



UKERC ENERGY RESEARCH LANDSCAPE: INDUSTRY

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1. Overview

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This industrial energy research atlas presents an overview of industrial-related energy research in the UK. The atlas is strictly related to energy demand reduction (or energy efficiency) rather than the broader but closely related activities of carbon emissions reductions and/or sequestration.

Following the IEA's definition, industrial energy research is classed as either focussing on a reduction in energy consumption in processes including combustion, or on the development of new techniques, processes and equipment for industrial application. Note that the term "industrial energy research" does not mean solely research carried out by or in industry (although it does include this), rather research into industrial activities, which broadly fits into one or both of the above categories.

The compilation of the atlas has been particularly difficult for the industrial sector. Research in other areas not covered by this atlas often has the side-effect of improved energy (or other resource) productivity. There is also problem of classification related to products manufactured for, and applied in, widely different areas and sectors other than industry. For example, products manufactured for the domestic sector are necessarily excluded from this document, although they inevitably drive energy trends within industry itself.

Characterisation of the Field

The industrial sector of the UK economy is the only one to have experienced a significant fall of roughly 40% in final energy demand since the first oil price shock of 1973/74. This was in spite of a rise of over 40% in industrial output in real terms. Consequently, the sector as a whole has seen a dramatic improvement in energy intensity; the primary cause of the drop in energy intensity (or energy ratio) for the

economy as a whole. But this masks different underlying causes: (i) improvements in end-use efficiency; (ii) structural changes in industry; and (iii) fuel switching from coal use in favour of 'cleaner' fuel.

The industrial sector is very diverse in terms of manufacturing processes ranging from highly energy intensive steel production and petrochemicals processing to low energy electronics fabrication. Whereas the former typically employs large quantities of (often high temperature) process energy, the latter tends to be dominated by energy uses associated with space heating. It is useful for analysis purposes to subdivide the multitude of processes into four broad categories: low temperature ($T_p < 394$ K), medium temperature ($T_p = 394\text{--}692$ K), high temperature ($T_p > 692$ K), and mechanical drives. There are around 350 separate combinations of industrial sub-sectors, devices, and technologies in the UK. Each combination offers quite different prospects for energy efficiency improvements and carbon reductions, which are strongly dependent on the specific technological applications. This large variation across industry does not facilitate a cross-cutting "one size fits all" approach to the adaptation of new technologies in order to reduce energy demand, but rather requires tailored solutions for separate industries. Conversely, certain "behavioural" or "good practice" measures are suitable for adoption across the board precisely because of their explicit independence from the type of technology employed.

Research Challenges

In the short term, the road map and priorities for enabling technologies for industrial energy demand reduction are quite clear. There are a variety of technologies that will lead to improvements in industrial processes, boiler operation, compressed air usage, electric

motor efficiency, the effectiveness of heating and lighting systems, and other ancillary uses (such as transport). But the prospects for the commercial exploitation of innovative technologies by the middle of the 21st Century are highly speculative. One of the principal research challenges over the longer term is to provide policy makers with a range of technology assessment methods that will enable them to assess ongoing progress with developments in high temperature processes, improved materials, process integration and intensification, and improved industrial process control and monitoring. Key amongst the appraisal methods applicable to the energy sector is thermodynamic analysis: energy, exergy and

'exergoeconomic' techniques. These approaches are usefully supplemented by techniques such as environmental life-cycle assessment (LCA), environmental cost-benefit analysis (CBA), and the generation of cost supply curves. Thermodynamic methods provide an indication of the maximum improvement potential available from different energy technologies. However, it is important to recognise that this 'maximum' – perhaps an 80% improvement in end-use efficiency in some cases - cannot be achieved in practice. Technical and economic barriers will limit the improvement potential to something closer to 30%. Even that would make a significant contribution to energy demand and carbon reduction in UK industry.

2. Capabilities Assessment

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The UK engineering and science communities are well placed to make significant innovations in terms of both the understanding of industrial processes and the development of novel techniques. Some of these are identified in other sections of the Atlas, for example under various aspects of the 'Demand Reduction', 'Future Sources of Energy', and 'Materials for Advanced Energy Systems' Themes. Mechanical engineers could potentially be at the centre of the drive towards greater thermodynamic efficiency of energy systems, but the UK has fallen behind its Continental European and North American counterparts in this regard. By contrast, British chemical engineers (a rather smaller community) have been internationally active in devising both new processes and methods for improving process performance. Expertise in some of the other fundamental sciences of industrial relevance, such as combustion, fluid dynamics and heat transfer processes, is high. Likewise the materials science and engineering

communities are well placed to develop novel materials that could withstand high temperature or corrosive environments, and that can be produced by way of energy efficient and environmentally benign methods. The attention of electrical engineers since the 1970s has been concentrated on electrical power generation and distribution, rather than its industrial end-uses like electric motors and lighting systems. Major strides have obviously been made in the electronic equipment and information technology areas, which contribute to reducing industrial energy intensity. There are significant economic and organisational barriers to the achievement of technical improvements aimed at producing a low energy and low carbon economy. Here the social sciences have a major role to play, and the UK is quite well placed in contributing towards their application in industry. But more needs to be done in terms of encouraging them to address energy issues in an industrial context.

Table 2.1 Capability Assessment

UK Capability	Area	Market potential
High	Combustion systems Advanced materials Process integration Process intensification	Global Global Global Global
Medium	Compressed air plant High performance electric motors High temperature processes Separation processes Thermodynamics of power and process plant Thermal insulation systems Industrial combined heat & power (CHP) systems for industrial processes Improved industrial monitoring and control Action research in professional practice Agile or lean manufacturing methods	Global Global Global Global Global Global European European Global Global
Low	Factor X improvements in resource productivity	Global

3. Basic and strategic research

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Basic and strategic research oriented towards solving industrial problems is mainly sponsored by the UK Research Councils, principally the Engineering and Physical Sciences Research Council (EPSRC), and the Carbon Trust. Traditionally the Research Councils have responded to grant applications submitted by individual academics: the so-called 'responsive mode'. More recently they have moved in the direction of more co-ordinated programmes via the Carbon Vision Programme (joint EPSRC and Carbon Trust), the EPSRC SUPERGEN Programme, and the UK Energy Research Centre (funded by three of the UK Research Councils - the Economic and Social Research Council (ESRC), the EPSRC, and the Natural Environment Research Council (NERC)).

SUPERGEN takes a new approach to supporting research into sustainable power generation and supply. This multidisciplinary initiative is managed and led by EPSRC in partnership with BBSRC, ESRC, NERC and the Carbon Trust. The initiative aims to help the UK meet its environmental emissions targets through a radical improvement in the sustainability of power generation and supply.

Researchers work in consortia, multidisciplinary partnerships between industry and universities, focused on major programmes of work. This promotes interaction, generation of new ideas and transfer of research results as well as significant step changes in tackling broad challenges rather than incremental progress.

The UK Energy Research Centre's mission is to be the UK's pre-eminent centre of research, and source of authoritative information and leadership, on sustainable energy systems. It undertakes world-class research addressing whole-systems aspects of energy supply and use, while developing and maintaining the means to enable cohesive UK research in energy. To achieve this it is establishing a comprehensive database of energy research, development and demonstration competences in the UK. It also acts as the portal for the UK energy research community to and from both UK stakeholders and the international energy research community.

Table 3.1: Research Funding

Programme	Funding Agency	Description	Committed Funds	Period	Representative Annual Spend
Carbon Vision Industry Programme	The Carbon Trust and EPSRC	Carbon Calculations over the Life Cycle (CCaLC): This research project is providing the tools required to develop step-change reduction in the lifetime carbon emissions associated with basic products and their manufacture. It will involve both environmental and economic aspects of carbon footprints and embodied carbon, enabling estimation of "carbon added" and "valued added" at each stage in the supply chain. In	£1.05m	3.5 years	£300k

		<p>addition, the work will develop a standard data acquisition methodology and databases for use in carbon inventory calculations. The research will produce a systematic approach to estimation of life cycle carbon inventory along the whole supply chain in different industrial sectors:</p> <ul style="list-style-type: none"> * Food Supply Chains * Chemical and Related Products * Building Materials * Bio-energy 			
Responsive mode	EPSRC	<p>Unlocking Low Carbon Potential: A multi-stranded research approach is being adopted. The action research process informed and informing research that draws on technical, economic, sociological and quantitative modelling. These strands will be integrated both through informal teamwork and through a series of dialogue research conferences involving both researchers and a wider stakeholder constituency. The consortium is centred around research projects in four different industrial sectors:</p> <ul style="list-style-type: none"> * Adoption of Air Cycle Conditioning in the Food Industry * Product Specification * Trigeneration in the Food Industry * Energy Service Companies 	£819k	3 years	£273k
Responsive mode	EPSRC	Various awards	£11m spread over 60 projects (with around 25 active at any one time)		£2.75m
SUPERGEN	EPSRC	SUPERGEN is EPSRC's flagship initiative in Sustainable	£26m (spread over 10	4 years	£6.5m

Programme		<p>Power Generation and Supply. SUPERGEN, now part of the Research Councils' Energy Programme, is managed and led by EPSRC in partnership with BBSRC, ESRC, NERC and the Carbon Trust. The initiative aims to help the UK meet its environmental emissions targets through a radical improvement in the sustainability of power generation and supply. The programme is supporting the development of new and improved products for efficient and sustainable power generation and supply. Of the ten consortia, the ones relevant to this Atlas are:</p> <ul style="list-style-type: none"> * Future network technologies * Photovoltaic materials for the 21st century * Conventional power plant lifetime extension * Fuel cells * Highly distributed power systems * Excitonic solar cells * Energy storage <p>In addition, three new consortia have been announced, including one in the area of energy infrastructure.</p>	consortia)	(since Nov. 2003)	
UKERC	ESRC, EPSRC and NERC	<p>The UK Energy Research Centre is the focal point for UK research on sustainable energy. It takes an independent, whole-systems approach, drawing on engineering, economics and the physical, environmental and social sciences.</p> <p>The Centre's role is to promote cohesion within the overall UK energy research effort. It acts as a bridge between the UK energy research community and the wider world, including business, policymakers and the international energy research community and is the</p>	Established in 2004 – part of a £28m interdisciplinary programme across research councils Towards a Sustainable Energy Economy	4 years (since Oct. 2004)	£7m

		centrepiece of the Research Councils Energy Programme.			
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Table 3.2: Key Research Providers

Name	Description	Sub-topics Covered	No of staff	Field
University of Bath, Department of Mechanical Engineering and International Centre for the Environment (ICE)	Lead on UKERC studies of 'Energy Demand Reduction in Industry'. Forms part of the 'Demand Reduction' Theme co-ordinated by Dr B Boardman of the University of Oxford's Environmental Change Institute. Bath contact: Prof. G P Hammond Expertise in the technology assessment of energy systems: an integrated approach is taken using a variety of assessment methods.	<ul style="list-style-type: none"> • Technology assessment of energy systems • Thermodynamic (energy, exergy, and exergoeconomic) analysis • Environmental life-cycle assessment • Environmental cost-benefit analysis (with colleagues in Economics) 	6 staff and research students specific to this research. 50 academic staff in the Department of Mechanical Engineering.	Electrical engineering Mechanical, aeronautical and manufacturing engineering Economics
University of Swansea, Civil and Computational Engineering Centre , School of Engineering	Over the last 30 years Swansea University has been at the forefront of international research in the area of computational engineering. Engineers at Swansea have pioneered the development of numerical techniques, such as the finite element method, and associated computational procedures that have enabled the solution of many complex engineering problems. Originally, the activities in this field were led by the academic staff of the Civil Engineering Department, which has	<ul style="list-style-type: none"> • Injection Moulding Process Intensification 	Total 30 (estimated <5 on this project)	Civil engineering Computational engineering

Name	Description	Sub-topics Covered	No of staff	Field
	<p>consistently achieved the highest rating in all the Research Assessment Exercises (RAE) carried out to date. To strengthen this research excellence, and to broaden its application to other areas of engineering, the Civil and Computational Engineering Centre has been formed by including academic staff and researchers from other engineering disciplines who are also active in computational or applied mechanics. The resulting group of researchers represents an unrivalled concentration of knowledge and expertise in this field.</p>			
<p>Coventry University, Applied Mathematics Research Centre, Faculty of Engineering and Computing</p>	<p>The Applied Mathematics Research Centre is one of a number of Applied Research Centres, or ARCs, set up by Coventry University as part of its drive to enhance its capability to deliver applied research and consultancy. Applied Mathematics has traditionally been one of the strongest disciplines at Coventry University, and offers a very high potential for the University to be at the forefront of research, both nationally and internationally. Over recent years, two related directions have</p>	<ul style="list-style-type: none"> • Reduction of Energy Consumption in Aluminium Smelting 		<p>Applied Mathematics</p>

Name	Description	Sub-topics Covered	No of staff	Field
	emerged, which are unique for the UK, and which offer the greatest potential. These are liquid metal Magnetohydrodynamics (MHD) and Complex Stochastic Systems.			
University of Glamorgan, Faculty of Advanced Technology , School of Technology	<p>Teaching of Engineering and Technology at Glamorgan is underpinned by a vibrant research culture within the Faculty of Advanced Technology. The Faculty has state-of-the-art teaching and research facilities, following a recent multimillion pound investment programme.</p> <p>There are around 165 research students across the Faculty, which has an international reputation for high quality research across all departments.</p>	<ul style="list-style-type: none"> • Development of New Combustion Configuration for Primary Glass Smelting • Feasibility of Firing Primary Glass Melters for Reduction of CO2 Emissions 	120 FT staff and 165 research students (whole faculty)	Engineering, Environmental Technology Construction and Management, Electronics and Computer Systems Engineering, Computing and Mathematical Sciences
University of Leeds, Institute of Materials Research	<p>Mission statement: to undertake internationally leading research and postgraduate training in selected fields in materials science and engineering for serving the future emerging needs of industry and society. The core activities are:</p> <ul style="list-style-type: none"> ▪ electronic and photonic materials ▪ carbon ▪ metallurgy 	<ul style="list-style-type: none"> • A Novel Alloy Electrode for Aluminium Smelting • Energy Efficient Tooling for Injection Moulding 	18 academic, 5 technical/admin.	<ul style="list-style-type: none"> • Non-Ferrous Metallurgy • Specialised Characterisation Techniques • Nanostructured Materials • Rapid Solidification • Modelling • Composite Materials

Name	Description	Sub-topics Covered	No of staff	Field
	<ul style="list-style-type: none"> ▪ characterisation modelling 			
University of Liverpool, Centre for Intelligent Monitoring Systems	<p>CIMS is operated via a Board of Governors with members drawn from a number of multinational companies and several local SMEs. CIMS has been involved in additional multimillion pound projects relating to monitoring a biodegrading process plant with AMEC Plc and monitoring widespread air quality with the Environment Agency and Merseytravel. Since 2002 CIMS has received further ESF funding for a £1.8m technology transfer project and is a partner in a €1.4m European project on air quality monitoring with Liverpool City Council, Suveca (Romania) and Naples (Italy).</p>	<ul style="list-style-type: none"> • High Voltage Current Interruption without SF6 	4 academic, 3 admin.	Diagnoses, measurement and monitoring of complex systems
University of Sheffield, Electrical Machines and Drives Research Group , Department of Electronic and Electrical Engineering	<p>The Electrical Machines and Drives Group is based in the Department of Electronic and Electrical Engineering, which achieved 5* ratings in the 1996 and 2000 Research Assessment Exercises.</p> <p>The Group undertakes fundamental and applied research on enabling technologies which are likely to be central to future developments in electrical power engineering. Its</p>	<ul style="list-style-type: none"> • Low Cost Energy Efficient Compressors for Refrigeration 	13 academic in EMD	Automotive, Healthcare, Aerospace, Industrial, Consumer Products, and Marine

Name	Description	Sub-topics Covered	No of staff	Field
	strategy, therefore, is to maintain a balanced portfolio of projects on a broad range of research topics, and to promote pullthrough of its R&D to commercial exploitation and applications encompassing different market sectors.			
University of Warwick, Process Technology Group (site under development)	The Warwick Process Technology Group is a Centre of Excellence for the research and development of miniaturised small scale and distributed process technologies for the chemical, electronic, aerospace, energy and automotive sectors, with a particular emphasis on the utilisation of renewable sources. This approach is required for the future development of sustainable, and more sophisticated, goods and services.	<ul style="list-style-type: none"> • Radiant Recuperative Burner for Industrial Furnaces Using Permeable Ceramic Membranes 		Multidisciplinary approach, incorporating engineering, chemical and physics research
University of Manchester, Group for Industrial Systems , incorporating the Centre for Process Integration	The Centre for Process Integration at the School of Chemical Engineering and Analytical Science (CEAS) of The University of Manchester is a world leader in the field of process design and integration with an outstanding international reputation for the quality of its research and technology transfer. A fundamental key of the successful relationship that the Centre for Process Integration has always maintained	<ul style="list-style-type: none"> • Efficient use of raw materials • Energy efficiency • Emissions reduction • Process operations 	11 academic staff	Chemical engineering, Process engineering, Chemistry

Name	Description	Sub-topics Covered	No of staff	Field
	with the industry is the Research Consortium - created in 1984 and now formed by 17 major companies representing different aspects of the process and utility industries.			
University of Bristol, Electrical Energy Management Group , Faculty of Engineering	The Energy Management Group is one of many research groups in the Department of Electrical & Electronic Engineering at the Bristol University Engineering Faculty . The group's strengths are in precisely controlling or converting electrical energy into other forms of energy. The group focuses on five research themes and has developed and researched electrical systems from ultra-efficient micro-power supplies to large electric machines, and from individual semiconductor components to complete vehicle drive or power generation systems. The group also provides an application-focused research environment in which students can gain valuable Research & Development experience.	<ul style="list-style-type: none"> • More Electric Technologies • Low Power Systems • Advanced Control and Testing • Intelligent Structures • Renewable Energy Management 	16 including postgraduates	Electronic and electrical engineering
Herriot Watt University, Energy Academy	A large research oven for studying industrial-scale baking processes in detail (developed in collaboration between APV Baker and Heriot Watt) is being used to investigate enhanced rates of heat transfer in baking. The Thermal Performance		2	Interdisciplinary

Name	Description	Sub-topics Covered	No of staff	Field
	Research oven (TPRO) is contributing to the development of a new generation of energy-efficient ovens and to the optimisation of various baking products (bread, buns, biscuits, cake and pizza).			
University of Sheffield, Chemical and Process Engineering	<p>A very important feature of the research environment in CPE is our interdisciplinary research groups.</p> <p>The focus of their research effort through their four groups means that they have been able to build up dedicated, high-quality facilities and to tackle problems larger than those typically associated with single university researchers.</p>	<ul style="list-style-type: none"> • Combustion and incineration group • Process fluidics group • Particle products group • Biological and environmental systems group 	21 academic, 17 research, 6 support, 80 postgraduate	Chemical engineering
University of Surrey, Centre for Environmental Strategy (CES)	CES is a specialist centre for Sustainable Development related research and postgraduate teaching. Co-ordinator of the Carbon Vision Industry project 'Carbon Calculations over the Life Cycle (CCaLC)'. Contact: Prof. A Azapagic.	<ul style="list-style-type: none"> • Environmental life-cycle assessment (LCA) 	40 staff including 18 research fellows. Additional 26 PhD students.	Chemical engineering Environmental sciences
University of Bath, School of Management, Centre for Action Research in Professional Practice (CARPP)	The Centre aims to help individual practitioners develop skills of reflective practice and to assist organisations to develop communities of inquiry.	<ul style="list-style-type: none"> • Co-ordinator of the EPSRC project 'Unlocking Low Carbon Potential', to help reduce the amount of CO₂ released by the food industry. • The project involves researchers from Bath, 	10 staff from 4 universities and OakDene Hollis Ltd.	Mechanical, aeronautical and manufacturing engineering Business and management studies Built environment

Name	Description	Sub-topics Covered	No of staff	Field
		Bristol, Nottingham and Manchester universities and companies such as Unilever, Northern Foods, Hygrade Foods, Baxi Technology and CompAir.		
Cranfield University, Process Systems Engineering Group , School of Engineering	The Process Systems Engineering group (PSE), led by Dr Hoi Yeung , working in partnership with Industry and Government, provides training, research, development and consultancy to meet the challenges of the competitive world market. The particular focus is addressing the needs of the oil and gas, water, process and energy industries.	<ul style="list-style-type: none"> • Energy efficiency in process plants • Environmental and economic optimisation of power plants • Biomass energy production system analysis and assessment • Renewable energy system optimisation 	4 academic	Process and systems engineering
Cranfield University, International Ecotechnology Research Centre	Focus on the design/innovation process, working within various organisations to improve their design performance and to learn what makes such improvements repeatable elsewhere. Team working in design is important, including a focus on design between organisations. To research such subjects we have to be both multi-disciplinary and very practical. Lead on the EPSRC Grant on 'Improving resource productivity through more sustainable solutions'. Contact: Prof. S Evans	<ul style="list-style-type: none"> • Eco-systems • Super-efficient car designs • Urban design and social inclusion • Integrating social/technical systems as well as ecodesign 	21 staff in Cranfield's Manufacturing Department.	Mechanical, aeronautical and manufacturing engineering
Imperial College	Active in Combustion and	<ul style="list-style-type: none"> • Combustion Large Eddy 	60 research staff	Mechanical, aeronautical

Name	Description	Sub-topics Covered	No of staff	Field
London, Department of Mechanical Engineering	Turbulence Research, particularly in the fields of turbulence, combustion modelling and CFD. Lead on the EPSRC Platform Grant on 'Computational Combustion Engineering'. Contact: Prof. W Jones	<ul style="list-style-type: none"> Simulation (LES) Development of PDF transport equation methods for turbulent combustion Development of CFD tools for practical combustion systems Modelling of turbulence 	and over 100 research students in the Mechanical Engineering Department	and manufacturing engineering
Department of Engineering Systems , London South Bank University	The Department is supporting a large number of programmes in the areas of fundamental and applied aspects of engineering. Knowledgeable staff, visiting professors and research fellows provides an inspiring environment to the post graduate research community.	<ul style="list-style-type: none"> Refrigeration Heat Transfer & Thermal Systems Energy Studies Acoustics Manufacturing Surface & Geotechnical Engineering 	13 staff leading relevant research groups.	Mechanical, aeronautical and manufacturing engineering

4. Applied research

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The term *Industry* encompasses a wide range of activities, resulting in a diverse set of organisations providing applied research within the UK. There is limited research that applies directly to energy demand reduction within industry but there is a large volume of research that relates to processes and individual components that are encompassed within the industrial and service sectors.

Three funding schemes have been identified which relate to industrial and service sector energy/carbon reduction. The DTI's *Technology Programme* covers an extensive range of research programmes, and although no call refers specifically to *Demand Reduction in UK*

Industry, a number have components that can be related back to industry.

The Applied Research Grants from the Carbon Trust is open to UK businesses and research institutions and aims to support the development and commercialisation of technology with the potential to reduce UK carbon dioxide emissions. There are approximately 100 current projects, with total committed funds of £90 million, of which £13 million has been spent thus far. They are endeavouring to encourage and support the progress of low carbon technologies towards large scale deployment.

Much of the applied research in the UK is relatively small scale and is being completed by smaller UK firms. There are a couple key players who are recognised globally. Key players in terms of large scale research establishments include AEA Energy and Environment and BSRIA.

A number of organisations address energy and carbon management, these are primarily consultancy firms. Closely linked with these are the

small numbers of firms that provide policy and strategy advise and consultancy services. These firms in general are relatively small when compared to the key players. Technological research is undertaken by a significant number of organisations ranging from academic organisations to technology companies. Company-based research is centred on looking at new technologies which can be applied to processes within industry.

Table 4.1: Research Funding

Programme	Funding Agency	Description	Committed Funds	Period	Representative Annual Spend
The DTI Technology Programme	DTI	The technology programme is a combination of business support products and information that the DTI are offering to businesses. It will identify new and emerging technologies critical to the growth of the UK economy. Those areas related to industry include: Bio-based industrial products and processes, smart materials and related structures, opto-electronics and emerging electronic technologies, manufacturing processes, modern built environment, creative industries, waste management and minimisation.	£320m (available for all studies)	2005-2008	£107m
Applied Research Grants (see here for a full list of all projects)	The Carbon Trust	100 projects The Carbon Trust's Applied Research Programme is open to UK businesses and research institutions and aims to support the development and commercialisation of technology with the potential to reduce UK carbon dioxide emissions. As such they are endeavouring to encourage and support the progress of low carbon technologies towards large scale deployment. When a call-for-proposals is open an on-line for a grant of up to £250K towards the cost of the project is available. A minimum 40% match funding is required, and, to be successful the project must demonstrate: <ul style="list-style-type: none"> • Genuine innovation and the potential to contribute to substantial reductions in UK greenhouse gas emissions • That the work is a well planned and builds on previous work in the area • That the results of the work will allow a clear step forward on the path towards commercialisation • That it represents good value for money 	£90m	Since 2001	£13m to date

Table 4.2: Key Research Providers

Name	Description	Sub-topics Covered	No of Staff	Sector
Rapra Technology Ltd	Rapra Technology was established in 1919, and is Europe's leading independent plastics and rubber specialist organisation, providing research, technology and information services for the polymer industry and for industries using polymers in their products or processes.	<ul style="list-style-type: none"> • Low energy compounding • Extrusion of Solid PVC by using liquid CO₂ 	130 staff	Manufacturing
MIRA Ltd	MIRA is a leading independent provider of product engineering, research, testing, information and certification to the worldwide automotive industry. The company dates back to the foundation of the Institution of Automobile Engineers in 1899. With heritage like that it's no wonder that we're at the forefront of technology today.	<ul style="list-style-type: none"> • Product engineering • Research • Testing • Information • Certification • Training 		Automotive
Furniture Industry Research Association (FIRA)	<p>FIRA is the research association for the furniture industry. It provides various services, and has a private consultancy arm known as FIRA International.</p> <p>It states its main aims as:</p> <ul style="list-style-type: none"> • support its members' businesses • add value to their products and processes • help improve their bottom line performance 	<ul style="list-style-type: none"> • Technical information • Testing • Consultancy • Business advice 		Furniture
PIRA	PIRA is a research association which covers a diverse range of industries. Its main focus is in packaging, including plastics, paper, printing,	<ul style="list-style-type: none"> • Information • Events • Consulting • Testing 		Various (packaging)

Name	Description	Sub-topics Covered	No of Staff	Sector
	publishing and consumer goods.			
Leatherhead Food International Ltd	LFI is a research association for the food and drink industry.	<ul style="list-style-type: none"> • Analysis • Research • Market data • Regulatory guidance 		Food and drink
PERA	Pera is an international network of technology development and industry support centre that helps firms to develop innovative new products, improve business performance and enhance management and leadership skills.	<ul style="list-style-type: none"> • New product ideas • Realisation of ideas • Innovating business processes • Exploiting globalisation • Business intelligence • Training and development 		Various
Food Processing Faraday KTN	The Food Processing Knowledge Transfer Network (KTN) facilitates the introduction of new techniques and equipment to increase the efficiency and quality of the food manufacturing industry in the UK. It is an initiative jointly sponsored by DTI and Defra and has an ambitious set of targets to deliver tangible benefits to its members. Our vision is to be recognized as a world class initiator, translator and disseminator of research and knowledge, which is applied to food processing and which leads to demonstrable improvement to UK Food Processing quality and efficiency.	Research Themes <ul style="list-style-type: none"> • Water, Waste, Energy • Safety, cleaning and hygienic production • Human factors 		Food and drink
CCFRA	CCFRA is the largest membership based food and drink research centre in the world. It undertakes R&D for the many industries associated with agriculture, food and drink manufacture, distribution, retailing and food	<ul style="list-style-type: none"> • Baking and Cereals Processing • Cereals and Milling 		Food and drink

Name	Description	Sub-topics Covered	No of Staff	Sector
	service: in essence those industries which together make up the agri-food chain.	<ul style="list-style-type: none"> • Food Chemistry and Biochemistry • Food Hygiene • Food Manufacturing Technologies • Food Microbiology • Food Raw Materials • Information and Legislation • Market Research and Product Intelligence • New Product Development • Worldwide auditing and HACCP • Sensory Science • Training 		
BHR Group	BHR Group Limited is an independent group of technology companies which provides knowledge-based fluid engineering services and process technology solutions utilising its core competence, facilities and expertise in process technology and fluid dynamics.	<ul style="list-style-type: none"> • Process intensification • Energy efficient systems/processes • Energy Efficient Kilns 		Manufacturing Consulting Engineers

Name	Description	Sub-topics Covered	No of Staff	Sector
Glass Technology Services Ltd	<p>GTS staff have over 20 years experience in the field of stack testing and environmental services. They give GTS a unique resource in this field which is recognised nationally and internationally.</p> <p>GTS has developed the necessary skills to operate at the high stack temperatures typically found in the glass industry.</p> <p>GTS undertakes energy efficiency and climate change levy studies in all sectors of the industry. GTS has a practical understanding of the glass industry's problems.</p>	<ul style="list-style-type: none"> • In factory testing / sampling • Hot end coating emissions • Recycling impact analysis • Energy efficiency studies 		Manufacturing
Schneider Electric Ltd	Schneider Electric is the leading UK and world expert in the development and manufacture of products for the distribution and industrial applications of electricity.	<ul style="list-style-type: none"> • Automotive • Construction materials • Railway rolling stock • Products for industry 		Manufacturing
C-Tech Innovation Ltd	C-Tech Innovation Ltd. is an internationally renowned, development and consulting company, with over thirty years experience, in providing innovation services to companies, universities and governmental bodies.	<ul style="list-style-type: none"> • Environmental Technologies • Gaseous Emission Treatment • Solid Waste Treatment • Wastewater Treatments 		R&D Science and Engineering Consulting Engineers
AEA Energy and Environment	AEA Energy and Environment, a business unit of AEA Technology, helps public and private sector organisations across the world find answers to the growing challenges of sustainable energy, climate change and related environmental issues.	<ul style="list-style-type: none"> • Energy and carbon management • Technology assessment • Policy and strategy consultancy 	180 staff	Management consultancy Consulting Engineers
EA Technology	EA Technology is a multi disciplinary consultancy and service provider, with a world class reputation for delivering innovative business solutions. We have over 40 years	<ul style="list-style-type: none"> • Electricity • Industrial • Petrochemical • Retail & Commercial 		Consulting Engineers

Name	Description	Sub-topics Covered	No of Staff	Sector
Greenfile Developments	<p>experience working for clients worldwide.</p> <p>Greenfile Developments were established in 1997 and are a specialist management consultancy and training company which focus on lean operations.</p>	<ul style="list-style-type: none"> • Process improvements • Sustainable development 		Consulting Engineers
Burnertech Combustion Engineers Ltd	<p>Gas Burner Design Project</p> <p>The design of a full range (14-750kW) of pre-mixed fully modulated gas burners having 5% higher efficiency than conventional burners, and incorporating DC combustion motors with lower electrical consumption and noise emission.</p> <p>In this design air and gas are pre-mixed in the combustion fan of the burner before being blown onto a perforated matrix material, where they are ignited.</p>	<p>This mode of operation leads to a much more controlled and shorter flame length and the following advantages:</p> <ul style="list-style-type: none"> • Smaller combustion chamber sizes are possible. • More restriction can be placed in the boiler to reduce flue temperature and increase efficiency. • Burner modulation is fully controllable. • A radical rethink of boiler design is made possible. 		Consulting Engineers
Cambridge Ltd.	<p>Magnetic Refrigeration Project</p> <p>The project will develop a prototype high efficiency magnetic refrigeration unit, capable of replacing conventional refrigeration systems in air-conditioning, industrial processes and domestic applications.</p> <p>The 'magnetic fridge' is estimated to consume up to 50% less energy than today's equivalent gas fridges that require environmentally toxic gases to operate. The proposed technology is considered to have a large potential for</p>	<p>This project aims to deliver the following key benefits:</p> <ul style="list-style-type: none"> • increasing energy/cost efficiency of running refrigeration equipment • elimination of all gas-based refrigerants (eg CFCs, HFCs, HCFCs etc) • elimination of refrigerant leakage leading to lower maintenance refrigeration products and reduced environmental impact 		Engineering Consultancy

Name	Description	Sub-topics Covered	No of Staff	Sector
	providing positive impacts on both economic and environmental efficiency.	<ul style="list-style-type: none"> • higher energy densities (this refrigerant is a solid and not a gas) with the potential for more compact devices • ease of recycling by avoiding gas refrigerants. 		
E A Technical Services Ltd	<p>Heat Pump With Integral Expansion Turbine:</p> <p>The objective is to develop and test a heat pump with a significantly increased performance brought about by reducing friction and utilising the work of expansion.</p>	<p>This project focuses on a patented heat pump methodology that enables recovery of the energy in the expanding vapour and significantly reduces friction. The net result is a heat pump that provides approximately twice as much heating or cooling for the same energy consumption as a conventional heat pump. The resulting heat pump can be used to heat homes using only 20% of the present electrical consumption and to provide air conditioning at half the current energy consumption.</p>		Engineering Consultancy
Freepower Ltd.	<p>Freepower has spent the last six years developing a novel method of producing electrical power from low grade (150°C upwards) waste heat from any source, be it engine exhaust, flare stack, central heating boiler, industrial process, oven, geothermal heat, or sun. The Freepower system will run on any of these sources without modification; when run on heat provided from renewable</p>			Consortium of industrial collaborators

Name	Description	Sub-topics Covered	No of Staff	Sector
	sources (landfill gas, biomass, geothermal) the electricity is genuinely renewable and when run on heat from other sources it provides energy efficiency enhancement. In both cases, since the system burns no fuel and has no emissions it comes within the clean energy mechanism.			
Horizon Ceramics Ltd.	From Ice to Fire: This project aims to revolutionise kiln construction by using a highly innovative method of manufacturing kiln components that fit together easily in an interlocking system. This will enable kilns to be constructed that have low thermal mass and low conductivity, yet overcome the disadvantages associated with the current ceramic fibre blocks.			
Lontra Ltd	Energy Efficiency Prototype Compressor: The objective is to build, test and refine prototypes of an energy efficient compressor to the point where manufacturers are prepared to enter into commercial partnerships for the development of compressor products.	Lontra considers applications where VSDs have the greatest energy saving impact to be its target market. This is estimated to account for 25% of the existing compressor market. An initial penetration of just 1% of this market would yield annual CO2 savings of 4,000 tonnes and could be reasonably expected to grow at 5%/year.		
PCA Engineers Ltd.	CO ₂ Reduction through better fan/heat exchanger design: The main technical objective is to reduce the motor power required to drive fans whilst			

Name	Description	Sub-topics Covered	No of Staff	Sector
	<p>maintaining or improving their effectiveness. Techniques based on computational fluid dynamics will be developed to enable fan power to be matched correctly to loads for forced cooling systems.</p>			
Perkins Engines Company Ltd	<p>Linking diesel engine research with next-generation biofuels:</p> <p>The objective of the project is to link the development of the next generation of diesel engines, based on the diesel homogeneous charge compression engine (dHCCI) principle, with the next generation of bio-diesel fuels, based on the biomass to liquid (BTL) approach.</p>			
Silsoe Research Institute	<p>Localised air delivery to reduce energy use in the food industry:</p> <p>In this project the main objectives are to design and demonstrate the operation of a full-scale localised cooling system and to define the energy savings that are possible in a factory environment.</p>			Research Institute
Spirax Sarco Ltd	<p>Development of a Steam-Trap Acoustic Sensor:</p> <p>The objective of this project is to better understand the steam and energy losses associated with aging steam traps. This will lead to more effective trap survey and maintenance practice. Specifically, the project is to develop an innovative steam trap acoustic performance sensor that will be of low enough cost for attachment to the majority of steam traps.</p>			

5. Development and Demonstration Funding

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Public Research, Development and Demonstration (RD&D) funding into energy has declined dramatically within the UK over the past two decades or so.

International Energy Agency (IEA) figures indicate that the scale of this decrease stands at around 90%, from around £250 million to under £50 million, in the period from 1988 to 1998. Whilst this mirrors the trend in many OECD countries, it is particularly severe within the UK because of the magnitude, which is significantly larger than that in any other OECD country. Secondly, the UK budget is now

on a par with those of the smaller Spanish, Danish and Norwegian economies, rather than the other leading economies in France and Germany.

The privatisation of public owned and operated utility companies (amongst others) in recent decades has partly caused this decline. For example, British Gas formerly spent £70 million pounds per year on R, D & D, but now Lattice, which took over most of British Gas's research functions, spent just £14 million in the 15 months to March 2002.

6. Research Facilities and other Assets

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Research on energy use in industry is highly dispersed; reflecting some 350 separate combinations of industrial sub-sectors, devices, and technologies in the UK. Specialist facilities can be found in the previous sections under basic and applied research.

7. Networks

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As for RD&D funding, the extent to which networks proliferate in the field of industrial energy research is somewhat limited. The only specifically industry related network that have been identified in the UK are the Ocean Margin LINK programme and the South East England Innovation Relay Centre (SEEIRC).

The SEEIRC is one of the many European Innovation Relay Centres (IRCs), which were established in 1995, to create a pan-European platform to stimulate trans-national technology transfers needs, and to exploit their research results. It provides services across the south east of England, excluding companies in London (normally within the M25 motorway), which include surveillance for nascent technologies, advice in sourcing new technology and expertise, help in promoting technology to potential partners, and practical tips on drafting

abstracts. Many of the requested and/or offered technologies are directly related to industrial processes and are therefore highly relevant to this Research Atlas. Full details of all the technologies can be found in the full Technology Offers and Requests document at <http://seeirc.org/TO-TR.pdf>.

The service is freely available to any company located in the counties of Berkshire, Hampshire, Oxfordshire, Kent, Surrey, West & East Sussex and the Isle of Wight. The SEEIRC has three consortium partners, the Defence Diversification Agency, Technology Enterprise Kent and Thames Valley Technology, with the entire network comprising 240 support organisations that help industry to find support partners across Europe, as well as in the UK.

Table 7.1 Networks

Network	Established	Description	Membership	Activities
Knowledge Transfer Networks (KTN)	The first KTNs were set up in 2005 and the network continues to grow.	KTNs have been set up by government, industry and academia to facilitate the transfer of knowledge and experience between industry and the science base. They bring together diverse organisations and provide activities and initiatives that promote the exchange of knowledge and the stimulation of innovation in these communities. KTNs encourage the active participation of all networks currently operating in their areas and aim to establish connections with networks in other fields that have common interests.	A full list of the 23 KTNs is available here .	Diverse areas, including aerospace and defence, chemistry innovation and resource efficiency.
South East England Innovation Relay Centre (SEEIRC, QinetiQ) (see also section 9)	The first Innovation Relay Centres were established in 1995 with the support of the European Commission.	The aim of the first Innovation Relay Centres was to create a pan-European platform to stimulate trans-national technology transfer needs and to exploit their research results. SEEIRC provides services across South East England, excluding companies in London (normally within M25). The service is freely available to any company located in the counties of Berkshire, Hampshire, Oxfordshire, Kent, Surrey, West & East Sussex and the Isle of Wight. The SEEIRC has three consortium partners: Defence Diversification Agency	The network comprises of 240 support organisations who help industry find technology partners across Europe, as well as in United Kingdom.	SEEIRC is the south east's link into the European Technology Brokerage network, which encourages innovation and exchange of ideas, by facilitating technology transfer across Europe. The service provides: A free service to watch for emerging technologies Advice in sourcing new technology and expertise Help in promoting your technology to potential partners Practical tips on drafting titles and abstracts Assistance in negotiations between

		Technology Enterprise Kent Thames Valley Technology		technology provider and receiver
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8. UK Participation in EU Framework Programmes

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CORDIS is an information space devoted to European research and development (R&D) and innovation activities. Research activities that are currently being undertaken are under Framework Programme 7 (FP7).

IST concentrates on the communications industry and moving forward with new communication systems. New Production and Processes Devices, is closely related to industry as it looking into life cycle optimisation in processes. The outputs from this area could feed directly into the research being undertaken in industry energy demand reduction.

Aside from the EU Framework Programmes, COST is a European wide support scheme set up by a Ministerial conference in 1971 to encourage co-operation in Science and Technology. Present areas that are relevant to industry which are supported included Agriculture, Food Science & Biotechnology, Environment, Forestry and Forestry Products, Material, and Telecommunications & Information Science Technologies.

Within COST there are now 34 participating countries including the 25 Member States of the European Community. COST supports the co-ordination and networking of existing research and activities of public value. **COST does not fund research.**

Table 8.1: EU Framework Programme Participation

Project	Objectives	Action line	Type of Action	UK Participant	Co-ordinator and partners	Total Funding	EU Funding	Duration	Annual Spend
THATEA : Thermoacoustic technology for energy applications	The objective of the THATEA project is to advance the science and technology behind the thermoacoustic energy conversion processes to such a level that would enable reaching conversion efficiencies at which the application of the technology becomes economically attractive. Thermoacoustic energy conversion is a generic cross-cutting energy technology that can be applied in a vast number	FP7: ENERGY.2008.1 0.1.1 Future Emerging Technologies (FET)	Collaborative project (generic)	The University of Manchester	Stichting Energieonderzoek Centrum Nederland, Netherlands 7 partners	€2.21m	€1.49m	2009-01-01 to 2011-12-31 36 months	€0.5m

Project	Objectives	Action line	Type of Action	UK Participant s	Co-ordinator and partners	Total Funding	EU Funding	Duration	Annual Spend
	of applications, requiring heating, cooling, or power both in industry and build environment.								
New Production Processes and Devices	Flexible and intelligent production processes and systems using advances in virtual production technologies, decision-aiding interactive systems, high-precision engineering and innovative robotics; Systemic research (including on biological processes) for sustainable waste management, risk control, reduced consumption of basic products and less pollution; Concepts for life cycle optimisation of industrial systems, products and services, in particular with a view to eco-efficiency and reduced emission of substances which are harmful to the environment	FP6	Nanotechnologies, Materials and Processes	DTI OST			€ 1300m	4 years	
CONRAD: Development and demonstration of a gas-fired recuperative confined	The main objectives of the project are: Improve efficiency and competitiveness of industrial processes in EU; Reduce the energy consumption and emissions of harmful compounds from industry.	FP5: Economic and Efficient Energy for a Competitive Europe, Efficient cross-sectoral	Cost sharing contracts	PED Technologies Ltd	Danish Gas Technology Centre A/S 8 partners	€2.62m	€1.22m	2000-04-01 to 2002-09-30 30 months	€0.49m

Project	Objectives	Action line	Type of Action	UK Participants	Co-ordinator and partners	Total Funding	EU Funding	Duration	Annual Spend
radiant burner		technologies and better managed industrial processes							
DIFFANSTEEL : Production of energy saving high silicon electrical steel by hot dip coating and diffusion annealing	<p>The objective of this project is to utilise these novel technologies to develop an economic integrated manufacturing route for high silicon steel laminations incorporating:</p> <ul style="list-style-type: none"> selective alloying by the preferential diffusion of Si from a Si rich coating applied to conventional low silicon steel strip; to develop rapid heating techniques for the new materials; to specifically develop a novel rapid surface finishing procedure, patented for stainless steel, for these new materials; to devise a lamination cutting process for the brittle high silicon steels; to produces energy-saving motor and transformer designs that can exploit 	FP5: Economic and Efficient Energy for a Competitive Europe	Cost sharing contracts	Cogent Power Ltd, C-Tech Innovation Limited	C-Tech Innovation Limited 6 partners	€2.15m	€1.35m	2002-11-01 to 2005-10-31 36 months	€0.45m

Project	Objectives	Action line	Type of Action	UK Participants	Co-ordinator and partners	Total Funding	EU Funding	Duration	Annual Spend
	<p>the new materials;</p> <ul style="list-style-type: none"> to assess the potential markets. 								
WREED: Development of an energy efficient to reduce the cost of drying food and food waste	The overall objective of the project is to develop a non-pressure steaming approach, with a man metric sealing method for continuous production with features for maximised energy efficiency.	FP5: Economic and Efficient Energy for a Competitive Europe	Cooperative research contracts	Production Engineering Research Association , Echo Food Systems Ltd. , Ceramic Drying Systems Ltd.	Ceramic Drying Systems Ltd. 7 partners	€1.45m	€0.73m	2001-11-01 to 2004-02-01 27 months	€0.32m
EASY2COOL: A cost-effective and energy-saving cooling system to allow high quality preservation of fresh and frozen foodstuff during transportation	Not available	FP5: Assuring electric power flow reliability and stability and increasing power line efficiency	No contract type	Nutrifreeze LTDI , Ewes Fayre , IFOS	Pacaro Export Import SRL 9 partners	€1.4m	€0.7m	2003-05-01 to 2005-04-30 24 months	€0.35m
AHEAD: Development and integration of advanced heat	This project is dedicated to the improvement of distillation processes. The objective will be reached by developing and adopting high-energy efficient	FP5: Economic and Efficient Energy for a Competitive Europe,	Cost sharing contracts	University of Manchester Institute of Science and Technology ,	COMMISSARIAT A L'ENERGIE ATOMIQUE 8 partners	€1.35m	€0.84m	2000-02-01 to 2003-01-31 36 months	€0.28m

Project	Objectives	Action line	Type of Action	UK Participant s	Co-ordinator and partners	Total Funding	EU Funding	Duration	Annual Spend
exchangers and process control for high energy efficient distillation column	heat exchangers and by developing dynamic process control.	Efficient cross-sectoral technologies and better managed industrial processes		Cal Gavin Ltd					
<u>WARMIT:</u> Development of simple, low cost heat recovery technology to help sme suppliers differentiate themselves by adding value to eco-efficient product	The overall objective of our work is to provide the European community of SME suppliers in our sector, with a materials, manufacturing and design technology and tool kit to develop exchangers for low grade heat recovery from low flow waste water, in a wide variety of domestic and industrial product groups and markets.	FP5: Economic and Efficient Energy for a Competitive Europe	Cooperative research contracts	Metallisation Ltd, A K industries Ltd, Select Moulds Ltd, Pera International	HRS Spiratube SL 7 partners	€1.14m	€0.57m	2001-01-01 to 2002-12-31 24 months	€0.28m
<u>EBMIP:</u> Efficient and Better Managed Industrial Processes	The objectives of this project are improvement of energy efficiency by the introduction of the efficient technologies and the reduction of the main pollutant emissions.	FP5: Efficient cross-sectoral technologies and better managed industrial processes	No contract type	Multimedia Sunshine Ltd.	Research and Development Institute for Thermopower Equipment 4 partners	€0.23m	€0.19m	2001-12-01 to 2003-11-30 24 months	€0.093m

9. International Initiatives

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The UK is involved in several international research collaborations, which are mainly confined to a European extent. Most of these involve the Department for Trade and Industry (DTI). They are, specifically, the DTI's Global Watch Service, Innovation Relay Centres (IRCs) and IEA's Energy Technology Data Exchange (ETDE).

The Global Watch Service provides support dedicated to helping UK businesses improve their competitiveness by identifying and accessing innovative technologies and practices from overseas.

IRCs are currently co-funded by the EC under the 5th Framework Programme as part of the Innovation and SME Programme.

Finally, ETDE is a multilateral organization formed in 1987 to further international information exchange. It is a group of countries/entities who have chosen to co-operate to meet a key information need in a more cost-effective way. There is an IEA Implementing Agreement on Industrial Energy-Related Technology Systems but the UK does not participate.

Table 9.1: International Activities

Name	Type	Description	UK Contact Point
Innovation Relay Centres (IRCs)	International Research Network	<p>The Innovation Relay Centres are currently co-funded by the EC under the 5th Framework Programme as part of the Innovation and SME Programme.</p> <p>Cross border group of IRC further exploit their synergies by establishing closer relations, by jointly organising and promoting (cross-border) technology transfer events, and by organizing company missions.</p> <p>The regions selected are based on client companies' expressed preferences on doing business with other companies in the covered regions. IRCs collaborating other than merely in particular technological fields but in determined regions have likewise formed IRC clusters.</p>	Zoe Bowers , London Technology Network
IEA's Energy Technology Data Exchange	International Information Exchange	<p>ETDE is a multilateral organisation formed in 1987 to further international information exchange. It is a group of countries/entities who have chosen to co-operate to meet a key information need in a more cost-effective way.</p> <p>ETDE's objectives are:</p> <ul style="list-style-type: none"> To compile and maintain a shared database on information related to energy research and technology. To disseminate information related to energy research and technology. To explore, and where appropriate develop, other ways of collecting and disseminating information related to energy research and technology. To support the work of the International Energy Agency. 	Claire Ball , DTI

