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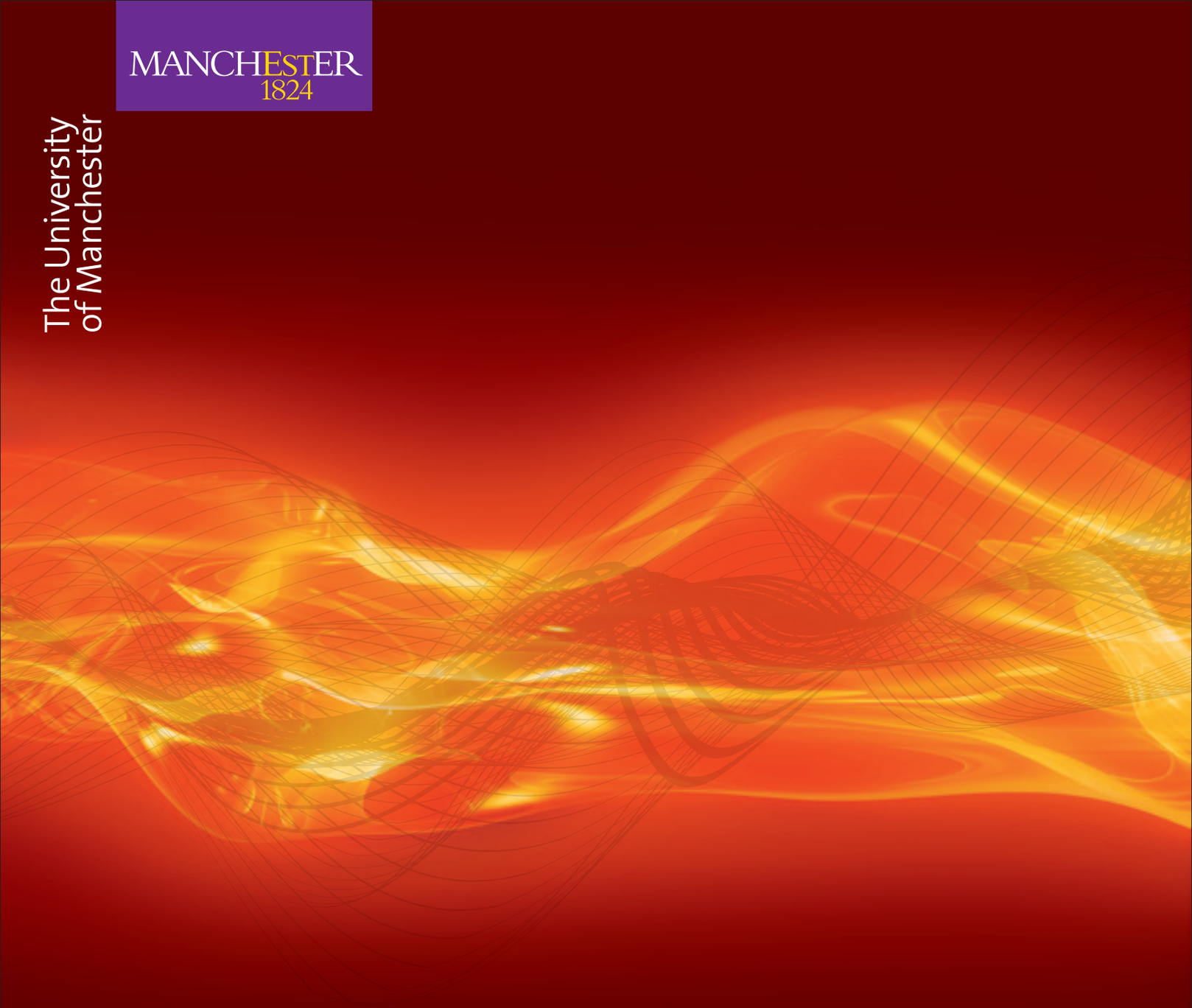

Manchester Energy

Developing world-leading technologies and solutions

www.energy.manchester.ac.uk

Welcome from the Vice-President and Dean

The supply of energy to a growing worldwide population is a significant global challenge. Manchester Energy has been created by the University to respond to this challenge, and to increase the impact of our research and educational activities. It coordinates the diverse range of expertise within the University and provides a forum for engagement with the full range of stakeholders from business and the public sector. This newsletter, the first in a regular set of updates, describes some recent highlights and outlines activities that will take place in the near future. I hope you will find it interesting.

Across the University, more than 200 academics work on research projects relating to energy. Our research portfolio covers a wide range of topics including energy sources, generation technologies, transportation of energy and consumption. Capability in energy policy, systems modelling and economics integrates this expertise, and contributes to the debate shaping future energy policy and the development of technical solutions that meet the needs of this policy. With more than 300 buildings on 120 hectares of estate the University campus also acts as a laboratory for testing new approaches to energy generation, distribution and use within the context of a major urban centre.

We have a broad base of energy research and make a major contribution in a number of challenge areas. Each challenge area is led by two members of academic staff and sees contributions from staff and students across the University.

Manchester Energy Challenge Areas:

- **Policy and system modelling**
- **Affordable energy**
- **Bioenergy**
- **Cities**
- **Future electricity networks**
- **Nuclear**
- **Offshore renewables**
- **Solar**
- **Sustainable hydrocarbons**

The vibrancy of Manchester Energy is enhanced by the links the University has with partners, who benefit from the research that we carry out and the education that we provide to current students and existing employees. We work closely with industrial collaborators such as BP, Rolls Royce and National Grid whilst our technology transfer company, UMI^3, manages energy related IP and develops spin-out companies that take our research from the laboratory into the field.

There is much opportunity to engage with external partners. We have recently launched a horizon scanning activity that will see the University begin to develop an innovation roadmap for our energy research in the next few months. Also, in spring next year the University will hold its first Manchester Energy week in which seminars, debates and a range of other events will be held. We would be delighted if you would like to be involved in either of these two opportunities, and invite you to register your interest by emailing info.energy@manchester.ac.uk.

Professor Colin Bailey

The Bigger Picture

by Kevin Anderson, Professor of Energy and Climate Change, Director of the Tyndall Energy Programme

Modern society is increasingly dependent on secure, reliable and affordable energy resources, services and systems of delivery, with mounting global pressure for these to be low-carbon and sustainable.

Our reliance on oil, coal and gas leaves us susceptible to both the vagaries of global energy demand and volatile fluctuations in fossil fuel prices. Moreover, the changing climate is imposing physical impacts on energy and electricity infrastructures. Against this challenging backdrop, it is necessary that we develop alternative energy resources and more sophisticated and prudent ways of using energy within our society.

As energy demand increases industry and governments are looking to academia to help develop diverse and green portfolios of energy resources, and to identify opportunities for substantive improvements in energy efficiency and conservation.

Historically, society has looked for quick fixes to issues of energy security and reliability, but the legacy of such short sightedness has led to one area of concern being addressed at the expense of another.

A more strategic approach and long-term vision is now required; one that makes a smooth but rapid transition from the current energy system to one with alternative energy resources and supply networks, through to new energy demands and patterns of consumption. All of this must be considered not only in terms of the appropriate technologies, but also in relation to their associated social, financial and environmental impacts.

Manchester Energy is leading the way in shaping and exploring alternative energy strategies. Through specialised and interdisciplinary research, it brings together a wealth of expertise from across the University to develop a 'systems thinking' and life cycle approach to tackling energy challenges. Overcoming disciplinary boundaries is a prerequisite to addressing real world energy issues. Identifying a fuel resource, through its conversion into useful energy, and onto understanding why and how energy is consumed, are all pivotal facets of Manchester Energy's research programme.

The breadth and depth of research being conducted at a university of Manchester's size mean engineers, natural scientists, architects, economists, geographers can work closely with each other and with experts in social policy, business and governance. It is the role of Manchester Energy to facilitate and maximise the value added from such collaborations, and to ensure close and appropriate links to private and public sector stakeholders.

Manchester Energy's scope of expertise permits it to tailor its analysis to meet needs locally, at the UK level, and more internationally. Furthermore, it is able to take a dynamic view of energy within a rapidly changing world, as well as address pressing issues of the day. Our capabilities in key areas of energy give Manchester a significant advantage in modelling long-term and sustainable energy systems, capturing issues of energy sourcing, supply, operation and use.

Ultimately, Manchester Energy has been established to translate the University's cutting-edge research into robust outputs and modelling tools for use by those outside of the academic community. As such it has identified Challenge Areas and associated research projects that, through collaboration with industry, it will develop and seek to commercialise. It is only though close liaison between academic researchers and external stakeholders that a robust and coherent transition to a sustainable energy future will be forthcoming; Manchester Energy's goal is to be at the centre of any such transition.

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Harnessing the Power of the Sun to Create Clean Fuel

The Sun provides far more energy than we'll ever need and we use this energy very inefficiently. A consortium including The University of Manchester, and the universities of East Anglia, York and Nottingham, is working on ways of more successfully tapping into this massive resource.

Up to now 'solar power' has focused on solar panels, which use photovoltaics to generate electrical power by converting solar power into electricity. The major stumbling block to using the Sun's energy in this way is the inefficiency during night time hours when we can't produce power from solar panels. We can't store solar electricity efficiently from the daytime in batteries, nor can we move the energy around the world, so the challenge is to find ways of creating storable, moveable and clean fuel from the Sun's power.

An EPSRC-funded project is concentrating on finding ways to produce solar fuels that can be both stored and shipped to where they are needed. The work was selected for the Royal Society Summer Science Exhibition in 2011.

Professor Wendy Flavell and her team at the University's Photon Science Institute are working on the ground-breaking physics that underpins the whole research project. Their work uses nanotechnology to harness sunlight to drive green chemical reactions. The group is working to build a solar 'nanocell' which uses small semiconductor clusters or 'quantum dots' to harvest the sunlight. Catalyst molecules are grafted to these dots and this chemical process can potentially make fuel.

When sunlight is absorbed by a molecule, chemical (or photochemical) reactions can occur- as happens naturally in photosynthesis. The University team is developing a system that produces the right reactions to create solar fuels, such as methanol.

The team is trying to make a photosystem where the light-harvesting quantum dots are connected to two molecular catalysts that perform the two actions necessary: oxidation and reduction. The catalysts developed by the team use compounds which are both plentiful and non-toxic, making the system even more sustainable.

Industrial collaboration is crucial to the future development of solar fuels. Manchester's researchers and academics have great relationships with industry and close ties with a world-leading research group that produces quantum dots right here in Manchester.

The technology could revolutionise our energy usage but there is a long way to go. As well as being able to withstand intense light and heat changes, the device developed must be suitable for conversion from the laboratory to a commercial scale.

A large part of the Sun's irradiance falls on the developing world, so it makes sense to concentrate on developing large-scale effective mechanisms for harnessing solar power in the hottest parts of the world. As well as helping to solve the energy crisis, this could also have an enormous economic impact for the developing world, as it will be able to provide commodities to the rest of the world.

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Integrating Renewables into Electrical Networks

The development and use of renewable energy is key to providing energy security and lessening the environmental impact of fossil fuels, but their delivery throws up challenges. More wind, tidal and solar energy means more opportunities for problems within the networks that transport energy to the user. The connection of extra generation to the networks can mean they are unsafe in the event of a fault occurring – the only way to resolve this is an upgrade of the substation equipment at massive cost.

A £4million fund from the Energy Technologies Institute is allowing Professor Sandy Smith and his team to develop a new fault current limiter technology to be tested on the current distribution network in 2014. They are working in partnership with Rolls Royce, who are providing technical input, and Applied Superconductors, who will develop the research. A network substation in Loughborough has been chosen for the test.

The University team has produced a prototype fault current limiter, using superconducting material, which can sit within the network system to limit the severity of faults. It is already of great interest to distribution network operators globally due to the financial savings it could deliver.

The new superconducting material is virtually invisible to the distribution system as it has very nearly zero resistance. It's only when the fault current appears that it transitions into a normal conductor, adding a resistance to the fault and limiting the current.

Research is at an early stage, and the next phase of work will concentrate on trying to cool the material down after large fault currents have passed through it. Currently the material works perfectly in the superconducting mode, but gets extremely hot very quickly when it quenches and turns into a normal conductor to limit the fault current. Distribution network operators will require it to rapidly cool down so that it can reconnect to the system within three minutes.

The team is also developing the superconducting wire to carry the high current levels normally found in an electricity distribution system. These are much higher than the first prototype was designed for, so tests using high voltage and high current will be carried out at the University's High Voltage facilities. Once both have been proved separately, the prototype will be tested at high voltage and current together at a commercial testing station.

The bulk market for the fault current limiters will be medium voltage distribution systems. If the technology is a success the benefits to industry and consumers alike could be dramatic, resulting in reduced costs of upgrading electricity distribution networks to integrate our wind, tidal and solar energy resources.

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Challenge Area Focus – Sustainable Hydrocarbons

It is likely that hydrocarbons will continue to form a significant proportion of global energy sources for years to come. The University of Manchester is home to one of the largest Petroleum Geoscience research group in the UK and their expertise coupled with that of other researchers from across the University make up the grouping of staff engaged in the sustainable hydrocarbons challenge area. Its expertise covers a broad spectrum of applied and fundamental geoscience and subsurface engineering topics, utilising state-of-the-art acquisition, modelling and interpretation tools on a wide range of outcrop and subsurface datasets.

The group conducts ground breaking, globally recognised research, and is regularly chosen to provide external and industry advice and guidance on applied subsurface technology and related policies. Professors Jonathan Redfern and Kevin Taylor, together with Drs. Mads Huuse, David Hodgetts and Cathy Hollis, are recognised industry leaders in their fields. Professor Mike Bowman is currently President-elect of the Petroleum Exploration Society of Great Britain

The group's research can be described through a series of focused themes addressing topical current and future challenges:

Carbonate Reservoir Research (Cathy Hollis): Carbonate reservoirs contain significant volumes of the World's hydrocarbon reserves. The group uses process-based, interdisciplinary approaches to predict and quantify carbonate reservoir properties and their distribution using state-of-the-art imaging and modelling.

Reservoir Characterisation / Digital Data Analysis (David Hodgetts): The group collects and analyses geological outcrop data using cutting edge digital techniques (LiDAR). These data provide information and insights into subsurface geology and reservoirs which may be hosts for hydrocarbons or act as storage for gas and CO_2.

Seismic Imaging of Fluid Flow Systems (Mads Huuse): Dr Huuse and colleagues are involved in detection and analysis of subsurface fluid flow and storage using seismic based techniques, calibrated to surface and borehole evidence. The team focusses on reservoir and seal characterisation and their distribution in a tectono-stratigraphic framework, providing a holistic analysis applicable to hydrocarbon and groundwater exploration and carbon storage.

Earth Surface Processes (Simon Brocklehurst): Research focusses on understanding and modeling sedimentary processes from 'source to sink'. Central to this is the development of a detailed, process-based understanding of landscape responses to tectonics and climate change and their predictive simulation.

Unconventional Resources (Kevin Taylor): This group is investigating unconventional hydrocarbon resources, likely resulting in opportunities for UK and global energy supply and security. Research is at an early stage, focussing on shale gas; it will integrate expertise in sedimentary geology, geochemistry, geomechanics, micro- and nano-scale imaging, and geobiology to address the technological challenges associated with safe and environmentally responsible extraction of these resources.

Increasing Recovery from Marginal Fields
(Mike Bowman & Rossmary Villegas): This group is establishing an integrated research centre to create new technology and capability to develop stranded, marginal fields that, if made economic, can change the value of many existing mature fields and stranded resources. Initially, research will focus on the development and application of specific technologies to unlock stranded resources.

N. & C. Africa Petroleum Geoscience & Basin Research
(NARG) (Jonathan Redfern): This group is focussed upon prediction and description of source rocks, regional depositional systems and reservoirs in one of the world's giant petroleum provinces. The knowledge gained helps reduce risk in exploration and targeting of new drilling opportunities and will develop a new stratigraphic framework for North Africa.

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Novel Biofuels

Last year the University joined the Carbon Trust and ten partner institutions to develop a sustainable and cost-effective biofuel from algae.

The group as a whole was awarded £8million over three years, and was tasked with finding a way of cultivating 70 billion litres of algae biofuel a year by 2030. This amounts to the equivalent of 6% of global road transport diesel, and would save more than 160 million tonnes of CO_2 every year.

Thousands of strains of algae are being screened to find the few that can produce large quantities of triacylglycerol lipids- a substance similar to vegetable oil. Additional research is developing methods for large-scale production. Construction will begin with a pilot demonstration plant in an equatorial region where algae are most productive.

Here at Manchester a team at Manchester Interdisciplinary Biocentre (MIB) and the Michael Smith Building, and led by Dr Jon Pittman, is concentrating on nutrient optimisation for high lipid yield and productivity. They are assessing the algal culture conditions that provide maximal cellular lipid content whilst maintaining a high cell density. The group is performing metabolic and gene expression profiling to gain a better understanding of the molecular mechanisms of lipid induction.

Jon Pittmans' team is also looking into the use of these profiles as biomarkers for the screening of algal strains for high lipid productivity traits, and for determining the optimal growth stage for lipid extraction. A second strand of the project at MIB is aiming to reduce the cost of biomass separation by using ultrasound technology.

Ultimately this research will allow researchers to generate or identify strains with enhanced oil yield that will enable the production of renewable fuel at low cost.'

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New £8 Million Facility for Nuclear Research

An £8 million refurbishment of an abandoned laboratory marks the latest commitment of the University's Dalton Nuclear Institute to address the skills and research needs associated with nuclear energy.

A key role for the new laboratory, now nearing completion, will be to provide world class research facilities for the government-funded Nuclear Advanced Manufacturing Research Centre. This new centre, a collaboration between The University of Manchester, the University of Sheffield and a consortium of industrial partners, forms part of the government's Low Carbon Industrial Strategy. The goal of the Nuclear AMRC is to enhance the capabilities and competitiveness of the UK civil nuclear manufacturing industry to respond to the resurgent demand for nuclear power plants, both in the UK and globally.

The laboratory is equipped with cutting-edge technology to allow researchers to focus on three key areas: new materials processing; welding and joining; and surface technology. This will be facilitated through new state-of-the-art equipment including laser processing, cutting and welding centres, tensile testing machines and autoclaves, together with existing electron and x-ray analytical facilities.

Research in each area will be underpinned by detailed analytical characterisation, thermo-mechanical testing in nuclear environments, and modelling and simulation, to ensure all technologies are optimised for manufacturing nuclear components. The scope of research will be enhanced by access to Dalton's other world-leading research facilities, including the soon to be completed Dalton Cumbrian Facility. This state-of-the-art centre will add significant capability in understanding potential radiation damage of materials in nuclear reactors.

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University Teams up with The Museum of Science and Industry on Energy

The University works hard to engage with the next generation of scientists, and strives to ensure that its work has an impact beyond academia. Key to this goal is developing meaningful and long-term relationships with external partners to bring about economic, social and cultural benefits.

A collaboration with the Museum of Science and Industry (MOSI) is allowing the University to bring its research and innovative technologies to a younger audience. MOSI is planning its next major development project, working with the theme of Energy and Innovation. A key challenge is to fire its visitors' imagination about energy, and to empower them to make wise energy choices through fresh resources, exciting interactive displays, and a brand new look at the energy story.

The University is supporting its work by providing several energy related display items. These include a composite cross-arm, a new technology which allows the up-rating of existing electricity power lines to increase tower voltage without structural change to the towers. The University has also provided new content for MOSI's Revolution Manchester Gallery including the novel wave generator 'the bobber' which is being developed at Manchester Highlight. It is shortly starting work on developing experiments for the Museum's new energy theatre which will form part of the Energy Galleries plan.

Ian Cotton, Professor of High Voltage Technology and developer of the cross-arm composite, commented: "Working with MOSI gives us the chance to showcase the fantastic work we do at the University within science and engineering, and to engage with school children and the general public to show them how our research is informing everyday life".

The museum is always looking for new collaborators and partners who can provide examples of technological innovation for use in its galleries.

John Beckerson, Senior Curator at MOSI, said: "MOSI's aim is to not only focus on the rich heritage of Manchester, but also to celebrate what we're doing in the region right now, and where we are going in the future. Working with the University gives us the opportunity to allow people to witness real innovation in action, and to see the wealth of incredible ideas which still come from this great industrial and scientific city".

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Energy and the Urban Challenge

Future energy policies will require not only robust technological development and economic strategies, but also the inclusion of information and strategies on the social dimensions of energy use. Energy is a fundamental part of contemporary societies and high carbon lifestyles are embedded in everyday activities of work, home, recreation, and so on. The University is at the forefront of the socio-technical approach to energy analysis, to bridge the gap between the natural and social sciences to realise more effective energy policies.

By using a 'systems thinking' method of research, Manchester Energy is utilising the enormous breadth of research expertise at the University to investigate the relationship between humans, energy practices, and the associated infrastructure networks within the context of cities.

This expertise is distributed across several schools and research centres, and engages with notions of sustainable urban development; ecological modernisation; energy use and thermal comfort; individual behaviours; low carbon design strategies; economic analysis and pricing models; public engagement with community energy projects; building regulations and their implementation; uptake of alternative energy strategies; integration of networked and autonomous energy technologies; upgrade of energy networks; fuel poverty and heat wave vulnerability.

The sociotechnical approach to energy research at the University is exemplified in a project at the Manchester Architecture Research Centre on zero carbon housing. The project is part of the Sustainable Practices Research Group (SPRG) a UK-wide research consortium that is examining social practices to understand the relationship between people and technology.

Rather than treating consumption as a matter of personal preference, SPRG researchers are investigating how consumption is influenced by everyday practices and contexts. With respect to zero carbon housing, the Manchester team is investigating how designers- architects, engineers, product manufacturers and so on- design low carbon lifestyles into houses, and how house occupants then adopt or subvert these design features.

There continues to be a significant gap between modelled and actual energy use in zero carbon housing, and this research focuses on the factors that create this discrepancy. The findings from this project will inform future building policy by improving zero carbon design strategies through inclusion of building occupant data.

The team is also investigating the uptake of energy saving technologies by ageing populations in the UK. Sustainable technologies such as heat pumps and mechanical heat and ventilation recovery systems can lead to energy savings, but they require different practices of household management that can be difficult for older residents to understand and undertake.

As such, a tension exists between the need to lower our carbon footprint through the adoption of energy efficiency technology, and our ageing population's ability to use such technology. The researchers are working with civil society groups such as Age UK to highlight the issues of energy efficiency and ageing populations.

Several research methods are being used, including interviews, site visits, and roundtable discussions with key stakeholders. It is hoped the research will produce policy recommendations that can improve the uptake of energy efficiency goals.

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From Ideas to Reality
- Innovation from The University of Manchester

The University of Manchester I³ Limited (UMI³) is the University's innovation company, and has two operational divisions: its intellectual property commercialisation services (UMIP), and its Innovation Centre (UMIC) with state-of-the-art incubator premises, and a vibrant enterprise conferencing and networking centre.

UMIP is wholly owned by the University and has a 20 year history of IP commercialisation. UMIP's role is to bring the University's ground-breaking inventions and software into the commercial world. Since 2004, UMIP has received more than 1900 disclosures from its research community, set up 27 spin-out companies and brokered 263 licences and assignments. It currently has around 100 projects at various stages of development.

Increasing numbers of UMIP's projects relate to energy. One of its high profile commercialisation projects is Arago, a joint venture between EPL Composites Solutions Ltd and a team from the National Grid High Voltage Labs at the Manchester. Arago Technology has developed an electrically insulating composite cross-arm, suitable for retrofit to existing transmission and distribution towers or as an option for new line build. The composite cross-arm can minimise the size of an overhead line or increase the capability of existing towers. In addition to managing the project, UMIP manages the intellectual property, works with the team to secure funding, and is responsibility for attracting Arago's management team.

UMIP also worked alongside researchers in the development of technology to detect leakages and blockages in long lengths of gas pipeline. UMIP licensed Acoustek to Pipleline Engineering Ltd - a major service provider in the oil and gas industry, and the technology received investment from BP. The technology has been trialled in the UK and the US and Pipeline Engineering Ltd is now commercialising a certified Acoustek system.

Working with industry is as important for UMIP as it is for the University. The Co-Managed Energy Innovation Fund is a recent development providing grants of up to £100,000 to allow University researchers to prove the commercial viability of their research. The fund, with a total value of £1 million, has been created by UMIP partnering with National Grid, Scottish and Southern Energy Power Distribution and UPF, and managed by MTI Partners. The fund will be distributed amongst staff at the University who are working on research and technologies focused on the electricity distribution and transmission networks.

Continuing its development of support for energy innovation, UMIC has recently launched the Low Carbon Innovation Centre. Based on the University campus, the Centre will support and accelerate the development of technology-based low carbon businesses, helping to significantly reduce UK and global CO_2 emissions. The Centre offers world class office and lab space and aims to bring together entrepreneurs, innovators and researchers, from within the University and beyond, through regular meetings, workshops and events. For more information please contact Tony Walker tony.walker@umi3.co.uk or call 0161 603 7780.

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Energy Education

Manchester Energy already provides a number of MSc and CPD courses of relevance to the energy sector. The University continues to develop its educational offering and is launching a new MSc course titled 'Renewable Energy and Clean Technology'.

The new course is designed specifically to position science and engineering graduates to contribute to the worldwide technology push for increased penetration of renewable energy sources, with a particular focus on electrical energy. An understanding of both the broader context of the emerging low-carbon energy systems and the technical detail of renewable energy options are essential for anyone aspiring to contribute meaningfully to the low-carbon energy transition. The 'REaCT' course is designed purposefully for such students – providing them with the skill sets necessary to lead in shaping the global low-carbon future.

For more details on this course and our other educational offerings, please visit the Manchester Energy website.

www.energy.manchester.ac.uk/impacts/educationandtraining

Horizon Scanning of Energy Research

Focusing on one of the biggest areas of research at The University of Manchester, the Energy Horizon Scanning activity will shortly begin to explore the innovations being developed at the University. Horizon Scanning is 'the systematic examination of potential threats, opportunities and likely future developments which are at the margins of current thinking and planning'[1]. The technique is commonly used in Foresight exercises to uncover emerging issues, and identify future surprises and shocks by looking ahead beyond usual timescales.

Funded by the University EPSRC Knowledge Transfer account, the Horizon Scanning activity will examine the potential to increase the impact of our current research, and will set priorities for the future research and education agenda by proposing a research and innovation strategy. The activity will engage with the energy research community across the University and involve participants from industry and public sector.

If you would like to find out more about the Horizon Scanning activity, please visit www.energy.manchester.ac.uk

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1 http://horizonscanning.defra.gov.uk/default.aspx?menu=menu&module=About

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