UNIVERSITY OF BIRMINGHAM

KEEPING 1.5°C ALIVE

How research at the University of Birmingham is powering climate action

FOREWORD
FOR A BETTER TOMORROW

Since the University of Birmingham's founding in 1900, it has stayed true to the radical vision of its first Chancellor, Joseph Chamberlain.

We established England's first civic University, a higher education institution into which students from all backgrounds were accepted on an equal basis. Birmingham's roots as a civic institution are now being revitalised for the climate change era as we look to embed sustainability in everything we do, to bring our research capabilities to work alongside the city, its citizens, and the broader region, to address real-world sustainability challenges, and develop solutions with global reach and benefit.

From developing low carbon innovations like hydrogen-powered trains and battery performance software, to modelling and projecting air quality, forests and hydrological water cycle responses under climate change, the University is taking academic work into the real-world to help policymakers and business leaders make informed decisions now for a better future tomorrow.

The Glasgow COP26 Summit was recognised as the world's last chance to 'Keep 1.5°C Alive' – and academic research is vital to achieving this collective goal. Birmingham's research engagement efforts demonstrate the importance of higher education institutions proactively engaging with partners — governments, the private sector and citizens. This report, based on interviews across our institution, builds on a series of essays produced by the University for COP26. These profile the real-world impact of the institution's work and its partnerships to make the commitments and interventions to realise the COP26 agenda to avoid dangerous impacts beyond a 1.5°C rise.

The report presents Birmingham's work to date across three chapters:

- **Part one -** 'Energy in Motion' outlines the University's work on the transition to clean energy, including low carbon heating, natural resource challenges in the clean-tech sector, and air pollution policies.

- **Part two -** 'Environmental Systems' looks at the extensive scientific research efforts aimed at quantifying and modelling climate change and its impacts today and forecasting future scenarios, both of which are vital to policy decisions.

- **Part three -** Explores the role of the University itself as a change agent a 'living lab' for testing and trialling innovation and an educator of future generations of climate-smart citizens.

This work has collectively helped us to produce a series of policy takeaways and recommendations for decision makers at local, regional and national levels, as well as businesses, which we have detailed in each chapter. The goal of all our efforts is to ensure the best academic evidence and research tools are harnessed to support the right decisions at this critical juncture in human history.

Adam Tickell
Vice-Chancellor and Principal of the University of Birmingham

1. ENERGY IN MOTION

CHARTING THE TRANSITION TO NET ZERO

Weaning the planet from fossil fuels is one of humanity's greatest challenges, requiring systems-level change, as well as careful design of policies to ensure effective outcomes.

Against a background of **rising energy costs,** greatly worsened by the geopolitical fallout of the Ukraine crisis, experts at the University of Birmingham are **helping policymakers** chart a direct course for net zero, while **understanding the risks, trade-offs and nuances** of individual policies.

Community engagement for a fair low carbon transition

After decades of sluggish action, governments are taking bold steps to launch initiatives, targets, policies and laws, from phasing out internal combustion engine vehicles to enforcing low emission zones in cities. However, while rapid action must be taken, decisions should not be made in a purely top-down manner. Net zero policies must accommodate the views, perspectives and needs of all citizens. 'We need strategies to ensure vulnerable populations have the relevant technical, financial and institutional resources,' says Dr Neelambari Phalkey, an interdisciplinary researcher in climate vulnerability and resilience to natural hazards. 'We need people to be able to adapt to what's coming their way'.

The University of Birmingham is pioneering **community engagement** models that support a more inclusive approach to low-carbon transition. As part of the work at Tyseley Energy Park, an energy, transport and waste nexus for the city — the University is working with Birmingham City Council on a master plan for the Park's future development, including mapping communities in East Birmingham and how they might be impacted by decarbonisation. 'We're looking at what housing types exist, the socio-economic standing of different communities and the challenges and opportunities for low carbon heating solutions,' says Professor Martin Freer, Director of the Birmingham Energy Institute (BEI) and the Energy Research Accelerator. 'Not only are we thinking about energy in the context of Tyseley Energy Park, but, for adjacent communities, we are asking: how can we help influence their journey?' A related policy commission chaired by Sir John Armitt and involving University researchers, aimed to understand how to implement community-level low-carbon heating. 'The challenge is to understand how you deploy solutions and remove the blockers,' says Professor Freer.

As a first step, BEI is spearheading the East Birmingham Community Heat Test and Learn project funded by the Cadent Foundation, a collaboration with Places in Common, the Active Wellbeing Society Council officers, political leaders, industry and citizens, focusing on heat decarbonisation and retrofitting buildings with more environmentally sustainable heating systems. 'This approach helps engage communities with research that could directly affect their livelihoods and allows for the recognition of community preferences that may be at odds with a given policy initiative,' says Dr Emily Prestwood, Development Manager for the BEI.

The Test and Learn project, organised under the East Birmingham Community Heat Task Force chaired by Liam Byrne, an MP for Birmingham Hodge Hill, uses an agile 'test and learn' approach to policy. A Community Learning Platform offers a shared space for residents, community groups, businesses, industry, and government bodies to explore opportunities, share knowledge and define future approaches and innovations. By bringing together diverse groups, it can effectively identify new measures, enable a common language on retrofit and heat decarbonisation, and facilitate better understanding of residents' lived experience of heating their homes. The initiative is also supporting the design of retrofitting business models that can be tailored for housing schemes across the UK.

The project builds on the spirit of the University's *Strength in Common* report written with Places in Common, a community mobilisation organisation, which critiqued top-down environmental decision processes that do not actively engage with the affected communities, and thereby miss opportunities to make net zero interventions that serve socio-economic goals. East Birmingham, for instance, has the greatest need for retrofit and new heating solutions, but its residents are the least able to afford new measures, making it a perfect pilot geography for exploring how low-carbon projects can deliver positive socio-economic outcomes, argues Dr Prestwood.

To be effective, low-carbon policies need to be made relevant to citizens. 'One of the big challenges is, how do you have conversations with people about decarbonisation and make that meaningful for them? asks Dr Prestwood.

> How do you develop policies that deliver carbonisation but also have other benefits people will recognise?

Dr Prestwood is also leading education outreach from the BEI and Tyseley Energy Park to 'engage people with our research and activities as, particularly in East Birmingham, there's currently low percentages of people compared to the national average who go on to higher education. So, we are encouraging interest and engagement with engineering and energy-related careers'.

Community engagement is an international effort for the University too. Francis Pope, Professor of Atmospheric Science, has worked with grassroots organisations and capital city authorities in Kenya and Uganda to strengthen community-government engagement in policy decisions around air pollution. 'What I'm most proud about is helping ensure that those in charge of top-down governance, and grassroots organisations, are in the same room, like slum organisations talking to capital city authorities,' says Professor Pope.

> You get change when top-down government combines with bottom-up organisations.

POLICY TAKEAWAYS

- While governments need to take bold steps, decision-making should be inclusive. This can be achieved through active outreach to all stakeholders to gather diverse views and opinions, identifying common blockers and obstacles and developing a common language, and by making low carbon transitions meaningful and beneficial to citizens.
- Low carbon policies can deliver socio-economic co-benefits; projects and initiatives in low carbon living should be aimed at disadvantaged geographies to align climate transition with the equity and 'levelling up' agenda.

How sustainable is clean tech?

The boom in low-carbon goods and technologies like electric vehicles is, paradoxically, increasing demand for finite metals and minerals, which could cause environmental damage if extracted through unsustainable mining and poses social risks such as child labour in the supply chain. The global distribution of raw materials is a policy concern too; limited domestic access could be a barrier to industries developing low carbon technologies.

Professor Robert Lee, at Birmingham Law School, is helping shape UK policy to anticipate raw material shortages and emphasise and support circularity, sustainability and good governance principles in low-carbon supply chains. Working with the Department for Food and Rural Affairs (Defra) Batteries Consultation Group, Professor Lee is leading the governance stream of Met4Tech, a UKRI-funded interdisciplinary research centre promoting a sustainable and circular low carbon economy.

Professor Lee focuses on critical materials energy transition, particularly energy generation and transport: elements such as dysprosium (for wind turbines), gallium (for solar panels), cobalt, graphite (for electric vehicle batteries), and platinum group metals (for hydrogen fuel cells).

> We're not going to get to net zero or transition from fossil fuels to renewables without adequate metal supply, and very few of these metals are mined in the UK. The country has never had an overt critical materials policy.

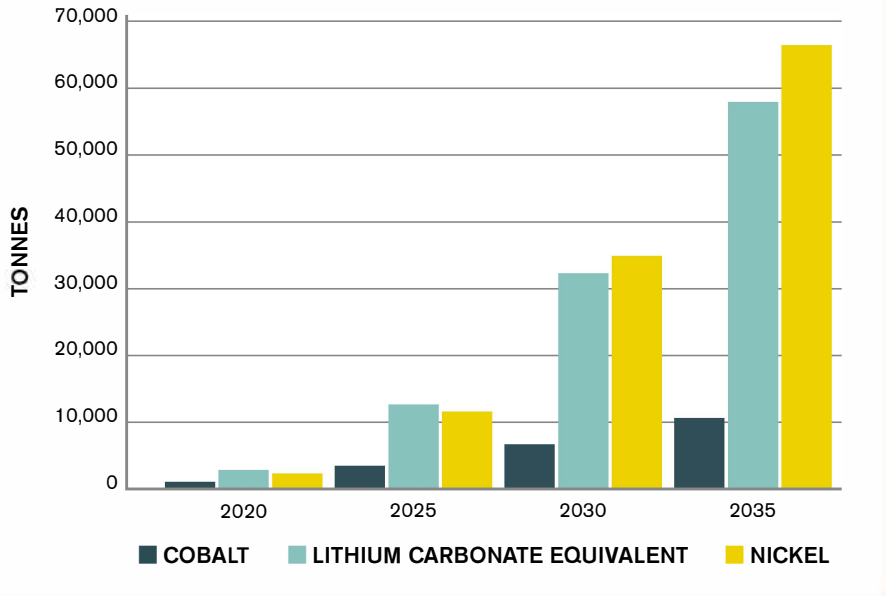
The deficit has widened since leaving the European Union, as the EU has its own critical materials list which the UK has now abandoned. 'It is vital to obtain an adequate supply of these critical materials,' argues Professor Lee. This challenge needs to be situated in the broader context of UK energy reliance and lack of sovereignty resulting from the decline of its fossil fuel reserves, notably in the North Sea; issues which have become more germane during the current geopolitical crisis in Ukraine.

The issues go further than the UK. With reference to metals and minerals availability and supply, Professor Emma Kendrick, Chair of Energy Materials, says the whole of Europe needs to pay attention to commodity supply chains as it rushes to set up 'giga-factories' to produce batteries and electric vehicles. The sustainability-focused EU 'battery directive' will force companies to improve handling and recycling, such as requiring a 'battery passport', a digital system that stores relevant battery contents data throughout the lifecycle. Professor Kendrick says: 'This is really important. Companies are going to have to start looking at the environmental impact of batteries more.'

Professor Lee suggests that governments may need to mandate industry to take back more materials for reuse in future batteries, through extended producer responsibility schemes. 'The government should regulate and make a plan for lithium-ion batteries and decide whether to recycle them and get access to the much-needed metals or let them go to a repurposed use like energy storage, which may place more dependence on primary sources of metals.'

The issue is not just regulatory; our experts are helping the battery industry achieve a circular economy, and innovation is critical to this. The Faraday Institution project Recycling of Lithium-Ion Batteries (ReLiB) is focusing on technical breakthroughs to optimise life cycle handling of lithium-ion batteries to reduce environmental harm from disposal and boost raw material supply

Figure 1: Critical materials expected demand growth, UK



Source: Faraday Institute, University of Birmingham[1]

1. https://www.birmingham.ac.uk/documents/college-eps/energy/policy/policy-comission-securing-technology-critical-metals-for-britain.pdf

by recovering valuable materials from the waste stream.

An allied research agenda is redesigning batteries themselves. Professor Kendrick, working closely with the private sector, is focusing on new ways to design sustainable batteries and optimise life cycle efficiency. Professor Kendrick is Director of About: Energy, a new joint spin-out from the University of Birmingham and Imperial College London, which is working on a significant industry problem: lack of high-quality inputs for modelling battery performance. Battery models are widely used in the design of cells and battery packs to improve performance and reduce costs, but they require input parameters that describe the electrochemical, physical and thermal properties of a battery. However, accurate models depend on the quality of the lab measurements of these parameters, an activity that requires complex technical skills and access to high-end instrumentation. About:Energy is working with industry by analysing and testing sample batteries and sending high quality data inputs for subsequent modelling. Professor Kendrick is also a co-author of an Innovate UK report called ACCELERATE with ANSYS-Granta, Intellegens, Deregallera and AMTE power, investigating tools to accelerate the development of sodium-ion batteries, a complementary less critical-resource dependent and more sustainable solution to lithium-ion formats.

While product innovation and circularity will support the development of sustainable supply chains, the UK's low carbon industries will doubtless venture abroad for essential commodities, and Professor Lee advocates for a stronger adherence to good governance in geographies like the Democratic Republic of Congo (DRC), a major source of cobalt, where there are an estimated 40,000 children working as artisanal workers, scouring through waste heaps of mine tailings trying to pick out cobalt.

Dr Nana Bonsu, Research Fellow at the Lloyds Banking Group Centre for Responsible Business, draws attention to the winners and losers of the net zero supply chain, in particular those resulting from inequalities between the countries producing raw materials and those manufacturing end products, mostly in China and the West. Dr Bonsu says: 'We know this transition is introducing a lot of socioeconomic and ecological issues within resource-rich countries in terms of water security, deforestation, emissions, air and water pollution due to resource extraction.' Dr Bonsu's insight speaks to a gap between climate policy and socio-economic inequality at the international level. Such challenges are true at both ends of the supply chain, as with the quantities of plastic waste being shipped to developing countries, often for landfill and incineration due to poor governance and traceability. Policy analysis by Dr Natasha Cornea, Lecturer in Human Geography, has provided guidance for the UK government that includes phasing out virgin plastics and creating a more 'open' and decentralised plastics recycling ecosystem.

While the UK's reliance on imported net zero commodities will increase, the country is also accessing more of its own geological resources. Cornwall, for example, is now a hotspot for clean energy resources, notably lithium. It is crucial that an ensuing clean-tech mining boom learns the lessons of history in terms of governance and environmental responsibility. Aleksandra Cavoski and Robert Lee, both Professors of Environmental Law, are working with the main stakeholders in Cornwall's mining industry to promote circular economy and good governance in the burgeoning sector. 'We are interested in better understanding legal and regulatory challenges in mineral exploration and development,' Professor Cavoski says. The work is not geared to monitor or chastise, but rather, is about fact-finding and identifying areas in which academic research could be of help. 'It's a very collaborative approach,' adds Professor Cavoski. 'We try to find out what the problems are and how we can help solve them.'

Cornwall's lithium boom is also catalysing private sector collaborations, through a partnership between a University of Birmingham spinout, Salinity Solutions, and the mineral exploration and mining industry. Based on a decade of research, Salinity Solution's compact, energy-efficient desalination system can concentrate the salts in groundwater to extract a mineral-rich brine. The company is currently field-testing its system with eco-technology company Cornish Lithium, which has secured agreements with the owners of mineral rights over a large area of the county.

POLICY TAKEAWAYS

- Raw materials for low carbon goods could become scarce. Governments will need to anticipate supply shortages and work with the private sector to strengthen a circular economy.
- Mining companies, researchers and governments must ensure the net zero mining boom starts on a sound ESG footing — particularly in developing countries rich in critical materials.
- To keep the 1.5-degrees target alive means new, innovative and more inclusive governance and policy development mechanisms to help reimagine and realise a different future that averts the worst effects of climate change. One such mechanism could be developing local-level participatory scenarios, which will help stimulate experts and creative debate and knowledge exchange among local stakeholders and decision-makers around climate change.

Decarbonisation, zero emission vehicles and air quality: not so fast

Net zero ambitions are laid out in quantitative targets, which often carry with them assumptions about the optimal technologies to get us there. Electric vehicles (EVs), for instance, are proposed to be the star actor in the shift to zero emission transport. The COP26 Glasgow Declaration, of which the UK was a signatory, included a call to rapidly accelerate the shift to 'zero' emission vehicles. This could be wrong-headed if it is conflated with EVs, according to Dr Suzanne Bartington, Clinical Research Fellow in Environmental Health. Her research speaks to the importance of critically engaging with new technologies and questioning purported benefits, relative to other investments.

Dr Bartington's research interrogates the relationship between air quality, decarbonisation and transport. As principal investigator of the Transition Clean Air Network, a consortium of nine universities, the UK Health Security Agency, commercial organisations such as HS2, public bodies (Network Rail), local authorities , and third sector organisations, Dr Bartington is leading research to better understand how different sustainability goals intersect. One risk in current policy discourse, she argues, is a flawed framing of EVs as 'zero emission', which ignores the pollution created in their production, as well as the non-exhaust emissions of the vehicles themselves, such as from brake, tyre and road wear, which contribute to haze and linked respiratory health problems.

A rapid increase in EVs may undermine emissions targets for particles, given the positive relationship between vehicle weight and non-exhaust emissions and the fact the EVs are typically heavier than conventional vehicles. There is also a concern that focusing on electrification could overlook the potential for broader policies designed to influence mobility choices at scale, such as the location of homes, workplaces and amenities, the quality of public transport, and opportunities for active travel — which can also bring benefits like greater physical activity, lower congestion and fewer road accidents — and the planning decisions that guide these. 'The market-driven EV focussed approach doesn't work in terms of trying to solve a systems-level problem with an individual choice solution. We are trying to influence the direction of the transport decarbonisation debate,' says Dr Bartington.

> We are making the case that decarbonisation policies must be holistic to deliver cleaner air, mobility equity and better health.

Dr Bartington was part of a Birmingham team that recently concluded a 'participating systems mapping' project, in which diverse stakeholders construct a model of the UK surface transport system via online workshops. The research revealed how unintended consequences of EV-focused transport policies might impact air quality, human health and social functions of the transport system. This project seeks views and opinions from diverse voices, captures social, behavioural and on-the-ground realities of the transport system which are missing from empirical models, or not incorporated into policy thinking, due to lack of relevant data and narrow approaches to evidence-gathering.

Academic research can challenge other popular but misguided environmental narratives, such as the current 'war on plastic'.

While plastic pollution is a subject of grave concern, plastics can deliver important environmental gains, such as lowering food waste. Andrew Dove, Professor of Sustainable Polymer Chemistry, is leading work on how to redesign plastics through stereochemistry, which can change the properties of materials to preserve their manifold benefits and lower environmental harms and risks.

Debates around banning of single-use plastics also tend to miss the bigger picture of the whole production chain and life cycle of the suggested alternatives, which for food packaging include bamboo, leading to large-scale diesel emissions during shipping for example.

POLICY TAKEAWAYS

- Electric vehicles are not pollution-free and they are only part of the answer to reaching low emissions targets. We should not focus on EVs and ignore the impacts possible through changes to public transport, active mobility and location of homes and amenities.

Net zero accounting — building climate literacy in government and business

All organisations are under pressure to report on their emissions, but the tools and accounting principles involved are only emerging. Companies can 'greenwash', presenting a misleading picture of their environmental performance by selecting favourable reporting methodologies, or simply shifting emissions into their supply chain by buying, rather than producing, a given good or service.

To produce comprehensive emissions performance data requires including so-called Scope 3 emissions – meaning those produced in the supply chain, rather than from organisation's own operations. These are, in many cases, where the majority of an organisation's emissions actually lie. Professor Ian Thomson, Director of the Lloyds Banking Group Centre for Responsible Business at Birmingham, has led work to quantify the presence of 'Scope 3' emissions and raise awareness about the need for more rigorous reporting data. Governments need such data to guide decisions like public procurement, tax rates, fiscal incentives and regulatory requirements for carbon disclosures on stock exchanges. Companies need visibility into Scope 3 performance to know how they are tracking against their climate targets. Noting the recent IPCC report, Professor Thomson identifies a shift in science and policy to promote full life cycle accounting practices. Unless you get the life cycle approach right, you make the wrong decisions, says Professor Thomson. A company might, for example, think a shift to digital technology is 'cleaner', which might not be true when factoring in the production of new equipment like servers. 'You have to get the numbers as comprehensive as possible to unlock proper decisions. Get them wrong, and well-intentioned policymakers will come up with the wrong answers'.

Professor Thomson led the research involved in 'Net Zero Accounting', a project funded by Research England's Strategic Priorities Fund, which explored how inappropriate greenhouse gas (GHG) accounting choices result in decision makers selecting options they mistakenly believe will reduce GHG when they will increase global GHG. The research showed how many decision outcomes linked to the UK government's Ten Point Plan for a Green Industrial Revolution are highly sensitive to choices made in the application of different accounting methods.

Professor Thomson sees his own and Birmingham's role as firstly, awareness-raising to ensure the problem gets the attention it needs. 'Right now, if you look at accountants in industry, a tiny minority have knowledge about this. This also applies to lawyers, engineers, the marketing people and so on. There's a big knowledge gap in this carbon literacy space,' he says. Putting numbers on Scope 3 exposure and showing how GHG accounting decisions can radically alter the outcomes of different net zero decisions, is a research-intensive exercise.

A further contribution of the University is helping to produce a new generation of business experts who are climate-literate and understand the realities and complexities of emissions accounting. Birmingham is the first academic institution in the world to introduce climate change into its undergraduate accountancy course. 'We have threaded this through the whole syllabus and are working on sharing that with other universities through online resources,' says Professor Thomson. 'Our goal is to make every single accounting and finance degree in the world have material on this.'

Professor Thomson is also working with the UN Principles of Responsible Management Education program to develop accounting, economics and finance carbon literacy projects. He is also collaborating with the West Midland Business in the Community regional board to make climate targets a major goal in the region, working with a group of leading companies through roundtables, knowledge toolkits and partnering.

> The University of Birmingham is providing support and advice for SMEs in the West Midlands through European Regional Development Fund (ERDF)-funded programmes.
>
> This includes reducing emissions, examining energy consumption, ethical raw material supply, and reducing and utilising waste streams. These collaborations both further Birmingham's research in real-world contexts and help the business community.

Thinking thermally

Climate change will create new emission sources, such as a boom in demand for cooling technologies due to rising temperatures. 'Business-as-usual projections suggest that the number of cooling devices could increase to 9.5 billion globally by 2050 from today's 3.6 billion. Providing cooling for all will require 14 billion devices by 2050 — which is 3.8 times as many devices as are in use now,' says Toby Peters, Professor in Cold Economy and Co-Director of the Centre for Sustainable Cooling. 'The challenge we face is how to provide access to cooling and cold-chains for all who need it, not just those who can afford it, in an efficient, affordable, resilient and sustainable manner.'

It is a challenge not appreciated by many governments yet. 'Most of our energy consumption globally is around thermal demands — heating in the North, and cooling in the global South — but we don't think about energy demand in a thermal way,' Professor Peters argues. Cooling is often a mere 'addendum in the renewable energy debate'.

For example, over 100 gigawatts (GW) of space cooling capacity was added in 2017, outpacing the record 94 GW of solar power generation added to the world's renewable energy infrastructure that year. Similarly, 2018 was a record year for global deployment of solar power with 104GW of installed capacity added, but energy demand resulting from the sale of new air conditioners (ACs) hit 115 GWs. 'My first job is to show governments that when you look at the transition to renewables, you need to be thinking thermally, not just about electricity.'

Professor Peters is working with governments and the United Nations Environment Programme (UNEP) to create cooling centres of excellence across Africa and India, focusing on training and capacity-building through polytechnics and apprenticeships. 'There is no point having a commitment to move to energy-efficient refrigerators and alternative lower global warming potential (GWP) refrigerants unless you have the business models to underpin them and the skills to install and maintain them,' says Professor Peters. 'You have to build capacity ahead of the curve, not behind it.' The Africa Centre of Excellence is hosted by the University of Rwanda in partnership with Defra, the government of Rwanda, UNEP, and four UK universities. It will scale up its work program across the continent and into India thanks to significant investment from Defra. The goal is for the centres to set up 'spokes' in other countries to allow knowledge to flow out into the community.

While Professor Peters works with industry, multilateral institutions, and philanthropic players, it is governments that drive the agenda, he says, by setting regulations and minimum energy efficiency standards for cooling equipment, implementing financial instruments like subsidies and taxes, and building the skills base to support development, deployment and maintenance of sustainable technologies and systems. 'It is very much a government engagement — you have got to have the government involved if you're going to deliver solutions.'

By 2050, the number of cooling devices globally could increase to

9.5 BILLION

104 GIGAWATTS

2018 was a record year with 104GW of solar capacity added worldwide.

POLICY TAKEAWAYS

- Thermal energy demands should not be underestimated. Cooling is a particular challenge for developing countries, which requires technology advances and new business models.
- Investment is needed to support the development, deployment and maintenance of sustainable thermal energy systems.

Realising the promise of rail

Rail is an inherently low-emission mode of transport, accounting for 10% of travelled miles in the UK but only 2.5% of transport emissions, making it a valuable part of a net zero transport mix. 'Rail has a significant advantage over other modes of transportation,' says Clive Roberts, Professor of Railway Systems and Director of the Birmingham Centre for Railway Research and Education.

But it is also a costly and technically complex sector in which governments make expensive, multi-decade, procurement decisions. Academic expertise is key in supporting the sector to address two key challenges: optimising the current rail system — such as reducing emissions and increasing accessibility — and making optimal choices when commissioning new rail infrastructure. Smart procurement choices are especially germane in emerging economies where such investments are significant due to the pressure economic growth places on transport infrastructure.

Professor Roberts is leading a broad research and policy engagement effort to improve the number of people who use rail; cut emissions of the rail system through alternative fuels in the form of hydrogen and greater driver efficiency through training; and support governments in emerging economies to make sound long-term decisions on new rail infrastructure.

'Start with the accessibility gap, which is surprisingly wide,' says Professor Roberts. 'When you take a journey, you don't necessarily care which mode you take, but in having a connected unit. One of the benefits of a car is it's one unit, you sit in it and arrive.' Professor Roberts and his team, partnering with the University of Cambridge, are exploring how to ensure rail is an inclusive and convenient mode of transport to encourage more people to use it.

> We find about a third of the travelling public in the UK have physical issues that stop them travelling by rail, including eyesight, their ability to step onto the train from the platform, the ability to use the ticket machines because they've got arthritis. If a third of the public can't use rail, that's problematic.

Professor Roberts has set up a Centre of Excellence focusing on Inclusive Passenger Experience (IPEC) which provides a physical space for the development and testing of innovations across the four thematic areas of inclusive design, passenger digital connectivity, passenger experience performance metrics and future passenger preferences and demand. IPEC is working on research to illuminate accessibility performance in areas including interfaces whilst planning and booking; interfaces and information during travel; journeys to and from stations; parking and wayfinding; and experience in stations.

Birmingham is also working to improve the emissions performance of the existing rail system and integrate the latest technology. At COP26, a team from the Birmingham Centre for Railway Research and Education demonstrated the hydrogen fuel technology that powers HydroFLEX, the UK's first mainline-approved hydrogen powered train. The technology, developed in partnership with Porterbrook and funded by Innovate UK, the UK's national innovation agency, converts air into electricity and water, with batteries providing traction power to the train. By utilising green hydrogen (produced with renewable electricity), the fuel cells are emission-free and generate clean electricity to propel the train. Birmingham research is helping bring down emissions from conventional vehicles too, through measures like driver training; capacity-building work with Edinburgh trams, for instance, saved 16% of traction energy.

In emerging economies, rail infrastructure is being built at a rapid pace, given rail's higher efficiency and the need to reduce road congestion which is bedevilling many large cities. Professor Roberts is working with governments across the world to support sound, long-term decisions that improve economic growth, cut emissions and support local industry and supply chains. He is a member of the Technical Advisory Panel to the Board of SMRT (Singapore), and a Technical Advisor to Guangzhou Metro in China, a nation with 10,000km of high-speed line, and 25 cities building or extending their metro lines.

The University of Birmingham has a joint research institute with Anhui province in East China to support the development of railway infrastructure. A physical presence in the nation brings huge implications for the real-world impact of Birmingham's rail research and Professor Roberts aims to develop a local research capability as a base for railway support in China and throughout Southeast Asia.

Professor Roberts is also delivering international education in Sub-Saharan Africa, Argentina, Brazil, Peru, Singapore, Saudi Arabia and the UAE, with some work backed by the UK Foreign, Commonwealth and Development Office (FCDO), in recognition of the developmental benefits of rail for economic growth, emissions reduction and industrial policy. This support comes at a timely moment for rail development globally. 'Rail is a growth area in a lot of places around the world, whether that's in a city, metros, high speed lines or freight lines, says Professor Roberts.' While this investment is positive, decision-makers need to make the right choices given the sums involved — often including significant debts. 'These are big sums of money you are spending so you want to be an educated customer and make sure you're asking the right sort of questions as you will be stuck with those decisions for a long time.'

POLICY TAKEAWAYS

- Academic expertise can help deliver financially sustainable rail infrastructure in developing countries.

2. https://www.ukrrin.org.uk/ukrrin-network-capabilities-set-to-expand-with-centre-of-excellence-for-passenger-experience/

We are delighted to work with the University of Birmingham. Together we are working with representatives from industry to create a living lab where we transform the world-leading research from the University of Birmingham into the technology solutions needed to drive the acceleration of net zero. It is only through collaborations such as this that we will be able to keep the promise of 1.5°C alive and guide the policy that will shape the energy solutions of tomorrow.

David Horsfall, Director at Tyseley Energy Park

2. ENVIRONMENTAL SYSTEMS
OBSERVING AND MODELLING TODAY, PREDICTING TOMORROW

Policymakers must take long-term decisions despite limited data about the scale, scope and dynamics of climate change and its impacts.

Seemingly attractive policies, like a rapid transition to electric vehicles, might not deliver the benefits expected, while other under-appreciated interventions could have co-benefits, such as simultaneously achieving climate goals with equity and inclusion outcomes. Decisions around financial incentives and market structures, for example, pricing carbon or putting economic value on enhanced ecosystem service provision by restoring and conserving forests, must also be taken based on data-driven evidence, together with robust modelling and projections to show likely future scenarios.

Understanding chemicals, plastics and clean air

While carbon emissions are central to climate change discourse, the pollution crisis is broader. A toxic slew of pollutants from chemicals and plastics affects our water, food, and air. Microplastics, for instance, were recently found in human lungs for the first time.

Governments and international bodies rely on scientific advice to understand the current scale of chemical, plastics and air pollution and make optimal regulatory choices to restrict or phase out substances that are toxic to human and ecosystem health, without over-reaching and constraining the adoption of useful products. The research tools involved in producing that evidence and data are being revolutionised thanks to advances in genomics, metabolomics, quantitative genetics, data science and toxicology.

Iseult Lynch, Professor of Environmental Nanosciences, chairs the Hazardous Substances Advisory Committee (HSAC) of Defra, its agencies and the devolved governments, which also includes Birmingham's John Colborne, Professor of Environmental Genomics, and Stuart Harrad, Professor of Environmental Chemistry. HSAC provides expert advice to the UK government on protecting human health and the environment from hazardous materials, including nanomaterials, microplastics and chemicals. This advice forms a critical contribution to the UK's national Chemicals Strategy. This is part of a 25-year national environment plan, by enabling a transition to new and advanced methodologies for hazard and risk assessment.

Part of HSAC's work, Professor Lynch explains, is to filter the evidence and provide guidance to government on the decisions most warranting of their attention. This includes horizon-scanning, using the 'Delphi' method, an inclusive decision-making methodology, which revealed an emerging priority among the scientific community to better understand the interplay of chemicals with each other and the environment, rather than viewing them in isolation.

'Amongst the scientists on HSAC, there is a real push to look beyond recognising chemicals individually and placing them in the broader context of how they interact and mix, alongside other stressors, such as climate change and biodiversity loss,' says Professor Lynch. The scientific community is also advocating for an intergovernmental panel for chemicals and waste. 'At the moment,' says Professor Lynch, 'existing chemicals legislation typically only asks 'is it safe to go into a product?', but not into what happens when a product is at its end of life as that comes under separate legislation.

> We need to think about the whole lifecycle and design materials and products with both safety and sustainability and circularity in mind.

The committee is helping regulators make speedier decisions, such as by analysing chemicals in groups and using alternative evidential data points to measure the impacts of hazardous substances like computational rather than animal studies. 'Where there are gaps in how fast those methods can be validated for use, and caution on the regulators side not to move too quickly, we need to find ways to cut through complexity, allow policymakers to take on board information and still make decisions,' argues Professor Lynch.

The Centre for Precision Toxicology, led by the University of Birmingham alongside 15 European and US organisations, is blending technology, science and law to establish a new cost-effective testing paradigm for chemical safety assessment — Precision Toxicology — that could revolutionise regulatory toxicology, replace animal testing, reduce uncertainty, and determine safety factors in assessing risks to human health.

Research at Birmingham is also addressing the multi-stressor challenge of chemical cocktails and climate stress, providing a scientific basis for updating standard regulatory testing guidelines for chemicals and advanced materials to better reflect the real-world challenges for species, ecosystems and pollutant mobility, to ensure preparedness for future climate scenarios.

POLICY TAKEAWAYS

- Decision makers should partner with the academic community to identify decisions most warranting of government attention. This should be based on scientific consensus and emerging trends and explore novel techniques for assessing toxicity and risk more precisely and rapidly.
- Avoid overly focusing on standardised (optimised) conditions for assessment of the (eco)toxicity of chemicals and their mixtures. This could miss the combined impacts of climate stress (such as increased temperature, water stress) and pollution on organisms and ecosystems.
- There is an urgent need to include higher temperature conditions into standardised ecotoxicity testing to identify at-risk organisms/ecosystems and prioritise mitigation strategies.

Similar research efforts – to more accurately quantify current pollution and support policymakers to best confront it – are underway in the field of air pollution. WM-Air, led by William Bloss, Professor of Atmospheric Science, is providing an improved understanding of air pollution sources and levels in the West Midlands. Funded by the Natural Environment Research Council (NERC), the project works in collaboration with over 20 cross-sector partners, applying environmental science expertise to improve air quality and health across the region. This work includes understanding air pollution sources, quantifying the benefits of policy options, and allowing individual interventions to be analysed against given air quality outcomes.

Professor Bloss is working with the West Midlands Combined Authority on modelling future air quality scenarios linked to net zero policy trajectories and optimising the resulting air quality co-benefits that result. Professor Bloss and his team are advising on an Air Quality Framework to help set a region-wide approach in the Midlands. 'Air pollution doesn't stop at the city boundary of Birmingham or Coventry,' he notes. As regulation around pollution tightens, the work of Professor Bloss and his team will be of increasing value as companies and organisations have to improve their performance by law rather than discretionary effort.

The UK's Environment Act 2021, for instance, allows local authorities to designate other public sector bodies as 'air quality partners' if they are responsible for emissions, and to require them to develop a reduction strategy with recourse to the Secretary of State for those that fail. That has implications for a range of public bodies potentially including the NHS and National Highways. 'We have been bringing this to their attention and identifying how much impact comes from an infrastructure or a fixed source industrial site,' says Professor Bloss.

The private sector also benefits from Birmingham's air pollution research. Professor Pope's research includes using low-cost air sensors to apportion air pollution to specific sources. This has been a useful tool for industry, sparking a collaboration with Dust Scan, an SME focusing on nuisance dust and air pollution from sites like construction and mining. Sensor data can provide deeper insight into not just overall pollution levels but underlying sources and causes and variations in different environmental and weather conditions. 'The vision is not only to use these sensors to measure the concentration of air pollution, but also to be able say what is causing the pollution – we don't just measure it but also attribute it,' says Professor Pope.

The collaboration was a result of Professor Pope's work in East Africa, which a senior Dust Scan consultant, Gordon Allison, learned through his engagement with Birmingham as a guest lecturer on a Masters course on air pollution. 'It showed how work in one country can cross boundaries rapidly and not always in the countries you might expect,' says Professor Pope. 'It came out of blue-sky academic research – asking, can we get more information out of sensors? And it later became clear there is potential to be commercially useful'. These insights help us understand the optimal environmental conditions for potentially polluting activities. 'You can be more proactive in decision-making in sectors like construction, about when you do what, where and when.'

POLICY TAKEAWAYS

- Use climate co-benefits – for example, cleaner air – to demonstrate there are health and environmental benefits from local actions to address the global carbon challenge, and so encourage early change.

OVER 20 PARTNERS

are applying environmental science expertise to improve air quality and health across the region.

> The vision is not only to use these sensors to measure the concentration of air pollution, but also to be able say what is causing the pollution – we don't just measure it but also attribute it.
>
> **Francis Pope, Professor of Atmospheric Science**

Modelling climate futures

Future climate scenarios are shrouded in uncertainty, as different modelled temperature bands suggest varying ecological dynamics, such as the level of carbon capture by forests. Research at Birmingham's Institute of Forest Research (BIFoR) is helping policymakers consider how future changes in climate and land use could inform decisions today.

Sami Ullah, Professor of Biogeochemistry, and a researcher at BIFoR, is spearheading research assessing whether forests will be able to capture the elevated levels of CO2 expected in the future. This research also explores whether the 'CO2 capture potential' of forests might be constrained by other factors such as the availability of nutrients and water and/or tree diseases under future climates.

Over the last five years, as part of BIFoR, the University has established a Free-Air Carbon Dioxide Enrichment (FACE) experiment within a mature native forest in Staffordshire. Researchers are exposing a mature oak-dominated woodland to CO2 at levels expected to be the norm by 2050. This ambitious, collaborative long-term research initiative (2016-2026) will produce findings to address fundamental uncertainties in the global carbon budgets of forests under future climates. This vital work will allow governments to take informed decisions about the role of forests in climate change mitigation.

BIFoR research has international dimensions. It has engaged with the recently announced FACE experiment in the Amazonian rainforest, through AmazonFACE, whose implications for development helped initiate UK government funding, through the Foreign, Commonwealth and Development Office (FCDO). BIFoR is also collaborating with the Australian-based EucFACE experiment, where mature eucalyptus trees are exposed to elevated CO2 levels in a Mediterranean-type temperate climate. These unique FACE experiments covering key global forest types will, by showing their likely CO2 capture performance in a future scenario, enable a more realistic assessment of the role of forests in carbon capture and climate change mitigation.

Professor Ullah believes governments are a natural partner to back long-term scientific data-gathering initiatives like BIFoR-FACE — and beneficiary of the resulting data. 'It's in the government's interest to fund such projects as they have the responsibility to mitigate climate change and to provide a home to biodiversity, prevent flooding, and provide ecosystems that are important for human well-being,' says Professor Ullah.

> Projects like BIFoR-FACE provide the government with the correct prediction and value of carbon credit that can go to the economic market.

Professor Ullah calls on governments to explore a global initiative inspired by the FACE program, to include other types of forests, such as boreal ecosystems and mangrove forests, so that 'we could have a fuller picture of the nature-based solution for climate change mitigation'.

Professor Ullah is also working at the national level, as part of a panel of experts on the Defra Nutrient Management Expert Group. This focuses on regulation and policy recommendations regarding the use of fertilisers and nutrients in landscapes to sustain food production, protect water and air quality and improve soil health. It encompasses the burden of greenhouse gas emissions like nitrous oxide and atmospheric pollutants such as ammonia, and weighing human health and ecological implications, while protecting the quality of the water and biodiversity. 'Nitrogen is the next carbon, and it has to be considered seriously,' says Professor Ullah. 'It has implications for food security and net zero as well as for the environment, through air, water, and soils.'

Understanding the sustainability dynamics of fertiliser and nutrients in agriculture is particularly important for the UK, as it departs from EU agriculture legislation. 'We are coming out of the EU Common Agricultural Policy in 2024/2025, so we will have to have our own regulations,' notes Professor Ullah. 'We are trying to develop more sustainable management portfolio resources in nutrients to deliver multiple benefits, including reductions in greenhouse gas emissions, mitigations, and climate change.'

Professor David Hannah, Professor of Hydrology and UNESCO Chair in Water Sciences at the University of Birmingham, is engaged in policy engagement programmes — understanding future water security and risks to inform decision-making now. With increased frequency of hydrological extremes such as floods and drought across the world, it is crucial for governments to understand the evolving risk landscape and how choices made today can create risks tomorrow.

Based on an analysis of outcomes for global model intercomparison projects to the end of the century (2100), Professor Hannah says: 'The greatest source of uncertainty is not between what climate model you use, but which hydrological model you run those climate models through to project future high and low flows. This tells us that we really need to better understand terrestrial hydrological processes to make projections of future extreme environments.

POLICY TAKEAWAYS

- Policymakers need to agree the optimum land cover configurations for 'nature-based solutions' at a national level. This will address climate change mitigation tigation and adaptation through restoration and conservation of forests.
- A percent 'land per nation' target can be an effective indicator of the wider targets to capture carbon and stop deforestation

'The water cycle is a major variable impacting our climate future and is often referred to as the "climate connector" as floods and droughts are the ways many people feel the impacts of climate change.'

Professor Hannah's research has also identified the impact of changing land use and land cover on the terrestrial water cycle, and the resulting feedback loops as ecosystems become more alike through agriculture and development which tends to reduce biodiversity and variety in favour of monocultures. The largest uncertainties in hydrological projection are found typically in areas with the most significant water security challenges. One issue Professor Hannah identifies is the impact of changing land use and land cover on the terrestrial water cycle, specifically the changing plant-water interactions as we convert more land to agriculture for food supply. Lower levels of biodiversity and less diverse land cover limit the routing options of terrestrial water, compared to naturally vegetated landscapes, Professor Hannah's research has found. As a result, monocultures are more vulnerable to climate disturbances, and this could weaken the resilience of the planet's terrestrial water cycle to stressors. Monocultures are less able to cope with climate extremes, such as droughts, because of their limited ability to respond to these stressors. 'As you move from mixed land use like forests and pastures to cropping one thing, this results in the homogenization of the water cycle. More diverse environments are more resilient and less vulnerable to changing conditions,' Professor Hannah asserts.

Another area where modelling is revealing important insights to the Scottish economy is in the work Professor Hannah is doing with Marine Scotland Science (MSS), part of Scottish Government, focusing on how trees can shade rivers, reducing solar radiation, and, in turn, protecting freshwater fish from rising temperatures anticipated in a warming climate. Wild Atlantic salmon is an industry worth £80 million a year. In collaboration with MSS, Professor Hannah has undertaken research producing statistical models of river temperatures at the national level for Scotland, which can be used to inform where streams are projected to see the highest eater temperature increases and thus, where riparian tree planting would have the greatest impact. This work culminated in an online tool where landowners could get a map of river basins with colour coding for hottest areas, which they can then use in planning applications for tree planting. This research is helping decision makers pursue more targeted interventions. 'We showed that with sparser planting, in more targeted locations, you can gain a bigger benefit that some less strategic, larger-scale interventions,' says Professor Hannah.

> Without such research evidence, you risk making interventions that aren't as impactful.

This research has international dimensions and relevance. The approach has been advocated by the inter-governmental conservation efforts of the North Atlantic Salmon Conservation Organisation (NASCO) review group and is now being replicated in other nations.

Scenario research — alternative pictures of possible futures and the pathways leading to them — can help us make sense of the complexity and uncertainty of the future, assisting decision-makers to design and implement policies to reduce and to adapt to negative effects of water extremes such as droughts, floods, and pollution[5].

Professor Hannah emphasises the importance of conducting scenario exercises in partnership with social actors, especially governments. This participatory scenario development raises awareness among policymakers of their risk trajectories and encourages them to focus on policies that work effectively in potential futures[6] .

POLICY TAKEAWAYS

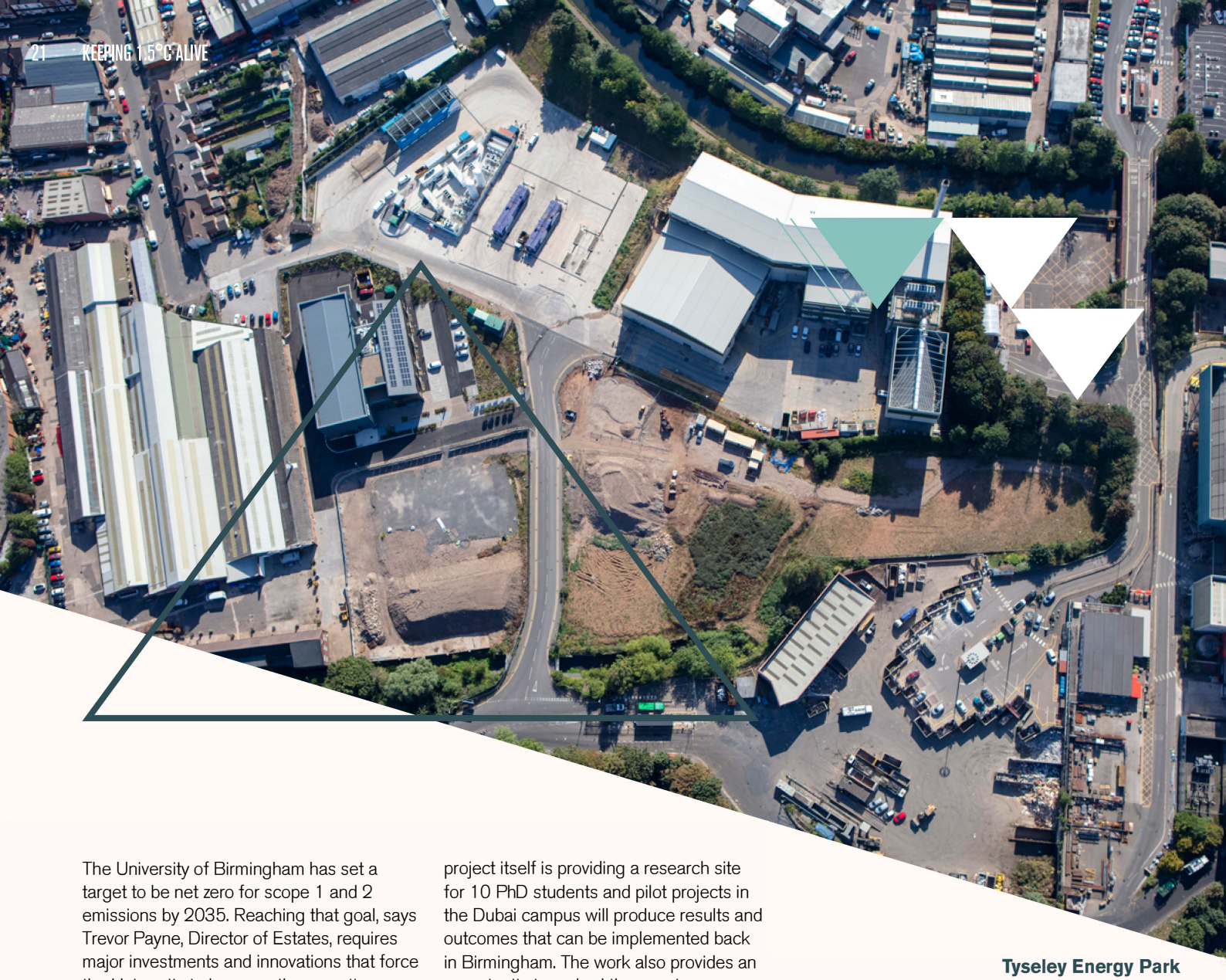
- Forecasting and scenario modelling can inform more targeted and precise interventions to harness nature with maximal impact.
- Modelling can reveal emergent risk factors such as the impact of monocultures on the water cycle.

3. https://nasco.int/wp-content/uploads/2020/02/IP1910rev_IP_EU-UK-Scotland.pdf,
4. https://nasco.int/wp-content/uploads/2020/05/CNL2042_APR_EU-UK-Scotland.pdf
5. https://onlinelibrary.wiley.com/doi/10.1002/hyp.14492
6. https://onlinelibrary.wiley.com/doi/10.1002/hyp.14492

3. UNIVERSITIES AS LIVING LABS
GOING FURTHER THAN RESEARCH

The contribution of higher education institutions to the 'Keep 1.5 Alive' agenda goes much further than research, essential though it is. Universities are also, in and of themselves, businesses under pressure to decarbonise.

They can be 'living labs' – testing grounds for innovation, and proximate sites for research to take flight. They are also educational institutions that help to nurture a new generation of climate-conscious citizens and bring a breadth of perspective and expertise to a challenge that crosses cultural, economic and political boundaries.



Tyseley Energy Park

The University of Birmingham has set a target to be net zero for scope 1 and 2 emissions by 2035. Reaching that goal, says Trevor Payne, Director of Estates, requires major investments and innovations that force the University to leverage the expertise of its academics, and to embody the very urgency that researchers are pushing for in wider society. 'As well as the academic conversation about climate change, there is a practical and operational reality: we have to decarbonise our estate,' says Payne.

The estate is working directly with academic and technical teams in areas like thermal insulation and heating, energy storage, power network infrastructure, and solar technology. It is also teaming up with outside partners. The Smart Campus Plan, delivered in partnership with Siemens, will upgrade the first 25 buildings on campus – (to be followed by a further 60 buildings in 2023) to improve energy efficiency, reduce CO2 emissions and enhance the working environment, by deploying technologies to collectively deliver an initial 5% reduction in carbon emissions, equivalent to approximately 2,856 tCO2 per year. The project itself is providing a research site for 10 PhD students and pilot projects in the Dubai campus will produce results and outcomes that can be implemented back in Birmingham. The work also provides an opportunity to embed the smart campus within a broader urban observatory funded by the UK Collaboratorium for Research on Infrastructure and Cities.

Urban Observatories, such as Birmingham Urban Observatory led by Lee Chapman, Professor of Climate Resilience, capture the complex interrelations and interactions of real systems with the environment, people and society for topics such as, air quality, decarbonisation of transport and flows of energy.

> The partnership between Siemens and the University of Birmingham provides a truly unique opportunity. It brings together strengths, determination and innovative mindsets to tackle society's greatest challenge of the climate emergency.

Faye Bowser, Head of Energy and Performance Services, Siemens UK&I Smart Infrastructure

Training a new generation

Education systems are starting to introduce climate change as a subject and discipline in its own right. Higher education is a critical learning stage for producing graduates with the cross-disciplinary skills and capabilities to grapple with the climate crisis.

Birmingham is taking a major step in the 2022/2023 academic year by launching a new cross-disciplinary undergraduate program, the BSc/MSci in Global Environmental Change and Sustainability. The program will teach students to engage with the latest research and translate it into policy and action.

The BSc/MSci spans modules ranging from philosophy, biosciences, engineering, and environmental sciences to history. Unusually, the course will draw students from a range of backgrounds, based on passion, rather than academic experience. 'Whether students come from social sciences, arts, biology or geography, we want a cohort that is mixed. We want those different perspectives,' says Dr Julia Myatt, Associate Professor in the School of Biosciences and Liberal Arts and Natural Sciences, and part of the new program development team.

The University is ideally placed to build such a program, with its interdisciplinary expertise, both in research and in education (through its Liberal Arts and Natural Sciences program), and the strength of its collaborations across departments, as well as its industrial links. Dr Myatt adds: 'We are bringing in external stakeholders, from companies, big or small, to give real-life experience to students. What challenges are they facing, and how can we address these? We're also looking at the sustainability transition of the University estate itself, as a challenge for students to learn from.'

The programme builds on Birmingham's research excellence, such as giving students access to lab space and research groups. But the material is also student-led, driven by what students want to do. 'It is not just focusing on the problems and understanding the issues; it's about solutions,' says Dr Myatt.

To underscore how climate change is not an isolated subject but a holistic perspective that touches all disciplines, Birmingham has also become the first Higher Education establishment to introduce climate change into its BSc Accountancy and Finance degree course. This coincides with regulatory tightening that requires companies and organisations to develop new accounting methodologies to quantify climate risk and impact.

The University is also weaving the Sustainable Development Goals into its entire teaching and learning portfolio. Professor Laura Green, Pro Vice Chancellor and Head of the College of Life and Environmental Science and University Executive Board Lead for Sustainability, says: 'Our aim is to ensure all our students and staff understand the critical issues around social and environmental sustainability and to teach discipline-specific knowledge of sustainability using the SDGs in all academic programmes. Whether students are studying nursing or theology, we want them to understand as they go into the workplace what sustainability will mean for them as professionals — or have the tools to find out. That's critically important.'

Birmingham is taking the lead in putting carbon literacy on the agenda — with the first accountancy programme in the world to introduce carbon accounting through all modules.

Birmingham is also rightfully under pressure from many students whose futures are at risk without fast and effective action on climate change. 'Many students are highly knowledgeable about climate change and want to know they are coming to a sustainable university,' says Professor Green. 'Birmingham has enormous expertise in sustainability, our goal is to co-create the future with our students.' Professor Green also reflected that the University's engagement with the wider city is strong, evidenced through strong collaboration with Birmingham City Council, West Midlands Combined Authority, Tyseley Energy Park, and the private sector.

POLICY TAKEAWAYS

- Policymakers should recognise the vital role that the arts and humanities can play alongside the sciences in helping to address climate change, by shifting the focus from costs to values; by listening to and amplifying voices from other times and places with direct experience of environmental change; by enabling people to imagine alternative and better ways of living; and by offering reassurance, consolation and inspiration as we transition to a new future.

Toolkits for business

The private sector is often hectored for failing to move fast enough — but shifting to net zero is neither easy to initiate, nor without challenges once in motion. The Lloyds Banking Group Centre for Responsible Business is a strategic initiative led by Birmingham Business School in partnership with, and funded by, Lloyds. It is helping support the business community to make better decisions about sustainability. A flagship book, Urgent Business, codified key findings from the Centre's research, including identifying five common myths preventing businesses from making meaningful change.

1. outmoded focus on profit
2. tendency to focus on specific interventions without considering backfire effects
3. over-reliance on 'ethical consumers' as drivers of change, rather than using design thinking to encourage better choices
4. disconnect between the climate change agenda of corporate leaders, versus the real decisions made by management, middle management and staff
5. lack of visibility

Imagining a better future

The arts and humanities may seem less prominent in climate change research and policy, but that is part of the problem in terms of how the crisis is framed and responded to. Poetry, literature and visual arts all exert a hold on the imagination and influence the formation of values and priorities. They can broaden thinking and build empathy.

Professor John Holmes, Professor of Victorian Literature and Culture in the Department of English Literature, believes the humanities, and cultural institutions, can help shift public attitudes and bring greater attention to the sustainability crisis. He co-ordinates Symbiosis, an interdisciplinary network of universities and museums promoting the use of arts in natural history collections, as a means to engage a wider, more diverse audience on issues around climate change and environment. 'Museums have a position of respect with the public so they are a good mechanism to engage a broader audience,' says Professor Holmes.

He also believes that while the sciences are critical to climate change research, we need active involvement from the humanities and the arts to win over people's hearts as well as minds to reach the momentum needed to change public opinion. Professor Holmes alludes to a 'cognitive gap' currently, with the status quo, where the scientific information fed to the public and policymakers is failing to generate enough impact. 'To get to a sustainable future,' says Professor Holmes, 'we need to imagine ourselves into that future. Literature and the humanities can play a role in helping people realise that active imagination'.

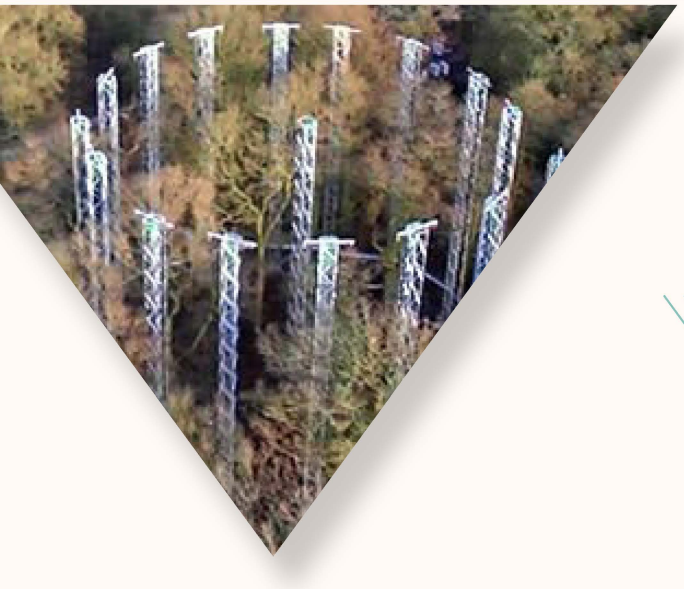
Carving of Pickerel by John O'Shea (photograph by Scott Billings)

CONCLUSION:
BRIDGING RESEARCH AND POLICY

There is an opportunity for the higher education sector to work in partnership with policy makers and industry to tackle the climate crisis.

Academic researchers and policymakers share the same goal of tackling climate change, but they have too often existed in separate worlds.

Although many researchers are aware of the policy implications of their work, this is not incentivised in the conventional career progression metrics, which have traditionally prioritised publications and citations.



Policymakers, for their part, may not utilise academic research for fear of 'paralysis by analysis' - a sense that the nuance and complexities of climate change and the unpredictable unfolding of policy interventions, make it hard to take firm and definitive steps. There are also practical constraints facing governments that could limit the traction of evidence-based research, whether it be political forces or the urgency of daily crises versus long-term decisions and strategies

But both communities need to work together effectively and the development of relationships, shared projects and co-developed initiatives and policies can help researchers and policymakers enrich and support each other. Birmingham is working to develop a common language and a shared framework to ensure research is a bridge for policymakers, and that relationships with governments at different levels are utilised to support the practice of research and ensure that it has impact.

Academics can help policymakers to think holistically, and to identify co-benefits of net zero interventions, such as the overlap between poor air quality and socioeconomic deprivation, which makes air quality improvements part of the wider policy narrative of 'levelling up'. 'From a political perspective, for clean air there is a regional narrative that 'local changes can benefit local health, irrespective of what happens elsewhere, which is different from the need for concerted international action around carbon,' says Professor Bloss. 'We're quantifying the regional and local benefits from combined air quality and climate action and introducing those insights into the conversation.' Members of Professor Bloss's team have also been seconded to the West Midlands Combined Authority to bring the latest science into policy. Similarly, the Foreign and Commonwealth Development Office (FCDO) commissioned Professor Francis Pope to write a departmental report for COP26 on the intersections between air pollution and climate change — and the benefits of addressing them together.

'Academics have longer timeframes than governments. A local authority has budgetary and political cycles that they need to be responsive to,' says Dr Joanne Leach, Research Fellow in the Department of Civil Engineering and Executive Manager of the UK Collaboratorium for Research on Infrastructure and Cities (UKCRIC). 'There's always an amount of uncertainty around whether a change in political leadership will result in lots of hard work getting thrown out. One way this plays out is in terms of the amount of time and energy that it is possible to invest because governments have to deliver and show a positive impact on a much shorter timescale.'

Academic institutions can be the change agent to help projects take flight. 'At the local end there's not a lot of capacity [in low carbon transition],' says Professor Freer. 'Most of the thinking is about making sure services which are in place get delivered. They have a good understanding of the planning process, but they don't have the capacity to think about what's coming next.'

Professor Freer sees the role of the University as 'helping organisations think through what the opportunities might be, and where they resonate with the ambitions of the City Council or the Combined Authority, then we can help with the next stage, which is the physical development'.

Professor Freer describes the University as 'not just bringing the thinking but also finance, business and industry around ideas and projects, and helping co-create solutions with the Combined Authority and City Council. We are providing a shared vision and journey which then provides confidence for industry partners to invest. It's about trying to stimulate thinking and hold the ring for others to come in and deliver solutions'.

Nick Grayson, climate change and sustainability manager of Birmingham City Council, speaks of the benefits that a part-time secondment to the University had on his thinking around the city's urban challenges. Grayson was a participant in the Liveable Cities project, a five-year (2012-2017) initiative to explore how cities could become healthier, fairer and greener. Those experiences helped inform the design of Birmingham's current City of Nature plan, a 25-year framework to become a 'biophilic' city. 'Nick has taken the experience of working with us on Liveable Cities and translated that way of approaching sustainability and climate change into the local authority context, and it is coming to fruition in the City of Nature plan,' says Dr Leach.

Mr Grayson says the secondment gave him exposure to 'multidisciplinary and transdisciplinary approaches, which was very influential on my mindset and my understanding of the city's challenges'. The tendency of city authorities to look at climate issues at a departmental level — such as putting air quality into the domain of the transport and highways division — is flawed. 'If we approach this in silos, all we do is accelerate bad decisions. Climate change is a classic example, in that everyone is signing up to tackle it without a clue how to deliver change, because we wouldn't be in the position, we're in if our systems weren't aligned in the way that they are,' Grayson argues.

'If we're going to do something with connectivity and transport, for example, we can't do it in isolation because it is linked with other problems,' says Dr Leach. 'We

divide problems up sectorally because that's the way we've done it for a long time now, but we should be looking at them collectively. Our solutions and interventions should not be delivered through one lens.'

Mr Grayson's participation in Liveable Cities was not just useful for guiding the city — it also helped academics to understand the real-world contexts in which their ideas would have to play out. He says: 'It was useful wearing the 'city hat' in discussions so we could keep ideas in the realm of reality and practically-oriented, always coming back to the final challenge: how do we make change happen?' He believes that, where possible, city councils should participate in university research initiatives, and academic leaders should join the corporate leadership teams of cities, such as through exchanges or away days, to increase the flow of ideas, perspectives and experiences in both directions.

Naturally Birmingham: A holistic strategy for a green, just and sustainable city.

The 2016-17 Parliamentary Inquiry 'The Future of Public Parks' found that the value of parks and green spaces was well documented but not well understood and therefore not fully protected in policy and vulnerable to funding cuts.

The Future Parks Accelerator ('FPA') programme, a collaboration between the National Heritage Lottery Fund, the National Trust and the Department for Levelling Up, Housing and Communities, was designed to help Councils find sustainable ways to manage and fund parks and open spaces across entire towns and cities. The University of Birmingham joined in December 2019, seeking to test proposals that could help the city better realise the value of nature and open green spaces.

As part of the learnings of this process, once funding concluded, a new governance plan for the city, the City of Nature Plan, has been recently developed, informed partly by the Liveable Cities initiative, to build on the aspiration to provide a basis for ensuring all of Birmingham's citizens get the opportunity to experience and benefit from nearby nature. The plan outlines five themes for embedding the value of green spaces across our Council and communities.

- **A Green City –** Ensuring green and blue infrastructure is safe, clean and sustainably managed.
- **A Healthy City –** Making sure every citizen can access green spaces to improve their health and wellbeing as part of the foundations of a Good Life.
- **A Fair City –** Ensure fair access to green jobs and that our workforce reflects our diverse communities; ensuring every citizen has access to good quality green space wherever they live, fast tracking those in greatest need first.
- **An Involved City –** Citizens will know, love, and protect green spaces and nature.
- **A Valued City –** Ensuring that the city better understands and captures the value of nature and green spaces, maximising their commercial and sponsorship potential and establishes new innovative funding avenues.

Research relevance, and building relationships

Along with factoring in the realities of political decision-making, academics need to go further in making their research accessible and relevant. John Bryson, Professor of Enterprise and Economic Geography, experienced first-hand the limitations of research during his 12 years chairing the Climate Change and Sustainability Committee for Worcestershire County Council. 'We consumed and digested very little academic research during this period, because of the complexities of aligning research with the specifics of the challenges we faced,' he says. 'Policymakers have a precise need which is often not aligned with the ways academic research is framed because that research is far too focused.' Professor Bryson adds that universities need to be open to the idea that they need different skills and people in order to smooth the flow of research into policy. 'Universities need cutting-edge academics, but they might not always be the person you want to put in front of the local councillor,' he argues.

'We have to be aware that we are speaking to people who are busy, and that do not have the background we have,' says Professor Aleksandra Cavoski, of the Birmingham Law School. 'The question is how do you use language to translate your findings into law and policy?' Not all academics want to get engaged in policy making or when they engage, as pointed out by the policymakers in the European Commission, they 'need to use much simpler language to communicate as academic language is difficult to use for policy purposes'. Dr Prestwood also emphasises the importance of working effectively with government, presenting evidence in a way that is accessible and meaningful, especially when working with under-resourced organisations such as Birmingham City Council.

The extended time horizons of academic work can also be useful to industry says Professor Kendrick. 'Academics can support industrial development through scientific insight into the processes, to understand the science and engineering behind them. In industry there isn't the time to understand the physics or chemistry behind manufacturing processes. That's where universities come in'.

William Bloss, drawing from his experience working with the West Midlands Combined Authority, argues that academics need to tailor their communications while retaining appropriate rigour, and this might require them to 'step outside your academic research comfort zone to put the science forward in way that is accurate and fair, but also effective and impactful in policy contexts around contentious issues'. He adds that academic-policy engagement benefits substantially from the trust and mutual understanding that flow from prior collaboration. 'The understanding and respect mean there is trust on both sides and you can have free and easy scoping conversation and get to a formal plan — there is something about the duration of interaction that enables substantive engagement'. Professor Hannah makes a similar observation. 'The Marine Scotland Science work was only possible because we co-created it with the government and local stakeholders (river and fisheries trusts) from the beginning,' he says.

Introducing BISCA.

The University of Birmingham is home to BISCA – The Birmingham Institute for Sustainability and Climate Action. Led by Professor David Hannah BISCA is a new collaborative platform to nurture expertise and develop meaningful partnerships.

Its aim is to facilitate climate action through the research community, students, policy and decision makers, and wider society. All of this activity will influence behaviour change and help to secure a healthier future for all.

www.birmingham.ac.uk/bisca

7. https://research.birmingham.ac.uk/en/publications/science-and-law-in-environmental-law-and-policy-the-case-of-the-e

FINAL WORDS

Tackling climate change is arguably the most important challenge in modern history. Achieving the ambition set out at COP26 to keep global temperature increase to under 1.5C requires a global effort and we must all play our part.

The Higher Education sector is key to addressing this challenge. This report amplifies the need for the sector to embrace greater meaningful partnerships with businesses and policymakers. This effort will not only reinforce the evidence base for robust measures and policies, but also help to support business and governments in the journey to a more secure environmental future.

Building on the success of the Addressing the Climate Challenge publication in 2021, the University's significant presence at COP26 and our work to strengthen partnerships with businesses, this report is another step on that journey. I am very proud that the University of Birmingham is strengthening its global collaborations – ensuring that we can help deliver on the shared goal of keeping 1.5 °C alive.

Lord Karan Bilimoria CBE DL
Chancellor, University of Birmingham

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