufacturing Processing: Work with businesses to identify which production stages are most energy intensive and strategies to improve efficiency and implement alternative low carbon technologies.

Horticultural SME decarbonisation: Further research could bring together policy-makers, SMEs, and stakeholder organisations to build relationships and start the process of co-creating a net zero transition plan for the sector.

Hydrogen and Industrial Decarbonisation

Challenge

South Yorkshire has long stood at the heart of the UK's industrial faculty, with advanced manufacturing, steel, glass and ceramics sectors driving regional growth and job creation for decades. The new South Yorkshire's Growth Plan, published in September 2025, recognises this heritage and sets out a renewed vision to build on this manufacturing legacy, utilising the region's capabilities and expertise in clean energy, innovation and research and development (R&D).

With a population of 1.4 million, South Yorkshire represents a significant regional economy (£39.6 billion gross domestic product (GDP)[1]) transitioning from its industrial heritage toward advanced manufacturing, healthcare and digital services. Manufacturing continues to be the bedrock of the region's economy, accounting for 15.3% of gross value added (GVA), significantly higher than the national average of 9.8%[2], which is now being supercharged by advanced manufacturing and clean energy. Indeed, South Yorkshire now ranks as the UK's third-largest region for employment in clean power and hydrogen[3].

Stretching from Sheffield to Rotherham, Don Valley, home of the University of Sheffield's Advanced Manufacturing Research Centre, is an established innovation district, with global significance. With 30 cutting edge R&D facilities sprawling over four adjacent sites, the internationally recognised translational research facilities set the region apart, supporting over 1,200 businesses with more than 3,500 employees and attracting world-leading advanced manufacturing companies, such as Boeing, Rolls Royce and McLaren Automotive[4].

At the national level, the region's capabilities in both advanced manufacturing and clean energy sectors are recognised in the Modern Industrial Strategy's Clean Energy[5] and Advanced Manufacturing Sector Plans[6]. The government named these and another 6 industries as key for future prosperity and economic growth, both at regional and national levels. The emphasis is placed on transition to low-carbon manufacturing, recognising this as not only a necessity to meet net-zero by 2050 targets, but also a strategic and economic opportunity for regions to sustain jobs, attract investment and lead in the manufacturing economy of the future.

However, key challenges for the region remain. At the end of 2025, the employment rate for South Yorkshire was 73.3%, 2 percentage points below national average. Both unemployment (4.7%) and economic inactivity (23%) rates exceed England's average (with 3.7% and 21.4% respectively) and the proportion of workers in severe job insecurity ranks second highest amongst all combined local authorities at 21.7%[7]. Furthermore, the advanced manufacturing together with other strategic sectors prioritised for growth, such as healthcare and digital skills, are all the fields with projected skill shortages in the region for 2026[8].

Whilst skill shortages might stagnate growth, some of the cornerstone companies are struggling to stay in operation. The recent Defence Growth Deal

1 ONS (2025) Regional economic activity by gross domestic product, UK: 1998 to 2023. Regional gross domestic product: all ITL regions. 2023 data.
2 Pratap Executive (2025) South Yorkshire Growth.
3 SYMCA (2025) South Yorkshire's Growth Plan.
4 Ibid.
5 UK Government (2025) The UK's Modern Industrial Strategy. Clean Energy Industries Sector Plan.
6 UK Government (2025) The UK's Modern Industrial Strategy. Advanced Manufacturing Sector Plan.
7 Yotru (2026) South Yorkshire Labour Market Data 2026: Employment, Wages + Apprenticeships.
8 Ibid.

identified South Yorkshire as one of five leading places in the UK in the defence industrial economy; the region provides specialist steel for use in the defence sector through Forgemasters, BAE Systems and Special Melted Products[9]. However, Speciality Steels UK, crucial to national defence, aerospace and energy industries due to their highly specialist, world-leading steel production capabilities[10], was placed in receivership in 2025 and is now under UK government control. This came after several years of financial uncertainty, during which most of the company's workers were placed on indefinite furlough, not only affecting multiple jobs, but also entire communities in Stocksbridge. Stocksbridge retains a strong sense of identity, rooted in its steelmaking heritage with British Steel and its predecessors historically being central to both the economic and social life of the town, providing welfare and community functions.

This issue is not limited to Stocksbridge. The steel industry in South Yorkshire has undergone significant change over the last 40-50 years. In 1971, 140,000 people were employed in the steel industry in Sheffield alone. This accounted for half of all the city's jobs. In just over a decade this fell by more than half to 57,000 in 1987[11]. This decline in employment numbers continued in the 1990s and 2000s. By 2024 metals production and manufacturing industries were estimated to employ around 15,000 people across South Yorkshire[12].

9 SYMCA (2025) South Yorkshire's Growth Plan.
10 Community Trade Union. (2025) Statement - Liberty Steel.
11 Hudson, R and Sadler, D (1989) The international steel industry: restructuring, state policies and localities. Routledge, Abingdon.
12 Office for National Statistics (2025) Business Register and Employment Survey.

With a population of **1.4 million**, South Yorkshire represents a significant regional economy of **£39.6 bn GDP**

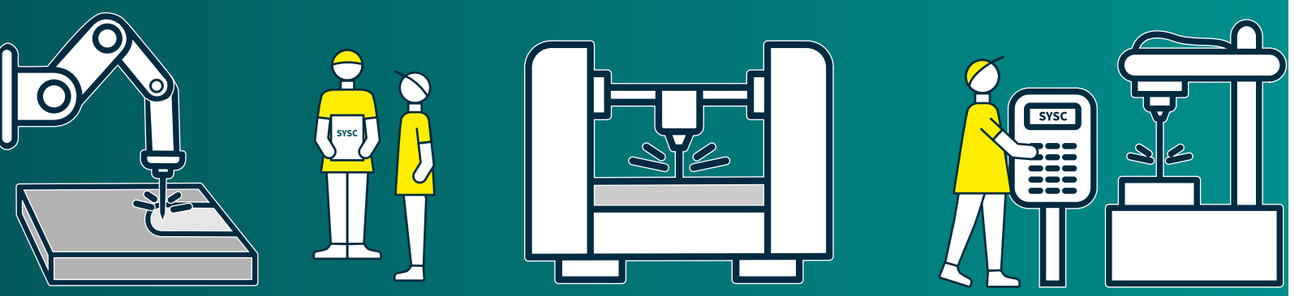
Its history of heavy industry is transitioning toward advanced manufacturing, healthcare and digital services

Manufacturing continues to be the bedrock of the region's economy

Manufacturing accounts for

15.3% GVA
South Yorkshire

9.8% GVA
national average



Additionally, steel and other energy intensive manufacturing industries within the region such as glass and bricks, require significant investment to decarbonise, or risk production moving elsewhere or ceasing entirely. These sectors are not only energy intensive, but also are defined by their hard-to-abate emissions profiles, due to the high temperatures needed. Electrification is not always possible to meet these challenges and decarbonisation via hydrogen potentially requires significant changes to production processes.

If done right, transitioning to low carbon manufacturing could ensure a prosperous future for the region and its residents, with green growth and clean energy supporting manufacturing and innovation hubs that are rooted in the region's history and heritage.

Research Response

Industry and manufacturing decarbonisation, especially of heat-intensive industries such as steel, ceramics and glass making, presents a substantial challenge that requires collaboration between local authorities, industry and academia to overcome. With this goal in mind, South Yorkshire Sustainability Centre (SYSC)' convened key stakeholders and partners across the region - including South Yorkshire Mayoral Combined Authority (SYMCA)', Forgemasters, Marcegaglia, Ardagh Glass, Aggregate Industries, Chesterfield Special Cylinders, E.On, Cadent to name but a few - to hold open discussions through the Industry Decarbonisation Roundtables series. During these discussions, some of the key challenges and barriers to decarbonisation were identified, including: the lack of clear, long term policy steer from the national government, high risk, high operational and capital costs of hydrogen, hydrogen supply uncertainties, readily available volumes of hydrogen in the region and further large scale feasibility studies required.

SYSC's research has sought to ascertain hydrogen economy readiness, benchmarking hydrogen economy maturity of the UK (in terms of investment, legislation, and strategy) against other G20 nations. The study found the UK to be one of the frontrunners, together with the US and China in hydrogen economy maturity. For the UK, and particularly regions such as South Yorkshire seeking to embed themselves in the hydrogen economy, this benchmarking provides insight into the country's competitive positioning relative to other G20 members.

This supports SYSC's State of Hydrogen in South

The steel industry in South Yorkshire has undergone significant change over the last 40-50 years

1971

140,000
employed in the steel industry in Sheffield alone

1987

in just over a decade this figure fell by more than half to
57,000

2024

15,000
employed in metals production across South Yorkshire

Yorkshire report findings. The report aimed to provide readily actionable recommendations for South Yorkshire's Investment Zone and consists of analyses of national and regional policy landscapes, regional manufacturing and innovation capabilities, supply chain maturity, and production capacity and demand. The report also assessed the opportunities and challenges to grow the sector in South Yorkshire. With hydrogen expected to account for 20-35% of UK energy consumption by 2035[13], the report found that South Yorkshire has the potential to be a national and even global leader in hydrogen and the way it is used safely, but quick and decisive action by regional policymakers is needed.

Although South Yorkshire is not within a hydrogen cluster at the moment, it is well connected to two large emerging hydrogen clusters, at Tees Valley and Humberside, whilst also holding 0.37 GW (enough to produce ~1,944 GWh annually) hydrogen production capacity (albeit currently restricted by grid headroom availability). Still, the report identified that the real strengths of the region and its leadership potential lies in hydrogen research, hydrogen use demonstrators and manufacturing for the hydrogen supply chain. The State of Hydrogen in South Yorkshire report was also presented to the SYMCA's South Yorkshire Energy Board, where it received positive feedback from Mayor Oliver Coppard and the Chair of the Board, David Bond. It was also featured at the UK Clean Energy Summit, hosted by the University of Sheffield, and in one of the Sheffield City Chambers of Commerce newsletters.

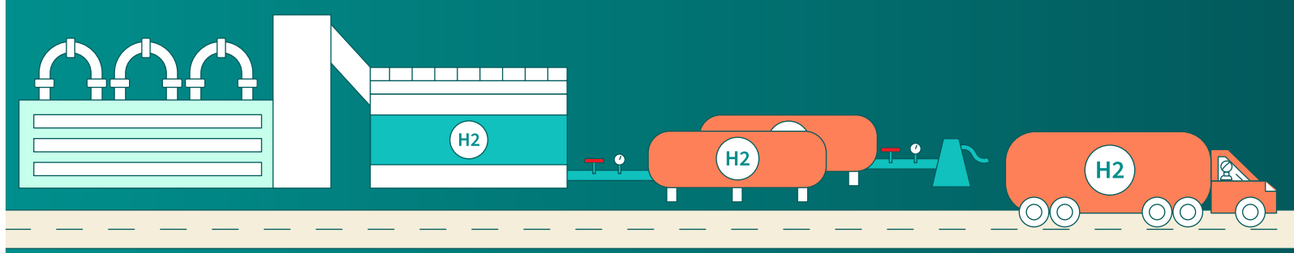
Another SYSC project further investigated how resilience could be built into hydrogen supply chains. The project identified the main challenges within the hydrogen supply chain to be raw material dependencies, weather risks, integration challenges, and sensitivity to stakeholder perceptions. In South Yorkshire, this means that resilience planning should be integrated with environmental regulation, energy market design, and community engagement. Supporting renewable energy communities and decentralised production would enhance both technical resilience and social equity, requiring cross-disciplinary collaboration. The project identified supply network integration as another driver of resilience. Building partnerships across transport, manufacturing, logistics, and heavy industry can foster collective resilience, reduce vulnerabilities, and create high-value jobs, supporting a just transition.

Another study utilised the regional optimisation model AENi to understand where hydrogen clusters could be established to achieve a cost optimal scale-up of hydrogen supply in South Yorkshire. The study considered 21 energy, heat and emission intense manufacturing companies of variable size in South Yorkshire. The AENi software, developed as a spin-out from the Brown group at University of Sheffield, was used to find a cost optimal network linking these sites to the grid supply point at Thurcroft. Although this was just an initial modelling exercise and further in-depth collaboration is needed to develop a more accurate model, including economic analysis to predict the most favourable roadmap for roll out, the current project findings show that a hydrogen network for industrial sites is likely feasible using existing electrical grid connections.

It is important to note that successful hydrogen deployment depends not only on technical feasibility, but on societal and institutional readiness. Hydrogen storage and road-based distribution systems will operate within industrial estates, logistics corridors and alongside residential communities. The existing evidence base is heavily weighted toward techno-economic modelling and carbon intensity analysis, with comparatively limited research examining multi-stakeholder social acceptance, particularly for storage and transport infrastructure. The Hydrogen Storage as a Service (HySaaS): Securing Social Licence for Hydrogen Storage and Distribution

Hydrogen is expected to account for
20-35% of the UK's energy consumption by 2035

South Yorkshire holds **0.37 GW hydrogen production capacity** - enough to produce ~1944 GWh annually



13 Illustrative demand based on analysis for the Hydrogen Transport and Storage Networks pathway (2023), as referenced in GOV.UK (2024) Hydrogen investment roadmap: Leading the way to net zero.

in South Yorkshire project aimed to address this gap by providing a structured, multi-stakeholder assessment of social acceptance focused specifically on hydrogen storage and distribution, the parts of the value chain most visible to communities and emergency responders.

The research found that acceptance of hydrogen storage and distribution is broadly positive but strongly conditioned by perceptions of safety and risk. Across all stakeholder groups, safety emerged as the dominant determinant of acceptance. Crucially, all groups responded positively to enhanced monitoring and transparency. More than 80% of public respondents indicated that additional monitoring systems would increase their comfort with hydrogen storage and distribution. This suggests that visible, data-driven safety mechanisms can materially improve acceptance.

The findings suggest that hydrogen storage and distribution can secure social licence if deployment is treated as a governance and trust challenge as much as a technical one. To improve social acceptance and reduce perceived risk, hydrogen demonstrator projects in South Yorkshire should aim to combine monitored assets, responder training and community engagement, thus strengthening the commercial case for hydrogen investment.

Beyond Industrial Decarbonisation

Lastly, it is important to note that hydrogen is relevant not only for industrial decarbonisation, but also essential for Sustainable Aviation Fuel (SAF) production. The UK's SAF Mandate, which came into effect in 2025, requires 2% of total UK jet fuel demand to be supplied as SAF, rising to 10% in 2030 and 22% in 2040[14]. This policy, designed to reduce aviation emissions, forces fuel suppliers to meet these targets or buy certificates, similar to Renewable Energy Guarantees of Origin (REGOs) certificates issued by Ofgem to certify electricity generation from eligible renewable sources - used as a mechanism for companies to prove renewable energy sourcing.

As SAFs require no engine modifications and because they can be produced from waste products, they are seen as an interim solution for emissions from aviation.

There are several certified routes for preparing SAF that differ in feedstock and/or processing methods to obtain synthetic paraffinic kerosene (SPK), which is then blended with conventional fuels, with the exact blend proportions variable and dependent on the pathway. All of these routes, apart from one, require hydrogen for their processing.

However, several key challenges remain in advancing SAF development and deployment, such as a lack of lifecycle data, limited evidence on the resilience of SAF supply chains under different feedstock, technology, and trade scenarios; and a persistent uncertainty over which SAF pathways should be prioritised, as each involves trade-offs among economic cost and scalability, environmental performance, technological maturity, and broader social and political acceptance.

SYSC research aimed to address these gaps through a comparative analysis of all certified waste-derived feedstock SAF life cycle assessments, supply chain resilience analysis and a stakeholder engagement study, which aimed to gauge perspectives across the SAF value chain and translate them into structured evaluations of competing pathways. One of the key findings from this research is that SAF deployment targets are likely to outpace the sustainable supply of biogenic waste feedstocks, creating potential bottlenecks and competition with other sectors. This highlights the need for diversified feedstock sourcing and resilient, internationally coordinated supply chains, integrating both biofuels and synthetic (power-to-liquid) fuels to achieve the necessary scale-up. For policymakers, the research highlights the need for stronger and more targeted incentives. SAF mandates, subsidies, and funding mechanisms should be designed to only favour pathways with the strongest evidence base for environmental sustainability and supply chain resilience.

Safety emerged as the dominant determinant of hydrogen storage and distribution acceptance **across all stakeholder groups**

Crucially, all groups responded positively to enhanced monitoring and transparency

More than **80%** of **public respondents** indicated that additional monitoring systems would **increase their comfort** with hydrogen storage and distribution

This suggests that visible, data-driven safety mechanisms can materially improve acceptance

14 DfT (2025) Sustainable Aviation Fuel (SAF) Mandate.

Hydrogen and Industrial Decarbonisation Recommendations for Regional Policymakers

1. Local policymakers should commit ongoing resources to support the continuation of the existing **Industrial Decarbonisation Roundtables so that there is a permanent, robust forum in which policymakers, regional industry leaders and academia can collaborate** to a) to identify, scope and deliver regional demonstrators and b) co-design regional policies that directly address policy gaps, barriers to growth and the operational requirements of the sector.

2. To support Local Growth Plan ambitions, policymakers, industry and academia should convene a **working group to determine how South Yorkshire can capitalise on its existing strengths to emerge as a national leader in the technologies and components that underpin hydrogen production, storage and transportation**, such as catalysts, storage tanks and pipeline materials. This offers significant potential for long term economic growth and national leadership.

3. In continued partnership with industry and The University of Sheffield, **local policymakers should identify and create defined hydrogen production and user site clusters** in South Yorkshire, and **take responsibility for attracting, directing and scaling business activity** in existing and emerging clusters.

    i. Scoping a Hydrogen Network for the South Yorkshire Region using the Network Optimisation Model AENi.

4. To promote regional readiness and support the region's Local Growth Plan, l**ocal policymakers should work with South Yorkshire's hydrogen projects**, such as ITM Power, GeoPura, Lhyfe, and Clean Power Hydrogen group **to ensure that they meet or are working to meet international certification requirements**, ensuring competitiveness in global supply chains.

    i. Towards a Unified Hydrogen Standard: Benchmarking G20 Nations' Hydrogen Economy Maturity.

5. **Produce an 'inclusive industrial transition' strategy** which centres on how large investments in industrial decarbonisation can capture value for the region as a whole, provide pathways to good and inclusive work, and benefit the region's SME base. This can build from current on-going work between SYSC and SYMCA on principles for an inclusive industrial transition.

    i. Implications of Steel Decarbonisation for Workers and Communities.

6. **Support industrial workers to become active participants in green industrial future realisation.** This includes access to skills provision and job support where retraining is required, but more broadly to provide open communication and engagement around opportunities and challenges of green industrial futures. Trade Unions can play an important role within this, alongside businesses and policy organisations.

    i. Implications of Steel Decarbonisation for Workers and Communities.

Further Research Opportunities

Hydrogen sector: More research needed to understand the optimal balance between policy support and long-term independence, particularly the extent to which subsidies enable growth but may reduce adaptability and innovation.

Scoping a SY hydrogen network:

- Carry out further partner engagement to understand which decarbonisation option is preferable/intended.
- Develop a methodology for analysing the economics of sub-sections of the network to predict the most favourable roadmap for rollout.
- Collaborate with partners in areas where the network cost is lowest in order to develop a more accurate model, and gauge willingness to pay.

Jobs and work: Research could support the development of a community-rooted taskforce in Stocksbridge to lead community and infrastructural renewal.

Inclusive industrial decarbonisation: There is ongoing research underway with SYMCA to develop a broader approach to 'inclusive industrial decarbonisation' that seeks to set out a framework for delivering sustainable industrial futures that also addresses key social, economic and cultural challenges.

Public acceptance: Further research should track how public attitudes evolve as hydrogen infrastructure becomes more visible and explore how monitoring data can be translated into meaningful public-facing safety indicators.

Just Transition

Challenge

Realising visions for a sustainable South Yorkshire creates challenges and opportunities for fairness and inclusivity. A sustainability transition that does not effectively address concerns over equity and inclusion risks exacerbating recent trends towards 'green backlash', destabilising efforts to move towards an ecologically secure future.

A *just transition* seeks to ensure that addressing the climate and biodiversity emergency does not exacerbate existing inequalities, but seeks to reduce them through embedding inclusivity and equity within sustainability actions. This means supporting marginalised communities, ensuring they share the benefits of the transition to low carbon economies. This includes supporting those who have experienced harm through, or were excluded from, previous economic and energy transitions, and/or those who may be put at a disadvantage by the transition (such as communities tied to high carbon economies, such as steel or oil refining). It also requires the needs of current and future generations to be recognised, for instance, through providing space for youth participation in decision making as they are the key stakeholders in a just transition.

Just transition is multi-faceted, requiring focus on the fair *distribution* of costs and benefits; *recognition* of different identities, cultures and needs; and ensuring inclusive *procedures* for decision-making. While these can be viewed at a regional level it is also necessary to understand differences across different domains of regional life (e.g. at home, work, businesses, leisure, travel). Implications are mediated by *time* (speed of change, historic influences on perceptions and experiences), and will differ between different *places*. The *depth* of change required or desired will also vary in different situations. In some instances, changes to ways of living or working might be relatively slow and incremental, in others more transformative change might occur[1]. More ambitious and proactive attempts to achieve a thriving sustainable future for the region might necessitate more transformative approaches. Developing effective policy and actions for just transition will need to consider each of these facets (summarised in Figure 1).

As well as practical challenges, there are cultural barriers to achieving just transition, such as established ways of life: the daily rhythms and routines built around ways of heating homes, doing business, work, leisure and travel. These norms vary across generations and different households, reflecting complex emotional and behavioural responses towards what feels normal and acceptable for different people. South Yorkshire's residents might need supporting through the emotional process of changing ways of life while providing the means for individual and collective thriving, particularly given the region's post-industrial legacy and enduring social and economic consequences of earlier industrial decline. For policymakers, while a narrow viewing of just transition might be grasped through existing policy ideas like 'inclusive growth', achieving more transformative change will require reconsidering how our existing institutions operate, make decisions and their underpinning objectives. This disrupts established norms and habitual working practices, therefore requiring deep commitment and sustained regional leadership to enact change.

1 Eadson, W., Castano Garcia, A., Butterworth, E. and Parkes, S. (2025) What is an urban just transition? Grappling with an unsettled problem in an industrial region. European Urban and Regional Studies.

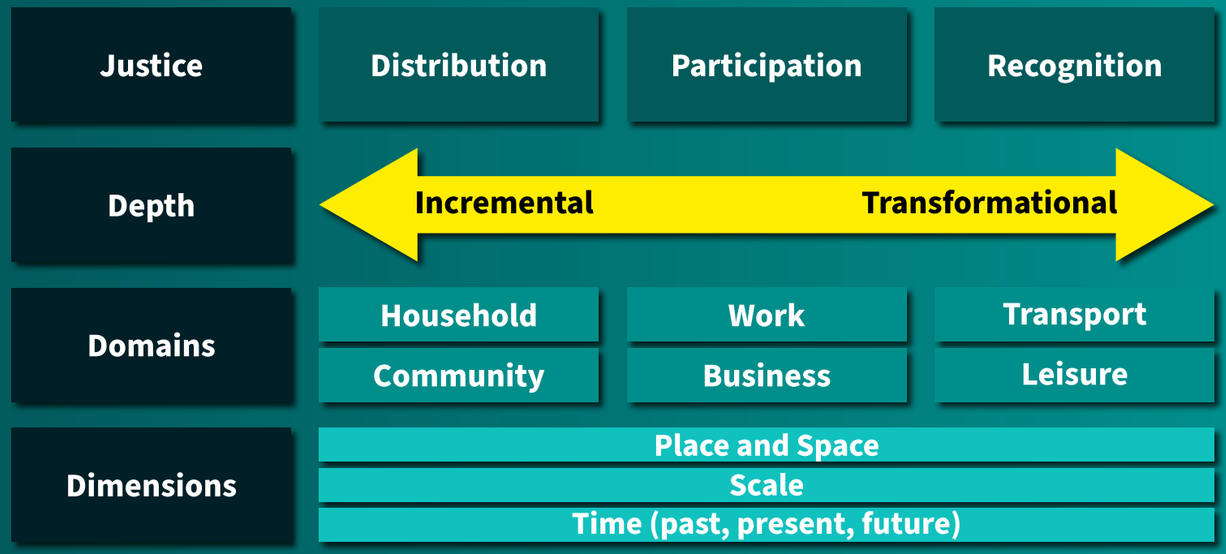


Figure 1: Illustrating justice aspects, domains of activity, depth/ambition, dimensions (time/space)

SYSC Theme	SYSC Just Transition Research
Residential Energy and Transport Systems	JUSTHEAT – lived experiences of home heating transitions
	Retrofit work in the context of modern methods of construction
	Let Zero – governance for equitable retrofit in the private rented sector
Food Systems and Environmental Restoration	Just transition for horticulture SMEs
	Nature recovery farming
Industrial and Commercial Emissions	Implications of green steel futures for workers and communities
	Place-based approaches to SME just transition
	Steel SME just transitions
Cross-Cutting	Youth visions for a sustainable South Yorkshire
	Income inequalities and sustainable futures
	Was the past more sustainable?

Figure 2: Research areas (homes, communities, workers, small businesses, young people)

What does this mean for South Yorkshire?

South Yorkshire has already undergone significant change over the last 40 years. Policymakers, practitioners, business owners, residents and workers who took part in our research all referred to the scarring our region has experienced through previous transitions, especially the industrial change experienced during the 1980s and 90s which harmed many of our communities. Tens of thousands of jobs were lost in mining and manufacturing sectors. Today 20% of local areas in South Yorkshire are in the top 10% most deprived in England[2].

The region's industrial legacy also creates new challenges. Over 22% of workers in Yorkshire and Humber will be affected by climate action[3]. Recent research puts parts of the South Yorkshire among those most vulnerable to the economic implications of transition in the UK[4].

The transition also brings economic opportunities. For instance, clean energy has been identified as a key opportunity area for the region. Effective mechanisms will be required to ensure that the economic benefits created by such opportunities can be harnessed by those that most need them, and that the value created for the region is used to invest in collective goods and services.

But just transition must not be viewed solely within the narrow frame of 'gross value added', jobs and skills. Just transition also concerns people that are not always thought of when it comes to decarbonisation, such as those vulnerable to fuel poverty and in cold and damp homes. Levels of fuel poverty are well above average in the region - ranging from 14% (Rotherham, Sheffield) to 16% (Doncaster, Barnsley), compared to an average of 11.4% for England - and many were excluded from the previous transition from coal to gas[5].

To be truly transformative, a just transition must build from understanding the lived experiences and perceptions of those affected. This has not been well-covered in previous research so our activities in South Yorkshire set out to address this gap.

2 Office for National Statistics (2025) English Index of Multiple Deprivation.
3 Robins et al (2019) Financing inclusive climate action in the UK. An investor roadmap for the just transition. The Grantham Institute.
4 Cantellow, T., Atkins, E., Fox, S and Robinson, C (2026) A net-zero vulnerability index for Great Britain. Regional Studies Regional Science.
5 KADA (2023)South Yorkshire Skills and Employment Evidence Base. A report for for the South Yorkshire Mayoral Combined Authority. 11a.i Appendix A.

Research Response

The South Yorkshire Sustainability Centre just transition programme set out to understand just transition challenges and opportunities for diverse, less-well-heard groups, through exploring their own histories, experiences and perceptions of a sustainable future. It cut across the different SYSC themes, including research on industrial decarbonisation, home heating, housing retrofit and food systems. We aimed to cover a range of different situations to explore the breadth of the challenge and provide solutions across different pieces within the just transition 'jigsaw'. These are outlined in Figure 1.

Each study was a discrete project with research questions and methodologies tailored to the area of focus, but with a shared concern for lived experiences and expectations, over time, and rooted in places. Transition is, by definition, a process of change, an emotional and culturally embedded activity which requires deep understanding of individual and collective perceptions and experiences. Summaries of the different projects can be found in our case study reports. Here we outline some of the key findings and cross-cutting lessons.

Industrial communities

South Yorkshire's industrial communities have experienced significant change over the last 40-50 years. The effects of the decline in coal and steel production were felt in communities across the region. Our research in the steel town of Stocksbridge sought to understand **lived experiences of industrial change** over time, and how this has shaped perceptions of decarbonisation[6]. Changes to the steelworks over time has reduced the role it has played in the economic, social and cultural life of the town, but it has remained central to local identity and to perceptions of what prosperity and community cohesion can look like. Our research found that a 'green' future was not often perceived as a source of renewed prosperity for the steelworks or the town itself, but could be envisioned as a means of preserving the continuation or survival of the town's steel heritage. The town has endured repeated cycles of uncertainty, unsettlement, change and loss since the 1980s. They were ambivalent about whether the green transition

6 This research was co-funded by SYSC and Swedish research councils, as part of an international study of green steel transformations. For more information on the study see here.

would be any different to the past harms they had experienced. The declining steelworks exposes a sense of vulnerability and a disconnect between national level policy priorities and local lived realities. The research highlighted the importance of supporting communities to collectively build their own understanding of what change has meant for them in the past, and how this can be used to shape what a sustainable future might look like. Common to much of our research, we found that support for successful industrial transitions is fostered through understanding cultural and emotional perceptions and experiences of change over time.

Workers

Our work in Stocksbridge also revealed **workers' perceptions of green industrial futures**. This was also viewed in the context of repeated moments of crisis and change within the steel industry. At the time of the research the works was in a period of deep uncertainty over its future, shortly before Liberty Speciality Steels UK was taken under government control. Workers had mixed views on what a green steel future looked like and what it would mean for them. Some were cynical about possibilities of achieving 'green' steel; others thought it would involve little change to their current operations. Sustainability transition was not seen by these workers as a particular opportunity for the business or workers, and this was partly reinforced by concern that high energy costs would continue to make business conditions difficult for steel producers. More broadly, there was a need to support workers to engage positively in the possibilities and challenges for green steel futures, as active stakeholders in change.

Jobs created and altered through a green transition also have the potential for creating decent and fair work which has good pay; is intrinsically rewarding; has good terms of employment; is healthy and safe; has work–life balance; and includes worker representation. However, it should not be assumed that all green jobs are good jobs. Our **research on housing retrofit** has demonstrated this, showing the importance to worker experience of how retrofit is delivered. For instance, modern methods of construction (MMC) can create more inclusive workplace cultures, with safe and consistent working conditions. However, MMC can also be repetitive and lower-skilled, replacing the varied work that currently exists in some parts of the construction sector. While retrofit can be a stimulus for creating green jobs[7] for a just transition, these jobs must be high quality[8]. This highlights the need to work with new and changing industries to develop a well-rounded approach to ensuring a just transition for workers – not just focused on skills supply, but on promoting inclusive business practices and pathways into work. Future green jobs are not necessarily inherently better or worse

7 Brown, D. et al. (2020), A Green Stimulus for Housing: The macroeconomic impacts of a UK whole house retrofit programme. New Economics Foundation, p. 35.
8 See SYSC Case 'What do modern methods of construction mean for housing retrofit jobs and working conditions?' in a Housing retrofit chapter for more information on this study

than previous types of employment and needs to be actively shaped through partnership between policy organisations, relevant voluntary sector organisations, skills providers, trade unions and business.

Home heating

Staying on the topic of housing decarbonisation, the **JUSTHEAT** project focused on home heating across different countries in Europe, and included South Yorkshire as an important case study. The project worked with 14 communities leading, resisting or excluded from the clean heat transition, revealing that expectations and attachments around heating are far more complex than current policy assumes. Drawing on 286 detailed oral histories about keeping warm and feeling cold at home, alongside archival research, art methods, and historic and contemporary policy analysis, we developed new understanding about how to achieve public support for a successful heating transition[9]. The research reveals diverse social, cultural, relational, emotional and financial outcomes that vary by place, household, and social group, underlining the long-lasting consequences of decisions about how homes are heated[10].

Key insights challenge mainstream approaches to clean heat and include:

- **Bricolage:** Households value feeling resilient, which for them means having multiple ways to heat their home. Yet clean-heat narratives often imply a "clean sweep" that reduces options and increases dependence on electricity networks.
- **Thermal delight:** Participants stressed that modern heating systems overlook the sensory pleasure of warmth. People desire more than basic comfort; they seek "thermal delight," often linked to radiant heat and shared, sociable experiences. Many romanticised solid-fuel fires, whether remembered or still used.
- **Anachronism:** Home heating is not experienced on a single timeline. Different European communities inhabit different historical moments, from Romanian wood-burning households living much as they have for centuries to Sweden's advanced, equitable heating systems. Individuals also move backward or forward in time when they change homes, showing that progress is not linear.
- **Emotional baggage:** Heating choices are rarely rational. They are shaped by deep emotional ties, formative memories and personal histories that strongly influence how people respond to the clean heat transition.

All of these cross cutting findings resonate in our South Yorkshire case studies. The study concluded that heating transitions should be led locally, prioritise communities left behind by previous transitions, and focus on what new systems can offer—especially comfort and thermal delight—rather than what they might be perceived to take

9 More information about JUSTHEAT can be found here: https://www.shu.ac.uk/centre-regional-economic-social-research/projects/all-projects/looking-back-to-move-forward-justheat
10 Ambrose, A., Davies, K., McCarthy, L., Shaw, B., & Shahzad, S. (2025). Low carbon heating transitions and Actor Network Theory: Entanglements with the fireside. Energy Research and Social Science, 126.

away (i.e. energy efficiency is sometimes perceived as synonymous with reduced comfort and flexibility)[11].

Small businesses

Small and medium enterprises (SMEs) are essential to achieving net-zero and collectively make up approximately 99% of South Yorkshire's businesses[12]. Yet, despite their aggregate economic and employment significance, SMEs are underrepresented in policy and just transitions debates[13]. Our UK-wide research, which included South Yorkshire as a key case study, shows that SME decarbonisation is shaped by diverse relationships – such as landlords, supply chains and intermediaries – and that businesses face highly varied challenges depending on sector, size and organisational characteristics[14]. Some SMEs, particularly those serving or comprised of vulnerable or marginalised communities, lack access to existing support and risk being left behind. To address this, we developed an operational framework that enables policymakers to diagnose different types of vulnerability, identify intervention points, and tailor support to specific groups of SMEs rather than relying on generic, one-size-fits-all programmes[15].

For South Yorkshire, these insights highlight both the scale of the challenge and opportunities for regional leadership. The region's manufacturing base increases the urgency for coordinated action, but existing support remains dispersed and limited in reach. Policy recommendations focus on building a coherent, place-based strategy[16]; establishing a regional SME decarbonisation steering group; using the just transition framework to identify and engage under-represented businesses; and working through diverse intermediaries - from accountants to community organisations - to reach vulnerable firms. Strengthening regional capacity could include creating a one-stop-shop to link SMEs with local solution providers, coordinating sector-specific support, and investing in climate literacy and skills provision across the further and higher education sectors. Policymakers should also recognise SMEs' wider roles as enablers and influencers of climate action, for example through programmes that support SMEs as climate citizens.

11 Ambrose, A., Shaw, B., Palm, J., Pelsmakers, S., Aho, H., Castano Rosa, R., ... Vornicu, A. (2025). Looking back to move forwards: a social and cultural history of heating in Europe - A summary of key findings across the UK, Romania, Sweden, Finland. Centre for Regional Economic and Social Research, Sheffield Hallam University.

12 Office for National Statistics (2025) UK business: activity, size and location.

13 Hampton, S., Blundel, R., Eadson, W., Northall, P. and Sugar, K. (2023) Crisis and opportunity: transforming SME governance for net zero. Global Environmental Change.

14 See 'Ensuring a just transition for Small and Medium Enterprises (SMEs) case study within this chapter for more information about this research

15 Eadson, W., Hampton, S., Blundel, R., Apostolopoulou, E., Latter, B., Witherley, D., Hardy-Jones, B., and Sugar, K. (2026) Just business? Rethinking SME climate action through a just transition lens. Energy Research and Social Science.

16 Eadson, W., Hampton, S., Blundel, R et al. (2024) Seven principles of place-based net zero policy for SMEs. UK Energy Research Centre.

Young people

Just transition needs to consider the roles of different existing and future generations. **Young people** are a particularly important population group. They have a long-term stake in the planning of sustainable futures, yet are generally excluded from participatory decision-making and research. Our Youth Visioning project addressed this by piloting an approach to understand how young people envision a just transition[17]. Our research found that students have strong environmental values; for example, they prioritise fairness and equality, safety and protection for everyone. Their illustrations and discussions during the research workshops included specific examples of shared green space, renewable energy, and community food growing, whilst protecting privacy and valuing their wellbeing. However, access to tools and knowledge to turn these values into action were limited. Most youth engagement is either consultative or extra-curricular, and not fully integrated into government strategies[18]). The Youth Visioning project demonstrated that young people recognise, and can imagine what a sustainable future looks like, drawing from values formed through early moral development in childhood and reinforced through social learning in family and school settings. It is important that children and young people are provided with a framework for attaching these values to later life career decisions.

Bringing it together: finding our place in history

A shared theme across our research was an emphasis on how change is experienced unevenly and heavily influenced by emotional, social and cultural factors. Much of our research focused on places and communities but with a recognition that looking to the past as well as future possibilities is essential to understanding how to develop actions for just transition in South Yorkshire. One project that exemplifies this is **"Was the Past More Sustainable?"**. This research explored which elements of past ways of life should be preserved and what we should never return to. This involved historical analysis across key domains of everyday life such as heating, transport, waste and air quality. The project has clear relevance for debates about a just transition by highlighting that environmental change is always socially and culturally shaped and unevenly experienced. The project asked not only whether past systems were more sustainable, but also who benefited from them and who bore the costs. By grounding sustainability debates in lived historical experience, the project challenges narratives that frame climate action as an inevitable loss of comfort and lowered living standards. It shows that societies have undergone major transitions before, often with improvements to health and wellbeing, such as cleaner air following the decline of coal. This reframing can help reduce resistance to climate policy and support fairer transitions by making change feel more familiar and legitimate.

17 See Case Study Youth Visioning in this chapter for more detail on this study.

18 Parsons, M., Godden, N. J., Henrique, K. P., Tschakert, P., Gonda, N., Atkins, E., Steen, K., & Crease, R. P. (2025) Participatory approaches to climate adaptation, resilience, and mitigation: A systematic review.

Just Transition Recommendations for Regional Policymakers

1. Recognising that economic gains can only create tangible benefit if felt by all the region's residents, local policy makers should **embed just transition principles and actions within key economic development programmes** such as the South Yorkshire Investment Zone and Local Innovation Partnership Funding, working with key partners, including academic institutions.

2. **Establish a regional just transition commission** to develop a just transition delivery framework. This should include representation from workers, community organisations, SMEs, young people, anchor institutions and sector bodies.

3. **Create a South Yorkshire 'Living Transitions' Programme.** Building from our findings which highlight the importance of emotional and cultural insights for just transition, we recommend that major decarbonisation initiatives are accompanied by programmes of activities, such as community storytelling, oral history and visioning, to both support the design of successful decarbonisation programmes and to enable their acceptance. This could be accompanied by transition hubs in priority neighbourhoods utilising trusted local spaces where residents co-create visions for change, access support and build shared narratives of a sustainable future.

4. **Embed youth voice and intergenerational justice in policy making.** This can include rolling out the model of climate engagement trialled through SYSC alongside further work to embed climate literacy into SY schools' curricula.

5. **Produce an 'inclusive industrial transition' strategy** which centres on how large investments in industrial decarbonisation can capture value for the region as a whole, provide pathways to good and inclusive work, and benefit the region's SME base. This can build from current on-going work between SYSC and SYMCA on principles for an inclusive industrial transition.

6. **Support industrial workers to become active participants in green industrial future realisation.** This includes access to skills provision and job support where retraining is required, but more broadly to provide open communication and engagement around opportunities and challenges of green industrial futures. Trade Unions can play an important role within this, alongside businesses and policy organisations.

7. **Establish a programme for regional decision-makers to share learning about different models of policy-making and economic development.** This will support development of policy and practice towards a genuinely transformational transition to a thriving sustainable future in South Yorkshire, which requires openness to exploring different ways of thinking, doing and understanding what 'success' looks like for South Yorkshire.

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