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NEWSLETTER

of the Coal Research Forum

EDITOR'S MUSINGS:

Welcome to the second edition of 2016. Well things are certainly beginning to look even blacker for coal now. The pace of closure of coal-fired power stations in the UK and Western world appears to be accelerating even though there still seems a future for coal to the East. Peabody, one of the world's largest coal producers has gone into administration and we have been promised a coal-free UK by 2025, according to Amber Rudd, the UK Minister for Energy. Even Membership of our own Forum has seen higher than normal number of those standing down last year, who are no longer involved with coal. But where is the reassuring back stop to ensure that the coal will not be missed. Oh, yes, Sizewell and Hinkley Point er… at least I think they are going to be there one day aren't they? Oui or non?

I came across an article by Professor Paul Younger of the University of Glasgow, erstwhile member of the CRF, which I have copied in full as it seemed to perfectly express my concerns about ending coal use in a better way than I could. I hope you find time to read it. It is titled "The end of coal: good riddance or dangerous gamble?"

Plans continue to make good progress for ECCRIA 11 at the University of Sheffield on 5th to 7th September and we hope that you will consider attending either as an attendee or even presenting a poster, but be quick! Student Travel and Conference Fee bursary support is also available so please see the first two articles in this Newsletter.

The main article in this newsletter is concerning the Annual meeting held in April at Imperial College London. It also features details of a joint divisional meeting of the Environment and Coal Characterisation Divisions held at the same time. For those who did not attend, this report and the slides on the CRF website should help.

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Student Bursaries for 2016-2017

Travel and subsistence bursaries of up to £300 are on offer to bona-fide full-time students who wish to attend appropriate National and International coal-related conferences, (please see the Calendar of Coal Research Events for details of future conferences), and whose supervisor is a member of the Coal Research Forum. To apply, please send the abstract submitted to the conference with a brief supporting letter from your supervisor together with details of the expected expenditure and other sources of funding applied for, to:

Prof. J.W. Patrick,
Dept. of Chemical and Environmental Engineering,
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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, this report will provide some brief details of the beneficiary, their topic of study and the reasons for wishing to attend the conference. Potential applicants should see the template for these reports on the CRF website, www.coalresearchforum.org, where such reports must comply with these requirements.

Please note that these bursaries are only for travel and subsistence to attend the conference, (i.e. not for conference or other fees). In addition, priority will be given to applicants who will be attending the whole of a conference rather than one day of a multi-day event and will be using the conference accommodation provided should this be required. It may not be possible to fund all applications for bursaries or meet the request in full as this will depend on the funds available at the time.

Student Conference Fee Bursaries for the 11th ECCRIA Conference, University of Sheffield, 5th to 7th September 2016

Although the oral presentation programme for the above Conference is now complete, (please see the conference website, www.maggichurchouseevents.co.uk/crf), the Coal Research Form wishes to encourage the submission of further abstracts from PhD students for the Conference Poster Session.

To encourage the submission of further abstracts for this Poster Session, the Coal Research Forum jointly with the RSC Energy Sector is offering a limited number of Student Conference Fee Bursaries for PhD Students to attend this Conference. Applications will be considered against a number of criteria, which will include but not be limited to, the most relevant subject matter, the quality of the abstract, and ensuring an even distribution of this funding across a wide range of Universities.

Those wishing to apply for this bursary, **preceded by the submission of their abstract(s)**, should complete and return the form on the downloads section of the Conference website, as an E-mail attachment, to the Conference Manager, Maggi Churchouse Events, (maggi@maggichurchouseevents.co.uk), by Friday 1st July 2016.

Please note that any abstracts submitted must comply with the format specified on the Conference website, (www.maggichurchouseevents.co.uk/crf), and in the first instance will be considered for poster presentation only. However, the author should specify whether he/she wishes this abstract to be subsequently put forward as an oral presentation, where this will be

considered by the Conference Programme Sub-group only if an appropriate slot becomes available in the programme.

If this application is approved then the applicant will have his/her Conference Fee reimbursed after the conference, provided that he/she has attended the whole conference. There bursaries are open to all PhD students of both CRF and non-CRF Members, including those who have already submitted an abstract.

An application for this student Conference Fee bursary, does not preclude an application for a CRF Student Travel and Subsistence Bursary through the normal CRF system, (please see above and the CRF website, www.coalresearchforum.org). However, due to the limitation of funding available, it is unlikely that a Student Conference Fee Bursaries and a CRF Student Travel and Subsistence Bursary will be awarded to the same student.

Where the student is a Member of the Royal Society of Chemistry, he/she will also be eligible to apply for an Energy Sector Knowledge Transfer Bursary, (a student travel and subsistence bursary to attend conferences).

Report of 27th Annual Meeting and Meeting of the Environment and Coal Characterisation Divisions 20th April 2016 Imperial College London

The 27th Annual Meeting of the Coal Research Forum was held in conjunction with joint Coal Characterisation and Environment Divisional meetings in the Chemical Engineering Department of Imperial College London's South Kensington Campus. The usual format was chosen, which was to hold the Annual Meeting at lunch time preceded and followed by a series of technical sessions.

The attendees where welcomed to Imperial College by Dr Marcos Millan who then handed over the proceedings to Dr Bill Nimmo, chairman of the Environment Division. The morning session, which formed the Environmental Divisional meeting, was entitled "The Control of Mercury and Trace Element Emissions". It comprised four papers.

Due to air traffic delays, Dr Lesley Sloss of the IEA Clean Coal Centre was unable to give the first presentation as scheduled and Mr David Graham of Uniper Technologies Ltd. stepped up to the plate! David's paper was entitled "An Overview of Mercury Monitoring Options". David began by explaining the formation of Uniper. In November 2014, E.ON announced that it would combine its conventional generation and energy trading businesses into a distinct company. This company, called Uniper, is a wholly owned subsidiary of E.ON and began operating on 1st January 2016.

David began by explaining that total mercury as emitted during combustion can exist as elemental mercury, mercury (2+) or particulate mercury. As the amount in particulate mercury is much less than the other two forms, the vapour phase monitoring of mercury in coal fired plants with modern control technology is regarded as acceptable by regulatory bodies. The amount of mercury emitted depends on the particulate matter (PM) control technology fitted; with an ESP up to 50% removal can be expected and this is mostly elemental and mercury 2+. With an ESP and FGD plant the collection rate rises to about 75% and mostly elemental mercury is removed. ESP with FGD and SCR removes about 90% mercury and also enhances the conversion of elemental mercury to 2+ which is water soluble and more easily collected. Flue gas mercury levels are linked to the mercury content of the coal. For example, a coal with 300µg/kg of Hg with an ESP would give a flue gas of ~17µg/Nm^3; adding FGD would reduce this with the same coal to about 8µg/Nm^3 and with ESP, FGD and SCR the flue gas would contain about 3µg/Nm^3.

Moving on to the measurement options David mentioned periodic sampling, (Method EN 13211: 2001). The Industrial Emissions Directive states that for boilers firing coal or lignite total mercury should be measured at least once a year. Flue gas is extracted at 20 to 30 litres per minute for 1 to 2 hours to obtain more than 1Nm^3. The probe/collector is maintained at >120^OC and the gas is passed into one of several mercury measurement systems which were explained by David in the next section on continuous monitoring of Hg.

For Large Combustion Plant (LCP) Best Available Technology BAT reference method (BREF) continuous monitoring is required unless it can be demonstrated by other means that the Emission Limit Values (ELV) will not be exceeded. The first stage is the reduction of Hg using either a wet chemical conversion, thermo-catalytic conversion or thermal conversion process. This is followed by an accumulation and separation process using amalgamation in a gold trap and finally measurement of the mercury. David identified four suitable instrumental techniques; atomic absorption spectroscopy (AAS), atomic fluorescence spectroscopy (AFS), atomic emission spectroscopy (AES and differential optical absorption spectroscopy (DOAS). David also described a semi-continuous method which uses mercury sorbents and was developed for use in the USA which has BREF approval.

Illustrations of the instruments available to undertake this type of analysis were shown and a cost comparison showed that the sorbent method was cheaper for the first two years but after that the continuous monitoring system became cheaper.

In summary David concluded that EU mercury monitoring requirements are increasing but that concentration levels are low for coal fired plant. Periodic measurement is possible to EN 13211:2001 with the requirement for an annual test under IED (from 1st Jan 2016) using an accredited test Laboratory (ISO 17025). LCP BREF requires continuous measurement to EN 14884:2005 unless there is an alternative means of demonstrating compliance (2021?). Various techniques are available to measure total Hg as Hg^O). Certification is limited but UK, European & US instruments have the required sensitivity. Capital outlay and running costs are high. There is a semi-continuous measurement prEN XXX which is a simple measurement with rigorous QA and has lower capital outlay but ongoing analysis costs to consider.

Safely landed, Lesley (Sloss) was able to present her paper entitled “International overview on trace element legislation and control”. Lesley began by reviewing the role of the IEA Clean Coal Centre and expressed what is probably universal disappointment at the UK government’s decision to opt out of providing funding for IEA CCC.

Lesley reviewed the existing legislation on mercury emissions in the UN Minamata Treaty, USA, China, the EU and India. All countries either have limits in place or have agreed to limits although not surprisingly they are not all the same.

The Mercury and Air Toxics Standards (MATS) set in the USA have evolved after several rounds of work [via CAMR (Clean Air Mercury Rule) and related vacated rules]. MATS applies to fine particulates, SO2, NOx, and several trace elements. The reduction for Hg is based on the performance of the top 12% performing plants in the country.

The 2013 Minamata Convention on Mercury has target areas for control and reduction as follows:- coal combustion, the chlor-alkali sector, products, air transport and fate research, artisanal and small-scale gold mining, waste management, supply and storage and cement and non-ferrous metals production.

The Minamata Convention requirements are that parties have obligations to reduce mercury from the coal sector under Article 8 - emissions to atmosphere; a National Plan is to be submitted to the Conference of the Parties within 4 years; new sources must comply with BAT/BEP (best available technology/best environmental practice) within 5 years and for existing sources – measures to be introduced within 10 years.

What does BAT (Best Available Technology)/BEP (Best Environmental Practice) mean for coal? It is defined at country level, based on economic, geographic and technical considerations. It could be anything from fuel switching/cleaning, through co-benefit effects to mercury specific control technologies.

How does the EU definition of BAT/BEP differ from the UNEP definition? The guidelines for both cover exactly the same processes and options but the EU BREFs are more detailed and the EU has a proposed emission limit range (1-9$\mu g/m_3$), whereas the UNEP guidelines do not.

Mercury capture is a complex process and the results of capture in particulate control devices depends on the coal type but can be negligible or >90%.

The UNEP Decision Tree is a basic tool to determine control options for specific plants. The conditions are very site specific and expert help is needed to determine optimal approaches. It has been further developed as an interactive programme – iPOG - inputting control options. This programme allows the operator to input plant and fuel parameters and to obtain values for stack mercury emissions, stack mercury speciation and mercury removal.

Lesley briefly highlighted a number of topics which included a list of the installation rates if technologies in the US (free report from IEA CCC); new and emerging Hg control systems; the 2005 statistics on emissions by region and main national emitters and mercury control in South East Asia.

Lesley's conclusions were that mercury legislation is becoming increasingly common and control technologies are readily available and affordable. New advanced multi-pollutant technologies are being developed to control ALL emissions from coal-fired plants. The final point remembered by the editor after this talk was that the main source of mercury emissions in the UK currently are from crematoria!

The third presentation of the morning was given by Dr Kevin Hughes of the University of Sheffield entitled "Experimental and modelling of gas phase mercury oxidation".

Kevin explained that mercury is released in its elemental state from coal combustion. However, in the oxidation phase the oxygenated species are not important it is chlorine that plays a major role and this needs to be reflected in any modelling studies. Under Oxyfuel conditions there are elevated concentrations of minor species (Cl) and elevated levels of CO2/H2O which may affect third body reactions. There are many conflicting published values of Cl + Hg rate coefficient.

The aims of the work described were to investigate the experimental measurement of Hg + Cl reaction and to compare results to other studies. Also, to develop a gas phase kinetic model of mercury oxidation and to compare it to independent laboratory-based measurements. Kevin's team intended to optimise model response to experiments, incorporate experimental measurements and re-optimise the model's response.

The experimental methodology was shown and can be followed by reference to the slides to be found on the Coal Research Forum website.

Kevin's conclusions were that Hg + Cl were measured experimentally and found to be dependent on an assumed Cl atom recombination rate and also dependent on initial Cl atom concentration. However, the results were found to be slower than other literature values but there were believed to be some uncertainty due to initial Cl value. The kinetic mechanism optimisation was found to be compatible with the Donohoue et al. measurement and compatible with their upper bound floating Cl measurement but not that at the lower bound fixed initial Cl.

The final paper of the morning session was entitled "Inductively coupled plasma (ICP) spectroscopy for on-line measurements of trace metal emissions at the 250 kW PACT CTF" and was presented by Mr. Janos Szuhanszki of the University of Sheffield.

Janos began by describing the PACT 250kW solid fuel CTF and its ability to fire 100% coal or 100% biomass. The test facility is well equipped to monitor many operating parameters during test firing.

Janos also described the ICP-OES which is a Continuous Emissions Monitoring Laboratory. It is a self-contained mobile mini laboratory which houses a Spectro CirosCCD ICP-OES: an **i**nductively **c**oupled **p**lasma – **o**ptical **e**missions **s**pectrometer. This instrument can produce emissions spectra of non-volatile/volatile elements:~ over 30 elements – Pb, Na, Zn, B, Al, Br, Ca, Cr, Sc, Cd, Fe, I, K, Li, Co, Cu, Ti, P, Si, Sn, Mg, Ni, Mn, Ag, Tl, S, V, Sb and Hg. The tests Janos described focused on elements that cause operational issues (slagging, fouling, corrosion) K and Na**,** are easily vaporised Hg, Cd, Pb and are toxic (heavy metals) Hg, V, Cr, Cd and Pb.

The key component of the ICP-OES is a custom-built, radial, demountable plasma torch. It's inductively coupled argon plasma torch can achieve – 6,000 K and can identify the emissions spectra (spectral lines) of various non-volatile metals and major, minor, trace and ultra-trace volatile elements. It is used to identify elements that are toxic, causes of operational issues, easily vaporised, etc.

The ICP-OES has been used at various waste-to-energy plants in the UK. Isokinetic sampling from the flue gas stack through a heated line allowed data to be collected over a 24 hr sampling period. Janos showed plots of data for nickel, cadmium and mercury.

Even without calibration, the ICP-OES is useful in that it can detect the presence of specific elements/isotopes. Calibration of the instrument will further benefit future data collection – quantification of the levels of elements in the gas-phase will enable element partitioning studies when combined with detailed ash analysis. This facility is good at analysing elements that can cause operational issues (slagging/fouling) and those in high concentrations.

The afternoon session, which formed the Coal Characterisation Divisional meeting, was entitled "The analysis and characterisation of coal and biomass for utilisation". It was chaired by Professor Ed Lester of the University of Nottingham and comprised six papers.

The session was opened by Dr Will Quick of Uniper Technologies Ltd whose presentation was entitled "Coal and Biomass Characterisation for a Power Generator". Will explained that Uniper is one of the few remaining utility-owned UKAS accredited fuel testing laboratories in the UK. Its role is to support Uniper UK, E.ON UK and external customers by offering fuel quality consultancy services and coal stock density and quality surveys.

Coal faces many challenges at present including the tightening of emission limits for both NOx and SOx and has to compete with the currently low price of oil and gas and the growth of renewables. The Carbon Price Support (CPS) is now ~£18/te CO2 compared with a price for coal of £40 te and there continues to be political uncertainty over future energy policy.

Coal now needs to be of low NOx potential and of low sulphur content. There is however a CPS exemption which applies to 'coal slurry for use in electricity generation'. This includes coal fines which were previously discarded.

Challenges faced by biomass matching cost to quality as only clean wood pellets are commodity traded. Quality standards have been established for pellets and whilst other biomasses may be cheaper than wood pellets, they are of variable quality and volume. Energy is also a new market for biomass growers and suppliers and also has sustainability issues.

The importance of fuel sampling and preparation was shown by the creation of an ISO standard on just this topic. Will then reviewed what he called the 'big six' – no mention of wild animals – just the most important parameters needed in fuel analysis. These were moisture, ash, volatile matter, sulphur, chlorine and calorific value (CV). Other tests included carbon, hydrogen and nitrogen, ash composition, trace elements, particle sizes, biomass purity and pellet durability. Tests carried out less commonly include ash fusion measurements, petrographic and char analysis, spontaneous combustion testing, bulk density measurements and Hardgrove Grindability (HGI) and Free Swelling Indices (FSI).

Why are these tests important?

CV provides the basic value for any fuel. Coal pricing is often based on a net CV of 6,000 kcals/kg (25,251 kJ/kg) which is then adjusted to the measured CV.

Moisture is an unwanted 'inert' which reduces net CV and can have an adverse effect on coal handleability.

Ash is also an unwanted 'inert' which if high mean more coal is required and more ash if formed and has to be sold or otherwise disposed of. Ash can also deposit and cause slagging or fouling and possible abrasive damage.

Volatile matter needs to be above a minimum figure to ensure flame stability but not too high to ensure mill safety and minimise spontaneous combustion. Volatile matter can also have an effect on NOx emissions.

Chlorine and sulphur produce acidic gases which can result in corrosion especially with biomass fuels.

Carbon content has an effect in EU Emission Trading Scheme, hydrogen content affects the net CV calculation and nitrogen content has an impact on NOx emissions.

Ash composition has been used traditionally to calculate slagging and fouling indices but Uniper has recently developed a new risk indices-based assessment which uses ash composition. The method uses a triplot index and can rank coals from very high risk to very low risk with three intermediate categories. Alkali chlorides can also play an important role in biomass fired systems through corrosion.

Trace elements are mostly of environmental concern with arsenic also having a poisoning effect on SCR catalysts. Wood fired plants must limit the amount of zinc and lead fired to limit corrosion. The handling of biomass ash deposits can present occupational hazards and also incur costs as they can be regarded as hazardous wastes.

Biomass purity to qualify for Ofgem ROC's requires a demonstration of non-fossil content. This can be done either by hand sorting the fuel, using a chemical marker, dissolving the cellulosic portion of using carbon 14 testing. The durability of biomass pellets must be demonstrated, as is particle size, hydrophilicity and fines content.

Other ad hoc tests include petrographic analyses of unfamiliar Russian coals, FSI testing of US coals which can result in burner deposition and the spontaneous combustion of highly reactive Indonesian coal.

Fuel buyers try to minimise the cost of coal delivered to their power stations, however the true cost includes many other factors involved in the generation of electricity. These include the power plant efficiency, the cost of reagents to treat flue gas, the cost of emissions and maintenance costs. To get a more accurate picture of true operating costs modelling of fuel quality is used by Uniper. It is known as Value in Use (VIU) modelling and it can optimise performance and costs across a portfolio of power plants. It can also quantify benefits of plant

improvements/upgrades that give enhanced fuel flexibility and can optimise coal preparation to deliver improved value coal products. VIU assessment needs fuel analysis, power plant design, operating and economic data. Two models which have been used are EPRI's VISTA Coal Quality Impact Model and Uniper Technologies' Fuel Evaluation Tool (FET). The FET model, developed in 2010, is routinely used by Uniper's coal buyers to optimise purchasing decisions and for steering coals around the European power plant fleet.

Will concluded his talk by illustrating the use of the FET by presenting data for eight different coals. Based on plots of relative mill performance, unit efficiencies, slagging and fouling, emissions, differential plant operating costs Will was able to show from a plot of total power generation costs that one coal was clearly gave the best overall performance.

Summarising the value of FET Will maintained that there was a recognition in Uniper that coal quality significantly affects power plant variable costs. It is the basis behind the transfer price agreement between Uniper's fuel traders and power station fleet and provides an incentive for fuel traders to purchase best value fuels. It also provides an accurate value assessment of out-of-spec and opportunity fuels and can identify the most suitable power plant for a given coal supply option. It optimises coal supply logistics and coal-related CO_2 emissions.

In summary Will listed the key areas of current concern over the use of coal. It is in a challenging market in which there is an increasing need for good quality data to address ever-tighter regulations. There is a drive to minimise generation costs and a move to use models rather than rely on 'personal experience'. For biomass, the issues are quality versus price, the value of pre-treatment options and meeting regulatory compliance (ROCs, GQCHP [Good Quality Combined Heat and Power] etc.). Finally, there is a need to improve models/ predictive indices to the level used with coal.

The second presentation from industry was given by Dr. Paul O'Meara, PANalytical whose talk was entitled "Analytical Techniques for Grade and Quality Control in Coal Mining". Paul identified the topics of his talk as, on-line elemental analysis of coal using neutron activation, phase and structural analysis of coal by X-ray diffraction and computed tomography and elemental analysis of unashed coal using X-ray fluorescence. Paul began by introducing on-line analysis using neutron activation analysis for coal analysis.

Coal is a high-volume commodity with yearly production values in excess of 7,800 million tons per year the four types, namely lignite, sub-bituminous, bituminous and anthracite, combined. Continuous evaluation of this amount of material is a significant, but necessary, challenge in order to determine the pricing and application for the coal. Statistical analysis of large volumes of material requires regimented sampling procedures, which can occasionally go wrong, leading to reduced profitability.

Cross-belt analysers eliminate this sampling effect by analysing the material as it moves on a conveyor belt, delivering real-time analysis, which can be used for process optimization. The vast majority of cross-belt analyzers are, in fact, neutron activation analysers.

Neutrons are used for two main reasons. Firstly, they are highly energetic and highly penetrating particles, which means that they can access large volumes of material, often through reinforced conveyor belts. Secondly, they interact with elements in the material in a way which causes the emission of gamma photons, which are also highly energetic and highly penetrative, allowing them to leave the sample and make it back to the detector. The probability of interaction between neutrons and atomic nuclei is dependent on the so-called "neutron cross section" which is strongly dependent on the nuclear construction of the element, the type of nuclear reaction and the neutron speed. By far the most common source of neutrons is californium-252, which undergoes spontaneous alpha decay. Neutron activation is also a non-destructive technique, making it ideal for the analysis of valuable commodities.

So what does this mean for coal analysis? Real-time, complete elemental analysis including carbon and hydrogen of a load of coal moving on a conveyor belt. The values of which can be used directly in empirical formulas for the calculation of ash content, moisture content and calorific content. The values for carbon, oxygen, hydrogen and sulfur are automatically fed into formulae to determine the average calorific content for the batch of coal that past over the analyser during the measurement time, which is usually about 2 minutes.

Such a device can be positioned at almost any point in the coal process, from the mine to the end user which can include gasification plants. The benefits for power plants include; load-in analysis to check contract specifications and intrinsic deviation on delivery; superior coal yard management, blending and bunker feeding and feed forward ash, moisture and calorific quantification for combustion and, therefore, boiler optimisation. It can also minimise slagging, derating, boiler outages and maintenance costs.

Moving on to phase and structural analysis Paul then described X-ray Diffraction (XRD) as a versatile, non-destructive analytical technique for the identification and quantitative determination of the various crystalline phases of compounds present in powdered and solid samples. It can also determine the amorphous content of substances. It can be used in the mineralogical quantification of coal and offers fast phase identification of minerals in coal and coal related materials compared to microscopy. It can be used to control erosion and abrasion of the mills by monitoring mineral content, it can be automated, is operator independent, non-destructive, no chemicals are required and has easy sample preparation.

Computed tomography (CT) is a recent, non-destructive state-of-the-art imaging technique which uses X-ray power to analyse the internal structure of different materials. It works on the basis of density contrast, taking the advantage of different levels of X-ray adsorption. Therefore, by this technique, different materials and the interior structure of coals in coals can be identified in 3D by X-ray computed tomography (X-ray CT). CT studies were shown on a block of coal with the distributions within the block of the mineral and pore size distributions. Images of coals after heat treatment were presented to show the changes in volume, voids and composition.

Paul then moved onto the elemental analysis of unashed coal using energy dispersive X-ray fluorescence. Coal is often graded and priced according to the concentration of certain components. Historically, the most important of these is the concentration of volatile compounds, phosphorus, elemental sulfur and other inorganic components, which would remain as ash after combustion.

The composition of the ash affects coal processing, handling and final usage and is, therefore, a critical parameter in the coal process. For example, coking coal used in steel production requires coal with low sulfur and phosphorus concentrations to ensure the quality of the steel being produced. Coal-fired power plants require coals with low sulfur to limit air pollution and minimize wear and tear on equipment.

The inorganic components in coal have traditionally quantified by analysing coal ash. Ashing a coal sample is time-consuming. Bypassing this step would, therefore, be highly beneficial in the coal process, whether it is for specification checking, sorting and coal yard management or blending.

It is now possible to produce reliably accurate reproducible coal pressed pellets for analysis by XRF. This, in combination with our series of Epsilon 3 EDXRF spectrometers, makes for a relatively inexpensive tool for the analysis of inorganic components in unashed coals. This application example demonstrates that small energy dispersive X-ray fluorescence spectrometers are capable of delivering accurate and reliable results for the determination of sulfur, phosphorus and ash content in coal without tedious and lengthy ashing procedures, making them an inexpensive solution for mine or pit management, stockpile sorting, load-in control, coal yard management and blending.

Paul ended by reminding us of the availability of rapid and accurate instrumental technology currently on offer for the better management of supply and usage of coal.

The remaining four presentations were given by post graduate researchers working in coal characterisation. The first talk was entitled "Experience and Limitations found with X-ray Fluorescence Analysis on Biomass Fuels, Low Grade Coal and Agglomerates", given by Stephen Chilton, University of Leeds**.** The scope of Stephen's work was to undertake elemental analysis of fuels and agglomerates and to compare any differences to external results. Upon further investigation Stephen found other groups are investigating similar issues at Leeds and as seen in the literature. The collaborative aims and objectives of the work are to improve reliability and accuracy in the technique.

Stephen described the work he was currently involved with which uses a 350kW thermal bubbling fluidised bed combustor. The bed material is silica sand, bed dimensions are $0.5m^2$ x 0.2-0.3m bed, fuel flow rate 30-35 Kg/hr fuel flow. It operates at 800 to 900^OC and uses ~9,000 litres per minute of air.

Measurements are taken using analysers for O_2, NO_x, SO_2, CO, and CO_2. Labview data acquisition software captures pressure and temperature data. Samples of fly ash, bottom ash, bed material and agglomerates are collected. A variety of coals and biomass samples are being tested.

Stephen explained there were options in the analysis of the slag, agglomerates, fouling samples? These included Optical Emission spectrometry (OES), Atomic Absorption Spectrometry (AAS), Inductively Coupled Plasma (ICP-OES) or wet chemistry. Factors which might influence the choice were time, cost, complexity, training needed, accuracy, repeatability, portability and result?

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Stephen described the principles of XRF analysis and then showed considerable variation in results obtained by the same method on the same samples. A number of factors were attributable to the variation including user ability/training, type of analysis, (i.e. quantitative, semi-quantitative or qualitative), power/size of device, XRF software/algorithms, standard-less fundamental parameters (SLFP), normalisation, sample preparation, sample chemistry/physiology and methodology.

Stephen concluded his talk by offering his recommendation for using XRF analysis for this type of samples. Firstly, use a standardised method for comparison, use results with caution and errors can be reduced by repetition. This is a 'Work in progress' the larger research community are addressing these problems but "Can XRF be used for low grade fuels and agglomerates?"

The second presentation entitled "The use of X-ray Photoelectron Spectroscopy for coal characterisation", was given by Dane Sexton of Cardiff University. The aim of Dane's talk was to introduce XPS as a method for coal characterization and to provide examples of various uses of XPS and how they have been applied in coal research.

What is XPS? It is a non-destructive, surface analysis technique measuring to a depth of 5-10nm It is used to determine electronic structure of atoms and molecules and involves the use of high-energy x-rays which can eject core electrons. It is typically used to analyse inorganic compounds, metals, and polymers. Energy contained within the incident light is absorbed by electrons within the metal, giving the electrons sufficient energy to be 'knocked' out of, that is, emitted from, the surface of the metal. This is the photoelectric process.

Photoelectric process was honed by Kai Siegbahn in the 60s who was awarded a Nobel Prize for his work developing XPS. XPS spectral lines are identified by the shell from which the electron was ejected (1s, 2s, 2p, etc.). Following the photoelectron emission, the atom will release energy through ejection of an Auger electron. A valence electron will fill the space of the photoelectron whilst another electron will be emitted to compensate for this – an Auger electron. It is a secondary electron effect.

The XPS instrument measures the kinetic energy of all collected electrons, both photoelectrons, and Auger electrons and an XPS spectrum will show both XPS (photoelectron) peaks and Auger peaks. Each binding energy (eV) is known to correlate to a specific element/chemical status

$$BE = hv - KE - \phi_{spec}$$

Binding energy (eV) is the energy required to remove an electron from an atom, a molecule, or an ion which allows us to determine what elements are present and in what quantities. The equipment uses an x-ray source which is targeted on the sample. The emitted electrons pass through a lens system into an electron analyser thence to an electron multiplier and an XPS spectrum is produced. An ultra-high vacuum chamber (UHV) is required to increase mean free path for electrons to ensure the photoelectron's kinetic energy will not be significantly altered.

Elemental identification enables the nature and quantity of elements which exist on the surface. It is an effective method of detecting surface contamination but cannot identify hydrogen peaks as there are no core electron. It is the electron – nucleus attraction (binding energy) that is used to identify the elements.

XPS has been used to measure surface effects of natural weathering of coal after 3 to 6 months. A wide survey spectrum is obtained which allows multiple element peaks to be viewed at once. The C1s peak intensity decreases – an indication of decrease in amount of organic materials on surface and the O1s peak intensity increases. The surface contents of Al and Si also increased with weathering.

Each element and type of bond has its own binding energy and by evaluating the intensity of each binding energy peak it is possible to determine the quantities of certain materials. For example, C-H and C-C bonds have a binding energy peak of 285.0 eV.

Surface bonding variation with particle size has been shown using the *C1s* peak spectra. Three different particle size coal chars created in a drop tube furnace to simulate blast furnace coal injection; <1mm, <500µm, <106µm. The two larger size chars had bimodal distributions. By grinding coals to smaller particle size reduced the oxygen-carbon bonding on the surface which have been found to enhance coal reactivity.

Dane also described the use of x-ray excited carbon Auger electrons to study sp^2/sp^3 carbon hybridization. The sp^2 percentage is estimated by a linear interpolation between diamond (100% sp^3) and graphite (100% sp^2) D values. A comparison between raw coals and coal chars showed a higher percentage of sp^2 bonding for chars. Smaller char particle size consistently had lower sp^2 character and more highly ordered graphitic (sp^2) bonding has been correlated with lower char reactivity.

Summarising Dane said that his work had shown that XPS allows the collection of both photoelectrons and auger electrons. XPS can provide a range of chemical information including elemental, bonding, and imaging information. His future work using XPS will investigate char reactivity variations with regards to particle size fractions, volatiles, and char residence times.

Patrick Mason of the University of Leeds gave the third presentation entitled "Thermal conductivity is solid biomass fuels". Wood and the stem structure of herbaceous plants are

constructed of cellulosic fibres with capillary voids running parallel which makes them highly anisotropic and porous. The porosity means they retain moisture and traps gas and air.

If you consider a particle of biomass as comprising three phase components: solid (lignocellulosic fibres: cellulose/hemicellulose/lignin + extractives); liquid (moisture in and between fibres) and gas (air filling the pores between fibres). Each component contributes to the thermal conductivity of the bulk material but the thermal conductivities are massively different, for example; the thermal conductivity of water at 300K: 0.61 $W.m^{-1}K^{-1}$ (Raznjevic 1976) and the thermal conductivity of dry air at 300K: 0.026 $Wm^{-1}K^{-1}$ (Shpilrain 2011).

The thermal conductivity can be modelled as a superposition of the three components: solid/water/air. These can be either considered in series or in parallel. Building a representative network of thermal resistances has been an approach to modelling the thermal conductivity in different axes. Phenomenologically, the relationships between: moisture content and thermal conductivity and between thermal conductivity and density in wood are linear. Patrick also tabled a graph in which the thermal conductivity was plotted against the density of solid wood bot parallel to the grain and across the grain. A linear relationship was shown for both with, intuitively, the higher conductivity being shown for samples measured parallel to the grain. The thermal conductivity (in a particular axis) can thus be approximated as a function of air content:

$$\lambda_{dry} = (1-\beta)\lambda_f + \beta\lambda_g$$

This can be expressed as a function of density:

$$\rho \propto (1-\beta)$$
$$\lambda_{dry} = A\rho + C$$
$$\lambda_{wood} \approx 1.5x10^{-4}\,\rho + 0.030$$

Previously reported work looked at the effect of moisture on conductivity and found that it rose with increasing moisture content. From this Patrick concluded that the thermal conductivity (in a particular axis) can be approximated as a function of moisture content:

$$\lambda_{eff} = (1-M)\lambda_{dry} + M\lambda_w$$

Patrick then investigated the thermal conductivity measurement of herbaceous biomass such as wheat straw and miscanthus. Whereas large samples of solid wood can be measured with conventional means of testing, wheat straw, miscanthus, olive residue and torrefied materials are difficult to get a consistent sample intact and of the right size.

The aim was to determine the thermal conductivity of small particles of these materials for modelling combustion and thermal conversion and the approach used was to create a homogenised, compressed sample from finely milled (powdered) material that would be suitable for measurement.

Biomass samples were made using a hydraulic press: 13mm diameter ~0.5 – 2mm thick. A bespoke test apparatus was designed and constructed to suit both sample size and required heat flow. The test rig used a 5W temperature-controlled heater on one side and an ice bath on the other side: thermocouples were inserted into brass rods 60mm apart. From the results it was possible to derive the thermal conductivity of actual fuel particles as a function of density. Patrick measured the data from homogenised-densified biomass plotted against density compared with published values of wood. Measured thermal conductivity of cross-grain and parallel grain pine samples compared well with published values for woods. As a check the measured thermal conductivity of a PTFE sample also compared well with published data.

The final presentation of the day was given by Joseph Perkins of the University of Nottingham and was entitled "The end of oil immersion microscopy?". The objective of this Engineering Doctorate was to develop several new image analysis methods to measure coal, char, mineral and ash materials resulting in a simple method that can characterise fuel in a way that enables power generators to understand the consequences of fuel choices. In more specific terms the project was aimed at using image analysis to predict how fuel types might perform in a pulverised fuel boiler in terms of burnout efficiency, slagging, fouling and NOx and SOx emissions.

Image analysis can be used to rapidly characterise fuels to predict boiler performance. Many behavioural aspects of coals can be 'seen' under an oil immersion microscope. The development of this technique of a fully automated tool for plant operators may be used to determine, for example, whether a coal is a blend or a single source fuel. However, there is no current technique for collating this information.

In light microscopy, oil immersion is a technique used to increase the resolving power of a microscope. This is achieved by immersing both the objective lens and the specimen in a transparent oil of high refractive index, thereby increasing the numerical aperture of the objective lens. Recently air microscopy has been used to carry out coal and mineral analysis and has advantages such as being able to analyse much larger areas and to identify mineral matter.

This work compared the results from air immersion versus oil immersion microscopy with twelve different carbon materials coals, cokes and chars, selected to represent a wide reflectance range from low rank coal, high volatile bituminous coals, low volatile bituminous, semi-anthracites through to coke material. Resin blocks were prepared and polished for each sample to allow air (at 100x magnification) and oil immersion microscopy (at 500x magnification) analysis. This was followed by automated petrographic analysis to evaluate macerals, micro lithotypes and to measure reflectance.

The results showed that oil immersion gave superior contrast and less sensitivity to sample blemishes. Air immersion showed a larger captured area, was 'cleaner' and had a much greater reflectance range (0.5 to 8.0).

Joseph identified additional work to be carried out which involved pyrolysis of the test samples in a DTF at 200ms, 1% oxygen and 1,300^{o}C to produce a devolatilised char sample. Char samples analysed using air and oil immersion microscopy, thermal analysis, density and particle size and shape – for comparison with the initial samples.

As is often the case Professor John Patrick, Chairman, (Academe), of the Coal Research Forum was invited to give his impressions of the event. John said that he had found it a very enjoyable and varied day with interesting new development being showcased at events such as this and he hoped many more similar events would follow.

Early Career Energy Sector Chemists' Symposium 2016

All chemists working in the energy area in the early stages of their careers were invited to attend the Early Career Energy Sector Chemists Symposium at The Royal Society of Chemistry, Burlington House, London, W1J 0BA on 16th February 2016. The Coal Research Forum awarded a £100 prize to the best fossil fuel related poster presentation. This year the prize was won by Dr Cairong Jiang of the University of St Andrews whose poster presentation abstract is as follows:-

Converting fossil fuel into electricity at high efficiency in a direct carbon fuel cell

Cairong Jiang

The BP Statistical Review 2014 summarised global energy trends and it was found that fossil fuels accounted for 87% global primary energy consumption. Coal, as one of the main fossil fuels, is responsible for 43.9% CO_2 emissions. The efficient use of coal will be a priority, as far as

the environmental impact is concerned. This could be achieved by the direct oxidation of coal in a fuel cell. We investigated the feasibility of such coal oxidation in a system called hybrid direct carbon fuel cells. This device is a combination of a solid oxide fuel cell and a molten carbonate fuel cell. Lignite coal, bituminous coal, and anthracite coal were selected for this research. The bituminous and anthracite showed a more promising performance than the lignite coal. The cells supplied with 1.6 g coal fuel continued to operate at 20-40 mA cm^{-2} for 100-140 hours and at 100-200 mA cm^{-2} for 20 hours. It demonstrates that the direct coal oxidation in fuel cell is a potential alternative technology for energy generation. This research offers the opportunity to use coal, waste and renewable carbon sources at high efficiency.

Newsletters from other organisations

Royal Society of Chemistry Energy Sector

http://www.rsc.org/images/energy-sector-newsletter-issue-21_tcm18-248032.pdf

EU Energy Focus

http://www.euenergyfocus.co.uk/newsletter

Brown Coal Innovation Australia

http://www.bcinnovation.com.au/Issue162016

General News Item

The end of coal: good riddance or dangerous gamble?

24th March 2016, Paul Younger, The Conversation

Although written with Scotland in mind I have chosen to include the whole of this article as I feel it summarises very well the complex issues faced by UK government – Ed.

Scotland has become the first part of the UK to stop burning coal to supply electricity following the closure of Longannet, its largest power station, on March 24. It is a sign of the times, with the rest of the UK's coal-fired power stations on death row after energy secretary Amber Rudd announced late last year that they will all be forced to close by 2025.

For many reasons, it is hard to mourn the demise of coal-fired power. Around 12,000 miners are killed around the world each year, most of them digging for coal; abandoned mines cause widespread water pollution; and coal-fired plants pollute the air with the likes of nitrogen and sulphur compounds, as well as the highest greenhouse-gas emissions of any major source of energy generation. In the absence of carbon capture and storage, a technology which would be ready more quickly if the government backed it properly, plant closure may therefore seem sensible – even while we should help those that lose their jobs and regret the loss of skills from the workforce.

That would be all there was to say were it not for a few harsh realities of electricity supply. There are two reasons why coal-fired power plants have survived so long. Coal is cheap; only since the US shale-gas boom has it been consistently beaten on price. And coal-fired plants are particularly suited to providing power on demand at short notice, as well as providing crucial stabilisation services for frequency and voltage across the grid.

If we are unable to dispatch electricity on demand, we must expect blackouts. To do away with coal-fired power before alternatives are available is bold, to say the least. Gas-fired plants can play the same role, of course, but we have not been building them in the UK in recent decades. And the economics for doing so have been made very difficult by the capacity-auctions system that helps to fund them, which has also seen many existing plants mothballed. As for nuclear power, it is low-carbon but provides electricity at a constant rate and therefore can't be increased to track demand. Besides, the ongoing fiasco over Hinkley C – and by extension

nuclear new-build in general – hardly makes it look a great contributor to energy security in the foreseeable future.

Among the renewable sources, the only one that offers equivalent dispatchable power is biomass combustion – burning mainly wood – but it also entails air-quality challenges and its sustainability is debatable. Hydropower is seasonally limited, while wind and solar are incapable of dispatchable output. The consequences are not just for the future, either – to compensate for the reduced coal-fired and gas-fired power, National Grid has been quietly allowing energy companies to set up "diesel farms" of temporary generators in England to provide extra power in peak, even though it's more damaging than coal.

But can't we just store renewable energy, whenever it is generated, and dispatch it at times of high demand? Let's be clear: we have the technology – it's the affordability and scale that are challenging. Of the myriad potential storage technologies, none are as yet close to being able to store electricity at comparable scale and cost to our only grid-level storage technology: pumped-storage hydropower. But pumped storage can only do so much. Let's assume the UK could muster sufficient wind power to meet one third of our typical daily electricity consumption (40 GW to 45 GW). In the absence of dispatchable power on demand, to offset the kind of three-day calm period that is common during spells of high pressure in winter, we would need to be able to store around 1,000 gigawatt hours (GWh) of power. Yet pumped storage hydropower in the UK only totals 30 GWh, from four stations.

If we are going to manage without Longannet and all the other gas-fired and coal-fired power stations, we would need at least 970 GWh of storage – more than a hundred pumped hydropower stations of comparable size to those we already have. This would be unlikely to cost less than £100 billion. And do we even have 100 plus upland catchments we'd be happy to impound and manage for this purpose? Even if most of the UK uplands were not (rightly) zealously protected conservation areas, it seems implausible that the UK could find sufficient sites.

Add the important caveat that you lose energy sending it back and forth to a storage facility, between 10% and 35% depending on the technology. This means that relying on renewables and increased storage means you would need substantially more total generating capacity than at present.

So far we have only talked about power quantity, whereas power quality is also crucial. To keep voltage within prescribed bounds requires "reactive" (or "wattless") power. Coal-fired power-stations have long been the mainstay of this activity – not least in Scotland. It has to be done regionally, so you can't make up for this with coal power from elsewhere. Wind turbines cannot provide reactive power control. Since nuclear is being phased out in Scotland, gas-fired power is again the only alternative.

So as we close plants such as Longannet, we can expect serious problems with voltage control. This bodes ill for the electrical appliances and devices on which we all increasingly rely. With the closure of Longannet, Scotland thus becomes the first area of the UK to take a serious gamble with reactive power. It will take not just good management but a serious amount of good luck for the fossil-fuel funeral wake not to be spoiled by flickering or failure of the lights.

In short, we may be heading into dangerous territory. The UK needs to get a strategy together for building new gas-fired or coal-fired power, fitted with carbon capture and storage technology, before the situation deteriorates any further. Source:- http://theconversation.com/the-end-of-coal-good-riddance-or-dangerous-gamble-56821

UK R&D priorities for Carbon Capture and Storage (CCS)
10th February 2016

The UK Government announced on 25th November 2015 that it was withdrawing the £1 billion of funding earmarked for its CCS Commercialisation Programme, effectively bringing an end to a competitive process that saw two projects bidding for Government support. Despite its decision to not proceed with either the White Rose or Peterhead projects under the CCS Competition, Secretary of State for Energy and Climate Change, Amber Rudd, and Energy Minister, Andrea Leadsom, have since made it clear that CCS remains a crucial tool for reducing UK emissions in the longer term. For more visit:-
http://www.coalresearchforum.org/CCS%20Research%20Priorities%202016%20final%20_2_.pdf

SUMMARIES 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.

Drax bid to convert plant from coal to biomass probed by EU

5th January 2016, unattributed, BBC News Business

The European Commission has opened an investigation into whether a plan by Drax to convert a plant from coal to biomass breaches state aid rules. The Commission said it would look into whether the move was unfair to competitors. Drax shares fell 3.3%. The UK aims to close all coal-fired generators by 2025, and recently won EU clearance to support a biomass plant being converted by RWE.

Drax said the inquiry was expected as part of the approval process. The Commission statement said it supported member states' efforts to increase the use of renewable energy, but not at the expense of giving an unfair advantage over competitors and consumers.

The Commission, the European Union's executive arm, said it "fully supports member state efforts to increase the use of renewable energy and pursue EU energy and climate objectives. "At the same time, EU state aid rules make sure that the cost of such support for consumers is limited and does not give certain operators an unfair advantage over competitors." The investigation will examine whether public funds "are limited to what is necessary" and do not distort the market for biomass fuels, the statement added. Last month, the Commission approved UK plans to subsidise the conversion of RWE's Lynemouth coal-fired power plant in northern England to burning biomass, a move seen as positive for Drax.
For more visit:- http://www.bbc.co.uk/news/business-35232547

New research digs into the mysterious origins of coal

21st January 2016, Lucas Joel, The Washington Post

Coal fuels much of our modern world; in the United States, burning coal produces about 39 percent of our electricity. How this fossil fuel came to be so abundant, though, has eluded geologists. New research suggests that the ancient shifting of Earth's continents may have something to do with it.

Much of the coal we mine today in places like Appalachia and Northern China dates to the aptly named Carboniferous Period (359 to 299 million years ago). Back then, plants were buried in relatively great quantities and, eventually, became fossilized as coal. Scientists long thought that this abundance of coal could be tied to the evolution of fungi. It was thought that the fungi that decay woody plant matter — preventing it from fossilizing into coal — didn't evolve until after the days of the Carboniferous. But according to a new study published in the Proceedings of the National Academy of Sciences, many lines of evidence suggest that fungal degradation

was not a root cause of the coal boom after all. “Before, it was thought that there was an evolutionary arms race between the plants and the fungi involved in decaying the plants’ woody matter,” says Kevin Boyce, a palaeontologist at Stanford University and lead author of the new study. Fossils of the plants, however, reveal that they “contained very little woody tissue,” which, Boyce explains, is the main plant part of the fungi. If present at all, it would have been degrading.

In other words, the plants that were forming the coal had little to lose from the introduction of such fungi. The researchers also found that, while vast amounts of coal also formed during the Cenozoic Era (which started 66 million years ago and extends into the modern day), this coal came, by and large, from very woody plants. So, the presence or absence of woody tissue — and, thus, wood-degrading fungi — does not seem to have been a primary driver of coal formation. But “if it’s not the fungi, then why is there so much coal?” Boyce asked. “I was aware that we needed an alternative explanation.” For more visit:- https://www.washingtonpost.com/news/speaking-of-science/wp/2016/01/21/new-research-digs-into-the-mysterious-origins-of-coal/

Kellingley and Hatfield machinery for New Crofton colliery

21st January 2016, unattributed, BBC News.

Machinery from the last deep coal mine in the UK has been saved to be used in a new, smaller drift mine nearby. The New Crofton Co-operative Colliery is to open near Wakefield, West Yorkshire, in June. (See CRF Newsletter No. 74 for article on its background, Ed)

A coal-cutting machine from the defunct Kellingley colliery is now in storage for use on the new site. Jonathan Clarke, the co-operative's director, said the "perfectly serviceable machine would get a new lease of life" and not be scrapped. A Joy CM15 Continuous Miner machine was the latest piece of equipment to be saved.

"Kellingley and Hatfield collieries have both contributed to the birth of a new coal mine, even though they've died themselves something good has come of it," Mr Clarke said. Equipment worth £750,000 had now been bought from the two closed collieries, he said. Kellingley, known locally as the Big K, was the largest deep pit in Europe and could bring up to 900 tonnes an hour to the surface. At its height it employed more than 2,000 workers and when it closed in December 450 people lost their jobs. Hatfield Colliery, near Doncaster, South Yorkshire, closed in June with the loss of 430 jobs. About 60 people are to be employed at the new drift mine to extract about 200,000 tonnes of coal annually. About 90% of that production would go to power stations, said Mr Clarke.

The £13m project was a "much cheaper way" to start coal production, he added. It would be a shallow drift mine about 650 ft. (200m) deep without large winding apparatus on the surface. Work at the new mine, which will be owned and run by its members, starts in June, with the first coal mined about 10 weeks later. The site at Crofton was originally earmarked for open cast mining by British Coal in the 1980s. Source:- http://www.bbc.co.uk/news/uk-england-leeds-35371920

German firm opens biomass research centre in Liverpool

26th January 2016, Jacqueline Echevarria, Energy Live News

A new biomass research centre has been opened in Liverpool. German firm ENTRADE Energiesysteme AG, owner of the 3,600 square metres facility, will use the site to develop new types of biomass fuel. It has partnered with waste recycling company Tidy Planet for food waste from airports which will be used to create fuel to power its combined heat and power plants. Peter Eaton, ENTRADE’s UK Operations Manager said: “With more presence and support provided in the United Kingdom we can ensure that we can make it affordable and easy to sign up for renewable heat and power in Britain.” Source:- https://www.energylivenews.com/2016/01/26/german-firm-opens-biomass-research-centre-in-liverpool/

Extracting rare-earth elements from coal could soon be economical in U.S.

2nd February 2016, Liam Jackson, Penn State News

The U.S. could soon decrease its dependence on importing valuable rare-earth elements that are widely used in many industries, according to a team of Penn State and U.S. Department of Energy researchers who found a cost-effective and environmentally friendly way to extract these metals from coal by-products.

Rare-earth elements are a set of seventeen metals -- such as scandium, yttrium, lanthanum and cerium -- necessary to produce high-tech equipment used in health care, transportation, electronics and numerous other industries. They support more than $329 billion of economic output in North America, according to the American Chemistry Council, and the United States Geological Survey expects worldwide demand for REEs to grow more than 5 percent annually through 2020. China produces more than 85 percent of the world's rare-earth elements, and the U.S. produces the second most at just over 6 percent, according to the USGS.

"We have known for many decades that rare-earth elements are found in coal seams and near other mineral veins," said Sarma Pisupati, professor of energy and mineral engineering, Penn State. "However, it was costly to extract the materials and there was relatively low demand until recently. Today, we rely on rare-earth elements for the production of many necessary and also luxury items, including computers, smart phones, rechargeable batteries, electric vehicles, magnets and chemical catalysts. We wanted to take a fresh look at the feasibility of extracting REEs from coal because it is so abundant in the U.S." For more visit:- http://news.psu.edu/story/390523/2016/02/02/research/extracting-rare-earth-elements-coal-could-soon-be-economical-us

Carbon dioxide captured from air converted directly to methanol fuel for the first time

2nd February 2016, unattributed, ScienceDaily

Research could one day create a sustainable fuel source from greenhouse gas emissions. For the first time, researchers there have directly converted carbon dioxide from the air into methanol at relatively low temperatures.

The work, led by G.K. Surya Prakash and George Olah of the USC Dornsife College of Letters, Arts and Sciences, is part of a broader effort to stabilize the amount of carbon dioxide in the atmosphere by using renewable energy to transform the greenhouse gas into its combustible cousin -- attacking global warming from two angles simultaneously. Methanol is a clean-burning fuel for internal combustion engines, a fuel for fuel cells and a raw material used to produce many petrochemical products.

"We need to learn to manage carbon. That is the future," said Prakash, professor of chemistry and director of the USC Loker Hydrocarbon Research Institute. The researchers bubbled air through an aqueous solution of pentaethylenehexamine (or PEHA), adding a catalyst to encourage hydrogen to latch onto the CO_2 under pressure. They then heated the solution, converting 79 percent of the CO_2 into methanol. Though mixed with water, the resulting methanol can be easily distilled, Prakash said.

The new process was published in the *Journal of the American Chemical Society* on Dec. 29. Prakash and Olah hope to refine the process to the point that it could be scaled up for industrial use, though that may be five to 10 years away.
For more visit:-
https://www.sciencedaily.com/releases/2016/02/160202143949.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sciencedaily%2Fmatter_energy%2Ffossil_fuels+%28Fossil+Fuels+News+--+ScienceDaily%29

US electricity industry's use of coal fell to historic low in 2015 as plants closed

4th February 2016, Suzanne Goldenberg, The Guardian

America's use of coal for electricity dropped to its lowest point in the historical record in 2015, delivering a new blow to an industry already in painful decline. The dirtiest of fossil fuels and America's biggest single source of climate pollution, coal accounted for just 34% of US electricity generation last year, according to the Sustainable Energy in America handbook on Thursday. It was the smallest share for coal in the electricity mix since 1949, the first year in which Energy Information Administration records were kept.

"It was a really big year," said Colleen Regan, a power analyst for Bloomberg New Energy Finance, who was co-author of the report for the Business Council on Sustainable Energy. "It was a landmark year with a long-term trajectory that we saw as the US decarbonising its power fleet." Coal made up 39% of electricity supply in 2014, the annual report said. For more visit:- http://www.theguardian.com/environment/2016/feb/04/us-electricity-industrys-use-of-coal-fell-to-historic-low-in-2015-as-plants-closed

Carbon dioxide stored underground can find multiple ways to escape

11th February 2016, unattributed, ScienceDaily

When carbon dioxide is stored underground in a process known as geological sequestration, it can find multiple escape pathways due to chemical reactions between carbon dioxide, water, rocks and cement from abandoned wells, according to Penn State researchers.

The researchers investigated the properties of porous rocks into which carbon dioxide is injected. These rocks, known as host rocks, function like containers for the carbon dioxide. The team looked at two abundant host rocks, limestone and sandstone, which have different chemical properties.

"We were interested in examining these rocks because they are widely found underground, but there have been concerns that carbon dioxide may escape once it's injected underground," said Li, associate professor of petroleum and natural gas engineering. "Even if it doesn't escape to Earth's surface, there are concerns that it may leak into groundwater drinking aquifers."
For more visit:- https://www.sciencedaily.com/releases/2016/02/160211185935.htm

Longannet closure means end of Fife opencast coal mine

13th February 2016, Leeza Clark, The Courier.co.uk

The impending closure of the Longannet power station near Kincardine has hastened the end of a massive Fife opencast site. Hargreaves is to end coal extraction at its Muir Dean site on the outskirts of Crossgates, bringing coal's reign in the Kingdom almost to an end. It is not known how many jobs this will affect but a spokesman for the company said it would do everything to minimise the impact through redeployment.

Fife Council's depute leader Lesley Laird said it showed the closure of Longannet at the end of next month was beginning to impact across Fife and beyond in terms of the coal industry and its associated suppliers. The authority's representative on the industrial communities alliance, Councillor Bob Young, added: "Activity at the Muir Dean site will now be geared solely towards restoration of the land there. "This announcement by Hargreaves is likely to mark the end of major coal extraction in Fife and it is therefore a historically significant time for Fife's mining communities and families." A spokesman for Hargreaves said the power station closure, decline in use of coal and mild weather had impacted on their plans. Source:- http://www.thecourier.co.uk/news/local/fife/longannet-closure-means-end-of-fife-opencast-coal-mine-1.924133

'Limited role' for natural gas in UK future energy mix

23rd February 2016, Matt McGrath, BBS News Science & Environment

The use of natural gas for electricity generation in the UK may have to decline significantly over the next 30 years, according to a new study. Without carbon capture and storage (CCS) technology, gas-fired electricity would have to fall to 10% of the mix to meet emissions targets for 2050. The new study also warns that current government policies will deter investment in gas. The report has been published by the UK Energy Research Centre. For more visit:- http://www.bbc.co.uk/news/science-environment-35632075

Southern Company leading global carbon capture research and development network for U.S.

24th February 2016, unattributed, PRNewswire

Southern Company today assumed leadership of the Carbon Capture International Test Center Network (ITCN), a global coalition of facilities working to accelerate the research and development (R&D) of carbon capture technologies. The National Carbon Capture Center (NCCC), a U.S. Department of Energy (DOE) research facility managed and operated by Southern Company, will serve as the host site for the ITCN.

Formed in 2012, the ITCN facilitates knowledge-sharing among carbon capture test facilities around the world with the goal of advancing the development and commercial deployment of carbon capture technologies. For more visit:- http://www.prnewswire.com/news-releases/southern-company-leading-global-carbon-capture-research-and-development-network-for-us-300225531.html

Shipping US wood pellets to UK is greener than burning coal

29th February 2016, unattributed, environmental research web

Demand for US wood pellets for burning in biomass power plants is rising in Europe. But will this reduce greenhouse gas emissions by replacing coal-based electricity? And will it increase tree harvesting in the southern US? With that in mind, a US team has shown that the greenhouse gas intensity of electricity from burning wood pellets is 74–85% lower than the greenhouse gas intensity of coal-based electricity.

"We still get significant emission reductions even after we include all lifecycle emissions of wood pellets, which are produced in the US and exported to Europe, as well as emissions due to market-induced changes in forest management practices and land use," Madhu Khanna of the University of Illinois, US, told environmentalresearchweb.

According to Khanna, the study reveals that wood bioenergy can be used to achieve compliance with the European Union's Renewable Energy Directive without negatively affecting forests in the southern part of the US. For more visit:-
http://environmentalresearchweb.org/cws/article/news/64164

Climate activists threaten to shut down world's major coal sites

1st March 2016, Damian Carrington, The Guardian

Climate activists will use direct action to try to shut down major fossil fuel sites across the world in May, including the UK's largest opencast coal mine in south Wales. The dozen international sites facing civil disobedience from the Break Free 2016campaign span the globe from the US to Australia and South Africa to Indonesia.

The Ffos-y-fran opencast mine, near Merthyr Tydfil in Wales, is about halfway through extracting 11m tonnes of coal. Ellie Groves, from the Reclaim the Powernetwork, said: "The only way we can stop catastrophic climate change is taking action to keep fossil fuels in the ground." "The local community have battled Ffos-y-fran for nearly a decade and now face the threat of a new mine next door at Nant Llesg," said Groves. "Enough is enough. We need a ban on opencast coal mining across Wales, and the rest of the UK." For more visit:-

http://www.theguardian.com/environment/2016/mar/01/climate-activists-shut-down-worlds-major-coal-sites-reclaim-the-power

Renewable plastic made from carbon dioxide and plants

9th March 2016, unattributed, ScienceDaily

Stanford scientists have discovered a novel way to make plastic from carbon dioxide (CO_2) and inedible plant material, such as agricultural waste and grasses. Researchers say the new technology could provide a low-carbon alternative to plastic bottles and other items currently made from petroleum.

"Our goal is to replace petroleum-derived products with plastic made from CO_2," said Matthew Kanan, an assistant professor of chemistry at Stanford. "If you could do that without using a lot of non-renewable energy, you could dramatically lower the carbon footprint of the plastics industry." Kanan and his Stanford colleagues described their results in the March 9 online edition of the journal *Nature.*
For more visit:- https://www.sciencedaily.com/releases/2016/03/160309135712.htm

Giant £4M battery connected to UK power grid

18th March 2016, Priyanka Shretha, energy live news

An industrial-sized battery has officially been launched near Wolverhampton and connected to the UK's electricity grid. The £4 million facility at Willenhall substation is part of new energy storage research led by the University of Sheffield. It claims one of the facility's unique capabilities is how quickly it can respond to demands from National Grid to import or export power at short notice – at 4/10th of a second. Earlier this month the National Infrastructure Commission said energy storage could contribute to innovations that could help consumers save around £8 billion a year by 2030.

Professor David Stone, Director of the Willenhall Facility and the Centre for Electrical Energy Storage at the University of Sheffield said: "As the demand for energy increases in the UK, storage systems are needed to balance supply. The first commercial projects are coming on line but there are still many technical issues to be explored in order to maximise the potential of these technologies and to reduce costs.

"This dedicated national research facility has been designed to offer enhanced frequency response to peaks in demand and is available to be used by other academic and industrial projects for their research and to test new technologies." Energy company E.ON's Uniper unit will use the battery for testing storage technology, looking at future possibilities for large-scale projects and how to overcome the challenges associated with connecting such technologies to the grid. Earlier this week Chancellor George Osborne announced energy storage would receive a share of a £50 million fund as part of his Budget. For more visit:-
https://www.energylivenews.com/2016/03/18/giant-4m-battery-connected-to-uk-power-grid/

New carbon capture membrane boasts carbon dioxide highways

18th March 2016, unattributed, ScienceDaily

A new, highly permeable carbon capture membrane developed by scientists from the U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) could lead to more efficient ways of separating carbon dioxide from power plant exhaust, preventing the greenhouse gas from entering the atmosphere and contributing to climate change.

The researchers focused on a hybrid membrane that is part polymer and part metal-organic framework, which is a porous three-dimensional crystal with a large internal surface area that can absorb enormous quantities of molecules.

In a first, the scientists engineered the membrane so that carbon dioxide molecules can travel through it via two distinct channels. Molecules can travel through the polymer component of

the membrane, like they do in conventional gas-separation membranes. Or molecules can flow through "carbon dioxide highways" created by adjacent metal-organic frameworks. For more visit:- https://www.sciencedaily.com/releases/2016/03/160318091014.htm

Ferrybridge C coal-fired power station closes after 50 years

23rd March 2016, unattributed, BBC News

A coal-fired power station has produced electricity for the last time after 50 years of use, said its operators SSE. Ferrybridge C power station, near Knottingley, West Yorkshire, will officially close on 31 March before being decommissioned. Its site close to the M62 and A1 has made the giant cooling towers a well-known landmark. SSE said a projected loss of £100m over the next five years made the continued life of the plant "unsustainable". The firm, which has owned Ferrybridge since 2004, has blamed rising costs and the impact of environmental legislation for the decision. Mick Gee, station manager, said: "It's always been a special place to work where people help each other without asking. A new multifuel "waste-to-energy" plant has been built alongside the Ferrybridge C site. Source:- http://www.bbc.co.uk/news/uk-england-leeds-35882006

Temporary ban imposed on coal gasification plans

25th March 2016, unattributed, BBC Wales Politics

A ban on chemically transforming underground coal into synthetic natural gas has been imposed. Natural Resources Minister Carl Sargeant has imposed a moratorium on underground coal gasification (UCG). Mr Sargeant said this forms part of a "precautionary approach" towards the development of unconventional oil and gas resources, which includes a temporary ban on fracking. Any council not proposing to refuse an application must refer it to ministers. Mr Sargeant said: "The direction has been issued to require that any planning application connected to the gasification of coal must be referred to Welsh ministers where local planning authorities are minded to approve them." It applies to any onshore application registered on or after 25 March and Mr Sargeant said it was to "avoid any ambiguity". A study by Duke University in the US suggested synthetic natural gas emits seven times more greenhouse gases than natural gas and almost twice as much carbon as a coal plant. Source:- http://www.bbc.co.uk/news/uk-wales-politics-35894034

Carbon capture stumbles in Saskatchewan

30th March 2016, Martin Rosenberg, the Energy Times

A much watched effort by Canadian to capture carbon dioxide from a coal-burning generation plant has run into difficulties, the *New York Times* reports. SaskPower's Boundary Dam has had several shutdowns and failed to achieve it emission cut targets. The project was one of the largest in the world attempting to remove carbon dioxide from the coal burning process, then compress the gas and route it to underground storage.

According to the *Times* report, "the system was working at only 45 percent of capacity. One memo, written a month after the government publicly boasted about the project, cited eight major problem areas. Fixing them, it said, could take a year and a half, and the memo warned that it was not immediately apparent how to resolve some problems."

Other efforts at carbon capture and storage have floundered at a time of declining costs for renewables and energy efficiency technologies and abundant supplies of cheap natural gas. European energy company, Vattenfall, in 2014 discontinued it carbon capture research tied to a gleaming research plant it built in East Germany. *IEEE Spectrum,* writing about the Vattenfall decision to nix carbon capture, reported, "Even in the European Union, which has decarbonisation policies, it has yet to become a commercial-scale, affordable option to keep older coal plants operating while producing fewer emissions." Source:- http://tdworld.com/news/carbon-capture-stumbles-saskatchewan

Fiddler's Ferry coal plant to stay open until March 2017

30th March 2016, unattributed, BBC News

A coal-fired power plant earmarked for closure will remain open until March 2017, its owner SSE has announced. The decision was made on Wednesday after a contract was secured by Fiddler's Ferry in Widnes, Cheshire, to provide "ancillary services" to the National Grid. The company previously said three of the four turbines would close by April. The one-year contract covers one of three available units at the site, which employs 213 people. Two other units will remain "online" as SSE seeks to enter the station's capacity into market auctions. The fourth turbine will be unaffected as it has a contract to provide "services to the electricity system" over winter 2016.

Martin Pibworth, from SSE, said the long-term future of the site "remains uncertain" but the firm was "pleased" to secure a 12-month contract, which starts on 1 April. The 45-year-old plant has been loss-making for two years and in November the government announced the permanent closure of all coal-fired power plants by 2025 as part of plans to lower carbon emissions from the electricity sector. The site provides two gigawatts of power to the north-west of England, which is enough to supply about two million homes with electricity. A consultation with staff and stakeholders is ongoing, the firm said. From:- http://www.bbc.co.uk/news/uk-england-merseyside-35930335

No coal will be burnt at Eemshaven power station

30th March 2016, unattributed, Dutch News nl

A controversial power station in northern Groningen will not burn coal and instead will be taken 'carbon-emissions free', energy company Nuon said. Nuon has begun a research project with Delft University of Technology to investigate using the plant as a super battery to store energy generated by wind and solar power farms.

Working with the university's Professor Fokko Mulder, Nuon is looking at storing seasonal surpluses after particularly windy or sunny weather in the form of ammonia. This could then be turned into energy in the plant, without releasing more carbon dioxide. Alexander van Ofwegen, director of Nuon Heat, said: 'There are three steps. First, you convert your electricity from wind into liquid ammonia. A chemical process is involved in this, which binds hydrogen to nitrogen to make ammonia. Then you save the ammonia in large tanks, which can be there as long as needed. So you always have a supply of fuel for those times when there is little wind or sun.' The idea – which is yet to be tested – could be rolled out in around five years. It aims to address an under-reported issue with renewable energy sources: the sun doesn't always shine, nor is it always windy, but we always want electricity. According to other reports, this means the end of potential coal burning at the plant, which became operational in 2013. It had been built to run on biomass, gas and also coal, but under pressure from environmental agencies, the coal unit was temporarily suspended in 2011. Source:- http://www.dutchnews.nl/news/archives/2016/03/no-coal-will-be-burnt-at-eemshaven-power-station/

Rapid decline of coal use leads to drop in UK emissions

31st March 2016, Damian Carrington, The Guardian

Plummeting coal use in 2015 led to a fall of 4% in the UK's annual carbon dioxide emissions, according to government energy statistics published on Thursday. Coal is now burning at its lowest level in at least 150 years. The closing of old polluting coal-power stations and the rapid rise in renewable energy meant coal consumption fell by 22% compared to 2014, the biggest drop ever seen outside of miners' strikes, according to analysts at Carbon Brief. Production of coal in the UK also fell to a new record low, dropping by 27% due to mines closing.

The rapid decline in coal use is continuing in 2016, with four more stations closed in the last fortnight, including Longannet, Ferrybridge and Eggborough, leaving six operational. The government has pledged to close all coal plants by 2025 to help meet climate change targets.

The future of the large new nuclear plant at Hinkley Point in Somerset is also in serious doubt, leading to concerns about energy security.

But experts said coal plant closures would not lead to the lights going out. "We have seen at least five years of "lights out" headlines, so far without so much as a flicker caused by insufficient capacity," said Prof Michael Grubb, at University College London. "Despite tight margins, extreme weather is far more likely to cause any household disconnections than insufficient generating capacity." For more visit:- http://www.theguardian.com/environment/2016/mar/31/rapid-decline-of-coal-use-leads-to-drop-in-uk-emissions

OECD warned govt about coal power plants; 500bn tonnes of carbon dioxide by 2050

3rd April 2016, Tharushan Fernando, Newsfirst

In July 2015, the Organisation for Economic Co-operation and Development, warned that new coal power plants, were the most urgent threat to the planet. The OECD urged the government to rethink plans for new coal-fired power plants as a study estimated that they will release more than 500 billion tonnes of carbon dioxide by 2050.

Many countries are moving away from coal power generation. China has planned to shut down all coal power plants in Beijing by the end of this year. Recently, the United States shut down a 5000MW Coal Power Plant. England too had decided to shut down all coal power plants by 2025.

After nearly 50 years of service, Scotland's last coal-fired power plant – the Longannet Power Station has finally gone offline, putting an end to over 100 years of burning coal for electricity. Angel Gurria, the Secretary General of the OECD, said in July 2015 that Governments must think "twice, or three, or four times" before allowing new coal-fired plants to go ahead.
http://newsfirst.lk/english/2016/04/oecd-warned-govt-about-coal-power-plants-500bn-tonnes-of-carbon-dioxide-by-2050/132629

Belgium quits coal power with Langerlo plant closure

5th April 2016, Megan Darby, Climate Change News

Belgium is the seventh in EU to go coal-free, joining Cyprus, Luxembourg, Malta and Baltic countries. Belgium's last coal power plant, Langerlo, closed on 30 March. It is the end of an era for a dirty fuel that accounted for 27% of the country's electricity generation in 1994. The EU country becomes the seventh to quit coal, joining Cyprus, Estonia, Latvia, Lithuania, Luxembourg and Malta.

CAN Europe campaigner Joanna Flisowska hailed the moment as "a significant step in the inevitable transition away from fossil fuels". Closing Langerlo reduces Belgium's carbon dioxide emissions by nearly 2 million tonnes a year, according to the NGO: more than 1% of the country's total.

Others in the 28-state bloc are phasing out coal. Portugal is aiming for a 2020 end date, the UK and Austria 2025, and Finland at some point next decade. Scientists estimate more than 80% of coal reserves worldwide need to stay unburned to hold global warming to 2C, the internationally agreed upper limit.
Yet with both fuel and EU carbon prices low, coal retains a significant share of the energy mix. In Germany, the EU's largest economy, it supplies more than 40% of electricity. Poland generates 85% from coal. Flisowska added: "To avoid worst impacts of climate change, the EU has to ensure that carbon emissions from its coal power plants are cut down much faster than their current rate." Source:- http://www.climatechangenews.com/2016/04/05/belgium-quits-coal-power-with-langerlo-plant-closure/

MIT breakthrough offers hope of non-burning coal plants with 50% less emissions

6th April 2016, David Rogers, Global Construction Review

A research team at the Massachusetts Institute of Technology (MIT) has devised a procedure for halving the carbon output of energy generated from coal. If it proves economical in the real world, it may have wide implications for many countries' energy policies**.** In a paper appearing in the *Journal of Power Sources* doctoral student Katherine Ong and Professor Ahmed Ghoniem outline an unconventional hybrid cycle that doesn't involve burning the coal.

Instead, the process pulverises the coal into dust and passes steam through it. This releases hydrogen and carbon monoxide, which enter a solid oxide fuel cell where the gases react with natural oxygen to produce electricity. The decrease in carbon comes from extracting gas from the coal rather than burning it, which copies a technique widely used in industrial chemistry to produce hydrogen gas. By not burning the coal, the technique avoids the spewing of ash and other airborne particulate. For more visit:- http://www.globalconstructionreview.com/news/mit-breakthrough-offers-hope-n7on-urn7ing-coa7l/

The plans to bring mining back to west Cumbria

8th April 2016, unattributed, ITV

Plans for a new mine in West Cumbria are being revealed to the public this weekend. West Cumbria Mining plan to use existing tunnels and portals left over from the old mines. They say they've found billions of tonnes of coking coal - which is used in the steel industry - that stretches out for five miles under the sea. The company is due to apply for planning permission next year. For more see:- http://www.itv.com/news/border/2016-04-08/the-plans-to-bring-mining-back-to-west-cumbria/

Analysts: Renewables deliver over a fifth of UK power

11th April 2016, unattributed, Business Green

EnAppSys confirms renewables provided over 22 per cent of UK power during the first quarter of the year, comfortably surpassing coal power output. Renewables are playing an increasingly important role in the UK's power mix and the trend is set to continue, according to the latest quarterly update from analyst firm EnAppSys.

The energy market analysts reported renewables share of the power mix reached 22.4 per cent in the first quarter of the year, comfortably surpassing coal power which provided 16.2 per cent of the mix and nuclear power on 19 per cent. Only gas provided more power, meeting 35.4 per cent of demand. The renewables sector also narrowly missed out on a quarterly generation record, according to the latest figures, delivering 18.78TWh of power compared to the 18.83TWh generated during the final quarter of 2015.

The update confirmed wind remains the dominant source of renewables in the UK, delivering over 46 per cent of UK renewable power, compared to 33.2 per cent from biomass and just over 13.5 per cent from hydro and 7.2 per cent from solar. However, solar output soared 82 per cent during the last quarter, thanks to a surge in new installations ahead of the government's controversial cuts to subsidies for the sector. The high levels of renewables output continue a trend for the sector, which has seen first quarter output quadruple since 2008 from 4.45TWh to 18.78TWh.

Paul Verrill, a director of EnAppSys, said the trend was set to continue, but would bring with it challenges for grid operators. For more visit:- http://www.businessgreen.com/bg/news/2454081/analysts-renewables-deliver-over-a-fifth-of-uk-power

Oxygen key to containing coal ash contamination

12th April 2016, unattributed, ScienceDaily

As energy companies decide what to do with aging coal ash disposal facilities in North Carolina and across the nation, they may be overlooking a fundamental but potentially critical variable -- oxygen.

In a new study appearing in the April issue of *Applied Geochemistry*, researchers from Duke University demonstrate that the level of oxygen in a coal ash disposal site can greatly affect how much toxic selenium and arsenic can be leached from the system.

"The tests that the Environmental Protection Agency relies on consider variables like the pH of the water, but they don't look at whether the system is aerobic or anaerobic," said Heileen Hsu-Kim, the Mary Milus Yoh and Harold L. Yoh, Jr. Associate Professor of Civil and Environmental Engineering. "We wanted to demonstrate that oxygenation actually matters a lot, especially for arsenic and selenium."

In the wake of a 2014 coal ash spill into North Carolina's Dan River from a ruptured Duke Energy drainage pipe, the question of what to do with other aging coal ash retention ponds and future waste has been a hotly debated topic. Duke Energy currently plans to dig up 24 of its 36 ponds in the Carolinas. But the 12 remaining ponds without a cleanup plan hold more than 70 percent of the 108 million tons of ash held in North Carolina ponds. For more visit:- https://www.sciencedaily.com/releases/2016/04/160412211142.htm

Energy minister hails university's 'visionary' state-of-the-art green energy centre

13th April 2016, Karin Goodwin,

Scotland's energy minister has heralded the construction of a university's £25 million green energy centre as a "visionary project", which will be a significant asset to Scotland.

St Andrew's University's state-of-the-art biomass facility, which is currently is being built on the site of the former paper mill at Guardbridge – just outside of the town – will not only help the institution meet its aim of becoming carbon neutral, but also create hundreds of local jobs in the north east of Fife, it has been claimed. It is due to be operational by the end of the year.

The university has also promised the project will support apprenticeship and graduate training, creating about 225 jobs under what it has dubbed the "Guardbridge Guarantee". The 6MW biomass centre will use only locally sourced wood from sustainable forests, creating green energy which will pump hot water four miles underground to St Andrews to heat and cool its labs and student residences. During a site visit to the University yesterday Scottish energy minister Fergus Ewing said: "St Andrews is leading the way with a visionary plan. This is a terrifically exciting project and a major investment. "St Andrews is to be commended for their sustainable energy research centre which will be a significant asset for Scotland as well as for the University." For more information visit:- http://www.thenational.scot/news/energy-minister-hails-universitys-visionary-state-of-the-art-green-energy-centre.16315

World's largest coal producer files for bankruptcy protection

13th April 2016, Terry Macalister, The Guardian

Peabody Energy, the world's largest privately owned coal producer, has filed for bankruptcy protection in the US following a collapse in commodity prices. The move was blamed by financial analysts partly on a mistimed and debt-fuelled expansion into Australia, but others saw it as a sign that the most carbon-intensive fossil fuel was threatened by tightening environmental regulation.

Coal is increasingly being replaced as a fuel for generating electricity by gas-fired plants or wind farms in some countries. Britain has promised to phase out such coal use by 2025 although China and India continue to build new plants. The price of key types of coal has plunged by 75% since a peak in 2011 and Peabody's filing to the US bankruptcy court in St Louis, Missouri, is one of the largest corporate failures in the wider commodity sector. "This was a difficult decision, but it is the right path forward for Peabody," said the company's chief executive, Glenn Kellow, who hopes that the company will eventually be able to re-emerge as a going concern. For more visit:- http://www.theguardian.com/environment/2016/apr/13/worlds-largest-coal-producer-files-for-bankruptcy-protection

Solar power sets new British record by beating coal for a day

13th April 2016, Adam Vaughan, The Guardian

The sun provided British homes and businesses with more power than coal-fired power stations for 24 hours last weekend. While solar power has previously beaten coal for electricity generation over a few hours in the UK, Saturday was the first time this happened for a full day. Analysts said the symbolic milestone showed how dramatic coal's decline had been due to carbon taxes, as solar had "exploded" across the UK in recent years.

National Grid data gathered by climate analysts Carbon Brief showed that 29 gigawatt hours (GWh) of power was generated on Saturday by solar, or 4% of national demand that day, versus 21GWh from coal-fired power stations. "This first for solar reflects the major shifts going on in the electricity system," said Carbon Brief in its analysis. "Last weekend's solar breakthrough could not have happened without the increase in solar capacity. However, an ongoing collapse in coal generation was the more immediate cause." For more visit:- http://www.theguardian.com/environment/2016/apr/13/solar-power-sets-new-british-record-by-beating-coal-for-a-day

Using methane rather than flaring it

14th April 2016, unattributed, ScienceDaily

Methane is an abundant and inexpensive gas. Although it would be a suitable energy source and base material for the chemical industry, huge quantities of it are simply burnt off around the world -- above all at oil fields and refineries. "On satellite images of Earth at night, the Middle East is brightly illuminated. This is not because the region has an especially high number of large, brightly lit settlements, but rather because of methane flaring at the oil fields," says Jeroen van Bokhoven, Professor for Heterogeneous Catalysis at ETH Zurich and Head of the Laboratory for Catalysis and Sustainable Chemistry at the Paul Scherrer Institute (PSI).

Another reason for this wasteful approach to methane is that, at present, it is not sufficiently profitable to convert the gas into methanol in liquid form, which is easier to transport and more reactive. On the industrial scale, this conversion is currently performed using an indirect, elaborate and energy-intensive method that involves the production of syngas as an intermediate step.

"Many chemists consider the easy, direct conversion of methane into methanol as a dream reaction," says van Bokhoven. He and his team have demonstrated a new approach to this in a recent study. The world of industry is also very interested in better utilising this abundant, inexpensive raw material, says the catalysis researcher. Rising global production of shale gas is resulting in the release of ever-greater volumes of methane. For more visit:- https://www.sciencedaily.com/releases/2016/04/160414113427.htm

Making iron without coal or carbon dioxide

14th April 2016, Adam Duckett, The Chemical Engineer

An industrial consortium has been formed in Sweden to develop a steel production process that emits water rather than CO_2 by using hydrogen rather than fossil fuels. The project partners – steelmaker SSAB, iron pellet supplier LKAB, and electricity generator Vattenfall – seek to

modify the direct reduction method of steelmaking. Conventional iron-making setups use hydrogen and carbon monoxide from natural gas or coal to remove the oxygen from iron oxide pellets, producing CO_2.

The consortium instead plans to reduce the iron using only hydrogen, produced by splitting water with electrolysis powered by clean electricity, an SSAB spokesperson told *The Chemical Engineer*. Rather than using fossil fuels and emitting CO_2 the process will use, reform and emit water instead.

Sweden is well placed to produce hydrogen using clean energy. It is the leading producer of renewable energy in the EU with 52% generated from cleaner sources including bioenergy, hydropower and wind. Announcing the project, SSAB CEO Martin Lindqvist explained that the company already runs one of the world's most CO_2-efficient iron-making processes but given that the company is the largest single source of CO_2 in Sweden and Finland it must assume responsibility for finding a long-term solution to reduce emissions even further.

"We today announce a new project that we call 'Hybrit' – hydrogen breakthrough iron-making technology. And the aim is to reduce emissions from iron-making to zero by eliminating the need to use fossil fuel for iron reduction," he said.

The team expects it will take 20 years to fully develop the process, with the pre-feasibility study finished by the end of 2017, pilot plant trials by 2024, and full demonstration completed by the close of 2035. Vattenfall CEO Magnus Hall explained a key challenge will be balancing on the grid such a large demand for renewable electricity – around 15–20 TWh – from a single source. Asked by reporters about the costs of the project, the consortium leaders said they wouldn't be known until the early stages of development are completed, though conceded it would be expensive and requires government support.

Mikael Damberg, Swedish minister for enterprise and innovation, welcomed the project, noting that the government has an ambition to become one of the first fossil-free states in the world.
"So in the long run it is necessary to replace coal in the steel processes," Damberg said. "And this requires a radical technological leap. Therefore I truly welcome this ambitious project…Success of the project will mean a great step in the battle against climate change but it also means a more competitive Swedish steel industry." Source:- http://www.tcetoday.com/latest%20news/2016/apr/making-iron-without-coal-or-carbon-dioxide.aspx#.Vx5tslYrK1s

World Bank head warns again new coal power plants

14th April 2016, Ed King, Climate Change news

The planet is in a race against time to stop construction of new coal-fired power plants across the globe, Word Bank head Jim Kim told media on Thursday. Despite 195 countries approving a new global deal to combat climate change last December, plans to build hundreds of carbon-intensive energy plants were still live, he warned. "We are working with countries to make renewables cheaper than coal and push forward efforts to mitigate the effects of climate change," said Jim. For more visit:- http://www.climatechangenews.com/2016/04/14/world-bank-head-warns-against-new-coal-power-plants/

Poland feels the pain of its love affair with coal

15th April 2016, unattributed, Yahoo News

For generations, the region of Silesia has been at the heart of Poland's love affair with coal as a source of pride and heroism. Election to Poland's top job has depended on maintaining coal's special national status and Prime Minister Beata Szydlo, a coal miner's daughter from Silesia, swept to office in October on a promise she would ring-fence the industry's 100,000 jobs.

It is a pledge she is now under almost as much pressure to break as to keep. The energy ministry has said the nation's biggest mining firm, headquartered in Silesia, risks running out of

cash at the end of the month. It is a familiar cry, and in the past, funds somehow appeared. This time, however, they may not.

Coal miners became heroes in Silesia when nine of them were shot dead in 1981 in an anti-communist protest against martial law. Now they are being asked to accept cuts in salaries that are among the highest in Poland because of the dangers of the job. Energy ministry officials supervising Kompania Weglowa (KW), the European Union's biggest coal mining company, say it cannot pay salaries in May if trade unions' reject a plan to cut the company's costs, more than half of which go on staff. For more see:- http://finance.yahoo.com/news/poland-feels-pain-love-affair-155505524.html

Midwest utilities retire more than 2,000 MW of coal-fired generation

15th April 2016, unattributed, Platts

Friday marked the retirement of another 2,000 MW of older coal-fired generation in the Midwest.

Though not unexpected, the coal retirements continued a trend in a region that for decades has relied heavily on coal to produce electricity. Coal still comprises a sizable share of the generation portfolio, but it is slowly being replaced by renewables, particularly wind, and natural gas. The latest retirements were concentrated in Indiana and Michigan. In Indiana, Indianapolis Power & Light shuttered its 341-MW Eagle Valley plant 67 years after it began operating. Eagle Valley is being replaced by a new 671-MW combined-cycle gas plant, whose construction is more than one-third complete and is targeted for commercial operation in spring 2017. For more visit:- http://www.platts.com/latest-news/electric-power/louisville-kentucky/midwest-utilities-retire-more-than-2000-mw-of-21283280

Fossil fuels could be phased out worldwide in a decade, says new study

15th April 2016, unattributed, ScienceDaily

The worldwide reliance on burning fossil fuels to create energy could be phased out in a decade, according to an article published by a major energy think tank in the UK. Professor Benjamin Sovacool, Director of the Sussex Energy Group at the University of Sussex, believes that the next great energy revolution could take place in a fraction of the time of major changes in the past. But it would take a collaborative, interdisciplinary, multi-scalar effort to get there, he warns. And that effort must learn from the trials and tribulations from previous energy systems and technology transitions.

In a paper published in the peer-reviewed journal *Energy Research & Social Science*, Professor Sovacool analyses energy transitions throughout history and argues that only looking towards the past can often paint an overly bleak and unnecessary picture. Moving from wood to coal in Europe, for example, took between 96 and 160 years, whereas electricity took 47 to 69 years to enter into mainstream use. But this time the future could be different, he says -- the scarcity of resources, the threat of climate change and vastly improved technological learning and innovation could greatly accelerate a global shift to a cleaner energy future. For more visit:- https://www.sciencedaily.com/releases/2016/04/160415125641.htm

China in heated debate turning highly polluting coal into gas as fears of environmental disaster lurk

15th April 2016, Stephen Chen, South China Morning Post

Scientists are caught in a heated debate on whether China's efforts to turn coal into gas would become an environmental disaster for the whole planet. China is building the world's largest synthetic natural gas industry, with more than 40 plants under construction or planned. When completed, these facilities would generate nearly 200 billion cubic meters of natural gas annually, more than the nation's total natural gas consumption last year.

Converting coal to gas as fuel for power generation could significantly reduce the discharge of air pollutants, such as fine particulates into the environment. To the Chinese government, the technology is considered a major weapon in the battle against smog.

But a joint study by researchers from Duke University and Stanford University in the United States in 2013 alleged that these massive projects in China could emit four times more carbon dioxide than coal-fired power plants, while generating the same amount of energy, due to the lengthy chemical reactions required by the sophisticated conversion process.

The study prompted international concerns. If all the coal-to-natural-gas plants planned by the Chinese government were built, they would emit more than 1 billion tons of carbon dioxide each year, according to Greenpeace. For more visit:- http://www.scmp.com/tech/china-tech/article/1936048/china-heated-debate-turning-highly-polluting-coal-gas-fears

Queensland bans underground coal gasification over environmental risk

18th April 2016, unattributed, The Guardian

The Queensland government has immediately banned underground coal gasification in the state, arguing the environmental risks outweigh economic benefits. Natural resources minister Dr Anthony Lynham says the ban, which would apply immediately as government policy, would be made official by the end of the year through legislation introduced into parliament.

The ban came after UCG pilot company Linc Energy, which last week went into voluntary administration, was recently committed for trial in the district court on five counts of wilfully and unlawfully causing serious environmental harm. “The potential risk to Queensland’s environment and our valuable agricultural industries outweigh any potential economic benefits from the particular industry,” Lynham said on Monday.

Queensland’s three trial sites, including Linc Energy’s site at Hopeland in the western Darling Downs, would now be decommissioned, he said. Lynham said although the pilot program was a failure and the industry wasn’t operating in the state anymore, there was still value in banning it by law. For more see:- http://www.theguardian.com/australia-news/2016/apr/18/queensland-bans-underground-coal-gasification-over-environmental-risk

MIT scientists make electronics out of coal

19th April 2016, Brook Hays, UPI

Researchers at MIT have successfully created electronics components out of coal. Their findings are proof that the natural resource is more than just a fuel source. "When you look at coal as a material, and not just as something to burn, the chemistry is extremely rich," Jeffrey Grossman, a material scientist at MIT, told MIT News.

In their initial investigation into coal's functional chemistry, Grossman and his colleagues determined that unprocessed, natural coal varieties offer an impressive range of electrical conductivities. In other words, it is versatile enough to meet a variety of needs in electronics manufacturing. The question was how best to process the mineral. Grossman decided to fabricate thin films by grinding coal into a powder and mixing it into a solution before allowing it to solidify on a substrate.

Traditionally, coal is looked at by material scientists and industrial chemists as purely a raw material -- something to broken down to the atomic level for use in creating new chemicals and materials. But the latest research suggests coal has inherent chemical properties useful to electronic engineers. By adjusting the temperature at which the coal was processed, Grossman and his research partners found that they could manipulate the material's properties for specific electronic purposes. The adjustability of its electronic and optical properties, combined with its high conductivity, thermal stability and robustness, make it a promising material. It's also relatively cheap to fabricate. Now, researchers need to determine how to best scale up the production process and begin testing a wider array of electronic components made from coal

films. Grossman and his colleagues recently described their experiments with coal films in the journal Nano Letters. Source :- http://www.upi.com/Science_News/2016/04/19/MIT-scientists-make-electronics-out-of-coal/6681461098322/

Battelle Scientists Converting Coal to Jet Fuel

20th April 2016, unattributed, Market Wired

Battelle scientists and engineers have demonstrated a process that turns coal into jet fuel. The next step is to commercialize the process. In a cost-shared program supported by the U.S. Department of Energy, National Energy Technology Laboratory (NETL) and the Ohio Coal Development Office (OCDO) of the Ohio Development Services Agency (ODSA), Battelle is demonstrating a new, hybrid, direct coal-to-liquids process for producing jet fuel using biomass-derived coal solvents.

The conversion of coal to syncrude is carried out at a relatively low pressure without requiring gaseous hydrogen or a catalyst. The syncrude can be upgraded to jet fuel and other distillates employing conventional petroleum upgrading technology.

"The Battelle process offers a significant reduction in capital and operating costs and a substantial reduction in greenhouse gas (GHG) emissions," said Satya Chauhan, the leader of Battelle's process-development team that also includes other Battelle supporting organizations. "Our objectives are to demonstrate a straightforward path to near-term commercial production of jet fuel from coal using biomass-derived coal solvents."

Chauhan has recently presented findings on the potentially breakthrough technology and has filed several patent applications. He will present more findings in August at the 2016 International Pittsburgh Coal Conference, to be held in Cape Town, South Africa. For more visit:- http://www.marketwired.com/press-release/battelle-scientists-converting-coal-to-jet-fuel-2116715.htm

Nuclear fusion contributes £84m to UK economy, says report

20th April 2016, unattributed, Power Technology

A report from Tokamak Energy revealed that nuclear fusion contributes nearly £84m to the UK economy every year. The report, 'An Impact Study of the Fusion Energy Research Cluster in Oxfordshire', stated that at least £300m is generated in exports as a result of research and development in the fusion energy field.

Figures released by the study show that nearly 1,000 people are employed in fusion energy research in Oxfordshire, and a further 800 suppliers rely on fusion energy research. The UK Atomic Energy Authority (UKAEA) carries out such research in the country, on behalf of the government and the EU, at the Culham Centre for Fusion Energy (CCFE).

Nuclear fusion releases clean energy, with no CO_2 emissions, without generating long-lived radioactive waste. Fusion creates energy by joining together small atomic nuclei, rather than splitting them. It is the opposite of nuclear fission, in which a large nucleus is split into two smaller nuclei with the release of energy. Tokamak Energy CEO Dr David Kingham said: "Billions are set to be invested into private fusion energy research in the US and Canada, and into large international facilities in Europe, but the unique cluster of capabilities in Oxfordshire gives us a clear competitive advantage. For more visit:- http://www.power-technology.com/news/newsnew-report-says-nuclear-fusion-contributes-84m-to-uk-economy-4869846

Protesters criticise Drax over use of subsidies for coal and wood power

20th April 2016, Terry Macalister, The Guardian

Drax faced protests during its annual general meeting in London over its use of public subsidies to support its massive coal and wood-burning power station. Banners were unfurled

by campaigners seeking to "axe Drax" outside its AGM in the capital on Wednesday, as well as at the Drax power station site near Selby, North Yorkshire.

Duncan Law, from the Biofuelwatch campaign group, said: "DECC [the Department of Energy and Climate Change] are calling biomass burning in power stations like Drax a 'transition technology', and a closer look at Drax's strongly suggests that the power station's lifespan is indeed limited. "But the impacts of the logging in the US, which is feeding Drax today, will be long-lasting, if not permanent. Precious wetland forests, once they have been cut down, may never recover." For more visit:- http://www.theguardian.com/business/2016/apr/20/drax-power-plant-protesters-criticise-renewable-subsidies-uk-coal-wood

The Biomass and Fossil Fuel Research Alliance (BF2RA) – Progress Update (April 2016)

Mr Peter Sage – BF2RA Technical Officer

The main objectives of BF2RA are to promote 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.

In addition BF2RA organises the annual Energy (formerly Coal) Science Lecture (ESL).

Currently membership of BF2RA comprises six 'world-class' power generation, equipment supplier, research and coal utilisation organisations, namely, British Sugar plc., Doosan Power Systems, Drax Group Ltd., EDF Energy, EPRI and GE Power.

BF2RA Project Portfolio

To date BF2RA has established a portfolio of 23 R&D projects (14 ongoing and 9 completed). Further projects are being recruited from BF2RA's 2016 targeted call for proposals and these are scheduled to start later this year.

Information on BF2RA's projects was presented at the BF2RA Technical Session that preceded the 2015 ESL, reported in the CRF January 2016 newsletter and will not therefore be repeated here.

The Energy Science Lecture

BF2RA has been organising this event since 2012 with the financial help of sponsorship from several organisations including the CRF.

Professor Rachel Thomson of Loughborough University presented the 2015 ESL at the ICAEW, London on 6th October 2015. Rachel's lecture was titled "Challenges for flexible operation of power plants: materials solutions" and was fully reported in the CRF January 2016 newsletter.

Dr Les King of Doosan Babcock has agreed to present the 2016 ESL. The title of his lecture is "How UK thermal power plant cleaned up their act.....for what future". This year's ESL will be

held at the University House Conference Centre, University of Leeds on Tuesday 20th September at 1800hrs. As in 2015 the event will include an afternoon technical session with oral and poster presentations on BF2RA research.

Participation at the ESL event is by invitation only so if you are interested then please email your details to the BF2RA Company Secretary at bf2ra@gardnerbrown.co.uk for an invitation.

For further information about BF2RA and Membership please visit www.bf2ra.org or email technical@bf2ra.org. A full list of the current BF2RA Projects was included in the Annex of the attachment of CRF E-mailshot No.38, (2015), issued on 19th December 2015.

CALENDAR OF COAL RESEARCH MEETINGS AND EVENTS

Date	Title	Location	Contact
Thursday 26th May 2016	**Mineral Engineering 2016**	**Yew Lodge Hotel, Kegworth, Leicestershire**	**Contact: Mr. Andrew Howells Chairman of the CRF Coal Preparation Division, Secretary of the MES Tel : 01909-591787 Mobile : 07510-256626. E-mail : hon.sec.mes@lineone.net**
12th to 16th June 2016	8th International Freiberg Conference on IGCC & XtL Technologies	Cologne, Germany	For information visit:- http://www.gasification-freiberg.com/en/
8th to 12th August 2016	The 2016 Pittsburgh Coal Conference	Cape Town International Convention Centre	For information visit:- http://www.engineering.pitt.edu/pcc/
Monday 5th to Wednesday 7th September 2016	**11th European Conference on Coal Research and Its Applications (11th ECCRIA)**	**The Edge, University of Sheffield**	**For further information on this Conference, please see the Conference website, www.maggichurchouseevents.co.uk/crf**
6th and 7th October	5th International Advanced Coal Technologies Conference	Jackson Hole, Wyoming, USA	For more information vist:- http://www.uwyo.edu/ser/conferences/international-conferences/2015-iactc.html
13th to 18th December	Coal-Gen	Orange County Convention Center, Orlando, Florida USA	For information visit:- http://www.coal-gen.com/index.html