NPL
National Physical Laboratory

Environmental *Measures*

A National Measurement Newsletter

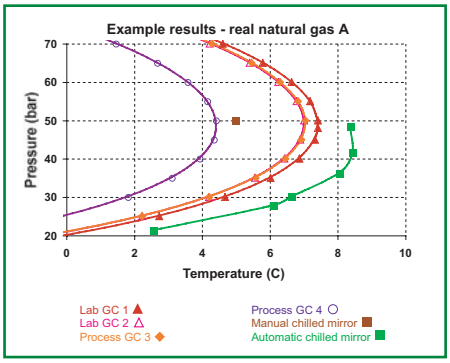
Summer 2007 | Issue 3

Inside:

Measurements to ensure safe transmission of natural gas

The Analytical Science Team at NPL have recently completed a Joint Industry Project comparing methods to measure the hydrocarbon dew point of natural gas.

Measurements of hydrocarbon dew point are essential at all points of entry to the UK's natural gas network as they determine whether gases meet legislative requirements in place to prevent the formation of hazardous liquid hydrocarbon condensate in pipelines.



The project was carried out in collaboration with three UK SMEs (Michell Instruments, EffecTech Ltd and Orbital Ltd) and National Grid, the owner and operator of the UK gas transmission system. Five NPL high-accuracy synthetic natural gas mixtures and seven real natural gas samples from different gas fields around the British Isles were analysed using six different analytical methods (see graph).

The highly successful project led to the SMEs gaining a valuable insight into the operation and performance of their instruments and, consequently, developing innovative analytical methods that will give them unrivalled access to European and International sales opportunities.

The project report can be downloaded from www.npl.co.uk/environment/hydrocarbondewpoint.html.

The web page also contains the full dataset generated during the project - this is freely available for use by the natural gas community to support research, legislation and standardisation activities.

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Department for **Innovation, Universities** & **Skills**

Take two bottles...?

NPL is developing novel techniques for the characterisation of fibres such as human hair, which could lead to development of more efficient and environmentally friendly hair care products.

Read the labels on a bottle of shampoo and you will see a huge list of chemical ingredients, including surfactants, foaming agents, moisturisers, anti-static agents, amino acids, stabiliser and perfumes. The UK market for hair care products is estimated at a massive £1bn each year, and the technology behind them is fast changing, challenging and increasingly reliant on nanoscale surface properties.

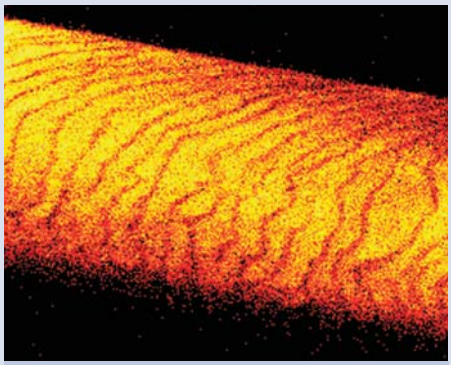
NPL, with Unilever, Intertek Measurement Science Group and the University of Sheffield, are working together on a DIUS-funded Micro and Nano-Technology project to develop nanoscale analysis of microfibres including cottons, synthetics and human hair.

Quantitative characterisation of fibre surfaces at the nano scale remains a massive challenge due to the extreme curvature, high topography and lack of systematic and validated measurement methods.

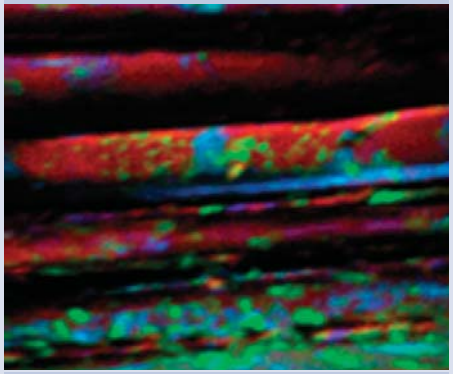
By developing the application and data interpretation of popular surface analysis techniques such as atomic force microscopy (AFM), secondary ion mass spectrometry (SIMS) and x-ray photoelectron spectroscopy (XPS), NPL aims to address the enormous technical challenges confronting scientists in the formulation of innovative surface treatments for fibre surfaces.

Through the development of analytical methods, it is possible to integrate nanoscale properties with compositional information to yield novel information on the impact of surface treatments. This allows rapid understanding of the chemical mechanisms that influence product performance. For example, measurements of the adsorption behaviour of active ingredients will lead to the production of more efficient and environmentally friendly products.

Together with its partners, NPL is developing robust and powerful methods to obtain physiochemical properties of nanoscale fibre surfaces and quantitative measurements of product performance. This will lead to wider use of novel surface techniques and enable the formulation of products with improved environmental and economic benefits.



Secondary Ion Mass Spectrometry (SIMS) image of an individual hair fibre, showing the cuticles.



False colour image of the distribution of three chemicals on hair fibres with a multi-component formulated treatment. Images taken by Dr Ian Fletcher (Intertek Measurement Science Group).

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MESSAGE in a mobile

Mobile sensors on pedestrians, cyclists and buses are to be used to better understand UK traffic pollution.

The Location and Timing Knowledge Transfer Network (KTN) has helped establish a national research project called MESSAGE – combining sensing and location technologies to gather and analyse environmental data in four cities. MESSAGE will investigate how eScience "grid computing" technology can be used to handle large amounts of data, including location information, from multiple sources across large areas.

The £4.1 million collaboration is formed by five universities led by Imperial College London. It involves 25 organisations including universities, industrial partners such as Nokia and IBM, plus transport authorities and city councils. The KTN has been involved from the beginning. It worked with academic partners in the planning phase to establish the technologies required, and introduced two industrial partners to the project.

MESSAGE will use conventional air quality monitoring sensors mounted on new, location aware, mobile computing platforms to deliver data on temperature, noise and carbon dioxide in Cambridge, London and Leicester. A new ultraviolet spectroscopy sensor called GUSTO will also be mounted on London buses to monitor a range of pollutants in the capital. The data will help scientists understand how traffic pollution is affected by factors such as the weather, street design and driving behaviour.

One of the technical challenges is to associate data with its source, which may be any one of 200 sensors moving around the country. "Location technologies are critical to MESSAGE," explains project coordinator Prof Neil Hoose of Imperial College London. "The information is only valuable if we can pinpoint where it was collected. We need to know where changes in pollution levels are happening before we can understand why." Sensors on pedestrians' mobile phones in Cambridge will use the mobile network to provide location references for the data they collect. In London, GPS enabled GUSTO sensors on buses will link data to geographic co-ordinates. They will then download data over wireless networks via roadside receivers along bus routes. Devices based on nanotechnology, called "motes", will also be deployed on buses in London, and in Gateshead and Leicester where they will be fixed to public infrastructure such as streetlamps. Then their location can easily be used to build a data map across the city.

The Location and Timing KTN is managed on behalf of The Technology Strategy Board by the National Physical Laboratory. Membership is free.

For more information on the KTN visit: www.locationktn.com or contact the KTN coordinator 020 8943 6382 info@locationktn.com

Black smoke - brighter future

NPL has recently taken over responsibility for DEFRA's Black Smoke Network, and, in collaboration with King's College London, is evaluating different methods for measuring this airborne "dark matter" with the aims of clarifying the uncertainties associated with each of them and maximising their value.

The Black Smoke Network involves the measurement of airborne carbon-containing particulate matter created by the burning of solid fuels and vehicle emissions, using optical reflectance. In 2006 NPL won the contract to redesign the Network and re-start 21 measurement sites around the UK.

The "Black Smoke" measurement technique consists of collecting airborne particulate matter by pumping air on to a clean filter, measuring the reflectance of the exposed filter, and converting the reflectance, pumped volume and filter size to a "black smoke index" measurement, expressed as $\mu g/m^3$, using a standard formula.

"Black Smoke" measurements are expected to correlate well with the elemental carbon measurements made by chemical analysis of the carbon collected on a filter, and with other optical techniques such as light transmission (aethalometry), but until recently the different health and air quality communities using the various measurements have not needed to compare the underlying methods with much accuracy.

Black Smoke measurements have been made throughout the UK since 1961 and they were the first means of measuring levels of particulate matter in ambient air. The measurements have declined in concentration dramatically over recent decades, and they are no longer required for legal air quality purposes. However, they have renewed importance for two reasons.

Firstly, the measures of general particulate matter (not necessarily carbon-containing) that are legally required (PM_{10} and $PM_{2.5}$, based on total mass of particles below 10 micrometres and 2.5 micrometres respectively) are proving difficult to model, with consequences for deciding what action to take to reduce particulate matter levels. Carbon-rich particles are a major part of the puzzle, providing good datasets to help improve the knowledge of PM_{10} and $PM_{2.5}$ – how they form, how they affect human health and how they can be reduced. Secondly, airborne particles have a major impact on the climate, comparable in scale with greenhouse gases, in part because of the absorbing properties of particles in the atmosphere, so measures of the optical properties of particles are highly relevant to the issue of climate change. However, the situation is complicated by the variable presence of reflective particles such as sulphates and NPL is drawing on its analytical science and optical science expertise to improve the basic measurement techniques and calibration procedure.

For many centuries the most obvious form of air pollution was the smoky haze found in industrial cities, tending to turn buildings and clothes – and in serious cases, phlegm and lungs – black. It is caused primarily by particles of soot that are formed during many combustion processes. In earlier times this was dominated by wood and coal burning, while more recently vehicle engines, especially diesels, have added to the mix of "Black Smoke".

For further information on the Black Smoke Network please contact Paul Quincey 020 8943 6788 paul.quincey@npl.co.uk

Calling all Measurement Innovators

Innovation leading to new product development is the lifeblood of industry – reaching new markets, launching new products, adapting existing products. But even the best products and ideas can fail in the design stage: sometimes an individual company lacks the particular expertise that will overcome some of the development barriers, or sometimes they lack the correct approvals or calibrations. With this in mind, DIUS has established a 'Measurement for Innovators Programme' (MfI), which links industry with the UK's National Measurement Institutes (NMIs) in a move to tackle measurement issues for innovators. A second round of funding has just been secured and now is the time for potential innovators to start scoping out their measurement requirements.

What's in it for my company?

The scheme is designed to enable companies to gain cost effective access to expertise and facilities contained in the National Measurement System (NMS) - National Physical Laboratory (NPL), Laboratory of the Government Chemist (LGC), National Engineering Laboratory (NEL) and National Weights and Measures Laboratory (NWML) – which could help innovators solve measurement issues e.g. by providing access to specialist equipment, or by having experts troubleshoot on-site measurement problems. There are three mechanisms by which an organisation can source assistance:

Joint Industry Projects

The aim of the Joint Industry Projects is to allow the NMS and industry to work together in a multi-partner project to produce rapid solutions to measurement problems (projects last less than a year). The benefits include:

- Develop or improve new products, processes or services
- Access to capital intensive test equipment at the NMIs
- Up to 50% funding from DIUS to match industrial funding (A minimum of 10% of the amount of DIUS funding must be cash with the remainder in-kind)

Consultancy

Designed specifically for SMEs, this allows a company to obtain up to 4 days free advice on a measurement issue from any of the NMIs. This can include face-to-face meetings, inspection of parts and site visits.

Secondments

The purpose of secondments is to allow people to transfer in or out of the NMI to the organisations. The scheme allows both NMI staff to be seconded to your organisation, or for a member of your staff to work at the NMI for a minimum of one week to a maximum of nine months on a full or part-time basis. The scheme covers many of the costs depending on the exact nature of the secondment.

What kind of projects are eligible?

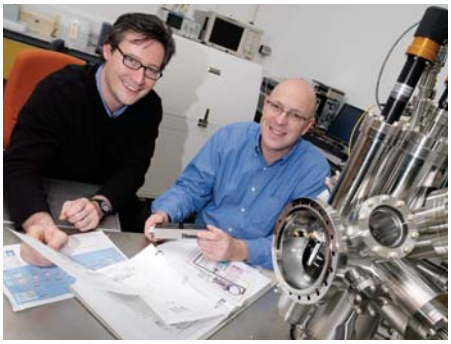
All proposed projects are considered on an individual basis – but there must be a measurement issue at the heart of the project and this newsletter contains some articles on 'Measurement for Innovators' projects relating to environmental issues, however proposals from all technology sectors are eligible.

What do I have to do?

The scheme is aimed at solving measurement problems. To take advantage of the scheme, firstly contact the NMI to discuss what your measurement problem is. Once the NMI has determined the most effective way help you, your contact will start the process to apply for funding.

Below are three examples of recent MfI projects.

Measurement issues with novel gas sensors



Alex Cuenat (NPL) and Victor Higgs (Applied Nanodetectors) discuss the use of Atomic Force Microscopy

Small-scale gas sensors are a crucial part of many security systems, for example those requiring detection of explosives or poisonous gases. The sensors currently available often give rise to incorrect readings or "false positives" triggering a false alarm and are therefore of limited value. Applied Nanodetectors is a UK SME that has devised a novel sensor array with the combined advantage of greater sensitivity and no false positive signals in a device that is physically smaller than those currently available. The company undertook an MfI consultancy with NPL, taking advantage of NPL's facilities and expertise, in order to understand better the measurement issues involved. As a result the company is now in a stronger position to compete for research funding.

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Website: www.lgc.co.uk

National Engineering Laboratory (NEL)
Tel: 01355 220 222
Website: www.tuvnel.com

Measurement of RF energy emissions from communications antennas

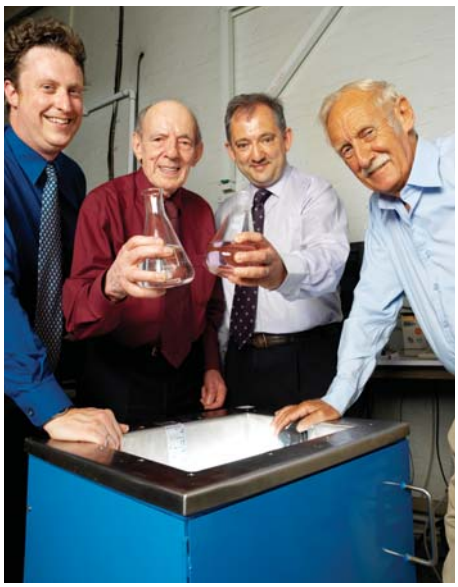
The design concept for the instrument

IndexSAR is a small UK company that specialises in RF monitoring equipment for safety purposes. It has developed a novel instrument that measures in-situ the rate of absorption by body tissue of RF energy emanating from wireless communications antennas such as mobile phone masts. The instrument is able to detect a wide frequency range and is portable and easy to use.

NPL, through a Joint Industry Project, worked closely with the company to improve the accuracy of the measurement. The prototype was extensively tested and compatibility with existing product testing standards was demonstrated.

A new technique for water sterilisation based on ultrasound

A UK SME, Ultrasonic Processors Ltd, is developing a method to kill bacteria in water using ultrasound. The process has potential for use in water treatment plants and domestic supplies and would be cost effective in remote areas where currently expensive UV sterilisation treatment is used. Mark Hodnett of NPL visited the company at their request under an MfI secondment, to assist with monitoring the performance of the processor under industrial flow conditions during trials at a clean water treatment plant. Novel instrumentation developed at NPL,



Mark Hodnett (NPL), Henry Ratcliff (the inventor), Bajram Zeqiri (NPL) and Trevor Bayliss.

which detects the acoustic signals produced by imploding cavitation bubbles, was used to correlate cavitation activity with "bug kill". The results look very promising.

Tackle your environmental "Grand Challenge" with EMRP

The new European Metrology Research Programme (EMRP) is taking a novel approach to ensure metrology R&D activities address socio-economic "Grand Challenges" including the Environment

The European National Metrology Institutes, backed by their funding Ministries, are in the process of pooling resources and establishing an R&D joint programme - the European Metrology Research Programme (EMRP) - addressing measurement challenges of common interest. The EMRP particularly aims to increase critical mass amongst the NMI research teams, increasing the ambition of the research projects and accelerating their delivery and impact. The new joint programme was developed within the NPL-led iMERA project, involving 20 partners from 14 countries, including DIUS, and will be delivered by the members of the NMI community under the auspices of EURAMET eV.

The EMRP introduces a novel approach in which metrology R&D activities addressing socio-economic "Grand Challenges", including the Environment, complement the traditional metrology approach of brigading R&D along SI Unit lines. The EMRP will be rolled out in a two stage process, initially in 2007 with EC "ERA-NET Plus" funding topping up the national resources. In a second larger phase the EMRP will be delivered, subject to final European Parliamentary and Council of Ministers approval, using Article 169 of the European Treaty. This is a mechanism enabling and facilitating large focused programmes of R&D, bringing together resources from both participating countries (19 to date) and the European Commission.

The "Environment Grand Challenge" is scheduled for the second phase of the EMRP, with work currently in progress to identify priority areas within the broad theme described in the EMRP http://www.npl.co.uk/international_office/emrp_final_document2007.pdf

If you have environmental issues or challenges that require measurement and metrology solutions at European level, now is the time to have your say. Short submissions can be made to Andy Henson the iMERA Project leader (andy.henson@npl.co.uk) who will ensure your views are made known as the programme priorities are developed.

Laying the foundations for the next generation of structural health monitoring

The first step towards creating a simple to understand Structural Health Monitoring system is being taken by NPL – the development of industrial demonstrators for renewable energy and civil engineering structures.

There is a wide industrial need for predictive systems that can monitor structures and inform the asset holders on their state of structural health. These structures include bridges, buildings, power plants, aircraft, chemical plants and more - all of great economic importance to the UK. Even just considering bridges, a simple and clear indication of the structural health will provide substantial economic benefits since there are over 10,000 bridges worth more than £1M each in the UK alone.

This project (Enabling the Next Generation of Structural Health Monitoring: Demonstrator, Validation and Best Practice) is a first step in the measurement grand challenge of creating a Structural Health Monitoring (SHM) system as simple to understand as a traffic light system. This system could provide early warning of potential problems and be a sophisticated indicator of the structure's current lifetime. This would lead to cheaper maintenance, lower running costs and provide advanced warning of failure, leading to enhanced safety. The purpose of this project is to accelerate the uptake of combined and multi-modal monitoring methods that support total life-cycle management of user-critical devices, structures and systems. This will be achieved by developing industrial demonstrators for renewable energy (wind turbines) and civil engineering structures (e.g. bridges, buildings). The selection of the demonstrators has been influenced by NPL's ability to cover several different material systems, including metallic, composite, and concrete. Sensor types will include full field displacement measurements provided by Digital Image Correlation (DIC) and embedded sensors such as fibre Bragg gratings and wireless sensing.

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Workshop on measurement of underwater radiated noise

On 23 May 2007, NPL hosted a one-day workshop on behalf of the Institute of Acoustics on the subject of the measurement of underwater radiated noise. The impact of man-made noise on the marine environment has been an increasing cause for concern, and it is now common practice for off-shore operators to be required by DIUS and/or DEFRA to undertake an environmental impact assessment before work may begin. This can affect operations as wide ranging as geophysical surveying, oceanographic research, off-shore drilling, and the construction of off-shore windfarms. The aim of the meeting was to increase awareness of the issues relating to underwater radiated noise and to illustrate current best practice for its measurement. The workshop consisted of a series of presentations by invited speakers from industry and academia with experience in the field. Topics covered included UK Government policy, parallels with techniques used in air acoustics, the latest information on the impact of noise on marine species and metrics for estimating the behavioural effects, methods of mitigation of noise impact, the use of passive acoustic methods of monitoring for marine mammals, noise generation mechanisms on vessels and good practice in the acoustic ranging of vessels.

The presentations from the workshop can be downloaded from the NPL web-site for those who missed the meeting at www.npl.co.uk/acoustics/events/23may07_workshop/index.html

For more details contact Stephen Robinson
020 8943 7152
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Characterisation of MEMS energy harvesting devices

The realisation of self-powered microsystems for medical implants, drug delivery, remote monitoring, or safety driven applications forms the basis behind a new project being run at NPL by the Functional Materials Group.

The goal is to replace batteries in these applications with an energy scavenging power supply, thus at a stroke eliminating the environmental hazards and costs associated with battery technologies.

Energy harvesting covers the scavenging of many low grade energy sources such as environmental vibrations, human power, thermal sources, wind energy and their conversion into useable electrical energy. This project is concerned mainly with the first two, where the transformation of mechanical to electrical energy is used to power small autonomous devices. The conversion can be achieved by a number of methods - however the most promising options for MEMS devices include magnetic, piezoelectric and magnetostrictive transformation. Example applications might include airborne particle detection in massively parallel autonomous sensing systems (motes), medical condition monitoring with embedded active drug delivery systems for diabetes patients for example, and the development of structural health monitoring systems that scavenge innate vibrations for self power - all represent a tiny fraction of how the development of this technology might improve our lives.

The global market for microsystems technology is estimated at $35B (2002 – Nexus: Market analysis for MST 2000-2005), with biomedical applications estimated at EU12B. There are a wide range of UK companies that would benefit from this understanding of this technology, from Healthcare to transport, from the Energy sector (reduced dependence on fossil fuel sources for routine battery charging for example) to the Aerospace and Defence sector where MST is given a high priority. The expected time frame during which this technology will be demonstrated extends from 2-5 years for Defence applications associated with the Smart Soldier concept to 3-7 years for domestic appliances (MP3 players with built in energy scavengers) for example.

Knowledge will be shared with all partners onboard the project, whilst the wider community will enjoy open access to the generic metrology output in the form of web based tools, new pre-normative standards documents, and the work will be further assessed for quality through the peer reviewed publication process. Case studies will demonstrate the concepts so that organisations not in the materials supply market will gain a better understanding of the benefits associated with energy harvesting.

Benefits

New ways for harnessing the 'free' energy from innate vibrations would enable industry to develop new autonomous sensing/actuation smart systems. The individual companies seconding this work will open up new markets (enhanced security through autonomous access control etc), while wider benefits include reduced costs and the environmental penalties of battery technologies. The research will also enable a significant step forward in the development of novel medical devices such as hearing aids, pumps for drug delivery, valves to control fluid flow, and catheters.

Energy harvesting devices demonstrators include self-powered switches, and a vibration sensor that uses traffic induced vibrations to power the sensor that logs bridge traffic. Advances in semiconductor power reduction means that more of these types of applications will be realised, including motes (autonomous wireless sensors/ transceivers), future soldier comms power scavenging systems, battery-less consumer products (ipods), etc.

Metrology solution

NPL's solution will be to develop a measurement workstation for the characterization of energy harvesting efficiency of small-scale devices (e.g. MEMS). The workstation will embed the vibrational generator system, the energy harvesting structure or device and measure using a Laser Doppler Vibrometer (or NPL AIMS interferometer), with traceable calibration afforded through the current NMS Engineering programme. The use of the workstation will then be examined on a series of energy harvesting devices. The workstation will be extended for invitro measurement ('BioSmart' platform) for the characterization of small-scale medical devices.

The metrology challenge is four-fold. Firstly a vibration fingerprint of the intended environment must be specified, this could come from measurement of vibration amplitudes on a road bridge. Secondly this vibration fingerprint must be reproduced traceably and repeatably in the laboratory. Thirdly the electrical output of the harvesting device must be measured coupled to a representative output load. Finally, the ability of a sensor device to maximize the transformation of energy in a fluid into electrical energy must also be characterized.

Requirement for metrological intervention

At present, developments in energy harvesting have concentrated on producing maximum energy output from a device with little consideration of realistic operating conditions. In order to be able to compare devices they must be measured under the vibration fingerprint of the intended application, and this must be done with a representative electrical load attached. Furthermore, the use of small implantable functional medical devices is being hampered by a lack of understanding of the power delivery and sensing capabilities of these devices.

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NPL Turns up the heat

NPL is giving energy companies the confidence to operate power stations at higher temperatures and increase efficiencies.

NPL has been assisting the power industry in developing test methods and evaluating materials that could be used in higher efficiency plant. By increasing the efficiency by operating at higher temperatures the environmental impact can be reduced as less carbon dioxide is produced per unit of energy generated. Traditional plants operate at up to 590 °C. New power stations operate above 620 °C and the next generation will need to go beyond 700 °C.

Materials and coatings used in the plant are approaching their limits and may deform or degrade at these higher temperatures. More resilient alloys are being developed, but not enough is known about their life expectancy. The inability to accurately predict their performance could lead to huge maintenance costs or dangerous in-service failure. One of the biggest challenges is to develop techniques which predict performance over decades.

NPL has focussed on developing test procedures and using these to compare the high temperature corrosion resistance of existing and new alloys to steam and combustion atmospheres. The development and understanding of such accelerated testing allows industry to make informed choices when selecting candidate materials for pilot scale testing, thereby enabling a more environmentally friendly energy supply from fossil fuels to become a reality.

Power generation from the burning of fossil fuels produces a large volume of carbon dioxide gas. The UK government is looking at alternatives which could help meet the national target of reducing carbon emissions by 60% of 1990 levels before 2050. These alternatives include renewables and nuclear power, but both of these have issues, whether it is security of supply or the prospect of new build. Hence fossil fuels, and in particular coal, which is still used to generate a third of UK power, remain the mainstay of power generation in the UK and reducing the CO_2 emissions from these plants is essential in the short to medium term.

The power generation industry is approaching the problem of carbon dioxide reduction in two ways. One method is to increase the efficiency of the power station, whilst the second approach relies on CO_2 capture and sequestration, which unfortunately has the drawback of decreasing the efficiency of the plant. In practice both approaches are considered necessary to meet the reduction targets set.

For more information please contact Tony Fry
020 8943 6220
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Forthcoming events

www.npl.co.uk/events

Enabling Innovation through Micro and Nanotechnologies
26 September 2007
NPL, Teddington

OFMC 2007 Optical Fibres & Optoelectronics Measurement Conference
15 - 17 October 2007
NPL, Teddington

Time and Frequency Club Meeting
27 November 2007
NPL, Teddington

UKAS Electrical Day
28 November 2007
NPL, Teddington

EM Day 2007
29 November 2007
NPL, Teddington

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