Front Cover Image – Thermal Barrier Coating

An SEM image of a plasma sprayed thermal barrier coating showing the Yttria Stabilised Zirconia top coat, thermally grown oxide and bond coat on a Ni-based superalloy. Such thermal barrier coatings are regularly used for reducing the temperature of gas turbine blades, vanes and combustion chambers. The low thermal conductivity of the YSZ reduces the heat flux from the gas stream into the metallic substrate, thereby reducing the quantity of cooling air required to maintain the substrate temperature to acceptable levels.
EMG newsletter lead

Materials Making a Difference

The UN Climate Action Summit in New York on 23rd September could not be clearer that we are not doing enough to combat greenhouse gas emissions to avoid catastrophic climate change. UN Secretary-General Antonio Guterres, called on the Summit to come with concrete commitments and not fancy speeches. This has been brought into stark contrast with the unprecedented youth protests around the world and led by the courageous Greta Thunberg. In the press release from the Summit there were some actions from government and business that caught my eye.

- France announced that it would not enter into any trade agreement with countries that have policies counter to the Paris Agreement,
- The UK committed to double its overall climate finance to 11.6 billion for 2020 to 2025,
- India pledge to increase renewable capacity to 175 GW by 2022,
- China said they would cut emissions by over 12 billion tons annually,
- The Russian Federation announced that they would ratify the Paris Agreement, and
- 130 banks – one third of the global banking sector – signed up to align their businesses with the Paris agreement goals.

Climate change is firmly back on the agenda and renewable energy is now recognised as providing a clean source of electricity and is increasingly becoming price competitive.

Research at Imperial College has revealed in the UK, between July and September, the capacity of renewable energy (wind, solar, biomass and hydropower reached 41.9 GW, exceeding for the first time the 41.2 GW capacity of fossil fuelled power plants. The annual growth of renewable energy and decline in fossil fuelled electric power plants is shown on the graph below.

![Graph showing Renewable energy capacity has overtaken fossil fuels in the UK](image-url)
Taking a snapshot on GridWatch UK [https://gridwatch.co.uk/], as I am writing this article, the total demand for electricity is 33 GW of which renewables accounts for 15 GW with an additional 6.4 GW of nuclear energy. This represents a huge shift in our energy mix but to meet the ambitions of the UN Climate Action Summit we still have a long way to go, for example, domestic heating and transport are still largely dependent on fossil fuels.

Energy materials remain at the forefront of innovation to achieve our zero carbon commitments. The need for increased efficiency in renewable energy is driving the search for new materials with both better performance and improved sustainability based on availability, environmental impact and end of life management. silicon remains the mainstay of solar PV technology, but thin film perovskites could revolutionise this business. At present the most efficiency perovskite solar cells are lead based but intensive research is seeking alternatives based on less toxic metals such as tin. Improved battery technology will be the key to unlocking the potential for electric vehicles with increasing the range between charges and more rapid recharging.

In March this year I had the opportunity to trek to Everest Base and took the opportunity to test an innovative ultra-lightweight thin film solar cell on ultra-thin glass under extreme terrestrial conditions. A duplicate of this solar cell has been flight tested in Earth orbit for the past three years on the AlSat-Nano satellite. This is an example of the testing of new materials that could fill gaps in our future energy needs.

These and other key materials topics will be the theme of an Energy Materials conference at IOM3 Euston Road at the beginning of May next year (date to be confirmed). This will be an opportunity to highlight the latest research and innovation in energy materials and the part we can play as materials specialists in meeting the UN goals on climate change.

Professor Stuart Irvine
Chair EMG
Energy Materials Information Streams

The EMG microsite is a mine of information relating to Energy Materials with links to various sources of information, including funding sources for collaborative research/development.

The EMG microsite is actively managed and regularly updated; the link to the appropriate location on the microsite is given below


Materials at High Temperatures, Volume 36, Issue 3&4, 2019

- Influence of Cr content on high-temperature oxidation behaviour of arc sprayed Ni–Cr coatings
- Mechanical properties characterisation of dissimilar joint of high-temperature materials using Thermo-Calc Classic (TCC) diagram analysis
- Prediction of surface oxidation weight gain on 7.8 wt% Cr-containing stainless steel electrode during electroslag remelting
- Yield strength anomaly and dynamic strain ageing behaviour of recently developed advanced ultra-supercritical boiler grade wrought Ni-based superalloy IN 740H
- A review of the thermal expansion of magnetite
- Creep behaviour of AISI 316H stainless steel under stress-varying creep loading conditions: primary creep regeneration
- A coupled creep damage evolution model and creep life evaluation
- Influence of joint thickness on Type IV cracking behaviour of modified 9Cr-1Mo steel weld joint
- Characterisation of dissimilar P91 and P92 steel welds joint
- Life assessment of SiMo 4.06 cast iron under LCF and TMF loading conditions
- Precipitation study in Ti-stabilised austenitic stainless steel after 207,000 h of service
- Long-term creep strength predictions from short-term creep test data for high Cr creep-resistant steels and microstructural evolution origin of over-predictions
- Effect of W–Mo balance on long-term creep life of 9Cr steel
- A critical-plane-based thermomechanical fatigue lifetime prediction model and its application in nickel-based single-crystal turbine blades
- Effects of the threshold stress and load level on the values of $h_1$ for the estimation of $C^*$
- Effect of Co on the microstructure evolution of modified HR3C austenitic heat-resistant steels during long-term ageing
- Creep life assessment method for online monitoring of steam turbine rotors
- Effect of W–Mo balance and boron nitrides on creep rupture ductility of 9Cr steel
The UK Energy Research Centre (UKERC) carries out world-class research into sustainable future energy systems. UKERC acts a focal point for UK energy research and a gateway between the UK and the international energy research communities. UKERC is funded by UK Research and Innovation Energy Programme. The Energy Programme is investing more than £625 million in research and skills to pioneer a low carbon future. This builds on an investment of £839 million over the past eight years (December 2011). Led by the Engineering and Physical Sciences Research Council (EPSRC), the Energy Programme brings together the work of EPSRC and that of the Biotechnology and Biological Sciences Research Council (BBSRC), the Economic and Social Research Council (ESRC), the Natural Environment Research Council (NERC), and the Science and Technology Facilities Council (STFC).

UKERC’s core research programme focuses on six research themes: Future energy system pathways; Resources & vectors; Energy systems at multiple scales; Economy, energy & societal preferences; Decision-making and Technology & policy assessment. Associated with the UKERC is the Energy Data Centre (EDC), based at the STFC Rutherford Appleton Laboratory, which is an outward-facing service for the UK energy research community, directing interested parties to publicly available energy and related data. The EDC aims to be a definitive information resource for current and past UK energy research and development activity.

The UKERC primary function appears to be agenda setting for policy makers, bringing market intelligence, policy and technology matters into a combined document see for example UKERC Energy 2050 report issued 2009 and updated 2013, with a hard copy version issued in 2010, “Energy 2050 – Making the Transition to a Secure Low-Carbon Energy System”.

UKERC is based out of University College London, and whilst has some permanent HQ staff is primarily a network of interested persons/organisations working together on common interest topics, e.g. ADVENT, “Addressing the Valuation of Energy & Nature Together”. Under this umbrella topic are 15 active projects e.g. Impacts Associated with Large Scale Adoption of Bioenergy CCS (BECCS), Terrestrial Biodiversity Impact Metrics and Constraints and Assessing Energy Pathway Impacts Outside the UK.

Being a native Bristolian I’m particularly drawn to another ADVENT project namely “Implications of Mixed Marine Energy Sources for Cultural Ecosystem Benefits”. The Bristol Channel-Severn Estuary (BC-SE) will be used as a case study to explore i) the implications of a mixture of potential marine renewable energy production methods on the cultural ecosystem benefits (primarily for different forms of recreation and residents) and ii) the extent to which people are willing to trade-off between biodiversity/cultural ecosystem benefits and the need for a clean, affordable, renewable and secure source of energy.

The Bristol Channel-Severn Estuary (BC-SE) is an interesting case study as several energy generating approaches have been suggested for the area including a tidal barrage (currently abandoned), tidal lagoons (with proposals for multiple locations) and offshore wind (the currently on hold Atlantic Array). It is also of environmental importance with many designated areas, attracts almost 50 million visitors annually and its coastal areas house 3.3 million people.

For more information on the activities of UKERC please visit http://www.ukerc.ac.uk/
Editor's Titbits Section

Food created from thin air

Nutritious and environmentally-friendly food can now be created out of thin air. That's the bold claim from Solar Foods, which says it has created a new protein source made using carbon dioxide, water and electricity. Solein is a unique single-cell protein made through a natural fermentation process, similar to the production of yeast or lactic acid bacteria – originally born out of a concept developed for a NASA space mission, it doesn't require arable land or irrigation and isn’t affected by climate conditions.

The product looks and tastes like wheat flour and contains around 50% protein content, 10% fat and 25% carbohydrates – it can be given texture through 3D printing or added to other dishes and products as an ingredient. Unlike conventional food production, Solein production doesn’t use water at unsustainable levels, which Solar Foods claims makes it 100-times more climate-friendly than any animal or even plant-based alternative. It is also ten-times more efficient in terms of land-use than soy production, with much higher usable protein yields per acre.

Time to reconsider renewables?

James Lovelock, the originator of the Gaia Theory, is about to reach his 100th birthday. From the 1960s, Mr Lovelock was an environmental pioneer and author of over 200 scientific papers concerning the climate change debate. What may surprise many is his parallel advocacy of nuclear power to support human survival on planet Earth.

Gaia Theory

Gaia Theory asserts that living organisms and their inorganic surroundings have evolved together as a single living system that greatly affects the chemistry and conditions of the Earth's surface. Scientists believe this “Gaian system” self-regulates global temperature, atmospheric content, ocean salinity and other factors in an “automatic” manner. Originally proposed by James Lovelock as the earth feedback hypothesis, it was first named the Gaia Hypothesis, then Gaia Theory, which comes after the Greek supreme goddess of Earth.

Lovelock more recently believes it is now too late to avoid significant global heating and significant climate change which will make large parts of the Earth’s surface much less hospitable for humans. He thinks the time has passed for sustainable development and that we have come to a time when developments are no longer sustainable. He proposes that we need sustainable retreat from an impending climate storm; that we must retreat in an orderly fashion from the coming threats to our global habitat, to mitigate adverse impacts on human health and happiness.

Nuclear V Renewables

In his own words: “I believe nuclear power is the only source of energy that will satisfy our demands and not yet be a hazard to Gaia and sustain a conformable climate.” “Renewable energy might have worked in earlier times... but to expect them to sustain our numbers today is no more than a romantic dream.”
Record market share for battery EVs in July 2019

Registrations of battery powered electric vehicles (EVs) almost tripled in July, pushing them to their highest ever share of the UK car market. That’s according to the latest monthly figures from the Society of Motor Manufacturers and Traders (SMMT), which reveals demand for battery EVs shot up by a staggering 158%, resulting in a 1.4% market share.

A total of 2,271 battery EVs were sold in July – out of more than 157,000 vehicles in total – compared with 880 during the same period in 2018. The report also found registrations of diesel vehicles fell for the 28th month, down 22.1%, while petrol vehicles remained stable, with 2,646 more registrations than in July 2018. Hybrid EVs increased by a substantial 34.2% in July, with around 7,758 of these low emission cars joining UK roads while plug-in hybrids continued their recent decline, with a 49.6% fall.

The fastest way to address air quality concerns is through fleet renewal so buyers need to be given the confidence to invest in the new, cleaner vehicles that best suit their driving needs, regardless of how they are powered.

Cost of energy ‘has tripled in the last 20 years’

The average cost of energy in the UK has tripled across the last 20 years. That’s the verdict from price comparison service Compare The Market, which says the average cost of domestic gas has risen by 221%, while the price of electricity has soared by 193%.

It notes these price rises outstrip those of all other goods and services across the economy, the collective price of which increased by an average of only 49%. Compare The Market notes around 15 million households have seen a significant rise to their monthly energy costs since the 1st of April as a result of Ofgem’s new price cap level, which it blames for the price of electricity and gas jumping by 11% and 9% respectively.

It suggests this meant households on a standard variable or default tariff face an average annual increase of £117.

Plastic-waste-to-hydrogen plant

Eleven waste-plastic-to-hydrogen facilities are to be created across the UK in a new agreement between north west-based Peel Environmental, Waste2Tricity and Powerhouse Energy. The first will be housed at Peel’s Protos site, comprising 54 acres near port Elsmere in Cheshire. It involves the use of advanced thermal treatment, employing pioneering distributed modular gasification (DMG) to produce hydrogen from unrecyclable plastics. Peel Environmental is currently submitting a planning application for the work and aims to create a ‘closed loop’ solution that allows plastics to be recycled on-site with leftover material used to create hydrogen.

Under the three-way agreement, Peel Environmental – part of the Peel L&P group, – will provide real estate and infrastructure support. Waste2Tricity will be the developer of the project and PowerHouse Energy will be the technology and services provider. [Source – PE – 13.08.19]
Minewater - alternative energy solution

Advocates claim there is enough geothermal energy in abandoned coal mines to heat 180 homes. Lanchester Wines' facility in Gateshead has by far the UK's biggest commercial minewater heating scheme. It supplies all the warehouse's needs, keeping millions of bottles of wine temperate, and also heats a neighbouring distribution depot. Advocates of using minewater for heating regard it as having particularly significant potential after the UK set the ambitious goal earlier this year of net zero greenhouse gas emissions by 2050.

A quarter of all UK homes and businesses, some 9m buildings, and most of its largest cities outside London sit on former coalfields. Coal mining, which employed 1.25m people at its peak, powered the British economy for well over a century but the last deep mine closed in 2015. One of its underground legacies is the warrens of galleries through which run an estimated 2bn cubic metres of water, heated by surrounding rocks to 12-16 degrees Celsius.

At present, minewater is a problem. Often high in iron and pollutants and potentially a threat to drinking water and rivers, its management by the publicly funded Coal Authority cost £18m last year. According to Coal Authority data, heating currently accounts for 45 per cent of the country's energy use and 32 per cent of its emissions. Meeting the government's net zero carbon emissions target will require slashing fossil fuel use. While half of UK electricity supply has been decarbonised, the UK currently relies on natural gas for about 70 per cent of its heat demand, according to minewater heat expert Charlotte Adams, a geologist and assistant professor at Durham university's energy institute.

Orbital marine power awards O2 contract

Orbital Marine Power, a leading developer of floating tidal stream turbines, has awarded the main manufacturing contract for the company's first commercial O2 tidal stream turbine to Scottish based TEXO Group, who will carry out the work at their quayside facilities in Dundee. The multi-million-pound contract marks the start of major construction for the company's new tidal stream turbine, the O2, which builds on the successful 2 MW SR2000 turbine which generated over 3 GWh in its first year of testing at the European Marine Energy Centre (EMEC) in Orkney, Scotland. The O2, capable of generating over 2 MW from tidal stream resources, will become the world's most powerful tidal turbine when it enters operation later next year (2020) as part of a long term project at EMEC.

The O2 project has been financed in a number of ways including EU Horizon 2020 funding and a £7m crowdfunding bond which Orbital successfully raised at the start of the year, one of the largest peer-to-peer debentures in UK history. The project also benefits from previously offered market support for the sector via the Renewable Obligation. [Source – MPS – 14.08.19]

Editor's Note: Unless mentioned the source of many of these titbits is Energy Live News.
Mini Feature

UK Climate Projections (UKCP) 2018
https://www.metoffice.gov.uk/research/collaboration/ukcp

UK Climate Projections is a climate analysis tool that forms part of the Met Office Hadley Centre Climate Programme which is supported by the Department of Business, Energy and Industrial Strategy (BEIS) and the Department for Environment, Food and Rural Affairs (Defra).

Representative Concentration Pathways (RCPs) are a method for capturing those assumptions within a set of scenarios. The conditions of each scenario are used in the process of modelling possible future climate evolution. RCPs specify concentrations of greenhouse gases that will result in total radiative forcing increasing by a target amount by 2100, relative to pre-industrial levels. Total radiative forcing is the difference between the incoming and outgoing radiation at the top of the atmosphere. Radiative forcing targets for 2100 have been set at 2.6, 4.5, 6.0 and 8.5 watts per square metre (W m^{-2}) to span a wide range of plausible future emissions scenarios and these targets are incorporated into the names of the RCPs; RCP2.6, RCP4.5, RCP6.0 and RCP8.5. Each pathway results in a different range of global mean temperature increases over the 21st century, see table below.

<table>
<thead>
<tr>
<th>RCP</th>
<th>Change in temperature (°C) by 2081-2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP2.6</td>
<td>1.6 (0.9-2.3)</td>
</tr>
<tr>
<td>RCP4.5</td>
<td>2.4 (1.7-3.2)</td>
</tr>
<tr>
<td>RCP6.0</td>
<td>2.8 (2.0-3.7)</td>
</tr>
<tr>
<td>RCP8.5</td>
<td>4.3 (3.2-5.4)</td>
</tr>
</tbody>
</table>

For the UK a series of graphics have been produced to summarise UKCP18 data as below for sea level rise by 2100 relative to the mean 1980-200 levels.
The summary data is that with global warming by 2100 the UK will get hotter, circa 3°C; dryer with circa 30% less rain fall, very little if any snow falling with no snow settling. The one set of data that is the most difficult to estimate so not yet available on the UKCP18 site is wind speed, except the general view that there will be more damaging storms and more periods of settled weather.
### Upcoming Events

**NEXT COMMITTEE MEETINGS**

11:00 27 Nov 2019, IOM3, 297 Euston Rd, London

**EMG WORKSHOPS/CONFERENCES**

#### OTHER WORKSHOPS/CONFERENCES/COURSES OF INTEREST

- **50 Years of Steel Alloy Design**, 7-8 Nov 2019, Sheffield, UK
- **25th International conference on Materials Science and Nanotechnology**, 18-19 Nov, 2019, Rome, IT
- **IMMT2019 International Conference on Recent Advances in Materials & Manufacturing Technologies**, 20–22 Nov, 2019, Dubai, UAE
- **International Conference on Coal Science and Technology 2019**, 24-28 Nov, 2019, Krakow, PL
- **Asset Integrity Management Operational Excellence Forum**, 28-29 Nov 2019, Amsterdam, NL
- **PVSAT - 16**, 15–17 Apr, 2020, Salford, UK
- **36th World Congress on Materials Science and Nanotechnology**, 13-14 May, 2020, Tokyo, JP
- **ECCC2020**, 14–16 Sept, 2020, Edinburgh, UK
- **ICF15 15th International Conference on Fracture**, 13 – 18 Jun, 2021, Atlanta, US