

## Advanced Materials in the North West

Cite as: Nelles, Jen, Kevin Walsh, Michalis Papazoglou, Elvis Nyanzu, Syahirah Abdul Rahman, and Tim Vorley. 2023. *Advanced Materials North West - Understanding Cluster Growth Potential Case Study*. Oxford, UK: Innovation Caucus.

### Case Study Overview

**Characteristics and history:** The North West region of England is considered by many to be the birthplace of the Industrial Revolution and has remained an industrial powerhouse during all six waves of innovation cycles. The region generates about 9% of the UK's GDP, has one of the largest aerospace sectors in the UK, and the largest digital economy in the UK after London and the South East (Office of National Statistics, 2022). The region boasts a conurbation of some of the world's best assets in advanced materials research and manufacturing. It is home to major firms such as Jaguar Land Rover, BAE Systems, Unilever, Tata Steel, Siemens, Pilkington, and Victrex. Due to the size of the area and its connections to neighbouring regions, the Advanced Materials industry is well served by world renowned research centres and institutes within the University of Manchester, University of Liverpool, University of Central Lancashire, University of Chester, University of Lancaster, Leeds University, and Sheffield University. The University of Manchester, for instance, has 10 separate institutes dedicated to various aspects of material science. This is in addition to the Henry Royce Institute for advanced materials research and innovation. There is a dedicated materials innovation factory and a Digital Innovation Facility within the University of Liverpool purposely developed to foster collaboration between academic and industry researchers and to drive advanced materials innovation. Other independent research and innovation centres in the area include Sci-Tech laboratories Daresbury and the Knowledge Centre for Materials Chemistry (KCMC). Whereas the size of the Advanced Materials industry and its related research facilities in the area cannot be understated, there is an acknowledgement of the lack of collaborative efforts among the various stakeholders to identify and drive a common agenda for the North West Advanced Materials industry as a whole. In its current form, only the few major companies in the area that operate in the Advanced Materials industry are obvious but these are supported by a vast supply chain of related firms that can be difficult to identify and classify as Advanced Materials companies. A strong leadership that can provide the much-needed coordination among stakeholders is critical to the development of the industry to allow the North West to drive innovation and enhance the competitive advantage of the UK.

**Geography and size:** The North West region of England, where this study is based, covers Greater Manchester, Liverpool City Region and 23 other local authority districts. It also has strong economic connections to neighbouring government office regions such as the North East, Yorkshire and West Midlands. Even though the majority of the large firms in the Advanced Materials industry in this area are based around the Mersey basin, companies operating within the Advanced Materials industry can be found in most parts of the North West. Whilst some of the larger firms undertake research, innovation and technological developments in-house, a significant proportion of such activities are based in universities and independent research centres. Even though the different political and administrative boundaries do affect the governance of some of the processes around the funding of research and development, as well as access to certain facilities, companies in these areas tend to work with other institutions and firms across such boundaries and beyond. It was, however, evident from the interviews that cross-boundary interactions between the various local administrations were virtually non-existent. In fact, one respondent likened the relationship between Liverpool City Region and Greater Manchester combined Authority to the rivalry between Manchester United FC and

Liverpool FC. Instead of the two largest combined authorities working together to create a recognised identity for the Advanced Materials Science industry in the North West, they seem to be competing for superiority.

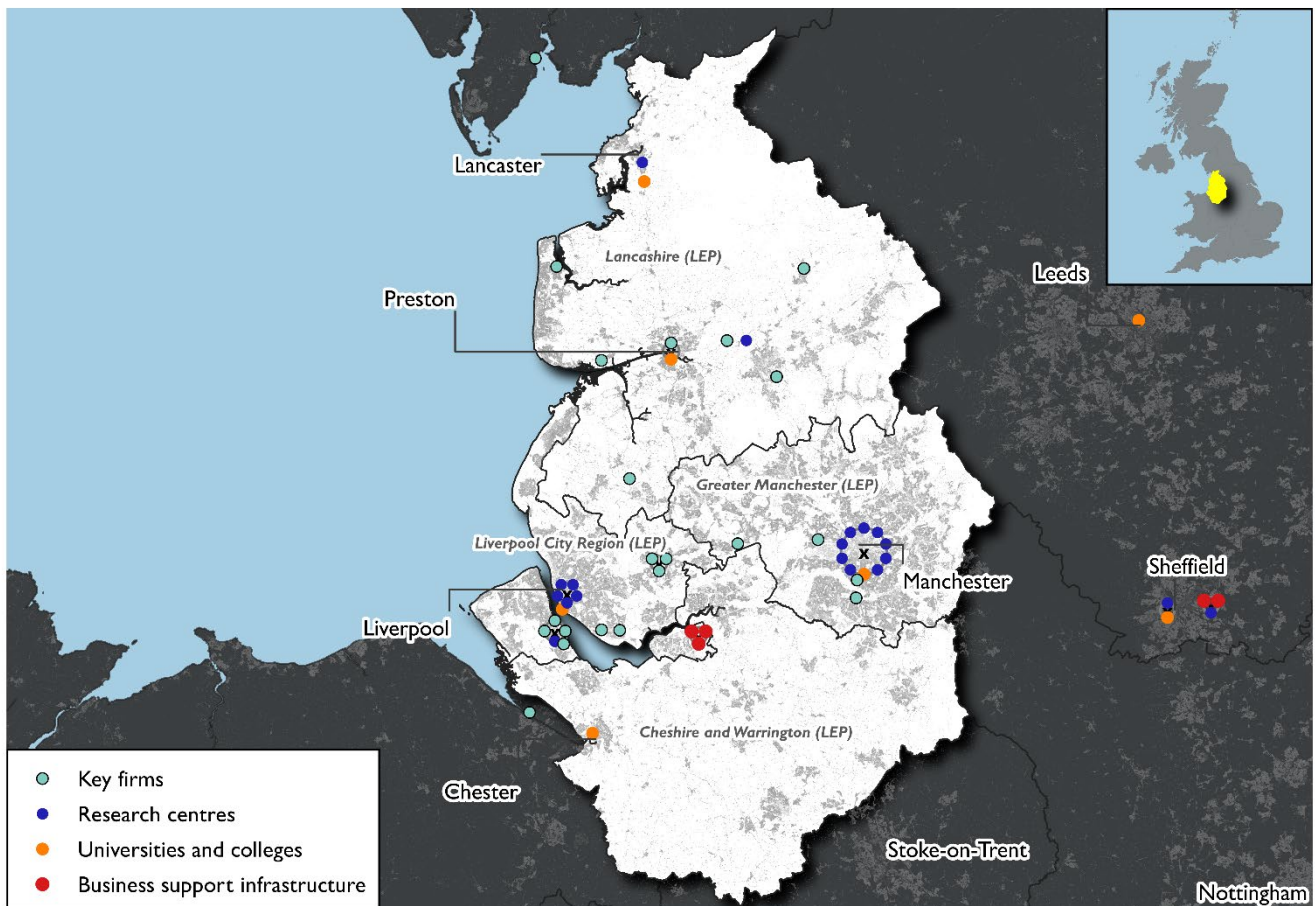


Figure 1: Advanced Materials in the North West map.

**Areas of potential future growth:** The Advanced Materials industry in the UK contributes about £14.4 billion in gross value added to the economy. Given the number of people employed in the industry, its gross value added per employee is 25% more than the UK average (BIES, 2022). The Advanced Materials industry in general is well placed to drive what has been dubbed the “next Industrial Revolution”, driven by the sustainability agenda and net zero objectives. There is an ongoing greater focus on advanced material research and innovation within government policy initiatives. The UK Advanced Materials industry was highlighted as one of the 7 technology areas of UK opportunity and strength in the 2021 Innovation Strategy (BEIS, 2021). To this end, the government is investing £95 million through the Henry Royce Institute in advanced materials research and innovation (BIES, 2022). As societies move towards a green economy, demand for sustainable advanced materials will continue to grow. There are firms and institutes in the Advanced Materials industry that are already at the forefront of this change; however, most of these institutions and firms are not collaborating, and progress is very minimal and at smaller scales. A clear indication of the UK Government’s commitment to net zero targets, elimination of fossil fuels and decarbonisation was highlighted as being critical to investments in material research and development at the firm level. Specific areas of potential growth include:

- Data and digitalisation
- Intelligent Materials
- The creation of materials for the renewable energy sector and decarbonisation, including materials for long range battery technology and conductors
- The development of lightweight and sustainable materials.

**Reflections:** The Advanced Materials industry in the North West has all of the necessary characteristics and basic ingredients to develop into an innovation powerhouse. It has a strong asset base that is rooted in well-established material science research institutions and has one of the largest conurbations of material development and application companies in the UK. The innovation potential of the industry is hindered by the lack of leadership that can coordinate the activities of the various stakeholders and players in the industry through well-defined objectives. Knowledge transfers between actors in the industry are limited and developments in areas such as big data, digitalisation, and the application of artificial intelligence and machine learning are inadequate.

## Core Assets

**Market structure and anchor firms:** The lack of a clear network of firms and the sheer size of the geography of the North West make it very difficult to obtain a comprehensive list of firms operating in the Advanced Materials industry in this area. According to the Greater Manchester Innovation Plan (2022) there are over 4000 advanced manufacturing companies in greater Manchester alone with about 180 firms specialising in advanced materials. However, most of the interviewees acknowledge that the bulk of the Advanced Materials companies are based within Liverpool City Region. This suggests that there are hundreds more firms in the region specialising in advanced materials. Majority of the large and significant Advanced Materials firms such as NSG Pilkington, Unilever and Johnson Matthey are located around Liverpool. There are also many more firms that feed that form part of the industries supply chain and operate in related activities.

Whilst some respondents felt that the presence of large corporations such as Unilever, NSG Pilkington, Victrex, and Johnson Matthey among others do drive other firms into the area to form part of the supply chain and drive innovation, other respondents felt the future of the innovation and growth of the industry lies with the many SMEs operating at various stages of the industry.

**Higher education and training institutions:** The North West region has several research-intensive universities actively working in material science. It is also well positioned to benefit from some of the leading universities in material science in neighbouring regions that also undertake material science research and offer both undergraduate and graduate-level degree programmes. This cluster of institutions includes:

- **The University of Manchester** offers many undergraduate and postgraduate programmes in various aspects of material science and boasts expertise in textiles and paper, corrosion and corrosion prevention, metallurgy, biomedical materials, and polymers. The university has a materials science department and 10 institutes dedicated to materials science research. These include the National Graphene Institute and the Graphene Engineering Innovation Centre. It is also home to the world-renowned **Henry Royce Institute**. This Institute, which focuses mainly on material science research and innovation, is a partnership between the National Nuclear Laboratory, the UK Atomic Energy Authority (UKAEA) and 6 of the UK's leading Universities (**Imperial College London, Oxford, Sheffield, Manchester, Leeds** and

**Cambridge**). The Royce is mainly funded by the EPSRC and provides expertise and specialised equipment and facilities to companies of all sizes, other academic institutions and the general public involved in material science research and innovation.

- The **University of Liverpool** is home to the **Materials Innovation Factory (MIF)**, which opened in 2017 in collaboration with Unilever, is open to academics and other companies seeking to leverage the expertise of academics and other experts in a well-equipped purpose-built environment to scale their research and development activities. The MIF is well-equipped with material science robotics and analytic equipment capable of handling multiple workflows. Areas of expertise at MIF include organic and inorganic materials, nanomedicines, genomic sequencing and high throughput formulation. MIF also hosts the **Leverhulme Research Centre for Functional Materials Design**, and the **Digital Innovation Facility**: though not necessarily focused on material science, this is a necessary platform for the integration of robotics, autonomous systems, data analytics and artificial intelligence in the development and application of advanced materials. The University of Liverpool also offers various undergraduate and postgraduate degree programmes in materials science and its related disciplines.
- The **University of Central Lancashire** has the **Research Centre for Smart Materials** and the **Functional Materials Group** with expertise in graphene, nanocomposites, films, fibres, biomaterials, alloys, polymers, and gels among others. Academics in these centres work collaboratively with partners from industry and other academic institutions in the Chemical and Advanced Materials industry.
- The **University of Chester** is home to **The Smart Composite Group**, an innovation hub that explores and develops multifunctional materials for industrial application. The centre has expertise in finite element modelling, composite machining and joining, and multifunctional composite and digital manufacturing of composites.
- The **University of Lancaster's Material Science Institute (MSI)** offers a wide range of facilities and equipment for the analyses and characterisation of materials, additive manufacturing of materials and nanoscale device fabrication to industrial partners and collaborators from other institutions working in the material science sector. They offer placement opportunities, internships, and equipment training. MSI is currently working with Bruker UK Ltd and LMA Ltd to pioneer nanoscale property mapping of subsurface and buried layers of materials.

Outside of the boundaries of the North West region, but easily accessible to businesses and academic collaborators in the North West, is the **University of Sheffield's Department of Materials Science and Engineering**. The Department has several facilities and the equipment to facilitate chemical and material science research which is accessible to public and private sector organisations as well as academics from other institutions. For instance, their **Materials for Innovative Disposition from Advanced Separations (MIDAS)** facility is well equipped for research and development in the management and disposal of radioactive wastes. Other facilities include the **X-ray Power Diffraction Research** facility, x-ray absorption and emission spectroscopy equipment, and the **Sheffield Tomography Centre**.

**Other research and anchor organisations:** In addition to these universities and institutions, other organisations support materials science innovation in the North West through the provision of specialised lab equipment and collaboration facilities. Notable among these are:

- **Sci-Tech Daresbury** in partnership with **Science and Technology Facilities Council (STFC)**: has over 30 companies working in various aspects of materials innovation and development from the same location.
- **The Knowledge Centre for Materials Chemistry (KCMC)** is another organisation which supports knowledge transfers between academia and industry to drive innovation in

materials chemistry through the facilitation of research and development collaborations. KCMC has facilities in both Liverpool and Manchester.

**Finance:** Materials innovation is a complex process, goes through multiple development cycles, takes several years, and requires some level of funding certainty to ensure that the innovation cycle, where successful, is complete. In this regard, companies, especially large companies, tend to rely on internal funding for their materials research and innovation. Whilst some respondents were quick to acknowledge the role of the EPSRC and Innovate UK in providing funding for materials research and innovation, most of the interview respondents indicated Innovate UK funding does not provide the certainty required to ensure the completion of the innovation cycle. As one respondent put it:

*If I apply for an Innovate UK programme... maybe we get the funding, maybe we don't... but when we do get the funding it runs to a point and it stops, the tap gets turned off... you may then have to win another competition in order to continue. There is no guarantee of follow up funding.*

The above sentiment was echoed by another respondent who highlighted that "...Innovate UK are funding some very interesting work below TRL level but then it dies" due to the lack of follow up funding. There is also a lack of awareness among SMEs about funding opportunities available through research councils and other outlets. Those who are aware of these opportunities highlighted challenges with navigating UKRI and Innovate UK funding application processes as barriers to accessing funding.

**Reflections:** The Advanced Materials Science industry in the North West has some of the best core assets in the country. There are world-renowned and well-equipped research and innovation centres in Manchester and Liverpool and other parts of the region as indicated above. There are several world-leading companies in materials development located within the regions. There are also a substantial number of SMEs working within Advanced Materials Science and supported by many more other companies that form part of their supply chain. In terms of asset base, the North West has a competitive advantage in materials innovation over other regions in the UK.

## Skills

**Talent pool:** The Advanced Materials industry in the North West has many academic assets in this area and there is a steady supply of talent. However, in recent years there have been recruitment challenges in getting appropriately skilled personnel in areas where they are needed. Some of the interviewees who work directly in this area highlighted issues relating to competing demands for skills from other sectors, especially in technology and digital fields. One interviewee highlighted a case where a PhD graduate was offered a £40,000 starting salary to work with them in Warrington, but a week before he was supposed to start working with them, he turned the job down in favour of another role in the banking sector in London, for a salary close to £100,000. One interviewee described the situation as "difficult for a company like Tata Steel to outbid a company like IBM or a Bank in the city of London when it comes to talents in AI, machine learning and most of the digital areas".

Other interviewees felt that although the university assets in the area are producing a lot of graduates with the necessary qualifications to work in the industry, most of these graduates are moving out of the area to other parts of the UK and abroad. They believed that this was partly due to the lack of

closer relationships between universities and companies in matching talented graduates to opportunities available in businesses. A much closer relationship between universities and companies to understand their talent needs and skill gaps will go a long way to improve employability, and also ensure that employees with the appropriate skills are made available to the industry. Some of the interviewees also highlighted their commitment to and investments in apprenticeship in various parts of the company to drive productivity and R&D.

**Local skills provision:** Whereas most of the interviewees acknowledge the importance of a sufficient pool of local skills and talents to materials science innovation, they didn't see the unavailability of local talent as a significant limitation to growth or innovation. Companies are prepared to recruit from anywhere in the UK and in some situations from other countries depending on the level of skills and experience required. Others took the view that the relatively low cost of living in the North West compared to London and the South East has some form of comparative advantage when it comes to accessing talent from other parts of the UK. Interviewees were mainly concerned with the number of graduates and the suitability of talents across the UK to be employed in materials science and digitalisation programmes.

**Reflections:** There were divergent views on the availability of relevant skills and talents in the industry. Respondents based in universities and research centres felt there is adequate talent available for firms to work with. On the other hand, respondents from industry suggested that there were difficulties in finding people with certain specialised skills. Respondents felt some of the university programmes were very generalised within Advanced Materials Science and that greater collaboration between universities and industry is required to ensure personnel with the appropriate skills are available when needed. Despite these divergent views, none of the interviewees had a strong inclination that innovation is being restrained because of the lack of people with relevant skills. The availability of local talent did not appear to be a significant issue so long as talent was available in the UK.

## Knowledge Exchange

**Firm research and development practices:** Compared to some of the other industries, the Advanced Materials industry is by default R&D intensive. The surge towards a green economy and sustainability mean that organisations are constantly looking for the next material that will give them a competitive edge. Research and innovation centres in the North West have seen significant increases in the use of their facilities, whilst some of the larger firms in the area like Unilever and Johnson Matthey have collaborated with universities in the area to set up R&D and innovation centres. Some of the respondents indicated that they have created in-house incubators and have deployed data analytics and machine learning as part of their research and development of new materials.

**Knowledge sharing and flows:** The presence of research and innovation centres such as the STFC labs at Sci-tech Daresbury, the Material Innovation Factory, the Royce Institute and the KCNC centres have improved collaboration between academia and industry. Universities are seeing greater willingness from their industry partners to collaborate on various R&D projects. Some of the interviewees from industry indicated they have increased the network of universities that they collaborate with in recent years and set up several collaborations with start-ups. Academia-industry

collaboration is not limited to universities in the North West region: some of the companies in the North West have formed partnerships with universities in other parts of the UK, and vice versa.

**Knowledge access and cultures:** At the firm level, there is an appetite for collaboration between firms, especially between SMEs and large corporations. Some of these collaborations have been facilitated by the materials labs, and innovation and research centres located across the North West. Companies are prepared to consult for other companies and share information on areas like supply chain information when they are not direct competitors. However, in general, there are limited collaborations between firms. This is partly due to the lack of a recognised network or governing body where a comprehensive list of companies working in materials in the North West can be accessed for collaborative opportunities. One interviewee noted that:

*There are a huge number of SMEs [in the industry in the North West] and part of the challenge is actually being able to identify all of the SMEs or the ones that are relevant, because we are happy to collaborate with SMEs as long as we know that they exist*

**Firm network relationships:** The lack of openness makes it difficult for companies to overcome similar challenges that they may be facing in isolation. Interviewees noted that the limited flow of knowledge is not necessarily due to the unwillingness on the part of the companies to share knowledge, but to the lack of leadership and organisation in creating a collaborative culture and environment. There are also adversarial relationships between academia and industry when it comes to intellectual property rights. Some of the respondents indicated that there are certain universities that they do not and will not work with because, irrespective of how much money the companies invest in their joint ventures, such institutions always want to solely own the rights to any intellectual property that may arise from their activities. Other respondents indicated that universities are not doing enough to identify collaborative opportunities within the industry, especially with SMEs.

**Reflections:** The North West has very impressive sets of innovation assets in advanced materials, considering the wealth of expertise available in the various academic intuitions and research centres across the region, the number of companies and the spectrum of advanced materials related activities in which they are engaged. The presence of key research and innovation centres has resulted in increased connections between academic experts and the industry. There are opportunities to drive materials innovation through networking and coordination of the activities of firms that can benefit from working in the same spaces.

## Networks of Coordination

There are no recognised governed networks within the Advanced Materials industry in the North West and the industry lacks the necessary leadership to collaborate and champion its activities. This is partly because of the segmented nature of the industry. Different companies focus on distinct aspects of materials, and it is sometimes difficult to achieve an appropriate level of critical mass where governance can be useful. The closest to a recognised network is the Materials Research Exchange spearheaded by Innovate UK KTN which holds networking events to enhance collaboration and knowledge transfer. While one respondent commended the ability of the KTN to bring potential partners together once they have a good understanding of the relevant issues and challenges, there

were suggestions that the activities of the KTN need to be significantly enhanced if they are to act as a governing organisation for knowledge transfer and networking.

**Reflections:** The innovation and product development potential of the Advanced Materials industry in the North West is significantly constrained by the lack of a recognised governing structure and network that will bring firms together and coordinate their activities. A common theme among respondents was “the lack of leadership”. The Advanced Materials industry in the region is not new; it has been there for a while and will probably continue to be there, but there is very little focus on enhancing the image of the North West as the centre of materials innovation in the UK. Resolving issues around cluster coordination, leadership and networking has the potential to accelerate Advanced Materials Science research and innovation in this area.

The *Innovate UK Plan for Action* for UK business innovation published in 2021 recognises the need to create a collaborative environment where people and organisations can come together to make effective use of the resources available and drive innovation (Innovate UK, 2021). What is perhaps even more important is ensuring such opportunities are well-streamlined; easy to understand and navigate; and well-communicated to stakeholders. A strong regional and sectoral leadership to promote and implement the activities linked to such strategies is also essential to the realisation of the aims and objectives of such initiatives.

Given the size of the material industry in the North West and the geographical spread of firms within the industry, a cluster leadership which is independent of the various political and administrative institutions is necessary to facilitate cross-boundary networking between firms, academia, and industry experts; and coordinate the activities of national and regional initiatives.

## **Discussion: Innovation opportunities and support needs**

**Evolution and market opportunities:** The Advanced Materials industry is currently in a good place in terms of its growth potential and market opportunities. The North West is home to many energy storage and generation companies that will all require some form of new materials as the country and the world in general move towards net zero and the green economy. There are opportunities for the use of big data, artificial intelligence, machine learning and robotics as part of new materials research, innovation and production. These developmental opportunities have the potential to improve the innovation capabilities of the Advanced Materials industry in the North West if the necessary steps towards cluster development and coordination of assets are put in place.

**Resilience:** Feedback from interviewees indicated that the UK lacks a clear and coherent national materials strategy. There appear to be some strategies available at the sub-industry group council level, but what informs such strategies is not clear. There are challenges in getting the right talents in the areas of digitalisation and the use of big data. Demand for talent in these areas remains very competitive and most often, material science companies in the North West are unable to compete with other organisations in other industries in other parts of the country. Another challenge to the industry is the level of R&D investment. Compared to other countries such as Germany and the USA, R&D investment in the UK is very low. This has the potential to put UK companies on the back foot in materials innovation.



### Areas of potential support and intervention:

- Establish a cluster (or clusters) with clear purpose and identity: In the Advanced Materials industry, this can be very challenging because there are different segments of materials science, and it is necessary to identify how best to focus the cluster activities to achieve the best possible impact(s). In the North West, there are many assets, players and actors in the Advanced Materials industry. However, the activities of stakeholders such as local administrative authorities, LEPs and research councils that support the industry are not well coordinated. It can be difficult for firms to navigate the various pathways available for support. The establishment of a cluster can certainly help direct and coordinate the activities of stakeholders to strengthen collaborations, networking, and knowledge transfers.
- Enhance the reputation of the region as a centre of excellence for materials science: When we talk about material science innovation, the North West is not the first area that one thinks about, even though it has arguably the best collection of material science assets in the country. The North West needs to develop a notable identity in materials science research and innovation that is recognisable not only in the UK but internationally. The establishment of a recognised cluster can help in this development, but it will also require a platform for the various stakeholders, especially the local and combined authorities in the region, to work together.
- Reconsider funding regarding innovation cycles: The funding of materials innovation needs to be reviewed in recognition of the life cycle of new materials innovation and development. There are suggestions that potentially good innovative products are not being developed because funding for such projects, when obtained from research councils, tends to be on a short-term basis with no guarantee for the next stage of product development. Such developments tend to terminate below TRLs. This approach to funding is stifling innovation in materials.
- Develop a national materials strategy: The development of a clear and coherent national strategy for materials development is required to generate the necessary private sector investment and interest in materials innovation. For instance, firms are not likely to invest in the research and development of new materials if they are not confident that the country is committed to its net zero objectives. Most of these organisations are already working on valuable products that require little to no R&D spending and will not seek to invest in new materials if they are not confident that it is the right direction to take.

**Reflections:** The Advanced Materials industry in the North West has the necessary core assets to develop into a recognised materials research and innovation powerhouse for the country. However, the industry is very segmented and lacks the appropriate leadership to collaborate with the activities of the industry as a whole. The development of any form of a cluster has to be pitched at a point where critical mass can be achieved. At the same time, administrative boundaries possess another challenge to the development of a recognised North West materials cluster that has the support of all stakeholders. For any such cluster development to be successful, there needs to be a recognition that the stakeholders and partners should clearly understand the purpose and motivation for the development of any cluster or clusters in the North West. The leadership of such clusters (s) and the process around its activities must remain open, transparent, and collaborative across the various political and administrative structures within the region.

## References

Innovate UK (2021): Innovate UK action plan for business innovation 2021 to 2025. Available at: <https://www.ukri.org/publications/innovate-uk-action-plan-for-business-innovation-2021-to-2025/>

Office of National Statistics (2020), Regional economic activity by gross domestic product, UK: 1998 to 2020. Available at: <https://www.ons.gov.uk/economy/grossdomesticproductgdp/bulletins/regionaleconomicactivitybygros sdomesticproductuk/1998to2020>

The Department for Business, Energy & Industrial Strategy (BEIS) (2021); UK Innovation Strategy: Leading by creating it. Available at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/1009577/uk-innovation-strategy.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009577/uk-innovation-strategy.pdf)

Greater Manchester Combined Authority (2022); Greater Manchester Innovation Plan. Available at: <https://gmlep.com/wp-content/uploads/2022/11/IGM-Exec-Summary-Nov-22.pdf>

The Department for Business, Energy & Industrial Strategy (BEIS) (2022), Further funding for Advance Materials. Available at: <https://www.gov.uk/government/news/new-business-secretary-announces-95-million-funding-for-super-materials-of-the-future-to-boost-uk-growth>

## Authors

Dr Jen Nelles (Innovation Caucus, Oxford Brookes University)  
Dr Kevin Walsh (Innovation Caucus, Oxford Brookes University)  
Dr Michalis Papazoglou (Innovation Caucus, Oxford Brookes University)  
Dr Elvis Nyanzu (Innovation Caucus, Oxford Brookes University)  
Dr Syahirah Abdul Rahman (Innovation Caucus, Oxford Brookes University)  
Professor Tim Vorley (Innovation Caucus, Oxford Brookes University)

## Research note

This research is a case study prepared as part of the Understanding Cluster Growth Potential project conducted in partnership with Innovate UK. For a copy of the main reports and additional case studies please contact [info@innovationcaucus.co.uk](mailto:info@innovationcaucus.co.uk).

## Acknowledgements

This research was commissioned by Innovate UK. We are very grateful to the project sponsors at Innovate UK for their input into this research. The interpretations and opinions within this report are those of the authors and may not reflect the policy positions of Innovate UK.

## About the Innovation Caucus

The Innovation Caucus supports sustainable innovation-led growth by promoting engagement between the social sciences and the innovation ecosystem. Our members are leading academics from across the social science community, who are engaged in different aspects of innovation research. We connect the social sciences, Innovate UK and the Economic and Social Research Council (ESRC), by providing research insights to inform policy and practice. Professor Tim Vorley is the Academic Lead. The initiative is funded and co-developed by the ESRC and Innovate UK, part of UK Research and Innovation (UKRI). The support of the funders is acknowledged. The views expressed in this piece are those of the authors and do not necessarily represent those of the funders.