MANCHESTER 1824
The University of Manchester

Energy research at Manchester

Working to ensure a just and prosperous net zero future

Energy

GLOBAL CHALLENGES
MANCHESTER SOLUTIONS

"Given the need to rapidly reduce carbon emissions, making sure our work has a near-term impact is paramount. Building strong and ongoing relationships with partners across industry, communities and all levels of government is central to making sure our work addresses real world challenges, can constructively challenge existing practices and assumptions, and is both useful and usable for a broad range of stakeholders."

Professor Carly McLachlan,
Professor of Climate and Energy Policy and Director of Tyndall Manchester

Why Manchester

Manchester is working to ensure a just and prosperous net zero future for energy.

Our experts are driving the energy transition, with the unique breadth and depth of research to tackle energy challenges, from beginning to end. We match science and engineering with social science, economics, politics, and arts, meaning our community of more than 600 experts address the entire lifecycle of the energy challenge. Our interdisciplinary approach creates innovative and lasting solutions to ensure a net zero future that benefits the environment, economy, and wider society.

Leading the energy transition

We look forward. By bringing together the brightest minds in engineering, science, policy and social science, we anticipate and answer the questions that demand bold and urgent action, for today and the future. Our applied solutions will make a positive impact on communities for generations to come through a dedicated focus on three grand challenges.

Challenge 1: Energy production and security

Our researchers are taking on the task of meeting supply and demand; ensuring efficient, reliable, and secure access as we decarbonise, decentralise, and digitalise our energy systems.

Challenge 2: Energy equity and engagement

Our experts in innovation, policy, politics, economics, behaviour and practices, and social justice, are working on solutions that engage governments, industries, and communities in driving universal access to reliable, affordable and sufficient energy sources.

Challenge 3: Energy and environmental sustainability

We're at the forefront of tackling climate change, delivering answers to the biggest questions facing our future, such as our pioneering methods to mitigate the environmental impacts of energy supply and demand.

Discover how we're developing pathways to ensure a low carbon energy transition while driving jobs, prosperity, resilience and equality.

Energy research at The University of Manchester is exceptionally important – and exceptionally interdisciplinary. The breadth and depth of our expertise interfaces with the broader sustainability challenges we face to secure our Sustainable Futures. It means we can support our industry and policy partners to make informed, impactful decisions that avoid unintended consequences.

Professor Michael Shaver,
Professor of Polymer Science and Director of Sustainable Futures

Contents

Our research strengths

At Manchester, we are dedicated to addressing the challenges that define our generation; challenges that demand bold answers and urgent action:

How can we address the energy price crisis and make energy affordable?

How do we ensure the energy transition is fair and reduces inequalities?

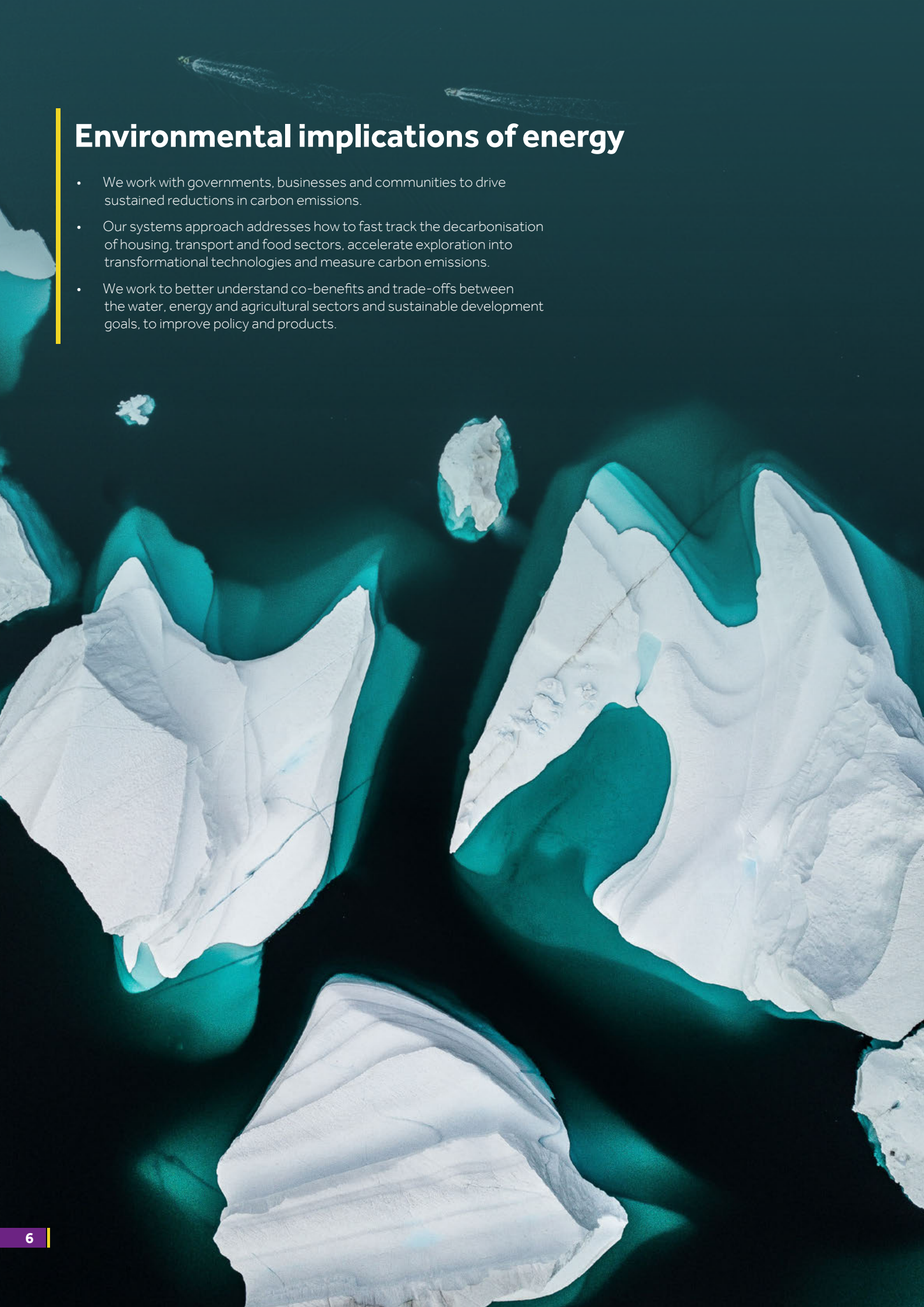
How can we make change more rapidly, without perpetuating the mistakes of our predecessors?

How do we quadruple the electricity supply to meet demand when we can't quadruple the infrastructure?

Working across disciplinary boundaries, we bring together brilliant minds to tackle these issues, drawing on our globally recognised expertise in the following areas...

Environmental implications of energy

- We work with governments, businesses and communities to drive sustained reductions in carbon emissions.
- Our systems approach addresses how to fast track the decarbonisation of housing, transport and food sectors, accelerate exploration into transformational technologies and measure carbon emissions.
- We work to better understand co-benefits and trade-offs between the water, energy and agricultural sectors and sustainable development goals, to improve policy and products.



Case study

Reducing climate change caused by shipping and aviation

Research conducted at the University's Tyndall Centre for Climate Change Research has influenced policy changes in the shipping and aviation sectors, bringing greenhouse gas emissions targets more in line with the Paris Agreement.

Challenging a costly oversight

Previously, greenhouse gas emissions from the international aviation and shipping sectors were largely unregulated and considered by many to be unproblematic sources. Research led by Alice Larkin, the University's Professor of Climate Science and Energy Policy, highlighted that the aviation sector produces 10% of UK CO_2 emissions. Without intervention, this was likely to increase to levels incompatible with the UK and global CO_2 mitigation targets.

The study also identified similar challenges within the shipping sector but highlighted greater potential for finding technical and operational solutions. Larkin concluded that it was necessary to set ambitious CO_2 targets for aviation and shipping as a matter of urgency.

Research, funded by the Northwest Regional Development Agency, was also conducted to explore the UK regional distribution of aviation emissions. It found that if aviation emissions continued to be unmitigated, they would consume a disproportionate share of future emission quotas. This would stunt healthy regional development by forcing a reduction in economic activity – increasing the investment in costly reduction technologies or jeopardising the overall climate reduction objective.

Introducing emission controls and highlighting the cost of inclusion

The research has informed policy decisions at regional, national and international levels for the past 15 years.

In 2018, the research influenced the adoption of climate change targets at the Marine Environment Protection Committee (MEPC 72) meeting, hosted by the International Maritime Organisation (IMO) – the UN body responsible for regulating shipping. The IMO estimates that because of this policy, the worldwide emissions reductions will be between 800 and 2,400 million tonnes of CO_2 annually by 2050 – greater than preventing all emissions from fossil fuels currently burnt in Germany.

Advising the UK government on aviation expansion

Larkin and Dr John Broderick submitted evidence to the Department for Transport's 2019 Aviation White Paper, accompanied by an expert statement of approval to the judicial review for the development of plans for a new runway at Heathrow Airport.

Following Larkin's statement to the Judicial Review of the Airports National Policy Statement (ANPS), the Court of Appeal ruled that the government's ANPS was unlawful because it failed to account for the UK's commitment to the Paris Agreement – an international treaty on climate change. In February 2021, Heathrow Airport acknowledged that they must prove expansion is compatible with the Paris Agreement before construction of the runway can begin.

Supporting Manchester's Climate Change Framework

The research has helped the city of Manchester better understand the implications of unregulated aviation expansion for its emissions reduction plans, and supported the new aviation emissions objectives included in the Manchester Climate Change Framework (2020–25).

The Framework was subsequently endorsed by Manchester City Council in March 2020, formally establishing it as the city's climate change strategy. The council owns a controlling stake (35%) of Manchester Airport and formally endorsed the draft Manchester Zero Carbon Framework (2020–38) in March 2019.

More research highlights

Tyndall Manchester's Super Low Carbon Live Music roadmap, commissioned by the band Massive Attack, set out emissions reduction goals to help make the live music sector compatible with the Paris Agreement. The project, led by Professor Carly McLachlan, Dr Chris Jones and Sarah Mander: empowered Massive Attack to become the first artists to commit their touring company to the UN Race to Zero, informed the UK government's commitment to supporting low carbon festival initiatives and spurred industry action at COP26.

Dr Alejandro Gallego Schmid, an expert in life cycle and circular economy assessment, co-led a new, open access Future Electricity Scenarios Framework, FuturES, helping the Chilean Ministry of Energy create feasible scenarios that will lead to an 81–100% renewables mix by 2050.

Find out more

tyndall.manchester.ac.uk

meri.manchester.ac.uk

manchester.ac.uk/climate-change

Policy and governance

- Manchester research has influenced bodies ranging from the United Nations' Intergovernmental Panel on Climate Change to the European Environment Agency.
- We bring together natural scientists, engineers, social scientists and economists to offer interdisciplinary approaches to complex policy problems.

Case study

Accelerating climate action on a city scale

Funded as part of the Centre for Climate Change and Social Transformation, researchers from The University of Manchester's Tyndall Centre for Climate Change Research developed a co-benefits toolkit to help the Greater Manchester Combined Authority (GMCA) embed climate and equality actions in all its decisions.

The GMCA has two ambitious targets: to become net zero carbon by 2038, and to address inequalities brought to light by the COVID-19 pandemic.

These challenges affect every part of public life, so the GMCA needed to transform its approach to delivering projects and services to ensure climate and equality considerations are integral and thought out at every stage.

Manchester's Tyndall Centre, which helped the GMCA become the first combined authority to set science-led climate targets, was engaged as a trusted partner to help deliver a solution that would empower the authority to achieve its climate and equalities ambitions.

Creating a co-benefits assessment tool

Based on literature, policy review and testing, researchers led by Professor Carly McLachlan and Drs Christopher Jones and Angela Mae Minas, working in collaboration with critical GMCA stakeholders, developed a co-benefits tool whereby users self-assess against nine categories: equalities, health, resilience and adaptation, housing, economy, mobility and connectivity, carbon, nature and environment, and consumption and production, as well as the 2038 Carbon Neutral target.

Users are asked to consider whether their project would have a long or short-term, and positive or negative impact against each policy goal.

All sections require a level of self-assessment apart from carbon, which specifically draws on Tyndall Manchester's expertise to allow comparison to best practice. This was to improve awareness, understanding and performance of emissions reduction.

The tool generates an assessment, awarding a colour to each of the nine areas. The report is then attached to the proposal sent to senior decision makers, with room for the officer to justify their approach. Crucially, it was decided that the tool would not average out results. Instead, each co-benefits area is awarded a colour – red, amber or green – with the aim of highlighting negative impacts that require mitigation or a value judgement.

Driving city-wide change

Every decision that goes to the GMCA must now be assessed against the tool. This means each policy, service or initiative – from a grant reporting on widening participation in cricket to investment in new homes – is assessed across the range of co-benefit areas. This is to ensure the key priorities on climate and equalities are embedded and assessed at the development stage, and that all activities can seek to maximise the benefits they deliver across the broadest range of GMCA priorities.

In its report, the tool highlights where the project fails to meet policy goals, either prompting the project planner to make changes or communicating to the GMCA where a value judgement or any trade-off is required.

Following minor modifications to the tool after the three-month pilot, the updated version has been adopted in GMCA with extra training materials for ongoing use.

The CAST and Tyndall Centre research teams are working to make an online version of the tool freely available to all local authorities.

More research highlights

Research by Professor Frank Geels from the Manchester Institute of Innovation Research, demonstrating how large-scale transitions are needed to deliver significant climate change, has transformed how reducing greenhouse gas emissions is understood and addressed by the United Nations' Intergovernmental Panel on Climate Change and the European Environment Agency.

The Tyndall Local Carbon Budget Tool has empowered 250 UK local authorities to focus on immediate emissions reductions. This tool enables local policymakers to set more ambitious targets, including Greater Manchester's commitment to be carbon neutral by 2038.

Find out more

tyndall.manchester.ac.uk

policy.manchester.ac.uk/about-us/

mioir.manchester.ac.uk

Energy inequalities

- Our dedicated Manchester Urban Institute explores options for more economically, environmentally and socially sustainable cities.
- Manchester's Sustainable Consumption Institute analyses the social relationships that hinder change and those that might enable the transition to greater sustainability.

Case study

Supporting planners to understand social and spatial vulnerability to climate change

Researchers at The University of Manchester have developed a mapping tool to provide a practical way to measure climate disadvantage and identify vulnerable groups. The findings have informed local planning and policy responses to climate change.

The link between climate disadvantage and social vulnerability

Climate change can impact anyone, but some people are more acutely affected than others. The extent to which people are affected depends not only on their exposure to events like floods and heatwaves, but also on various forms of social vulnerability.

Disability, absence of community support, and lack of private transport and income can make people more vulnerable to climate impacts. Until now, practitioners lacked the tools to bring together climate change data with an understanding of social and spatial vulnerability.

To tackle this problem, Manchester researchers developed the free-to-use Climate Just (*climatejust.org.uk*) resource, which provides evidence, guidance and case studies to support the development of more socially aware responses to climate change.

The interactive maps in the mapping tool, and the key concept of climate disadvantage that underpins it, demonstrate how important a knowledge of social vulnerability is to decision making.

Research to support the planning process

The Climate Just mapping tool is the brainchild of Richard Kingston, Professor of Urban Planning and Geographic Information Science at the University, who worked on the resource with Professors Sarah Lindley and John O'Neill.

Professor Kingston has spent the last 20 years developing methods and tools to make Geographic Information Systems more accessible.

The Climate Just mapping tool stems from his research into the role of information and communication technology in supporting planning and development processes.

The team placed potential users of the tool at the heart of its development in a bid to ensure it could support planning at a local level, as well as UK-wide policymaking in response to climate change.

As a result, the tool shows geographical distributions of:

- characteristics such as older age or existing ill health, which could influence how heatwaves or floods lead to negative impacts;
- physical aspects of the local environment that could heighten or offset the severity of heatwaves or floods;
- factors suggesting how well people can prepare, respond and recover from heatwaves and floods.

Impact on planning practice

The Climate Just mapping tool provides a practical mechanism to measure climate disadvantage and identify affected groups and areas, and social vulnerability is now included in practitioner guidance published by UK professional planning bodies.

It has informed climate adaptation strategies and risk assessments at both a local and national level. The Town and Country Planning Association and the Royal Town Planning Institute now recommend the tool to help illustrate the impacts of climate change on different communities.

Furthermore, under the 2008 Climate Change Act, the UK government must provide a nationwide climate change risk assessment every five years. The mapping tool also informed the 2017 UK Climate Change Risk Assessment Evidence Report (CCRA), produced by the Committee on Climate Change. The CCRA drew on Climate Just to highlight, for the first time, social equity as an influence on susceptibility to climate change.

More research highlights

The University of Manchester's Sarah Mander and Charlotte Brown have developed a novel technology to create heat vulnerability index maps to inform city resilience planning. Adopted by Bristol City Council, the tool has led to a local 'summer' extreme weather plan to protect the City's most vulnerable.

Led by Professor Sherilyn MacGregor, experts at the Sustainable Consumption Institute are investigating a more inclusive approach to sustainability by exploring how the knowledge and practices of immigrants from the Global South can contribute to building just and sustainable cities in the Global North.

Find out more

mui.manchester.ac.uk/

tyndall.manchester.ac.uk/

sci.manchester.ac.uk/

> *"To make an impact on health inequalities, we have to understand the link between the cost of carbon and the cost of living crises. Having a whole systems approach to energy research is what we are building across our faculties to be able to address inequalities. Co-producing energy solutions with our communities and neighbourhoods, and making sure we leave no-one behind is key to ensuring solutions are ready for implementation for applied solutions. Working across the local, national and international policymakers is essential to bring about change."*
>
> **Professor Arpana Verma,** Clinical Professor of Public Health and Epidemiology

Energy poverty

- We are home to a world-leading research hub on socio-ecological resilience and sustainability in relation to the urban environment.
- Our community of experts, led by Professor Stefan Bouzarovski, has been recognised by the European Union for their work in tackling energy poverty.

Case study

Combatting energy injustices

The University of Manchester's research has revolutionised how policymakers see the issue and outlined plans for how to address energy and fuel poverty across Europe.

Energy poverty occurs when a household is unable to meet its basic energy needs, including lighting, heating and cooling their homes. Without adequate support, this marginalised population go unseen and unsupported, and are exposed to increased health and wellbeing problems.

Research led by Stefan Bouzarovski, Professor of Geography at Manchester, has established a framework to explain how domestic energy deprivation affects households and communities over prolonged periods of time, and in relation to existing political and economic inequality.

Characterising energy poverty

The research recognised geographical differences and similarities in energy poverty patterns across the world, ultimately establishing energy poverty and vulnerability as a distinct regional and urban phenomenon, capable of influencing the development trajectories and characteristics of entire communities.

This has generated a shift in understanding, highlighting how the crisis is affected by inadequate housing and heating systems, economic precariousness, and political uncertainty.

Impact through understanding

Documenting the extent of the problem across European countries and cities, the research has helped policymakers understand what really causes energy poverty, what it's like to experience it, and how it's connected to wider socio-economic challenges.

This work has resulted in the EU directing a programme of extensive measures on a historically unprecedented scale and ensured that energy poverty is recognised and integrated into relevant EU regulation and policy.

Campaigning for a better future

Through a prolific programme of European-wide engagement – 100 events, 200 high-level presentations, ten policy briefs, two sets of EU member state energy poverty reports, and three pan-EU energy poverty reports – the University generated wide-scale awareness of the crisis and its causes.

As a result, the research shaped the policy direction of the European Commission's Vulnerable Consumer Working Group, the body responsible for developing EU energy policy.

It is considered an essential tool for building a fairer energy transition in the EU.

The research has framed national energy poverty policies, influencing the work of the UK's largest fuel poverty charity, National Energy Action, the Spanish National Poverty Strategy and the national energy and climate plans of nine EU countries.

The impact has also been felt at an urban and regional level, where it has helped several European municipalities to set up tailor-made energy poverty mitigation strategies.

More research highlights

Manchester researchers working as part of the Centre for Research into Energy Demand Solutions (CREDS) are addressing the 'diversity penalty', providing policy recommendations to tackle the relationship between ethnicity and energy poverty.

Manchester experts led the development of the first-of-its-kind ENPOR Energy Poverty Dashboard, which supports policymakers in mitigating energy poverty in the rental sector.

Find out more

energypoverty.info

step-in-project.eu/urban-living-lab/

seed.manchester.ac.uk

Renewables

- Our expertise includes development of materials to extend asset life and robotics for offshore wind inspection.
- We're home to a wave and current tank that is unrivalled internationally, thanks to its ability to produce waves and turbulent currents, in combination or in isolation.

Case study

Reducing the cost and risks of offshore wind farms

Manchester scientists are working in collaboration to revolutionise technology to improve the efficiency and lower costs of offshore wind farms.

In 2020 more than 10% of electricity generated in the UK (enough to power 4.5 billion homes) was by offshore wind, and over the last five years, the cost has fallen by 50%, making it one of the cheapest sources of electricity in the UK.

The UK's offshore wind capacity could rise from 10 GW to 80 GW in the coming decades, creating an industry that has the potential to be worth £2 billion per annum. However, the operation and maintenance of offshore wind assets is challenging, potentially hazardous and requires highly specialised skills, which are in short supply.

De-risking offshore wind operations

The Holistic Operation and Maintenance for Energy from Offshore Wind Farms project (HOME-Offshore), funded by UK Research and Innovation, has been set up to explore new technologies to de-risk offshore wind operations, reduce costs and make better use of existing assets.

The project unites expertise across different organisations and subject specialisms to develop solutions using state-of-the-art modelling and data science, machine learning, advanced sensing and robotics.

It's a collaboration between the universities of Manchester, Durham, Warwick, Strathclyde, Heriot-Watt and 16 partner companies and organisations and focuses on three key issues:

Firstly, wind farms are complex systems, involving multiple infrastructures that require expertise from numerous sub-specialisms to work. The University of Manchester, with Durham and Strathclyde universities, used modelling and machine learning to bring together the expertise across multiple disciplines and offer holistic solutions.

Secondly, arranging people to inspect remote sites accounts for as much as 80-90% of the offshore operation and maintenance OM costs. To address this and the skills shortage – HOME-Offshore examined the value of robots.

In addition to investigating robots beneath the waves (to assess subsea structures such as cables), aerial robots (to assess the state of turbines), and robots within the electrical structures (such as offshore substations), the project explored communication, robot design, sensor, and structural problems.

Thirdly finding and addressing problems early is key to reducing operation costs. Using advanced sensing coupled with a better understanding of system physics and machine learning, HOME- Offshore explored how to better predict failure.

Improving wind farm maintenance through collaboration

The project's success resulted in several research outcomes being taken forward as follow-on projects, including the Multi-platform Inspection Maintenance and Repair in Extreme Environments project, a collaboration between scientists and engineers at the universities of Manchester, Bristol, Royal Holloway London and Royal College of Art's School of Design, and experts at Offshore Renewable Energy Catapult, Thales UK, Plant Integrity and Wootzano Ltd.

The HOME-Offshore project also improved the use of advanced maintenance techniques, such as:

1. Discovering a new sensing technology that, for the first time, provides a way to measure the physical integrity of critical subsea power cables, accurately forecasting their current and future health.
2. Using third party providers to manage drone-based turbine maintenance, which could save the industry 1% in costs, worth up to £9 million per annum by 2030, based on value to least investment.
3. Confirming the feasibility of mobile robots to monitor live HVDC (high-voltage, direct current) substations, enabling real-time inspection data to be conducted in areas with high electromagnetic fields.

More research highlights

Manchester researchers, led by Professor Tony Peaker, have identified the material defect restricting solar panel efficiency. This research breakthrough will help to unlock the full potential of solar panels, increasing efficiency and helping to transition to more renewable energy.

Manchester researchers, led by Professor Tim Stallard and in collaboration with cross-sector partners, are driving a game-changing tidal energy project. TIGER (Tidal Stream Industry Energiser Project) aims to demonstrate the cost and energy efficiencies of tidal via a project in the English Channel.

Find out more

se.manchester.ac.uk/research/

Power and energy networks

- We have more than 100 years of industrial collaboration experience, including a long-standing partnership with National Grid, recognised by a nomination for The Royal Academy of Engineering's 2022 Bhattacharyya Award for the environmental and economic benefits delivered to the UK.
- Our High Voltage Lab is the largest test and research facility in UK academia specialising in electricity transmission.
- We have expertise in addressing generation, grid and network expansion, energy conversion, demand management, digital transformation and ensuring energy security.

Case study

Creating a fairer and greener energy supply

Researchers at The University of Manchester have been working with Electricity North West Ltd to help them move to renewable fuels while keeping costs down.

The cost of green energy

Sustainable fuel supply is a complex issue. Moving towards greener sources can mean huge outlays for suppliers, and can cause reliability and access issues for customers, even in developed countries.

As demand for electricity grows and power networks age, the cost of keeping up with demand while adapting the network for new technologies increases dramatically.

In a project led by Dr Haiyu Li, Manchester's researchers have worked with Electricity North West Ltd (ENWL), a distribution network operator based in north-west England, to help it better manage its network, improve sustainability, and save money for the company, and customers.

Researchers developed a way to model the relationship between network voltage and demand, so that ENWL can provide a fast reserve service to National Grid by making adjustments and reducing the load when the network is stressed, without the customer noticing any impact.

This research demonstrated how this new method could help to reduce the amount of energy used at peak times.

Reducing costs for companies and consumers

ENWL has been able to reassess how to upgrade the distribution network without incurring additional costs (both financial and carbon).

The models and planning tools developed with The University of Manchester also allow ENWL to accurately measure, in real-time, the demands on the network and keep power flowing smoothly. In areas where spare capacity is quickly running out, this is an invaluable tool for keeping the network reliable.

Addressing key areas for UK electricity supply

The team fostered collaboration between the University's Department of Electrical and Electronic Engineering and the Tyndall Centre for Climate Change Research.

This addressed three key areas that impact electricity supply in the UK: smart distributions networks for managing supply with demand; managing power flow fluctuations; and assessing the carbon footprint of different network investment options.

This has enabled ENWL to change its network investment policies towards making investment in the network, increasing its customer base, and confidently connecting a greater number of renewable energy sources to the network, helping it prepare to meet the government's 2050 carbon-reduction targets and reducing customers' energy bills.

Transforming the country's electricity network

This work delivered on the UN Sustainable Development Goal 7: to ensure access to affordable, reliable, sustainable and modern energy for all.

The technologies developed by the University could fundamentally change electricity supply in the UK. The research, now piloted and proven to be successful on a regional level, has been approved for rollout at a national level.

This will ensure that the same process of investment in the electricity distribution network can be adopted elsewhere in the country, enabling faster decarbonisation of electricity networks.

More research highlights

Manchester's research with National Grid has enabled the creation of a new low-impact T-pylon, which is now being constructed to connect the Hinkley Point C nuclear power station to the UK grid.

A project led by Dr Tony Chen, demonstrated the viability of retro-filling old SF6, a highly potent greenhouse gas, assets with an alternative — rather than replacing equipment completely at an estimated cost of around £15 billion.

Find out more

se.manchester.ac.uk/research/

manchester.ac.uk/highvoltagelab

Nuclear

- Manchester's Dalton Nuclear Institute is home to the most comprehensive nuclear research portfolio in UK academia, supporting fusion and covering the whole fission fuel cycle.
- Our expertise includes societal engagement, nuclear for hydrogen production, waste and governance.
- We're home to the Dalton Cumbrian Facility, a centre conducting cutting edge radiation research, while our dedicated irradiation facilities are within the Henry Royce Institute for advanced materials research.

Case study

Improving the safety, security and reliability of the UK's nuclear industry

Research by Manchester's Nuclear Graphite Research Group has helped to ensure the safe continued operation of the UK's ageing advanced gas-cooled (AGR) nuclear reactors by up to ten years.

Working with bespoke technology

Around 18% of the UK's electrical power is generated by graphite-moderated AGRs licensed by EDF Energy Nuclear Generation Limited. They are between 30 and 40 years old, and well beyond their design life of 25 years.

Maximising the lifespan of AGRs is critical: they are expensive to replace and integral to our electricity supply. However, these face life-limiting factors which could affect their safety. Over time, the AGRs irreplaceable core can start to degrade and affect its structural integrity. The Office for Nuclear Regulation (ONR) require EDF Energy to demonstrate, through their safety case, that they have adequate understanding of the material changes to the graphite and their rate of progression, to ensure safe operation of the core.

Currently, the UK is the only country to employ AGR technology as most of the world uses pressurised water reactors. This means, while other regulators can share knowledge and expertise as a global community, the ONR is alone and reliant on developing its own, UK-based community to advance its knowledge.

Advancing nuclear knowledge and skills

To help the ONR combat these challenges, the Nuclear Graphite Research Group (NGRG) was created: an independent panel of graphite experts, led by Professor Abbie Jones and based at The University of Manchester.

The NGRG, the largest pool of expertise in graphite in universities worldwide, conducts research to develop independent models and provide advice.

Using advanced modelling and simulation, and the development of material model, the NGRG can undertake stress analysis – that is completely independent from EDF Energy – to give ONR the impartial evidence to verify or challenge the licensee's safety case, and ultimately ensure the safe operating of reactors.

The NGRG created bespoke facilities and software to create a UK hub of expertise on nuclear graphite so they can advance their research capabilities. It has created independent software (ManUMAT) with several statistically based models to carry out structural analysis of graphite, and established new laboratories for handling irradiated graphite at the University's Henry Royce Institute.

In supporting the UK regulator, the NGRG has investigated mechanisms of graphite behaviour that were previously impossible or impractical to conduct. This has included establishing novel approaches to nuclear graphite research, spanning multiple aspects of graphite core degradation, such as core weight loss, brick cracking and oxidation lifetime behaviour.

Additionally, the Group has discovered microstructure/property relationships and identified and shared ways to extend reactor operating life by up to ten years by assessing the structural integrity of reactor graphite components and understanding age development processes.

At the forefront of nuclear graphite technology

The NGRG has helped to deliver an economic impact valued at £1.5 billion per year by extending the operational lifetime of nuclear reactors, and supported an annual UK supply chain income of around £650 million and 2,000 jobs.

The continued safe operation of EDF's AGRs has saved more than 17 million tonnes of CO_2 emissions each year – the equivalent of taking 7.5 million cars off the road — in addition to enabling the UK to save up to £745 million in excise from the Climate Change Levy.

The UK is at the forefront of the nuclear graphite community worldwide due to the NGRG's research. The NGRG openly shares its knowledge with the ONR, government bodies and the public through technical and peer reviewed reports, publications and presentations. They've also created a bespoke nuclear graphite technology course aimed at building professional capability within the nuclear sector.

The Group's commitment to enhancing skills has contributed to the UK's net zero ambition by enabling AGRs to continue producing low-carbon electricity while providing the UK with the expertise to build, operate and maintain high-temperature gas-cooled reactors – the government's preferred advanced reactor technology for the future.

More research highlights

Lyra, a robot developed by researchers Frank Allison, Professor Barry Lennox, Matthew Nancekievill and Keir Groves and named a Best Invention of 2022 by Time magazine, is helping to plan safe and efficient decommissioning of redundant nuclear laboratories.

Net Zero: a strategy for action, an impartial roadmap assessing the role of nuclear, by Dr Will Bodel and Professors Gregg Butler, Juan Matthews and Francis Livens, was referenced in the government's objective assessment of nuclear energy and the potential of High Temperature Gas Reactors.

Find out more

dalton.manchester.ac.uk

rainhub.org.uk

royce.ac.uk

Carbon capture and storage

- Our interdisciplinary research and technical expertise puts us at the forefront to drive effective delivery of CCS.
- Manchester's research expertise spans understanding of the policy requirements, the science and engineering that can deliver chemical, biological or physical capture and storage, and the public and societal acceptance of these technologies.

Case study

Mapping carbon storage potential and security in saline aquifers

Manchester researchers have created a first-of-its-kind tool to map and rank potential carbon storage areas in the North Sea for their capacity and ability to store CO_2.

Carbon storage challenges

For the UK to meet its net zero targets, it will need to upscale its carbon capture and storage (CCS) activity and, critically, identify sites capable of retaining more than 99% of the CO_2 for more than 100 years.

Currently, only 26 operational large-scale CCS facilities exist worldwide, with a combined capture of just 40 Mt CO_2 per year – whereas the European CO_2 storage demand is expected to reach 300 Mt per year by 2050, including CO_2 from cement production, heavy industries, hydrogen production and fossil fuel power generation.

Many European countries have insufficient subsurface CO_2 storage capacity to meet their decarbonisation targets, setting the scene for commercial cross-border carbon storage networks to be established. Two-thirds of the potential storage areas are under the North Sea, which has an extensive re-deployable workforce and infrastructure put in place by the oil and gas industry.

This huge opportunity comes with the challenge of storing a gas with complex behaviour during the pressure and temperature ranges between surface and storage conditions. CO_2 storage can only be considered at depths greater than 750-800 metres below the sea level, where the conditions mean the CO_2 properties are more like cooking oil than a gas.

Could the North Sea be the answer?

The complex subsurface behaviour of CO_2 means not all reservoirs are able to support CCS. The key to success is identifying reservoirs overlain by thick layers of mudstone that will trap the CO_2 and being able to distinguish thin sandstone layers and other overburden structures that could compromise these seals.

For any subsurface storage site, it is key to establish that CO_2 can be safely stored for hundreds of years, which requires a much better understanding of the overburden and in particular the immediate sealing rocks above any injection target reservoir.

Manchester scientists have developed a new approach to map and rank the containment confidence, capacity and storage potential of saline aquifers and disused oil and gas fields in the North Sea using 'off the shelf' data created by the petroleum industry. The approach looks at the ability of a given subsurface layer to store CO_2 and it quantifies the ability of its overburden mudstones to retain CO_2 using a 'containment confidence' matrix.

Developing a carbon storage mapping tool

Dr Christopher Lloyd and Professor Mads Huuse have developed a methodology to map and quantify the potential for carbon storage and assess containment confidence in the North Sea. The team analysed geophysical and geological data from the Norwegian and UK northern North Sea, focussing on the saline Utsira aquifer and overburden seal. Through detailed analysis of that seismic data, they developed a containment confidence matrix, a first-of-its-kind tool to rank the potential CO_2 storage areas in terms of their ability to retain CO_2.

Through this matrix, each element on a map of the aquifer-seal combination was assigned a Containment Confidence (CC) score identifying the areas with the lowest CC and therefore sites recommended to avoid for CO_2 storage, while sites with the highest CC score, were identified for further evaluation of storage capacity.

The matrix provided a methodology that subsurface geologists and industry could apply to any sedimentary basin. While the size and shape of the basins may vary, actual rock types are similar in many basins across the globe. As a result, the methodology could be used to map the CCS potential in most other basins across the world, empowering a global acceleration of CCS projects.

More research highlights

Research undertaken at The University of Manchester is exploring how industrial clusters can develop and deploy carbon capture and storage with a strong social licence to operate as part of a just transition which is fair and sustainable to a net zero world.

Led by Professor Peter Budd, academics in the Department of Chemistry and Chemical Engineering are exploring world-class research on separation and purification technology. The process is based on fabricating Mixed Matrix Membranes with POSS and GO (Graphene Oxide) for CO_2 separation.

Find out more

chemistry.manchester.ac.uk

meri.manchester.ac.uk

> *"Scientists and engineers at Manchester are driving the development of novel technologies, exploring fundamental understanding, and delivering cutting-edge knowledge to the next generation to ensure a sustainable future. Through our groundbreaking research and innovation, Manchester is playing a vital role in securing a sustainable future for our planet."*

Dr Lin Ma,
Presidential Fellow (Academic)

Subsurface and geoscience

- Manchester has one of the largest teams of UK academics working in subsurface and geoenergy.
- Our expertise spans geothermal energy and thermal aquifer storage, hydrogen storage and shallow seismic evaluation for windfarm location, the use of the subsurface for nuclear waste disposal and carbon capture and storage.
- We're developing a new generation of geoscientists with our master's course in Geoscience for Sustainable Energy.

Case study

Realising the UK's geothermal energy potential

Manchester researchers are working to support the UK's net zero targets by determining the potential of the Carboniferous Limestone for generating geothermal energy.

Exploring geothermal energy's potential in the UK

Geothermal energy has the potential to support the UK's net zero targets by providing a sustainable future source for heating and cooling, particularly for agricultural and domestic buildings, but also public facilities such as swimming pools.

Currently, the lowlands of the Netherlands, Belgium and Germany have working geothermal systems from the same geological strata. Now, Manchester researchers are working with the British Geological Survey and University of Bristol to explore whether this potential can be realised in the UK.

Professor Cathy Hollis, Chair of Carbonate Geoscience at The University of Manchester, explains: "Geothermal has not made the headlines in the UK as a source of renewable energy like wind power because it's a very young industry here. Over the last ten years it's been talked about a lot but now's the time to explore its potential at pace."

Could Carboniferous Limestone be the solution?

One source of geothermal energy comes from the Carboniferous Limestone, which is a major bedrock in the UK.

It dominates the White Peak area in Derbyshire and much of the landscape across the Yorkshire Dales, Pennines, southern Scotland and southwest England and Wales. It also sits in the subsurface beneath most central UK cities, including Manchester, Sheffield, Nottingham and Bristol.

In England, the Carboniferous Limestone is a major aquifer for shallow water supply, and naturally supplies geothermal water, heated to around 20-40 °C, such as in Buxton, Matlock Bath and Bath Spa.

With opportunity comes challenge

While the Carboniferous Limestone's abundance in the UK shows opportunity, there are two key challenges: firstly, although Carboniferous Limestone exists underneath most cities, it is not present everywhere.

Secondly, the ability of the rock to sustain the flow of warm or hot water is uncertain.

One aspect of the rocks that might help to maintain fluid flow from depth are caves, which intersect to provide pathways for warm water. Networks of deep, often vertical caves that cut through the subsurface may help to make geothermal a viable option for the supply of heat, by delivering sufficient volumes of hot water from depth.

Because of the depth of the limestone, the water would be hotter than the sub-40-degree temperatures measured in natural hot springs.

Professor Hollis explains this is not the only option: "At Manchester, our community is looking at multiple options, so if geothermal doesn't work in Carboniferous Limestone, we're already looking into the potential of mine water, deep sandstone aquifers and the reuse of old oil and gas wells to supply geothermal water."

Supporting the UK's net zero targets

In a project funded by The Natural Environment Research Council, and in collaboration with the British Geological Society and the University of Bristol, Manchester subsurface experts are determining where these caves form, and why.

Answering these questions, as well as the crucial question of when they were formed, will establish whether they are present at depths of two-to-three kilometres beneath the Earth's surface. This is the depth required to be an effective future heating source and will help to predict the role that the Carboniferous Limestone will play in the UK's geothermal future.

The project, currently in its first year, consists of two distinct phases: characterisation of the rock to build a geospatial map of caverns (focused on the White Peak of Derbyshire) and building models to understand how these caverns form.

"Geothermal in the UK has a lot of potential to supply hot water for heating. Using our subsurface expertise, we're driving decisions on how best to leverage that potential," says Professor Hollis.

The research findings will contribute to an ongoing evaluation of the ability of the Carboniferous Limestone to produce geothermal heat, and could lead to future investment in deep geothermal technology in the UK.

More research highlights

Researchers, led by Professor Kevin Taylor, are exploring aquifer thermal energy storage in a collaborative project with Imperial College London and the British Geological Survey to deliver low-carbon heating and cooling in the UK.

Researchers in our Departments of Earth and Environmental Science and Chemical Engineering are improving workflows and models for the safe and secure storage of carbon in subsurface reservoirs.

Find out more

meri.manchester.ac.uk

Sustainable fuels including hydrogen

- We work on hydrogen (including bio-hydrogen) projects, spanning production, storage, transport and usage.
- We're part of the Supergen Bioenergy Hub, a national programme developing innovative approaches for dealing with the engineering, policy and societal challenges associated with bioenergy.

Case study

Growing a sustainable, low-carbon UK bioenergy sector

Research conducted at Manchester provided the scientific foundations to grow a sustainable bioenergy sector and underpin the UK's Bioenergy Strategy.

Bioenergy has become the largest renewable energy technology in the UK, contributing to more than 30% renewable electricity, 80% renewable heat and 5% total transport energy.

The UK government has strong ambitions to increase bioenergy as part of its industrial strategy and climate change commitments.

Researchers at The University of Manchester, led by Dr Andrew Welfle, delivered the robust, science-evidenced support the government needed to grow a sustainable bioenergy sector by delivering on the four pillars outlined below.

Establishing bioenergy research themes

Manchester hosted the Supergen Bioenergy Hub between 2012-2018, the UK's bioenergy research programme and network that brings together academia, industry, government and societal stakeholders to develop sustainable bioenergy systems.

Through the network, Manchester experts influenced the UK's Bioenergy Strategy by establishing a research framework focused on three objectives: promoting bioenergy; promoting biomass resources; and promoting the best uses for biomass.

Unique analysis tools to pinpoint opportunities

Dr Welfle developed the Biomass Resource Model tool that evaluates the availability of biomass by considering land systems, industries and supply chains within a chosen geography.

The tool enabled the identification of the leading biomass resources that could be sustainably mobilised in the UK to reduce reliance on imported biomass and highlight low-carbon fuel options for the UK's heat, power and transport sectors.

Increasing greenhouse gas performance

Manchester researchers pioneered methods of applying life cycle assessment (LCA) analysis, including how best to use LCA to validate bioenergy projects compared to fossil fuel energy systems.

The investigation revealed that the greenhouse gas (GHG) performance of the UK's current strategy, based on wood pellets imported from North America, delivered up to 80% less GHGs than fossil fuels.

By analysing each step of the process life cycles, researchers identified practices that should be avoided to ensure reductions in GHG emissions when replacing fossil fuel systems.

Working collaboratively with government

Dr Welfle completed a knowledge exchange secondment to the UK Department of Energy and Climate Change (DECC), contributing analyses that allowed the formulation of clear recommendations, including:

- The majority of the 2,000 UK bioheat scenarios analysed 'demonstrated significant potential GHG savings far below the UK's benchmark for sustainable generation and compared to that of fossil fuel generation'.
- Food and agricultural wastes that have no other uses 'present potentially significant opportunities for generating low/ net zero carbon energy'. Use of waste resource for energy may also provide mechanisms to decarbonise multiple UK emission inventories well beyond energy.

The impact of scientific evidence to drive change

Manchester researchers worked closely with UK government departments and advisory organisations during the eight-year project to provide the scientific research to develop the UK Bioenergy Strategy.

During his secondment to DECC, Welfle also influenced the refocusing of the UK's Renewable Heat Incentive (RHI) to prioritise heat bioenergy generated from waste materials. This resulted in a more than 80% increase in bioheat generation from these fuels.

The impact of Manchester's research has helped secure an additional £110 million from HM Treasury to extend the UK's Renewable Heat Incentive scheme and develop future renewable heat support.

More research highlights

Experts at the Henry Royce Institute, in collaboration with industry and other academics, have developed a blueprint of the UK's hydrogen materials testing requirements creating a comprehensive picture of current UK capabilities, while identifying gaps requiring future funding.

Dr Vincenzo Spallina, based in the Department of Chemical Engineering, is leading RECYCLE (Rethinking low carbon hydrogen production by chemical looping reforming) to demonstrate how enhanced auto-thermal reforming can deliver cost-effective hydrogen production with a minimum CO_2 capture rate of 95%.

Find out more

se.manchester.ac.uk/research/

tyndall.manchester.ac.uk

Greenhouse gas removal

- We lead major projects, including an assessment of bioenergy and carbon capture and storage (BECCS) in the NW industrial cluster.
- We also work in collaboration with other universities to advance cross-cutting research on the environmental, economic, social, cultural, ethical, legal and governance issues around greenhouse gas removal (GGR).

Case study

Calculating how to optimise siting bioenergy with carbon capture and storage facilities

Manchester experts have created a model to calculate the end-to-end carbon costs of the transportation involved in bioenergy and carbon capture and storage (BECCS) supply chains.

BECCS has the potential to deliver cost-effective greenhouse gas removal at scale and could be crucial to helping the UK meet net zero targets.

The UK is rich in a wide array of biomass sources ranging from forestry, agricultural residues and industrial wastes. However, until now, there has been no clear picture of where these potential sources lie and how to measure the economic and environmental impact of the transportation and storage process.

Understanding BECCS potential in the UK

Manchester experts, Dr Muir Freer, Dr Amanda Lea-Langton, Dr Andrew Welfle and Dr Clair Gough, have created a tool that enables policymakers and industry to calculate this and aid decision-making, by providing – for the first time – the end-to-end carbon costs of the transport involved in BECCS supply chains.

Manchester experts worked on two key elements:

Firstly, they undertook high spatial resolution biomass mapping to identify the UK's entire biomass resource distributions from waste and residue products. With competition for land fierce, making growing biomass-specific crops expensive, the team documented everything from food waste to wood residues and animal by-products, along with the volumes available, and presented in user-friendly 3D spike maps, enabling users to quickly locate the areas rich in abundant and more affordable biomass.

Secondly, the team created a digital twin model that maps all the transportation networks across the BECCS supply chain (including biomass, CO_2 and any energy output), acting as a virtual version of the UK's transport network, called the Carbon Navigation System (CNS) model.

From this, the high spatial resolution biomass data is plugged into the CNS model, which allows the simulation of entire BECCS supply chains anywhere in the UK. The model then routes the biomass feedstocks, as well as how the CO_2 is transported to offshore storage sites and all the energy outputs produced at the facility to its end-users (electricity, biofuels and hydrogen).

From this modelling of the supply chains, the model can optimise the carbon emissions associated with the transportation aspects of the supply chains by automatically switching between trucks, rail, shipping and pipelines to minimise emissions, and find the optimal siting location for specific supply chains.

Strengthening the UK's leadership in BECCS delivery

Looking ahead, the UK could be at the forefront of BECCS delivery.

Manchester's innovative modelling allows the UK to strengthen this advantage by giving users insight into the impact of different types of BECCS supply chains. The sophisticated tool allows policymakers and industry to accurately understand where biomass sources are and the volume that exists, how best to transport the energy, store resulting CO_2 while incurring minimum emissions, and which supply chains perform better in which areas.

The research team has already begun to show industrial clusters how the model can maximise profitability and sustainability. A recent partnership with Glass Futures revealed the economies of scale created by local glass producers coming together to use BECCS to power their furnaces.

Alongside, the team is working to decarbonise carbon-intensive industries and provide more sustainable long-term revenue streams. For example, the model was used as the basis of a three-month secondment to help Uniper Energy build a roadmap to convert a fossil-fuel facility into a BECCS facility.

Additionally, through collaborative engagement with governmental departments (six meetings to date), the team is influencing net zero policy, demonstrating the full-chain benefits of BECCS and its alignment with the UK strategy of cluster collaboration.

Finally, the end to end 'carbon-cost' modelling tool can handle any energy output. It identifies where potential energy demand is, and optimally sends the energy to end users. This means the sophistication of the tool has the option of multiple applications and can be repurposed to simulate any technology or supply chain.

More research highlights

Our experts, led by Dr Rob Bellamy, are helping to develop the GGR technologies and policies that contribute to net zero, responsibly through the National Carbon Removal Research Hub and in collaboration with Oxford University, the University of Edinburgh, University of Bristol, University College London, Imperial College London and the University of Leeds.

Dr Clair Gough's work as part of Feasibility of Afforestation and Biomass Energy with Carbon Capture and Storage for Greenhouse Gas Removal, considered how society will need to change to accommodate GGR technology.

Find out more

tyndall.manchester.ac.uk

seed.manchester.ac.uk

Advanced materials for energy

- The University is recognised as the global knowledge base in graphene and 2D materials and has partnered with more than 100 companies including Ford and Inov8 on graphene applications.
- We are home to the Henry Royce Institute for advanced materials research, the UK's national centre for materials research and commercialisation.

Case study

Helping Rolls-Royce plc improve jet engine efficiency

Our research has enabled Rolls-Royce plc to better predict the performance of the thermal barrier coatings on their jet engine components. The coatings have helped boost engine performance and reduce fuel consumption.

Addressing the problem with thermal barrier coatings

Thermal barrier coatings (TBCs) enable engine components to operate in demanding thermal and environmental conditions during service operation. Improved TBCs, and the protection they offer, allows engines to run hotter and more efficiently. Determining the long-term performance of new TBCs, especially what can cause them to degrade and fall off, was too complex to predict using standard laboratory tests, but was needed before introducing them into an engine.

An innovative methodology to reduce risk

Materials scientists at Manchester, led by Professor Ping Xiao, developed a stringent methodology of novel testing processes to accurately predict the mechanical, chemical and physical performance of TBCs across the lifetime of a commercial jet engine when subjected to high temperatures and mechanical loads.

They developed tests focused on three key material characteristics:

- multidimensional residual stress;
- the strength of the interface between the TBC coating and the engine parts;
- interfacial adhesion.

The University's research significantly reduced the risk of Rolls-Royce plc introducing TBCs onto key components of in-service engines. The heightened confidence in the lifelong TBC system performance allowed an increase in engine cycle temperatures, boosting engine performance and reducing specific fuel consumption.

Delivering cost and carbon savings

More than 4,000 in-service Rolls-Royce Trent series engines utilise TBC coatings assured by Manchester testing strategies. Since 2013, the Trent series engines have recorded 70 million flight hours. An average 2% fuel saving over 70 million flight hours is equivalent to a saving of 3.6 million tonnes of fuel, worth approximately £1.5 billion in fuel costs and an 11.2-million-tonne reduction in CO_2 emissions.

Rolls-Royce plc is developing next-generation materials for use in gas turbines, where temperatures can reach 2,000°C. The materials used must meet increasingly stringent environmental, performance and fuel efficiency targets while ensuring that Rolls-Royce plc maintains its international competitive advantage.

Professor Ping Xiao's research helped develop the understanding of the current generation of coatings' performance limits, and the ongoing research will enable the design of next-generation coatings crucial to future aeroplane performance and efficiency levels.

More research highlights

Manchester engineers led by Dr Lee Cunningham are pioneering a new CO_2-busting building material, Concretene, delivering an estimated savings of 25-30% in CO_2 emissions.

Watercycle Technologies, a Manchester spinout, is revolutionising water filtration. Through its development of advanced graphene/polymer composite water filtration membranes, it has developed a high flux, low fouling membrane which, when coupled with its advanced membrane distillation (MD) technology, can treat highly concentrated wastewater from industries as diverse as desalination, mining, oil and gas, textiles, food and drink.

Find out more

graphene.manchester.ac.uk

royce.ac.uk

manchester.ac.uk/advanced-materials-beacon

uominnovationfactory.com

"Reducing energy emissions to zero rapidly requires all hands on deck. All sectors and all scientific disciplines need to be working towards this goal together. We've been painstakingly building such interdisciplinary links across The University of Manchester's energy research. We have a strong tradition of applied and industry-focused research, while recognising that scientific advances often occur within each discipline's haven of isolation. Drawing on the strengths of both Manchester's applied and blue-skies research helps us to address "wicked problems" such as climate change."

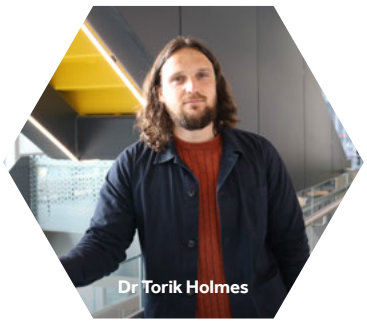
Dr Maria Sharmina,
Reader in Energy and Sustainability within Tyndall Manchester and Co-director of Policy@Manchester

"Transforming the energy system to respond rapidly and adequately to climate change is society's most fundamental challenge, and one of the biggest it has ever faced. This challenge is multidimensional, and requires bringing together knowledge not only about various energy technologies that are needed to replace fossil fuels, but also about the social, cultural, economic, and ultimately political challenges of transforming our lives to meet this challenge, and to do so in a way that reduces, not increases, inequalities, and enables all to thrive."

Professor Matthew Paterson,
Professor of International Politics and Director of Sustainable Consumption Institute

Research expertise

The scale of our interdisciplinary research activity sets us apart. We're able to combine disciplines and capabilities to meet both the challenges of leading-edge research and the external demands of government, business and communities.


Dr Torik Holmes

Our Sustainable Futures research platform convenes a remarkable breadth and depth of interdisciplinary researchers to develop sustainable solutions to environmental challenges, including how the complexity of our net zero ambitions can enable or exacerbate other global challenges in resilience, health, resources and justice.

Through this community, we bring together the expertise of our specialist interdisciplinary research institutes and centres, listed here, to deliver real world solutions.

Henry Royce Institute

the UK's national institute for advanced materials research and innovation, accelerating the invention and take-up of new materials systems.

royce.ac.uk

Dalton Nuclear Institute

is home to the most comprehensive nuclear research portfolio in UK academia.

dalton.manchester.ac.uk

The electrification network

brings together scientists, engineers and mathematicians with economists, policy experts and social scientists, to offer a one-stop community of interdisciplinary experts, to address the techno-social-economic challenges of increased electrification.

Manchester Environmental Research Institute

home to one of the largest collections of UK subsurface and geoscience research, leading the way in interdisciplinary environmental research.

meri.manchester.ac.uk

The Industrial Decarbonisation Research and Innovation Centre

(IDRIC) provides solutions to challenges currently faced by energy-intensive industries (such as steel, chemicals, and cement) in the UK.

idric.org


Left - **Dr Rosa M. Cuéllar-Franca,** Senior Lecturer in Chemical Engineering
Right - **Dr. Ahu Gumrah Dumanli-Parry,** ICAM Kathleen Lonsdale Research Fellow

Dr Maria Sharmina

Manchester Institute of Innovation Research

addresses the grand challenges of climate change, energy security and resource efficiency, through technological and business model innovation.

mioir.manchester.ac.uk

The power and energy systems network

one of the largest power and energy groups in UK academia, covering power electronics to system level research.

manchester.ac.uk/highvoltagelab

Manchester Urban Institute

explores options for more economically, environmentally and socially sustainable cities.

mui.manchester.ac.uk

National Graphene Institute

is a world-leading interdisciplinary centre for graphene and 2D materials research.

graphene.manchester.ac.uk/ngi/

Thomas Ashton Institute

is a partnership between Manchester and the Health and Safety Executive that enables the co-production of world-leading research in regulatory science by encouraging genuinely cross-disciplinary research.

ashtoninstitute.ac.uk

The Productivity Institute

funded by the Economic and Social Research Council, works directly with policymakers and businesses to better understand, measure, and enable improvements in productivity.

productivity.ac.uk

Sustainable Consumption Institute

uses systems-thinking to help us understand how we can transform approaches and attitudes on a global scale, to align energy and material production and consumption with global carbon reduction targets.

sci.manchester.ac.uk

ICAM

is a partnership between bp and selected globally leading universities that acts as a platform to enable the effective application of advanced materials for the transition to net zero. Its main research themes include low carbon energy, sustainable operations, and underpinning sciences.

icam-online.org

Tyndall Manchester

delivers interdisciplinary research to inform climate and energy policy and legislation at all levels, empowering local, national and industry leaders to catalyse change.

tyndall.manchester.ac.uk


Dr Lin Ma,
Presidential Fellow (Academic)

Our facilities

Our campus hosts more than 330 buildings providing a test bed for tomorrow's energy systems. This includes world-leading living labs – test and research facilities where our researchers are pioneering solutions to ensure more environmentally sustainable, healthier and equitable ways of living.

Our leading researchers in energy are using physical spaces on campus to bring together brilliant minds and do things that matter; using the scale of the labs, and their proven influence, to deliver holistic solutions for future generations.

Our facilities include:

The High Voltage Lab is the biggest electrical infrastructure test facility in UK academia. Here, interdisciplinary teams innovate at pace, working with industry and governments worldwide, to develop solutions for deployment on the live electricity network.

eee.manchester.ac.uk/research/facilities/high-voltage-lab/

Dalton Nuclear Institute's pioneering nuclear research is divided between our on-site facilities in Manchester and our dedicated Dalton Cumbrian Facility. The University's main campus hosts multiple specialist laboratories and facilities for fundamental and industry-focused nuclear research across the full fuel cycle. Our dedicated research base, the Dalton Cumbrian Facility, provides academia and industry the opportunity to carry out high-end research in radiation science and nuclear engineering decommissioning, plus access to industry-leading equipment vital to UK nuclear research.

dalton.manchester.ac.uk/research/facilities/manchester-facilities/

The Robotics for Extreme Environments Laboratory is a sister site to the Dalton Cumbrian Facility based in Cleator Moor, Cumbria. Here our specialist facilities enable researchers to work on a range of projects including: mobile ground robots for exploration or routine inspection; water vehicles for inspection and maintenance; and characterisation methods, as well as path planning and map generation.

dalton.manchester.ac.uk/research/facilities/cumbria-facilities/

Our dedicated labs are keeping the UK at the very forefront of aerodynamics. With specialist facilities, including the UK National Wind Tunnel Facilities (NWTF), we're pioneering the flow control technologies and measurement techniques of tomorrow.

mace.manchester.ac.uk/research/facilities/wind-tunnels/

Our wave tanks allow for large model testing, including whole systems in real-world simulated environments. Our vast tanks include a five-metre by 20-metre-wide purpose-built Wide Flume capable of recreating highly accurate oceanic conditions, while our two narrow flumes provide unidirectional waves for testing wave energy conversion.

Our campus is the central hub for the **Henry Royce Institute**. Housing more than £200m of Royce facilities and equipment, including the The Henry Moseley X-ray Imaging Facility (HMXIF) which provides state-of-the-art X-Ray Computer Tomography (XCT) equipment for scientific and industrial research.

royce.ac.uk

The Sustainable Materials Innovation (SMI) Hub creates trusted sustainable solutions for plastics use, working with companies of all sizes to address a variety of business needs.

smihub.ac.uk

The National Graphene Institute is equipped with 1,500m² of class five and six cleanrooms - which have an atmosphere more than a million times purer than air - and the latest technology for nanoscale and characterisation projects.

graphene.manchester.ac.uk/ngi/

Through its advanced facilities, **The Graphene Engineering Innovation Centre** enables companies to design, develop, scale and 'de-risk' the next generation of innovative products and processes.

graphene.manchester.ac.uk/geic/

Modelling and Simulation Centre covers the entire range of the engineering sciences, from the microstructure of materials to the flow of ocean currents. Our researchers work with the power generating industries, including renewable energy, aerospace, automotive, biomechanics and civil engineering companies on projects ranging from the fundamental physics of turbulent flow to strategies for simulations involving multiple failure mechanisms.

mace.manchester.ac.uk/msc/

The Manchester Centre for Robotics and AI is one of the UK's top robotics centres, with a world leading reputation for research combining robotics and AI. We house a network of capabilities that put us at the forefront in the design of robots and autonomous systems for real world applications.

robotics.manchester.ac.uk

The Rolls-Royce University Technology Centre houses a modern, industry-standard laboratory - the Intelligent Electrical Power Networks Evaluation Facility (IEPNEF) - and is designed to support the development of more-electric technologies for future aircraft, marine and land-based vehicles.

eee.manchester.ac.uk/research/facilities/rolls-royce-utc/

Our **battery storage and battery test systems** group is home to world class facilities for the characterisation and system integration of high-power energy storage technology. Our test suite includes: Siemens SIESTORAGE battery-based energy storage system; 1MJ supercapacitor-based energy storage system; NH Research 9200 battery tester; and ESPEC AR680 environmental chamber.

eee.manchester.ac.uk/research/facilities/

"Energy companies are crying out for support with circular economy innovation and Manchester is at the forefront. Through our interdisciplinary approach we help our partners sustainably manage both renewable and finite resources, and recover value rather than wasting energy, materials and water. Live projects include how to implement circular economy principles in geothermal, how to address the end of life of solar panels in Malawi and Kenya, and how to implement bioenergy in Indonesia."

Dr Alejandro Gallego Schmid,
Senior Lecturer (Associate Professor) in Circular Economy and Life Cycle Sustainability Assessment

"Fusion has the potential to be a low carbon source of energy in the long term. In order to achieve this we need highly interdisciplinary research in areas such as materials, engineering, tritium, plasma physics, robotics, chemistry and the social sciences. We are a member of the Fusion Centre for Doctoral Training and work closely with national and international labs, academics and industry partners. We also directly engage with the public, media and policy makers. This world leading research, engagement and training of the next generation is vital in order to make commercial fusion a reality."

Dr Aneeqa Khan,
Harwell Research Fellow
in Nuclear Fusion

Get in touch

We work in collaboration with international, national, and regional partners and policymakers, to devise solutions with real-world impact.

Whether you're a policymaker, or represent an international blue chip, ambitious SME, or a charity with an eye for innovation, we're here to support you in developing an innovative response to your energy needs.

> *"Energy research at Manchester is an international and diverse research community with ample prospects for interdisciplinary collaboration, which, I think, is essential to delineate the intricacy of multiple entangled energy issues and confront the formidable challenge of attaining a just and inclusive energy transition."*

Hayato Koga,
PhD researcher in
Human Geography

Academic collaboration

Research Explorer enables you to discover the University's research publications, impact, activities and much more. You can also search for researchers and view their research profiles. Explore our database at ***research.manchester.ac.uk/***

Industry partnerships

Engagement with the University can take many forms, with differing levels of commitment.

- Collaboration with us allows you to gain fresh insights to inform your business strategy and leverage the technology to innovate, or access cutting edge research.
- Consultancy is a quick and flexible way of providing you access to the expertise you need, when you need it. Activity includes: technical expertise and specialist opinion; contract research; access to specialist facilities; and contribution to advisory boards.
- Our SME support includes knowledge exchange services that translate world-leading research to strengthen UK businesses, increasing economic growth and societal benefit. We have a comprehensive range of supportive programmes and funding to fast-track business and innovation aspirations. Examples of small projects include Impact Accelerator Accounts (IAAs), feasibility studies and student projects.
- Our portfolio of Strategic partnerships, characterised by high-level engagement activities across multiple disciplines, allow us to partner on significant research projects, while delivering skills development and knowledge exchange activities.

Whatever your needs, our dedicated Business Engagement Team can help your organisation harness the innovations and research power of The University of Manchester. Visit ***manchester.ac.uk/collaborate/business-engagement/*** to start the conversation.

Policy engagement

Our research aims to make an impact on lives locally, nationally and globally through influencing and challenging policymakers with robust research-informed evidence and ideas. Policy@Manchester is The University of Manchester's sector-leading policy engagement unit and connects expert research with policymakers and influencers. It nurtures long-term policy engagement relationships and seeks to enhance stakeholder understanding of pressing policy challenges.

Our support includes:

- Building policy relationships. We are always looking for opportunities to connect researchers with a policy audience.
- Our Civic Engagement Team provides a platform to connect local and national policymakers, thought leaders and decision makers through the GM Policy Hub targeted events.
- High quality outputs such as policy articles, publications and briefing notes from our leading academics.
- Organising informal conversations allowing you to explore initial areas of interest.
- Arranging experts for roundtable discussions.
- Hosting panel events at the Labour and Conservative party conferences, offering expertise and evidence on pressing policy topics.

If you work in policy, for an NGO or a charity, contact Policy@Manchester to discover how we can help. Visit ***policy.manchester.ac.uk*** or email ***policy@manchester.ac.uk***

Find out more

Discover how we're developing pathways to ensure a low carbon energy transition while driving jobs, prosperity, resilience and equality at ***manchester.ac.uk/energy-beacon***

"Nature offers creative solutions to many of the engineering problems we face today. My research draws inspiration from the biological world to develop smart materials and engineering strategies that will strive for cost effective and greener material technologies towards advanced sensors and optoelectronic devices."

Dr. Ahu Gumrah Dumanli-Parry,
I C A M Kathleen Lonsdale
Research Fellow

"At The University of Manchester we have the capability and expertise to make sure we can design, test and de-risk innovations that can be installed onto the future low carbon electrical network. World class high voltage testing facilities, complement academic and engineering thinking to accelerate innovations onto the electrical network."

Dr Vidyadhar Peesapati,
Knowledge Transfer
Research Fellow

"It's fantastic to be working with so many other people at the top of their research fields. I really benefit from being surrounded by people who can bring insight about complex topics and share their expertise in areas that impact on my work – whether that's through formal collaborative projects, or from chatting in the corridor."

Dr Robin Preece,
Reader in Future
Power Systems

Discover how we're developing pathways to ensure a low carbon energy transition while driving jobs, prosperity, resilience and equality.

manchester.ac.uk/energy-beacon