ENERGY RESEARCH ACCELERATOR

At the forefront of energy transformation

THERMAL

ENERGY RESEARCH ACCELERATOR

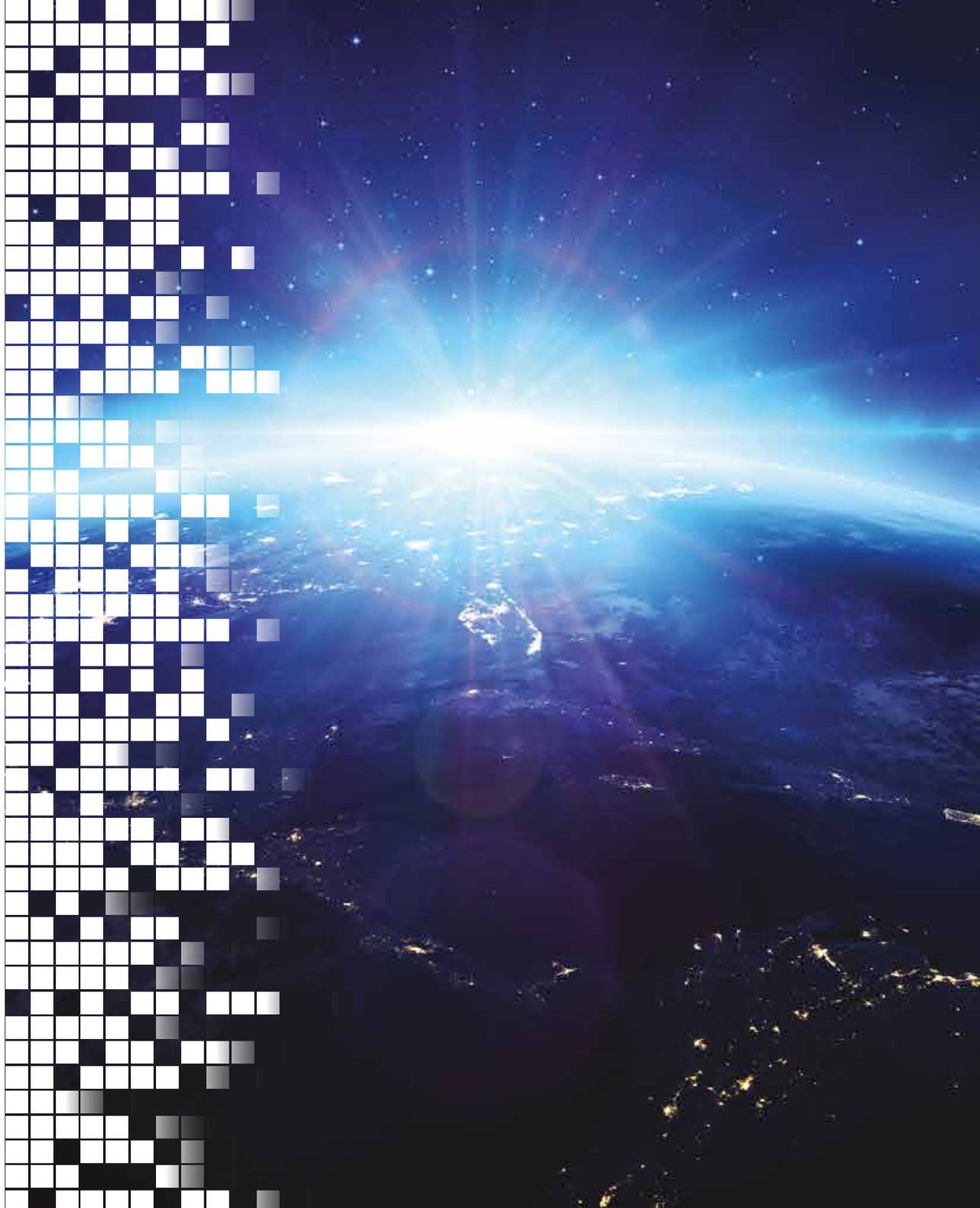
The Thermal Energy Research Accelerator (T-ERA) is one of three work streams that form the Energy Research Accelerator (ERA), a capital investment of £60million by Government to tackle some of the biggest challenges facing the global economy. By transforming research and development in three critical areas: Thermal Energy, Integrated Systems and Geo-Energy, ERA seeks to build on the expertise of six leading Midlands universities*, the British Geological Survey and the regional industrial base to deliver a step-change in energy research and development, securing the UK's leadership position in the sector.

T-ERA is driving the development and integration of a range of thermal and cryo energy technologies, delivering innovation in the sector as well as collaborating with industry to convert innovation and emerging technologies into practical solutions with powerful global benefit. It will deliver jobs and apprenticeships, wealth creation and the next generation of scientists and engineers in the energy sector and emerging industries.

"The Energy Research Accelerator… will put the Midlands at the heart of international energy research and development"

The Right Honourable Sajid Javid MP, Secretary of State for Business, Innovation and Skills, December 2015

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



T-ERA ENERGY RESEARCH ACCELERATOR

Heating and cooling in our buildings and infrastructure accounts for more than half of our total energy consumption and is set to grow dramatically over the next 15 years. Energy consumption for cooling is projected to exceed heating within 40 years, yet 84% of heating and cooling is still generated by the burning of fossil fuels. In order to meet our climate and energy goals we must sharply reduce the energy we consume for thermal loads and specifically move away from the use of fossil fuels. The key now is to engage UK industry as customers and collaborators to drive innovation in the global supply chain.

A vital component of T-ERA will be the International Manufacturing Thermal Energy Research Accelerator (IM-TERA) developed in collaboration with the Manufacturing Technology Centre (MTC). This will create an environment that allows companies to refine technologies, to optimise the development of products and to reduce the time it takes to bring this innovation to market.

Expertise

Thermal Energy Storage

The Birmingham Centre for Thermal Energy Storage (BCTES) at the University of Birmingham was established with the support of the UK Engineering and Physical Sciences Research Council (EPSRC), in addition to a number of research grants on the theme of energy storage. Comprising new laboratories, state-of-the-art equipment, and a pilot manufacturing line for thermal energy storage materials, components and devices. The research within BCTES aims to provide a balance between energy demand and supply and utilise the waste heat generated through various applications including energy produced from energy generation or industrial processes.

BCES focuses on the following research activities:

- Phase change based microstructured composite materials for applications between approximately room temperature and 1500˚C
- Novel nano-pore based insulation materials for elevated temperature applications
- Components and devices using composite materials
- Applications through integration and optimisation with energy networks and industrial processes
- Advanced manufacturing technologies for materials, components and devices, including scale-up
- Economic analysis and policy

Cryogenic Energy Storage

The Birmingham Centre for Cryogenic Energy Storage (BCCES) at the University of Birmingham is the first centre in the UK to have a research facility for energy storage using cryogenic liquids and comprises of new laboratories, state-of-the-art equipment, and a major demonstration facility.

Thermal energy storage is often commonly thought of in terms of heating and high temperatures, however energy can be stored more effectively and with a higher energy density by cooling materials. Cryogenic energy storage (CES) technology uses off-peak electricity to liquefy gases such as air and carbon dioxide, which is then stored in a tank ready to be used later. When heat is applied, the liquefied gas expands many times over and is used to drive energy generation equipment.

BCCES focuses on the following research activities:

- Novel cold storage materials with an aim to further increase energy storage density and life-span, improve charge-discharge kinetic performance and reduce costs. These materials can help further reduce the footprint of CES plants and tank size of cryogenic liquid fuelled vehicles
- New thermodynamic cycles and processes with an aim of developing more efficient cycles and processes. These cycles and processes can help improve energy efficiency of gas liquefaction plants – one of the largest electricity consumers. The work can also help develop novel cooling and refrigeration technologies
- Systems integration, control and optimisation with an aim to develop tools for designing new technologies through integration of CES with energy networks and industrial processes, and for assessing and optimising the performance of integrated technologies under current and future energy scenarios
- Pilot-scale liquid air energy storage facility testing with an aim to carry out detailed study for both component and system level performance improvement, to validate our work on integration and optimisation, and to provide an education and training base for undergraduate and postgraduate students and engineers working in the area
- Cold economy with an aim to investigate the societal and economic impacts of the cold chain for the UK and abroad, thus providing a guideline for the scientific and technological research

Cold and Power

Around 14% of Britain's electricity and £5.2billion is spent each year on energy for cold across the grid and transport. These figures will be significantly higher in warmer countries, whilst in rapidly developing nations like China and India investment in cooling is starting to boom. The world needs cooling in many forms – for thermal comfort, industrial processes, medical uses and a 'cold' chain of refrigerated food storage and transport.

Research focuses on the following activities:

- Storing cold and power is an important part of making best use of the resource, and also allows the storage of 'wrong-time' renewable energy to use in grid and transport cooling applications. This includes novel materials and methods for storage, efficient insulation materials and methods, and advanced materials manufacturing technologies
- Hybrid engines: we are working to deliver a prototype transport auxiliary power and cooling system, funded by Innovate UK and in partnership with the Dearman Engine Company, and Hubbard Refrigeration Products. AuxPac will reduce CO_2 emissions from refrigerated trucks and air-conditioned buses. The Dearman Engine Company is developing a piston engine that runs on liquid air, delivering both power and cold, and which can serve as an efficient and zero-emission transport refrigeration unit (TRU)
- Economy and policy study provides guidelines for the scientific and technological research, and also provides evidence for government, industry and funding agents to aid their decision making processes

Smart Grids and Integration

Advanced facilities at the University of Birmingham are being used to further understanding of the operation, control and management of smart grid systems powered by energy from distributed sources.

Research focuses on the following activities:

- Technologies for smart grids
- Application of power electronics such as FACTS (Flexible AC Transmission System)
- HVDC (High-Voltage Direct Current) in transmission and distribution systems
- Integration of PHEVs (Plug-in Hybrid Electric Vehicle) into power grids
- Super AC/DC power grids for large scale renewable energy delivery
- Protection and control of distribution networks with distributed generation
- Micro-generation and Micro-grid
- Smart metering and wide area monitoring and awareness
- Power system economics
- Large scale power system optimisation and planning
- Analysis and control of power system stability
- Power quality and harmonics
- Energy Union
- Global Power & Energy Internet

The Thermal Belt

A partner in five energy-focused Centres for Doctoral Training, the University of Loughborough is home to internationally recognised research groups, centres and experts in energy generation, energy supply and demand, nuclear energy and waste management, electrical and thermal energy storage and sustainable transport systems.

The Thermal Energy Systems in the Built Environment Centre (TESBEC) at the University of Loughborough works in close partnership with ERA as part of the Institute for Cold and Heat Energy Research (ICHER).

These new centres of excellence in research will focus on:

- Early stage development of cold and hot thermal technology integration
- Thermal energy materials formulation
- Thermal (very hot through to very cold) energy storage solutions
- Manufacturing technologies that will feed into the IM-TERA at the Manufacturing Technology Centre (MTC)

Bioenergy

The European Bioenergy Research Institute (EBRI) at Aston University delivers world-class, ground-breaking research into all aspects of bioenergy. The team of internationally-renowned scientists is currently developing technologies that are capable of turning organic waste products such as sewage sludge, garden and crop waste into heat, power and electrical sources, as well as fuel and chemicals.

The European Bioenergy Research Institute (EBRI) at Aston University in Birmingham leads the '5BIO Midlands Research Accelerator' within T-ERA. The main objective of this scheme is to stimulate research, innovation and knowledge transfer between businesses, scientists and chemical engineers across five key areas: biomass, biorefining, bioenergy, biofuels and bio-products.

EBRI focuses on the following research activities:

- Catalyst development
- Production and characterisation
- Thermal process development
- Biofuels and chemicals production
- Heat and power system evaluation
- Bioenergy markets
- Feedstock assessment
- Technology evaluation

Sustainable Thermal Energy Technologies

Recent funding from EPSRC and ERDF has enabled the University of Warwick to establish a Sustainable Thermal Energy Technologies Laboratory in the School of Engineering with cutting-edge facilities and expertise to undertake research in low carbon heating and cooling technologies.

Such technologies include – heat driven refrigeration, air conditioning and heat pumping systems, solar heating systems, thermo-chemical energy storage technology for storing heat and analytical property measurement of materials used in these technologies.

The funding of £1.95M as part of T-ERA will be used to enhance and extend the range of equipment and laboratory space that is already in place.

Industry 4.0

Industry 4.0 has been heralded as the "Fourth Industrial Revolution" and promises to transform the way we manufacture products; improving productivity and competitive advantage.

Industry 4.0 aims to leverage digital technologies to create cyber-physical systems and informatics to create the "Smart Factories" of the future.

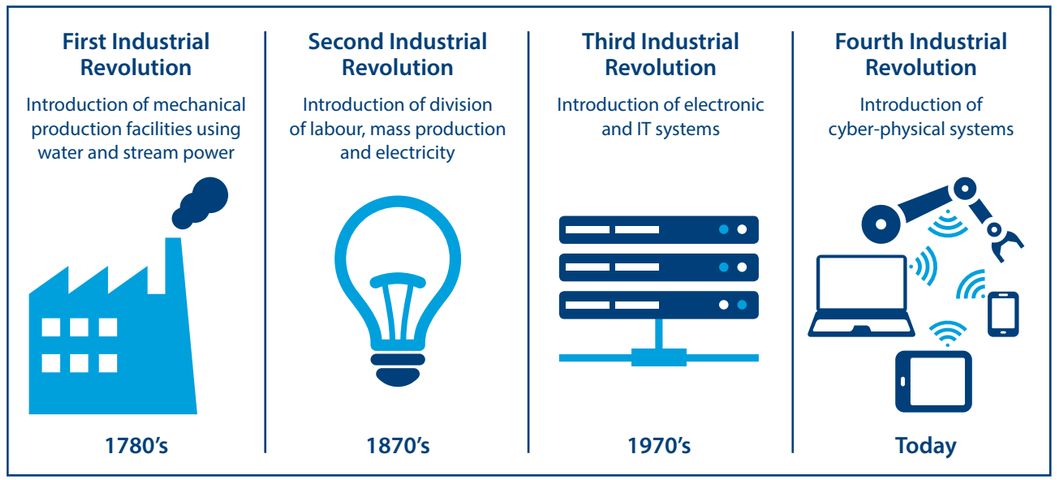
The Industry 4.0 approach ensures the interoperability of cyber-physical systems with human operators, communicating using the "Internet of Things" and "Internet of Systems". By using virtualisation, manufacturing spaces are modelled in virtual space. In operation, sensor information provides feedback from manufacturing processes and compares measured data against computer models, ensuring quality and providing early feedback of potential error conditions.

Factory in a Box Concept

The Factory in a Box (FIAB) concept is a modular approach to factory design, where the manufacturing process is segmented into a number of pre-fabricated elements, which can be transported to the desired location.

FIAB techniques have the potential to enable new manufacturing business models, the franchising of technology production internationally and enable new approaches to exporting innovation.

Industry 4.0 techniques can help in the design of FIAB applications. The T-ERA, will leverage Industry 4.0 and FIAB techniques to produce the next generation of innovative, thermal energy technologies at scale.



Case studies

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, however, the need for cold is generally met with out-dated, disproportionately polluting diesel systems. Dearman is working with industry and academia to affect 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, began 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.

A heated exchange

British Gas, South Tyneside Homes and Spirax Sarco were interested in developing new storage technology that could be retro-fitted to heat pump installations to make use of off-peak electricity to generate savings, and approached the University of Warwick for assistance with developing different thermal storage designs.

Modular stores were developed that were constructed from polypropylene sheets containing narrow channels carrying water, with thin walled sheets forming an effective plate heat exchanger. However, although polypropylene is lightweight and chemically resistant, it is difficult to bond.

A team within The Interdisciplinary Centre for Storage, Transformation and Upgrading of Thermal Energy (i-STUTE), at the University of Warwick investigated different thermal energy storage materials and exchanger designs to overcome the issue of providing a low cost modular storage system that could be retro-fitted in unused spaces.

The team identified and tested suitable storage materials and demonstrated the efficacy of the heat exchanger design. Experimental results were used to develop a validated system performance model that was used to predict potential economic savings.

Supporting Infrastructure

Highview Liquid Air Energy Storage Facility

The UK's first dedicated research facility for energy storage using cryogenic liquids was opened by The Secretary of State for Business, Sajid Javid MP in 2015. To support the University of Birmingham's cryogenic research Highview relocated its 350kW/2.5MWh LAES pilot plant to Birmingham. The technology can integrate waste heat or cold from industrial processes to increase the system's overall efficiency to over 70%.

The technology could transform future energy systems, reducing the costs of integrating intermittent generation into the electricity system and ensuring power is available when it is most needed. The cryogenic energy storage plant is also connected to the University's electrical grid, providing a small amount of power to the campus.

Smart Grid and Real Time Simulator

Unique facilities at the University of Birmingham are being used to improve understanding of the operation, control and management of smart grid systems powered by energy from distributed sources.

A smart power grid and real-time simulator provides the capability to:

- Realistically simulate smart power grids with the integration of distributed power generation including wind, wave and fuel cell generation systems
- Monitoring and control as well as real-time information integration, monitoring, protection and closed-loop control functions

Thermal Properties Lab

Based at the University of Warwick the Thermal Properties Laboratory will be extended into five newly refurbished test cells. This new space will accommodate additional equipment for analysing thermal properties of materials and provide important information on the behaviour of composite materials as they are used in thermal stores.

Thermal Technologies Lab

The Thermal Technologies Lab at the University at Warwick will be enhanced by the provision of further test equipment and control and data logging facilities. New in-house manufacturing capability will also be provided by the purchase of micro-TIG welding equipment and a laser cutter to allow rapid proto-typing of the bespoke heat-exchangers being developed. New thermal baths will extend the ability to test thermal systems that require controlled heating and cooling.

The European Bioenergy Research Institute

The £20million EBRI building at Aston University contains state-of-the-art facilities including a demonstration power plant, thermal processors, and laboratories which allow companies to explore and develop practical bioenergy solutions.

Research equipment includes the Pyroformer pyrolysis unit, a 400 kg/h fluid bed gasifier, a 400 kWe Combined Heat and Power (CHP) engine and a wide range of laboratory-scale pyrolysis, gasification and hydrothermal processing reactors. Catalytic upgrading facilities, extensive product analysis and characterisation equipment and catalyst design, production and characterisation facilities are co-located at the EBRI. Biorefinery and biofuel synthesis and evaluation, algae production and biomass pre-treatment and characterisation facilities are also installed.

The Manufacturing Technology Centre

The £40million Manufacturing Technology Centre (MTC) based at Ansty Park near Coventry was founded by the Universities of Birmingham, Loughborough and Nottingham in partnership with TWI Ltd. The collective vision for the MTC is for it to become a world-class global research facility, 'making the future' through transformational manufacturing technology development.

The Centre currently focuses on five major technology themes:

- Netshape manufacturing (NSM)
- High integrity fabrication
- Intelligent automation
- Advanced tooling and fixturing
- Computational engineering

The International Manufacturing Thermal Energy Research Accelerator

The University of Birmingham and Loughborough University are entering into an exciting collaboration with the Manufacturing Technology Centre to develop the IM-TERA, co-funded by Government, industry and the Universities themselves.

The Centre will be leveraging Industry 4.0, and other novel manufacturing approaches with the aim of scaling up and modularising the production of technologies that will improve the efficiency of thermal energy systems.

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