UNIVERSITY OF BIRMINGHAM

think

Business with Birmingham

Energy special edition

We are *bursting* with energy

Government has committed £60 million in a new energy research project.

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inside

Business with Birmingham

foreword

The Birmingham Energy Institute is driving technology innovation and developing the thinking required to solve the challenges facing the UK as it seeks to develop sustainable energy solutions in transport, electricity and heat supply. Co-ordinated research, education and global partnerships are at the heart of our vision. By creating technology and guiding policy today we aim to help shape energy solutions of tomorrow.

Our research strengths lie in the following technology areas:

- **Energy Storage**
- **Nuclear Energy**
- **Hydrogen and Fuel Cells**
- **Transport**
- **Oil and Gas**
- **Bioenergy**
- **Wind Energy**
- **Energy Materials**

supported by capability in energy policy, economics and social science. We work closely with business of all sizes locally, nationally and internationally. Through the government funded Energy Research Accelerator (ERA) project our aim is to help our business and industry partners deliver energy technologies to market, creating growth, jobs and the much needed energy solutions. Please read on to find out how Birmingham is supporting companies like yours to find solutions to their energy challenges.

Professor Martin Freer
Director of the Birmingham Energy Institute (BEI)

think energy

Energy Research Accelerator (ERA)

The regions collective expertise across the energy research agenda has led to the announcement earlier this year, by government, confirming a commitment of £60 million in a new energy research project. The Energy Research Accelerator (ERA) is a multimillion research hub which will build on the expertise of six leading midlands universities*, the British Geological Survey and the surrounding industrial base to deliver a step change in energy research and development, securing the UK's leadership position in the sector.

The Energy Research Accelerator will develop new ways to reduce energy costs in manufacturing – adding competitive advantage to the UK in today's global markets – and will catalyse new research to secure the UK's international lead in new energy technologies across the region's leading universities, develop and deploy technologies, as well as create significant inward investment for the region and the UK. At the University of Birmingham, the project draws on expertise in energy research and, in particular, Thermal Energy technologies (T-ERA – Thermal Energy Research Accelerator) and its excellent relationships with industry.

A vital component of T-ERA will be an Advanced Thermal Manufacturing Centre (ATMC) that will be developed in collaboration with the Manufacturing Technology Centre (MTC). This will create an environment that will allow companies to optimise the development of products to rapidly deliver them to market.

'By building on the Midlands' industrial heritage and technical expertise, ERA will not only help ensure the region maintains its position as a manufacturing and innovation hub, but can create jobs and wealth to fulfil its potential as an Engine for Growth.'

Gordon Waddington, ERA CEO

'Gordon's experience in building partnerships combined with his strategic vision and industry knowledge will be key to overcoming the challenges that can hold innovation back from delivering on its potential.'

Dr Helen Turner,
Director of Midlands Innovation

As well as delivering innovations in the sector, the project aims to collaborate with industry to convert innovation and emerging technologies into practical solutions with a powerful global benefit and value. In addition it will deliver jobs, and apprentices, wealth creation and the next generation of trained scientists and engineers for the energy sector and for the new industries that will emerge.

Energy Research Accelerator

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* Partnership between six leading UK Universities – the Universities of Birmingham, Nottingham, Warwick, Loughborough, Aston and Leicester – and the British Geological Survey (BGS).

think rail

Tracking energy consumption

Metro operation companies are usually one of the largest electricity consumers in the big cities such as London, Beijing and Shanghai. In statistics, more than 50 percent of the energy in a metro operation company is consumed by train tractions. However, most of the metro systems have not been designed to consider the energy optimisation. With the large consumption of traction energy, a small portion of energy saving will lead to a significant economic and environmental benefit.

The Birmingham Centre for Railway Research and Education (BCRRE) has been working in the area of energy optimisation for railway systems in the last decade. Researchers from the Centre are working on an integrated energy optimisation technology, which aims to reduce the traction energy consumption for metro systems- incorporating the optimisation of timetable, train running trajectory, and braking regeneration energy.

A recent trial has been undertaken on Beijing metro to validate the energy optimisation results from simulations. The researchers record the traction energy consumption using existing automatic train operation system, manual driving without guidance, and manual driving with guidance of optimised train running trajectories. The results show that around 15% of energy can be saved if using these trajectories. This encouraging initial result validated the significant potential benefit to apply the integrated optimisation technology to metros.

Birmingham Centre for Railway Research and Education

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think hydrogen

Fuel cell technology in full flight

Unmanned aerial vehicles (UAVs) are used for a wide range of industrial and commercial purposes, from power line surveillance to documentary filmmaking, as a way to boost efficiency and safety and cut labour costs.

The four-and-a-half-year SUAV project to dramatically extend the duration of mini-UAVs is cruising ahead. Using a microtubular solid oxide fuel cell (µSOFC) power system, the Birmingham Centre for Fuel Cells and Hydrogen are working towards considerably increasing the flight duration of small drones – thus reducing mission costs.

In collaboration with 10 companies and universities from seven European Countries, SUAV – the first of its kind in Europe, aims to get our first SOFC-powered drone in the air during November 2015.

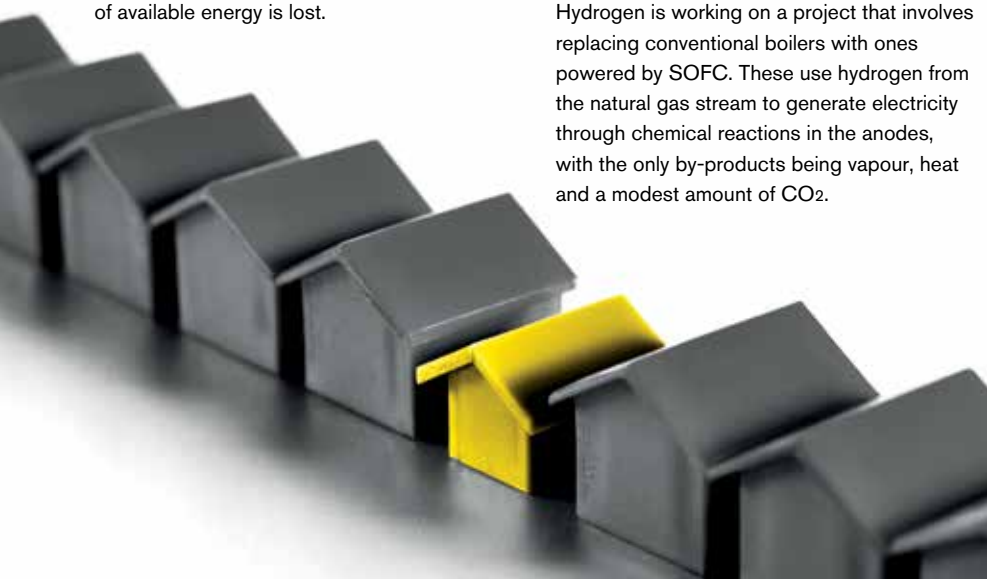
Working with Dutch company HyGear and with SURVEY Copter, a subsidiary of industry partner, Airbus Group, the research group have taken the existing battery pack from its mini-UAV and swapped it for a fuel cell unit. Using SOFC allows us to use more readily available fuels such as propane.

With more than €3m of funding from the Fuel Cells and Hydrogen Joint Undertaking (FCH JU), we are designing, optimising and building a 350W µSOFC stack, designing and building a fuel processor to convert propane into suitable SOFC fuel, and integrating these components into a mini-UAV platform.

The success of the SUAV project, will open up new opportunities in other weight-limited and man-portable applications.

Bringing low carbon living a (door) step closer

According to the World Business Council for Sustainable Development, traditional buildings consume 40 per cent of the world's primary energy for cooling, heating and power. Most of this energy is in the form of electricity generated at centralised power stations, where, at the moment, up to 70 per cent of available energy is lost.



The only way to drastically reduce CO_2 emissions in line with EU targets is to move from conventional centralised power generation systems to highly efficient onsite micro-generation technology.

The Birmingham Centre for Fuel Cells and Hydrogen is working on a project that involves replacing conventional boilers with ones powered by SOFC. These use hydrogen from the natural gas stream to generate electricity through chemical reactions in the anodes, with the only by-products being vapour, heat and a modest amount of CO_2.

The project, entitled 'durable solid oxide fuel cell tri-generation system for low carbon buildings' (TriSOFC), takes it a step further, because as well as providing heat and power, the system can also provide cooling.

It's a three-in-one system – and the first of its kind. Although desiccant technology already exists, this is the first time it is being integrated with fuel cells.

In collaboration with our seven university and industry partners across Europe, we are building a 1.5kW low-cost durable LT-SOFC tri-generation prototype system.

TriSOFC, which is supported by the European Commission through FCH-JU funding, aims to define, develop and deliver tri-generation technology in low carbon residential and commercial buildings.

This system has the potential to reduce CO_2 emissions by 70 per cent compared to a traditional energy production system that uses separate condensate power plant, boiler and compressor-driven cooling units. The commercialisation of the system will bring economic as well as environmental benefits.

Keeping cool

Refrigerated transportation plays a vital role in carrying goods from manufacturing sites to primary storage centres and, from there, to retail stores and other secondary distribution points. Current refrigerated trucks run on vapour compression systems, powered by a separate auxiliary diesel engine or the main diesel engine itself. Vehicles with internal combustion engines are noisy and emit a considerable amount of greenhouse gases. Even when trucks are stationary, they have to keep their engines idling, which uses up diesel. Fuel cell technology promises to solve these problems.

Working collaboratively with Unilever, a research group in the Birmingham Centre for Fuel Cells and Hydrogen are running a research project called 'fuel cell integration for refrigeration applications', which focuses on how to use fuel cell technology in a refrigerated truck.

A solid oxide fuel cell (SOFC) provides the energy to allow the refrigeration system to be on all the time – even when a truck's engine is switched off. This means no noise and no emissions. In addition to these environmental benefits, the SOFC system will reduce wear-and-tear on vehicles and cut diesel consumption. Besides electricity, a solid oxide fuel cell (SOFC) provides heat, producing temperatures of 650-700°C. Rather than wasting the heat, it can be used to run thermally driven refrigeration.

A prototype is now being developed, the first part of which should be built by Spring 2016.

Birmingham Centre for Fuel Cells & Hydrogen

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think nuclear

Training for the *next* generation

As the UK moves towards decarbonising its' electricity generation, nuclear energy is likely to have an important role to play. At present the UK generates close to 15% of its electricity through nuclear energy. However, on a timescale of 10 years, most of this plant will be decommissioned. If the UK is to remain committed to climate change targets, then many believe that an investment in nuclear energy is required at least at a level consistent with maintaining existing generating capacity and perhaps even increasing this up to 40% of electricity generation.

The first of these new generation reactors is likely to be built at Hinkley Point (Hinkley Point C) and is a French design EPR reactor, to be operated by EDF. The twin nuclear reactors will deliver 3.2 GW of electricity baseload.

The Japanese company Hitachi-GE plan to construct nuclear power plants of the Advanced Boiling Water Reactor (ABWR) design in the UK. The first of these will be constructed in Wylfra, Anglesey, in North Wales.

We are working with EDF to help them keep their fleet of Advanced Gas-cooled Reactors (AGRs) in operation and develop training material for the operators of the next generation reactor. We are working closely with Hitachi-GE in helping them bring their technology to the UK as they establish a R&D base.

Key to these developments is providing skilled and talented people into the nuclear energy sector. Birmingham has been training nuclear engineers and scientists for over 50 years and every year close to 100 people graduate from our programmes in Nuclear Engineering, Nuclear Science and Materials, Physics and Technology of Nuclear Reactors (PTNR) and Nuclear Waste Management, and Decommissioning (NWMD).

Birmingham Centre for Nuclear Education and Research

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think cold

A liquid asset

Though thermal energy storage has been commonly thought of in terms of heating (relative to ambient), energy can just as well be stored by cooling materials. Cryogenic energy storage systems use off-peak electricity to liquefy air. The cryogenic liquid that is formed is stored in a vessel then vapourised into a gas during an expansion process, which drives a turbine. This system generates electricity when it is most needed; taking off-peak electricity and using it at peak times will help to solve the 'wrong-time wrong-place' energy generation and supply problem.

The Centre for Cryogenic Energy Storage (BCCES) has built an excellent relationship with industry since its inception, creating partnerships with Highview Power Storage, the Dearman Engine Company, Air Products, Energy Generation and Supply KTN, ARUP, and the Energy Technologies Institute.

Cryogenic liquid can additionally be used to improve the efficiency of diesel generators, routinely used as reserve capacity for the National Grid. The system is also an efficient method of generating electricity from low-grade waste heat from power stations or industrial processes. Furthermore, CES can be built alongside liquefied natural gas (LNG) terminals to recover cold energy. Unlike some other energy storage technologies, CES does not require scarce resource, and is not limited by geography or geology.

The early work behind CES was undertaken in the UK by Prof. Yulong Ding, the Chamberlain Chair at the University of Birmingham, who holds patents covering CES and cryogenic engines. A recent report 'Liquid Air in the Energy and Transport Systems' (Centre for Low Carbon Futures, May 2013) and major conference at The Royal Academy of Engineering drew on expertise from academia and industry to share the contribution CES could make to the energy system, and its benefit for the UK economy.

Birmingham Centre for Cryogenic Energy Storage

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A clean break

Dearman is a technology company developing zero-emission cold and power systems for transport and the built environment.

The transport of food and medicine, management of data, and modern transportation all demand cooling. The need for cold is generally met with out-dated, disproportionately polluting diesel systems. Dearman is working with industry and academia to effect systemic change in the way cold and power is provided globally.

The Dearman engine, an innovative piston engine, utilises the rapid expansion of liquid air, or liquid nitrogen, to deliver efficient zero-emission power and cooling. Working with the Birmingham Centre for Cryogenic Energy Storage (BCCES), and partners across the Midlands such as the MTC, Dearman is rapidly developing applications for this clean cold technology.

Partnership with BCCES has enabled Dearman to conduct durability and efficiency testing on the engine with a focus on tribology – the study of friction, wear and lubrication. More importantly, collaboration with BCCES has enabled Dearman to develop the knowledge and skills needed to develop its revolutionary clean cold technology, as it moves quickly from idea, to commercially available product.

Dearman's first application, a zero emission transport refrigeration unit, has begun on-road trials in 2015. New applications, such as hybrid systems for buses and a back-up power and cooling system for buildings, are being developed at the company's own facility, the world's first dedicated clean cold R&D facility.

As the company grows, so it is recruiting more talented engineers and analysts, a number of which have joined the company as graduates from the University of Birmingham.

'The University is establishing itself as a centre for excellence in cryogenic research, and the UK has the potential to become a world leader in clean cold technologies. Partnerships between industry and academia will be crucial in realising this opportunity.'

Toby Peters, CEO, Dearman

Birmingham Centre for Vehicle & Engine Technology Research

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think policy

A room with a view

The University of Birmingham's Business School recently collaborated with the Industry and Parliament Trust on a series of events to facilitate relationships between its business partners and Government. Such Parliamentary Commissions provide a trusted platform to discuss broad themes with the aim to stimulate debate between industry and politicians.

Professors Steve Brammer and Matt Cole recently sat on the Industry and Parliament Trust's Sustainability Commission, chaired by Caroline Spelman MP. Other commissioners included Members of Parliament, Members of the House of Lords and representatives from businesses such as Rolls Royce, 3M, Diageo and Nestlé. During a number of policy based and case study led roundtable discussions in Westminster, the commission explored the sustainability experiences of a range of prominent businesses and considered what UK Parliament can do to further support sustainable business practices. Key issues included how to ensure sustainability throughout supply chains, the relationship between environmental regulation and competitiveness, and the roles played by innovation and resilience.

A key finding of the commission is that innovation-led sustainability can generate significant economic returns for business, but businesses need to do more to integrate the sustainability agenda within all of their functions and activities. Greater collaboration between business, government and civil society is also needed to further expand the opportunities for sustainability and to 'spread the word' from businesses that are fully engaged with sustainability to those that are less engaged. The Sustainability Commission report was published in February 2015.

We have also delivered policy documents on 'The Future of Nuclear Energy in the UK', 'Pathways for Energy Storage in the UK', 'The Economics of Low Carbon Cities – A Mini-Stern Review for Birmingham and the Wider Urban Area' and 'Liquid Air Technologies – a guide to the potential'. The latest Policy Commission is focussing on 'Doing Cold Smarter'.

Birmingham Centre for Environmental and Energy Economics and Management

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think thermal

Closing the generation gap

Thermal energy storage (TES) is a technology based on heating a storage medium so the thermal energy in the system can be used at a later time. TES response time is of minutes for GWhs scale applications. TES can help to provide balance between the energy demand and supply on the grid, and utilise the waste heat generated by the different energy generation systems.

Around 90% of the global energy budget is spent on the conversion, storage, and transmission of thermal energy. Fossil fuel-fired and nuclear power generation are thermally based systems and emits a huge amount of waste heat. TES technology allows the utilisation of waste heat and, therefore, increases system efficiency and reduces CO_2 emissions. The integration of TES in coal-fired and nuclear power plants also increases the peak shaving capability of the plant. Moreover, TES can play a pivotal role in large scale solar thermal power generation.

We are working with a number of companies to help create and deliver the thermal energy storage technologies of tomorrow. We have projects sponsored by China State Grid linked to the development of novel thermal energy storage materials. We are also exploring how to integrate thermal energy storage into heat networks, which will become part of the solution for how we create and manage domestic heating in the future. This is one of the major energy challenges in the UK as 40% of our energy is associated with heat.

Birmingham Centres for Thermal Energy Storage

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THE UNIVERSITY OF BIRMINGHAM:

HAS A PORTFOLIO OF OVER 335 PATENTS, HAVING GENERATED 157 RECORDS OF INVENTION AND 89 NEW PATENT FILINGS IN 2013/14 ALONE

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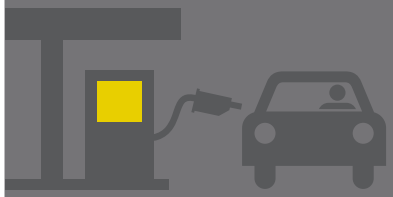

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