UKERC

UKERC ENERGY RESEARCH LANDSCAPE: COAL CONVERSION

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1. Overview

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Characterisation of the field

The scope of the coal conversion research topic covers science and engineering activities focused on coking and briquetting applications, the development of underground coal gasification for non-direct power and industrial applications, and various options for coal to synfuels and chemicals.

For basic and applied strategic research, the range of disciplinary inputs includes chemistry, physics, metallurgy and materials science, environmental sciences, mechanical, combustion and chemical engineering, geology and the built environment. Increasingly, a range of disciplines from the social sciences and economics are providing some input into coal related issues. These include assessments of public awareness and attitudes to the use of coal within a sustainable energy mix and the growing use of economic drivers to ensure ever better environmental compliance by coal end users.

Coal conversion research includes coal characterisation, the efficiency of conversion and environmental performance, components development and systems integration. The more basic research comprises the characterisation studies, including the development of innovative analytical and modelling techniques. The applied research programmes are usually designed to provide practical solutions for improvement of the energy efficiency, environmental and economic performance of the various technologies and techniques. Such applied research will often incorporate some basic studies but as means to an end rather than an end in itself.

Research Challenges

Globally, there is a growing concern about fuel diversity and security of supply, particularly with regard to oil and natural gas. For the UK, supplies are very dependent on imports, prices are uncertain, while some suppliers show a willingness to use their oil and gas to influence political decisions. Global demand for oil has been increasing significantly due to the economic development of China and India while oil exploration has failed to keep up with production. Consequently, the use of coal, which is available from a much wider range of sources and has greater price stability than oil and gas, is increasingly attractive. On a global basis, coal use is increasing rapidly, and by 2030 may well reach a level of more than 4,500 Mtoe, corresponding to close to a doubling of current levels. The main market will be in the developing countries, especially China and India, while OECD use will decline. While most of the coal will be used directly in the power generation sector (see the coal combustion landscape), there will still be a significant amount used for coal conversion applications. These include coking, which is commercially proven, underground coal gasification, with a number of large scale trials underway, together with a growing interest in coal to liquids and coal to chemicals schemes, with the deployment of these technologies now at the large scale demonstration stage.

The key coal conversion research challenges are to develop and deploy methods by which coal can be used cleanly, efficiently, and in a sustainable way. In particular, with increasing industrialisation in many developing countries, the need for steel has resulted in a significant increase in the use of coal in the iron and steel sector, which is currently the next largest coal-using sector after the power sector. The R&D needs in the metallurgical industry mirror to a degree those in the power generation sector. Thus there is a need to improve the overall performance and cost effectiveness of existing units while also seeking ways to advance the technology to ensure future environmental compliance, including minimising CO_2 emissions. In broad terms there is a need both to improve the operational flexibility and availability, while reducing energy use through higher efficiencies and also ensuring improved emissions control. The R&D drivers continue to be:

- More consistent oven operation with coals of different rank now available for use from wide ranging sources;
- Reduced operating costs;
- More consistent coke quality and higher production levels;
- Increase of the coal injection rate to improve the cost effectiveness of blast furnace operations; and
- Support for coke oven life extension.

With regard to CO_2 and other greenhouse gases, as well as the benefits arising from increased process efficiency, there is the Ultra Low CO_2 Steel-making (ULCOS) initiative. This seeks to significantly reduce CO_2 emissions and is part of the International Iron & Steel Institute Global CO_2 Breakthrough Programme.

Underground coal gasification (UCG) is the in-situ gasification of coal in the seam, which is achieved by injecting oxidants, gasifying the coal and removing the product gas through boreholes drilled from the surface. The gas, a combination of hydrogen, carbon monoxide, methane, and carbon dioxide can be processed to remove the most of the carbon as CO_2 before it is passed on to end users, thereby providing a source of clean energy with low greenhouse gas emissions. The potential for UCG includes maintaining an acceptable level of security and diversity of energy supply while also reducing emissions of environmental concern. There have been several studies to consider the possible role of UCG as part of a carbon abatement technology strategy. The idea would be to use UCG in combination with carbon capture and storage (CCS) since there is scope to inject CO_2 into adjacent coal seams, which offers the prospect of enhanced coal bed methane (CBM) production alongside CO_2 storage. There is also the option of storing large volumes of dense-phase CO_2 in the voids that would be created by gasifying coal at depths in excess of 800 metres.

There have been several major international large-scale trials undertaken, from which the basic feasibility of UCG has been proven. In particular, the use of highly accurate directional drilling technologies, which can achieve extended reach wells penetrating more than 20 km laterally at depths of over 400 meters, has helped reduce the cost of recovery. With such control, around 80% of the original energy content of the solid coal can be recovered from a production borehole as syngas. This can be used either as a fuel for power generation and industrial heating or as a raw material for conversion into hydrogen, liquid fuels, synthetic natural gas and other chemicals.

Further detailed studies are required to prove the technology of precision drilling process control at greater depths, to fully evaluate any possible environmental impact on underground aquifers and adjacent strata, and to establish the economics of commercial scale operations. Such work is now getting underway, with considerable emphasis in the UK while in Australia, there are plans being implemented to test UCG with coal liquefaction as a possible means to improve the attractiveness of both technologies. At the same time, there is a growing interest in the extraction of shale gas and it remains to be seen what the market impact on UCG will be since in both cases the production costs have yet to be determined.

For coal liquefaction, there are two technology variants. Direct liquefaction converts coal to a liquid by dissolving it in a solvent at high temperature and pressure. The liquid is then hydro-cracked to provide a range of high-grade liquids that can either be used directly or upgraded further to produce transport fuel quality products. With indirect liquefaction, the coal is first gasified to form a synthetic gas mixture, which can then be adjusted to give the required balance of hydrogen and carbon monoxide. This mixture is cleaned of sulphur and then reacted over a catalyst to produce various high-grade products. These include transport fuel substitutes and chemicals. For both processes, the challenges are essentially the same, to achieve high efficiencies of conversion while ensuring that the economics of the processes are such that the technologies can be established on a commercially sustainable basis. This will then offer a viable alternative to petroleum based oil products, while offering a defensive means to reducing exposure to oil price volatility.

At present, a series of large scale demonstration projects are either operational or at the planning stage in China, Australia, Indonesia and the USA. In South Africa, there are plans to significantly expand its commercial scale indirect coal liquefaction process production. In all cases, there is a need to ensure very high standards of environmental performance, while establishing a small carbon footprint. That said, the liquefaction technologies readily lend themselves to the application of CCS techniques.

2. Capabilities Assessment

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For coal conversion activities within the UK, coal use in the metallurgical sector remains the second largest after power generation and there continues to be a significant industrial presence through Tata Steel Europe (formerly Corus) and SSI UK, a 100%-owned UK-based subsidiary of Sahaviriya Steel Industries Public Company Limited, which is the recent new owner of Teesside Cast Products following its acquisition from Tata Steel. Tata Steel Europe, together with a select group of UK universities that retain appropriate high quality research expertise, continues to address the ongoing significant R&D challenges. However, within the UK and elsewhere in Europe, there is continued pressure from potentially lower cost imports of coking coals from several countries. As such, it is doubtful whether there is a significant global market potential arising from these UK R&D activities.

In contrast, there is a significant and increasing focus on UCG, reflecting both the need for diversification of the UK energy mix and the fact that this approach could provide access to the large-scale UK coal resources inaccessible by conventional mining, including the substantial resources under the southern North Sea. In 2009 and 2010, the UK Coal Authority received applications for, and granted, some 14 conditional near offshore UCG licences to companies interested in developing the technology further in Great Britain. These conditional licences enable prospective operators to secure the rights to the coal while projects are developed but do not permit UCG operations to commence until all other rights and permissions are in place, including financial closure. The areas include Swansea Bay, the Humber Estuary and the Firth of Forth. Currently, these various projects are at the preparation stage.

There any major global market opportunities for UCG demonstration and deployment in many coal producing countries. Several UK companies, while active on the development of the UK prospects, are also advising on and developing schemes for technology exploitation overseas in countries such as Indonesia, China, India and Vietnam. Other countries and regions where the technology is of interest include Australia and Eastern Europe. Several universities have built up expertise relevant to UCG and opportunities to utilise their skills are increasing, in part through funding being available via the European Commission.

For coal liquefaction, previously, the British Coal Corporation (BCC) led the UK R&D activities culminating in a successful technical demonstration of their direct process scheme. However, at the time of the privatisation of the UK coal industry, this work ceased when the BCC coal research facilities were closed. Several UK universities maintain some levels of R&D expertise but there have been few opportunities to develop and utilise such skills, as this has not been a recent priority topic for UK R&D funding, while opportunities for EU financial support have been limited. This reflected the lack of economic drivers for the technology due to the very high capital investment required and the potential volatility of international oil prices. However, that global situation is changing and coal liquefaction is seen as potentially strategically important to certain countries, such as China, Australia and the USA. However, the UK capability to now contribute to this particular development is extremely limited.

Table 2.1 UK Capabilities

UK Capability	Area	Market potential	Timescale
High	• Coking techniques • Coal injection techniques	• Limited to the UK and other parts of the EU • Limited to the UK and other parts of the EU	• Now • Now
Medium	• UCG expertise (technology and consultancy)	• Probable global market input.	• Underway with full commercial opportunities within 5+ years
Low	• Coal liquefaction techniques	• Possible market input in countries with very large indigenous coal sources and growing needs for liquid fuels. However, concerns remain regarding competitiveness especially if CCS is introduced for large scale coal based applications.	• 5+ years

3. Basic and applied strategic research

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Within the UK, almost all the basic research is undertaken by universities, as there are no significant independent research institutes remaining. Some of this could be supported, in principle, by the EPSRC through its 'responsive mode' programme while there may be scope for support from the Biomass and Fossil Fuel Research Alliance should the R&D be of interest to the members. All UK universities that are involved in coal related research enjoy good links with UK industry and, as such, most can be involved in R&D collaborative activities with such companies. This is generally through the provision of basic and/or more fundamental research to support an applied, industrially focussed activity.

University-based coal conversion research falls into several different clusters ranging from coal characterisation studies, investigation of emissions from coal conversion processes, supporting studies for component development, together with, at present, a limited input on social studies of public perceptions to coal-based energy technologies.

The universities can be grouped as follows, according to speciality:

- Traditional, practical based research groups working on all aspects of the understanding of coal conversion processes and associated environmental performance, including small scale test-work and associated modelling
- Environmental sciences groups concerned primarily with the monitoring and evaluation of emissions from coal conversion processes
- Research groups that are more concerned with techno-economic aspects of coal conversion
- Groups that are now applying social science assessment techniques to various situations for coal conversion processes

The UK industrial partners themselves are primarily involved in applied research and development, which is focused around large-scale trials on pilot plants, to provide results that can be scaled up with some confidence to demonstration and commercial scale activities. Certain industrial partners also support basic R&D through their membership of BF2RA and via the EPSRC (see table below), for whom selected UK industrial supporters provide comment on proposals received.

Recently, for the reasons outlined above, coal conversion basic and applied strategic R&D in the UK has been primarily limited to blast furnace applications although this is now changing with the growing interest in underground coal gasification.

Table 3.1: Research Funding

Funding Stream	Funding Agency	Description	Committed Funds	Period	Representative Annual Spend
The Biomass and Fossil Fuel Research Alliance	BF2RA	BF2RA was established in September 2009 as a private not for profit company, with a membership that includes representatives from the ESI, major equipment manufacturers, major fuel users and the research sector. Its objectives are to promote research and other scientific studies into key aspects of the production, distribution and use of biomass and fossil fuel and their derivatives. Through its Industrial Members, it provides part-funding primarily for EngDs and PhDs. Since 2010, it has established a portfolio of 12 projects, with a gross value of ~£1.8m. The reduction of carbon emissions from fossil fuel based systems is a key requirement, for which priority themes include the utilisation of fossil fuel and biomass; materials development; advanced cycles for fossil fuel/biomass utilisation and issues relating to performance; and control of emissions and products arising. In principle, coal conversion R&D could be included, although this has not been the case up to now.	~£300k to date	Indefinite	~£150k

Conventional generation and combustion	EPSRC	The EPSRC supports long term research and postgraduate training in order to support UK economic competitiveness and quality of life. This includes providing funding to university partners in projects supported by the Technology Strategy Board. While its energy portfolio includes research on conventional power generation and combustion, the EPSRC had decided to constrain financial support in this area to allow greater support for the less developed, low carbon technologies, such as CCS, which will have a key role to play in the UK's low carbon future. Thus, in recent years, there has been little support for non-CCS applications until, in mid 2012, there was a non-CCS call to establish a research consortium to address the key challenges in conventional power. Key topics included the need for improved plant efficiency, flexibility, fuel flexibility, and sustainability. As such, coal conversion R&D does not readily fit the current EPSRC guidelines. While there is scope, in principle, to seek support for generic studies of the handling, characterisation and properties of coal for some conversion processes, these would be unlikely to be viewed as priority applications.			Not applicable.

Table 3.2: Key Research Providers

Name	Description	Sub-topics covered	No of staff	Field
Cranfield University: Centre of Energy and Resource Technology	Main interests include underground coal gasification and the use of the gas produced, and utilisation of waste gases from coke and steel making in energy systems	• Characterisation of coal and related products • Pyrolysis and gasification processes • Operation of deep and shallow UCG schemes - impact of changing operating conditions on gas quality • Use of gases in gas turbines and combustion engines • Techno-economics and process modelling • Risk and reliability studies • Environmental impact assessments	35 academic and research staff	Chemical Engineering, Energy Engineering, Mechanical, Metallurgy and Materials
Heriot-Watt University, Institute of Petroleum Engineering	Interests in determining use of UCG as the basis for future coal extraction techniques	• Stress-sensitive petrophysical and rock property data • Geo-mechanical appraisals of reservoirs • Coupled modelling • Sand control Compaction drive and subsidence prediction • Underground Coal Gasification	29 fulltime academic staff 92 researchers	Earth Systems and Environmental Sciences
Imperial College, Department of Chemical Engineering and Chemical Technology	This Department is interested in all aspects of coal characterisation for various coal processing routes	• Coal pyrolysis, hydropyrolysis and liquefaction • Coal devolatilisation • Characterisation of coal products distribution • Coal conversion	42 full time academic staff, 49 research staff	Chemical Engineering

Name	Description	Sub-topics covered	No of staff	Field
		characterisation • Extract reactivities • Analytical techniques development		
Imperial College, Department of Materials	Interests include the physical/chemical properties of coal and chars, conversion residues, characterisation and the development of analytical methods.	• Coal microstructure • Mineral distributions and properties • Deposition/fouling/slagging mechanisms under various process conditions • Materials for underground coal gasification •	34 Full time academic staff 76 research staff	Metallurgy and Materials
Keele University, Institute of Environment, Physical Science and Applied Mathematics Research	Ongoing research in Coal Bed Methane and associated petro-physical behaviour (Current Drilling on Campus) Underground Coal Gasification/CCS in collaboration with University of Oviedo and CARBONENERGY Australia	• Engineering and high resolution geophysical monitoring and investigation of the geo-reactor process zone • Tectonic processes • Hydraulic fracture	6 full time academic staff 6 researchers	Earth Systems and Environmental Sciences
Newcastle University, Newcastle Institute for Research on Sustainability	Production, cleanup & use of syngas from UCG Assessment of environmental implications of UCG-CCS	• Better understanding of the North East's extensive coal resource and its suitability for gasification • Development of directional drilling technology for gasification	5 academic staff 15 researchers	Earth Systems and Environmental Sciences; Chemical engineering; Electrical and Electronic

Name	Description	Sub-topics covered	No of staff	Field
		• Control of the gasification reaction • CO_2 storage in the coal seam voids created through UCG • Synthesis gas cleanup to enable a range of end uses • Assessment of environmental risks from UCG-CCS		Engineering
Newcastle University, School of Chemical Engineering and Advanced Materials	Main interests are fundamental studies of coal utilisation, with emphasis on pollutants formation and release.	• Carbonisation • Environment • Physical/chemical properties • Release of nitrogen. sulphur and chlorine species during carbonisation • Coal thermo-plasticity • Chemistry of pitch and pyrolysis products in coking processes • Coal swelling characterisation • Coal petrography	36 full time staff 12 research staff	Chemistry; Chemical Engineering
University of Bath, Department of Chemical Engineering	Main interests are basic studies of coal under various processing schemes	• Basic reactions of coal pyrolysis schemes • Physical/chemical properties of coals and coal chars structures • Characterisation and analyses	18 full time academic staff	Chemical Engineering; Metallurgy and Materials
University of Cardiff, School of Engineering	The School of Engineering has a specific interest in	• Oxy-coal injection into blast furnaces		Chemical Engineering

Name	Description	Sub-topics covered	No of staff	Field
	coal injection processes	• High temperature coal fragmentation		
University of Greenwich, The Wolfson Centre	Main interest is handleability (i.e. transportation, storage and discharge). Additional expertise in maintaining bulk particulate properties (ie. blend homogeneity) and minimisation of particle attrition or agglomeration in storage.	• Characterisation of particle properties • Design of bulk storage and reclaim equipment • Pneumatic conveying • Quantification / control of generation of fugitive particles through handling operations		Mechanical, Aeronautical and Manufacturing Engineering
University of Kent, School of Engineering	Sensors and instrumentation	• Oxy-coal injection to blast furnaces flame imaging • Flame stability and temperature measurement • Physical characterisation of particles		Electronic Engineering, Electrical and Electronic Engineering
University of Leeds, School of Civil Engineering	This department is interested in underground coal gasification	• Geo-mechanic modelling • Hydro-geological modelling • Process modelling		Civil engineering
University of Nottingham, School of Chemical, Environmental and Mining Engineering	The University undertakes R&D on all aspects of coal utilisation, including characterisation, handling, preparation, conversion. There is also work on the synergies of CO_2 capture in association with underground coal	• Carbonisation, • Liquefaction, • Pyrolysis, • Hydro-pyrolysis, • Briquetting • Coal thermo-plasticity • Carbonisation strength/structure properties	25 full time academic staff 22 research staff	Chemistry; Chemical Engineering

Name	Description	Sub-topics covered	No of staff	Field
	gasification.	• Coal liquefaction products characterisation • Coal petrography • Novel binders for briquettes • PAH emissions control • Analytical methods development • CO_2 capture in conjunction with UCG		
University of Strathclyde, Carbon Materials and Energy Group	Main interests are structural issues for coal utilisation processes	• Coal conversion • Coal products characterisation • Coal structures		Chemical Engineering, Mechanical, Aeronautical and Manufacturing Engineering
University of Ulster School of the Built Environment	Focus is on techo-economic analyses of various coal utilisation schemes using the ECLIPSE modelling package	• All coal based energy conversion processes		Chemical Engineering; Chemistry; Mechanical, Aeronautical and Manufacturing Engineering

4. Applied Research and Development

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There is a limited number of organisations that undertake applied coal conversion research and development in the UK. These include two major industrial companies, one of which, Tata Steel Europe, provides technical support to its metallurgical business and the other, CPL Industries Limited, which undertakes some work to support its position in the UK coal products market.

Tata Steel Europe (formerly Corus, which had been formed through the merger of British Steel and Koninklijke Hoogovens) is an international company that provides steel products and services to customers worldwide. In the context of coal conversion, its R&D focus is primarily short-term with the emphasis on reducing emissions from coke ovens, improving coke quality and the efficiency of coke making, maximising the impact of direct coal injection into furnaces as a way of reducing costs and improving efficiency.

CPL Industries' activities include the supply and distribution of coke, smokeless fuels and other products such as central heating oil, diesel, petrol, lubricants, marine fuels and gas oil to the UK domestic market. Its coal based R&D includes work to optimise the production of smokeless fuels for domestic and industrial applications, using by-products of carbonisation such as anthracene oil and coal tar pitches. These form the basis of products such as activated carbons, binders and materials for the construction industry.

Table 4.1: Research Funding

The funding providers for applied research and development are, at present, limited to the UK Technology Strategy Board and the Research Fund for Coal and Steel, the latter being described in Section 8.

Programme	Funding Agency	Description	Committed Funds	Period	Representative Annual Spend
The Carbon Abatement Technology (CAT) Programme	Technology Strategy Board	The Technology Strategy Board (TSB) stimulates technology enabled innovation in the areas which offer the greatest scope for boosting UK growth and productivity. Energy generation and supply is a high priority and for coal the TSB has supported industry led R&D, with supporting basic research input from universities and other research organisations. To date, jointly with DECC and the Northern Way, the focus has been on carbon abatement technologies. Consequently support for coal conversion technologies is not a priority topic.			

Table 4.2: Key Research Providers

Name	Description	Sub-topics covered	Scale of Operation	Sector
CPL Industries Limited	This company has research interests in the production of coal products for domestic and industrial applications.	• Briquette products for domestic applications • Coking products for metallurgical applications • Coal products characterisation • Analytical procedures		Manufacturing
Gastec at CRE A trading division of Kiwa Ltd	This company has interests in the characterisation of smokeless fuels and cokes for the domestic sector	• Appliance and fuel testing • Promotion of solid fuel use in the domestic sector	35 staff	Consulting engineers
Ricardo-AEA	Ricardo AEA provides consultancy to public and private sector organisations across the world to find answers to the growing challenges of sustainable energy, climate change and related environmental issues. This includes some input on coal related issues.	• Energy and carbon management • Technology assessment • Policy and strategy consultancy • Environmental and economic performance	6 staff working on coal related consultancy	Consulting engineers
Tata Steel Europe	It is a major UK industrial company, with interests in all aspects of coking and coal injection for blast furnace	• Carbonisation characterisation • Coal injection characterisation		Manufacturing

	applications.	• Coal and coke properties • Coal/coke impacts on blast furnace operation • Blending for coking and coal injection		
UCG Association Ltd	This UK based organisation, formerly the UCG Partnership Ltd, is a world-wide centre of expertise and information on commercialisation of UCG.	• Regulations, licensing, legal and finance • Annual Conference dedicated to UCG • Organises annual training course	3 plus support via Advisory Council and Research Group	Consulting engineers
Wardell Armstrong llp	This company offers consultancy and feasibility studies to companies interested in all forms of coal extraction and in particular Underground Coal Gasification	• Geological and Hydro-geological evaluation • Coal properties • Environmental and social studies including ESIA	350	Consulting engineers

5. Demonstration Funding

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In principle, a project that focuses on some form of significant carbon abatement in a blast furnace could apply for demonstration funding via either the TSB Programme or the EU FP7 Programme (see also Section 8). For coal liquefaction, the lack of any industrial champions would preclude any possibility of a demonstration project being put forward from the UK. For UCG, while demonstration funding sources are not currently available, the UK Coal Authority has issued licenses for industrial scale pilot projects to characterise and assess the UCG potential in various offshore locations. Should some of these be successful, then the next step could be either a major technology demonstration, for which UK/EU funding would be sought, or direct commercial applications.

Licensee	Location of industrial pilot project	Region
Clean Coal Energy Ltd.	Canonbie Offshore Area	Scotland
	Swansea Bay Offshore Area	South Wales
East Coast Energy Ltd.	East Anglia Offshore Area	Eastern England
	Humberside Coastal Area	Eastern England
	Sunderland Offshore Area	North East
Europa Oil & Gas Resources Ltd/Oxford Energy Consulting Ltd.	Holderness Offshore Area	Yorkshire
	South Humber Offshore Area	Eastern England
Riverside Energy (Amble) Ltd.	Amble Offshore Area	North East
Riverside Energy (Liverpool) Ltd.	Liverpool Bay Area	North West
Riverside Energy (Scotland) Ltd.	Central Firth of Forth Area	Scotland
	Musselburgh Offshore Area	Scotland
Riverside Energy (UK) Ltd.	Thames Estuary Area	South East
Riverside Energy (West Cumbria) Ltd.	West Cumbria Offshore Area	North West
Thornton New Energy Ltd.	Area 1-NT39	Scotland

6. Research Facilities and Other Assets

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Gastec at CRE offers independent R&D/testing/certification facilities for small-scale coal-conversion applications, namely smokeless fuels for the domestic sector. For larger scale industrial applications, there continue to be some large-scale test facilities available, but only via two industrial organisations, as set out in the table below.

Table 6.1: Research Facilities and Assets

Name	Description	Type of asset	Number of Supporting Staff	Annual Operating Budget
Tata Steel Europe	Laboratory, pilot and plant scale ovens	Used for own R&D		
CPL Industries Limited	250kg moving wall test oven Pilot scale briquetting press Domestic appliances for solid fuels testing	Used for own R&D		
Gastec at CRE	Domestic appliances for solid fuels testing	Independent testing and certification facilities		

7. Networks

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There is one network relevant to coal conversion R&D in the UK. The Coal Research Forum acts to promote informal networking with the benefit of developing collaborative relationships between members having similar interests.

Table 7.1 Networks

Network	Date Established	Description	Membership Profile	Activities
The Coal Research Forum	The Coal Research Forum (CRF) was formed in 1989 to bring together those organisations in UK with interests in coal research, with the aim of promoting and integrating their interests.	The objectives of the CRF are to: • Contribute to and encourage development of a national policy on UK coal research. • Promote coal and energy research with funding bodies. • Encourage and promote submission of proposals on coal research. • Record successful funding applications for UK coal research. • Encourage dissemination and exchange of information on coal research. • Further develop the co-ordination of coal research activities between universities, industry and others. • To publicise the achievements and successes of coal research in the UK.	The members comprise those organisations and individuals with an interest in coal research. The activities are co-ordinated by an Executive Committee with members from industry and universities. The CRF has six research divisions: Combustion, Advanced Power Generation, Coal Conversion, Coal Characterisation, Environment and Coal Preparation.	The Divisions each hold meetings, seminars and talks to update members on current coal research issues and to establish where further research and development (R&D) is needed. • There are two meetings each year, in the Spring and Autumn, of the whole Forum, which bring together wider audiences on topics of more general interest to members. The Forum also provides information such as: • A register of UK Coal Researchers. • A report on Coal R&D Successes in the UK. • A Handbook on British, European and American Coal Sample Banks. • A report on Coal Research and Engineering Needs in the UK. • A four monthly newsletter, which contains information on research events, current research contracts, and other topical news.

8. UK Participation in EU Activities

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The EU 7th Framework Programme (FP7) does not support work on coal conversion as such although there is some scope for projects to reduce CO_2 emissions from such processes, e.g. coking. This leaves the Research Fund for Coal and Steel (RFCS), which is administered by the European Commission. This funds projects on coal conversion, which can include research and demonstration projects, accompanying measures, as well as support and preparatory actions. The number of new projects supported each year varies and depends on the total budget available as well as on the budget claimed by each individual project. Thus if a high cost project is rated highly and is funded, its inclusion means that the level of funding for additional projects is reduced.

Projects that involve UK organisations and either remain active or will commence in early 2013 are listed below. In each case, contracts have been signed with the Commission to implement the R&D programme and information is in the public domain.

Table 8.1: UK Participation in EU Activities

Project	Objectives	Action Line	Type of Action	UK Participants	Co-ordinator and partners	Total Funding	EU Funding	Duration	Annual spend
HUGE 2 Hydrogen oriented underground coal gasification for Europe - Environmental and Safety Aspects	• To address safety and environmental aspects of underground coal gasification, through trials of a two borehole system in a mine • To investigate practical solutions for prevention of possible leakages by use of reactive barriers to prevent contamination of underground aquifers and potential leakage of poisonous and explosive gases into the surrounding strata.	RFCR-CT-2011-00002	Project	UCG Engineering Ltd.	Główny Instytut Górnictwa, Poland 7 partners	€2.07m	€1.24m	July 2011-June 2014	€0.69m

Project	Objectives	Action Line	Type of Action	UK Participants	Co-ordinator and partners	Total Funding	EU Funding	Duration	Annual spend
ECOWATER Enhanced treatment of coke oven plant wastewater	• To reduce discharges of priority substances and priority hazardous substances (PS and PHS) in coke oven effluents in order to meet the objectives of the EU Water Framework Directive • To characterise the behaviour of PS and PHS in the coke oven wastewater treatment process • To study the chemical and ecological impact of coke oven effluents upon the quality of local river basins • To enhance the efficiency of biological effluent treatment plants using novel molecular biology approaches • To investigate the use of advanced photo-oxidation, filtration and adsorption techniques for the abatement of PS and PHS in effluents.	RFCR-CT-2010-00010	Project	Tata Steel University of Sheffield	Tata Steel, UK 3 partners	€1.05m	€0.63m	July 2010-December 2013	€0.30m

Project	Objectives	Action Line	Type of Action	UK Participants	Co-ordinator and partners	Total Funding	EU Funding	Duration	Annual spend
FECUNDUS Advanced concepts and process schemes for CO_2 free fluidised and entrained bed co-gasification of coals	• To integrate schemes for the co-gasification of coal, biomass and wastes with processes for CO_2 separation and capture, based on fluidised bed and entrained flow gasification processes.	RFCR-CT-2010-00009	Project	Imperial College of Science, Technology and Medicine	IRC-CNR, Spain 8 partners	€2.88m	€1.73m	July 2010-June 2013	€0.96m
SPRITCO Generation of swelling pressure in a coke, transmission on oven walls and consequences on wall degradation	• To improve the knowledge of the swelling pressure generation phenomena • To develop advanced methods to measure phenomena and their consequences on ovens • To develop a prediction model of wall pressure.	RFCR-CT-2010-00006	Project	University of Nottingham	Arcelormittal Maizieres Research SA, France 5 partners	€1.94m	€1.17m	July 2010-December 2013	€0.55m

Project	Objectives	Action Line	Type of Action	UK Participants	Co-ordinator and partners	Total Funding	EU Funding	Duration	Annual spend
DENSICHARGE Improving the use of alternative raw materials in coking blends through charge densification	• To improve the use of alternative materials in coking coal blends by delivering technological solutions to increase oven charge bulk density for EU plants, through an integrated series of trials supported by process development and mathematical modelling • To investigate charge pre-treatment/densification methods to increase use of alternative materials in coking blends at existing plants • To evaluate the influence of alternative raw materials, blends and pre-treatment processes on charge bulk density, carbonisation, coke oven operating conditions, coke quality and yield • To assess the economic and environmental feasibility of alternative materials and pre-treatment technologies for industrial coke production.	RFCR-CT-2010-00007	Project	Tata Steel University of Nottingham	Tata Steel, UK 8 partners	€2.87m	€1.72m	July 2010-June 2013	€0.96m

9. International Initiatives

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The IEA Clean Coal Centre has produced a significant number of technical and economic assessments on coking, coal liquefaction and underground coal gasification. In addition, the IEA Greenhouse Gas R&D Programme undertakes assessment activities of relevance to the above-mentioned technologies.

Table 9.1: International Activities

Name	Type	Description	UK Contact Point
Clean Coal Centre	IEA Implementing Agreement	The IEA Clean Coal Centre provides a source of unbiased information on sustainable use of coal worldwide. Services are delivered to governments and industry through direct advice, review reports, facilitation of R & D and provision of networks. The Centre provides technical assessments, economic reports and market studies on specific topics throughout the coal chain. It also provides data bases on coal characterisation, coal fired power plants and emissions standards.	The managing director is Dr John Topper. The UK is represented by Mr Tom Wintle of DECC tom.wintle@decc.gsi.gov.uk
Greenhouse Gas R&D Programme	IEA Implementing Agreement	The IEA Greenhouse Gas R&D Programme (IEA GHG) is an international collaborative research programme. IEA GHG focuses its efforts on studying technologies to reduce greenhouse gas emissions. IEA GHG was established in 1991 and aims to provide its members with informed information on the role that technology can play in reducing greenhouse gas emissions. The Programme has three main activities which are: • Evaluation of technologies aimed at reducing greenhouse gas emissions, • Promotion and dissemination of results and data from its evaluation studies, • Facilitating practical research, development and demonstration activities (R,D&D)	The managing director is Dr John Topper. The UK is represented by Ms Louise Barr of DECC louise.barr@decc.gsi.gov.uk