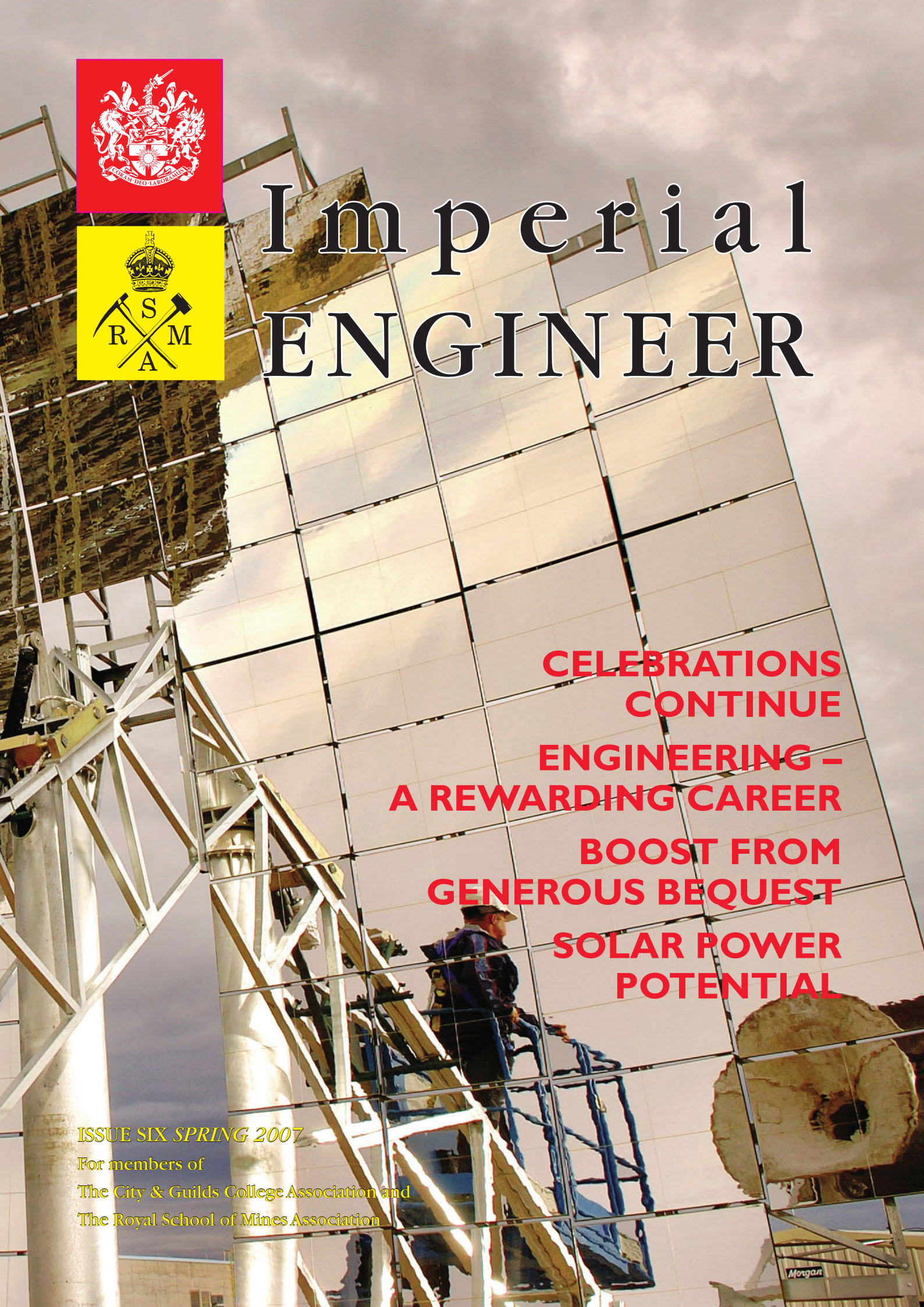

Imperial ENGINEER

CELEBRATIONS CONTINUE

ENGINEERING – A REWARDING CAREER

BOOST FROM GENEROUS BEQUEST

SOLAR POWER POTENTIAL

ISSUE SIX *SPRING 2007*
For members of
The City & Guilds College Association and
The Royal School of Mines Association

ISSUE SIX *SPRING 2007*

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FEATURES

COVER PICTURE: Dish engine systems for concentrated solar power (CSP) from Stirling Energy Systems , at the Sandia National Laboratory in Albuquerque, New Mexico. See article on CSP starting on page 14.

Imperial ENGINEER

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COPY DEADLINE FOR THE NEXT ISSUE IS MONDAY AUGUST 12 2007

The editorial board of *Imperial Engineer* reserves the right to edit copy for style and length.
Views expressed in this magazine are not necessarily those of the editorial board.

John Banyard

TIME has flown by since my last musings and my year as President will soon end. On May 8, I shall hand over to Peter Garratt. It would be easy to use this opportunity to review my year, but I wrote previously about the dangers of becoming totally retrospective. I therefore wish to pick up on the theme of Lord Browne's address at the splendid CGCA annual dinner held on March 6. The event is reported in full elsewhere in this *Imperial Engineer,* but the message was very important.

Lord Browne identified a number of major problems that face society as we move into the 21st century. He pointed out that these problems can only be solved by engineers and scientists, because they are the only people who have the necessary skills to do so. The general population will not accept major reductions in their living standards, no matter how passionately they are argued for. What is needed is technological development that will enable the necessary changes to be accomplished so that our society can continue to prosper and the world to develop. This will mean a huge responsibility will fall on engineers in the future and the way in which they work will undoubtedly be impacted as well. For CGCA it means that our future members will work in an environment very different to the one in which most of us spent our professional lives.

I cannot forecast what those changes will be – it's just too early to say and technology is developing at a frightening pace. What is important is that CGCA should remain flexible and dynamic and be prepared to embrace engineering of the future, in whatever form it evolves.

Imperial College must do so too if it is to retain its current position as the pre-eminent science and technical institution school in the UK. Therefore, the alumni association must be prepared to follow – it cannot lead. I'm sure that we have the foundations in place for the next 100 years: we must now build on them with care.

Finally. I should like to thank the executive and the committee for making my year in office so enjoyable and offer my very best wishes to Peter as he prepares to take over the reins.

Roger Clegg

PRESIDENTS REPORT

IF YOU are not aware already, 2007 is the centenary year of Imperial College. Althoughthere may be some older constituent parts of the College, it is, nevertheless, a momentous occasion to celebrate Imperial's achievements and its standing as one of the finest university institutions in the world. It must be remembered that part of this success can be attributed to the contributions of the constituent colleges and their alumni over the many decades, including the RSM and the Association.

Whilst Imperial as an institution and a commercial venture continues to go from strength to strength, it must be remembered that for the students of the College, studying and living in London is becoming ever more challenging. This is where I see that the RSMA has a dual function in supporting the current students and their activities as well as providing a link for alumni to come together and catch up on old times.

In addition to the sheer expense of living in London, funding from the main college to the RSM CSC (the old RSMU) has shrunk dramatically over recent years. Although the students have found innovative ways of raising external sponsorship, it is not always enough to cover the costs of some of the activities and opportunities the students have; it would be a crying shame if the current and future students were to miss out on an integral part of student life which we enjoyed and benefited from purely because of lack of funding.

Your membership fees and donations are vital in assisting students (home and overseas) in research through financial hardship as well as supporting some of the social events that we took for granted when we were students.

In an effort to highlight more of our activities the committee undertakes and supports, I am delighted to announce the launch of the RSMA website (www.rsmaonline.org.uk) which is now live. Whilst the website is still in its infancy, the RSMA would appreciate any feedback - after all it's your website. Also, we have been in discussions with the RSM on improving access to merchandise for alumni members. Remember those cufflinks that you bought 20 years ago and, despite the battering, you still wear; or the sweatshirt that won't quite fit around that waist anymore? Keep an eye on the website for updates in the next couple of months.

Lastly, as my presidency comes to an end in the Summer, this will be the last report I make for *IE*. I would like to thank both the committee and Chapter manager – Teresa Sergot – for their support and their continued efforts in keeping the RSMA and its values alive. It is a credit to them and benefits many hundreds of people. I would also like to thank the students who re-introduced to me late-night drinking as well as reminding meof the reasons why I took on the role. It's been a privilege to serve the RSMA and I look forward to many years of mutual interaction with this fine institution and its members.

IN BRIEF

EGM motion for new recruits

THE RSMA's AGM on June 21 and final year dinner will be preceeded by an EGM at 6.15pm in the Sherfield Building.

The motion is to update the student membership section and introduce an option to charge a nominal fee for membership of the RSMA.

It's a thought...

JUDGING from *building the connection*, the booklet issued with *Imperial Matters*, we've noticed that only one of the alumni to make donations to Imperial's funds was not an engineer. Fond memories of days at Imperial obviously bear fruit!

New MSc

A NEW MSc in sustainable energy futures has been announced by the Energy Futures Lab. Starting in October, it will cover topics from clean fossil fuel to sustainable transport and energy storage and transmission.

Busy Giles!

EX-RSMA president Giles Baynham married Sandra Lutz on January 5 in a very snowy Whistler. A large contingent of Brits attended including RSM and Imperial alumni.

Giles, not being one to waste time, also became a father in just over a month. Abigail was born on February 9.

Online reading

Once again, high levels of contributions mean that some articles have had to be abbreviated. If specified go to www.imperial.ac.uk/engineering/about/alumni/imperial engineer to read them in full.

Centenary pull

Sir Richard Sykes pulls the first pint of Centenary Ale in the college union bar. Created by Blindman's Brewery in Somerset to appeal to a wide range of drinkers, it's available in all licensed outlets at Imperial. Picture: Colin Whyman

THE PEALING of the Queen's Tower bells marked the official launch of Imperial's Centenary year on January 30.

The day was packed with events, including a themed lunch based on a 1907 RSM alumni annual dinner menu found in College archives (see page 10), a chance to see the unions' mascot cars and musical performances by current students.

Centenary cakes were ceremonially cut and distributed on all the college campuses by staff in period costume. Over 5,000 slices were eaten within a matter of hours!

Fundraising

January also saw the launch of the Centenary campaign which aims to raise £207 million from philanthropic donations. July 2010 will be the culmination of a 10-year fundraising campaign that has so far raised £123 million. It will be used to provide scholarships for gifted students; contribute to building and refurbishment, and support the college's mission to develop its academic activities.

Launch day ended with a grand tour of Imperial College's history and the launch lecture by the Rector, Sir Richard Sykes. In 'From Albert to Z-bosons and beyond' he set the challenge that, by 2050, Imperial's people would be 'partners of choice for governments, commerce and industry across the world'.

The lecture is online at www3.imperial.ac.uk/aboutimperial/events/onlinelectures.

Share your story on the Centenary website

You can find out all about Imperial's past through an interactive timeline or browse other people's experiences and memories of the College on the Centenary website. Add to the site yourself by sharing your memories and pictures of Imperial online.

There are already accounts of the 1945 King George VI visit and a student being trapped up the Queen's Tower! Other features of the site include a downloadable Centenary screensaver, e-postcards and details of Centenary events, news and merchandise. Visit www.imperial.ac.uk/Centenary

Carol Marsh

News from RSMA Trust

LAST summer, the RSMA Trust once again provided bursaries for two RSM students to take part in the Undergraduate Research Opportunities Programme (UROP). They were MSc geology students Elizabeth Stock and Russell Garwood.

UROP allows undergraduate students to get a taste for research by working for a few weeks alongside postgraduate and post-doctoral researchers in one of the RSM's many research groups.

Elizabeth worked with Dr Jamie Wilkinson, who specialises in fluid inclusions in ore minerals. Her project was 'Footwall veins in the Red Dog District, Alaska: fluid conduits for giant SEDEX ore deposits'.

Russell Garwood worked with Dr Mark Sutton, who recently joined the staff of the Earth Sciences and Engineering and is an expert in the investigation of fossils in 3D, using X-ray and CT scanning. Russell spent the summer trying to reconstruct the soft tissues of a fossil arthropod from the mid-Jurassic period. The experience got their final year research projects off to flying starts.

The Trust has produced a standing order (with a Gift Aid declaration) for annual donations. For copies phone 020 7594 1184.

Peter Harding prize

Since last summer the Trust has raised over £3,000 towards an annual prize in honour of a much-missed alumnus. The target is £5,000. Look out for news of a summer event aimed at raising the balance.

Legacy doubles OC Trust potential

CGCA's Old Centralians' (OC) Trust has recently received a legacy just short of seven figures, reports chairman of the Trust, Chris Lumb.

'We are most grateful to Professor Peter Lindsay, who died last June. He left us the value of his London home. It has doubled our funds and will greatly enhance the work that we do in support of student hardship, extra-curricular activities and projects. To read an obituary on this remarkable man, see page 27.

Senior engineer is new Principal

THE FACULTY of Engineering's new principal will be Professor John Wood, who will succeed Professor Dame Julia Higgins in the late summer. He is currently chief executive of the Council for the Central Laboratory of the Research Councils.

Professor Wood has a strong background in engineering, with a career comprising numerous public and industrial appointments in the UK and worldwide. He is a fellow of the Royal Academy of Engineering, chair of the European Strategy Forum for Research Infrastructures and, from 1997 until 2001, was chair of the Office of Science and Technology's Foresight on Materials panel. He joined the CCLRC in 2001 on secondment from the University of Nottingham, where he was Cripps professor of Materials Engineering, head of department and dean of Engineering.

His many honours and prizes include the William Johnson International Gold Medal in 2001 for his lifetime of achievement in materials processing. He was appointed CBE for services to science. in the 2007 New Year Honours

UROP research helps TV history

CAMERAS were on campus in April to interview geology Megan Heaney about her researches into early Indian history for a BBC programme to be screened in the autumn. It will co-incide with the 60th anniversary of Indian independence.

The History of India, with TV historian Michael Wood, will include the early development of the Harrapan civilisation in the Indo-Gangetic Plains – one of three great early civilisations.

A few years ago, Megan was granted an RSMA UROP bursary. She used it to analyse satellite imagery and build a geographic infrastructure system (GIS) of important archeological sites. It showed the distribution of Harappan civilisation settlements in the Ganges plain around now dried-up rivers. Recent research has shown that the subject was also studied by a much older RSM geologist in the late 1880s, reports Sanjeev Gupta, reader in sedimentolgy in the Department of Earth Science and Engineering. The researcherwas Colonel RF Oldham, who is also known for discovering the earth's core.

Sanjeev talks Michael Wood through the research on early Indian settlements while Megan operates the machinery to show it on the screen.

Putting a spurt on for charity

KURT BUDGE, RSMA's next president, lined up in Greenwich Park for the third time for the London Marathon on April 22.

He ran for Notting Hill Housing Trust. It provides homes for the homeless and support for vulnerable people in their own homes in 17 London boroughs and develops innovative projects which give homeless people a real prospect of independence and offer people the chance to contribute to the life of their neighbourhood.

You can still sponsor Kurt by going to www.justgiving.com/kurt2007. Or send a CAF or bank cheque (Gift-Aided preferably), payable to the 'Notting Hill Housing Trust', to 16 Grimwood Road, Twickenham, TW1 1BX.

Also running was head of Materials Mike Lee. He last ran the race in 1982 with brother Bob. This time they supported Kidney Research UK. You can still sponsor them by going to www.justgiving.com/LeeBros.

Concern voiced over skills shortages

IN KEEPING with recent practice, featured speaker John Morton gave his remarks before lunch at December's CGCA Christmas celebration. John is chief executive of the Engineering and Technology Board, an organisation created to promote the contributions made by scientists, engineers and technologists to UK PLC. His remarks on 'Engineering UK – Pride and Prejudice' assessed the present state of education and training.

At university level the picture is generally positive but we are facing a critical shortage of skilled workers. John identified a combination of causes – from losing tomorrow's highly-skilled technicians to inappropriate university courses, to a continuing weakness in skills like secondary level maths and science. These are sobering thoughts as we look back on a decade of relatively satisfactory economic growth. Happily our skills gap doesn't include the Queen's Gate culinary staff and we were well fed and watered.

Use it or lose it!

PAST president David Hattersley writes that if there are not at least 12 people on his next London walks in July, September and December, 'walks with a past president' will, come to an end. See pages seven and 23.

DEVELOPMENTS AROUND THE ENGINEERING FACULTY

Paper and string create bond

LAST autumn, first and second years from Civil and Environmental Engineering took part in the usual 'buddy' scheme and built some of London's most famous landmarks on the Queen's Lawn! And it was all done with paper, string and tape, plus an additional £10 budget.

After nitial visits to their assigned monuments, the groups of 10 students had five weeks to develop scale models and submit a detailed plan on how the project would be managed. They also defended their project decisions to a panel of judges.

WITH ST PAUL'S: From left, Francesco Zhou, Jonathan Watkins, Nicole Li, Gareth Hopkins and Manna Hopkins and Manna

Under the miscroscope

THE UK's first FEI Titan 300-80 S/TEM microscope, unveiled at Imperial last October, means scientists can look at materials on the atomic scale. It also enables spectroscopy to be carried out with unprecedented energy resolution and atoms to be identified and their local environment investigated.

The project is led by Dr David McComb, Materials, for the London Centre for Nano-technology (LCN), an interdisciplinary collaboration between Imperial and University College London.

Programme could change fuel production

THE multi-million pound Shell Imperial Grand Challenge, a joint research programme between Imperial and Royal Dutch Shell, was launched in February. It will research processes to enhance extraction of difficult hydrocarbons, with minimal release of greenhouse gases.

Programme director, Professor Geoffrey Maitland (Chemical Engineering and Chemical Technology) describes the programme as an opportunity to bring together new ideas from a broad range of engineering and science areas. 'It has the potential to change dramatically the way oil, gas and coal are produced', he said.

Science and engineering expertise from the Energy Futures Lab will drive the new programme.

Climate Change Institute hopes to break down barricades

DR BOB Noland (Civil and Environmental Engineering) has been working on policies to mitigate the major climate impact of 'contrails' – aircraft vapour trails. They are sensitive to temperature, humidity and vary with altitude.

Contrails can produce up to 10 times the CO_2 emitted by aircraft and spread into cirrus clouds, trapping heat.

Operational strategies being worked on for air traffic controllers will be used to navigate aircraft around parts of the atmosphere particularly prone to the effects of contrails. The work will contribute to a guide book for air traffic controllers being produced by the EC to deal with environmental issues.

Speaking of Imperial's new Climate Change Institute, Dr Noland praised the benefits of interfaculty working. He said, 'The Institute hopes to break down the barriers between the different areas of research. It's all about interaction, an approach that adds value to the work of all the researchers involved.'

Challenge for Solarspirit

IN JULY 2008, Imperial mechanical engineering students will be the only UK team in the Frisian Solar Challenge in the Netherlands – the only solar-powered boat race in Europe.

The entry, Solar Spirit, a one-man, fibre-glass boat will be powered by five 175W solar panels. It will be driven by an electric outboard motor that will source its power from both solar and battery.

The team's tutor, Dr Shaun Crofton(Mechanical Engineering) said: 'There are many challenges for engineers in the future and this project encompasses the most pressing. This group has risen to the challenge.'

See www.solarspirit.co.uk for more information.

THE TEAM: Thomas Middleditch, Oliver Carson, Chris Burrows and Peter Huthwaite.

Web for journey into space

ENTREPRENEURIAL aeronautical engineering PhD student Michael Halls-Moore, is selling advertising space on a new website to fund his dream to journey into space.

Michael, whose research has a focus on space and aircraft travelling at hypersonic speeds in the upper atmosphere, says: 'I put my skills to good use and built buymetothestars.com'. He's also planning to make the website 3D and more interactive.

Companies or individuals can pay to display a stellar object on the website's front page which then links to the website of their choice. The bigger the object chosen, the the higher the advertising charge.

The source of some of these articles and some of the words come from* Reporter, *newspaper of Imperial College.

Reunion event rises to a crescendo

NOVEMBER'S Decade Luncheon was notable for the record turnout of over 100 and 58 representing the 1950s! This event often starts a little quietly as members find their contemporaries and their way to the relatively modern venue. But after a few introductions and recognising familiar faces, the bar opens and everything warms up, reaching a crescendo towards the end with a Boomalaka with our current students.

As always, the proceedings were enlivened by short reminiscences from each of the decades. Tom Lewis (50s) explained IC was preferable to Cambridge as there were more nurses. Nigel Knowles (60s) remembered the Colcutt Tower controversy and John Betjeman's involvement,

Bruno Guillaume (80s) noted that whilst there is a lot 'new' about IC, the labs seemed very much as he had left them. He compared student grants with permanent indebtedness.

Fiona Grandison (90s), past president of CGCU, recalled the slave auction and Bo failing by only half a mile to reach Brighton on the Veteran Car Run. She apologised for switching her career towards merchant banking but noted how well her Guilds' training had stood her in good stead. The current generation completed the speeches.

Once again, many thanks to all the speakers who contribute so much to the character of the event.

LEFT: Fiona Grandison speaks for the 90s. ABOVE: Just a few of the 1956 contingent.

This year, as it is Imperial's centenary, there will **not** be a Decade Luncheon. Rather we will help with the College celebrations, especially over the Re-Union Weekend (September 14–16). We plan to include aspects consistent with our Decade Reunion Luncheon traditions especially during the buffet lunch on the Saturday.

David Law

Danish break

PAMELA Nwaneri, (above, centre with friends) of Electrical & Electronic Engineering, was just one of the many Guilds' students who benefited, in the year ended September 2006, from awards and bursaries made by the Old Centralians' Trust.

After her placement, Pamela said: 'Overall, I can now appreciate learning on the job and I am motivated to learn new things by self study. Read Pamela's full story on the website – address page two.

The Jessel Rosen Travel award sent Pamela to FL Smidth in Copenhagen to work with programmable logic controllers.

A total of £31,631 was paid by the OC Trust for awards like the Holbein Memorial Award; to support 14 on the UROP scheme, and to help others with lodging costs or other needs.

The Trust is always ready to receive applications from current students. For details see www.cgca.org.uk.

DIARY DATES

Saturday April 28
Walks with a Past President, Regent's Park & Primrose Hill. Venue: Baker Street metropolitan Line station on the concourse, 10.30am *

CHANGE OF DATE TUESDAY MAY 22 AGM & President's Evening, Read Lecture Theatre, Sherfield /170 ueen's Gate, 5.30pm

Thursday June 21
RSMA EGM/AGM and Final Year Dinner, Ante Room and Main Dining Hall, Sherfield Building, 6.30 /7pm

Sunday July 22
Walks with a Past President, The River Wandle Trail Venue: tbc, 11am.*

Friday September 14
Engineering Faculty Departmental Alumn Reunions

Sat/Sun September 15/16
Imperial College Alumni Reunion Weekend

Saturday September 29
Walks with a Past President, Bloomsbury. Meet outside Dominion Theatre in Tottenham Court Road, 10.30am *

Thursday October 25
Engineering Careers Fair and Networking Reception. Queen's Lawn Marquee, 11am.

Wednesday October 31
CGCA House of Commons Reception, Dining Room A, House of Commons, 6 – 9.30pm

Saturday December 1
Walks with a Past President, Camden Town & St Pancras. Meet at Camden Town Underground in booking hall, 10.30am*

Wednesday December 12
CGCA Christmas Lunchtime Seminar, 170 Queen's Gate, 12 for 12.30pm. Contact Teresa Sergot (as below)

** New members and their guests are most welcome. If you are interested see cgca.org.uk to register interest or email David Hattersley at davidhattersley@aol.com Tel: 020 8504 8263.*

For more information and booking for any of these events, contact Teresa Sergot t.sergot@imperial.ac.uk or phone 020 7594 1184

DINNER DATES

A glittering affair

by Colleen Richardson

DURING a glittering CGCA annual dinner at the Carpenters' Hall, suitable to Centenary year, the toast to Imperial College and the CGCA was proposed by Lord Browne of Madingly. Lord Browne is president of the Royal Academy of Engineering. In his speech, he spoke of the college formation 100 years ago creating one of the finest academic institutions in the world.

Speaking of Sir Richard Sykes, he said that it required leadership to make a good institution into a great one and he felt great pleasure to be able to pay tribute to him.

'Richard Sykes is an inspiration to many in demonstrating that a life spent in business can be a useful prelude to some real activity afterwards. A century ago, one's horizon was set at birth by one's background. The changes since then have been immense – limiting disease, mass communication and transferring knowledge at low cost.

These advances have been made possible by scientists and engineers, but now we have to live with the consequences of this progress. The impact of economic growth on the environment includes the risk of fundamental climate change. These global challenges, as in the past, will again be met by scientists and engineers.

RSMA dine in style

WITH a return to the elegance of a black tie 'do', the RSMA annual dinner filled the first floor of Exhibition Road's Polish Club. Once again a large contingent of students was sponsored by alumni.

They heard Merlin Marr-Johnson, CEO of Palladex reply to RSMA president Roger Clegg's toast to the Association by admitting that he sees RSM as his alma mater. Merlin, the youngest CEO of a public company, spoke about the importance of gold in the old USSR and his experiences of its mining on such a vast scale.

He also spoke of experiences with vodka-drinking geologists and the problems faced nowadays over investing in the wake of past broken promises between the west and east. In particular, he stressed how important it is to commit totally to the region and try to learn Russian.

Next year's president Kurt Budge toasted the guests and RSMCSC president Seb Turner replied, bringing the formal proceedings to an end.

Having failed in her photography of the RSMA dinner, production editor Lynn Penfold chose this picture (above) of RSMA folk at the CGCA dinner. From left, Richard Martin, treasurer Rup Banerjee, president Roger Clegg, Elspeth Farrar, Teresa Sergot, Coen Louwarts and secretary Paul Holmes

ABOVE: Warwick Faville (left) with Bo and (at the wheel) CGCU president James Fok and guest Lord Browne.

***LEFT: Colleen Richardson and Adrian Winchester toast the dinner. Colleen and Adrian were editor and producer respectively of* Imperial Engineer's *predecessor* Imperial College Engineer**

Before president John Banyard responsed to Lord Browne's toast to the CGCA and Imperial's centenary, the Dean made two awards. One, the Holbein Memorial Award for 'Sportsman of the Year', went to Matthew Taylor and the second to Bo driver Simon Hamlin.

John then welcomed the many guests and thanked those responsible for organising such a successful evening – especially Warwick Faville, Teresa Sergot, Chris Lumb, Professor Bob Schroter and Rogers Knight.

The President mentioned that the centenary celebrations would culminate in July, when Imperial would finally break away from London University.

Before raising his glass to his guests, the President also thanked Chris Lumb for his work in running the Old Centralians' Trust Fund.

Replying on behalf of the guests, Sir Richard Sykes spoke about how the College had lived up to the hopes of Edward VII in making many significant contributions to the world around it. He gave examples from the World Wars and then mentioned Imperial's 14 Nobel Prize winners. He said that today our major research goals lie in areas of health, environment and energy and that many of the solutions lie at the intersection of diverse technologies and disciplines.

WE NEED YOUR NEWS

Let us know your news and stories.
Or have you an idea for a feature?
Editorial assistance is available!
Contact is Teresa Sergot
(address on page two).

COPY DEADLINE FOR NEXT ISSUE IS MONDAY AUGUST 12 2007

Any pieces not in this issue will be published next time

RSM goes from strength to strength

by RSMCSC president Seb Turner

WHAT a year it's been! The RSM continues to strengthen and it has been an honour to steer the ship at this important time in College history.

With all but a few of our major annual events now behind us, it is an ideal time to reflect on the successes of this year and to look forward to next year.

Our major events, including the Freshers Dinner, Christmas Ball, bar nights, and most recently the Bottle Match, have all seen a surge in attendance. Tickets have sold out, profits have been made, and attendees have had some great times.

Our clubs and societies have also had a successful year. The De La Bêche society continues to go from strength to strength, promoting an interest in geology outside the academic arena with two weekend field-trips, to Bude and Snowdonia, and a very successful symposium.

Our sports clubs have also continued to strengthen - Hockey club, for example, discovered this year that they were at least 100 years old with the remarkable discovery of a 1906-07 RSM hockey team photo in a garden shed in mid-Wales! (See next page) It seems a fitting reward that this year they have also made the ULU cup final.

Most recently, the 2007 Bottle Match was held in London and, unfortunately, the Bottle was not retained after a 10 year winning streak. The prestigious trophy is now in Cornwall, waiting to be challenged for again next February.

An intensely close rugby match finished with a score of 5-3 to Camborne. Although this is a disappointing loss for us, it is very positive to see that the competition is very much still alive and will continue for a very long time to come.

Our loss in the rugby match was reflected in all other sports except squash, but in all cases the competition continues to become increasingly equally matched and I am confident that over the coming years we will regain some silverware!

And so to next year. As elections for next year's committee are upon us, I'm confident that the next generation of the RSM will continue the hard work of this year's committee.

I've come to realise that the continued success is not simply about finances, management and advertising. It's just as much about promoting and enjoying the historical RSM spirit which has bound students for generations going back to 1851.

LINE out in Harlington: the low score of 5–3 indicates how well-matched RSM and Camborne were this year. For full story, see www.rsmonline.co.uk/bottle

CGCU events grow bigger and better

by CGCU president James Fok

THE CITY and Guilds College Union has enjoyed a successful year once again, in academic and welfare representation and in social events.

The Union has worked very closely with the Faculty and individual departments, solving many immediate issues and also setting out visions for the next few years leading to the full implementation of the Faculty's fresh look into engineering teaching, EnVision Project 2010.

Our events have grown bigger and better. Despite earlier set-backs, the CGCA-supported Freshers' Ball was well-attended by both engineers and miners, all of whom enjoyed a wonderful evening.

A string of successful events followed, including the Lord Mayor's Show celebrating the College centenary with good coverage on the BBC, and Bo's annual London to Brighton Veteran Car Run. Bo arrived at Brighton in style in the usual late 3 – 4pm slot, after a number of mechanical faults and failures.

After a well-deserved Christmas break, students returned to yet another action-packed but quieter term with the Raising And Giving Week as the highlight.

The Union managed to secure nearly £1,000 for Cancer Research by auctioning individual officers, whilst also winning the presidential yard of ale competition between the three original constituent colleges.

Finally, the Union has kept up a strong relationship with a number of external bodies including the CGCA. The Worshipful Company of Carpenters has again been a strong supporter of the sabbatical appeal. And the Union is particularly grateful for all the generous donations, allowing another strong crowd of students to attend the annual dinner.

A strong contingent of students at the CGCA annual dinner with Rector, Sir Richard Sykes, Bob Schroter and Spanner and Bolt.

MORE THAN 100 YEARS ON!

***ABOVE:** The RSM Hockey Club 1906-7, a picture recently donated by Carole Inman. Pictured are EB Pollard, CC Cow, RR Mitchell, GB White, H de Varinay, E Wraight, PLM Battye (captain), LH Bartlett, HL Oakley, TB Greenfield and AW Blanford.*

***RIGHT:** The menu for old students' 34th dinner, held in the year Imperial came into being.*

***A CHAT** with his wife's aunt has shown Richard Woodhead (Elec 1969) that he has a longer association with Guilds than he thought. Aunt Ida's father-in-law, Harold Scarlett, took an electrical engineering degree at the Central Technical College and graduated in 1906. He's pictured (right) second from the left, five rows back. He first joined Purcell & Mobbs and then Accles & Pollock. Fifth from the left, seated, is Professor WE Dalby who was the third CGCA president.*

A copy of these three memories of the past and lists of those pictured are available by going to www.imperial.ac.uk/engineering/about/alumni/

We should like to hear from you if you have information about anyone pictured or know anything about Purcell & Mobbs.

Continuing *Imperial Engineer's* look at the demand for resources, the problem it creates and some of the steps taken for a sustainable future. Contributions in the following 13 pages are by Imperial alumni and others and concentrate on non-hydrocarbon topics

A nuclear industry for Australia?

THE AUSTRALIAN Uranium Mining Processing and Nuclear Energy Review (UMPNER) released its final report just before Christmas 2006. This document (see http://www.pmc.gov.au/umpner) contains an excellent compendium of information about the nuclear industry, which could appropriately be placed in libraries and used as a text book all over the world. Briefly, its findings (in my words) are as follows:

- Australian mining and export of uranium could be expanded substantially, subject to acceptable non-proliferation safeguards. The case for other nuclear fuel cycle activities in Australia (such as enrichment, fuel fabrication and reprocessing) is uncertain or unproven.
- The safe disposal of high level radioactive waste in Australia is readily achievable technically.
- Because of Australia's abundant reserves of cheap high-grade coal, nuclear power is currently uncompetitive economically for generating electricity here. However, if economic penalties are to be applied to the environmental costs of burning fossil fuels, nuclear power would be the next most economic option for base-load generation.
- The nuclear industry generates minimal emissions of greenhouse gases.
- The nuclear power industry and the commercial nuclear fuel cycle do not handle or produce materials suitable for making atomic bombs.
- Skills shortages, government policies, legal restrictions and the lack of an appropriate regulatory framework are currently restricting the growth of the nuclear industry in Australia.

Misconceptions

My own submission to UMPNER was aimed at dispelling misconceptions which are rampant in the community about some of the above matters, and particularly about the safety of the industry. Apart from the Chernobyl reactor accident, nuclear power generation has an astonishingly good safety record. Even including Chernobyl, its record is good compared with other power generation

Not dangerous

Routine operations of the nuclear industry do not expose workers or the public to dangerous levels of radiation. Although there have been accidents affecting workers, nuclear power is one of the safest industries in which to work.

Don Higson assesses the future for nuclear power in Australia

Public exposures due to radiation and radioactive materials released from nuclear plants in normal operation are very small compared with natural background radiation. (Natural radiation itself varies widely around the world – up to at least 100 times the average level – without any discernible adverse effects on health.)

There have been two major reactor accidents involving core-melting during the 50-year history of nuclear power generation. The accident at Chernobyl in 1986 was the worst that could happen – a full core meltdown with no containment. About 50 people died due to radiation exposure from Chernobyl and there are realistic projections that some thousands of further casualties may eventually occur due to the massive release of radioactive material.

Apart from Chernobyl, there has never been a death recorded due to accidental exposure to radiation from a commercial nuclear power reactor.

The other core-melt accident occurred at Three Mile Island (TMI) in the USA, in 1979, in a light water reactor (LWR) which was equipped with a proper containment structure. It did not cause any radiation injuries or result in a significant radioactive release to the environment.

Engineers learn from experience

- that modern designs of LWR are far less prone to a risk of accidents than the TMI design, and
- that modern containment buildings, which are massive steel-reinforced concrete structures, would withstand the impact of the largest aircraft.

Minimal risk

Hence, modern nuclear plants in proper containment structures present essentially minimal risk to the public, either from accidents or from terrorist attack.

Apart from being extremely safe, nuclear power plants have less environmental impact than other types of power station. I would not want to live next door to any power station but, if I had to, give me nuclear every time.

Working on the development of nuclear submarine propulsion for Rolls-Royce & Associates followed a degree and PhD in chemical engineering at Imperial (1951-57) for Don Higson. He joined the Australian Atomic Energy Commission in 1964 and specialised in reactor safety assessment. Don has also worked as a consultant to the International Atomic Energy Agency on nuclear safety and safeguards. He is a fellow of the Institution of Engineers, Australia; a Fellow of the Australasian Radiation Protection Society (ARPS); former editor of the ARPS Newsletter (which he founded in 1995), and a member of the Publications Commission of the International Radiation Protection Association (IRPA).
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PLANES *versus* TRAINS

'For rail travel, carbon dioxide emissions and fuel use per passenger- kilometre are typically at least an order of magnitude lower (than air travel) according to the Royal Commission on Environmental Pollution 2002. The Commission for Integrated Transport reached a similar conclusion, but its report does not detail the load factors *etc* on which it is based.

Airlines, however, claim to have achieved parity in fuel consumption and it is reported that the Airbus A321 consumes less energy than a Eurostar trainset. Can this difference be explained?

The 10:1 ratio applies to the total 'radiative forcing', not the carbon dioxide production and fuel use alone, and it measures the total climate change impact of aircraft flying at altitudes of 9 – 13 km. This is calculated by multiplying a fuel use ratio of c3.5. This figure contrasts with others generally in the range 1 - 1.5 for most human activities.

Much of the reported difference in fuel consumption is due to the following:

- The Royal Commission accepted in 2002 that trains have to travel greater costing distances than planes. So the effect on rail's fuel usage from London to Glasgow is proportional to costing distances of 401.5 miles from Euston against 345 from Heathrow and less from Luton.
- In its 1994 report, the load factor for long distance trains 'at typical occupancy' was given as 50%. British Rail 1993 data for Intercity trains showed an average load of 33% for the 225 trains. When queried with the Commission, it stated that it had used a forecast of future occupancy!
- Since 1994, the advent of low-cost airlines has increased the industry load factor from 65% to over 80%, (the Commission's 2002 report did not include this improvement). BA has also achieved this figure for domestic flights. Furthermore, Easyjet's 737-300s have 149 seats against BA's 122. Ryanair's 737-800s have 189.
- The Royal Aeronautical Society 2002 report *Greener by Design* showed that between 1976 and 1994, aircraft fuel consumption per passenger-km halved. The improvement is continuing on budget towards the ACARE 2020 targets. The Rolls Royce Trent 1000 will burn 12% less in 2008 than the 800 does now – and produce less NOx and noise. Boeing claimed that the weight reduction due to plastic fuselage, plus engine improvements, will result in the 787 burning 75% less fuel per seat-km than the 707.

Tony Lucking asks: 'Are planes 10 times more evil than trains?'

Greener by Design also stated that high-speed trains achieved 80 passenger miles per gallon against 70 for short-haul aircraft. However, this was 1997 data for aircraft achieving only 70% load factors. Adjusting this to 80% indicates parity in fuel consumption.

- The 1994 Royal Commission report showed a French TGV burning 10% more fuel than a BR 225. The new Virgin Pendolinos have 439 seats versus 480 , increasing fuel burn per seat by 9%. They need 6800HP versus 4850 for the 225s and have air conditioning, 146 on-board computers, electrically-operated doors and tilting mechanisms.
- The A321 Airbus is more fuel-economical than the Eurostar trainsets.
- A report by the Oak Ridge National Laboratory for the US Department of Energy shows that by 2003 intercity trains were using 18% less fuel than planes. Plastic fuselages etc will close this gap soon. And a US paper by David S Lawyer notes a 25% deterioration in fuel usage per seat following the introduction of the new Amtrak Acela trains. He found also that in the USA, no allowance had been made for fuel used to carry cargo in passenger aircraft.

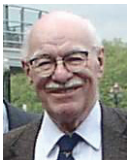
The 'radiative forcing' factor of c.3 is believed to be largely due to contrail/cirrus formation by aircraft flying at heights of 9 – 13 km. This is less of a problem at the lower altitudes used by short-haul aircraft. Prof David Lee found that a 6000ft drop reduces contrail formation by 47% – albeit with some 6% increase in fuel consumption (four to five years' technical progress on engine design).

A recent study by the CAA found that London-Amsterdam flights generated no contrails. And a Lufthansa report states that 30% of surface transport emissions are found at aircraft altitudes ie surface transport should not be rated at 1, and is perhaps one of the '1.5' activities. The *Greener by Design* team suggests that the correct factor is between 1.3 and 1.5

So there is persuasive evidence that

- planes use no more fuel per passenger than high-speed trains;
- the three-times multiplier is too high for short-haul flights;
- surface transport has a higher multiplier than one.

So it seems that, at worst, planes are only slightly more evil than trains.



ARRIVING at the RCS in 1942 to take physics with radio (compulsory in those days), Tony Lucking then spent 'four gap years' on India's NW frontier. After returning to the Guilds (Electrical Engineering) he joined Standard Telephones. The next 10 years in management consultancy included work at several airlines and designing the transport system for the Newport steel works. Among others he wrote for* Aeroplane, Flight *and* Aerospace, *occasionally doing so today. Member of, and later hon consultant to, the Air Transport Users Council, Tony is air transport committee member of the Royal Aeronautical Society and the London Chamber of Commerce.

LEIGH CLIFFORD, 59, graduated as a mining engineer from Melbourne University and then gained his masters in engineering. He has worked throughout the world in a number of roles for Rio Tinto, was appointed chief executive in 2000 and is due to retire this May. In a conversation with Paul Holmes, hon sec of the RSMA, he sets out how Rio Tinto is tackling the chronic shortage of graduates entering the mining industry

'Engineering is a rewarding career'

LEIGH: Seven years ago, before the boom and competition from a plethora of small mining companies, we were able to meet our requirements from existing universities. When demand started going up, we targeted universities around the world that have a mining, metallurgy, geo-science focus and started to develop a relationship. Examples are the Colorado School of Mines and universities in Western Australia. We've complemented that relationship with undergraduate and post-graduate scholarships as well as some university-sponsored R&D. What we are seeing is interesting. When I was in Queensland a while back, they told me that the number of people entering the mining industry is back on track. So you're seeing a conscious effort to try and get more students to enter universities. Companies have got to maintain their graduate recruitment.

PAUL: Why do you have an apparent bias towards supporting university courses in Australia/USA/Canada?

LEIGH: Last year we recruited nearly 250 graduates in Australia with a large number from the USA and Canada. We've need to employ people who want to work where we operate. You might say that we should target Imperial College. Imperial is a great university but it hasn't got a mining faculty.

PAUL: Should colleges such as the RSM offer a specialist masters course in mining?

LEIGH: You've got to take a step back and think about engineers in general. We recognise mining is not just about pure mining metal issues: it's about a range of engineering disciplines. We need to make sure we encourage people to think about mining. In some places we're encouraging what they call conversion courses, so that a guy who has a civil degree can gain some sort of post graduate qualification that then enables him to get a statutory qualification. Some of the problem is getting the lecturers, so it might be that a more flexible approach of seconding people to several universities should be encouraged.

PAUL: How can the mining industry make itself more attractive to young students?

LEIGH: I think that is narrowing the issue too much. It depends on where you live. If you live in London you have a different view of the world. If you are in Western Australia you see Rio Tinto in the news every day. In London you see Barclays, HSBC, Morgan Stanley. We must explain engineering is a rewarding career that can take you in all sorts of directions. We have to talk about engineers rather than specific disciplines.

PAUL: As an individual who has spent his entire career in one company and has worked his way up to CEO, do these opportunities still exist for today's graduates?

LEIGH: Someone who starts at Rio Tinto has as good a chance as someone from outside. If you do so, given the nature of our business, you have to have pretty broad experience. You can't just weave your way to the top at head office: its just not credible.

PAUL: Why doesn't Rio Tinto help fund universities for the future leaders in mining rather than giving billions to shareholders?

LEIGH: My view is that the mining industry has to be very targeted and we need to work with the universities that are in the regions where we operate or have the skills we need. That might mean providing some of our specialist skills to teach courses or provide seminars. I think we need to do more of that. Look, shareholders are the ones who put the money into our company. These are ordinary men and women who have invested their retirement savings and they want their return. At the end of the day, the government is going to support universities or individuals through fees. You have to be careful about general philanthropy. We are targeted so I leave general philanthropy to our shareholders.

PAUL: At a previous AGM, one of Rio Tinto's goals was 'to ensure it attracts and develops capable leaders and, in particular, that we build a team to lead the company in years to come'. On a scale of one to10, how successful do you think you've been?

LEIGH: We have very targeted management development courses at all levels within the organisation. This has helped us identify emerging talent and strengthen our gene pool. I don't know about one to 10 but we are a lot better now than five years ago. That doesn't mean we can't be better: we could be quite a bit better. However, if we are on seven, now we were less than that previously.

PAUL: What do you think you can do more of?

LEIGH: I think we could engage more with universities. I'm reliant on the universities to ask me to talk. I think a lot more people are willing to do that. Just talk, not a prepared speech, just stand up and let the audience ask me questions about where we are going.

PAUL: What does the future hold for Leigh Clifford after retirement in May?

LEIGH: The afterlife! I'm going to do some different things – some pro-bono, others for a potential dollar.

PAUL: What's the one thing you weren't taught as a mining engineer graduate?

LEIGH: Look, it wasn't one thing. The 'people leadership dimension' isn't something you get taught at university. How you interact with peers and subordinates; how you work with people.. In my opinion, you can't learn that in a lab or lecture theatre: you have to experience it in life.

Concentrating solar p energy security and clima

by Neil Crumpton

NOW THAT public awareness and concern about global warming is becoming widespread, attention is turning to possible solutions. Environmental groups say that to avoid the worst effects of dangerous climate change, atmospheric carbon dioxide levels should be kept below 450 ppm equivalent (2°C) mark. This means that developed countries have to reduce their emissions by around 90% by 2050. Furthermore, significant reductions are needed before 2030 to reduce impacts and burdens in the subsequent decades.

Yet global primary energy demand is forecast by the International Energy Authority (IEA) to increase by nearly 60% by 2030. The advisory board to the German government forecasts a doubling of current demand by 2050 and about four times by 2100 as the global population increases to around 9 billion. Worse, several major countries, including China, India and Indonesia are currently ordering new coal-fired power stations not fitted with carbon capture and storage equipment. Specific emissions from gas-fired power generation are also likely to rise with increasing liquefied natural gas (LNG) use.

Low output

Some countries particularly the US, UK, France and Russia are promoting nuclear power as a significant solution even though nuclear power only generates 3.1% of global energy consumption.

In public debates in the last year, nuclear supporters have claimed that nuclear power is the only tried and tested solution to climate change. And the director of the World Nuclear Association, at a conference last November, suggested a 20-fold increase in global nuclear capacity, to tackle global warming, to around 9,000 reactors.

Yet even a marginal increase above the current 3.1% global nuclear contribution is likely to be compromised by the availability of sufficiently high-grade uranium ores to avoid excessive carbon emissions from the mining and milling of progressively lower-grade ores. The expectation of new high grade ore discoveries is a considerable gamble at this critical time. So too are moves to problematic thorium fuel or a dangerous plutonium-fueled global economy based on tried and as yet failed reprocessing technology.

Better alternative

Yet there are tested and proven renewable technologies which could be scaled up to supply a significant percentage of future global energy needs over the next few decades. The most resourceful technologies are wind power and concentrating solar power (CSP).

Concentrating solar power comprises large fields of mirror arrays in hot deserts which focus sunlight on to pipes to raise steam for electricity generation. The technology is essentially simple and benign. Around 350 MW of steam turbine based CSP schemes have been operating quietly and almost forgotten in California's Mojave desert for over 15 years. Their development was undercut by political and fiscal support for fossil fuel and nuclear generation.

150 MW parabolic trough mirrors at Kramer Junction, California.

Yet detailed studies over the last decade by the German Aerospace Centre, funded by the German government, clearly indicate an enormous global potential for CSP technologies, as do US Department of Energy studies. Earth's desert solar resource is staggeringly enormous. *

The energy equivalent of about half a million tonnes of oil (3.9 m barrels) falls on each square mile of hot desert each year – the equivalent of a layer of oil 8 inches deep. Worldwide, the 12.75m square miles of desert receive around 80 million Terawatt hours annually (80m TWh/y). In comparison, global final energy consumed (after conversion losses) in 2003 was 85,000 TWh/y, nearly 1,000 times less. Indeed, the total presently known fossil energy resources on earth are equivalent to just 47 days of solar energy in deserts.

CSP technologies can convert roughly 15% of that incident energy into useful electricity and around 35% into heat for sea water desalination.

Mirror 'fields' covering an area of 4 - 5 square km (1.6 - 1.9 square miles) are needed to generate 1 TWh/y of electricity. CSP schemes covering just 0.3% (175 x 175 miles) of earth's hot deserts could generate all current global electricity consumption (17,000 TWh/y). If needed, just a few percent of the world's hot deserts could generate all forecast or foreseeable global energy demand, including the energy required for sea water desalination.

Clearly, not all desert areas are suitable for CSP schemes as large areas are either sandy or sloping and some areas may support particularly valuable ecosystems. But only a small percentage of the suitable areas is needed. Electricity generated by 1 square mile of CSP in a relatively barren desert area would require, in comparison, over 100 square miles of biomass plantation, possibly from cleared rainforest.

An additional major environmental

ower for te protection

benefit of steam driven CSP technology is sea water desalination using heat from the steam cycle (up to 40 litres per kWh) and electrically-powered reverse osmosis if necessary.

Such fresh water production is especially needed in developing countries with rapidly increasing populations and arid regions suffering increasing desertification due to climate change. So solar power from the world's deserts could, in itself, protect earth's biosphere and rainforest ecosystems, while supporting a significant increase in the human population and their likely energy needs.

Falling prices

The German studies estimated that the generation costs of CSP technology would fall, by the time about 5 GW of schemes are built, to around 5 euro cents/kWh by 2015 (3.3 p/kWh) and 4 cents (2.7p/kWh) by 2040. US Department of Energy studies also estimate costs falling to just under 5 US cents/kWh after about 5 GW of scale-up. Currently, about 2 GW of capacity is under construction or proposed. Heat storage in molten salts at CSP plants would add value as it would enable 24-hour baseload operation and operation during cloudy times.

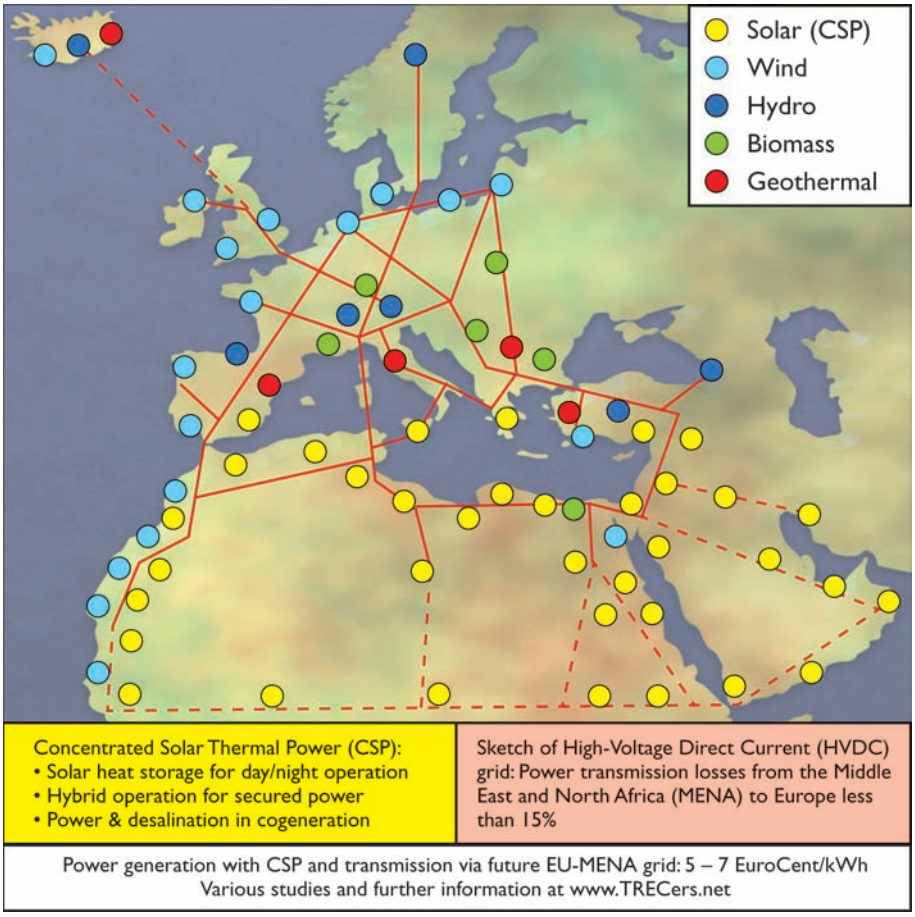
A massive scale-up of CSP capacity is possible. The technology essentially comprises steel, glass, concrete, a heat storage medium (salts) and conventional steam turbines. The raw materials for the structures are abundant, non-toxic and recyclable. The structures themselves are relatively simple and could be constructed by a relatively unskilled workforce. The energy payback time of CSP systems is estimated at about five months and a lifetime of 25 – 35 years is expected.

There are hot deserts in northern and southern Africa, the US and south America, Australia and the Middle East through Pakistan to India and extending into China. Around 90% of the global population lives within 3,000 miles of a hot desert. So, 'low loss' high-voltage (HVDC) direct current grid lines are proposed.

Power loss of around 5% per 1,000 miles is estimated. This means that, for an estimated cost of around 1 eurocent over 3,000 miles, transporting cheap solar power could still be cost competitive with indigenous renewable sources. Globally, there are currently about 55 HVDC links in operation including the interconnector between the UK and France.

The TRANS-CSP report details the phased construction of a European HVDC 'supergrid' which extends via numerous links under the Mediterranean to CSP schemes in the Sahara desert to form a 'solar supergrid' (www.TRECers.net). CSP schemes with thermal storage could provide much of necessary back-up to deliver power around Europe on demand.

Any degree of dependence on energy sources outside Europe has been questioned by the EU in recent years, even though countries like Algeria have been reliable suppliers of oil and gas to Europe for several decades. In the coming decades, the common threats and impacts of climate change, the pressures caused by growing Saharan populations and an awareness of CSP technology could create a mutually beneficial relationship. For example, 1,000 TWh/year of electricity exports to Europe might result in a third of the freshwater deficit in the north Saharan countries being produced by 'export' CSP capacity.



Non-oil plastics

There is another possibility worth exploring. In a completely unrelated report to the German government, a German petrochemicals group recently proposed that synthetic, rather than oil-based, plastics could cost-effectively be made if a cheap source of energy were available. The process would initially produce methanol from largely existing industry kit by combining carbon dioxide scrubbed from the atmosphere with hydrogen generated by high-temperature thermal dissociation of water in a thorium-powered nuclear reactor.

However, methanol is a tradable commodity which could be exported from countries with otherwise 'stranded' solar CSP resources, such as Australia. It could

(continued on page 19)

Neil Crumpton has been a campaigner at Friends of the Earth since 1994 after becoming a member in the 1970s. He graduated in electrical engineering at Liverpool University in 1977, moving straight into work on naval radar systems at shipyards in the UK and Argentina. He subsequently worked on oil and gas survey ships based in Asia and Africa. Neil works from home in Bethesda, north Wales and from the organisation's Cardiff and London offices.

Mitigating global warming by storing carbon dioxide underground

THE PRINCIPAL environmental challenges facing the world this century are global warming and ocean acidification caused by emissions of carbon dioxide, CO_2, into the atmosphere. Increasing energy efficiency and development of nuclear power and renewable energy sources are ways to reduce CO_2 emissions. But there is another option: carbon capture and storage (CCS) which involves the separation of CO_2 from large point sources, such as fossil-fuel-burning power stations, followed by its transport and injection in deep underground geological formations.

Martin Blunt discusses a way to deal with this problematic greenhouse gas

This allows a smooth transition away from our present pattern of energy consumption, where 85% of the world's energy needs are met by oil, gas and coal. Furthermore, it offers developing countries, such as China and India that are fuelling their economic growth with coal-burning power plants, a technology that avoids increases in CO_2 emissions.

CO_2 is injected deep underground where it has liquid-like properties with a density close to water. Candidate sites for storage include abandoned coal seams, depleted oil and gas fields and deep saline aquifers. While injection into coal seams and hydrocarbon reservoirs have benefits associated with enhanced oil and gas production, aquifers have the greatest storage potential.

Long-term

The International Energy Agency has estimated that up to 10,000 Gt of CO_2 could be stored worldwide in aquifers, which is equivalent to many centuries of CO_2 emissions at the current rate of around 25 Gt/year.

One attractive, possible site for storage is the North Sea. This is a major oil- and gas-producing province containing relatively well-characterized geological formations with an existing pipeline infrastructure close to fossil fuel-burning power stations. The offshore location reduces possible hazards due to accidental leaks of CO_2.

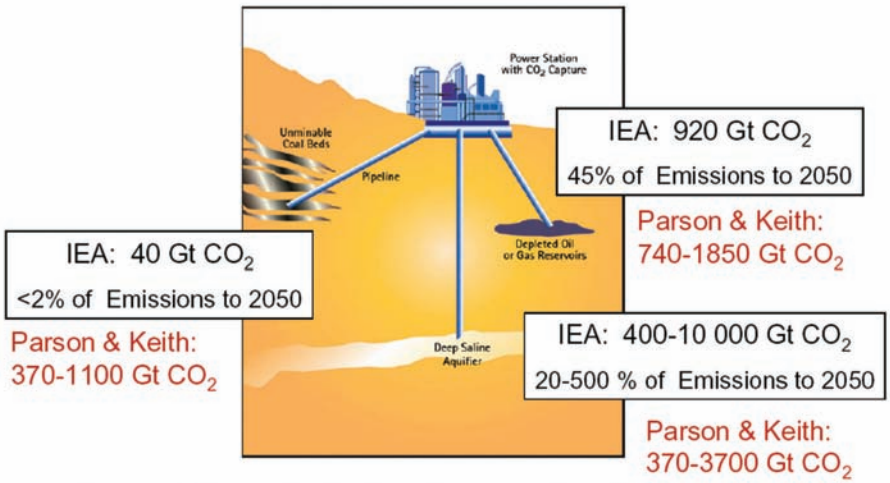
The Department of Trade and Industry and British Geological Society have estimated that aquifers in the North Sea have a storage potential of 700 Gt CO_2, in contrast to 6 Gt in oil fields and 13 Gt in gas fields. However, storage in oil fields comes with the added benefit of enhanced oil recovery (EOR). At typical reservoir temperatures and pressures, CO_2 is miscible with the light oils found in the North Sea and so the injection of CO_2 sweeps out oil, offsetting the costs of CO_2 capture and injection.

Carbon capture and storage is just one – important – component of an integrated plan to reduce CO_2 emissions. The volumes of CO_2 involved are huge.

Potential

Every person in the UK is responsible for 10 tonnes of CO_2 per year. If, globally, 1 GT carbon per year were stored underground – representing around 15% of current CO_2 emissions -- at a density of around 600 kgm^{-3}, the volume of CO_2 injected (around 20 million m^3/day) would be similar to current world oil production.

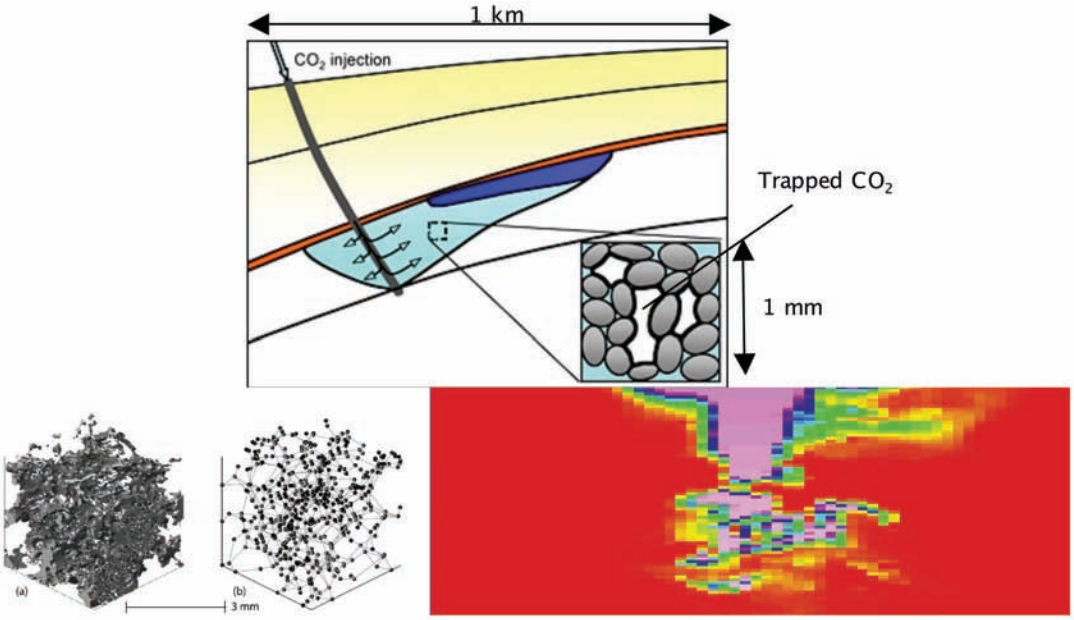
Potential underground storage for CO_2



Source: Freund, IEA - Comparative potentials at storage costs of up to $20/t CO_2

Source: Parson & Keith, Science 282, 1053-1054, 1998

There is sufficient capacity in deep aquifers to store a significant fraction of global CO_2 emissions for many years. The first application of carbon capture and storage in the UK is likely to be in mature oil fields in the North Sea, because of the associated economic benefit of enhanced oil recovery.



When CO_2 is injected into an aquifer or oil reservoir, it will tend to move upwards, since it is less dense than water. As it moves, water displaces the CO_2 (this process can be accelerated by injecting water) and CO_2 is trapped as tiny bubbles in interstices in the porous rock (top figure). This trapped CO_2 cannot escape and will be safely stored for thousands of years, over which time it will slowly dissolve or precipitate as carbonate. Understanding this process requires experiment and numerical modelling at the millimetre (bottom left) and kilometre scales (bottom right). Top image by Ruben Juanes

While CCS is a new technology, the essential components – separating CO_2 from other gases and injecting underground – are well-established in the oil industry. There are some 70 CO_2 injection projects worldwide, most of them in Texas where natural underground sources of CO_2 have been used in EOR schemes for 30 years.

In the North Sea, the Sleipner project is now in its 11th year. Gas from a reservoir is produced and the CO_2 contained in it is separated from natural gas (methane) and reinjected into a saline aquifer.

There are several other planned projects under consideration by BP, Shell and Statoil in the North Sea, to combine CCS with EOR as a relatively inexpensive way to demonstrate the process.

Storage headache

One of the major concerns in any storage project is the potential leakage of the CO_2 into the atmosphere. It is necessary to ensure that the CO_2 remains underground for hundreds to thousands of years. In oil and gas reservoirs, buoyant hydrocarbon has resided for millions of years, below impermeable geological seals.

However, the integrity of the cap rock of saline aquifers cannot be guaranteed with such certainly. Furthermore, the high injection pressures may fracture the rock, allowing CO_2 to escape or it could leak through abandoned wells. While this is unlikely and rarely hazardous – after all without CCS the CO_2 would be released to the atmosphere anyway – it is wise to design a process where these risks are as small as possible.

Over hundreds of millions of years, the CO_2 will slowly dissolve in water and may react with the rock, precipitating carbonate. Brine containing dissolved CO_2 is denser than native brine and so it sinks slowly. Hence, once dissolved or reacted, the CO_2 will not reach the atmosphere.

However, during the initial injection phase, the liquid-like CO_2 is less dense and more mobile and will tend to travel rapidly to the top of the formation and channel along zones of high-permeability rock. It is during this stage that the CO_2 may leak.

One way to design a process where this cannot happen is to inject water as well as CO_2: the water traps CO_2 in the micron-scale pore spaces of the rock and renders it immobile.

This process is the same as happens when water is injected into hydrocarbon reservoirs to push out oil – due to trapping, around half the oil is left underground. Injecting CO_2 into an oil reservoir helps displace this oil, since it mixes with it – hence the benefit of EOR – but will itself be trapped by water.

At Imperial College, a cross-departmental team of researchers, in collaboration with Shell under the Shell-Imperial College Grand Challenge Programme on Clean Fossil Fuels is studying CCS. One component of the research is the design of injection to render the CO_2 immobile. This requires us to know the transport properties of CO_2. Using small-scale experiments and modelling , as well as advanced computer simulation, we will be able to predict where the CO_2 is likely to travel.

UK to lead?

The UK has a golden opportunity to take a lead in CCS, working with the oil industry to demonstrate carbon storage with EOR. Our research will continue to study the prediction of CO_2 movement underground and the design of efficient injection strategies.

Martin Blunt was recently appointed head of the Department of Earth Science and Engineering. He has an MA and PhD in physics from Cambridge University and worked for BP at their research centre in Sunbury-on-Thames before becoming a faculty member in Petroleum Engineering at Stanford University. He returned to the UK to become a Professor of Petroleum Engineering at Imperial College in 1999. Martin conducts research on multiphase flow in porous media with application to improved hydrocarbon recovery, carbon dioxide storage and contaminant transport.

Report comes out against Severn barrage

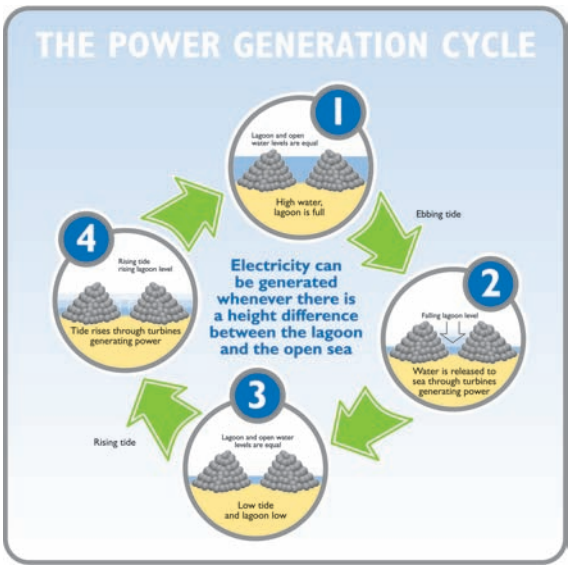
FOLLOWING an extensive study, the environmental group Friends of the Earth (FoE) is maintaining its opposition to a Severn barrage. Its new report, available by mid-May, examines the pros and cons of the barrage and comes out in favour of studying the potential for large electricity generating 'tidal lagoons' in the Severn estuary. (See www.foecymru.co.uk) FoE maintains that the barrage would significantly damage internationally important and legally protected habitats.

Over the last few years, calls for a re-appraisal of the Severn Barrage project have been made by the Severn Tidal Power Group (STPG). This comprises a small number of hydro engineers and construction company representatives. It claims that the prospect of carbon-free power and flood defence against climate-related storm surge and sea level rise is worth the cost, now estimated at £14 billion. Indeed, the annual output of the barrage, which could be operational by around 2017, could comprise nearly 25% of the government's 'aspirational '2020 renewable electricity target. The barrage's annual output (17 TWh/year) would be around 4.3 % of current UK electricity demand.

FoE opposes the barrage mainly because the 10 mile structure would retain a body of water 5 metres high which would permanently submerge over half of the inter-tidal mud and sand flats. These flats are important feeding grounds for 10s of thousands of birds, including rare and threatened bird species. The scheme would also disrupt the passage of migratory fish and severely moderate the Severn Bore.

Such significant environmental concerns would probably not arise if a different impoundment technology, called tidal lagoons, were considered. Lagoons are offshore rock-walled structures which would impound an area of sea and which fill and empty via electricity generating turbines. The group warns that the barrage, or a significant capacity of lagoons for that matter, could damage development and investment in other leading marine UK renewable energy technologies.

The FoE says that new shoreline coastal defence techniques can address the increasing flood risk to Severnside and Gloucestershire. Such techniques would be the most appropriate, and potentially ecologically enhancing, strategy to defend against sea level rise. This is projected at 18 – 59cm by 2100 in the latest Inter-governmental Panel on Climate Change (IPCC) Fourth Assessment. A much smaller flood barrier, or the recently proposed 1GW 'Shoots' barrage, located between the two road bridges, is considered more favourably. Such structures could offer both flood protection to Gloucestershire and carry the London–South Wales mainline railway which currently runs through the leaking 1886 Severn tunnel.



Power generated from lagoons as proposed for Swansea Bay. (From Tidal Electric)

Another concern is that a huge 8.6 GW Severn barrage would generate large pulses of electric power for a few hours after each tide. Such pulses of power, while predictable, would not be easily integrated onto the National Grid. For example, power swings of up to 6 – 8 GW per hour, albeit in a known direction, would exceed by a factor of 10 likely hourly swings of the cumulative output of a major windpower programme generating 20% of 2020 UK demand. FoE does suggest, however, that such power integration problems could be minimised, albeit at further cost, by the construction of new inter-connector links to continental Europe, and/or possibly new storage technologies.

Looking further into the future, FoE estimates, given reasonable UK-wide energy efficiency improvements, that the barrage would generate about one percent of 2050 UK energy demand, hardly vital to UK energy security. Such power could be generated indigenously, using renewables or carbon capture and storage technologies, or be imported from less ecologically sensitive areas. The barrage would also preclude indigenous power from the projected large lagoons, which would not impede shipping, in the same prime area of the Severn estuary.

At the present time, FoE sees no clear need for the barrage. If global warming effects have been underestimated, and melting Greenland and Antarctic ice sheets are likely to cause a sea level rise of several metres or more, then there would still be many years to assess the predicament and plan structures of the necessary height, strength and location.

Friends of the Earth concludes by saying that 'A barrage across the Severn Estuary would be a monumental and iconic structure; a landmark in British history. If it is ever to be built it must be built for the best of reasons and at the most appropriate moment in time. To build the Severn barrage at this time would be an act of poor global leadership. Destroying unique, internationally important and legally protected conservation areas under the guise of energy security, climate protection and coastal defence would set a damaging precedent.

'Much more could be done to address energy security and protect the climate in the next few critical decades by investing in less damaging and more powerful renewable energy generating technologies which would tackle future storms and sea level rise directly.'

See page 22 for another view.

CO_2 – cause or effect?

The following is an email exchange regarding climate change between managing editor Bill McAuley and Lord Monckton of Brenchley. Lord Monkton was a scientific policy advisor to Margaret Thatcher. A full interview is planned with Lord Monckton for the autumn edition.

FROM BILL MCAULEY

For some years now I've been looking for a published correlation between atmospheric CO_2 concentration increase and the (presumed) proportional decrease in O_2 concentration. I've been unable to find any such work, leading me to suspect that this elementary verification of the effects of global combustion has not been performed! Are you aware of any references on the subject?

FROM LORD MONCKTON

This point has passed me by altogether. My knowledge of the relevant chemistry is not very great. Given the very small proportion of CO_2 in the atmosphere (less than four parts in 10,000 by volume), I'd be surprised if there was much of a trade-off between more CO_2 and less O_2. The calculation would also be complicated by the fact that chlorofluorocarbons (emitted by volcanoes) can disrupt the stratospheric O_3 layer, splitting each molecule into an O atom and an O_2 molecule. Of all the numbers in the debate about global warming, I think that one of the least uncertain is the increase in atmospheric CO_2 concentrations. This is measured at numerous points round the world and produces a characteristic annual sawtooth graph. I've inspected records from several stations and have remarked (no one had noticed before) that the amplitude of the annual variation in CO_2 concentrations is greater the further one moves towards the North Pole. The fact is that there is more CO_2 in the atmosphere than there used to be. The debate is about the extent to which the relatively small additional concentrations have much of an effect on temperature. My calculations suggest that the effect is about one-tenth that projected by the IPCC – and I reached that result using the IPCC's own methods and data. I've had the calculations peer-reviewed by one of the IPCC's own reviewers, who thinks I'm right. I hope this helps.

FROM BILL MCAULEY

Thanks for your prompt reply. The oxygen issue is important because, if the correlation is not 100%, it would suggest that some of the CO_2 increase could be the RESULT of global warming, not the cause. Since there is 50 times more CO_2 dissolved in the world's oceans than in the atmosphere, it wouldn't take much warming or change in ocean currents to change the equilibrium very substantially. Your observations regarding variability in the polar regions demonstrates this, since there is a greater winter/summer variation in ocean temperatures at higher latitudes.

FROM LORD MONCKTON

The palaeo-climatological temperature record, reconstructed by reference to the CO_2 ratio of 180 to 160ppmv in air trapped in Antarctic and Greenland ice at depth, indicates there is a lag of 800–4000 years between a change in temperature and a change in CO_2 concentration. It is always the temperature that leads; not vice versa. In today's conditions, we are adding CO_2 to the atmosphere in appreciable quantities, and this may be responsible for some of the increase in global temperature over the past century. The increase in temperature (however caused) then induces the warmer oceans to outgas CO_2, causing what is known as the 'CO_2 feedback'. It's extremely difficult to quantify the magnitude of this feedback, but most authorities believe it to be small – of the order of 20ppmv out of the 100ppmv increase in CO_2 concentration since pre-industrial times.

Concentrating solar power

(continued from page 15)

be used as an automotive fuel or in CHP power generation schemes. So, at larger CHP sites, which could be CCS-equipped, there is the potential for considerable carbon-negative power generation.

The vision of a world powered to a significant extent by huge areas of simple and safe mirror schemes in hot deserts will be surprising to most. But alternative scenarios are surprising and alarming. CSP technology is largely tried and tested. Yet, recently £7 billion was recently announced for further research into nuclear fusion which is at least 30 years away from commercial reality, if it works at all. Now, Russia, China, the US and India are all considering expensive space 'exploration and exploitation' programmes.

Moon fuel?

Recent news articles indicate that one of the main drivers is the possible exploitation of Helium 3 extracted from moon rock for use as a fuel in fusion reactors on earth. This could result in the weaponisation of space to secure the future supply route well before fusion power was even ever proven.

Meanwhile, Morocco, Algeria, Tunisia, Egypt, Jordan, Israel and Turkey have all expressed interest in nuclear fission power in recent months. Morocco and Egypt may soon order Russian reactors which could result in further proliferation through Africa. Yet the larger of these countries could each generate all global electricity from the CSP resources within their borders.

Earth and its family of species stand at a fork in their evolutionary tree. Will humans choose the path of nuclear power, a limited and/or dangerous technology, or pursue a far safer, simpler, benign and unlimited solar technology?

* See www.TRECers.net or www.TREC-UK.net for more information.

ENVIRONMENTAL METALS

by Bill Bradford

THE TITLE of my article arises from the catalytic behaviour of the platinum group metals (pgm). Platinum, palladium and rhodium are now highly sought-after catalysts to control automotive emissions. Other pgm applications are also growing in significance. Please note that pgm is not synonymous with platinum, although platinum leads the pack. I'm a 'pgm bug' and tableII shows why!

My first involvement with the pgm arose from a very unusual project. The venture capital (mining finance) group I was working for had been approached by a small private corporation, based on the West Coast USA who claimed to be able to produce 'isotopic' precious metals by an electroytic process. I was asked to investigate. I will return to the outcome of this investigation later.

I first wrote about the pgm in 1990 when I was working with the Earth Science Department of the Open University. What's surprising is how relatively little the scene has changed.

First, some basic information about them. (See Table I for pgm comparisons with silver and gold.)

New valuables?

Gold and silver have long been used as stores of wealth and, fairly recently, this has applied also to platinum. The other pgm have not yet acquired this label, although they have many of the necessary qualifications (high value per unit of mass, resistance to corrosion and/or wear, scarcity and, for some of them, an attractive appearance).

One big difference however between platinum and gold is that platinum's supply and demand are generally close to balance. Although platinum can be recycled fairly easily, there is little metal in jewellery, inventory or investment hands, so a significant platinum shortage (real or perceived) can have a very immediate and profound effect on price. By contrast, there is a large 'overhang' of gold in the form of central bank gold stock, and privately owned jewellery, bar and coin, which can promptly put a dent in any supply deficit.

The effect of environmental legislation has also made platinum a 'must have'. The other pgm have until recently had a subsidiary role. Palladium (Pd) and rhodium (Rh) are now steadily gaining in importance, while ruthenium (Ru) and iridium (Ir) still have minor industrial roles. Osmium (Os) is almost invisible in application or investment terms. Gold has comparatively few industrial applications.

How do you find an economic pgm deposit in nature? The answer is, with very considerable difficulty. I'm going to offer a simple model of the earth's crust to illustrate. I'm deliberately ducking some significant complexities, but I think it helps to explain both the rarity and the high price of the pgm.

Magma make-up

The molten magma below the earth's crust can be regarded as containing four main chemical constituents – silicon oxide (SiO_2), magnesium oxide (MgO), aluminium oxide (Al_2O_3) and iron oxides (FeO/Fe_2O_3). These four oxides combine chemically in various ways when they solidify to form primary rocks. Virtually all rocks crystallising from magma contain some SiO_2. Those that are high in SiO_2 and Al_2O_3 have relatively low densities: those that are high in MgO and Fe_2O_3 have relatively high densities. Other oxides or elements are present but in lower concentrations.

Plate tectonics is now a well-accepted explanation for the characteristics and behaviour of the earth's crust. The continental (generally above sea level) plates are very largely composed of primary (igneous) rocks where SiO_2 and Al_2O_3 predominate (called acidic rocks); oceanic (generally below sea-level) plates are composed of primary rocks

TABLE 1: PHYSICAL CHARACTERISTICS OF THE PGM, COMPARED WITH SILVER AND GOLD

Metal	Symbol	Atomic number	Density (g/ml at 20°C)	Colour	Melting point (°C)	Boiling point approx (°C)	Brinell hardness
Ruthemium	Ru	44	12.45	Dull grey/silvery white	2310	4900	200-300
Rhodium	Rh	45	12.41	Greyish white	1960	4500	100-120
Palladium	Pd	46	12.62	Greyish white	1552	3980	40-42
Osmium	Os	76	22.61	Bluish grey	3050	5500	300-670
Iridium	Ir	77	22.65	Silvery white	2443	5300	200-240
Platinum	Pt	78	21.45	Greyish white, lustrous	1769	4590	40-42
Silver	Ag	47	10.5		962		26
Gold	Au	79	19.3		1064		20

TABLE II - PGM AND GOLD PRICES (US$ PER TROY OUNCE)

Date/ % increase	Platinum	Palladium	Rhodium	Iridium	Ruthenium	Gold
January 1993	360	110	1821	125	25	330
January 2007	1150	340	5736	400	692	625
% increase	319	309	315	320	2867	189

where MgO and Fe_2O_3 predominate (called basic rocks). Where plates collide the oceanic (basic) plates slide under the continental (acidic) plates. It is, therefore, relatively rare to find basic rocks on or near-surface in continental plates.

Pgm are always associated with basic rocks. When you go looking for pgm on land you are, therefore, looking for basic rocks in places where you normally find acidic rocks. Add to this all the uncertainties of mineralisation, and the odds against finding an economic pgm deposit are very, very high.

Winding gear at a pgm mine. (Pictures from Johnson Matthey)

Alluvial rush

If you are very lucky you may find pgm in the residues of worn down (weathered) rocks. These residues originally settled in riverbeds and are called alluvials. The big, old gold rushes all started in alluvial deposits. There has never been a comparable platinum rush, partly because pgm-bearing alluvials are rarer and smaller than gold ones, but also because for a long time nobody attached any value to pgm. When found, pgm were considered to be a contaminant of gold. It took a long time before pgm began to be valued. Their recent attractions have been largely research-stimulated in conjunction with the control of automotive emissions. Early pgm production came (and to a small extent still does) from alluvials in Colombia and Russia.

A clear illustration of pgm's growing importance is in their price. (See table II, above) Prices are normally quoted in US$ per troy ounce (a troy ounce = 31.1g). I have given a price comparison between the monthly averages for January of 1993 and 2007. I have rounded the prices to the nearest whole dollar.

The two dates chosen are simply the most recent and most historic that have come easily to hand. I have also deliberately made no adjustments for inflation or attempted to discount the prices in time terms.

You can now see why I am a pgm and not a gold bug!

To return to the original project. My assignment was to visit the site of the test operation, located close to the Oregon/Washington state border. What followed were 10 days of highly-focused testwork, many hours of heated argument with a very angry US investor and the ongoing worry that I might just end up in the Columbia river with concrete boots. The process turned out to be without any technical foundation that I could find and, perhaps as a bonus, I survived.

Was it a scam? I felt at the time that the leading individuals concerned really believed in their ideas and that, whatever I did or said, they or their successors would continue following their dreams somewhere in the US West. However, I suspected that some of the junior associates on the periphery believed in the Barnum principle, 'there's a sucker born every minute! We were very nearly one of them.

A few additional words of warning for the potential investor in pgm exploration: an economically significant deposit contains pgm values in the single figure parts per million (ppm) range – very low. Accurate analysis, although much easier than it used to be, still requires extreme care. Economic pgm concentrations in rock are comparable with gold.

Future prediction

Future forecasts are always dangerous but here goes. The demand for platinum will continue to grow faster than global economic rates. The same will be true to a lesser extent for palladium and rhodium. The minor pgms will probably follow past, medium-term trends. Although geologically and chemically very similar, each of the pgm needs to be considered as an individual commodity. Each deposit of pgm has a different profile and needs careful investigation before serious investment is considered.

The automotive industry is a rapidly growing user of pgm-based catalysts and it looks as though North America will follow the hybrid-powered car route, while Europe will follow the diesel-power route. I won't go into the detail of catalyst demands of each power type, but it suggests that Europe will see pgm demand rising faster than the US. China, India, Russia and Latin America? – who knows!

Johnson Matthey publishes Platinum Metals Review *with regular updates on the pgm scene. Copies –www.platinum.matthey.com/publications. Or ring 020 7269 8400*

Bill Bradford (MinTech 1957) has worked for a number of employers, including GEC, Federal Nigerian Government, UNDP, Selection Trust, Seltrust Engineering, Mitchell Cotts, and Matthew Hall. He was also a Flying Officer in the RAF, and a consultant and tutor for the Open University. He is a governor of two local schools and active in Rotary.

Alumni share their views...
Deep nuclear waste disposal

FROM
TOM PUGSLEY (MINING 1964)

PROF GIBB presents a plausible argument (*IE* issue three) for high temperature very deep disposal of nuclear wastes. However there are implementation concerns to be overcome. They are:

■ High tectonic stress levels in strong rocks (igneous and metamorphic rocks) that will exist at 4 to 5 km depths. Failure (wall spalling and elongation dependant on the direction of major principal *in situ* stress) of small drill holes in deep mines, 2 to 3 km, in depth has been experienced. Tectonic stresses concentrate in strong rocks such as granites and horizontal stress levels can be two to three times (or more) vertical levels at a particular elevation and isotropy is probably reached at some unknown depth. For 1m diameter holes this could be a significant design issue and that some predictable method of destressing such holes would be required.

■ I would suggest that the technology for drilling such deep holes in the 4 to 5 km range is not proven technology in the hard rock industry and is probably resident in the oil/hydrocarbon industry and for carboniferous era formations which are much less competent and generally easier to drill.

■ Reduced permeability at depth is due to increasing tectonic stress levels and the geothermal gradient – hence groundwater becomes increasingly saline and corrosive. Glassing of the lower reaches of boreholes would have to be predictable and extensive to produce the desired seal and without thermally inducing peripheral spalling.

In view of the increasing interest, and urgency, in reviving and expanding nuclear power generation worldwide, perhaps a full-scale pilot project is warranted. There is a wealth of geotechnical knowledge in the deep hard rock mining industry that may contribute some value to this approach.
TPugsley@xstrata.ca

PROFESSOR FERGUS GIBB REPLIES

Tom Pugsley is correct in suggesting 4 - 5 km deep boreholes in hard rocks are 'not proven technology', at least at the large diameters required, and right to draw attention to the potential tectonic stresses at such depths, although site selection would aim to minimise these.

All versions of both LTVDD and HTVDD would use fully-cased holes and the heavy-duty steel casing should provide a suitable measure of protection for the waste containers against wall spalling and deformation, at least until they are safely sealed into the borehole. There is, however, one variant of HTVDD in which the casing might be withdrawn from the disposal zone after deployment of the packages and when stresses could present a threat to the containers. In this case the partial melting of the granite could begin at as little as 100 days after emplacement of the containers and extend for 10s of cm into the wall rock possibly providing the predictable method of 'destressing' the wall rock around the containers sought. In another variant of LTVDD, the use of malleable Pb-based high-density support matrices should also protect the containers from small to moderate sized tectonic deformations.

Although the large diameter (0.5-0.8m) holes required for all variants of very deep disposal (other than for Pu) have not yet been drilled to depths in excess of 4km, there is considerable experience of drilling smaller holes (0.2-0.4m) to such depths in hard rocks. Examples are the KTB scientific wells (0.37m at 6km) and the Urach-3 geothermal well (~0.2m at 4.4km); the lowermost 2.5 km of the latter were in granite. Nevertheless, it is true that a 0.8m hole to over 4km, while possible, would stretch this technology to its current limits (SKB Report R-00-35). I share with Tom the belief that there is a wealth of geotechnical knowledge in the hard-rock mining industry, especially in areas like vertical tunnel boring and the sinking of large diameter shafts to depths of 2 or 3 km, that could make a major contribution. I welcome his suggestion of a pilot project.

The potential of tidal power from the Severn estuary

FROM PETER ACKERS,
(CIVIL 1944)

Neither Bill McAuley's article nor that by Ashley Catterall gave a proper account of the potential for tidal power from the Severn. The project was very fully examined by the Severn Barrage Committee some 25 years ago and the optimum scheme as an ebb generating one going from Brean Down to Lavernock Point with an installed capacity of 8750 MW, some seven times the maximum output of our largest nuclear station.

Its annual contribution to the UK's electricity demand would be 17000GWh. The tides would never be excluded from the estuary, either during construction or operation, so the serious problems envisaged by both contributors would not arise. The proposed method of construction would use caissons, all of which would have gated passages that would remain open during construction, those in the turbine caissons having to be closed off only when the bulb turbines were installed. The openings through the sluice caissons would remain open until the scheme came into operation, when they would close during the ebb tide.

The tidal range upstream would be reduced, in effect not emptying so far, so feeding grounds for birds would be available during the whole tidal cycle. Also, because of the reduction in suspended sediment concentration that would follow from the reduced tidal currents, the estuary would become more productive which should improve the overall ecology.

Other benefits include reducing flood levels upstream which will continue to increase as sea levels rise. The upper estuary would become available for pleasure boating as currents would reduce and it would never drain out. Subsequent studies have all confirmed these findings.

Another question is whether the existing system can accommodate such heavy inputs of power twice a day .This was answered by running the CEGB's model of the whole country's generating system which confirmed that it could, without additional storage capaity.
ackersp@constructionplus.net

Past president goes back to walk roots

WALKS with a Past President' has had its sixth birthday and it's timely to review the humble origin.

'A Walk with the President' took place in May 2001 during the final days of my presidential year. Its purpose was to remind Guildsmen of their College's long and meaningful association with the City of London and the 16 livery companies which contributed to its foundation.

Walking with a City guide seemed the proper way to proceed and we planned a route through the City to include eight halls that Saturday morning and the other eight on an evening the following week. We went into one on each occasion for a tour and a glass of wine. Whilst chatting in one, I was asked if our guide could show us more of the City on another day.

Malcolm Dick has stayed with us for what must by now be more than 20 walks. He and I are active members of our respective City companies, and our enthusiasm to see more of our capital city and its environs shows no signs of diminishing.

Detail of the walks, and application forms, may be downloaded from the Events Section of the Association web site www.cgca.org.uk.

Our next dates are July 22, September 29 and December 1 (all Saturdays). See Diary Dates (page seven) and very important notice (page five).

The modest fee includes the cost of a drink at the hostelry Malcolm selects as a suitable finishing post and many of us elect to stay on for lunch and a chat.

Surplus funds naturally go towards the running of the Association and this sum would be greatly enhanced by an influx of new members. Families and well-behaved dogs are always welcome as are your weekend guests!

For further information please ring 020 8504 8263. I look forward to meeting you.

David Hattersley

ALUMNI NEWS & VIEWS

Five pages of who's doing what and where

CHEMICAL ENGINEERING 1960

Home to the New Cavendish for another year

THE NEW Cavendish Club, near Marble Arch, hosted this year's reunion group of the 1957–60 C & G chemical engineers on February 14.

Eleven were present and are pictured, from the left and standing, Brian Stevens, David Martin, Alan Cleugh, Barry Daniels, Mike Heath, David Wilbraham, Paul Gallagher and Don Latimer; and seated Tony Davis and Malcolm Cross. Missing from the photo due to dashing for a train is Alan Nethercott.

The Club was, as always, tolerant of our complete reorganisation of the bar furniture to accomodate the group and, again, provided the photographer. We discussed who may be attending the college reunion activities though at that time plans were still fluid.

Proposed date for 2008 – same venue – is Tuesday February 12.

Hong Kong promotion

WYSS YIM (DSc 1997 and DIC 1974) has recently been retitled professor of the department of earth sciences, at the University of Hong Kong. He is the current president of the Subcommission on Continental Shelves, International Union for Quaternary Research.

MECH ENG 1954

Reunion plans

THE 1954 Intake Mech Eng Reunion Lunch has been arranged for Tuesday September 25 at 170 Queen's Gate. The cost will £40 a head, including drinks

Organiser Richard Wood has circulated all those who attended the 2004 lunch but would be delighted to hear from any others. It was a large intake, he says.

Contact Richard on 01332 559700 or email richard@annewood.fsnet.co.uk

BOOKS

HUGH CHARE, who graduated from RSM in 1970, has published a book, *Chaya Four One*. Details can be viewed at www.trafford.com/06-0715. hugh.chare@hawaiiantel.net or +1 808 572 3020

FOLLOWING the last issue featuring water matters, a publication of some interest is The Water Revolution – Practical Solutions to Water Scarcity, published by International Policy Press. ISBN number is 1-905041-13-6 and copies can be obtained for £12 by e-mailing info@policynetwork.net or calling 020 7836 0750.

SPECIAL CENTENARY WEEKEND

A SPECIAL alumni reunion weekend is planned for this September 15 and16. In particular, the departments of the Engineering Faculty are inviting their alumni to return and see what's going on. There will be a reception, tours and talks on Friday September 14. More info from Teresa Sergot – see page two.

MAN STILL NOT DEFINED!

IN SPITE of Jack Sandy's generous offer of donations to charity for the best entries, none of our women readers has come forward with a riposte to his non-PC piece in issue three of *Imperial Engineer.*

Maybe they felt that something so unstable as man would be impossible to define. Or perhaps they were too busy combining a career with all the traditional women's jobs they are still expected to fulfill! ***LP***

Richard still rolling into work!

HAVING found out that I go into Rolls-Royce (where I used to work) every Monday, I was asked contribute a piece for this issue.

The Rolls-Royce Heritage Trust was founded in 1981 and has now amassed a large collection of aero-engines. Quite a few retired engineers meet during the week to restore engines for display purposes and, occasionally, to running order,

The photograph shows me (second from right) hard at work on a 5-cylinder opposed-piston multi-fuel engine as used by the military.

Other engines in the picture are an RR Phantom 3 and, less obvious, an engine produced for the Princess 'R'.

If you are interested in visiting the collection, I can arrange visits, Contact me on richard@annewood.fsnet.co.uk.

Richard Wood (Mech 57)

Crossing over troubled waters

NOW back in the UK, Anna Tompsett and Joe Mulligan are busy in Cambridge working on their MPhil in engineering for sustainable development

But they are still involved with Engineering Without Frontiers (EWF) which, with two local NGOs, took them to the Dadiya hills in Nigeria for 2005-6, and have helped set up their replacements for the next two years.

Using the CGCA Jessel Rosen Graduate Overseas Award, they have helped identify the best place to build a river crossing to give year-round access over remote land prone to flooding and start work by casting culverts.

Despite difficulties with finance and the rains, their work included building a composting toilet block and helping design and set out a church and primary school.

ABOVE: at the excavation of the approach slopes with a store they built.

For more details see their reports, address on page two.

ELECTRICAL ENGINEERING 1973

A LUCKY 13 Triodes met in the George (at the top of Fleet Street), in January. They always meet there on the first Friday after January 1 at 7pm to celebrate 34 years away from Electrical engineering.

We will hold our next reunion at the George on Friday January 4 2008. So maybe we'll see you there? ***Martyn Hart***

For more news of members see article on the website – address on page two.

MINING ENGINEERING 1964

Wine, golf and...

LAST SEPTEMBER, 10 mining engineers, who graduated in 1964, and their wives, gathered for three very convivial days at the RSM 2006 Reunion in Niagara-on-the Lake, Ontario. The event was organised by Cliff Davis, Tom Pugsley and their wives Jean and Teresa, who are all resident in Canada.

The programme included outings and pub meals in the town of Niagara-on-the-Lake with its 250 year history, theatre visits, a wet boat trip at Niagara Falls, golf for the enthusiasts, spa treatments for the ladies, a visit to a winery where we lunched in style, a trip to the Welland Canal between Lakes Erie and Ontario and of course a splendid dinner on the last night. With much ground to cover, we reminisced about RSM days and caught up on careers that had taken our year across the globe.

Miners and their wives had travelled from Australia, UK, Thailand and Bulgaria to be present. It's surprising how many are still very active in the minerals industry or another closely-related field.

Those 1964 miners present in Canada were: Julian Bennett, Keith Bennett, Brian Calver, Cliff Davis, Mike Dixon, Tom Pugsley, Lionel Sainsbury, Dave Thomas, Mike Turner and Lawrie Williams,

The Reunion of 1961–64 Miners, having become a regular event, the next will be in Cape Town in 2008. Count me in! ***Lionel Sainsbury***

ENJOYING a boat trip at Niagra Falls!

Dick is third among equals

Professor Dick Selley (Geol 64, above), senior research fellow in the Department of Earth Science and Engineering, has been elevated to honorary membership of the Petroleum Exploration Society of GB. Of the seven honorary members of the PESGB elected in the last 40 years, three have been from the Royal School of Mines.

A fitting tribute to a loyal friend

DESPITE being the oldest, largest, loudest and grumpiest, the Old Skool Miners was the winning team among a merry band of old and current RSM footballers (and a few brave supporters) who met at Harlington in January. They gathered for a football tournament in memory of Nicolas Perrier (Geology 99, MSc 00) a fellow RSM footballer who sadley dies last summer.

Opposing teams were the Whippersnappers (the present team) and the Tweenies (the recent old boys).

Maturity outshone the fancy footwork of youth and play ended with Old Skool winning two games and drawing two. Whippersnappers lost two and drew two, while the Tweenies won one, lost one and drew two.

A tribute line-up at Harlington during January.

In traditional RSM style, the bus headed for the South Ken Union bar with a trip to Cavanaghs to complete the night.

'It was a great day and a fitting tribute to a loyal friend', writes Ros Hodgson. 'Nick's sister Alix braved the cold to watch the games and was surprised and touched at how many took part. Nick was a very special man and is sadly missed and fondly remembered by all who knew him.'

A bi-annual Nicolas Perrier Celebration Dinner will be held at the New Cavendish Club in June 2008. Contact Rosamund Hodgson through the Alumni office if you wish to attend. Or Rosamund.Hodgson@tubelines.com.

HONG KONG

Christmas cheers

AN ENTHUSIASTIC group of 'Imperial Engineers' operating in Hong Kong get together occasionally for lunch or an evening. 'Peter Pun (Civil PG 60) hosted a horse-racing evening last summer', writes David Sorton (Civil 71, fifth from right.) Pictured are 13 enjoying a pre-Christmas lunch in Hong Kong's tallest building, the magnificent IFC2, above the Airport Express Station, on the harbour front in Central District.

Is Ian the highest miner?

EMAILING from San Rafael mine, owned by MINSUR SA, Ian Dun (MinTech 71), inset with friend, would like to hear (and so would IE) from any alumnus working higher than his 4500m above sea level. The mine produces 14% of the world´s tin production and is three hours from Juliaca and five hours from Cuzco in Peru. Phone +51-1-2158330 (ext 2530) or email igordon@minsur.com.pe. See www.minsur.com.pe

Winter warmer in Canada

EIGHT RSM alumni from a total attendance of 35 mainly mining people gathered on a warm, sunny day last December in Toronto, at the Jason George pub. A gathering takes place every month on the last Friday of the month. Pictured are, from left, Chris Farrow, Richard Garnett, John Orton, Louis Badone, John Law, Harry Burgess and Howard Stockford. Mike Davies was having lunch! For details contact hburgess@micon-inter national.com

Remembered throughout the world

COLIN DIXON

COLIN DIXON, who was born in 1933 and died in 2006, gave his life to the RSM's geology department, graduating ARSM, BSc in 1957 and being instantly appointed assistant lecturer in mining geology.

He became lecturer in 1959 and senior lecturer in 1974, retiring in 1999. He thus spent 45 years in the department apart from one sabbatical year as a research Fellow at the École Nationale Superiore des Mines de Paris from 1968.

During his early years Colin was involved in applying computing to geology and using geostatistics in the evaluation of ore reserves. His *Atlas of Economic Mineral Deposits* was widely acclaimed in industry and academe when it was first published in 1979. It remains a classic and highly-regarded and is available on Amazon.

Colin served on many committees and councils at Imperial and the AUT. He was a human seismograph, with his ear constantly close to the ground. He knew everybody who mattered, in the College and outside.

Colin was Sir John Knill's righthand man in doing much to advance the professionalism of geology. Together they set

up the Institution of Geologists and when it merged with the Geological Society he served for many years on its council and as chairman of the fellowship and validation committee.

However, Colin will be best remembered as a conscientious teacher and student mentor. For many years he was director of undergraduate studies and senior tutor with overall responsibility for the pastoral care of students.

His rough, gruff manner was occasionally off-putting to new students, but they soon realised that he was rather like a lobster – hard on the outside but soft on the inside. Throughout the world RSM alumni are grateful for his duty of care and remember him with affection.

Dick Selley, from an article for the Geological Society

A man of many 'wizard wheezes'

CHRISTOPHER DELL

CHRIS DELL, who died recently10 days before his 86th birthday, was well-known in the minerals industry for his outstanding contributions to the science, practice and teaching of mineral processing. He was an ingenious inventor producing at least three major contributions – the Leeds flotation column, the Leeds laboratory flotation cell and a counter-current decantation column. He was always coming up with new 'wizard wheezes'.

His philosophy for the design of flotation circuits was to keep it as simple and practical as possible using graphical techniques including release analysis, multi-component release analysis and timed batch tests. He helped develop what is now mineral engineering at Leeds University, introducing many of these methods into the course especially in the final year projects. Chris also taught practical subjects such as materials handling and solid/liquid separation.

He had an early concern for environmental matters. A good example of this was his investigation of the lead content of his garden soil and home-grown vegetables as a result of using compost from leaves fallen in the streets of Leeds.

Chris Dell graduated in mining from the RSM in 1941 and spent the rest of the war working on sights for low-level bombing at the Royal Aircraft Establishment, Farnborough.

From 1946 to 1952 he worked at the Mufuleira concentrator in the copper belt of Northern Rhodesia, for a time as plant superintendent. Several years followed at the Coal Research Establishment as head of section. In 1959 he joined the Department of Mining at Leeds University as a lecturer becoming a senior lecturer in 1966. He was a fellow of the Minerals Engineering Society and the Institution of Mining and Metallurgy.

Among many activities, Chris was a keen gardener, producing particularly fine delphiniums, a talented oil painter and a fine singer. After retirement he became interested in archaeology after finding a Roman well under his kitchen in Aldborough.

The affection and respect in which Chris was held was shown by the large numbers who gathered in Ripon Cathedral to bid him farewell.

Joe is passenger in Bo in 1948. Driver is Ivan Nixon who supplied this story. Ivan's wife is in the back.

Engines were his life

JOE PIDGEON

FREDERICK JOSEPH 'Joe' Pidgeon (Mech Eng 1939 & 48) died on February 3 at his wife's home in Argentina after a long illness that stretched back to early 2006 when he was still in the UK.

Joe's passion was very early types of cars. Besides at one stage owning an 1897 French Hurtu, which he drove in the annual Brighton Run when not driving CGCU's Boanerges, he had a life-long interest in an early Trojan tourer. He used it to and from College and, as a member of the College Motor Club, drove it in pre-war cross-country trials. Its advantage was its solid rear axle.

Joe was still in the process of a major rebuilding of this same car in 2006 when he fell seriously ill. He was secretary of the City and Guilds Motor Club pre-war, when trials were popular.

Joe's other love was flying. It started in 1934 when he joined the College gliding club, going on to learn flying at London University's air squadron. This became the RAF Volunteer Reserve and when war came he reported to the Air Ministry. Joe flew Sunderland flying boats among others and finished the war as a squadron leader.

Joe pursued a career in engineering with the Ministry of Supply then, from 1957 till retirement, worked all over the world for various branches of the UN.

To read his son John's transcript of Joe's war experiences, visit www.imperial.ac.uk/engineering/about/alumni/

Bon viveur and kind teacher

PETER LINDSAY

PROFESSOR PETER LINDSAY, who died last June aged 86 achieved, with great distinction, an ambition to remain technically active well beyond his retirement. At the time of his death he was a research professor in Queen Mary, College London's department of electronic engineering, continuing to win research grants from industry and the US Air Force Office of Scientific Research.

His most recent work benefited from the availability of advanced computer simulation tools, producing new understanding of complex behaviour in high power electron tubes. He had just presented a paper at an international conference in Michigan on vacuum electronics, the field in which he enjoyed a worldwide reputation for over 50 years.

Born Boleslaw Luciow in Poland and a promising pianist, he had completed a year at university when Hitler invaded Poland in September 1939. He escaped to France where he joined the Polish Army but, failing to reach the Dunkirk beaches in time, he made his way to La Rochelle on the west coast and sailed to England.

In 1990 and 2000 he returned to celebrate his escape with champagne and oysters.

In London, the Polish authorities arranged for his entry to Imperial where, in quick succession he gained a BSc, MSc and PhD, the last for work on electron optics.

Peter joined Universal Rototype in 1948, then the EMI Electronics Patent Department and, eventually, GEC Research Laboratories, Wembley. He specialised in research on microwave electron tubes (valves) and produced seminal papers on electron velocity distributions and noise phenomena in magnetron devices. A key point came in 1954 with the award of a post-doctoral fellowship at Columbia University in New York, after which he returned to GEC. In 1960 he was appointed to lead Raytheon's new electron physics laboratory in Massachusetts. Returning to England Peter was appointed lecturer in electrical engineering at King's College. He was promoted to reader in 1970 and to a personal chair in physical electronics in 1974 and served as dean of engineering.

Peter Lindsay published over 100 technical papers and was awarded a DSc degree at London. He was a fellow of the Institution of Electrical Engineers and the Institute of Physics and CGC. He wrote books on quantum mechanics and quantum electronics; was editor of the International Journal of Electronics and served on the UK Electronics Research Council.

Peter was devoted to music, good food and fine wines. He was a member of the British Epicure Society and a *Chevalier du Taste-Vin*, organising visits to France's most celebrated restaurants.

Peter Lindsay was invariably good company. His strongly-held views on so many subjects occasionally caused discord, but his great intelligence and love of life always shone through. His extreme kindness to generations of students was a feature of his academic career and his sense of humour was especially appreciated by his close friends.

(From an obituary on Queen Mary College website written by Xiaodong Chen and Charles Turner.)

Mining engineer and successful entrepreneur

JOHANNES DE VILLIERS

JAN Coetzee deVilliers was born into a Huguenot family in Pretoria and graduated in law from Cape Town University in 1952.

To finance his student years, Jan looked for vacation work that paid well and found it in Northern Rhodesia's Rhokana copper mine. He decided that his future lay in the mining industry. This led Jan to the RSM after winning an Anglo American bursary. He was a mature student, already married to Amondi, and held with considerable respect by the younger members of his cohort who elected him union vice president. By then he was a father and after graduation in 1958 the family returned to the Rhokana mine.

Later Jan moved to Johannesburg to take up positions as a mining and then management consultant, but also to develop entrepreneurial ambitions. Amondi was an enthusiastic and able partner and they tried their hand at a variety of enterprises including chickens, hydroponics and a popular nursery school. Most successful was an employment agency that kept Jan working beyond normal retirement age, until the attractions of a quiet life drew him to his final home in Knysna.

A man of great charm, Jan will be fondly remembered.

Brian Wallace

LATE NEWS

As we went to press we heard of the deaths of RALPH PRITCHARD (Mech 48, Civl 50) and JOHN HUTCHINGS (Chem Eng 53).

A gentleman of the old school

GORDON WALLACE

GORDON 'Jock' Wallace followed his father into the mining industry and graduated in mining engineering from the RSM in 1958. He rowed for Imperial College becoming captain of the IC boat club and was elected president of the RSM student union.

Jock and Caroline were married at the end of his final term at RSM, the wedding becoming a major student event.

Jock's first job was on the Rhokana mine in what is now Zambia. In 1966 he joined Selection Trust in London where an early assignment was to establish a survey grid on a remote mine in Iran; an urgent excuse for a visit back to the RSM for some advice on the choice of theodolites and other essential equipment.

Jock had a very successful career with Selection Trust and was project manager for a range of major feasibility studies before his appointment as consulting engineer for the diamond mining operations in Sierra Leone and Ghana, and then the mines in Canada and Australia.

After retirement to Suffolk Jock started a second career as a teacher, completing a full-time course and taught at a secondary school. Locally he also became treasurer of the parish church and, ultimately, chairman of the governors of the primary school.

Family, Labradors and competitive pistol shooting (he made his own ammunition) remained lifetime interests. Jock died in June 2006, aged 70. ***BW***