MANCHESTER 1824
The University of Manchester

GLOBAL CHALLENGES, MANCHESTER SOLUTIONS

Addressing global inequalities
Advanced materials
Cancer
Energy
Industrial biotechnology

At The University of Manchester our pioneering discoveries, interdisciplinary collaboration and cross-sector partnerships are tackling some of the biggest questions facing the planet.

Global challenges, Manchester solutions

Contents

Research is fundamental to The University of Manchester. We're committed to both the discovery of new knowledge and its application for social and economic value.

We have a range of high-quality research at this University that is rivalled by few other universities and much of our best research combines expertise from across disciplines, making the most of the opportunities that our size and breadth affords.

As a result, our researchers are able to work together to find innovative solutions to some of the world's most persistent and pressing questions.

The five research beacons covered in this brochure showcase concentrations and combinations of high-quality research activity that are distinctive to this University and demonstrate how our interdisciplinary approach is improving the lives of people around the world.

Through this work we're improving knowledge of inequalities to help bring about a fairer society. We're developing advanced materials that can withstand the harshest environments.

Our experts are investigating all aspects of cancer so that we can reduce its profound and devastating impact on so many families. They're pioneering the energy systems of the future and developing sustainable alternatives to the finite resources used in everyday manufacturing.

The scale of research activity at Manchester allows us to bring the best minds together to find new ways forward. By working together, we're advancing knowledge for a better world.

Professor Dame Nancy Rothwell
President and Vice-Chancellor
The University of Manchester

There are pronounced inequalities across the world. While progress has been made in some areas, it's still the case that food, health care, infrastructure, resources and opportunities are plentiful for some yet scarce for others.

Addressing global inequalities to improve lives

For almost two centuries, The University of Manchester has been leading the way in tackling global inequalities. From poverty to social justice, from living conditions to equality in the workplace, we seek to understand our world and change it for the better.

Poverty
The entire field of international development is undergoing a transformation – in its ideas, institutions, financing and political relations. We're no longer looking at binary opposites of rich and poor, or developed and developing.

In September 2015 the UN Millennium Development Goals of 2000 will be replaced with the Sustainable Development Goals. These new goals will be universal: all countries will have to rethink how they can offer a decent life for societies present and future. 'Development' will become a truly global project.

At Manchester we're taking the lead. Researchers work with colleagues from across the disciplines, and with organisations locally and internationally, to find answers to alleviate poverty around the world.

Humanitarianism and conflict resolution
Social responsibility is as important a goal for the University as our commitment to outstanding research and teaching.

Our Humanitarian and Conflict Response Institute (HCRI) is key to both these aims, bringing together the disciplines of medicine and the humanities to facilitate improvements in global crisis response, while providing an internationally leading centre of training for humanitarian practitioners.

"To help those still trapped in poverty, we need path-breaking research to identify improved policies and approaches to supporting the efforts of the chronic poor to overcome the obstacles that block their prosperity."

David Hulme, Professor of Development Studies


AID
AID

Through HCRI, we've pioneered a range of unique and exclusive partnerships with world-leading non-governmental organisations to shape the way that research, teaching and humanitarian aid and interventions are delivered. Nowhere has this been more prominent than through the Institute's partnership with UK-Med, which hosts the UK International Emergency Trauma and Medical Registers (UKIETR/UKIEMR) – an initiative funded by the Department for International Development and directed by Professor Tony Redmond OBE, Deputy Director of the HCRI.

The UKIETR/UKIEMR has more 2,000 registered volunteers from across the UK and coordinates the national medical response to overseas disasters. We've worked with UKIETR and UK-Med to deploy medical teams to three of the most significant global humanitarian crisis responses of recent times: in the Philippines, in response to Typhoon Haiyan; in Gaza, following the 2014 Israeli-Gaza conflict; and in Sierra Leone, in response to the Ebola virus epidemic.

Our expertise is helping to bring about positive changes in global health policy. Professor Redmond has chaired numerous networks to improve and professionalise humanitarian response, while Dr Amy Hughes from the HCRI has published recommendations on the World Health Organization's minimum standards for foreign medical teams.

Our practical humanitarian fieldwork collaborations with UK-Med, the British and International Federation of Red Cross and Red Crescent Societies, and Save the Children informs research and knowledge exchange across our international network of partners. For example, Dr Jessica Field is co-employed by the HCRI and Save the Children as a humanitarian affairs adviser on the charity's Humanitarian Effectiveness project.

Ethnicity

Many of the barriers to equality – discrimination, exclusion and constraints on social mobility – heavily impact on ethnic minorities and migrant communities. Those who identify as African, Arab, Bangladeshi, Caribbean and Pakistani are more than twice as likely as the white British ethnic group to be living in England's most deprived neighbourhoods.

We're making a major contribution to the understanding of issues of ethnic diversity, integration, immigration and identity. At the University's Centre on Dynamics of Ethnicity (CODE), we set out to map and track the contemporary patterns of ethnic inequalities and how these relate to the changing ways in which ethnic identities are perceived, acted upon and experienced.

Funded by the Economic and Social Research Council (ESRC), CODE assembles specialists from sociology, economics, demography, geography, politics and history. Through collaborations with the Joseph Rowntree Foundation and the Runnymede Trust, we've produced briefings and area profilers that make data on ethnic inequalities publicly accessible.

"We seek to not only offer an important contribution to intellectual debates around humanitarian effectiveness, but also to transform the way Save the Children and others approach how they can help communities affected by humanitarian crises."

Dr Jessica Field, Humanitarian Affairs Adviser,
Humanitarian and Conflict Response Institute and Save the Children


CEX

Employment inequalities

From differences in pay to lack of opportunities to build a career free from discrimination, inequalities in the workplace have a profound effect on individuals, societies and economies, locally and globally.

Our research on inequalities focuses on people's experiences of work, divisions and experiences in the labour market, and emerging patterns of vulnerability, exploitation, marginalisation and exclusion. This activity includes the research undertaken by the Fairness at Work Research Centre (FairWRC) and the European Work and Employment Research Centre (EWERC) at the University.

We have an international reputation for our contributions to labour debates – and our research impacts on the real world. Our work on global value chains and inequalities has had particular impact, for example with Cadbury on cocoa production in Ghana, and for garment workers in Bangladesh following the Rana Plaza disaster.

The ESRC funded a high-profile project on lesbian, gay and bisexual employees' experience of discrimination, bullying and harassment at work. We've completed investigations into social inclusion, trade unions and the experience of migrant workers across Europe, supported by the ESRC and the Leverhulme Trust. With funding from the International Labour Organisation, the Russell Sage Foundation and the European Commission we've conducted more than two decades of research into gender inequalities, including the impact of economic austerity policies, minimum wage regulation and low-wage work, and more.

A fairer, healthier world

We're experts in unravelling the social inequalities that stand in the way of better health care for all – for example, our research has led to a better understanding of urban health issues in cities across Europe, and we're investigating the relationship between ageing, well-being and work, and the barriers to people exercising in later life. Health care researchers based at the University develop evidence to influence policies that help improve the health and well-being of the most disadvantaged in society. Our strengths in the field of global health range from the improvement of care for women in low and middle-income countries to engagement with donors and policymakers.

Our research is helping to bring about a fairer and more just world.

"We work with inspirational midwives who are working with limited resources and few developmental opportunities. The Centre for Global Women's Health is helping to support them in their work."

Tina Lavender, Professor of Midwifery
and Director of the Centre for Global Women's Health

ADDRESSING GLOBAL INEQUALITIES

THE CHALLENGE

Around **800 million people go hungry** in the world **every day**[1]

1,400

1,400 **women will die today**, as they do **every day**, from **illnesses** related to **pregnancy** and **childbirth** which are **easy to diagnose** and **treat**[3]

20%

15%

10%

There are **pronounced income inequalities across the world** and these are widening in many countries. For example, in the **US the wealthiest 1%** of the population now takes **20% of all income** before tax, compared to around **15% in the UK** and around **10% in Sweden**[4]

Unequal opportunities, social injustice and discrimination and prejudice produce widespread inequalities by gender, ethnicity, educational background and other characteristics. These inequalities are revealed, for example, in different job and earnings prospects across people's lives.

£45m

Our research led **Cadbury to switch to Fairtrade cocoa** and **invest £45 million** in cocoa growing **communities**

HOW WE'RE TACKLING IT

Around **335 academic staff** and **PhD students** are **working at The University** of **Manchester** to **address global inequalities**

Our employment **expertise has informed** the **European Commission**, the **European Parliament** and the **United Nations' International Labour Office**

We work with **Age Concern UK** and **local governments**, including **Manchester City Council**, **to inform policy** and **service delivery** for **ageing societies**

Our insight into **humanitarian efforts** and **technologies** has influenced **Médecins Sans Frontières, Save the Children, Handicap International** and the **International Federation of the Red Cross and Red Crescent Societies**, and has been recognised by the **British Academy**

1. International Federation for the Red Cross and Red Crescent Societies 2. Unicef 3. World Health Organization
4. Alvaredo F, Atkinson AB, Piketty T and Saez E. The World Top Incomes Database. 2012.

Researcher profile

Professor Armando Barrientos

Armando is based at our School of Environment, Education and Development. He joined us as a lecturer in 2001.

Globalisation, poverty and inequality, and climate change are different dimensions of our growing global interdependence. Whereas three decades ago international development policy debated conditions in the 'Third World', today our debates refer to the 'Global South'.

Ensuring prosperity and justice in the south is a requisite for prosperity and justice in the north. Addressing global inequalities requires strong and effective governments as the route to global prosperity and justice.

Working with partners through our Chronic Poverty Research Centre (2000–10), we identified the nature and causes of extreme and persistent poverty in low- and middle-income countries, and potential remedies.

In particular, we've thrown light on the rapidly emerging welfare institutions in developing countries. Combined with economic growth, these have contributed to a large and sustained reduction of extreme poverty in the world.

"The University has much to contribute to shaping research, ideas and policies across the world. The international nature of our students and researchers helps us to make this happen."

Armando Barrientos, Professor in Poverty and Social Justice

Each age is defined by the materials it has to hand, influencing, improving and defining life as we know it. As the world evolves, new, transformational, advanced materials are urgently required to tackle major challenges in sectors such as health, energy, security and the environment.

Transforming our world through advanced materials

Advanced materials allow us to work in the most demanding environments, on the frontiers of the energy sector, or inside the human body. The University of Manchester is leading the way by developing the innovative solutions required to solve some of the world's most critical problems.

Research and innovation in advanced materials underpins all manufacturing sectors and pervades all spheres of economic and social activity. It's essential to the UK's economic growth. Advanced materials have the power to transform almost every industrial sector and every aspect of our lives, from aircraft to packaging, from computers to clothing, from nuclear plants to mobile phones.

We need metals that can survive in the harshest conditions, enabling us to dig at deeper ocean depths or to transport the fuels of tomorrow. As the world becomes more connected we need to travel more often and at greater speeds, and to be able to communicate with more immediacy. To meet the needs of industry and society, we'll need stronger, lighter materials.

The University of Manchester is world-leading at developing new and existing materials for extreme environments. We also lead the world in the characterisation of materials from the atom to the component – measuring and exploring materials to help us fully understand their properties and potential.

Graphene and other 2D materials

A shining example of the University's excellence in advanced materials is graphene; the world's thinnest, strongest, most conductive material, isolated at the University in 2004. Its potential is vast – giving us the possibility of flexible, bendable electronics, portable, energy-efficient water filtration and desalination plants, corrosion-proof coatings, anti-cancer drugs, and energy sources sewn into a person's skin.

Demonstrating the remarkable properties of graphene won Sir Andre Geim and Sir Kostya Novoselov the Nobel Prize in Physics in 2010. The physicists led a team that managed to isolate graphene from graphite using

"You cannot help but wonder what else graphene has in store for us."

Professor Sir Andre Geim, Professor of Condensed Matter Physics

simple sticky tape; peeling layer after layer of graphite until they were left with a layer one atom thick – graphene. When they observed its properties, the true realisation of what they had achieved became clear.

Now more than 200 researchers across more than a dozen academic disciplines at the University work on graphene and related 2D materials.

One of the most exciting areas of graphene and related 2D materials research is in membranes – thin barriers that allow water to pass through them while blocking off all impurities. Dr Rahul Nair leads the way in this field and is working alongside leading companies to create water filtration and desalination devices, as well as researching liquid and gas separation.

"We should be able to use this material for various applications, such as anti-corrosion coating, chemical protection coating and food packaging." said Dr Nair. "We need to do more fundamental research to make use of this membrane for desalination application and we're working with our industrial partners for water filtration."

The heart of advanced materials innovation

Our track record for research power is reinforced by vast capital and research investment, with more than £248 million of live research projects. More than £120 million of this capital investment is for graphene. The recently opened £61 million National Graphene Institute is the UK's home of graphene research and commercialisation, where our world-class academics are partnering with some of the most visionary companies to produce the applications of the future.

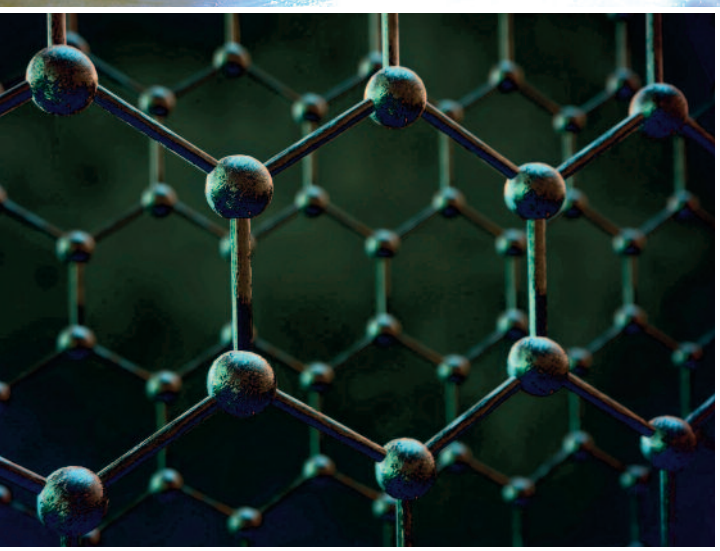
In 2017 the Graphene Engineering Innovation Centre will open its doors; an industry-led centre that will bring graphene products closer to the market. And, in late 2014, the Chancellor of the Exchequer George Osborne announced that the University would host the £235 million Sir Henry Royce Institute for Materials Research and Innovation. Supported by a number of partner universities, the Institute will play a crucial role in addressing the challenges facing society and help make advanced materials a catalyst for economic growth in the UK.

Focusing on 12 areas of materials research, including graphene and related 2D materials, it's expected that the Institute will attract some of the world's leading materials scientists and reinforce Manchester's reputation as a global centre of expertise in advanced materials. Proposed in answer to a challenge by the Chancellor to establish a 'northern powerhouse', the Institute will galvanise the economy of the north of England and the UK as a whole, while ensuring that the UK leads the world in the development and application of advanced materials.

Commenting on the announcement, Professor Colin Bailey, the University's Deputy President and Deputy Vice-Chancellor, said: "With Manchester being named as the European City of Science, as well as the considerable funding graphene has enjoyed over the past few years, it's an exciting time for the city and should prove to be inspiring for the next generation of scientists and engineers."

"The Sir Henry Royce Institute for Materials Research and Innovation will be a world-leading centre for materials research, and is testament to the excellent research taking place at The University of Manchester, the partner institutions and more widely throughout the UK."

Professor Colin Bailey, Deputy President and Deputy Vice-Chancellor



National Graphene Institute

Vital to industry and everyday lives

Crucial to the success of the Sir Henry Royce Institute and the graphene centres is industrial partnership. In all of our advanced materials research we're working with dozens of industrial partners to bring discoveries from the lab to the lives of real people.

For example, we helped Rolls-Royce develop an aero engine that is 25% more fuel efficient than its closest competitor. At the £64 million BP International Centre for Advanced Materials (BP-ICAM), a collaboration between BP, Manchester and partner universities, researchers from a variety of disciplines, institutions and sectors work together to deliver fuel for generations to come. And in graphene alone we're working with more than 35 commercial organisations.

Not only is our expertise recognised by industry – it also has royal approval. We've received the Queen's Anniversary Prize twice for our pioneering work on nuclear materials and for our x-ray imaging of materials behaviour respectively. Our imaging capability has benefited sectors including nuclear, aerospace, oil and gas, airport security, automotive, biomedical materials, manufacturing and defence. It also produces wider benefits for medical and life sciences, cultural heritage, palaeontology and food technology, as well as training future engineers and scientists.

Another area where advanced materials can make a critical difference is nuclear energy. Professor Tim Abram is working on advanced nuclear fuel materials that will benefit both the current and the next generation of nuclear reactors.

Current fuel materials have performed well under normal operational conditions, but are not able to withstand some severe accident conditions – such as those at Fukushima. Professor Abram leads the Rolls-Royce Nuclear University Technology Centre at Manchester and works closely with Rolls-Royce, Westinghouse, the National Nuclear Laboratory and EDF. He has strong links with overseas laboratories, including Idaho National Laboratory and Oak Ridge National Laboratory in the US.

Leading research into the future of fuels, developing new, transformational materials, and partnership with some of the world's leading companies – these are just a few of the reasons why The University of Manchester is the world's leading centre for advanced materials research and commercialisation.

"Our work is aimed at developing so-called 'accident-tolerant' fuels that can survive much higher temperatures, providing improved safety. Other improvements in key properties such as thermal conductivity will help to extend the lifetime of the fuel, offering improved economic performance."

Tim Abram, Professor in Nuclear Fuel Technology

ADVANCED MATERIALS

THE CHALLENGE

3.5m

Approximately **3.5m people die each year** due to **inadequate water supply**, **sanitation** and **hygiene**

New nuclear build is **valued at £60 billion** in the **UK**

21%

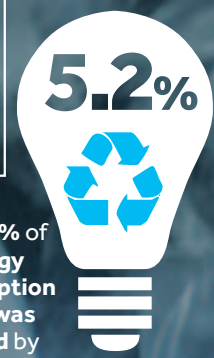
Transport accounts for a **fifth** of the **UK's carbon emissions**

Businesses that **produce** and **process materials make up 15% of the UK's GDP**

10km

Deep sea platforms **drill for oil 10km below the seabed**, at temperatures of **more than 200°F** and under **pressures of 20,000psi**

Globally, **corrosion costs** more than **$2tn** per year

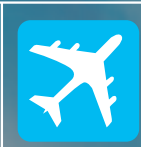


Just 5.2% of **UK energy consumption** in **2013 was provided** by **renewable sources**

Salt canopies above drilling sites **can be taller** than **Mount Kilimanjaro**

HOW WE'RE TACKLING IT

Single-layer graphene is a **million times thinner than a human hair** and **will revolutionise health care**, **water** and **consumer electronics**



3D

Our **3D characterisation capability** is **enabling us to study the properties** of **new protective coatings** for **materials** such as **aluminium used in planes**

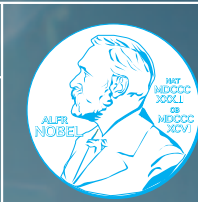
BP has four senior staff permanently onsite at the University, giving them an **immediate pipeline** to **our expertise**

25%

An **aero engine developed by Rolls-Royce with the University** is **25% more fuel efficient** than its closest competitor

Dalton Nuclear Institute's paper on **welding for nuclear new build** received **more than 230 citations** over a decade

230



2D

We're home to the **global knowledge base** in **2D materials**, with **two Nobel laureates** and more than **£170m of current investment**

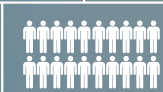
WHY MANCHESTER?

We have more than £248m of **research projects**

£235m

MANCHESTER

Manchester has been chosen as the home to the **Sir Henry Royce Institute for Materials Research and Innovation**, a **hub to accelerate knowledge** and **applications of advanced materials** for the good of **industry** and the **economy**



200

More than 200 researchers work on **graphene** and **2D materials**

The University is home to the **$100m (£64m) BP International Centre for Advanced Materials**, the **£61m National Graphene Institute** and the **£60m Graphene Engineering Innovation Centre**

Researcher profile

Professor Phil Withers

Phil is Professor of Materials Science and Director of the BP International Centre for Advanced Materials (BP-ICAM), a university-industry collaboration established in 2012 that is leading the way in advanced materials research for the oil and gas industry.

I came from Cambridge in 1998, and one of the things I like about Manchester is that it's very entrepreneurial. We're very agile in the way we can focus on the big issues. For example, the work we're doing in the nuclear area has really grown in the last ten years and now oil and gas is hot on its heels. It's that ability to identify something and move forward quickly that is very powerful.

I was attracted to the University because of its world-class reputation but also because of its connection with companies. Many of these companies are based in the north-west, such as Airbus, BAE Systems, or Rolls-Royce. We work hand-in-hand with them to develop new ideas.

The atmosphere here is very exciting with more than 85 PhDs and postdoctoral researchers working on delivering new materials for energy, which is absolutely critical to the UK.

"The really interesting thing about BP-ICAM is that we have a day-to-day relationship with BP. Every day we have BP people working in our offices – it's a very hand-in-glove way of working."

Phil Withers, Professor of Materials Science and Director of BP-ICAM

More than one in three of us will be diagnosed with some form of cancer. The disease can have a devastating impact on the lives of patients and on their friends and family who feel its economic and emotional fallout. As our population ages, health services and taxpayers face an increasing bill.

Loosening cancer's grip

Research is a key weapon in our fight against cancer. Survival rates from the disease have doubled in the last 40 years in the UK. Developing new treatments to cure cancer and tackle side-effects is crucial, but this work must be carried out alongside new methods to change lifestyles, build resilient health services and help people reduce cancer's impact.

The University of Manchester has a rich history of cancer research, stretching back to the early 20th-century research of Sir Arthur Schuster into x-radiography and radium. Today, we're working on the full range of ways to tackle what is the cause of more than one in four deaths in the UK.

"As the problem of cancer grows, our response to it is also stepping up," said Professor Sir Salvador Moncada, Director of our Institute of Cancer Sciences. "Things happening right now in Manchester will have an impact around the world.

"Indeed, we're contributing to the understanding of not only prevention, early diagnosis and effective management of the disease, but also to the understanding of emotional and community support that's required for the patients and their families."

Fundamental science and drug discovery

Discoveries made by our cancer scientists have led to a greatly improved understanding of how cell division goes wrong and the mechanisms behind the onset of the disease. This has led to breakthroughs such as clinical trials with AstraZeneca for the drug anastrozole, which is now the first-line treatment for both early and advanced breast cancer, with sales of more than $1 billion per year.

"Cancer is a priority for The University of Manchester. Our resources are concentrated on meeting a serious local and international need by tackling every part of cancer's impact on people's lives."

Professor Sir Salvador Moncada, Director of the Institute of Cancer Sciences

Our trials have played a key role in developing international standards. One example is the ALL3 trial, designed by Professor Vaskar Saha, which focused on acute lymphoblastic leukaemia (ALL), a form of cancer diagnosed in around 370 children a year in the UK. This work has helped to improve the outcome by 10% for children with relapsed ALL in the UK, Netherlands, Australia and New Zealand. The next phase of this work, which will include all of Europe and Japan, is now underway.

At the Cancer Research UK Manchester Institute, our work spans the whole spectrum of cancer research, from investigating the molecular and cellular basis of cancer to translational research and the development of therapeutics. Professor Richard Marais is the Director of the Institute, as well as the current President of the European Association of Cancer Research, and his work is focused on melanoma. Numbers diagnosed with this particular form of skin cancer are continuing to rise, with almost 13,000 people diagnosed in the UK each year. Professor Marais is leading a team whose work includes the development of a new generation of drugs to overcome the resistance that melanoma sometimes develops to existing drugs.

Behaviour change

Research at Manchester has helped identify reasons for the growing number of skin cancer cases. Work by our researchers has established a changing pattern of diagnosis by looking at UK patient data for ten years. They found that rather than those with more money or those from the sunnier south of the country, it's the less affluent in the north who are increasingly likely to develop a skin cancer. This is due to the rise in cheaper holidays and tanning salons. The research was followed up with education programmes, such as behaviour change programmes to make sure sunbeds are used safely.

Psychologists such as Professor Chris Armitage are working on the science of behaviour change, applying new techniques to encourage weight loss, eating fruit and reducing or stopping smoking and alcohol consumption among hard-to-reach groups such as children and adolescents.

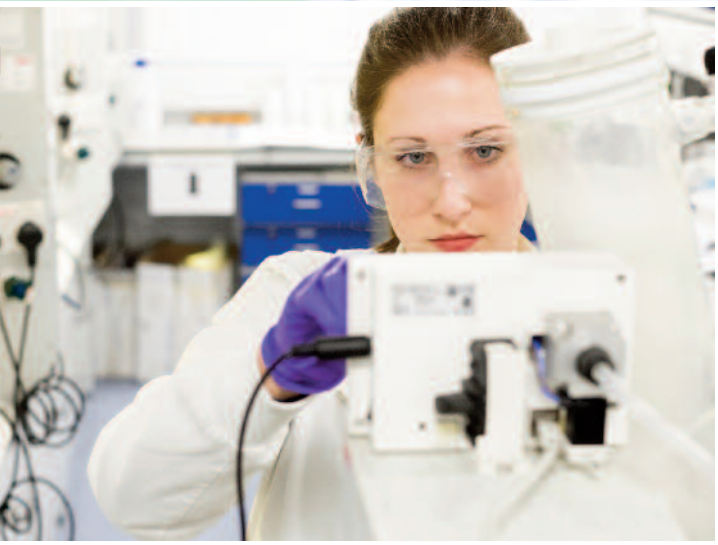
The consequences of cancer

New drugs and understanding of the mechanics of cells are improving individual outcomes, but the World Health Organization still expects 22 million new cancer cases a year around the world by 2020 – an increase from 14 million today. Each new case represents someone unable to work, suffering the side-effects of the powerful treatments they are given, and a carer or carers looking after them and perhaps dealing with their death.

We've contributed substantially to government initiatives that have helped the 90,000 working people a year diagnosed with cancer return to work after treatment. Studies involving GPs, patients, managers and occupational health workers all contributed to this research base.

"We're testing this family of drugs in clinical trials to establish that they are both safe and effective in cancer patients, potentially providing urgently needed new treatments for patients who have run out of options."

Professor Richard Marais, Director of the Cancer Research UK Manchester Institute



Manchester Cancer Research Centre

Not everyone survives cancer and the impact on their carers and families, whether at home or in a hospice setting, can take a huge personal toll. The University piloted the Carer Support Needs Assessment Tool to help carers ask for help with the physical and psychological cost of looking after someone who is dying of cancer. Around 4,500 people have now been helped with this tool and it is being rolled out across the country.

An all-round approach

We're one of the best placed universities in the world to access patients and transform findings into practical benefits. Hundreds of researchers are based in our Faculties and the Institute of Cancer Sciences, the Manchester Cancer Research Centre and the Cancer Research UK Manchester Institute.

We work with six NHS organisations – providing unrivalled access to patients and samples – coordinated by the Manchester Academic Health Science Centre.

This partnership approach is evident in our close links with the Christie NHS Foundation Trust. The University has a long history of working with the Christie's scientists and health care professionals, right back to the early part of the 20th century when researchers collaborated on early uses of radiotherapy.

Western Europe's largest cancer centre, the Christie jointly employs staff with the University to work at the Institute of Cancer Sciences, working on tools to look at radiotherapy's side-effects, developing new drugs and bringing one of only two proton-beam therapy centres in the UK to Manchester.

Nowhere is this partnership approach demonstrated better than through the Manchester Cancer Research Centre. A new £28.5 million building opened in 2015 to house an additional 150 scientists and a further 100 clinical trials support staff using new and advanced equipment. This is a joint venture between the Christie, Cancer Research UK and the University, and will deliver even more world-class research into cancer biology, drug discovery and clinical trials.

Cancer is a disease that affects so many, in different, often devastating ways. We want to loosen cancer's grip and improve the lives of those it affects.

"We play a key role locally but we're also able to look much further afield to generate the number of patients required for large-scale studies. Our strength lies in this international ability to enrol large numbers of patients."

Vaskar Saha, Professor of Paediatric Oncology

CANCER

THE CHALLENGE

In 2012, according to the World Health Organization:

14m
14 million new cases of cancer

8.2m
8.2 million people worldwide died from cancer

More than one in three people **will develop** some form of **cancer** during their lifetime

200+ The number of different **types of cancer**

OUR RESEARCH

6x NHS organisations **collaborate** with the **University** as part of the **Manchester Academic Health Science Centre** (MAHSC)

60,000
60,000 women will be invited to join a study into whether **personalised breast cancer risk prediction** can be introduced into the NHS Breast Screening Programme – the **largest study of its kind** in the UK

25%
of people with **lung cancer live for two or more years** after diagnosis **thanks to Manchester** research

1.5m
women with **breast cancer** across the world are now **benefitting from endocrine therapy** approaches developed at the University

8%
8% of all England's **complex single gene diagnostics** are handled at the Centre for Genomic Diagnostics and Innovation **based at the University** / Central Manchester Trust

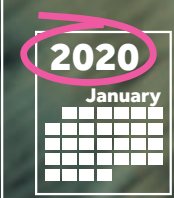
£30m
£30 million is invested in attracting **internationally leading** investigators to the **Manchester Cancer Research Centre**

100,000
patients a year benefit from **better nutrition** before and after treatment

OUR PARTNERSHIPS

We work with organisations including:

OUR GOALS



More than two-thirds of newly diagnosed patients in the Greater Manchester region will **live for more than five years** as part of **MAHSC's vision for 2020**

One of the top five: we aim for Manchester to be among the five **best integrated cancer systems in the world by 2020**

Researcher profile

Professor Sir Salvador Moncada

Sir Salvador is the Director of our Institute of Cancer Sciences. He was attracted to Manchester by the positive changes being implemented in relation to cancer research and cancer treatment here.

There have been significant improvements in the survival of patients with some forms of cancer but not in all of them.

We need to find ways of diagnosing the disease early, before the symptoms develop. Early diagnosis is the holy grail of cancer research. It will increase significantly the number of people we can cure from the disease.

One of the most significant projects here has been the building of the new MCRC facility, where we'll be locating researchers and clinical scientists from the University and our partners – The Christie NHS Foundation Trust and Cancer Research UK.

In the MCRC, researchers, clinical scientists and people involved in translational research will come together.

This synergy of different types of scientists will help us find solutions to the problems of early diagnosis, create better management and improve the outcomes.

We are also working in close collaboration with industry in order to bring our patients the benefits of newly discovered treatments as soon as – and in the safest way – possible.

"There aren't many other places where researchers, clinicians, charities and patients mingle so freely. By working together in the same space we deliver results faster and more effectively."

Professor Sir Salvador Moncada,
Director of the Institute of Cancer Sciences

The University of Manchester is finding solutions to some of the biggest energy challenges we face, from the sustainability of sources to the social factors that stand in the way of equal access to power.

Securing our energy future

As the world develops, we're using more and more energy in our everyday lives. The more our cities grow, the more energy we use to fuel our vehicles, light our streets and heat our buildings. That raises big questions about where energy comes from, how smartly we use it, how accessible it is and what impact there is on the environment.

At Manchester we're finding the answers. We're looking at the whole energy system – generation, transport, storage and eventual usage – to produce technologies and approaches to secure the world's energy future.

Generation

The breadth of expertise at Manchester means we're able to carry out research into virtually all forms of energy generation. We're at the forefront of nuclear research and we're producing pioneering work in emerging renewable technologies and bridging fuels.

Nuclear energy

Across the world, there is a pressing need for low-carbon, secure and affordable energy – this has led to a renaissance in civil nuclear power. New nuclear build and existing reactor life extension programmes are underway in the UK and further afield, contributing to the nuclear market's considerable positive impact on the economy.

In the Dalton Nuclear Institute, Manchester has the UK's largest and most networked academic centre for nuclear R&D and high-level skills development. With world-class facilities and collaborative links, the Institute drives innovation and delivers world-leading applied research across the full nuclear fuel cycle.

Our nuclear expertise is built on a strong research heritage, with a focus on meeting the challenges of today and the future. Dalton Nuclear Institute brings

"The size of the University and the sheer range of knowledge here allows us to bring people together from a huge range of research areas. This helps us to find innovative ways to tackle some of the world's biggest energy challenges."

Ian Cotton, Professor of High Voltage Technology and Director of Manchester Energy

together world-leading experts across disciplines, such as radiation science and nuclear engineering, and gives them access to some of the most extensive and advanced nuclear research facilities in Europe, including our Dalton Cumbrian Facility near Sellafield.

Research activities at the Institute, including the five-year New Nuclear Manufacturing (NNUMAN) programme funded by the Engineering and Physical Sciences Research Council (EPSRC), support the competitive growth of the UK nuclear industry through research and innovation. It underpins the safe and extended operation of existing reactors and the future development of more efficient new-build nuclear power plant with a longer lifespan. We also undertake back-end research on spent fuel, decommissioning and waste management.

Bioenergy

Bioenergy can deliver a continuous supply of low-carbon, renewable energy in the form of heat, electricity, transport fuels or other energy vectors (including hydrogen and substitute natural gas).

At Manchester, we seek to enable the production and use of bioenergy in a sustainable manner.

We're finding ways to produce fuel from algae – engineering bacterial enzymes and hacking metabolic pathways to turn carbon into gases such as propane. We work internationally, such as in the Philippines, where we're looking at how rice straw that's burnt as waste can instead be harnessed as an energy source.

With an energy resource that's so inter-linked to land use and food production, it's important to ensure that real greenhouse gas reductions are being delivered along the supply chain and that systems are implemented in a way that promotes positive socioeconomic benefits. At Manchester we have experience of assessing greenhouse gas balances and the wider impacts of bioenergy from feedstocks in many countries, from forest residues in North America to soy plantations in Argentina.

More than 60 core researchers and additional support staff, from the humanities, life sciences, and engineering and physical sciences, are involved in bioenergy research. In addition, we lead the EPSRC-funded SUPERGEN Bioenergy Hub.

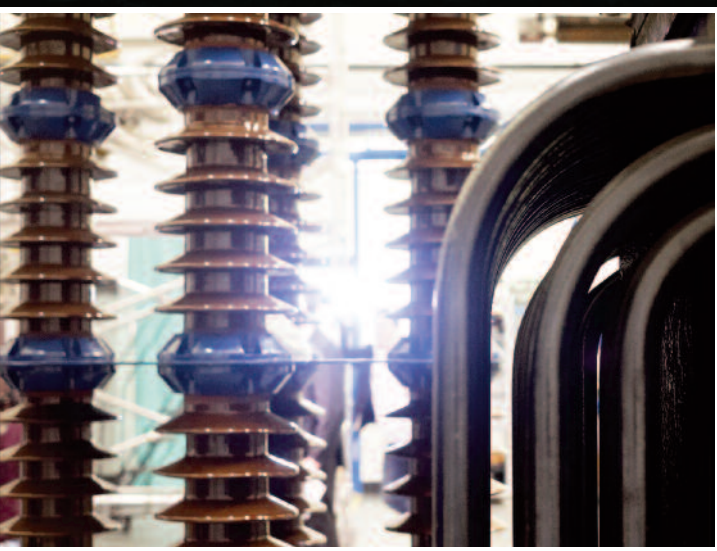
Marine, wind and solar

Our work is optimising offshore structure design to withstand the extreme loadings that they must take. We're developing models and measurement techniques that can quickly identify faults in renewable energy systems. One such programme deploys advanced computer models to increase confidence in turbine design methods and support increased investment in tidal stream power.

For the solar sector, the challenge is to manufacture photovoltaic devices that are more efficient, less expensive and better integrated into the energy grid. We're developing a solution that uses quantum dots to increase the efficiency of solarcells and, working with colleagues from the National University of Singapore, we've found that combining graphene with similar materials can create extremely sensitive photovoltaic devices.

"The Dalton Nuclear Institute is a world-leading centre of expertise and fully deserves this recognition. With the country on the cusp of a nuclear renaissance, research and development in the nuclear sector can be a significant driver of our future economic growth."

The Rt Hon the Lord Jenkin of Roding
on the presentation of the Queen's Anniversary Prize to the University



Dalton Cumbrian Facility

Oil and gas
We're helping the hydrocarbon sector to extract bridging fuels more efficiently from conventional reserves. We're also improving understanding of the technical and social implications of extracting from unconventional reserves using techniques such as fracking.

Our reach in this area is global and our work is helping oil companies to recover oil more efficiently – for example, our studies into rock outcrops in South Africa are resulting in a better understanding of how to mine deep ocean basins.

Energy transport

To meet the UK's carbon targets, our electricity grid will need to be almost entirely decarbonised by 2050, sourcing its energy from low-carbon sources and increasingly interacting with neighbouring countries' grids.

The multi-energy systems (MES) of the future will allow networks such as electricity, heat, cooling, fuels, transport and water to optimally interact with each other, unlocking technical, economic and environmental value. This could transform energy networks in urban areas – leading to the birth of truly 'smart' communities and cities. Our work in MES is underpinned by our leading research in electrical power systems. We work closely with industry to deliver projects such as VISOR, a £7.4 million initiative to demonstrate the role of measurement and monitoring technologies – an essential step in ensuring the success of our low-carbon future.

At our National Grid High Voltage Research Centre, we have the largest high-voltage laboratory of any UK university, capable of testing equipment designed for use on Great Britain's 400kV power system. Research here, in collaboration with EPL Composites Solutions, led to new technology that can significantly increase the capacity of existing overhead line infrastructure.

Storage

Energy storage will play a key role in decarbonising our energy system. We're developing new storage devices for utility and grid applications such as low-temperature fuel cells, batteries and supercapacitors. One of our most exciting recent discoveries has been the role that graphene could play in a sustainable and secure energy future. By incorporating nitrogen to thermally expanded graphene oxide, we increased its capacitance, creating a form of storage that could be suitable for large-scale industrial use.

An investment of more than £3 million by EPSRC has seen us create facilities that can better characterise, test and evaluate energy storage solutions. Our research is finding ways to manage the intermittency of renewable generation and to improve the capability of electric vehicles to provide a reliable and viable form of green transport in the UK.

Energy use

The energy challenge is not just about generation, transport and storage – it's also about how we use energy in our homes, businesses and communities. Energy use can go unnoticed, despite being part of our everyday lives: from the electricity that we require to provide lighting and entertainment to the fuel needed to transport goods on to shelves – not to mention the energy used by industries to process, manufacture and package goods. We contribute to one of the EPSRC's End Use Energy Demand Centres, researching what drives energy demand within sectors including

"We are among the first in the world to try to capture the true diversity of energy demand in cities and project how this will change when smarter technologies will be available."

Dr Pierluigi Mancarella,
Reader in Future Energy Networks, Electrical Energy and Power Systems Group

ENERGY

THE CHALLENGE

x2 **Global electricity use** is likely to **double in the next 20 years**

More than half of the world's population now lives in urban areas

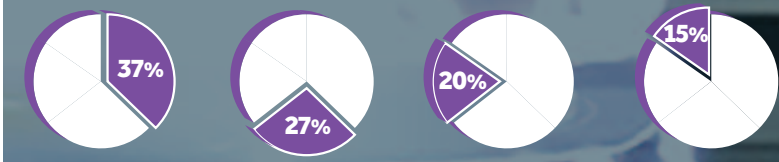
The UK could generate **50%** **of its energy needs from biomass** by 2050

33% **of our energy** used is for transport

UK CO_2 ↓ 80%

The UK is legally required to **reduce CO_2 emissions by 80% of 1990 levels by 2050**, meaning a reduction in our reliance on fossil fuels

The current UK electricity mix is made up of approximately:



37% coal | 27% gas | 20% nuclear | 15% renewables

Every year a typical large coal-fired power station produces about **10m tonnes** of **CO_2** and **200k tonnes of gases** associated with **ACID RAIN** and **4,000 tonnes** of **FLY ASH**

Energy bills are typically **8% of household income**

Globally, renewable power capacity is **expected to grow by 50% by 2020**, according to the International Energy Agency

HOW WE'RE TACKLING IT

Our projects are worth **£75 million**, covering **energy generation**, **energy systems** and **energy use**

We're home to leading energy research facilities including **nuclear irradiation facilities** at our **state-of-the-art Dalton Cumbrian Facility**, a **1MW** energy storage test bed, **the largest wave flume in the UK** and the **only 400kV-capable HV lab** of **any UK university**

We have **on-campus** energy storage test facilities

We have 150 academic **staff** and 500 PhD **students** and postdoctoral **researchers working on energy research**

Strategic partnerships include:
National Nuclear Laboratory, **EDF Energy**, **Amec Foster Wheeler**, **Rolls-Royce**, **National Grid**, **Siemens**, **Arup**, **Electricity North West and BP**

international shipping and the food and drink industry. We're examining how the public will respond to new technologies such as smart meters or cope with any unreliability in electricity supply.

Energy in cities

Cities are both the key sites of energy production and consumption. They're also the main sites of social, economic and technological change. As they evolve, we need technologies and policies that meet the needs of the individuals and organisations that inhabit them. Our work has already outlined how social housing landlords could cut fuel bills and raise living standards, and provided insights into fuel poverty in eastern and central Europe.

We work closely with partners across the region to evaluate new technologies and techniques. The District Information Modelling and Management for Energy Reduction (DIMMER) project, for example, will provide pioneering insights on our energy future. The data gathered will be used to create models that represent energy use across entire areas and take account of future advances in technology and possible changes in consumer behaviour.

The Triangulum project, on which we're working with partners including Siemens, will see €9 million invested in Manchester to develop the smart energy systems of the future. And our University Living Lab initiative transforms our campus, effectively a small town, into a test bed for tomorrow's energy systems.

Climate change policy

We're driving policy in the search for alternative energy solutions that will help avoid dangerous levels of climate change.

This impact on policy is a vital goal of research at Tyndall Manchester, a founding partner in the Tyndall Centre for Climate Change Research. Here, natural scientists, engineers, social scientists and economists work together to provide considerable and diverse capability in all aspects of energy and climate change. Tyndall Manchester researchers are regularly invited to contribute to high-level policy debates, locally and globally. For example, our insights led to the UK becoming the first country in the world to introduce cumulative carbon budgets into legislation.

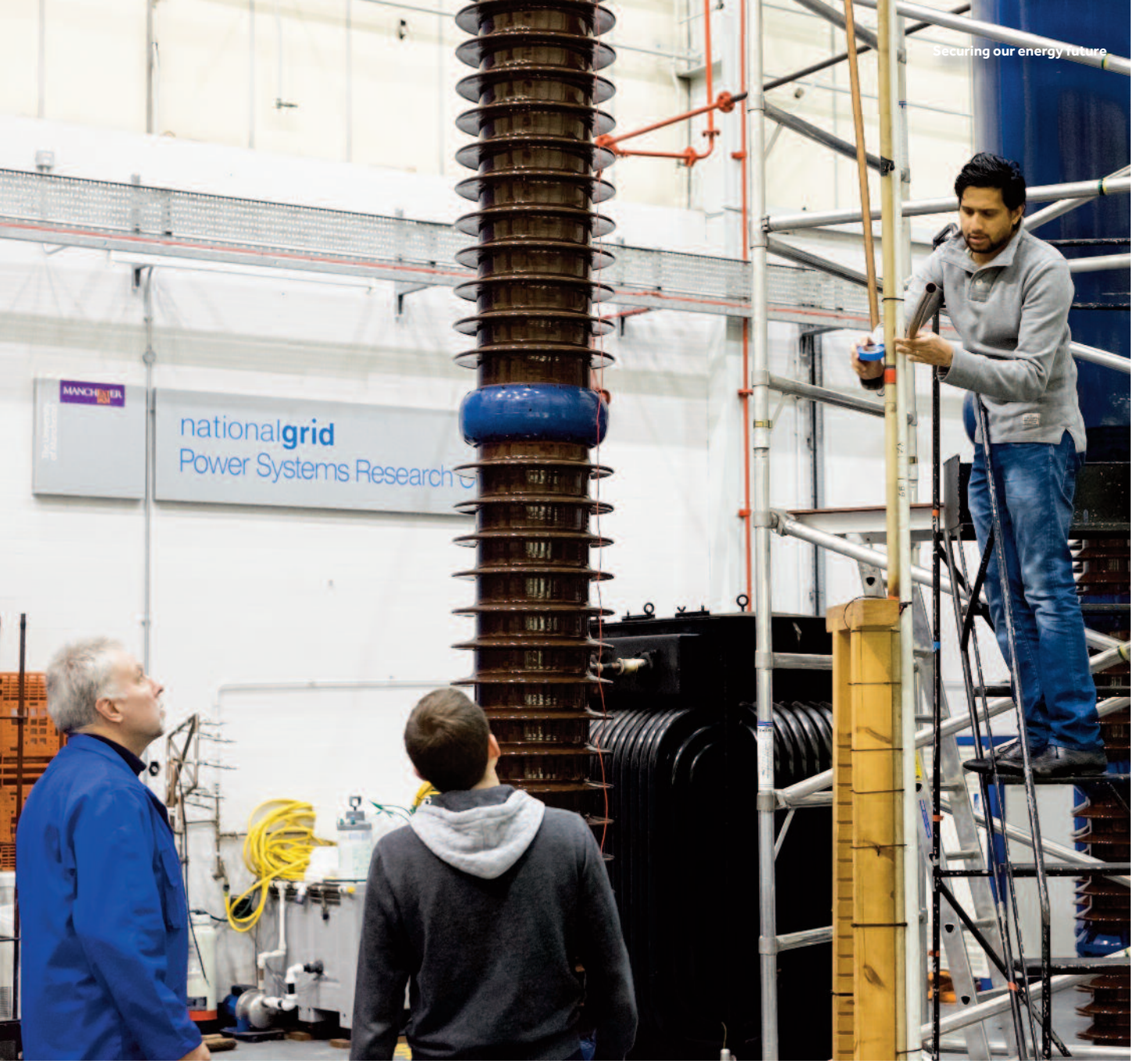
Through the Resilient Electricity Networks for Great Britain consortium, we're looking at how population and industrial growth, climate change legislation, changes in energy demand and the incorporation of renewable generation will impact on the UK National Grid. And, through the STEPPING UP consortium, we'll be engaging with industry and policy makers to understand how innovation on a smaller, local level can drive a bigger step change in the sustainability of water, energy and food.

Efficiency from source to user

To get to tomorrow's consumers, energy will have to come from a mix of sources and travel new routes, going further and faster with a minimal carbon footprint. At Manchester we're making sure the systems are in place for this journey to happen.

"Fuel poverty is about so much more than income and energy efficiency. It's the interplay between the environment, government policy and family circumstances. Our broad findings will be relevant to any government or corporate body that wishes to address fuel poverty."

Stefan Bouzarovski, Professor of Geography


nationalgrid
Power Systems Research

Researcher profile

Professor Barry Lennox

Barry is Professor of Applied Control and holds the EPSRC Chair in Nuclear Decommissioning. His main role at the University is Research Director at the Dalton Cumbrian Facility.

Most of my work is on developing tools for decommissioning at Sellafield. We're developing robotic devices that can go into the ponds used to store nuclear waste, swim around and provide further information regarding the material within them. This will help when the waste is finally removed from the ponds and disposed of appropriately.

Some of the material has been stored for 40 to 50 years. The pools are walled by concrete, which won't last forever, so we have to do something quickly.
We hope that our research will make decommissioning cheaper. The budget for decommissioning Sellafield is £53 billion over the next 100 years. If we can save 5 to 10%, that's a huge amount of money that can be spent elsewhere.

One of the differences with Manchester's approach is the push to benefit industry and society. We do a lot of 'blue-sky' research, but the Knowledge Exchange team and UMIP (the University's intellectual property agent) drive us to go further.

Working with companies puts you under pressure, but it's exciting. We're solving real problems and advising people who are making multi-million pound decisions.

"Companies are attracted by Manchester's reputation. We have the people here who make collaborations happen and commercialise our work."

Barry Lennox, Professor of Applied Control
and Research Director at the Dalton Cumbrian Facility

Fossil fuels have been the primary energy source for society since the Industrial Revolution. They provide the raw material for chemicals and materials used in the manufacture of everyday products including medicines, personal care products and plastics.

Leading the revolution in industrial biotechnology

At The University of Manchester we've set out a bold vision to rethink the design of sustainable chemicals manufacture for industrial and health care needs. Key to this vision is our Manchester institute of Biotechnology (MIB) – this leading industry-interfaced research institute is driving bio-based chemicals synthesis in the UK.

As we transition from oil and gas to more bio-based economies in the 21st century, the major needs for chemicals manufacture are smart, predictable and sustainable. Industrial biotechnology offers an attractive alternative to traditional manufacturing technologies, using biological resources such as plants, algae, fungi, marine life and micro-organisms to create sustainable chemicals, materials and energy.

A bio-industrial revolution

Just as Manchester was at the heart of the first Industrial Revolution, The University of Manchester is now leading the way, both nationally and across Europe, towards a bio-industrial revolution. Industrial biotechnology and bio-based chemicals manufacture underpin one of the largest industrial sectors, forming the cornerstone of a €1.2-2 trillion European bio-economy responsible for 22 million jobs.

Combined with the emerging science of synthetic biology, industrial biotechnology has the capacity to transform the UK and European industrial landscape and revolutionise manufacturing processes.

Centres of excellence

Embedded in the MIB are a number of internationally recognised centres of excellence that provide unrivalled facilities to support and enhance our activity in the chemicals manufacturing sector. Most recent is the Centre for Synthetic Biology of Fine and Speciality Chemicals (SYNBIOCHEM), established with the award of £10.2 million by the Biotechnology and Biological Sciences

"There is no industry better positioned than industrial biotechnology to respond to society's grand challenges as we tackle an ageing and ever-increasing population, affordability of health care, resource efficiency, food security, climate change and energy shortages."

Professor Nigel Scrutton, Director of the MIB

Research Council (BBSRC) and the Engineering and Physical Sciences Research Council.

SYNBIOCHEM will develop new products and methods for drug discovery and production, focusing on new antibiotics and agricultural chemicals as well as new materials for sustainable manufacturing. More broadly, the Centre will provide the general tools, technology platforms and know-how to drive academic discovery and bring benefits to industry.

A beacon of investment and collaboration

The MIB was completed in 2006 and represented the first university-based, purpose-built interdisciplinary research institute of its kind in the UK. The MIB is the engine room for driving innovation, enabling our industrial biotechnology research to go from strength to strength.

"A multidisciplinary approach is essential if we're to transform the traditional chemical and chemical-related sector to a sustainable and competitive one that draws on disciplines such as organic and synthetic chemistry, biochemistry, molecular biology, enzyme kinetics, genomics, proteomics, bio-informatics and bioprocessing," notes Professor Nigel Scrutton, Director of the MIB.

The establishment of multi-skilled, interdisciplinary teams with critical mass gives us unique capabilities. Distinguished by a strong international profile, the 52 lead MIB investigators collaborate with colleagues from across the University, while nearly a third of the Institute's current research portfolio involves overseas partners.

A hub for EU- and industry-funded programmes, we also have a strong track record in forging industry and stakeholder collaborations in the fine chemicals sectors, with partners including GlaxoSmithKline, Shell and Pfizer.

Through these partnerships we're well placed to translate scientific discovery into commercial reality. For example, Professor Nick Turner, in collaboration with Professor Romano Orru at the Free University of Amsterdam, devised an efficient synthesis of telaprevir, currently the leading medicine in the treatment of hepatitis C, helping to ensure that this drug becomes more widely available and affordable. The researchers have patented this route and have licensed the technology to Codexis for commercial manufacture.

The MIB and GlaxoSmithKline have established Europe's largest public-private partnership dedicated to the development of sustainable pharmaceuticals manufacture. The flagship €26.4 million CHEM21 project brings together six pharmaceutical companies, 13 universities and four small-to-medium enterprises from across Europe.

At the forefront of technology and research

Manchester's unique capabilities and vision for chemicals manufacture is precisely aligned with major government themes, including the 'eight great technologies' that will propel the UK to future growth.
Our standing as one of the leading institutions in industrial biotechnology is shown by the fact that the MIB leads four national BBSRC Networks in Industrial Biotechnology and Bioenergy, providing

"SYNBIOCHEM will become a UK and European centre of excellence for expertise and resources for the (re)design, engineering and analysis of biological parts, devices and systems for sustainable fine and speciality chemicals."

Professor Nick Turner, Co-Director of SYNBIOCHEM

industry-academic leadership in the chemicals, natural products, glycoscience tools, and biotechnology and bioprocessing arenas. At the UK Catalysis Hub at Harwell, the MIB leads the biocatalysis and biotransformations theme, focusing on the discovery, scale-up and manufacture of novel medicines.

New discoveries in biotechnology hold the key to developing treatments for some of society's most debilitating conditions. At Manchester we're ideally placed to translate this knowledge into application.

For example, published in *Nature and Nature Comms*, Professor David Leys and Dr Ivan Ahel from the Cancer Research UK Manchester Institute demonstrated their success in deciphering the structure of a protein found in bacteria that could reveal new drug targets for inherited breast and ovarian cancers, as well as other cancers linked to DNA repair faults. Professor Scrutton and his team made a significant breakthrough towards developing an effective treatment for neurodegenerative diseases. Published in *Nature*, the researchers detailed how an enzyme in the brain interacts with an exciting drug-like lead compound for Huntington's disease to inhibit its activity, demonstrating that it can be developed as an effective treatment for such diseases.

Professor Andrew Munro, together with industrial partner DSM, redesigned an enzyme catalyst to enable it to convert the natural product compactin into the cholesterol-lowering drug pravastatin. This resulted in a patented process for production of this drug. The team have since built on this research to develop a single-step fermentative method that will allow efficient, industrial-scale production.

We're also transforming the industrial production of flavours and fragrances. In partnership with GlaxoSmithKline, our researchers used synthetic biology to engineer bacterial strains to produce flavours and fragrances that belong to the monoterpenoid family of compounds. This will provide 'natural' routes to the synthesis of these compounds and significantly enhance their market value. It will also reduce the environmental impact associated with classical chemical synthesis and release industry from the constraints of limited availability from natural resources.

Manufacturing the future

The MIB has confirmed the University as a powerhouse of industrial biotechnology in Europe. We're also helping to develop the future generation of investigators through a number of EU training networks hosted at the MIB. And as the Institute approaches its tenth anniversary, we'll be extending its scope by investing in new infrastructure that will allow us to translate basic science discovery into commercial success.

We'll be building on our research success to become a global centre for pioneering science.

"Improving the sustainability of our drug manufacturing processes through collaborations such as CHEM21 will not only reduce our industry's carbon footprint but will also provide savings that can be reinvested in the development of new medicines, increase access to medicines through cost reduction and drive innovations that will simplify and transform our manufacturing paradigm."

John Baldoni, Senior Vice-President of Platform and Technology Science, GlaxoSmithKline

INDUSTRIAL BIOTECHNOLOGY

THE CHALLENGE

The UK is the **seventh largest chemicals producer in the world** – chemicals is the **UK's most successful sector**, inputting into supply chains from new bio-based ingredients in **personal care** products to **bioplastics** and bio-based **synthetic rubber** for tyres

Industry accounts for almost **three-quarters** of **chemicals consumption** in the **EU** **70.7%**

The number of **tonnes of CO_2** emissions **spared by industrial biotechnology**

50%

Half of all **medicines** will come from biotechnology in 2015

THE POTENTIAL

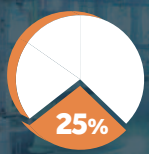
2025 **£360b**

TODAY **£35-53b**

£360 billion: the **predicted global sales** for industrial biotechnology by 2025 – the current level is £35-53 billion

The **amount of electricity saved** by households on laundry by being able to wash at 30°C **30%**

The number of jobs estimated **to be created in Europe** by the **bio-based chemicals** market **by 2020** **90,000 JOBS**



The share of bio-based processes in **all chemical production** is likely to **increase** from less than 2% in 2005 **to 25% in 2025** *(OECD 2009)*

Renewable energy generation is **expected to triple** between 2008 and 2035

75bn litres BIOETHANOL

The number of **litres of bioethanol** that could be **sustainably produced** at a competitive cost by 2020, which would **represent about €15 billion** in **additional revenue** for the agricultural sector

WHY MANCHESTER?

MIB

The MIB is **one of Europe's leading** industry-facing **research facilities**

Almost a third of **MIB's research portfolio** involves **overseas partners** **30%**

€25 million

CHEM21, one of many **EU science programmes** in chemical synthesis **based at Manchester**, is worth **€25 million**

MANCHESTER

The **University leads four** of the **Biotechnology and Biological Sciences Research Council's Networks** in **Industrial Biotechnology** and **Bioenergy**

Researcher profile

Dr Claire Doherty

Claire is the network manager at IBCarb – Glycoscience Tools for Biotechnology and Bioenergy. This is one of four BBSRC-funded Networks in Industrial Biotechnology and Bioenergy that the University leads.

My role is to help foster collaborations between academia and industry working in glycoscience, to help develop industrial biotechnology processes. I'm based in the MIB – an entire facility dedicated to industrial biotechnology research within the University – which has provided an excellent starting position for me to build on for IBCarb.

I'm very proud to be part of the industrial biotechnology revolution that is taking place here. Industrial biotechnology offers a sustainable solution to the production of the chemicals that we use every day to enjoy our current standards of living.

I can't wait to see the products and processes that are being developed by IBCarb network members – especially those based here in Manchester – being brought to market.

"We have access to top researchers in the field and state-of-the-art facilities. These provide fantastic support for our network's activities."

Dr Claire Doherty, Network Manager,
IBCarb – Glycoscience Tools for Biotechnology and Bioenergy

Find out more

For further information about these five research beacons, including contact details and short films, visit:
www.manchester.ac.uk/beacons

To learn more about research activity at The University of Manchester, including our impact, research environment and key people, visit:
www.manchester.ac.uk/research

Want to collaborate with us? Visit:
www.manchester.ac.uk/collaborate

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www.manchester.ac.uk/study

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