No. 70 **May 2014**

NEWSLETTER

of the Coal Research Forum

EDITOR'S MUSINGS:

Preparations are now well under way as we begin the countdown to our next conference. This will be the 10th European Conference on Coal Research & Its Applications and it is to be hosted by the University of Hull. The programme is complete and registration is open so please check out the website www.maggichurchouseevents.co.uk/crf. Don't forget that the CRF can provide travel bursaries for students of its members who wish to attend. This edition of the newsletter contains a report on the Combustion Division seminar entitled "Combustion for Low Carbon Power Generation"" which, along with the AGM, was held at the University of Warwick on April 8th 2014.

It is worth noting that in 2014 the Coal Research Forum will be celebrating 25 years in existence. Two groups met in late 1988, one representing the energy industries (Energy Industries Research Liaison Group) and the other representing the academic community. The aim was the formation of a body to promote coal science and engineering in the UK. The result of this meeting was the formation of the Coal Research Forum and the rest is, as they say, history.

"A new report by the Intergovernmental Panel on Climate Change shows that global emissions of greenhouse gases have risen to unprecedented levels despite a growing number of policies to reduce climate change. Emissions grew more quickly between 2000 and 2010 than in each of the three previous decades". This is the first paragraph of the latest IPCC press release dated 13th April 2014. As I read it I began to ask myself questions like: Are these findings a surprise? Probably not. Will anything significant be done as a result of this report? Probably not. **Can** anything be done to arrest climate change? Probably not. **Will** anything be done that will make a measurable difference? Probably not. Given the increasing global demand for energy and burgeoning population, is it sensible to try to control climate change? Probably not. Would it be better to try harder to adapt to climate change rather than try to combat it? Probably. Anyway those are my views, what do you think?

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Student Bursaries for 2014-2015

Up to 6 travel and subsistence bursaries for up to £300 are on offer to bona-fide full-time students wishing to attend appropriate National and International coal-related conferences, (please see the Calendar of Coal Research Events for details), such as the "Tenth European Conference on Coal Research and its Applications", (10th ECCRIA), to be held at the University of Hull on 15th to 17th September 2014, (for details, please see page 1, Editor's Musings). To apply, please send the abstract submitted to the conference with a brief supporting letter from your supervisor to:

Prof. J.W. Patrick
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The requirements for eligibility for award of a bursary are that the recipient will submit a short report about his or her impressions of the conference to the Newsletter Editor for inclusion in the next edition. In addition, the report will provide some brief details of the beneficiary, their topic of study and the reasons for wishing to attend the conference.

Report of the 25th Annual Meeting and Meeting of the Combustion Division

Tuesday April 8th 2014,
The Business School Lecture Theatre
University of Warwick

Having cracked the entry code to the Business School, the attendees gathered for the 25th Annual Meeting at what was a first for us at this venue, the University of Warwick. The attendance was rather smaller than hoped for but nevertheless a reasonable group filed in to the comfortable lecture theatre B0.12. The meeting was opened by a welcome address from Professor Jihong Wang of the University of Warwick. The format of the day was, as in previous years, two sessions involving presentations with the theme "Combustion for Low Carbon Power Generation" from the Combustion Division separated by the Coal Research Forum Annual Meeting and reports from the Divisional Chairmen. This was followed by the final session of presentations from the Combustion Division.

Session 1 was chaired by Professor Jon Gibbins of the University of Edinburgh who began the proceedings by introducing Mr Richard Dean of Alstom Power Ltd. Richard's talk was entitled "The White Rose Project". Richard had previously presented some of Alstom's work in biomass and CCS technology at a CRF seminar at Drax in April 2012. This was essentially an update on the status of the project at this point in time.

The White Rose Project is a new, ultra-supercritical 426MWe (gross) Oxy-Power Plant located at the Drax Power Station Site, Selby, North Yorkshire. All of its flue gas will be treated and 90% of the CO2 produced will be captured, producing 2 million tonnes CO2/year. The unit will be biomass co-fired leading to zero - or negative - CO2 emissions. It is to be the anchor project for National Grid's regional CO2 transport and offshore storage network. The CO2 is to be permanently stored in a deep saline formation offshore beneath the North Sea.

The White Rose Project was the preferred bidder in the UK's £1 billion CCS Commercialisation Programme. The Front End Engineering and design (FEED) contract has been awarded - signed by the UK Government on 20th December 2013 - and is underway. This detailed risk reduction and planning programme will lead to financial close, final investment decision (FID) and construction commencement. Work is continuing with the UK Government (DECC) towards project contract and Contract for Difference (CfD). NER 300 application has been made and

this is also sponsored by UK Government; it is the only CCS project in the New Entrants Reserve (NER) competition with the European Investment bank (EIB) due diligence on-going. Re-engaging with the funding community is in progress after strong interest shown during the pre-FEED phase. Project objectives are to demonstrate Oxy-combustion CCS technology as a reliable, flexible and competitively priced low-carbon technology; to help reduce CO2 emissions in order to meet future environmental legislation and to combat climate change; to improve the UK's security of electricity supply by providing a coal-based low carbon electricity generation option; to generate enough low carbon electricity to meet the energy needs of more than 630,000 homes and to act as an anchor project for the development of a CO2 transportation and storage network in the UK's most energy intensive region.

The timescale for the project is that the FEED and risk reduction phase will take two years and will end in 2015; construction ~4 years; start-up/commissioning ~2019; commercial proving and testing 1 – 3 years and full commercial operations commencement ~ 2021 – 2023.

The partner objectives are as follows:- Alstom having validated Oxy-combustion CCS technology at pilot-scale is seeking to demonstrate the technology's efficiency and value on a large scale demonstration project; Drax is actively looking for possibilities to reduce CO2 emissions and recognises CCS as an essential medium to long term decarbonising solution for existing and new-build coal-fired power plants and BOC is seeking to demonstrate efficient large scale air separation units to meet the needs of future Oxy-combustion projects. With these aligned objectives, Drax, Alstom and BOC joined forces to develop the White Rose Project at the Drax site. Upon demonstration, Alstom and BOC will be able to commercialise Oxy-combustion technology for full scale applications.

Oxy-combustion was chosen for the White Rose Project as the technology is very similar to existing air-fired operation and is developed from well-known systems and processes. The air and gas separation units have already been developed as part of other industrial processes. Compared to post-combustion technologies, Oxy-combustion does not require large quantities of chemicals that are new to the power plant environment for CO2 removal. Quantities of gaseous emissions (NOx and SOx) released into the atmosphere are very low. Oxy-combustion has the potential to be retrofitted to existing plant if sufficient land is available and the technology has been proven through pilot projects around the world.

The Oxy-combustion system for CCS entails the use of oxygen mixed with recycled CO2-rich flue gas instead of air for the combustion process. Nitrogen is eliminated from the system leading to flue-gas consisting largely of CO2 and water. This flue-gas is further treated and compressed before being transported for storage.

In addition to conventional coal-fired power stations the Oxy-combustion process requires an Air Separation Unit (ASU) which produces near pure oxygen from air and a CO2 processing unit, known as the Gas Processing Unit (GPU), to treat and compress the captured CO2 to meet pipeline specification.

Some modifications to the power plant are also necessary, for example, CO2-rich flue-gas is partially recycled to maintain the required temperature and heat absorption rates in the boiler, water is removed from the flue-gas before treatment in the GPU and air leakage into the boiler and flue-gas system has to be minimised

Oxy-combustion is reliable in that the main components exist thus drawing on a high degree of conventional technology. The process is fuel flexible and is applicable to all types of boilers, firing systems and fuels. There are no constraints anticipated on scale-up for units based on the Schwarzepumpe pilot.

A considerable amount of effort is needed to validate the CO2 transport and storage options in order to ensure the success of the project. Transport development has included the onshore route planning with a now completed public consultation; offshore route planning is on-going.

A route corridor for the offshore pipeline has been identified and surveys are now complete. A regional assessment has been completed for CO2 storage development and Block 5/42 has been identified as a prime target leading, in 2012, to the receipt of the UK's first CCS license. Store appraisal is in progress with the first appraisal well drilling completed in summer 2013.

The overall benefits include investment and jobs and the project will boost UK economy by £1.3bn and generate 4,000 skilled jobs to 2020 and 400 permanent long term jobs there after. By 2030 the area's economic output is expected to increase by 0.8% per year, attracting up to £11billion foreign investment, supporting 11,000 jobs' and creating 2,000 new jobs. The UK-based CCS industry should benefit by between £3 - 6.5bn p.a. nationally by the late 2020s, sustaining between 70,000-100,000 jobs. In terms of CO2 reductions, the cost of achieving 2050 targets could be £32bn higher by 2050 without CCS. In addition, CCS could be a major contributor to the 4th Carbon Budget Period targets (c.a. 119 Mt/a).

The UK CCS Commercialisation programme and NER 300 funding via the European Commission are essential to take CCS from the demonstration stage to full commercialisation.

Richard closed his talk by reminding us that the White Rose Project will show that abated fossil-fuel power stations will be able to generate flexible, reliable and affordable power as mid-merit plants, providing security of supply and grid stability complementing base load nuclear generation and intermittent renewables.

The second presentation of this session was given by Dr Robin Irons of E.ON New Build and Technology Ltd. His talk was entitled "Combustion issues in low-carbon fossil power plants for the 21st Century". Robin began by posing the question "What is acceptable combustion and what are the factors which will determine acceptability". The answer was, according to Robin, the nature of the fuel and comburent, which will affect combustion and emissions, and materials and flexibility which will determine acceptability. Starting with the fuel diet available to power generators today, the UK coal 'basket' is as wide as ever and fuel of choice varies rapidly with regulation, politics and economics. To illustrate the continuing role for coal in the UK today, Robin showed the power mix for a typical day this year. Of the 34TW being generated on 24th February 2014, 39% was from coal.

Robin then described a new E.ON plant burning wood waste in a fluidised bed combustor. The CHP plant located near Sheffield is called Blackburn Meadows and is of about 30MWe. The acceptability of using biomass depends on variables such as base coal quality and variability, amount type and variability of biomass being used, economic incentives, boiler design, emission regulations and emission control technologies available in the plant.

Robin then dispelled the myth that all natural gas is the same and talked about EASEE-gas and their gas quality specifications. He explained that there are a number of gas quality specifications in existence and mentioned the importance of the Wobbe Index (see below if necessary!). The performance of gas fuels of differing WI was shown for four identical GT units where as WI increased so did the NOx levels.

(Editors tutorial:
*The **Wobbe Index** (WI) or **Wobbe number**[1] is an indicator of the interchangeability of fuel gases such as natural gas, liquefied petroleum gas (LPG), and town gas and is frequently defined in the specifications of gas supply and transport utilities.*
If V_C is the higher heating value, or higher calorific value, and G_S is the specific gravity, the Wobbe Index, I_W, is defined as:

$$I_W = \frac{V_C}{\sqrt{G_S}}.$$

The Wobbe Index is used to compare the combustion energy output of different composition fuel gases in an appliance (fire, cooker etc.). If two fuels have identical Wobbe Indices then for given pressure and valve settings the energy output will also be identical. Typically variations of up to 5% are allowed as these would not be noticeable to the consumer.

The Wobbe Index is a critical factor to minimise the impact of the changeover when analyzing the use of substitute natural gas (SNG) fuels such as propane-air mixtures. The Wobbe Index also requires the addition of propane to some upgraded biomethane products,[2] particularly in regions where natural gas has a high calorific value such as Sweden [3])

Hydrogen can be found in gas fuels which fall within the EASEE guidelines and these can have issues when burnt in gas turbines. Flashback and burner damage has been seen in the past from using fuels with high levels of non-methane hydrocarbons. However, improved burner design has largely reduced the incidents of such damage.

Robin then raised the issue of whether CCS was relevant to combustion issues. Corrosion has been shown to be an important consideration and we were shown the differing corrosive effects resulting from burning a relatively benign Colombian coal and the high chlorine/high sulphur Thoresby coal (Ed: not problem for long methinks!).

He then briefly mentioned a project that E.ON has been sponsoring, OXY-Cap, (see later for more details). Part of the project was carried out at the University of Edinburgh. It focused on a study to determine factors such as the safe level of O2 in the O2/CO2 primary recycle stream, mill safety and ignition/combustion fundamentals under Oxy-fuel combustion. Robin described the ignition chamber and showed some results regarding what pressure ratio was needed to induce ignition for various coal concentrations. Robin then moved on to discuss the use of hydrogen as a new, stand alone energy vector. The use of excess renewable power to produce hydrogen by hydrolysis is feasible and it would not be regarded as a fossil fuel. The scale of use would be determined by the market drivers and plant such as gas turbines which would need to be reconfigured to be able to use hydrogen.

Robin then moved on to newer cycles and described briefly the Allam Cycle. This is a new system, developed by a company called NET Power, which is different from currently operating power plants because CO2 would become a key ingredient when burning the fuel. CO2 would be put into the NET Power combustor at a very high temperature and pressure along with the fuel, such as natural gas or coal, and oxygen. Using CO2 as a so-called working fluid - used to make the turbine function - it would pass through the system in a loop, to be recycled and used again. It is claimed that a system has been developed where it is possible to actually make use of the impurity itself to try and assist the removal of that impurity from the power system. It is also claimed that the technology would be cheaper to operate than current power stations. The system is geared to CCS, which would see the CO2 from fuel combustion funnelled into a pipeline or a tanker instead of being released into the air. The whole cycle happens at a high pressure of about 320 atmospheres, the gas emerges with a pressure and level of purity that is "capture ready" - or ideal for storage.

The Industrial Emissions Directive (IED) has set new tighter limits for ‘old’ pollutants, such as NOx, SOx and dust, and there is a National Ceiling Directive for ‘new’ pollutants such as black carbon, PM2.5 and mercury. Some of the reductions in pollutants are driven by the process requirements themselves, i.e. SO3 on CO2 removal.

Robin concluded his talk by reminding us that the fundamentals of combustion have not changed; the market place continues to change requiring new innovations as fuel composition changes – sourcing/blending/regulation/innovation, emissions constraints tighten, operational requirements mean old plants must operate in different ways and new cycles/configurations come to market. All of these factors offer new RD&D challenges in the field of combustion.

After a break for coffee the baton was taken up by Professor Mohammed Pourkashanian from the University of Leeds who introduced us to PACT. He began by explaining that PACT was an acronym for Pilot-scale Advanced Capture Technology and that these facilities provide a national, specialist R&D capability for combustion and carbon capture technology research.

PACT is a collaborative activity between the Universities of Cranfield, Edinburgh, Imperial College London, Leeds, Nottingham and Sheffield. It forms part of the UK Carbon Capture & Storage Research Centre (UKCCSRC) (www.ukccsrc.ac.uk) jointly funded by the Department of Energy and Climate Change (DECC) and the EPSRC. It encompasses advanced fossil-fuel energy, bioenergy, carbon capture and storage and utilisation technologies for power generation and industrial applications. The aim of PACT is to catalyse and support industrial and academic research to accelerate the development and commercialisation of novel technologies for carbon capture and clean power generation.

PACT facilities bridge the gap between bench-scale R&D and large-scale industrial pilot trials, enabling users to develop and demonstrate their technologies to provide the necessary commercial confidence before committing to the significant costs of large-scale trails. PACT offers a cost-effective and comprehensive research capability by consolidating state-of-the-art facilities and providing shared access to industry and academe.

PACT has sites at the Universities of Edinburgh and Cranfield and core facilities at Beighton near Sheffield. The PACT Core facilities host the 1 tonne/day Carbon Capture Plant, 150kW Gas Turbine System, 250kW Air Combustion Plant and 250 Oxyfuel Combustion Plant alongside analytical facilities and other supporting facilities.

Edinburgh PACT facilities include the Advanced Capture Testing in a Transportable Remotely-Operated Mini-lab (ACTTROM). This is an integrated, mobile carbon capture media testing laboratory which is designed for long-term on-site testing of CO2 capture media on real flue/process gases with a possibility of multiple parallel tests. The facility is transported to the test site and connected directly to on-site flue/process gases. It is remotely monitored and operated by the University of Edinburgh and is about to go on site at Peterhead.

PACT forms part of new energy facilities at Cranfield and include a 750kWth burner rig for gas turbine hot gas path research, a 350kWth circulating fluidised bed facility, a 50kWth chemical/calcium looping facility, a 150kWth pulverised fuel rig and a dense-phase CO2 flow loop rig.

The budget for the UK CCSRC Programme for the period 2011 to 2015 is £125m and includes projects in all major castors of the technology, i.e. Whole system, CO2 capture – pre- and post combustion, Oxyfuel, CO2 monitoring, transport, storage and utilisation and conversion and generation.

Mohammed then provided a description and some results from the 250kW air/Oxy combustion plant located at Beighton. The rig is cylindrical in shape with eight sections, down-fired and of dimensions 4.5m high, 0.9m in radius. It can fire coal, biomass or mixtures of both. Gas is also fired but mainly for preheating. It has two interchangeable scaled coal/biomass burners based on Doosan Power's commercial low NOx burners. The rig also has a dedicated, high precession air metering skid and a high efficiency particulate filter. Furnace pressure (negative) is balanced by an exhaust fan. Temperature and water flow for cooling the combustion rig, flue gas duct and heat exchanger are monitored and a SCADA system incorporating internet monitoring is utilised.

Data was shown at 200kW using coal and preheated air in which the measured conditions in the rig were compared to that obtained from modelling. In addition, in-flame temperature profiles using suction pyrometry were measured together with heat flux profiles using an ellipsoidal radiometer and total heat flux probes. Laser Induced Fluorescence (LIF) techniques were used to obtain in-flame and exhaust species profiles

3D Particle Image Velocimetry (PIV) and Laser Doppler Velocimetry (LDV) techniques were also used. Flame characterisation, including data on shape, luminosity, and frequency, were obtained using 2D and 3D flame imaging with photographs and videos and computer tomographic reconstruction of the flame in 3D. Particle velocity profiles within the top section of the furnace (for both non-reactive and reactive species) were also obtained. Data obtained from the rig and predictive measurement was generally very encouraging.

Solvent-based CO2 capture plant available at PACT is used in the testing and development of alternative solvents, for benchmarking and energy requirements, solvent degradation and enhancement studies and real aged solvents assessment. It is also used for plant and system modelling, the assessment of plant flexibility and performance with different fuels (e.g. biomass) or other conditions, integrated systems modelling and control and the validation of baseline economics. Some of the results from test runs using the PACT gas turbine and CO2 capture rig were presented together with predicted data from modelling exercises. The agreement between the datasets was found to be good.

Mohammed then moved on to describe some of the activities of the SuperGen Bioenergy Hub. The impact of this activity is that it will remove some of the significant technical barriers to bio-CCS development. It will progress current understanding of the potential of bio-CCS for the UK energy system so that realistic projections of deployment, costs and achievable GHG reductions can be incorporated into policy development. The project will accelerate UK development of bio-CCS technology and will consolidate the UK's position as world-leaders in understanding the technology for decarbonisation of existing coal based power generation infrastructure. It is a multi-partner project which includes the University of Leeds. It is envisaged that PACT will be used by project partners to achieve some of the project activities.

Mohammed brought his review of PACT to a close by mentioning the recent partnership signed in January 2014 between PACT, UKCCSRC and Invensys. This partnership would provide access to all the latters process simulation model including DYNSIM; EYESIM (Virtual Reality software) under negotiation with US) and will be available for all to use for initial period of three years.

Next up was Professor John Oakey from Cranfield University who spoke about "The EPSRC OxyCAP Project". This activity is jointly funded by the EPSRC and E.ON and is valued at £1.79m. Its partners are the universities of Leeds, Cambridge, Nottingham, Kent, Edinburgh, Cranfield and I.C.London. Industrial partners are E.ON, Ansys and Doosan Babcock. It has been in progress from 2010 to 2014.

At the time the project was being proposed, (2009), there were significant gaps in our knowledge regarding PF combustion under Oxy-fuel conditions. Some of the more important gaps were in combustion behaviour, for example, what is the impact of using different coals on ignition behaviour, impact of varying recycle, modelling and monitoring? Optimum recycled flue gas (RFG) ratio - how do we achieve similar combustion and heat transfer characteristics to an air fired operation. Carbon burnout; the existing database needed to be expanded from pilot plant studies. Ash formation, slagging and fouling- what is the effect of CO2-rich atmosphere on ash formation? Materials – what is the impact of varying boiler and recycle environments on materials in terms of water wall/superheater corrosion and acid dew-point corrosion. Fine particulates, SO3, NOx, trace metal emissions - what differences will there be in the conversion of fuel-S to SO2, SO3 and sulphur remaining in ash, levels of unburned carbon, condensates in recycle? Radiative Heat Flux measurements - what changes in heat flux with operating conditions?

OxyCAP objectives were agreed and comprise; the development of a new generation of large-eddy simulation (LES)-based CFD models for coal combustion; the development of a validation and verification environment that integrates experimental results; the development of computational sub-models for key areas e.g. radiation, particle ignition and individual particles.

Measurement of the effect of the partial pressures of O2 and CO2 on Oxy-coal combustion phenomena and establishing novel experimental techniques for testing new coals and further sets of combustion conditions. Analysis of the interaction of Oxy-combustion products with boiler materials, based on realistic flue gas environments and ash slagging behaviour under Oxyfuel combustion conditions. In overall terms the project aimed to increase UK advanced scientific capacity in this area.

The project activities were divided amongst the various partner universities with the modelling work being undertaken by Leeds, Cambridge and Imperial College. Ignition studies and imaging were carried out at Edinburgh and Kent whilst ash transformations were studied at Nottingham, Cranfield and Imperial College. Pilot scale testing was performed at Cranfield and Leeds. Materials studies were undertaken at Cranfield.

John described in more detail some of the activities carried out by individual universities. For example, coal/biomass dust ignition tests in Oxyfuel atmospheres were carried out at the University of Edinburgh. At the University of Nottingham the impact of CO2 and steam on devolatilisation and char burn-out in relation to normal air firing was assessed by a comprehensive drop tube furnace (DTF) programme. The results have indicated that enhanced volatile matter yields and char burn-out rates can be achieved in CO2.

The University of Cambridge studied Oxy-coal combustion in a CH4/O2/CO2 burner. The experimental work provided data for LES modelling. At Imperial College their team worked on the LES of the CRIEPI (Central Research Institute of Electric Power Industry [of Japan]) pulverised coal burner and also studied ash transformation and deposition in Oxy-fuel environments. Researchers at the University of Leeds worked on the development of a 250 kW Solid Fuel Combustion Test Facility and LES CFD modelling of the Oxy-fuel combustion. Project activities at the University of Kent comprised 2D and 3-D flame imaging and flow metering and on-line sizing of pulverised coal. Cranfield was involved in two main activities, namely, experimental trials in a 100kW retrofitted oxy-combustor, and also the development of a kinetic model using Aspen Plus.

John summarised progress arising from the Oxy-CAP progress as follows:- new data has been generated on combustion behaviour, new models have been developed, ignition/burn-out, recycle and ash behaviour; many new skilled researchers trained, and increased UK capacity for oxy-combustion research.

John concluded his talk by outlining the aims and aspiration of a follow on project Oxy-CAP2 – "To accelerate progress towards achieving operational excellence for flexible, efficient, controllable, safe and environmentally sustainable Oxy-fuel fired power plants."

To achieve these goals the following have to be addressed:-

- Oxy-combustion burner design for new and retrofit applications
- Impacts of fuel (coal and biomass) and load changes on boiler/recycle environments and ash behaviour
- Improved understanding of the behaviour of S, N and metals including Hg and their impacts on corrosion, gas cleaning requirements and downstream CO2 separation
- High temperature (fireside) and low temperature (acid dew-point) corrosion, improved materials and component life prediction.
- Development of predictive computational modelling integrated with a dynamic system simulation capability

The final speaker of the first session was Dr Gang Lu of the University of Kent whose talk was entitled "Sensors and Instrumentation Systems for Oxy-coal Combustion Diagnosis". Dr Lu gave a presentation which described in detail the activities of the University of Kent in the Oxy-CAP project.

The rationale for investigating Oxy-coal flames using imaging is that the flames are complex and advanced techniques are required in order to provide reliable, non-intrusive and on-line monitoring of such flames. 3-D/2-D visualisation and characterisation techniques are necessary to fully reveal the dynamic nature of Oxy-flames. The presentation forms an overview of recent developments in 3-D/2-D flame imaging techniques carried out at the University of Kent.

In view of the nature of the Oxy-flame in a real furnace, the development of a 3-D flame imaging technique faces a number of technical challenges. These include the need for a suitable system hardware platform for a large-scale installation; the number of image projections available for the reconstruction; improved accuracy of the reconstruction; computer algorithms for the characterisation of burner flames including flame stability and identification of the internal flame structure and flame front movement.

The 3-D flame imaging system has eight imaging fibre bundles, each having 30k individual optical fibres with a 92^{o} objective lens. Four of the eight fibre bundles are joined onto a single eyepiece, forming four identical images into the same camera. A tomographic algorithm which combines the Logical Filtered Back-Projection and Simultaneous Algebraic Reconstruction Technique is utilized for the 3-D grey-level reconstruction of flame sections.

Experiments have been carried out on a small-scale Oxy-gas burner rig to monitor the flames using the 3-D flame imaging system. A 2-D flame imaging system was also used for flame temperature and oscillation frequency measurements.

The 2-D system has been tested on a 9MWth heavy-oil-fired CTF at Zhejiang University, Hangzhou, China; a 660MWe coal/biomass-fired boiler at a power station in UK, and a 660MWe heavy oil fired boiler at a power plant in Saudi Arabia.

The 2-D and 3-D systems have recently been tested on the PACT 250kWth PF rig at Beighton with the University of Leeds. Due to the limitation of fibre length, only four of eight probes of the 3-D system were used. A variety of air-coal firing conditions were created, including variations in primary air, setting of the secondary air (SA) and tertiary air (TA) splitter.

Dr Lu concluded his overview by confirming that 3-D/2-D flame imaging systems have been developed for the visualisation and characterisation of air- and Oxy-coal flames, including flame temperature, emissivity and soot distribution measurements. The systems have been tested on various combustion test rigs under different air-firing and Oxyfuel-firing conditions in the UK and China. Recently Oxy-coal tests have been conducted on the PACT 250kWth PF rig at Beighton for different air-firing conditions. Further Oxy-gas tests will be conducted at the Gas Turbine Research Centre at Cardiff University. It is envisioned that a combination of the data from measurement systems and CFD modelling results will lead to an in-depth understanding, and subsequent optimisation of Oxy-fuel combustion.

An excellent lunch was followed by a networking break and at 1.30pm Greg Kelsall, Chairman for Industry, officiated at the CRF Annual Meeting. Items discussed included the report for 2013, review of actions, report by Chairman/Secretary and Treasurer, the election for vacancies on the Executive Committee and any other business. Divisional meeting reports were then provided by the respective chairmen or David McCaffrey.

At 2.10pm Session 2 of the Coal Combustion Divisional meeting began, chaired at this time, by Professor Pourkashanian.

The first paper of this session was given by Dr Richard March of the University of Cardiff and was entitled “Integration of CCS with gas turbines (including the UKCCSRC project). Richard divided his talk into two parts: the first being “The use of CO2 to improve stability and emissions of an IGCC burner”. Richard explained that fuels with high hydrogen content are resilient to blowoff and prone to flashback, especially in the presence of high turbulence, elevated pressure and preheat. Three potential flashback mechanisms are; boundary layer flame

propagation, turbulent flame propagation in the core flow and upstream propagation of coherent structures. To investigate the viability of CO2 to improve flame stability a gas turbine combustor was developed. It was operated at approximately 500kW at atmospheric pressure with 400^{O}C air preheat.

Richard showed the key findings to be that lean flashback was observed in a gas turbine combustor due to propagation of coherent structures followed by boundary layer flame propagation or turbulent flame propagation in the core flow. Diffusive injection of carbon dioxide can prevent structure propagation, whilst reducing burning rates and flame temperature. Reduction in local flame temperature at the point of injection is reduced to a greater extent than global flame temperature which reduces NOx and the likelihood of flashback without significantly affecting turbine inlet temperature.

The second part of Richard's talk was entitled "Methane Oxy-combustion in a swirl stabilised gas turbine burner". The overall design aim was to develop an Oxyfuel gas turbine, using recycled CO2 as a moderator (rather than N2 as in air). Hence the project objective was to examine the relationship between CO2 and N2 diluted swirl flames. Given that swirl burners involve a complex interaction between chemical and fluid dynamic timescales, a systematic study of the stability envelope was conducted.

A generic swirl burner was developed which utilised different vane configurations to alter geometric swirl number (28mm exit diameter). Richard reported that achieving a stoichiometric methane Oxyflame was not possible with a traditional swirl burner (not without the redesigned burner looking like a rocket motor anyway!). However, it was possible to operate without a diluent, but the momentum required to sustain the recirculation zone is only possible at very dilute (oxygen) conditions. Replacing N2 with CO2 as a combustion diluent appeared to widen the stability range of the swirl flame. Initial results are encouraging and subsequent tests will evaluate the effects of pressure. Next steps are for a larger scale burner installation into a High Pressure Optical Combustor (up to 500 kW).

This paper was followed by Dr Karen Finney of the University of Leeds who talked to us about the "EPSRC Gas-FACTS project". Gas-FACTS is a three-year EPSRC-funded programme (FEC of over £3m) started in 2012 and scheduled for completion at the end of 2015. Five academic institutions are involved, the universities of Cranfield, Edinburgh, Imperial College, Leeds and Sheffield. Industrial partners and expert panellists include utilities, OEMs, SMEs, consultants and international research partners: SSE, ESBI, Scottish Power, Howden, Doosan Power, Siemens, Sulzer, BG, HATS, Visage Energy, Carnegie Mellon University and cense.

The Gas-FACTS project will provide important underpinning research for UK CCS development and deployment on natural gas power plants, particularly for gas turbine modifications and advanced post combustion capture technologies that are the principal candidates for deployment in a possible tens-of-£billions expansion of the CCS sector between 2020 and 2030, and then operation until 2050 or beyond, in order to meet UK CO2 emission targets.

The project will also develop rigorous assessment methods and a framework to maximise pathways to impact that could support other RCUK research activities on gas CCS. Globally, there is already interest in gas CCS in Norway, California and the Middle East, and this is likely to become more widespread if cheaper gas leads to more widespread use. This work will be undertaken through work packages with the following aims, lead organisation in bold:

WP1: Gas turbine options for improved CCS system performance
Leeds- Sheffield-Cranfield-Edinburgh
To quantify the scope of gas turbine modifications to improve the technical, environmental and economic performance of integrated CO2 capture on CCGT plants. Small gas turbines will be modified to run with steam or recycled flue gas replacing some of the normal air feed to increase back-end CO2 concentrations (which will help make the CO2 easier to capture).

WP2: Advanced post-combustion solvent capture for future gas power systems
Leeds/**Imperial College**/Cranfield/Edinburgh
To quantify through modelling and experimental testing the scope for improving post-combustion capture system performance on CCGT plants through a combination of advanced liquid solvents, including novel amine mixtures, and improved transient performance. Solvents that are used to take up CO2 and then release it in a pure form that can be stored underground will be modified so that the amount of energy required to do this is reduced. The equipment the solvents are used in will also be designed to turn on and off quickly to allow CCS power plants to compensate for fluctuations in output from wind turbines.

WP3: Integration and whole systems performance assessment
Leeds/Imperial/Cranfield/**Edinburgh**/Sheffield
In close collaboration with an external Experts Group the participants will undertake integration and whole systems performance assessments. This will include a 'Gas-FACTS Impact Handbook' combining impact tables with state-of-the-art surveys to ensure that pathways to impact pursued by Gas-FACTS researchers are co-ordinated with other significant activities, including excellent science and stakeholder plans, to maximise their effectiveness. Gas-FACTS results will be implemented in the freely-available IECM package for access by any potential users.

WP4: Impact delivery and expert interaction activities
Leeds/Imperial/Cranfield/**Edinburgh**/Sheffield
Impact delivery and expert interaction activities will be based on establishing an Experts Group including representatives of the UK CCS academic community, global academic community, UK policymakers, UK Regulators, NGOs, power utilities, OEMs and SMEs. WP4 will also run a programme of engagement activities to impact, including project meetings, specialist meetings on topical issues and results, web-based dissemination and document publication (reports, responses to Parliamentary inquiries, journal papers, articles etc.).

Next up was Professor Rachel Thomson from Loughborough University whose paper was entitled "'Flex-e Plant' – the Future Conventional Power Consortium". In order to meet UK Government targets to reduce CO2 emissions by 80% by 2050, rapid growth in electricity generation from intermittent renewable energy sources, in particular, wind, is required, together with increasing constraints on the operation and environmental performance of conventional coal- and gas-fired plant. Unprecedented demands for operational plant flexibility will pose new challenges to component integrity in ageing conventional plant, which it is widely recognised will play a crucial role in maintaining security of supply.

In parallel, demands on fuel flexibility to reduce emissions, i.e. firing gas turbine plant with low-carbon syngas or biogas and firing/co-firing steam plant with biomass, will create new challenges in plant engineering, monitoring and control and materials performance. Improved plant efficiency is a key requirement to cut emissions and to make decarbonisation economically feasible. The continuous development of novel, stronger high temperature materials may also enable component replacement, rather than complete new build plant, to maintain the essential reserve of conventional generation capacity. Finally, the decarbonisation transition involves new and complex economic and environmental considerations, and it is therefore important that these issues of sustainability are addressed for the development of future conventional power plant.

The research programme will consider the key issues of plant efficiency, plant flexibility, fuel flexibility and sustainability and how these four intersecting themes impact upon plant operation and design, combustion processes in general and the structural integrity of conventional and advanced materials utilised in conventional power plants. The project began in August 2013, ends in February 2018 and is valued at £2m.

The consortium comprises six leading UK Universities with a proven track record in the area of conventional power generation it is led by Loughborough University, and will be working with Cardiff and Cranfield Universities, Imperial College London and the Universities of Nottingham and Warwick. The industrial partners collaborating in this project include several major UK power generation operators, OEMs, Government laboratories and SMEs companies in the supply chain for the power generation sector. The Energy Generation and Supply Knowledge Transfer Network will be a formal delivery partner of the consortium.

Dr Simon Hogg, the Director of Durham Energy Institute based at the University of Durham followed with his paper which was entitled "EPSRC Future Conventional Power Consortium". The project was launched on 10th September 2013. It has five academic partners, the universities of Cambridge, Durham, Edinburgh, Leeds and Oxford; three industrial partners, Alstom, SSE and AnSys. Other partners include the strategic consulting, engineering and project delivery company SKM, (Sinclair Knight and Merz) and the National Grid.

The project themes are plant efficiency and fuel flexibility and sustainability. Plant efficiency will be addressed by the universities of Oxford, Cambridge and Durham and AnSys and Alstom. Plant flexibility will be the focus for the universities of Edinburgh and Leeds and SSE, AnSys and Alstom. Fuel flexibility will be the remit of the universities of Leeds and Edinburgh and Alstom, whilst sustainability will be targeted by the universities of Durham and Edinburgh, the National Grid and SKM. This project complements rather than overlaps the Flex-e-Plant project and as such provides opportunities to hold joint training workshops, annual assemblies and other dissemination events. Both this and Flex-e-Plant projects are funded for 5 years duration.

The activities that are to be carried out by Simon's team fall within the Research Theme 3 – Plant Efficiency. Within this theme are four project activities which were described in more detail. In activity 1 "Lowering thermal stresses and improving axial clearance control" there is a need to identify and understand the limiting factors in steam turbine aerothermal behaviour during cooling-down and start-up. This requires the development of new advanced computer modelling techniques which will be used to design new reduced order models (ROM) to achieve high fidelity results at low fidelity effort. Activity 2 "Improving radial clearance control". This may be achieved by using improved sealing leading to the development of more compliant alternatives to conventional labyrinth seals. Activity 3 is "Wet steam effects". Erosion from droplets in wet steam is a major issue in fossil LP's and LWR Nuclear HP's and LP's. Designers try to keep steam wetness to less than 12% and employ other measures (course water extraction) to avoid unacceptable erosion rates. However, wetness modelling is not well understood and only relatively crude design models/rules exist at present. It is realised that wetness effects will become even more acute under flexible operating conditions. Improved dynamic wetness models are needed and this is currently being addressed. Activity 4 is Biomass/coal firing. Although a significant amount of experience has already been obtained by the power generators from the co-firing of a wide range of coal / biomass mixtures, with carbon capture other issues concerning contaminants in the combustion gases will need to be addressed.

Simon then posed and then answered the question "What will be possible at the end of the programme that is not possible now?" The principal expected outputs to help to reduce carbon emissions and increase flexibility of conventional fossil fuelled power plant will be for plant flexibility – a validated dynamic power plant simulation tool, allowing operators to assess scenarios for more flexible plant operation; for plant efficiency – better clearance control (heat transfer methods and new seal technology) and wetness methods under part-load conditions, allowing designers to produce turbines capable of more flexible operation; for fuel flexibility – more efficient and cleaner combustion of different biomass and biomass/coal blends in conventional plant, with reduced rates of deposition and for sustainability – robust messages delivered to the power industry concerning the impact of wind penetration on the need for flexible capacity investment under different socio-economic energy scenarios.

Simon concluded his talk by comparing and contrasting the work of this project to that of the Flex-e-Plant and stressing that there was no overlap. At this early stage of the project further results will undoubtedly be produced and disseminated.

The final paper was given by our German guest Dr Andreas Kemp of the University of Duisburg-Essen who attempted to explain to us the complexities of "Large-Eddy Simulation of Pulverised Coal Combustion". As far as the editor is concerned a tutorial is needed again!!

*[Optional tutorial: **Large eddy simulation (LES)** is a mathematical model for turbulence used in computational fluid dynamics. It was initially proposed in 1963 by Joseph Smagorinsky to simulate atmospheric air currents,[1] and many of the issues unique to LES were first explored by Deardorff (1970).[2] LES grew rapidly beginning with its invention in the 1960s and is currently applied in a wide variety of engineering applications, including combustion,[3] acoustics,[4] and simulations of the atmospheric boundary layer.[5] LES operates on the Navier–Stokes equations to reduce the range of length scales of the solution, reducing the computational cost.*

The principal operation in large eddy simulation is low-pass filtering. This operation is applied to the Navier–Stokes equations to eliminate small scales of the solution. This reduces the computational cost of the simulation. The governing equations are thus transformed, and the solution is a filtered velocity field. Which of the "small" length and time scales to eliminate are selected according to turbulence theory and available computational resources.[6]

Large eddy simulation resolves large scales of the flow field solution allowing better fidelity than alternative approaches such as Reynolds-averaged Navier–Stokes (RANS) methods. It also models the smallest (and most expensive[6]) scales of the solution, rather than resolving them as direct numerical simulation (DNS) does. This makes the computational cost for practical engineering systems with complex geometry or flow configurations, such as turbulent jets, pumps, vehicles, and landing gear, attainable using supercomputers. In contrast, direct numerical simulation, which resolves every scale of the solution, is prohibitively expensive for nearly all systems with complex geometry or flow configurations.]

Andreas began by explaining that turbulent combustion of gaseous and liquid fuels is the key to power generation in technical installations like gas- and coal-fired power plants or internal combustion engines. Enhancing the efficiency of turbulent combustion processes is a prerequisite for enhancing overall plant efficiency and for reducing noxious emissions. His group develops methods and models that help to understand the complex processes involved in combustion and their interaction with the turbulent flow.

The modelling is based on their in-house code PsiPhi and on the open source CFD Software "OpenFOAM", for which new libraries and solvers are developed by the group. The new software modules are then validated and verified against analytical and experimental data, and the findings are published in international journals or presented at conferences.

The research group had been developing a variation on LES known as C-LES since 1999. Andreas compared the features of the classical CFD approach known as RANS (Reynolds Averaged Navier-Stokes) turbulence model to LES and showed the superiority of the latter.

Andreas then described the application of their models to a number of flames and compared actual to predicted data for certain parameters. The burners in question were CRIEPI, IFRF flame B1 and the Aachen – OXYCOAL AC furnace. Typical data compared included axial and tangential velocities and mean gas temperatures.

Andreas summarised his presentation by indicating that LES of coal combustion is a reality (a new paradigm!) and that pilot-scale combustors can be predicted reasonably. Andreas feel that now is the time to apply and improve sub models such as subgrid and devolatilisation modelling and radiation. Further work is currently in progress on gas and biomass combustion.

Due to the absence of Professor John Patrick the closing remarks were given by your truly! I was very impressed by the quality of the papers and their presenters and mused that at one time, (no doubt long ago) coal was always the main feature of a Combustion Division meeting whereas now it is more of a peripheral player. Clearly the editor is once again showing his age! Trying to keep my comments brief I was very happy with the events of the day and thanked the University of Warwick and Professor Jihong Wang for the excellent facilities and hospitality, the presenters and not forgetting all of the attendees. I then wished everyone a safe journey home and hoped to see them at Hull for ECCRIA 10 in September.

The 14th Annual Advanced Power Generation Technology Forum (APGTF) Workshop

"The Role of Fossil Fuel Power Plant in Providing Flexible Generation"

The 2014 APGTF Workshop, supported by the CRF, was held at '1VS' (1 Victoria Street) Conference Centre, Westminster, London on the 12 & 13 March. It covered a complex set of challenges around the key issue of power plant flexibility through a mix of keynote talks, technical presentations and panel discussions. An attendance of 124 delegates across both days ensured a lively debate on the topics discussed which included: What is the future role of fossil fuels (coal, natural gas and indeed shale gas) in providing such flexible generation? How might it do this while meeting a 'low-carbon' requirement? How might alternative fuels, approaches and technologies increase future options for fossil fuels? What are the RD&D challenges?

Workshop Presentations and the Report of the Panel Discussions are available to download at:

www.apgtf-uk.com

LCRI Conference 2013: Low Carbon Market Transitions

About the Low Carbon Research Institute: *The LCRI was set up to unite and promote energy research in Wales, UK to help deliver a low carbon future. The multidisciplinary LCRI aims to support the energy sector, UK and globally, to develop low carbon generation, storage, distribution and end use technologies, and to offer policy advice. The LCRI carries out research, education and training around eight main themes of low carbon: photovoltaics, hydrogen energy systems, marine energy, bioenergy, low or zero carbon built environment, large scale power generation, low carbon transitions and policy and a graduate school. The following article concerns the LCRI's latest conference.*

The Low Carbon Research Institute (LCRI) was joined by over 160 delegates in Llandudno at their fifth annual LCRI Conference 2013: Low Carbon Market Transitions on 5th and 6th November. The conference examined the work of the LCRI in the current economic climate, with speakers discussing the way our research is having an impact upon the Welsh economy, by developing technologies and services, and creating jobs.

The conference aimed to bring together academics, policy makers and industry professionals to look holistically at the low carbon agenda. It focused on the R&D and innovation needed to deliver government policy objectives in Wales, the UK and internationally, together with the technological, economic and social challenges and opportunities this involves. It was a chance for delegates to hear from each of our projects, to learn in-depth information about the LCRI Convergence Programme, as well as to understand the work of the wider LCRI as a whole.

The conference was opened by Alun Davies, AM and Minister for Natural Resources and Food. The Minister said that the Welsh Government believes that climate change is taking place and is caused by human activity. The Government wishes to achieve a successful low carbon transition, while addressing poverty and focusing on green growth. Mr Davies confirmed that "the LCRI has a central role to play in what we want to achieve as a nation in the future." The key note speakers included Professor Phil Jones, Chair of the LCRI, who discussed the need for,

and benefits of, working towards a low carbon economy. Professor Jim Watson, Research Director for UKERC gave a presentation entitled "*Energy policy in flux: implications for electricity markets*". He discussed the UK's low carbon transition, energy policy tensions, and the roles electricity markets will play.

Dr David Clarke, CEO of the Energy Technologies Institute, gave a presentation entitled "*Creating an affordable energy system for the UK: It's a question of innovation".* This discussed the challenges presented by the UK's growing energy needs, the various energy source options available, and the need for a secure and sustainable energy mix. Malcolm Grimston, Honorary Senior Research Fellow from Imperial College London presented "*The Challenges of delivering Nuclear New Build even when the UK Government wants it."* He explored the costs and benefits of investment in nuclear power, and the socio-economic factors affecting the process.

The two day event included breakout sessions, which comprised of presentations, talks, discussions and Q&As given and led by the LCRI Convergence programme projects: Large Scale Power Generation (LSPG), Low Carbon Built Environment (LCBE), Hydrogen, Welsh Energy Sector Training (WEST), Solar Photovoltaic Academic Research Consortium (SPARC), Marine, Scenario Modelling and Smart Operation for a Low Carbon Energy Region (SOLCER) as well as the LCRI's Bio Energy team based in Aberystwyth University.

The Conference also included 15 exhibitors consisting of the LCRI Convergence projects, the Bio Energy team, as well as the BEST project, the Climate Change Consortium for Wales, SEACams, SLR Consulting, Anglesey Energy Island Programme, and the Energy Innovation Centre.
Professor Peter Pearson, Director of the LCRI said: "What we have shown through this conference is how much can be achieved through cooperation across disciplines, research teams and Welsh universities, working with partners in industry and local government, and with partners in other UK, European and international universities, supported by research funds from the UK research councils, industry and Europe."

Coal reigns in UK energy sector

28th January 2014, EnAppSys

Electricity generation in Great Britain (GB) continued to fall last year, although coal-fired power still provided the dominant share of total energy production, according to the *2013 GB Electricity Supply & Generation* report from energy market data specialists EnAppSys *(Note: EnAppSys is an independent and specialist information unit providing electricity and energy market data, systems and applications to parties with an interest in the UK energy market).*

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Last year the total electricity supplied in GB was 285TWh, a fall of 1.5% from 2012 and 11.5% lower than the pre-recession peak of 322TWh in 2007. This reduction is equivalent to the electricity consumption of 8.7m homes*.

The report says that falling power generation is a direct result of declining electricity consumption in the last six years, a trend driven mainly by the economic slowdown. During 2013 coal-fired power stations continued to be the dominant source of generation, providing 41% of all GB power requirements, whilst combined cycle gas turbine (CCGT) units provided 26%, nuclear 21% and wind farms a further 6%.

Although total levels of electricity generation have fallen since 2010, levels of coal-fired generation have climbed 22% in the same period despite a reduction in coal-fired power stations as older facilities are closed down.

The rise in coal's share of the country's power output has been attributed largely to declining activity in gas-fired electricity generation, which is mainly the result of falling coal prices, the collapse of the EU ETS (European Union Emissions Trading Scheme) carbon price and rising LNG (liquid natural gas) prices due to amongst other factors, Fukushima. The drivers on coal

prices are the reduction in US coal consumption due to gas displacing coal for power generation because of the shale gas boom.

The largest increase in electricity generation from a single fuel type has come from wind farms, which produced 48% more electricity in 2013 compared to 2012 and 405% more than in 2010. This growth enabled wind to provide 6% of total generation last year and 8% of total generation in Q4 2013.

Paul Verril, a director of EnAppSys, said: "Last year several older coal-fired stations were closed down as a part of a European Union-led directive to reduce Europe-wide sulphur and nitrous oxide emissions and the introduction of the UK's carbon floor price, with further closures expected in the coming years as further European directives are implemented. Nevertheless, coal continued to dominate UK power production. "In the future, increases in gas-fired and wind capacity are expected to replace lost coal capacity, with wind in particular forecast to provide a greater share of total energy production as more projects come on stream."

Other features of the 2013 GB power generation and supply market highlighted in the report include:
• EDF Energy remained GB's largest generator of electricity last year, providing 30% of total electricity generation mainly through its fleet of nuclear plants.
• The "big six" - Centrica-owned British Gas, EDF Energy which is owned by the stock-market-listed European energy firm based in France Électricité de France, the two German-owned firms npower and E.ON UK, the Spanish-owned Scottish Power, and the listed Scottish firm SSE - still dominate supply in the GB market with the data indicating significantly over 80% market share in 2013.
• Coal plants saw utilisation rates rise from 41% in 2010 to 57% in 2013, with decreasing coal and carbon prices resulting in increased levels of activity at coal-fired stations despite the UK carbon floor prices introduction in April.
• Electricity generation produced 127 million tonnes of carbon dioxide in 2013 – the second lowest figure in the last five years and down 7% from 2012 as several coal plants went offline and as levels of generation from wind farms increased. 2013 levels were 8% lower than the five-year high in 2010 when total electricity supply volumes peaked at 328TWh.
• Since 2007 southern England and London have seen lower falls in electricity consumption than in other regions, indicating a stronger economic resilience in this part of the country. While demand levels in London have now flat-lined against those in 2012, demand in Northern Scotland and Northern England, for example, has fallen more than 25% since 2007. However, some of this reduction is due to the increase in installed embedded wind and solar generation in these regions.
The EnAppSys report provides an overview of GB electricity generation, supply and demand during 2013 and is available at www.enappsys.com

* Based on DECC's 4,222kWh figure for average annual electricity consumption per household in England, Wales and Scotland.

EnAppSys's experienced analysts use aggregated data from different electricity data sources to provide subscribers with informed and user configurable energy information and analysis, energy management systems and energy related applications.
http://www.enappsys.com

ARTICLES FROM THE TECHNICAL PRESS

News alerts in coal and energy research

Please be aware that links to some of the news articles are not retained on the web indefinitely. Consequently, links which were active when the newsletter was written may, in time, become unavailable. It is hoped that this will not detract from the value of the article.

Synthetic natural gas from excess electricity

6th January 2014, unattributed, Science Daily

"Power to gas" is a key concept when it comes to storing alternative energy. This process converts short-term excess electricity from photovoltaic systems and wind turbines into hydrogen. Combined with the greenhouse gas CO2, renewable hydrogen can be used to produce methane, which can be stored and distributed in the natural gas network. Researchers have now succeeded in further optimizing this process.
For more visit:-
http://www.sciencedaily.com/releases/2014/01/140106094557.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sciencedaily%2Fmatter_energy+%28Matter+%26+Energy+News+--+ScienceDaily%29

Green revolution? German brown coal power output hits new high

7th January 2014, unattributed, Spiegel On-line International

Germany plans to wean itself off CO2-belching coal-fired power stations. But new figures show that coal power output in 2013 reached its highest level in more than 20 years. Researchers blame cheap CO2 emissions permits, and demand urgent reforms.

In 1990, Germany's brown coal-fired power stations produced almost 171 billion kilowatt hours of power. At the time, many old eastern German plants were still in operation.

It was a situation that the German government wanted to change, with the aim being that of radically reducing the output of the CO2-polluting lignite plants, but that's not happening. In 2013, it rose to 162 billion kilowatt hours, the highest level since reunification in 1990, according to preliminary figures from AGEB, a collection of industry associations and research institutes.

Electricity output from brown coal plants rose 0.8 percent in 2013, said Jochen Diekmann of the German Institute for Economic Research. As a result, Germany's CO2 output is expected to have risen in 2013, even as power from renewable sources has reached 25 percent of the energy mix. For more visit:
http://www.spiegel.de/international/germany/researchers-alarmed-at-rise-in-german-brown-coal-power-output-a-942216.html

U.S. carbon emissions from fossil fuels rose in 2013 as coal use ticked up

13th January 2014, John H. Cushman Jr, Inside Climate News

The 2 percent rise in energy-related CO2 emissions marks a shift from five years of declining emissions amid the economic recession. When all the data is in, it looks like carbon dioxide emissions from the burning of fossil fuels will have gone up 2 percent in 2013 from the previous year, the U.S. Department of Energy (DOE) said on Monday. The main reason, it said, is an uptick in the use of coal for electric power. But it's also a sign of growing economic activity in general.

Ever since the deep recession began in 2008, U.S. emissions of carbon dioxide had been going down. CO2 is the principal greenhouse gas that's causing climate change. About 40 percent of emissions from the energy sector come from combustion of coal in power plants. The Obama has proposed rules to control these emissions from newly built plants, and is also drafting rules to govern existing power plants. In a brief analysis, the DOE's statistical arm said it expected emissions from coal to continue rising from 2013 to 2014, and emissions from gas to fall.
For more see:
http://insideclimatenews.org/content/us-carbon-emissions-fossil-fuels-rose-2013-coal-use-ticked

Carbon dioxide tamed: Making this ubiquitous gas industrially useful

18th January 2014, unattributed, Science Daily

Using a copper catalyst to unite carbon dioxide with organic molecules under mild conditions could make this ubiquitous gas industrially useful.

Hung Duong of the A*STAR Institute of Chemical and Engineering Sciences in Singapore and co-workers have shown that a copper catalyst can incorporate carbon dioxide into organic molecules under much milder conditions. The commercially available catalyst consists of a copper atom joined to a bulky ligand called 1,3-bis-(2,6-diisopropylphenyl)imidazol-2-ylidene (IPr).

Some reactions involving carbon dioxide require high-energy starting materials that contain reactive metals such as lithium or magnesium. However, these metals often destroy other sensitive chemical groups in the molecule during the reaction. Milder starting materials that contain tin tend to be highly toxic, "so we looked at the use of more environmentally benign organoborons," says Duong.

The researchers tested a range of molecules that feature a carbon-carbon double bond close to a boron-containing chemical group. They assumed that the copper catalyst works by knocking the boron group off the molecule and briefly taking its place so that it can shepherd carbon dioxide into the right position to bond with the molecule. The products of the reaction contain a carbon-carbon double bond and a carboxylic acid group, arranged in a very predictable pattern. "These are highly versatile building blocks for organic synthesis," explains Duong.
For more visit:-
http://www.sciencedaily.com/releases/2014/01/140118122419.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sciencedaily%2Fmatter_energy+%28Matter+%26+Energy+News+--+ScienceDaily%29

EU establishes reference materials to improve coal analysis

20th January 2014, unattributed, The Daily Fusion

Three certified reference materials to improve the quality of coal analysis have recently been developed by the Joint Research Center (JRC), the EU in-house scientific service, for use in laboratory quality control and method validation. These reference materials are hard coal, brown coal and furnace coke. Knowing the heating value and the trace element load is important to reduce the environmental impact of coal. Sulfur and trace elements from coal are sources of air-borne pollution.

Burning coal is a major source of CO_2 and contributes to global warming. According to a January 2013 edition of The Economist the European countries of the Organization for Economic Cooperation and Development (OECD) used approximately 450 million tonnes of coal for energy production, heating and steel production in 2012. The new reference materials are certified for their heating value, ash, sulfur, chlorine and trace element content.

“These reference materials improve the quality of coal analysis, which provides accurate data for evaluating the environmental impact,” says a JRC scientist. “Heating value and sulfur and ash content also set the financial value of coal.” The certified values were established in two intercomparisons of laboratories of demonstrated competence. 22 laboratories submitted values, which were used to certify heating value, sulfur content, the mass fractions of mercury, lead, arsenic, antimony, selenium, nickel, cadmium and others.
http://dailyfusion.net/2014/01/eu-establishes-reference-materials-to-improve-coal-analysis-26071/

Seven countries responsible for 2/3 of climate change, research shows

21st January 2014, Charlotte Malone, blue and green tomorrow

New research has found that just seven countries, including the UK, account for 63% of climate change. Relative to population size, the UK has pumped the most greenhouse gases into the atmosphere because of historical use of coal.

The research, which is published in the *Environmental Research Letters* journal, aimed to identify which countries were most responsible for climate change by measuring carbon emissions, as well as other greenhouse gases, from the industrial age through to 2005.

The top contributor was found to the US, which has released more than double the emissions of China, which ranks second. Russia, Brazil, India, Germany and the UK followed. Collectively, these seven countries account for 63% of global warming, according to the research.

However, when the emissions are analysed against population size, the UK has contributed the most pollution per person. The researchers said this is because of the UK's prolific use of coal in its past, which accounts for a large portion of its cumulative fossil fuel emissions.

Whilst developed countries were found to be "*responsible for the vast majority of historical emissions"*, the paper noted that some developing countries, most notably China, are closing the gap and in some cases are now polluting more than developed nations. The researchers also noted that assessing emissions based on where products are consumed shifts the allocation of current emissions from major producer countries, such as China, to countries in North America and Western Europe. For more visit:-
http://blueandgreentomorrow.com/2014/01/21/seven-countries-responsible-for-two-thirds-of-climate-change-research-shows/

Coal plant closure warning over electricity supply

5th February 2014, unattributed, Coal International

The UK's electricity generating capacity at coal and nuclear power plants faces a 75% shortfall in the next decade, according to a new report by energy data specialist EnAppSys. According to the report, if this lost capacity is not replaced the country could lose capacity at plants that provided 41% of electricity generation in the UK last year.

EnAppSys estimates that in the next ten years coal generation could fall as low as 8GW and nuclear generation to 1.3GW due to the closure of ageing power plants, well below the combined 37.5GW of current capacity. Tougher environmental laws and age are triggering the closure of these plants, said the report, as operators find it increasingly difficult to meet strict emissions targets, while decommissioning looms for the majority of nuclear stations in the next 10 years.

Speculation that the UK government will announce a freeze on the carbon floor price, essentially a charge on emissions, could encourage some operators to continue running their coal plants. However, added the report, this alone will not solve the impending capacity crisis. In the absence of significant build of electricity storage projects in the UK there must remain sufficient conventional capacity to provide power at times of system stress when levels of generation from renewable sources are low.

A significant upsurge in the number of conventional generating plants coming on stream will therefore be required in the next decade. EnAppSys' report stresses that the UK will need between 10 and 20GW of new capacity to meet demand with the consensus favouring gas-fired generation to plug the gap. For more visit....
http://mqworld.com/article.php?id=15576

Waste from age-old paper industry becomes new source of solid fuel

12th February 2014, unattributed, Science Daily

In today's search for renewable energy sources, researchers are turning to the hi-tech, from solar and hydrogen fuel cells, and the very low-tech. The latest example of a low-tech alternative comes from an age-old industry: paper. A new study reveals a sustainable way to turn the huge amounts of waste from paper production into solid fuel with the added bonus of diverting the sludge from overflowing landfills.

Chinnathan Areeprasert, Peitao Zhao and colleagues note that making paper, from debarking and chipping wood to the final steps of pulping and refining, creates a tremendous amount of wood fibers and other wastes. Sending this sludge to landfills can be problematic, because substances can leach out and pollute groundwater. But recently, researchers have been exploring ways to turn the planet's growing waste streams into useful products, such as fuel and fertilizer. One such process is called subcritical hydrothermal treatment (HTT), and it uses heat and pressure to break down and remove various components of a mixture. In one case, researchers used HTT to turn sewage into a clean, solid fuel. Early studies show it can transform paper sludge into fuel as well. Areeprasert's team decided to figure out the best HTT conditions for this process, and to test them in a pilot plant.

They tried different temperatures and defined the optimal conditions for converting paper waste into fuel using HTT. The resulting product had a composition similar to coal. Importantly, the amount of energy that can be recovered from the fuel is higher than the energy required making it. The researchers conclude that this method for making fuel is both sustainable and lends itself to commercialization.
http://www.sciencedaily.com/releases/2014/02/140212112751.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sciencedaily%2Fmatter_energy%2Ffossil_fuels+%28Fossil+Fuels+News+--+ScienceDaily%29

UK failing to harness its bioenergy potential

19th February 2014, unattributed, Science Daily

The UK could generate almost half its energy needs from biomass sources, including household waste, agricultural residues and home-grown biofuels by 2050, new research suggests. Scientists found that the UK could produce up to 44% of its energy by these means without the need to import. A new study highlights the country's potential abundance of biomass resources that are currently underutilized and totally overlooked by the bioenergy sector.

Study author Andrew Welfle said: "The UK has legally binding renewable energy and greenhouse gas reduction targets, and energy from biomass is anticipated to make major contributions to these. The widely discussed barriers for energy from biomass include the competition for land that may otherwise be used to grow food and the narrative that biomass will have to be imported to the UK if we want to use increased levels of bioenergy. But our research has found that the UK could produce large levels of energy from biomass without importing resources or negatively impacting the UK's ability to feed itself."

The research involved analysing the UK's biomass supply chains and investigating how different pathways that the UK could take may influence the potential bioenergy that the country could generate from its own resources up to 2050. For more visit:-
http://www.sciencedaily.com/releases/2014/02/140219075215.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sciencedaily%2Fmatter_energy+%28Matter+%26+Energy+News+--+ScienceDaily%29

Peterhead carbon capture plant moves ahead with Shell agreement

24th February 2014, unattributed, The Engineer

The first industrial-scale application of Carbon Capture and Storage (CCS) technology moved forward today after Shell signed an agreement to begin Front-End Engineering and Design (FEED) of the Peterhead carbon capture project in Scotland. The project, led by Shell with

support from SSE, owners of the Peterhead gas power station in Aberdeenshire, aims to capture 10 million tonnes of CO2 over 10 years. If successful, the project will represent the first application of CCS technology at a gas power station anywhere in the world. For more....
http://www.theengineer.co.uk/energy-and-environment/news/peterhead-carbon-capture-plant-moves-ahead-with-shell-agreement/1018087.article

Coal gets a bad rap – CO2 cools the earth and creates more plant growth

5th March 2014, Bob Ashworth, EnergyBiz

It is important to refute the bad rap that coal is getting. Coal gets a bad name because people say the carbon dioxide released to the atmosphere during the combustion of coal warms the earth. This is completely false. The empirical data (actual measurements)[1] show that atmospheric CO2 concentrations have no discernible effect on global temperature, see Figure 1. The land-sea temperature change shown is data from the United Kingdom's Hadley Climate Research Unit and the lower troposphere temperature change from the Microwave Sounding Unit satellite. The average CO2 plot is from the Mauna Loa Observatory in Hawaii. While CO2 levels increased some 20 ppmw from 1998 until today, global temperatures did not increase as predicted by the Intergovernmental Panel on Climate Change (IPCC) models - they fell! For more visit.....
http://www.energybiz.com/article/14/03/coal-gets-bad-rap-co2-cools-earth-and-creates-more-plant-growth

'Eco' coal pellets to help Poland cut emissions

6th March 2014, unattributed, ForexTV.com

A company in Poland is manufacturing coal-based pellets which it says could significantly reduce carbon emissions from the country's power-generating plants. The pellets combine coal with cleaner burning biofuel ingredients, producing a fuel that is just as efficient as conventional coal, but more environmentally friendly. Jim Drury has more. For more see....
http://forextv.com/top-news/eco-coal-pellets-to-help-poland-cut-emissions/

UK and China sign £20m low carbon innovation deal

7th March 2014, Priyanka Shrestha, Energy Live News

The UK and China have signed a £20 million agreement to work together in developing innovative low carbon technologies.

The three-year programme will support research to develop new low carbon methods of manufacturing processes and technologies, urban living and offshore renewable energy production in the two nations. Under the Memorandum of Understanding (MoU), both the countries will each commit £10 million of "matched resources", with approximately £6.6 million available each year. Energy Minister Greg Barker welcomed the programme saying: "Investing in innovation and science is essential for both the UK and China to address energy supply issues and meet emissions targets as well as drive long-term economic growth. In the UK we have ring-fenced a science budget worth £4.6 billion per year and invested £29 million in joint projects with China."

The agreement was signed by representatives from the National Natural Science Foundation of China (NSFC) and the Engineering and Physical Sciences Research Council (EPSRC) as part of the Research Councils UK (RCUK) Energy Programme.
Source:- http://www.energylivenews.com/2014/03/07/uk-and-china-agree-20m-low-carbon-innovation-deal/

China sticks with coal gasification to curb smog despite potentially big rise in CO2 emissions

12th March 2014, Coco Liu, Environment & Energy News

While experts worldwide have opened fire on China's move to produce natural gas from coal, Chinese policymakers appear to be standing pat on their decision. During a recent press

conference in Beijing, Wu Xiaoqing, vice minister of China's Ministry of Environmental Protection, told reporters that "central and western China are rich in coal and have a bigger environmental capacity; we encourage adopting coal-to-gas technology there, and use the produced gas to replace coal needed in the eastern part of the nation." Wu's claim came at a time when doubts are running high on whether or not China will continue its support for building massive synthetic natural gas plants. While the plants can convert coal to cleaner-burning natural gas, associated water stress and environmental damages could pose another problem.

Those concerns have already forced Beijing once to put coal-to-gas development on hold. The Chinese government called off the approval of new synthetic natural gas plants in 2010 and only recently renewed its interest.

In the press conference Saturday, words from the Chinese official indicated why. "According to our monitoring, only three of 74 recorded cities met the new national air quality standards throughout last year," said Wu. He added that Beijing and surrounding areas saw air pollution on more than 60 percent of days in 2013, and city clusters in the Yangtze and the Pearl River deltas also experienced chronic smog problems. "Those regions account for only 8 percent of China's lands, but they consume 43% of the total coal the country uses," Wu explained. "Emissions from coal combustion are a key source of pollutants; if we want to curb air pollution, we have to curb the use of coal." For more visit:-
http://www.eenews.net/stories/1059995991

Rio Tinto chief urges carbon capture progress despite research funding halt

21st March 2014, Lenore Taylor, The Guardian

A Rio Tinto executive has claimed it is “fruitless to keep indulging in idealistic discussions about climate change” because fossil fuels are “here to stay” and has demanded more investment in carbon capture and storage. But the company, along with other Australian coal producers, has stopped payments to the industry’s much-vaunted Coal21 fund to help finance research on that technology.

In a speech to the Energy Policy Institute of Australia on Friday, Rio Tinto’s head of energy, Harry Kenyon-Slaney, said: “It is clear we can’t just wish away fossil fuels. Any solution to climate change must recognise the ongoing significant role of fossil fuels in the global energy mix. It would simply be impractical and unrealistic not to do so. For more see.....
http://www.theguardian.com/business/2014/mar/21/rio-tinto-chief-urges-carbon-capture-progress-despite-research-funding-halt

Newly discovered North Sea coal 'Could power Britain for centuries'

30th March 2014, Jack Moore, Yahoo News

Scientists have discovered huge coal deposits under the North Sea that could power Britain for centuries. Data from North Sea oil and gas exploration has been used to build a picture of the large coal deposits. "We think there are between three trillion and 23 trillion tonnes of coal buried under the North Sea," Dermot Roddy, former professor of energy at Newcastle University, told the Sunday Times.

"This is thousands of times greater than all the oil and gas we have taken out so far, which totals around 6bn tonnes. If we could extract just a few per cent of that coal it would be enough to power the UK for decades or centuries," he continued. Geologists are yet to discover the scale of the coal deposits, despite already knowing that Britain's coal resources stretched out into the North Sea.

Roddy is to reveal plans to sink the first boreholes by the end of 2014 at a Royal Academy of Engineering conference. Professor of petroleum exploration at Imperial College London Richard Selley said that such discoveries of unconvential energy stores were "game-changers".

"A decade ago the talk was all about peak oil and gas but that has gone out of the window," he said.

"The big game-changer is seismic imaging, which has become so sensitive that we can now pinpoint the 'sweet spots' where shale gas, oil and coal are to be found."There have also been huge improvements in horizontal drilling . . . and in hydraulic fracturing [fracking], which lets us get the gas and oil out of rock. If we put aside the green issues, then in perhaps 10 years we could be self-sufficient in gas and possibly oil too." Energy companies previously deemed such stores inaccessible but technological advances such as gasification have allowed underground pumps to turn the coal into gas useful for power-generation. Source:-
https://uk.news.yahoo.com/newly-discovered-north-sea-coal-could-power-britain-123321211.html#RvlKSrJ

What will climate policy mean for coal?

31st March 2014, unattributed, Science Daily

Limiting climate change to 2 degrees C means shutting down coal power plants -- an unpopular proposition for coal power companies. But a new study shows that delaying climate policies could prove even worse for power plant owners.

Coal power plants are a major source of greenhouse gas emissions, and new plants are planned around the world, particularly in India and China. These new power plants are built to run for 30-50 years, paying off only after years of operation. But stringent climate policies could make the cost of emission so high that coal power generation is no longer competitive, leaving new power plants sitting idle and their owners and investors with huge losses -- a problem known as stranded capacity.

"If we are serious about meeting climate targets, then the reality is that eventually we will have to start shutting down coal-fired power plants. But the longer we delay climate action, the more stranded capacity we'll have," says IIASA researcher Nils Johnson, who led the new study, published today in the journal *Technological Forecasting and Social Change*. "Delaying action encourages utilities to build more coal-fired power plants in the near-term. Then, when policies are finally introduced, we have to phase out coal even more quickly and more investments go to waste," he says.

The new study finds that as much as 37% of global investment in coal power plants over the next 40 years could be stranded if action is delayed, with China and India bearing most of these costs. The study explored strategies to reduce stranded capacity in coal power plants, while limiting future climate change to the internationally agreed 2°C target. For more see.....
http://www.sciencedaily.com/releases/2014/03/140331114235.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sciencedaily%2Fmatter_energy%2Ffossil_fuels+%28Fossil+Fuels+News+--+ScienceDaily%29

Beijing stops issuing permits for coal production

31st March 2014, unattributed, WantChina Times

The Chinese government has stopped issuing permits for coal production and operations, considered a positive measure for the sector as coals firms are now allowed to operate freely without having to pay for other licensed coal companies. Some experts said that having to obtain a permit for coal production and operations of a business were obstacles in the way of the development of the sector. In addition, they suggested that the government cancel the qualification of companies that held the rights to operate the railway but were earning a profit by charging higher fees from other railway users. Thus, limited railway resources could effectively serve coal-related firms. For more see....
http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20140331000092&cid=1102

German study criticises rising CO2 output from coal plants

2nd April 2014, unattributed, Reuters Africa

Germany's 30 biggest power stations in 2013 raised their carbon dioxide output by 4.6 percent year on year to 239 million tonnes, a study from the Oeko-Institut research institute said on Wednesday, blaming low European carbon prices." Despite the expansion of renewable energy, emissions from coal-to-power production rose in 2013. The background is the crisis of the EU Emissions Trading Scheme (ETS)," the influential Freiburg-based institute said in a press release.

"Should a strengthening of the ETS fail, it will be necessary to introduce legal instruments in order to reach climate targets," it added. The EU ETS was intended to discourage coal-burning by putting a price on carbon emissions and making them tradeable. But oversupply of permits has held down carbon prices to such low levels that they no longer deter utilities. EU governments have set in motion a plan to boost prices by temporarily removing permits from the market. For more see....
http://af.reuters.com/article/energyOilNews/idAFL5N0MU38A20140402

An estimated trillion tonnes of coal found off Wales' coast

6th April 2014, James McCarthy, Wales On-line

Now King Coal is set to rule the waves... scientists claim vast reserves under the sea could power the nation for generations to come. A trillion tonnes of coal could be lying under the sea off Wales – according to scientists who say the vast deposits would be enough to keep the lights on for hundreds of years. Scientists made the discovery after studying data from seismic tests and boreholes made for oil and gas exploration. Instead they used it to build up a picture of coal deposits.

Dr Harry Bradbury is chief executive of Five Quarter, the firm behind the discovery. He said: "Off Wales as a whole, there is in all likelihood, more than one trillion tonnes of reserves as yet untouched. "Not all of this would be usable or accessible, but it is still very large scale." Off the UK he estimated there was between three and 23 trillion tonnes.

Five Quarter is planning to sink its first boreholes in the North Sea as early as autumn. But, as yet, it has no plans for Wales. "In the North and Irish Sea there is much more coal than anything we have on shore," he said. "When you look at the raw data I can't even enunciate the biggest number because it has got so many zeros." The firm's work revealed up to 20 layers of coal extending from the coast far out into the sea. "We can say there are at least three trillion tons of coal sitting in the sea," Dr Bradbury said. "There is coal in Wales in Swansea Bay and in Liverpool Bay coming into Wales." There are also reserves off Anglesey. For more visit:-
http://www.walesonline.co.uk/news/wales-news/now-king-coal-set-rule-6923421

German coal industry underpins renewable push

10th April 2014, Richard Anderson, BBC Business News

Germany is an enlightened leader in the global battle to reduce CO2 emissions, a pioneer in renewable energy and community power projects and a champion of energy efficiency. Or so the common narrative goes. But try telling that to Monika Schulz-Hopfner. She and her husband, along with 250 other residents of Atterwasch, a quiet village near the Polish border, face eviction from their home of 30 years to make way for the Janschwalde-Nord coal mine. And not just any old coal, but lignite, the dirtiest form of this ancient fossil fuel that is mined in vast opencast pits. If the plans go ahead, the village, parts of which date back more than 700 years, will be demolished. "Since the plans for the mine were unveiled in 2007, we have lived with this constant threat, which has taken over the lives of every individual and the community as a whole," says Mrs Schulz-Hopfner. "Every single decision we make is affected by it." And the residents of Atterwasch are not alone. In the eastern German region of Lausitz, nine villages are under threat, where up to 3,000 people could lose their homes to make way for five new lignite

mines that are fuelling the country's renewed thirst for coal. Two further mines are under consideration. For more visit:-
http://www.bbc.co.uk/news/business-26820405

Ministers confirm mines closure

11th April 2014, unattributed, Press Association

Britain's historic deep-pit coal mining industry is on the brink of extinction after the Government decided there was no case for investment to keep two of the last three sites open in the long term. Ministers have agreed to a £10 million loan, alongside £10 million from the private sector, to support the "managed closure" of the mines at Kellingley in North Yorkshire and Thoresby in Nottinghamshire.

Together the sites, operated by Britain's largest coal producer, UK Coal, employ 1,300 people. They are to be wound down by autumn 2015. The Government backing spares the company the prospect of immediate insolvency which would have cost the Treasury "significant losses and liabilities" from redundancies and unpaid taxes.

In a written statement to MPs, energy minister Michael Fallon said: "The taxpayer is better served by supporting a managed closure of the mines."However, deep coal mining remains an inherently risky business. There is no value for money case for a level of investment that would keep the deep mines open beyond this managed wind-down period to autumn 2015. "Private sector investors who wish to put in the substantial investment that would be needed to maintain the mines beyond autumn 2015 without government support remain free to do so."
Mr Fallon said the Government intended to participate in a private sector-led consortium "to avoid the immediate insolvency of UK Coal".

The proposal, which ministers have been considering since March 21, would see the deep pits face a phased shutdown and UK Coal's six surface mines sold off. For more visit:-
http://news.uk.msn.com/uk/ministers-confirm-mines-closure-2

IPCC report: Climate needs swift shift to clean energy

13th April 2014, Wendy Koch, Asbury Park Press

A rapid shift to less-polluting energy will be needed to avoid catastrophic global warming, because global emissions of heat-trapping greenhouse gases have accelerated to unprecedented levels, the United Nations reports today. These emissions - largely from the burning of oil, gas and coal - grew more quickly between 2000 and 2010 than in any of the three previous decades and will need to be slashed 40% to 70% by mid-century and almost entirely by century's end to keep global temperatures from spiralling out of control, according to a landmark report by the U.N. Intergovernmental Panel on Climate Change. Even those emissions cuts might not be enough. The IPCC report, striking a particularly urgent tone, says countries might even need to enlist controversial technologies that remove carbon dioxide from the atmosphere. For more visit:-
http://www.app.com/usatoday/article/7593073

Greenhouse gas emissions from today will be felt for at least 1,000 years

13th April 2014, unattributed, Science Daily

Greenhouse gas emissions from today will greatly affect our descendants for at least 1,000 years. In 1,000 years, between 15 and 40 per cent of the CO2 we emit today will still be left in the atmosphere," says one professor. "We are talking about effects 30 generations ahead. This is something people need to take to heart now." "In 1000 years, between 15 and 40 per cent of the CO_2 we emit today will still be left in the atmosphere," says Professor Anders Hammer Strømman at the Norwegian University of Science and Technology (NTNU).

"We are talking about effects 30 generations ahead. This is something people need to take to heart now." It doesn't stop with 30 generations either. The effects of our actions today will be measurable for longer than that. The content of greenhouse gases in the atmosphere grew

stronger over the past decade than ever before. "It is time to wake up," says the climate researcher. Hammer Strømman is co-author of the latest report from the Intergovernmental Panel on Climate Change (IPCC) that will be presented 13 April. Here, the researchers will present several possible solutions to mitigate climate change. Hammer Strømman is a professor at the Department of Energy and Process Engineering, Industrial Ecology Programme at NTNU. For more visit:-
http://www.sciencedaily.com/releases/2014/04/140413094119.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sciencedaily%2Fmatter_energy+%28Matter+%26+Energy+News+--+ScienceDaily%29

Post-Fukushima Japan chooses coal over renewable energy

14th April 2014, unattributed, Eco-business.com

Prime Minister Shinzo Abe is pushing Japan's coal industry to expand sales at home and abroad, undermining hopes among environmentalists that he'd use the Fukushima nuclear accident to switch the nation to renewables.

A new energy plan approved by Japan's cabinet on April 11 designates coal an important long-term electricity source while falling short of setting specific targets for cleaner energy from wind, solar and geothermal. The policy also gives nuclear power the same prominence as coal in Japan's energy strategy.

In many ways, utilities are already ahead of policy makers. With nuclear reactors idled for safety checks, Japan's 10 power companies consumed 5.66 million metric tonnes of coal in January, a record for the month and 12 percent more than a year ago, according to industry figures.

"You cannot exclude coal when you think about the best energy mix for Japan to keep energy costs stable," said Naoya Domoto, president of energy and plant operations at IHI Corp., a developer of a technology known as A-USC that burns coal to produce a higher temperature steam. "One way to do that is to use coal efficiently." For more information visit:-
http://www.eco-business.com/news/post-fukushima-japan-chooses-coal-over-renewable-energy/

Methane hydrate: Dirty fuel or energy saviour?

17th April 2014, Richard Anderson, BBC Business News

The world is addicted to hydrocarbons, and it's easy to see why - cheap, plentiful and easy to mine, they represent an abundant energy source to fuel industrial development the world over. The side-effects, however, are potentially devastating; burning fossil fuels emits the CO2 linked to global warming. And as reserves of oil, coal and gas are becoming tougher to access, Governments are looking ever harder for alternatives, not just to produce energy, but to help achieve the holy grail of all sovereign states - energy independence.

Some have discovered a potential saviour, locked away under deep ocean beds and vast swathes of permafrost. The problem is it's a hydrocarbon, but unlike any other we know. Otherwise known as fire ice, methane hydrate presents as ice crystals with natural methane gas locked inside. They are formed through a combination of low temperatures and high pressure, and are found primarily on the edge of continental shelves where the seabed drops sharply away into the deep ocean floor, as the US Geological Survey map shows.

And the deposits of these compounds are enormous. "Estimates suggest that there is about the same amount of carbon in methane hydrates as there is in every other organic carbon store on the planet," says Chris Rochelle of the British Geological Survey. In other words, there is more energy in methane hydrates than in all the world's oil, coal and gas put together.

By lowering the pressure or raising the temperature, the hydrate simply breaks down into water and methane - a lot of methane. One cubic metre of the compound releases about 160 cubic metres of gas, making it a highly energy-intensive fuel. This, together with abundant reserves

and the relatively simple process of releasing the methane, means a number of governments are getting increasingly excited about this massive potential source of energy. For more see....
http://www.bbc.co.uk/news/business-27021610

EU green light for UK carbon capture and storage project

17th April 2014, Matt McGrath, BBC News

A UK project to capture CO2 and bury it under the North Sea looks set to receive a 300m-euro boost from the EU.The European Commission has confirmed that the **White Rose carbon capture and storage** (CCS) project is in line to win the cash (equivalent to about £250m). The gas will be siphoned off from a new coal-fired power station and stored in undersea rock formations. Climate scientists believe CCS has a key role to play in reducing future CO2 emissions. Building large-scale demonstration plants that capture carbon from coal or gas and secure it in permanent storage sites has not been easy. In 2012, the European Union was **unable to find a single project to fund** when it attempted to spur the development of the technology. Undeterred, the EU Commission again asked governments to submit written proposals on CCS and, according to officials; the UK has nominated the White Rose project. As it is the only eligible plan to have been put forward, it is expected that a grant of 300m euros will now be forthcoming in June. "The UK has confirmed the White Rose CCS project," said an EU spokesman. "The project will hence be considered for an award expected by mid-2014. If awarded, this project could boost the local economy and create jobs when they are most needed." For more visit:-
http://www.bbc.co.uk/news/science-environment-27063796

The Biomass and Fossil Fuel Research Alliance - Project Portfolio (April 2014)

The Biomass and Fossil Fuel Research Alliance (BF2RA) was established in September 2009 with the objectives of promoting research and other scientific studies into:-

- the production, distribution and use of biomass and fossil fuel and their derivatives.
- the minimisation of by-products arising from the use of biomass and fossil fuel and to assess the environmental impact caused by such materials and the development of products thereof and
- the provision of funding for such work and to publish the useful results, to make grants to any person or persons engaged in or connected with research work, and to advance the education of such persons.

Additionally BF2RA has organised the Coal Science Lecture since 2012.

Currently membership of BF2RA comprises seven 'world-class' power generation, equipment supplier, research and coal utilisation organisations, namely, Alstom Power, British Sugar plc., Doosan Power Systems, Drax Group Ltd., EDF Energy, E.ON New Build and Technology Ltd. and EPRI,. To date BF2RA has established a portfolio of 14 R&D projects one of which has now been completed. Current projects are a mix of PhD and EngD studies with 3 or 4 year durations.

Presented below are summary details of the BF2RA project portfolio.

Grant 01 - Dynamic Modelling and Simulation of Supercritical Coal-fired Power Plant with CO_2 Capture Ability (2011 to 2014)

University of Hull. Academic Supervisor - Dr Meihong Wang

The aim of this project is to develop a dynamic model for the whole supercritical coal-fired power plant. It is proposed to model the water/steam cycle and the air/flue gas cycle of a typical supercritical coal-fired power plant. This dynamic model for supercritical coal-fired power plant will be linked with the dynamic model for CO_2 post-combustion capture plant (being developed by another PhD project). This will enable us to explore a key design and operation issue - whether such a supercritical plant with CO_2 capture ability can satisfy the UK grid requirement.

Grant 02 - Intelligent Flame Detection Incorporating Burner Condition Monitoring and On-Line Fuel Tracking (2010 to 2013)
University of Kent. Academic Supervisor – Professor Yong Yan
This project aims to develop a cutting edge flame monitoring technology that can also indicate the condition of the burner and track the type of coal and/or biomass fuels. Specific objectives are: to develop a technology for flame stability measurement, burner condition monitoring and on-line fuel tracking through digital imaging and flame signature analysis; to evaluate the technology under a range of biomass firing, coal/biomass co-firing, and oxy-fuel fired conditions on a combustion test facility and on a full scale multi-burner furnace; and to make recommendations for improvements of existing furnaces through the use of the new technology.

Grant 03 - Impact of Biomass Torrefaction on combustion behaviour in co-firing (2010 to 2014)
University of Nottingham. Academic Supervisor – Professor Colin Snape
The principal aims of this project are to investigate a number of the key fundamental issues associated with the development of torrefaction technology for a wide range of biomass materials that will help to promote the more widespread use of torrefied materials especially in the UK.

Grant 04 - Avoiding Sintering of Coal-Fired Shallow Fluidised Beds (2011 to 2015)
University of Nottingham. Academic Supervisor – Dr Hao Liu
The project is focusing on the investigations of the main causes of bed sintering/defluidization during 'lump' coal combustion in shallow fluidized bed combustors. The project will also investigate the effect of co-firing biomass on the bed materials' sintering and fluidization. The 'alkali getter' technique will be explored to alleviate/avoid bed sintering/defluidization during co-firing biomass with lump coal in shallow fluidized beds.

Grant 05 - Milling and Conveyance of Biomass (2011 to 2015)
University of Nottingham. Academic Supervisor – Dr Carol Eastwick
The aim of the project is twofold, to investigate milling behaviour of a range of biomass materials and to investigate how these milled biomasses impact pipe wear. This is being achieved by bench scale milling, analysis of the milled products and design and use of a test rig to rank milled products in a test pipeline.

Grant 06 - A New Classification System for Biomass and Waste Materials for use in Combustion (2011 to 2015)
University of Nottingham. Academic Supervisor – Professor Colin Snape
The overall aim of this project is to develop a classification system for non-coal materials, analogous to those which have been widely applied in the utilisation of coals. This includes characterisation of biomass and waste materials in terms their elemental and chemical analyses and investigation of de-volatilisation and char burn-out and to develop the new classification system as a predictive tool for combustion behaviour and its efficacy when applied to blends with coals

Grant 08 - Modelling chemical and micro-structural evolution across dissimilar interfaces in power plant alloys (2011 to 2015)
Nottingham University. Academic Supervisor – Professor Graham McCartney
This project addresses the Materials Development priority theme of the BF2RA call in that it is directly relevant to the performance, in-service, of fusion welded joints between dissimilar alloys (e.g. steels and nickel alloys or different steel grades). It will also be pertinent to the development of advanced plant components which require protective coatings by weld overlay or thermal spraying for the more aggressive operating environments of biomass combustion.

Grant 09 - Development of a Novel Feeding System for Pressurised Combustion/Gasification Processes (2012 to 2015)
Sheffield University. Academic Supervisor – Professor Vida Sharifi
The overall objective of this project is to develop a novel and reliable feeder for continuously feeding solid fuel such as coal, biomass and waste into high pressure environments. Such a feeder will aim to enhance the commercial viability of high pressure biomass/coal gasifiers and combustors and to achieve this will need the following properties - high reliability, low construction, maintenance and operating costs, low power consumption and wide applicability.

Grant 11 - Development of Novel Coatings to Resist Fireside Corrosion in Biomass-fired Power Plants (2012 to 2015)
Cranfield University. Academic Supervisor – Professor John Oakey
The fundamental research challenge to be addressed in this PhD project, and its overall aim, is to use a novel, rapid coating development methodology to identify coating compositions that will resist the fireside corrosion environments found on superheater and reheater tubes in combustion plants firing a high proportion of biomass fuels.

Grant 12 - Integrity of Coated Ferritic Alloys under High Temperature Creep and Fatigue (2012 to 2016)
University of Nottingham. Academic Supervisor – Dr Wei Sun
The overall aim of this project is to concentrate on investigating the integrity of coated samples subjected to high temperature exposure and steady/cyclic mechanical loadings. Specific objectives will include gaining a better understanding of presently developed coatings and the associated key failure mechanisms, ranking of the potential coatings based on testing results and provision of generic understanding of factors limiting coating service life.

Grant 14 - Biomass Exacerbated Cyclic Oxidation of Steels in Steam (2013 to 2017)
University of Birmingham. Academic Supervisor – Dr Brian Connolly
The overall aim of this research is the development of a model for steam side oxidation growth and spallation both prior to and after the initial spallation event based on laboratory observations in simulated cyclic steam oxidation experiments. This will build on current research at the University of Birmingham investigating/modelling steam oxidation and spallation of austenitic stainless steels.

Grant 15 - Biomass Co-firing to Improve the Burn-out of Unreactive Coals in Pulverised Fuel Combustion (2013 to 2017)
University of Nottingham. Academic Supervisor – Professor Colin Snape
The overall aim of this research is to determine for a selection of unreactive bituminous coals the extent to which relatively small emissions of biomass can (i) increase volatile yields and so reducing ignition temperatures and (ii) improve char burn-out. Key deliverables from this research will include an understanding of how biomass can improve the combustion performance of unreactive bituminous coals and quantification of the amount of biomass needed to maximise the beneficial effects.

Grant 16 - Modelling of Biomass Milling (2013 to 2017)
University of Nottingham. Academic Supervisor – Dr Carol Eastwick
This study will use data generated by the Milling and Conveyance of Biomass project (Grant 05) and use this as a base to investigate and validate modelling approaches. The overall aim of the research is to identify the most pragmatic modelling approaches for use in the energy industry and so understand the implications of milling to biomass choices. The output from this research will be a validated model and an understanding of the fundamental science behind biomass milling, with a clear appreciation of the advantages and limitations of the modelling methods.

Completed Research. A one year post-doctoral research project on the low temperature ignition of biomass (Grant 10), lead by Professor Jenny Jones of the University of Leeds was completed in late 2013. This study determined the ignition properties and temperatures for a

range of relevant biomass fuels. The influence of (i) moisture (ii) particle size (iii) oil content (iv) oxygen concentration in the ambient atmosphere, on ignition and reaction was investigated. The results were used to categorize the biomass in terms of its ignition risk in both storage, milling, and transport in entrained flows.

The CRF in conjunction with BF2RA held a seminar on selected BF2RA research at the University of Nottingham in October 2013. At this event an overview of all the BF2RA projects was given and details on selected BF2RA projects including the completed study on the low temperature ignition of biomass were presented – see www.bf2ra.org for presentations. An overview of the BF2RA Research Portfolio was presented at the APGTF Workshop at London in March 2014 (the CRF collaborated in organising this event) – see www.apgtf-uk.com for presentation.

BF2RA held its 3rd Open Call for proposals in early 2014. It is anticipated that this Call will result in the supporting of 5 further projects that will commence in late 2014.

For further information about BF2RA and Membership please visit www.bf2ra.org or email technical@bf2ra.org

CALENDAR OF COAL RESEARCH MEETINGS AND EVENTS

Date	Title	Location	Contact
Thursday 15th May 2014	**"Minerals Engineering 2014", organised by the Minerals Engineering Society, (MES), and co-sponsored by the Coal Research Forum, (CRF), the South Midlands Mining and Minerals Institute, (SMMMI) and the RSC Energy Sector.**	**Yew Lodge Hotel, Kegworth, East Midlands.**	**Mr. Andrew Howells, Secretary of the MES, Tel : 01909-591787 Mobile : 07510-256626. E-mail : hon.sec.mes@lineone.net**
3rd to 5th June 2014	Power-Gen Europe	Cologne, Germany	http://www.powergeneurope.com/index.html#showcase_3
Monday 15th to Wednesday 17th September 2014	**10th European Conference on Coal Research & Its Applications, ECCRIA 10, Biennial Conference Organised by the Coal Research Forum**	**The Business School, University of Hull, Kingston-upon-Hull**	**For further information on this Conference, please see the Conference website, www.maggichurchouseevents.co.uk/crf**
Tuesday 30th September 2014	**The 2014 Coal Science Lecture Organised by the Biomass and Fossil Fuel Research Alliance, (BF2RA), with sponsorship from the British Coal Utilisation Research Association, (BCURA), to be given by Peter Emery, Production Director of Drax Power Ltd.**	**The Chartered Accountants' Hall, 1, Moorgate Place, London, EC2R 6EA**	**Mr. J.D.Gardner, BF2RA Company Secretary, Gardner Brown Ltd., Calderwood House, 7 Montpellier Parade, Cheltenham , GLOS , GL50 1UA. Tel : 01242-224886 Fax : 01242-577116 E-mail : john@gardnerbrown.co.uk**
5th to 9th October 2014	12th International conference on greenhouse gas control technologies: GHGT-12	Austin, TX, USA	Sian Twinning, IEAGHG, Orchard Business Centre, Stoke Orchard, Cheltenham, Gloucestershire GL52 7RZ, UK Tel: +44 1242 680753 Fax: +44 1242 680758 Email: sian@ieaghg.org Internet: ghgt.info/index.php/Content-GHGT12/ghgt-12-overview.html
Date to be announced	**"The Control of Mercury and Trace Element Emissions" Coal Research Forum Environment Divisional seminar**	**Venue to be announced**	**Dr. Bill Nimmo Chairman of the CRF Environment Division Tel : 0113-343-2513 E-mail : w.nimmo@leeds.ac.uk**