Scientists for Global Responsibility
Scientists · Architects · Engineers · Technologists

SGR Newsletter

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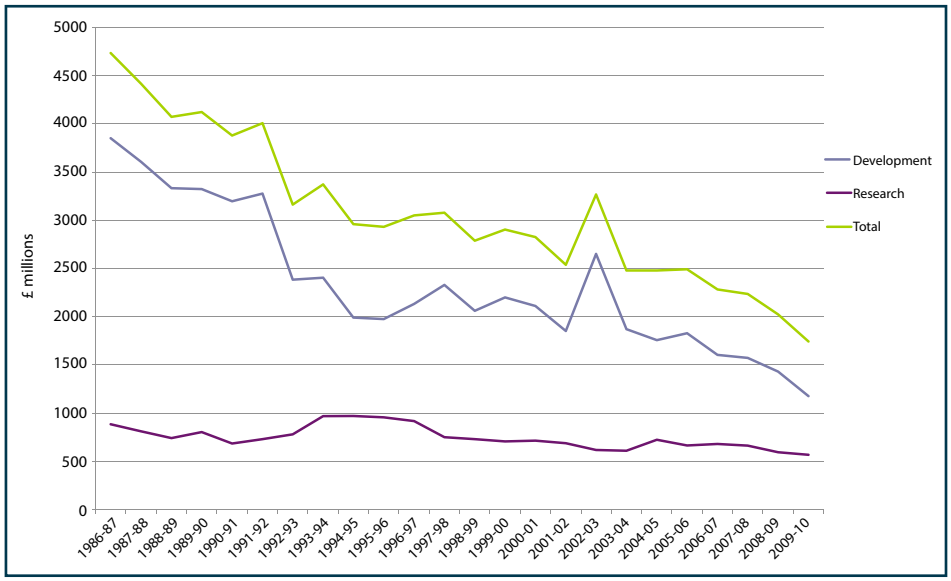
Special 20th anniversary issue

The decline of UK military R&D



UK Ministry of Defence spending on R&D from 1986 to 2010.[1]

Latest official statistics show that UK government spending on military research and development has fallen considerably over the last ten years – something that SGR has been calling for. Stuart Parkinson assesses the significance of the changes.

The end of the Cold War led to high hopes that there would be major cuts in international military forces, together with its associated spending. While in Russia and other former Soviet countries spending cuts of about 90% took place, in the West the cuts were much more limited.[2]

The UK situation demonstrates this well. From a 1980s peak of over £40 billion (in 2010/11 figures), total military spending only fell by 30% by 1997 and then began to rise again. By 2009/10 it was approaching its Cold War peak following the major spending increases during the '9/11 wars'.[3]

However, UK public spending on military research and development (R&D) has followed a somewhat different pattern.

UK military R&D spending: charting the decline

Figure 1 shows the R&D spending by the Ministry of Defence (MoD) from 1986 to 2010.

During the 1980s, the MoD had dominated public R&D spending, being responsible for around 50% of the total spend. However, in the late 1980s, the spend fell significantly. Part of the cause was the declining tension between the West and the Soviet bloc, but an equally large factor was change within the way *all* R&D was being funded in the UK. This was due to the deliberate government policy of encouraging a shift from public to private funding for science and technology. Annual spending on publicly funded military R&D thus fell from nearly £5 billion to £3 bn in the decade up to 1995. A particularly controversial example of the privatisation trend was the transfer of management of the Atomic Weapons Establishment to the company, Hunting-BRAE in 1993/4.[4]

However, during the late 1990s, the decline in spending virtually stopped, with the MoD's R&D budget remaining roughly constant at about 35% of the total government R&D spend. This was a much higher proportion than most other industrialised countries, except for the USA (see Box 2 on p.27 for more discussion of international comparisons). The UK was still pursuing the development of numerous major new weapons systems, despite the lack of a clearly perceived 'enemy threat'.

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A few words from the Director

This year SGR reached an important milestone – the 20th anniversary of its formation. We have come a long way – and some of the articles in this special issue take a look at the journey the organisation and the individuals within it have taken, as well as some of the important successes that we have achieved (see p.5, p.28 and p.33). Also in the Newsletter, we reflect on some key obstacles that stand in the way of a much more positive role for science, design and technology within society – but we highlight some real signs of hope as well. In this editorial, I want to give an overview of some of these – and also announce some exciting changes that we are planning for SGR.

Obstacles

Perhaps no starker reminder could have been given about the challenges that society faces in using science, design and technology for a peaceful, just and sustainable world than some key events that happened during the week of SGR's 20th anniversary in late June.

This was the week of the 'Rio+20' summit in Brazil, and much has been written on the incredible lack of ambition demonstrated in the final summit agreement.[1] Governments committed only to vague aspirations with no clear set of actions or targets on curbing global environmental damage, tackling overconsumption of natural resources or reducing poverty.

As if to emphasise the lack of priority given to sustainable development, the UK government chose that week to announce a new £1.1 bn contract with Rolls-Royce for development work on the Trident replacement nuclear weapons programme.[2] The work will be on the submarines' nuclear propulsion system. It is an 11-year contract, which demonstrates just how distorted this government's long-term priorities are for developing and deploying new technologies. Furthermore, given that parliament is not due to make a final decision on whether to go ahead with Trident replacement until 2016, this shows a depressing lack of respect for the democratic process.

This snapshot of examples from June is not, of course, a one-off. The Coalition government has continued its shift away from environmentally friendly policies in the months since, while the UK's military policies are in no way unique among the nuclear weapons states – all of whom are involved in some sort of renewal or upgrade programme (see p.13). In addition, it is not hard to find areas of scientific research – such as synthetic biology (see p.21) or geoengineering (see p.34) – or science education (see p.17) that are causing serious ethical concerns.

Opportunities

But it is also important to look at what positive activities and changes are out there, and what role can be played by science, design and technology professionals in expanding these.

Firstly, as discussed in the front-page article, there has been a major fall in publicly funded military R&D in the UK. Meanwhile publicly funded R&D in some civilian areas – including renewable energy – has grown. On top of this, developments in offshore wind, tidal stream and wave energy are accelerating, with the UK being a world leader (see p.11). There is also the real possibility that large city-level sustainable energy projects – combining energy conservation with microgeneration – may soon start to be deployed in the UK based on the success of existing smaller schemes (see p.18). And there are some refreshing new ideas being proposed to help reduce tensions in places like the Middle East (see p.7).

Big plans for SGR's future

These more positive developments bring me neatly to the exciting plans we have for SGR. Over the coming months, the organisation will be moving its office base north, from Folkestone to Lancaster – specifically into a new cutting-edge environmental development. This development – which is nearing completion as this newsletter goes to press – will include 41 super-insulated homes, built to the highest level of the UK's Code for Sustainable Homes. It will include office and workshop facilities in an eco-renovated industrial building, and community facilities for use by the residents. Energy will be provided by solar panels, a biomass boiler and hydro power plant. A 'travel plan' will include a car-share scheme and facilities to support cycling. For more information on the development, see http://www.lancastercohousing.org.uk/

SGR will occupy one of the offices, with room to expand the staff and volunteer base as funding allows. But the SGR connection does not stop there – residents of the houses will include me and a couple of other SGR members.

I'm really looking forward to the next stage of SGR's development...

Stuart Parkinson

References

1. For example, see: Worldwatch Institute (2012). 27 June. http://www.worldwatch.org/node/11037
2. BBC News online (2012). 18 June. http://www.bbc.co.uk/news/uk-18497362

The new National Co-ordinating Committee

The election for SGR's National Co-ordinating Committee (NCC) for this year was held during the Annual General Meeting on 19 May (see report on p.33). The new NCC is as follows:

Chair: Philip Webber
Treasurer: Alasdair Beal
Secretary: Harry Tsoumpas

Committee members:
Martin Bassant, Martin Cobley, Tim Foxon, David Hookes, Tom Woolley

Paul Marchant has since been co-opted onto the NCC.

SGR

The new NCC and staff (from left to right): Harry Tsoumpas, Tom Woolley, David Hookes, Tim Foxon, Alasdair Beal, Stuart Parkinson (Executive Director), Martin Bassant, Philip Webber, Kate Maloney (Office Manager), Martin Cobley

New project challenging military science

Researcher Barnaby Pace reports to the SGR AGM

In January, SGR began a new project examining UK government funding of military and security R&D. One of the main aims of the project is to publish detailed proposals for a radical shift in government science and technology spending, so that it will better contribute to long-term peace and security. Project researcher, Barnaby Pace, has been successful in using freedom of information requests to obtain detailed figures from the Ministry of Defence on their funding of R&D programmes. This will enable a much more in-depth critique than previous work in this area. The final report is due to be published later this year.

The project is funded by the Network for Social Change, Lush Charity Pot, the Trust for Research and Education on the Arms Trade, and donations from SGR sponsors. We are very grateful for this funding.

SGR has also continued to disseminate its research on the military influence on science and technology – including previous reports and some early results from the current research. One especially high-profile example was a presentation by Stuart Parkinson at a side meeting at ongoing negotiations on the Nuclear Non-Proliferation Treaty in Vienna. SGR's research has also appeared in a new booklet, published by our international partners, INES (see p.4). So far in 2012, over 1,100 copies of SGR's publications in this area have been downloaded from the website.

As we were going to press, Campaign Against Arms Trade and the Huffington Post UK published new figures for military funding of research at the UK's top universities. SGR was quoted in the media coverage, and a comment article was published on the SGR website.

Climate change and energy activities

SGR has continued to make valuable contributions to debates on a range of climate and energy issues.

In the spring, Philip Webber gave a presentation at a conference at the London School of Economics examining the influence of climate change research on policy. Tom Woolley gave a presentation on sustainable building materials at an ARC-PEACE conference in Copenhagen (see p.35).

In the summer, SGR wrote to Ed Davey, the Energy and Climate Change Secretary, adding our voice to the growing criticism of the latest Draft Energy Bill and related energy policy. Specifically, we criticised the proposed financial support for nuclear power, lack of restrictions for new fossil fuel plant, limited support for renewables and a lack of ambition on energy conservation.

In June, through INES and other international organisations, we urged world leaders to commit to strong action on sustainable development at the 'Rio+20' summit. In common with many, we were outraged by the lack of government action that emerged from this event.

In September, Stuart Parkinson took part in a lively roundtable discussion at University College London between campaigners and scientists concerning UK research on geoengineering.

In recent months, we have also responded to requests for information and opinion from a range of organisations and individuals including Friends of the Earth, GlobeScan, Media Lens and the British Psychological Society.

Other new project work

SGR is currently contributing to two external projects. The first is a project examining the influence of the Atomic Weapons Establishment on academic research – and highlighting the problems this causes. The work is being co-ordinated by the Nuclear Information Service, which will publish the final report later this year.

The second is a European Commission-funded research project on nanotechnology, co-ordinated by the School of Physics and Astronomy at the University of Nottingham. During the four-year project, SGR will be hosting a number of student placements focussing on the ethics of nanotechnology.

Ethical careers update

SGR has taken part in four ethical careers events so far in 2012. Alan Cottey, Richard Jennings and Louisa Radice ran a stall at a careers fair at Cambridge University, while Phil Webber ran a stall at Leeds University. During the summer, Stuart Parkinson ran stalls at two careers fairs in the Lancaster district – one at the university and one at a further education college as part of the 'Climate Jobs' roadshow. The university event included a presentation to interested students.

Interest remains high in SGR's ten ethical careers publications, with about 1,000 copies downloaded so far in 2012.

Security and disarmament activities

SGR's broader work on security and disarmament has continued unabated this year.

Early in the year, in response to increasing tensions over Iran's nuclear programme, Stuart Parkinson wrote an article for the website and newsletter of our international partners, INES. This examined the evidence for weaponisation within the Iranian programme and argued that a military attack was not the way to deal with the concerns. The article attracted a good deal of online interest – and some of the issues are taken up in a separate article by Keith Barnham in this Newsletter (see p.7).

In April, Stuart gave two presentations on arms conversion – one to a large public meeting in Hereford to mark the Global Day of Action on Military Spending, and one to peace campaigners in Lancaster.

In August, Barnaby Pace appeared in a BBC Radio 4 documentary entitled *Greening the Military*, arguing that efforts to reduce the environmental impact of the military should not be used as a smokescreen to avoid tackling the problems of militarism.

In recent months, SGR has also responded to requests for information from various organisations and individuals including BBC Radio 4, Campaign Against Arms Trade, and the Movement for the Abolition of War. Some of SGR's research was quoted in a new book, *The Economics of Killing*, by leading peace campaigner Vijay Mehta.

SGR representatives have also taken part in several conferences and other peace-related events during the year, on issues including armed drones, nuclear weapons and 'Missile Defence'. Several SGR members also wrote to the Natural History Museum and the National Gallery to complain at their hosting of social events for arms industry representatives.

In brief

- Since the last newsletter, SGR has gained two new sponsors. The first is Jenny Nelson, professor of physics at Imperial College London where she researches on solar photovoltaic cells. The second is Sandy Halliday, a chartered engineer and principal of Gaia Research, a leading sustainable building consultancy.
- In February, Stuart Parkinson gave a presentation on a course for science teachers, entitled *Science and technology: when does use become misuse?*
- In May, the academic journal Science and Education published an online article discussing corporate influence on science, including a detailed and positive critique of SGR's research in this area.
- In July, following the grant award from the Lush Charity Pot (see p.3), a short article about SGR appeared in the summer issue of Lush Times, which has an impressive circulation of half a million!

Commit universities to peace – international campaign update

There has been a great deal of international activity this year following the launch 18 months ago of a new campaign to challenge military involvement at universities. The campaign is being co-ordinated by the International Network for Engineers and Scientists for Global Responsibility (INES), and SGR took part in one of the launch events last spring in Germany (see *SGR Newsletter 40*). This was followed by a national student conference to roll out the campaign in that country. Campaign groups are also active in other countries.

German successes

Germany already has a head start in de-militarising its universities. Following World War II, universities were forbidden from being involved in military R&D and that led to many universities adopting a 'civil clause' in their charter, which committed the university to work only on civilian projects from that time onwards. The current campaign aims to build on that history, urging those universities with civil clauses to adhere to them and those without such clauses to adopt them. The campaign has broad support from national trade unions, student groups and peace groups.

There are now campaigning 'student committees' promoting demilitarisation and/or the civil clause at nearly half of German universities. There have also been some important successes. At the University of Bremen, which has a civil clause, the space corporation OHB (involved in the Galileo satellite system) offered to sponsor a professorship if the clause were dropped. A broad coalition of students, academics and others convinced the university senate to vote to keep the clause and reject the corporate funding. Meanwhile, a campaign at the University of Frankfurt led to massive vote in a student ballot in favour of the introduction of a civil clause at that university.

Japanese campaigns

The history of Japanese academia has much in common with Germany's. Civil clauses are also present in many universities. Military funding only started to enter Japanese academia in 2004 following a major change in the legal status of universities, which also allowed a wider range of funding sources to be accepted. Many Japanese academics and students have been deeply upset by this, and campaigns have started – given extra impetus by the INES campaign – to restate the peaceful intentions of university research and resist military funding. One particularly high-profile campaign has been at Niigata University. Niigata had been one of the four targets originally selected by the USA for atomic bombing in 1945, so the campaign has a special significance there.

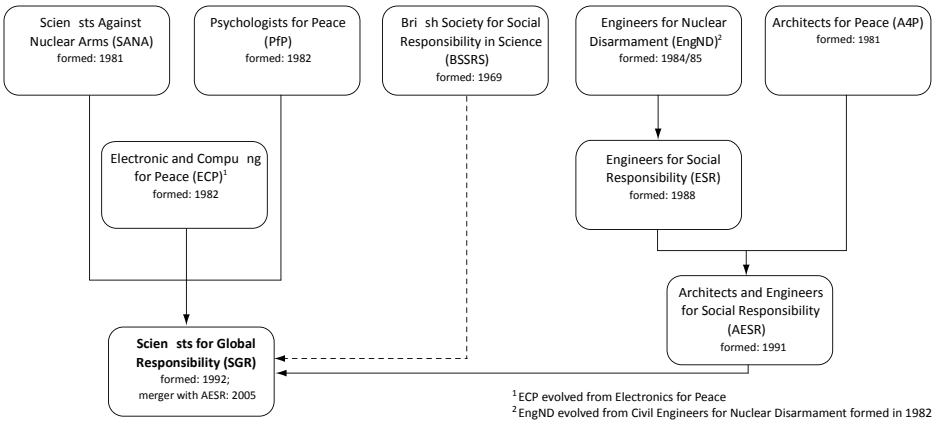
In the UK

The UK obviously has a very different history to Germany and Japan, and so military funding does not evoke the same wide level of criticism in this country. Nevertheless, numerous student groups campaign on anti-militarism, especially local groups of Campaign Against Arms Trade (CAAT) and CND, and SGR actively supports this work. In addition, CAAT has just published new research showing that engineering, science and business departments at Britain's leading universities still receive large amounts of funding (see p.3).

More information about the 'Commit universities to peace' campaign can be found in a new 36-page booklet just published by INES. It can be downloaded from: http://www.inesglobal.com/civil-clause-brochure-2012.html

20 years of Scientists for Global Responsibility

Scientists for Global Responsibility (SGR) was formed in the UK in 1992, from the merger of several smaller groups concerned with science, technology and peace issues. Since then it has grown in size and influence – with other organisations also becoming part of the SGR 'family'. It has undertaken a wide variety of activities to promote more ethical science and technology – from publishing groundbreaking reports on military and corporate influence on science and technology to playing a leading role in 'The Climate Train to Kyoto'. This article traces the history.



SGR family tree

SGR's roots

SGR's roots go back to the early 1980s, when tensions between NATO and the Soviet bloc were growing and concerns about the possibility of nuclear war were resurfacing. With scientists and technologists being at the heart of the military machine – but also being key in helping society to understand and challenge the threat that humanity faced – concerned professionals in the UK and elsewhere started to form groups to assist the peace movement in its campaigns.

The formation of Scientists Against Nuclear Arms (SANA) was a typical example of this trend. In 1981, Open University physics professor Mike Pentz organised a conference to found a new scientific group to help challenge the threat of nuclear war. Over 100 people attended and the organisation quickly grew. SANA went on to produce numerous publications about the scientific and technical issues. Perhaps most famous was the book, *London after the Bomb*, which examined the devastation that would occur should a nuclear attack be launched on the city. SANA also attracted support from leading scientists such as Nobel Prize recipient, Maurice Wilkins.

Several other groups of professionals also set up at this time, including: Electronics and Computing for Peace (ECP); Psychologists for Peace (PfP); Civil Engineers for Nuclear Disarmament (CEND), which grew into Engineers for Nuclear Disarmament (EngND); Architects for Peace (A4P); and the Medical Campaign Against Nuclear Weapons.

In the early 1990s, as the Cold War ended and concern shifted to global environmental issues, SANA and its sister organisations reflected on their future. At a conference held in London on 21st June 1992, SANA, ECP and PfP agreed to merge to form SGR, with Philip Webber – one of the authors of *London after the Bomb* – as Chair. The overall aim became the promotion of ethical science and technology. At around the same time, changes were also happening in the other organisations, including the formation of Architects and Engineers for Social Responsibility (AESR). Figure 1 shows the organisational evolution.

SGR's early years

During its early years, SGR's most notable achievements were in (co-)organising several prominent conferences covering a range of ethical issues in science and technology. These included the 'Science for the Earth' conferences at Cambridge University from 1992 to 1996 and a large conference on 'Science: Ethics and Dilemmas' in 1993. Speakers at these events included influential figures in scientific and environmental circles such as Stephen Hawking and Jeremy Leggett.

In 1996-7, SGR took a leading role in organising 'The Climate Train to Kyoto'. This ambitious project was intended to raise awareness of the threat of climate change in the run-up to critical intergovernmental negotiations that were due to take place in Kyoto, Japan, in December 1997. The project centred on sending 36 scientists and environmental campaigners by train (with the final leg by boat) from Europe to the negotiations – en route highlighting the threat from polluting activities, such as flying. Ben Matthews co-ordinated the group's activities during the journey. A representative of the project, Michelle Valentine, gave a short speech to the high-level plenary of the conference. The project achieved significant media coverage – including a lead item on Channel 4 News.

Ethical careers – promoting a positive alternative

Some of SGR's predecessors had carried out activities promoting science and technology careers that avoided military work, including publishing a booklet, *Your Career and the Arms Industry*. SGR sought to build on this work by producing more general ethical careers guides for scientists and engineers. This project began in 1999 and over the following seven years SGR produced ten publications. These included an introductory booklet, a booklet of inspiring case studies, and eight subject-specific briefings focused on issues including climate change, space science, cleaner technologies, the arms industry and animal experiments. The publications were edited by Stuart Parkinson and Vanessa Spedding.

The publications were – and continue to be – very popular, especially with students and recent graduates. A total of over 33,000 copies have been distributed, either as downloads from the SGR website or via stalls at university careers fairs.

Challenging the power of vested interests

A major concern for SGR has been the influence of powerful vested interests within science and technology – most notably the military and large corporations. A key aspect of this concern is the degree to which these powerful interests shape the research and teaching agendas, prioritising work that leads to technologies with military and/or short-term commercial applications rather than alternatives. This concern is made especially acute by the long-term UK government policies that support maintaining a large military – and a willingness to deploy it frequently – and that have allowed large corporations to have a dominant influence on society. SGR profoundly questions whether either of these sets of policies are in the public interest. The situation is

made worse by the close relationship that has become deeply established between the professional science and engineering institutions and these powerful interests – and the unwillingness of the professions to question this situation.

With these concerns in mind, SGR embarked on a targeted series of activities to challenge the situation. In 2003, we began the first in a series of projects to expose the degree of influence that the military has on science and technology in the UK and more widely. We launched our first report, *Soldiers in the Laboratory*, to a packed event at the Houses of Parliament in 2005. Researcher Chris Langley introduced the findings, noting that the Ministry of Defence provided one-third of the public funding for UK research and development, and that the arms industry also had a major say in the R&D agenda.

We disseminated the report widely – to policy-makers, security analysts, scientists and engineers, peace campaigners and others. The report was followed up by two shorter briefings, including one focusing on the connection between UK universities and the military. Further policy-orientated research is continuing. Over the past seven years, we have given dozens of lectures and presentations, including at the Royal Institution in London and the UK Festival of Science. The work has also had extensive media coverage including opinion articles in the *New Scientist* and numerous science and engineering publications. Over 13,000 copies of our three publications in the area have been downloaded from our website. As major government spending cuts were being planned in 2009, we used our research to argue that any cuts to government R&D funding should be focused on the MoD's budget. This also received a large amount of media coverage.

In 2007, we broadened our investigations to include the corporate influence on science technology. Chris Langley and Stuart Parkinson co-authored an in-depth report, *Science and the Corporate Agenda*, which highlighted the extent of the influence of short-term commercial interests over the research, teaching and public communication of science and technology. It looked at the influence of five industrial sectors: oil; pharmaceutical; tobacco; arms; and biotechnology. Again, the report received a lot of media coverage, and over 4,000 copies have been downloaded from our website.

AESR joins the SGR 'family'

In the early 2000s, discussions began between SGR and AESR about pooling our resources and this led – in October 2005 – to a joint Annual General Meeting in London where members approved AESR merging with SGR. Philip Webber remained Chair of the combined organisation, while Kate Macintosh, Chair of AESR, became Vice Chair. Stuart Parkinson, Executive Director of SGR since 2003, also retained his post.

Although the range of professions now included in the organisation was wider than that originally envisioned when SGR was formed, there were felt to be important benefits from the new combination of professions, not least in approaches to tackling environmental problems, which increasingly demand integrated multidisciplinary approaches to be successful.

The 2005 conference also marked an upturn in annual conferences – with more speakers and large audiences. Themes for these events included the low carbon economy, sustainable buildings and communities, emerging technologies, and resource depletion and conflict. One issue that repeatedly arose at these events was the potential and need for arms conversion in order to move to a greener society. This became an increasingly prominent theme in SGR's lectures and campaign work.

The *SGR Newsletter* too became a weightier publication, including a larger number of more in-depth articles. The growing online publication of its articles has led to it becoming an important alternative to mainstream science and technology media.

Commentary and campaigning

SGR's unique combination of expertise and radical ideas has allowed the organisation to engage both in supporting campaigning coalitions and providing commentary on current events.

In order to have an impact on policy-makers, SGR has often worked in collaboration with campaign coalitions. One successful example of this was the Renewable Energy Tariff coalition, whose effective lobbying led to the introduction of the Feed-In Tariff for small-scale renewable energy technologies in the UK. Another notable example was the Rethink Trident campaign, which was the focus of a front-page article in *The Independent* in 2007 in the run-up to the parliamentary vote on replacement of the Trident nuclear weapons system. SGR has also worked with campaign groups on numerous other issues, including challenging the building of new nuclear power stations and the commercial planting of genetically modified crops.

Commentary has included many activities, such as publishing articles, short reports and email bulletins. For example, we published original research modelling GM pollen dispersion in 2002 and in-depth analysis of the flawed case for the Iraq war in 2003. Another example is the monthly email newsletter on 'Population, Consumption and Values', which ran from 1999 for ten years.

Now more than ever...

Over the last 20 years, SGR has made a critical contribution to debates on the use and misuse of science, design and technology. Our role has varied between being a think-tank, an education provider, a campaign group, and a forum where ethically concerned science, design and technology professionals can explore ideas that the mainstream overlooks. In general, we have demonstrated that significant numbers of scientists, engineers and other professionals are willing to stand up for peace, social justice and environmental sustainability – and are not content to accept that powerful, unaccountable interests can pull the strings of the professions to suit their narrow, short-sighted priorities.

While we are only a small organisation, we do think we have been an agent of change and can claim a contribution to some of the positive trends seen in recent years:

- UK government R&D spending by the military has fallen markedly in the last decade (see p.1);
- The renewable energy sector in the UK has grown exponentially in recent years;
- Interdisciplinary research centres – especially those related to environmental or peace issues – have become numerous at universities in the UK;
- Several leading UK professional science and engineering institutions now have ethical codes that cover social and environmental responsibility.

This article includes contributions from Stuart Parkinson, Philip Webber, Kate Maloney, and Alasdair Beal. A longer version is available on the SGR website at: http://www.sgr.org.uk/pages/20-years-scientists-global-responsibility

Many of the outputs mentioned can be downloaded from the SGR website.

Breaking the deadlock: Iran's nuclear programme in context

Keith Barnham suggests renewable energy technologies can play a key role in arresting the spread of nuclear weapons in the Middle East and elsewhere.

The disastrous consequences of possible military intervention in Iran were described in a recent SGR-authored article.[1] President Obama will be keen to prevent any precipitate action by Israel in the run-up to November's presidential election. I suggested a new initiative to break the deadlock in a letter that the London Guardian published (in an abridged form) on 15-3-12:

> *"Your leader ("Straining at the leash", 6-3-12) urges the US to create "incentives for Iran to change course on enriching uranium". Here is a suggestion. In return for stopping all enrichment activity, the US offers to build a solar cell factory and a wind turbine factory in Iran, each capable of manufacturing systems producing one GW of electrical power a year. This would cost less than a new nuclear reactor. Within 10 years Iran could have around 15 GW of new electricity capacity, much more than its nuclear programme will produce in that time. Such distributed electricity generation is also more secure against disruption by earthquakes and hostile neighbours."*

This article will discuss the background to this proposal, weaknesses in the Nuclear Non-Proliferation Treaty (NPT) and ways renewable technology could help economic and political progress in the developing world.

Nuclear and renewable energy costs

The cost of solar photovoltaic (PV) power has fallen sharply as factories manufacturing over 1 gigawatt (GW) per year have come on stream, mostly in China.[2]

The *Kombikraftwerk* project has used real-time output of renewable generators to show that 78% of the German electricity demand can be supplied by PV and wind power with back-up from biogas.[3] With colleagues I have recently shown that peak electricity prices on the German and Italian grids are falling as the PV contribution has risen and the German grid is coping with wind and PV contributions above 30%.[4] We conclude that the fastest and cheapest route to a low carbon electricity supply would be a moratorium on all new electricity generators other than the renewables.

Renewable electricity is particularly appropriate for Iran:

1) In much of Iran 1 MW of PV will produce twice the energy (MWh) as the same 1 MW system in much of Germany.[5]
2) The wind resource in Iran is comparable to that in Germany,[6] which has already installed 29 GW of wind power.[7]
3) Wind and PV can supply those regions of Iran not connected to the national grid.
4) The renewables require no fuel and so provide more security of electricity supply than nuclear power.

The costs of my proposal are presented in Box 1. In short, construction costs for a second nuclear power station are around $6.4 billion, whereas my estimate for wind turbine plus PV factories is around $2.7 billion.[8] Iran may go for a cheaper model from Russia or South Korea for its second reactor. However, much of the increased cost in my estimate is due to post-Fukushima safety enhancements. Given Iran's earthquake history, it would be unwise to economise on safety.

The capacities that could be installed in the next ten years for each of the two options are compared in Box 2. With 15 GW of renewable power, the renewables option is far superior to the 1.8 GW of nuclear power.

The experience of Germany has been that it is the power (GW) that matters rather than energy (GWh) in

Box 1 – Cost comparison of nuclear and renewables

Nuclear

The latest figure for the 1.6 GW European Power Reactor is around £7bn.[9] Iran's second reactor is expected to be 0.915 GW (see Box 2) which @ 1.6 $/£ gives

New reactor construction cost = $6.4bn.

Renewables – technology costs

Wind. The construction cost of onshore wind power is (2.1 – 2.7) $/W and falling.[10]

Photovoltaics. The average retail price a solar cell module has fallen from 4.5 $/W in January 2009 to 2.29 $/W in March 2012.[11] However, the retail market has yet to see the full benefit of the fall. The average spot price of a PV module was 0.745 $/W on 4-7-2012.[12]

Renewables – factory costs

Commercial sensitivities mean factory costs are not always easy to find.

Wind Turbine Factory. I obtained an informal estimate from an investment analyst of $100 million for a factory producing 1 GW of wind turbines per year. This is consistent with my estimate of $130m based on figures from a newspaper report[13] of the turbine plant (excluding port infrastructure) that Siemens is building in Hull. (Siemens has not responded to my requests for information on plant capacity. However, it must be at least 1 GW/y to make an impact on the UK Crown Estate's 25 GW target for the North Sea in 2020.[14]) I took the lower estimate as Iran will probably want smaller turbines than the large offshore units planned by Siemens.

Cost of a wind turbine factory producing 1 GW/y = $0.1bn.

Solar Cell Factory. A $1.3bn investment has been made for new PV plants totalling 0.5 GW/y in Japan.[15] $2.6bn for a 1 GW/y plant is consistent with the rule of thumb from the investment analyst mentioned above that the capital cost of a PV plant should be recouped in the first two years of operation. This means $2.0bn for the capital cost assuming the spot price of PV modules is 1 $/W.

Cost of a factory producing 1 GW/y of thin-film PV modules = $2.6bn.

Renewables – installation and balance of system costs

Wind. The turbine cost is a small part of the construction costs presented above. Installation and civil engineering costs dominate. Hence an Iranian purchaser is not going to see much advantage from the donation of the factory unless some installation subsidy is agreed as part of the deal with the US.

Photovoltaics. Balance of systems costs of PV (installation, area related costs, grid connection) are generally approximately equal to the $/W module costs. One assumes these will be paid by the purchaser. The cell cost to the purchaser will be lower because the factory will not have to recoup the capital cost. A smaller subsidy than for wind could be agreed as part of the deal with the US.

meeting demand (which is also measured in GW).[4] The peak price of electricity in Germany has fallen significantly thanks a typical peak PV contribution of 28% of the grid supply in terms of power, but only 3% in terms of energy. Energy comparisons ignore the time variation of PV. PV power peaks close to the time of peak demand.[4,19]

However, even if one compares energy yields, the renewable option is still significantly better. Assuming 70% capacity factor for nuclear, 30% for wind and 20% for PV:

Energy generated in 10th year, (wind + solar PV) : nuclear = 3 : 1

Weaknesses in the Non-Proliferation Regime

This suggestion for Iran highlights a problem with the NPT first noted by the late Joseph Rotblat.[20] As part of the incentive for non-nuclear weapon states to sign the NPT, Article IV states "Parties to the Treaty.....shall also cooperate in..... the applications of nuclear energy for peaceful purposes, especially in the territories of non-nuclear weapon states Party to the Treaty..." Rotblat proposed the words "nuclear energy" should be replaced by "the most appropriate form of energy". He was also concerned that the IAEA pursues Article IV activities more vigorously than overseeing safeguards. This is still the case. In 2010 only 38% of the IAEA's budget was spent on safeguards verification.[21]

Iran is a prime example of an NPT signatory state whose nuclear programme has developed according to Article IV. That was with support from Russia, but France has helped the Iranian uranium enrichment programme.[22] The 2015 NPT review conference should finally accept the wisdom of Rotblat's argument. International assistance for the development of renewable energy sources could also be expanded through mechanisms set up, for example, under the UN Framework Convention on Climate Change.

An important difference from the nuclear case is that exports to developing countries should be of wind and PV *factories*. This makes particular sense for donor states at the present time. The rise of the large PV factories in China has led to smaller PV production lines being mothballed or closed around the world.

Wind turbine and solar panel factories are much simpler to replicate than a nuclear reactor. If developing countries replicate the first factories, they can expand renewable electricity generation at an even faster rate. Ideally, replica factories should be wind and PV powered.

I can report some encouraging news. After discussing PV at a recent conference in a developing country, I was invited to their renewable energy ministry. There I was informed, in confidence, that discussions with a certain country on the supply of a PV factory were already underway.

Political and economic advantages of renewable technology in the developing world

Could PV and wind power become a force for political and economic advance in the developing world?

One of the first schemes to be implemented, the DESERTEC project,[23] plans to cover large areas of the North African desert with PV and solar thermal plants and bring the power to Europe by high-voltage direct current transmission. I do not like criticising any solar project that has managed the difficult task of raising significant funding, but I am concerned about some aspects of this scheme:

1. Clearly, improved national and international grid connections would mean the renewables could be better exploited. A good example is Italy where most of the hydropower storage is in the Alps in the far north and the best PV resource is in the south. As I have pointed out elsewhere, thanks to PV, the cost of electricity on the southern Italy grid fell to zero in the early afternoon of 2-5-2012.[4] However, governments that are anti- renewables have used the need for grid upgrades and storage and even the promise of PV electricity from DESERTEC, as reasons to cut domestic PV incentives.
2. One of the fastest growing contributions to electricity demand, particularly in southern Europe, is the use of air conditioners in domestic and office buildings. DESERTEC will bring electricity generated by the sun 2000 km or so to satisfy a rising demand caused by the sun beating down on the roofs of the buildings creating the demand! The money could be better used to build PV factories in North Africa and for developing 'Smart Windows' which generate electricity as well as *reducing* air conditioning demand.[19] I described the latter at the SGR AGM in 2005. Sadly, it has been very difficult to obtain funding for this technology. Smart windows reduce air conditioning demand by preventing direct sunlight from entering the building. Instead, it is diverted onto QuantaSol's 40% efficient solar cells.[24] The cells generate electricity that can power the air conditioning when it is needed and where it is needed.
3. Politically, how will the local population, which has seen the oil resources in neighbouring countries exploited by and for Europeans, view DESERTEC covering their land with devices to exploit their solar resource? Better to fund the factories that provide the wind turbines and solar panels that can power off-grid villages, irrigate the desert and power self-sustaining greenhouses. The latter can extract moisture from the desert air to enable the crops inside to grow on a self-sustaining water cycle.[25]

Given that wind and PV costs are falling well below the rising nuclear cost (Box 1), the motivations of any sunny, oil-rich state that opts for a nuclear programme deserves close scrutiny. Abu Dhabi has recently signed an agreement with a South Korean company for four nuclear stations; the first in the

Box 2 – Build time and power capacity comparison for nuclear and renewables

The Hull turbine factory is expected to take 2 years to build.[13] Iran has experience of manufacturing turbines on license.[16] First Solar's 1 GW/y thin-film factory in Malaysia took 2.5 years to build.[17]

Assume 2.5 years for each factory, so 7.5 years of active production each at 1 GW/y

Total wind and PV power installed after 10 years = 15 GW

The International Atomic Energy Agency (IAEA) says Iran is planning three more reactors totalling 2.16 GW to start in 2012, 2013 and 2015.[18] All three are of a different type to the existing Russian-built Bushehr-1 (capacity of 0.915 GW) which took 37 years to build.[1] The Iranians could have another 0.915 GW reactor operational by 2022, though a supplier has yet to be named.[18]

Total nuclear power likely after 10 years = 1.8 GW

United Arab Emirates.[26] Saudi Arabia has announced a 16-reactor programme, with the Chinese as possible suppliers.[27] In the latter case the weapons option has been admitted. A member of the Saudi royal family has let slip that that the kingdom might consider developing nuclear weapons, given that Israel has them and Iran may be developing them.[28]

I suggest that such countries could spend their massive oil revenues on supporting R&D on the solar applications suggested as alternatives to DESERTEC. Also they should join with existing groups researching how PV and wind can efficiently generate solar fuels such as hydrogen (from water) and methanol (from atmospheric CO_2).[29] Solar fuels produce a lot less carbon than biofuels and do not compete with food crops. They must, sooner rather than later, start replacing these states' depleting oil resources. I am not a chemist and cannot guess which of the many approaches to solar fuel generation will win. However, the fact that we now have 'triple-junction' PV cells being manufactured with a sunlight-to-electricity efficiency greater than 40%[24] must boost the practicability of solar fuel generation based on PV.

The ambiguity surrounding Saudi Arabia's nuclear programme suggests they may be losing confidence in the NPT regime. This is not unexpected, given the recent report in *Der Spiegel* that Germany is supplying Israel with submarines that can carry nuclear missiles.[30] The first three submarines were constructed in the UK, though it is not clear if these are also nuclear compatible. By signing Article I of the NPT, Germany and the UK have both agreed not to transfer "control over such weapons.....directly or indirectly" to "any recipient whatsoever". Whatever sophistry the German and UK governments use to argue that the submarines do not give Israel "control" over their nuclear weapons is beside the point. What matters is that Iran and Saudi Arabia are aware that the countries pressing them to adhere to the NPT are violating the spirit, if not the letter, of the treaty in enhancing Israel's nuclear capability. These are the weapons that are leading Iran and Saudi Arabia to consider the nuclear option themselves.

Can renewable power help solve the Israeli-Palestine conflict that is at the root of this particular nuclear instability? Hopefully, the peace process will be revived should Obama be re-elected. The US could offer to provide wind and PV factories as part of the peace deal. These would fuel economic development in Israel, Gaza and the West Bank. The latter two would no longer be dependent on Israel for their electricity. Furthermore, this dispute is fundamentally about the ownership of land. But who owns the wind and sunlight above the ground? Solutions to disagreements over the most problematic of the disputed areas could be facilitated by internationally supported agreements that the wind and PV from these regions could supply electricity (and water) to both Israel and Palestine.

The message for our political leaders is that German experience has shown that the renewables can supply all our electricity needs. Furthermore, renewables are now the cheapest, quickest to install and lowest carbon options. Donor countries seeking political and economic influence in developing countries need to realise that renewables are far more useful than nuclear to a developing country, and far safer technologies.

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What kind of low carbon future do we want?

Tim Foxon summarises new academic research examining the major choices for the UK as the nation tries to de-carbonise its electricity system.

The 2008 Climate Change Act set a goal of reducing the UK's carbon emissions by 80% by 2050 (from 1990 levels), based on recommendations from an independent Committee on Climate Change. The Committee's initial recommendations, corresponding to a 34% reduction by 2020 and a 50% reduction by 2025, have been accepted by the UK government as legally-binding targets. The latest Carbon Plan[1] for reaching these targets was published in December 2011. This sees the government setting the framework for achieving an affordable, low carbon and secure energy supply, with businesses, particularly large energy firms, having a key role in providing innovation and investment to deliver 'low carbon solutions'. The Plan focuses on technological solutions, principally 'front-of-pipe' solutions, such as low carbon electricity generation mainly through offshore wind turbines and new nuclear power stations, and 'end-of-pipe' solutions, such as capturing and storing emissions from coal and gas-fired power stations. Measures to reduce energy demand, such as the government's Green Deal[2] financial mechanism, which is due to come into operation in autumn 2012, rely on households voluntarily installing measures to improve their energy efficiency to reduce their energy bills over the lifetime of the measures. However, there is little discussion in the Plan of the role of wider civil society in bringing about a low carbon transition, or of alternative visions of a low carbon future.

In work undertaken by the author in collaboration with engineering and social science colleagues at nine UK universities, we have been exploring alternative pathways to a low carbon electricity future for the UK[3,4,5]. This work aims to investigate how adopting alternative ideas and frameworks governing energy systems could lead to quite different outcomes in terms of electricity demand and the mix of technology used to generate it by 2050. Drawing on interactions with stakeholders from the UK government, advisory bodies such as the Committee on Climate Change, energy companies such as E.On and National Grid, and NGOs such as WWF and the Centre for Alternative Technology, and modelling of electricity networks, we developed three 'transition pathways' for the UK electricity system from now to 2050.

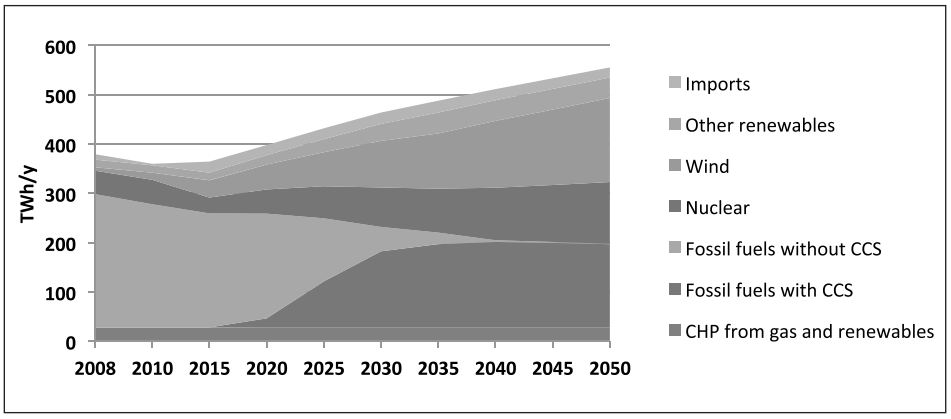

Figure 1. Electricity generation (TWh/y) in the industry-led pathway 2010-2050[6]

In our industry-led and state-led pathways, electricity demand continues to increase, as the impact of voluntary or state-led energy efficiency measures is balanced by increased demand for electric household heating, such as air-sourced heat pumps, and electric vehicles, including plug-in hybrid and battery electric cars. This demand is met by high levels of new large-scale centralised low carbon generation, in the form of onshore and offshore wind, new nuclear power stations and coal and gas generation with carbon capture and storage, with unabated gas power stations acting as backup. The mix of generation to 2050 in the industry-led pathway is shown in Figure 1.

Clearly, there are significant risks associated with this pathway. In the coming years, both nuclear power and carbon capture and storage technologies could be ruled technologically unfeasible or prohibitively expensive, and society could decide that new nuclear power stations are unacceptable for proliferation, safety and waste reasons. Large-scale renewables, such as offshore wind, are also likely to be expensive, and the costs of investing in them would lead to higher household energy bills, putting pressure on low-income households living in poorly insulated homes.

In our community-led pathway, wider civil society plays a leading role in a low carbon transition, as more people become involved in groups such as Transition Towns and take a more active role in managing their energy demand and providing local energy solutions. Community-led energy service companies (ESCos) increasingly take over energy provision from large energy companies that fail to adapt. In this pathway, overall electricity demand is reduced and there is much more local generation, in the form of onshore wind, solar photovoltaics, solar water heating and biomass-fuelled combined heat and power (CHP) systems. As these technologies become more widely adopted and accepted, their costs come down, and the large-scale, capital-intensive nuclear power and carbon capture and storage technologies are gradually seen as more expensive and less desirable. The mix of generation to 2050 in the community-led pathway is shown in Figure 2.

Of course, there are also significant risks associated with this pathway. Local generation technologies could turn out to be more expensive and difficult to install, particularly in the retrofitting of existing houses and the building of district heating schemes. The emphasis on biomass-fuelled CHP would result in a huge demand for locally sourced energy crops and the infrastructure for distributing them, to avoid reliance on imports of unsustainably sourced biofuels. Efforts to reduce final energy demand could be partially offset by 'rebound effects', in which households choose to use some of their cost savings to increase other energy-intensive activities. Moreover, this pathway relies on significant numbers of people being willing and able to take an active role in managing their energy consumption and where their energy supply comes from.

This work highlights the challenges involved in realising any pathway to a low carbon energy system in the UK, but they are not insurmountable. Current UK government carbon plans may be relying too much on market solutions, large energy firms and voluntary incentives to deliver the wholesale transformation of our energy systems needed to meet our carbon targets. At the very least, these changes require wider public consent and probably much higher levels of public involvement in energy demand and supply issues. We hope that this and

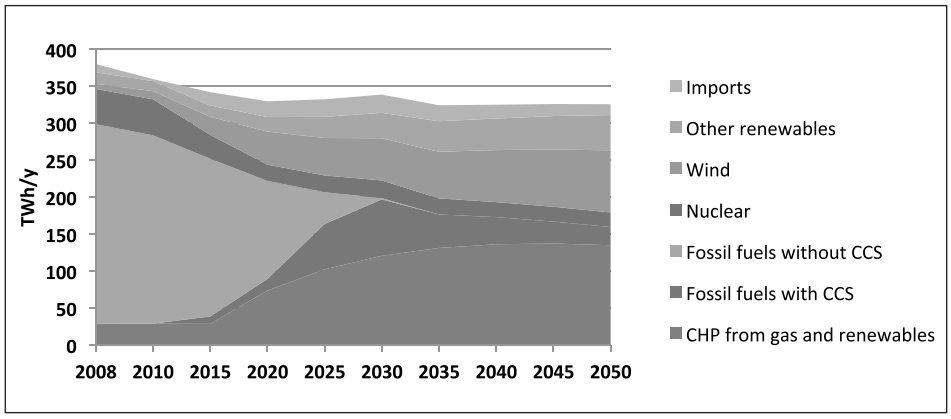

Figure 2. Electricity generation (TWh/y) in the community-led pathway 2010-2050[5]

other work can contribute to a more informed and engaged public debate about what kind of low carbon future we want, which is surely needed.

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Energy from the ocean: the UK dimension

AbuBakr Bahaj outlines the recent positive progress in generating electricity from offshore wind, wave and tidal current resources in the UK. He also assesses the future challenges in a sector in which the UK is a global leader.[a]

Over the last 20 years, renewable energy has become a critical part of the supply mix, driven by our desire to use sustainable resources, reduce pollution emanating from fossil fuels, and create new industries and jobs. Although still driven by what are termed as subsidies, the renewable energy industry is maturing, with huge investments being ploughed into it. Global investment in the sector in 2011 was estimated at $257 billion, a 17% increase on 2010. A large proportion of the funds have targeted solar and wind power, and overall investment in these two sectors exceeded that for traditional fossil fuels. This is now a major industry that is likely to grow further, displacing and augmenting traditional electricity generation facilities.

Offshore wind power

In the last five years, the deployment of offshore wind power has rapidly increased – particularly in the UK where 1.8 gigawatts (GW) of installed capacity was achieved in early 2012. Going offshore, the wind resource is much larger than onshore – with higher wind speeds being present for longer periods. It also avoids the aesthetic objections that some have to onshore turbines. Currently the UK is leading the way with a potential of 18 GW of capacity to be realised by 2020. These achievements are extremely important, especially in responding to government targets for reducing carbon emissions from energy generation, while diversifying the energy mix and creating new industries. The UK's targets and support policies have resulted in major investments by large companies, such as Siemens and Samsung, in manufacturing, installation, infrastructure, and job creation – especially in 'Round 3' wind farm development, which is planned to take place up until 2020.[1]

The challenges of an expansion in offshore wind generation are multifaceted, encompassing the technical, economic and human resources needed to support the deployment and maintenance regimes for these wind farms. Initially, wind turbines with a power rating of 2 MW were installed in the early 2000s, but now 5 MW is the norm with 10 and 20 MW machines under serious design consideration. Prototypes of these latter turbines are expected to come on stream within the next three years. From a technical viewpoint, operating in the sea clearly has its own challenges, including the design of the foundations, electrical cabling and operation within a constrained weather window. Going far from the shore and using larger machines will need new and innovative thinking in terms of materials, components and other measures to enhance reliability and ease of maintenance. Bringing power to the shore will require new infrastructure at ports to support manufacturing, deployment and maintenance, as well as new cable topographies based on high voltage DC and – more importantly – grid outlets geared to cope with the intermittence of power generation sources.

Power from waves and tidal currents

Other ocean-based energy resources are tidal currents and waves. The UK is at present the world

The Pelamis Wave Power device

leader in both wave and tidal current conversion[2] both technologically and in their deployment at sea. In terms of the latter, the UK has a shoreline energy resource of approximately 10% of the 2500 GW estimated to be available globally. If the UK were to make full use of, say, 10% of its resource for power generation – which would require a very large capital investment – tidal currents could deliver around 220 terawatt-hours per year (TWh/y), roughly half of the UK's electricity consumption today.

While most incident wave energy is dissipated in deep water, there is nevertheless a significant nearshore resource estimated to be 1300 GW globally, with a technically exploitable resource of 100-800 TWh/y. The UK has one of the most energetic wave climates in the world, with the potential to provide up to 50 TWh/y.

At present, there are no arrays of multiple devices of wave or tidal technologies operating out at sea, and many of the challenges of offshore wind mentioned above also apply to wave and tidal energy generation. However, individual devices at capacities of around 1 megawatt (MW) or less are currently operational at test centres or in sheltered sites in the UK and elsewhere. Most notable are the SeaGen device of Marine Current Turbines Ltd, rated at 1.2 MW and operating at Strangford Lough, Northern Ireland, the Pelamis Wave Power device rated at 0.75 MW and Aquamarine's Oyster machine rated at 0.80 MW, which are currently being tested at the European Marine Energy Centre, Orkney Islands.

The next steps for all these technologies will be to achieve credible operational experience in the sea, including testing out arrays or farms of multiple devices. This will help to improve the economics by reducing the installation cost of the technologies. For example, the installation cost per MW for the leading wave and tidal current technologies is currently in the range £7 – £10 million, with the lower value representing multi-MW installations and the higher for a single commercial prototype. A pathway to cost reduction to attain future parity to the presently 'acceptable' cost of £3 million per MW for offshore wind is currently being pursued by developers supported by funders, either through economies of scale or by optimising and streamlining the operation and maintenance of the devices.

A promising future

Project development for wave and tidal technologies in the UK is now following a similar procedure to that taken for offshore wind farms. The Crown Estate, which owns the seabed around the UK coastline, has awarded leases to marine energy projects for a series of sites in the Pentland Firth and Orkney waters. These 'Round 1' leases for marine energy permit ten demonstration and commercial projects totalling 1.4 GW of potential capacity for different technologies (600 MW wave energy devices, 800 MW tidal current devices) at an estimated cost of £4bn to be installed by 2020. These schemes will require an additional investment of up to £1bn from public sources to develop and build new grid connections, harbours and other supporting infrastructure in Orkney and Caithness. The idea behind the venture is that the Crown Estate will support these activities as a powerful partner with the ability to tackle bottleneck issues such as permitting, consenting and financial support. The government has proposed that the current system of Renewable Obligation Certificates (ROCs) will be used to support marine energy development, allocating 5 ROCs per MWh to the first projects – which is approximately 2.5 times that for offshore wind. As a result, electricity utilities are now starting to make large investments that will allow array-type technologies to be deployed.

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Notes

1. Offshore wind farm development in the UK to date has taken place in three stages – known as Rounds 1, 2 and 3 – the first of which began in the early 2000s.
2. Exploiting tidal currents avoids the use of barrages, which have been much criticised for their potential impacts on local wildlife.

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Copies of the paper are available from the author for personal use, email: <A.S.Bahaj@soton.ac.uk> More information is also available from the SERG website above.

Nuclear disarmament: then and now

Rebecca Johnson highlights the limited progress in nuclear disarmament since the end of the Cold War. Nevertheless, she argues that new academic research can help to reframe nuclear threats, providing future opportunities for more effective international initiatives to ban nuclear weapons.

While media in some countries carry stories about Iran's nuclear ambitions, most people in the world (including many that jammed city streets for nuclear disarmament in the 1980s) think nuclear threats disappeared or greatly diminished when the Cold War ended. As a growing number of leaders, including President Obama, evoke the vision of security in a world without nuclear weapons, a new civil society movement, including progressive scientists and physicians, is coming to the fore with practical and transformative ideas about how nuclear weapons can be banned and eradicated – in our lifetimes!

More than 20 years since the end of the Cold War and the elimination of the nuclear-armed Cruise and Pershing Missiles and SS20s under the 1987 Intermediate-Range Nuclear Forces Treaty, there are still over 19,000 nuclear weapons in the world.[1] This is considerably less than the 70,000 nuclear weapons in US and Soviet arsenals in 1986, but there are now more nuclear-armed states (at least nine according to non-proliferation assessments) and several potential proliferators.

There has been recent progress codifying reductions in the deployed strategic arsenals of Russia and the United States through the 2011 New START Treaty. In addition, the five nuclear weapon states recognised by the Non-Proliferation Treaty (NPT) have instituted a 'P5' process to talk about nuclear weapons issues such as transparency and confidence-building. Nevertheless, it is clear that traditional arms control and non-proliferation measures have not progressed very far in the past 15 years. The Comprehensive Test Ban Treaty (CTBT) negotiated during 1994-96 has still not entered into force, despite being signed by 183 countries and ratified by 157.[2] The 66-member Conference on Disarmament in Geneva, which negotiated the CTBT after concluding the 1993 Chemical Weapons Convention, has been paralysed since 1997. Despite adopting a mandate to negotiate a ban on the production of fissile materials in 1995, the Conference has been unable to sustain more than a few weeks of negotiations on this measure in 18 years, due to a toxic combination of political and structural factors.

Stuck in the past

Most disarmament and non-proliferation efforts since 1995 continue to be stuck in a 'numbers game' that is dominated by the Cold War powers. The conduct and limited objectives of this approach bear little relation to how the concepts and practices of international relations, strategic stability, human and global security and attitudes towards nuclear deterrence, proliferation and use have been changing since 1991. The debates in the military-defence establishments of the USA, Russia, Britain and France cling to out-dated assumptions about the defence role and indispensability of nuclear weapons, including their doctrines and operations, as if the weapons still had the utility and cachet assigned to them in the 1950s-1970s. All four of these nuclear-armed states expect praise for much touted (but strategically marginal) reductions in their arsenals, while they continue to devote significant funding to modernising their design capabilities and laboratories for renewing, developing, refining and testing their nuclear weapons systems – even claiming that such expensive developments are necessary for them to comply with the CTBT. Similarly, in order to achieve ratification of New START by the US Senate, the Obama administration felt it necessary to promise an additional $85 billion for the US nuclear labs. Such trade-offs are pernicious because they ensure that there are ongoing financial, industrial, scientific and political vested interests in continuing make, deploy and incorporate nuclear weapons in security thinking. This is despite the growing realisation by thoughtful sections of the military and political establishments that nuclear weapons cannot (and must not) be used, and that they are far more of a security liability and a threat to stability than an asset. China has yet to demonstrate leadership in disarmament, but it is interesting to note that, notwithstanding its huge strides technologically and economically in recent years, Beijing has chosen to retain its longstanding positions on nuclear use, deterrence and the maintenance of a relatively small and de-alerted arsenal. (These positions used to be regularly dismissed by Western analysts as doctrinal rationalisations to compensate for economic and nuclear limitations.) At base, however, the P5 behave as if they are in a fantasy world where they can issue rhetorical visions of a world without nuclear weapons while indefinitely possessing and modernising their own nuclear arsenals and somehow closing the door to proliferators.

Political game-changer

That's the disappointing news. The future looks considerably more interesting, and science and scientists have an important role to play. Faced with the disconnect between 'nuclear free world' rhetoric from leaders and nuclear business-as-usual from military-industrial decision-makers, compounded by group-think and collusion by many arms controllers, progressive elements from civil society and governments are now mounting a new challenge. They are leading a process to demonstrate that nuclear weapons are a global humanitarian problem that cannot be safely managed, and that a treaty banning at least their use, deployment and production is a necessary and achievable step towards their total elimination.

Three important elements in this humanitarian-centred approach to nuclear abolition are:

1. updated scientific studies showing that 'nuclear winter' and widespread famine would occur if only a small fraction of today's arsenals were used against cities in a regional war;
2. progressive delegitimisation of nuclear weapons and doctrines. These include academic challenges to the justifications trotted out by nuclear-dependent governments that these weapons of mass destruction are useful or necessary for deterrence, national security and 'ultimate insurance in an uncertain world'. In addition, the combination of economic pressures and opportunity costs have drawn into the open many military practitioners' scepticism about the utility of nuclear weapons;[3] and
3. growing recognition that a treaty banning nuclear weapons is a practical and achievable near-term objective that can be led by non-nuclear governments, and would be a transformative game-changer to accelerate the elimination of current arsenals. Such a treaty would go some way to reducing the value attached to getting and keeping nuclear arms, as well as overcoming the deficiencies in the NPT, whether or not the nuclear-armed states are on board from the beginning.

Nuclear famine

Soviet President Mikhail Gorbachev was persuaded to kick-start disarmament talks in the mid-1980s by US and Soviet scientists who demonstrated that nuclear war would cause planet-wide 'nuclear winter'.[4] Such studies have now been updated with data derived from climate change research and calculations based on the use of only a small fraction of today's arsenals in a 'limited' or regional nuclear war.[5,6] Researchers used a scenario of war between India and Pakistan in which a hundred Hiroshima-sized bombs (small by today's

standards and amounting to just 0.04% of the nuclear explosive power available to the nuclear-armed states in 2011) are used on urban areas. The research demonstrated that the explosions and fires would propel millions of tonnes of soot, smoke and debris into the upper atmosphere, darkening the skies, causing temperatures across the planet to fall by an average of 1.25°C, and disrupting rainfall. These effects could persist for over a decade, with devastating consequences for agriculture and the health and life-cycles of many species. Building on this research, physicians such as Ira Helfand from the Physicians for Social Responsibility and the International Physicians for the Prevention of Nuclear War (IPPNW) have conducted analyses of the health and humanitarian consequences if nuclear weapons were used in a regional war in today's conditions. Bearing in mind increases in global population and urbanisation since the 1980s, Helfand and others have concluded that in addition to the millions that would die from the direct effects of the nuclear detonations on South Asia's major cities, over one billion people around the world would be put at risk of starvation and death due to famine, epidemics of infectious diseases and other health and security disasters that breed on the backs of large-scale hunger and malnutrition.[7]

Political initiatives and responses

Studies such as these have helped to reframe the debate and bring new thinking to the table. In November 2011, the Red Cross adopted a groundbreaking resolution on nuclear weapons. Expressing concern "about the destructive power of nuclear weapons, the unspeakable human suffering they cause, the difficulty of controlling their effects in space and time, the threat they pose to the environment and to future generations and the risks of escalation they create", the Red Cross called for "negotiations to prohibit the use of and completely eliminate nuclear weapons through a legally binding international agreement".[8]

A few months later, Norway's Foreign Minister Jonas Gahr Støre announced his intention to convene an international conference on the humanitarian consequences of nuclear weapons in Oslo in spring 2013. Following this, 16 states participating in the NPT Preparatory Committee meeting in May 2012 presented a joint statement on the humanitarian dimension of nuclear disarmament, which quoted from the Red Cross and called for states to "intensify their efforts to outlaw nuclear weapons and achieve a world free of nuclear weapons".[9]

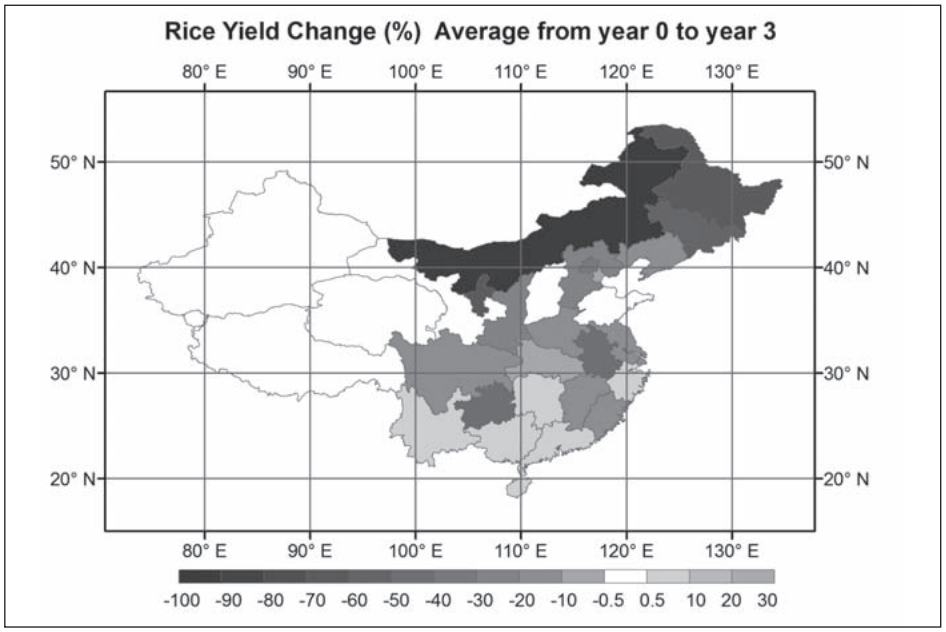

Figure 1. Map of projected rice yield reductions (%) in China for the first 4 years after nuclear conflict between India and Pakistan.[7] Very large negative changes are seen in most areas, with only a few areas experiencing a small increase. White regions are provinces for which model simulations were not conducted.

Despite the growing importance of humanitarian concerns and pressure for a nuclear abolition treaty being signalled in the 2010 NPT Review Conference,[10,11] nuclear-armed governments appear to be surprised by these developments. They have typically deployed three kinds of arguments in opposition:

- that the only practical disarmament steps are the ones they are already engaged in;
- that their nuclear deterrence policies mean that they possess nuclear weapons in order for them not to be used; and
- they try to diminish the relevance of international humanitarian law by reducing it to the 8 July 1996 Advisory Opinion of the International Court of Justice, which, they say, did not conclude that the use of nuclear weapons would violate international law in all circumstances.

It is too early to judge whether reawakening concerns about the humanitarian consequences of nuclear weapons will change the political context sufficiently to drive more substantial and effective progress towards nuclear disarmament. Those looking through the traditional lens of strategic stability and arms control, which includes most people in the policy establishments of the nuclear-armed states, maintain that states with nuclear weapons have primary security interests and have to be the main actors in nuclear disarmament. Humanitarian and human-security approaches by contrast make disarmament an equal responsibility for the nuclear-free countries. Only nine countries are capable of launching a nuclear attack but the consequences of even limited uses would be globally devastating. So everyone has direct and primary security interests in prohibiting the weapons and preventing their use.

At present, possession implies deployment implies doctrines and operations for use (necessary for signalling 'credible deterrence'). The non-nuclear countries know their role in the physical elimination of the arsenals will be marginal, but the humanitarian approach emphasises their rights and responsibilities to strengthen the international and legal obligations. A growing number now argue for a multilateral treaty to ban the use, deployment, production, transfer and proliferation of nuclear weapons. Negotiations involving nuclear possessors will at some stage need to work out the provisions, conditions, timelines and verification requirements for eliminating the weapons completely, but history teaches that this is more likely to become feasible when the weapons have lost their strategic value and their use and deployment are outlawed.

Want a 'nuclear free world'? Time to ban the bomb!

As we have seen with the Chemical Weapons Convention, the 1997 Mine Ban Treaty and the 2008 Cluster Munitions Convention, many effective treaties start with highlighting the consequences of use. If the Conference on Disarmament remains blocked, treaties can be initiated by groups of concerned

governments and carried forward to conclusion, adoption and entry into force through other multilateral processes. Even if not all of the countries possessing the weapons of concern join the treaty, they become progressively constrained by its provisions and legal status.

Humanitarian disarmament approaches do not undermine current arms control or present a 'nuclear weapons convention' as the only answer. By focussing on use rather than numbers, they aim to delegitimise and outlaw the weapons. International legal recognition that nuclear detonations would violate international law and be treated as a crime against humanity would greatly increase the political and legal pressure on nuclear armed states to take their weapons off deployment and undertake the necessary steps to dismantle and eliminate them.[12,13] Compared with the nuclear threats, policies and arsenals still around more than 20 years after the Berlin Wall was pulled down, reinvigorating nuclear disarmament and changing the status quo would be a major step forward.

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Sustainable building materials: how eco-friendly are they?

Insulation has little 'wow' factor compared to solar panels, but greater potential to reduce carbon emissions cheaply. However, it is crucial that we consider the energy required for their manufacture: natural, non-toxic materials consume the least energy and are safer for human health, argues Tom Woolley.

There is general acceptance of the need for buildings to be well-insulated but much less awareness of the wider environmental and social impact of mainstream insulation materials. New buildings must meet high energy-efficiency standards, and the UK government is also introducing the new – but somewhat flawed – Green Deal scheme to encourage greater retrofitting of existing buildings. While there is a strong case for increasing our use of renewable energy sources to help to reduce carbon emissions – although less so for micro-renewables on individual houses – improving the fabric of buildings is a far cheaper and more effective way.

The importance of establishing a thermally efficient building envelope, a concept known as 'fabric first', is accepted by many experts, but there is a surprising lack of expertise in how best to insulate buildings. For many, insulation is insulation: it does not matter what you use as long as the insulation supplier says it has a good thermal resistance. However, insulation materials perform differently and some are not appropriate for renovation. Furthermore, manufacturers' claims about thermal performance can be misleading; a product may not perform as well once it is installed.

Embodied energy of insulation materials

Insulation should be selected according to strong environmental criteria. The market is dominated by synthetic materials, many of which are made from petrochemicals and contain toxic chemicals that may harm the indoor environment. They also present a pollution hazard when disposed of in landfill. The energy required to manufacture, transport and install them – called the embodied energy – is largely ignored by energy efficiency advocates. Bodies like the AECB (now also known as the Sustainable Building Association), which used to promote use of ecological building materials, now support the use of synthetic materials and argue that the damage these materials do to the environment can be justified by the energy they save over the building's lifetime.[1]

However, there is growing evidence to the contrary, as recently demonstrated by work in Finland[2] which examined the total energy used in the early stages of building construction, called the 'carbon spike'. The carbon spike can outweigh the energy efficiency savings over the lifetime of a building. De Selincourt[3] argues that this problem is a "ticking time bomb", as carbon emissions during construction will enter the atmosphere sooner and cause warming earlier than emissions during operation. Work in the UK on the

carbon foot-printing of buildings[4] also shows that embodied energy is at least equivalent to operational energy. Embodied energy can be significantly reduced by using much more environmentally friendly materials.

It is now possible to select from a wide range of low impact, renewable materials that have a much lower embodied energy and do much less harm to the planet, based on timber, wood fibre, hemp, wool, straw, earth, lime, and recycled sources. Timber frame construction is still not established despite attempts by some public sector organisations to adopt a 'wood first' policy.[5] However, low impact, renewable materials also have many other advantages over synthetic materials. They can handle moisture and store heat more effectively, and are healthier to install and live with, and their manufacture and disposal are less polluting to the environment.

There is some prejudice against natural renewable materials over their durability, but building owners are increasingly choosing environmentally friendly products even when they are more expensive. As a result, even during the current recession, the production of ecological materials is growing. As the output of natural materials increases, their unit cost comes down, making them more competitive.

Other problems of synthetics

Many of the manufacturers of synthetic insulation products use 'greenwash' statements to convince architects and their clients to use petrochemical-based synthetic products. They claim their materials are healthy, good for the environment and perform better than natural materials. Many architects and the general public accept this without question.

However, claims about the recycled content of many man-made fibre insulations have been criticised by the UK Advertising Standards Authority.[6] Health risks from fibres, glues and flame-retardants remain a problem despite a 2003 report by conservation body WWF drawing attention to toxic chemicals found in the blood of young people.[7]

Foam insulation products are based on petrochemical 'polyols' and toxic additives such as isocynates. Most manufacturers have reduced the use of ozone depleting foaming chemicals but have substituted other greenhouse gas chemicals. Some insulation foams contain soya but are still 80% polyurethane. The Pharos Project, which campaigns for transparency in the building materials market, recently reported the death of a spray foam applicator in Massachusetts, USA.[8] Emissions of volatile organic compounds in buildings are not regulated in the UK, whereas in Germany there are strict emission levels and indoor air quality standards. These have affected the selection of flooring, glues for flooring, paints, boards and other finishes as well as general building and insulation materials.[9]

Eco-friendly options

A more environmentally responsible approach would be to use natural, non-toxic, renewable, bio-based materials that require little energy for their manufacture and lock carbon dioxide into the fabric of the building, known as carbon sequestration.

Ecological materials fall into three main categories:

1. Composites of biologically based materials mixed with binders such as hemp and lime, or earth and straw. These can be used with a timber frame to create solid walls, and even floors and roofs.
2. Manufactured composites such as wood fibreboards, flax, hemp, wool and other insulation combinations (known as 'quilts and batts'), usually using natural glues and resins present in the materials.
3. Low impact products made from genuine recycled materials such as 'foam glass'.

Other bio-based materials are available that not only outperform lightweight synthetic insulation materials, but also help control dampness in buildings and are breathable, helping to make buildings healthier. Some of these materials are being adopted by mainstream construction in the UK. For instance hempcrete – a mixture of hemp and lime – has been used to construct large food and wine warehouses, offices, and a superstore. There are also some social housing schemes that have been built with 300-400 mm solid hempcrete walls. The solid wall is breathable, fire proof, non-toxic and provides a good level of insulation.[10]

It is regrettable that mainstream advice on eco-building materials fails to give due attention to natural materials. For example, the BRE's widely used Green Guide[11] fails to give ecological materials a better rating than those made from petrochemicals, and even gives a high environmental rating for PVC windows! Alternative certification is now available through Natureplus,[12] a rigorous international environmental standard, which only approves materials that contain little or no petrochemicals and considers manufacturing, sourcing of materials, and ethical issues. In 2011, a wide range of UK companies formed the Alliance for Sustainable Building Products[13] to press for greater use of eco-friendly building materials.

Tom Woolley is an architect with Rachel Bevan Architects and a member of SGR's National Co-ordinating Committee. His new book Low Impact Building explores these issues in greater depth and will be published by Wiley in 2013.

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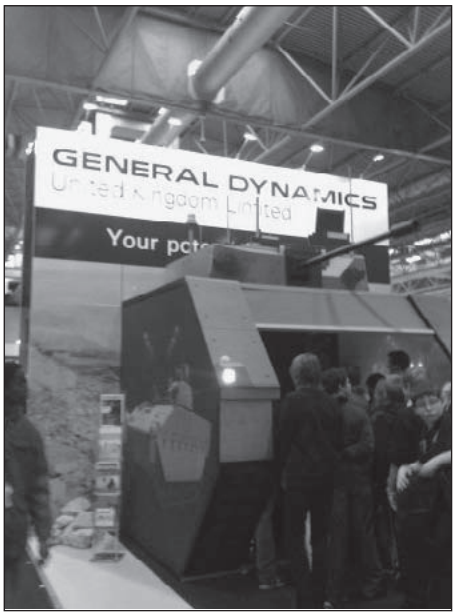
Challenging corporate influence within science communication

Alice Bell argues that corporate sponsorship of science communication has gone too far, and announces a new campaign to challenge it.

You might have heard of the Big Bang Fair.[1] A major part of National Science and Engineering Week, it attracts tens of thousands of schoolchildren every year. It's run by Engineering UK in partnership with various science and engineering organisations, but supported by a host of industrial sponsors, one of which is BAE Systems.[2] It's tempting to crack a joke about arms manufactures knowing their big bangs – except that glamorising weapons isn't funny...



General Dynamics' mock-up of a tank at the Big Bang Fair

When a peace campaigner stumbled across the event last spring, she found that BAE had more than just space for a logo, it had a stall where they were handing out toy submarines. Disgusted by this and by several of the other stalls she spotted, she posted a gallery of pictures online (see photo), commenting "basically it's an arms fair for children with a bit of environmental destruction thrown in for good measure". If the Big Bang Fair makes you uncomfortable, you might want to avoid the Science Museum. Their Energy Futures gallery is sponsored BP; their content on climate science bears a Shell logo.[3]

I'm not necessarily against the corporate sponsorship of science communication. I'd rather such things were funded through taxation, but I'm also pragmatic. I paid my way through university with a job at the Science Museum, staffing several of the sponsored galleries and events. I judged last year's Google Science Fair. I've written for newspapers that carry advertising. I didn't feel limited by any of these sponsors. In fact, I loved sharing Capital FM's old equipment with schoolchildren in the Science Museum's old hands-on radio gallery, and I thought Google used its brand effectively to connect teenagers with some inspiring ideas. It's worth noting the Science Museum's collection has roots in the old Patent Office museum; that's where they obtained Stephenson's Rocket. Industry is part of science and, when you can tap into it, holds a lot of expertise.

But there are questions to be raised about who is involved in science communication, as well as the nature and transparency of deals with publicly funded institutions. There's been a fair amount of criticism of the sponsorship of the arts in recent years, with groups like Liberate Tate and Reclaim Our Bard drawing particular attention to the role of oil money in galleries and theatre. And yet, there's been little activism around science in public culture. There was a press release from Scientists for Global Responsibility and Campaign Against Arms Trade condemning BAE's involvement in the Big Bang Fair when it first launched in 2009,[4] but that's about it. Mention the Science Museum to environmental activists and they'll refer to the Shell sponsorship with some distain, but you are much more likely to find them on the roof of the National Gallery.

Perhaps this is due to the same reason that science museums also complain that it's hard to get sponsorship: science lacks the mainstream sparkle of arts. At best, kids' stuff, at worst a bit esoteric and dull. I also suspect it's caused by a lack of political awareness (let alone active criticism) within the science communication profession, and within much of the scientific community at large.

What science lacks in glamour, it more than makes up for in allusions to authority, openness, honesty and rigour. There's a reason shampoo adverts carry a science bit, and I'm not sure I want public institutions to be used to provide such ethos. I also worry that, especially in an age of creeping cuts, science communication professionals will avoid working on anything too critical or controversial, lest they put a future crucial sponsorship deal at risk. I worry corporate PR ends up capturing a lot of publicly funded creative endeavour, initially financed through science or culture budgets.

Done well, the public communication of science is more than feeding knowledge to the masses and ensuring the next generation of undergraduates (though that's important too). It's a chance to take research out of its bounded ivory towers and enrich it with a broader perspective. It's a chance to think about the science we do, why and how. It's a chance to make the science we want, not just blithely pass on the science we've been given. It has incredible transformative power. And the UK is a world leader in the field. We spent a few hundred years building some amazing science communication institutions. That's a precious resource.

Science communication needs to see industry as more than just moneybags; to stand up for itself, and use sponsorship deals as a chance to further open up industry to public discussion, appreciation and scrutiny. Science communication needs to use industry, not be used by it. We all need to be asking questions. Otherwise, who is sponsoring whom exactly?

A new campaign – Science Unstained – has recently been launched to raise awareness of these issues. Find out more at http://scienceunstained.co.uk/

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Local sustainable energy projects: learning the practical lessons

Philip Webber assesses the lessons for UK energy policy from a series of award-winning programmes using micro-renewable energy technologies and domestic energy conservation measures in West Yorkshire, and from new academic research on city-level sustainable energy programmes.

Designing low carbon plans – theory or practice?

How do you design a low carbon plan? With so many possible technologies and other options to consider, a standard financial tool is a marginal abatement cost curve (MACC). This is a plot of the cost per tonne of carbon dioxide saved, against the total amount of carbon removed for each action. An example is shown in Figure 1. An 'ideal' programme starts with the most cost-effective actions (on the left) and works through the list until you reach the carbon reduction target (dotted line).

Based on these graphs, energy efficiency measures that are estimated to lead to a cost saving over their lifetime would be carried out immediately, while the more expensive supply-side measures would be carried out last. But generally even the most cost-effective measures are not installed without some external help. There are many reasons – mainly that energy saving is not high on people's personal spending agendas but, even when it is, many people distrust installers, and this can be compounded by negative media coverage.

In my own experience in leading large-scale low energy programmes for over a decade, we did not follow a MACC analysis. This was mainly because the public funding mechanisms during the period created a series of incentives to install solar photovoltaics (PV) before insulation, for example, rather than the other way around. This highlights the importance of taking account of the practical experience, as well as the economic and technical research, when developing workable policy options. Unfortunately, as I discuss later, this is what current UK energy policy is failing to do. Before coming to this, I will outline our work in Kirklees, West Yorkshire.

Sustainable energy programmes in Kirklees

Table 1 gives a brief summary of the main programmes[1,2] that we undertook in Kirklees between 2000 and 2011.

SunCities Solar Villages

When we started the first project 'SunCities Solar Villages' in 2000, the solar industry was in its infancy, and the UK government and the EU were offering grants for large-scale PV piloting and testing. One key aim of the project was to purchase PV modules at a large scale to stimulate the market, create jobs and reduce the price of the technology. This project funded the installation of around 2,000 PV systems in Germany, the Netherlands, and Kirklees. I reported on this programme in an earlier *SGR Newsletter*.[3]

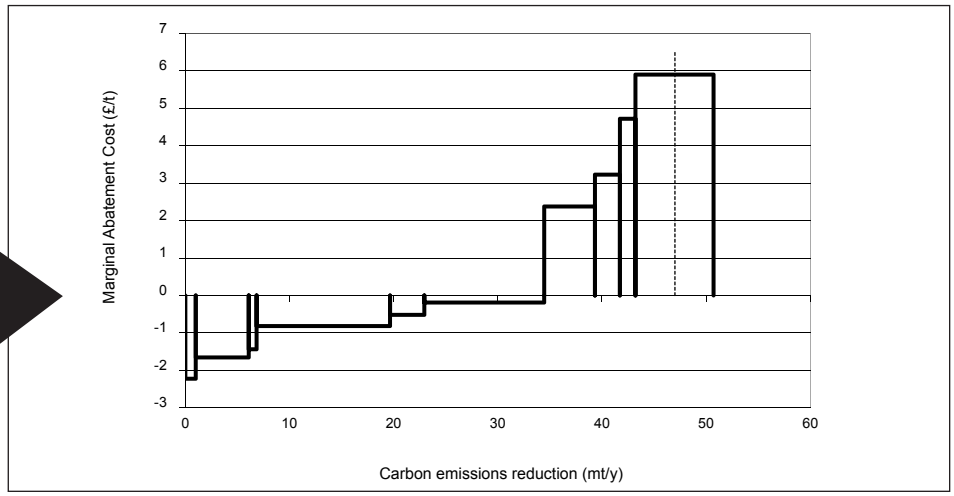

Figure 1. An example marginal abatement cost curve. The measures towards the left-hand end tend to be energy efficiency improvements (e.g. home insulation, energy efficient lighting), which have a negative cost over their lifetime because the cost of the energy saved is greater than the cost of installing the measure. The measures towards the right-hand end tend to be the more expensive supply-side options, such as nuclear power or solar photovoltaics.

What difference did the solar panels make? The PV and solar thermal panels were an 'add-on' for a number of local housing projects, including new-build houses, a housing refurbishment programme, a new 'carbon neutral' development, some electrically heated housing for older people, and a few care homes. In a significant number of cases, the solar panels helped combat fuel poverty and were also part of new, good quality, cheap-to-rent-and-run housing where formerly there had been very poor housing with associated crime and community problems. The extensive consultation process created a real sense of community. In some areas, people became very enthusiastic about reducing their electricity bills and seeing how much money they could save by using appliances when the sun was shining. What the PV did – because it was highly visible – was create a 'buzz', something that was a subject of local discussion, media attention and even a royal visit. The fact that the new housing was much better insulated did not. Another key factor in the success of the scheme was that no-one had to pay for any of the new appliances – either the PV was 100% funded by the project, or it was paid for by the landlord (the council or the housing association). The housing association was also very supportive due to the reduced running costs. But the carbon reductions due to the PV were small compared to those due to improved home insulation, and the insulation was much more cost-effective.

Another point to note is that the price of PV fell by a factor of four over the period of the project. Obviously, this project only played a small role in helping to bring technology costs down but, nevertheless, this shows the rapid rate of cost reduction in this area.

Warm Zone

The next big project in Kirklees was Warm Zone. This was a £21m investment to install free cavity and loft insulation in any home that wanted it, and where it was technically feasible. This was easily the largest UK insulation programme at the time (and still is one of the largest). By the end of Warm Zone, over 50% of the approximately 180,000 houses in Kirklees had been insulated with loft and cavity wall insulation. We also referred people for boiler upgrades via the Warm Front scheme (another grant scheme). Households were also offered free debt, care and benefits advice, a free carbon monoxide monitor, low energy light bulbs, security advice via the police and smoke alarms via the fire brigade. Via the Primary Care Trust, we fast tracked households with those suffering from severe illness or disability.

Programme	Period	Total spend	Number of households with energy measures installed	Main measures installed	CO_2 saving (tonnes/ year)	Main contractors	Funding source
SunCities Solar Villages	2000-05	£1.8m	518	350kWp PV; 63 solar thermal; insulation measures	110	Solar Century; Solar Energy Systems; Sustainable Energy Systems	Nine funders including EU, DTi, Kirklees Council, and housing associations
Warm Zone	2007-10	£21m	51,155 (NB many households had both measures)	42,999 loft insulation; 21,473 cavity wall insulation	~23,000	Miller Pattison (via Scottish Power); Yorkshire Energy Services	Carbon Emissions Reduction Target (CERT); Kirklees Council
RE Charge	2008-11	~£3m	281	236 solar PV; 23 solar thermal; 22 others	336	Yorkshire Energy Services	Kirklees Council; Feed-in Tariff

Table 1. Kirklees low carbon community programmes 2000 – 2011

The free service included scaffolding, cutting of new loft hatches for access, and even, in extreme cases, a loft clearance service to enable the insulation to go in. We would also top up loft insulation (which many other schemes would not do).

The benefits of Warm Zone were many. We achieved the highest take-up rates of any similar project in the UK. We delivered a very large energy and money saving for householders. However, much of the impact of this was hidden by energy price inflation. Our door-to-door advice service made a big difference to many disadvantaged people's lives, including some in severe financial hardship. We helped them to access not just adequate insulation, but a whole range of measures to help lift them out of poverty. The project also helped in stopping several gas leaks and instances of low-level carbon monoxide poisoning.

The Warm Zone also demonstrated substantial regeneration benefits.[4,5] We counted over 100 direct jobs created with associated economic benefits. The health benefits of warmer, drier housing includes reduction in the severity of many illnesses (respiratory conditions, angina etc), and increases in children's educational performance. Typically, the insulation paid for itself in around five years via savings on heating bills, but economic assessment shows that the wider benefits are much greater. These include up to 40 years of energy savings due to the insulation products, 15 years of health-related benefits, and four years for job creation and contribution to the local economy. Our estimate was that the total benefits by around 2050 would be around £250m from an investment of £11m from Kirklees Council plus £10m from the energy industry via the national Carbon Emissions Reduction Target (CERT) scheme.

However, despite our high take-up rates, significant numbers of properties remained uninsulated. In total, this included about 35,000 houses with cavity walls, and a similar number with solid walls or very thin or irregular cavities that we could not fill. This demonstrates the limitations of a voluntary marketing approach – even with a free product and extensive local publicity, including radio and TV coverage, billboards, buses and community organisations.

RE Charge

Over roughly the same time period, we offered free renewable energy installations up to the value of £10,000. RE Charge gave grants for PV, solar thermal, biomass, heat pumps and even a micro-hydro plant. A condition was that the property had to be insulated with cavity and loft insulation. The installations were paid for via a council interest-free loan only repaid at property sale (so typically after several years). Advertising was minimal, but we quickly built up a large interested customer base, which was addressed on a first-come first-served basis until the money ran out. Clearly, this highlights the much greater cost of renewable installations at around £10,000, compared to the simplest insulation, which costs typically under £500.

In implementing this scheme, the key issue was the choice of which renewable energy technology to install. Householders received a free assessment of the best 'fit' to their lifestyle. In 85% of cases, we found that the most cost-effective technology fit was actually PV. We had problems with the domestic biomass systems available. Often there were hidden costs in upgrading flues and also problems in ensuring that people knew how to operate the boilers (which are obviously very different to gas appliances), including lighting and cleaning.

Lessons

One of the main conclusions I take from these schemes is that large numbers of householders (and landlords) remain unconvinced even by cheap, reliable, and easy-to-fit cavity and loft insulation with a lifetime guarantee backed by a coalition of reputable local public bodies. Insulation is invisible, silent and not 'fashionable' so it does not really advertise itself. Unlike a PV panel, there is no meter clocking up the energy saved. In contrast, in quite poor housing areas where the council upgraded homes with external wall insulation (block insulation plus render), this was extremely popular. Houses looked brighter, as well as being quieter and warmer. The popularity was such that those not eligible for free external wall insulation were willing to pay several thousand pounds to have their home as good as their neighbours! Clearly appearance and perceived status can be a more powerful driver of change than cheaper non-visible solutions.

This echoes a common view within marketing – that larger numbers of people are motivated by status or fashion rather than by moral or environmental reasons. Others still – the so-called 'hard-to-reach' groups – will only listen to trusted 'leaders' within their community. This highlights the importance of a range of publicity, engagement and marketing processes,

including capitalising on attributes of a given technology that appeal to individuals' sense of status.

Current UK energy policy: ignoring the lessons

An important factor in the success of the Kirklees Warm Zone programme was the Labour government's CERT scheme. This mandated carbon reduction targets for energy companies, which they had to achieve through supplying 'subsidised' insulation for householders. However, because a relatively low price was put on each tonne of carbon saved, the effective subsidy for even the cheapest energy saving measures was only around 50%. In Kirklees, this was matched by the funding from the local council – hence the ability to carry out a much larger and more successful programme. Much more could have been done across the country if the funding through CERT had been higher. Indeed, the emissions reductions under CERT funding (about £1.3bn/year) had a 30% underachievement against target by summer 2011.[6] Despite this, CERT was fairly successful at getting homes better insulated via the simplest and cheapest measures. But the Coalition government will stop CERT (and Warm Front etc.) by the end of this year and launch a completely new programme – the Green Deal – accompanied by a new grant scheme called ECO (Energy Company Obligation), which will be used to subsidise approved measures under the programme.

The Green Deal will offer householders (and small businesses) loans up to £10,000 to pay for efficiency measures identified in a whole house/building assessment, as long as predicted energy savings exceed loan repayments each year of the loan period (up to 20 years). Repayments will be paid via the electricity bill and will stay with the property not the householder. The idea is that, if the cost is balanced by savings, there is no net cost to the householder or the government. Also, the carbon saving from reduced household energy consumption will not be gobbled up by extra spending on (say) a high carbon flight abroad. The problem with this is that offering something at zero cost is not generally a sufficient incentive to achieve high take-up rates. Also people are wary of signing up to long term agreements based on uncertain future predictions. In fact, the government's own impact assessment[7] predicts a massive reduction in the amount of efficiency measures deployed because of what it calls the 'hassle factor' (the process of signing up to a loan agreement etc). In addition, support for micro-renewables through the Feed-in Tariff and Renewable Heat Incentive has been limited to a few hundred million pounds per year.[8]

It seems that key lessons from the Kirklees programmes and elsewhere are not being taken on board by the current government. As we have seen, there are many non-monetary obstacles to households taking even cost-effective action on energy conservation. Additional financial incentives are therefore critical in kick starting such programmes. Significant upfront finance is also needed to support micro-renewables programmes. Yet when sufficient investment is provided to a well-organised domestic sustainable energy programme, many obstacles can be overcome, and the benefits – economic and social, as well as environmental – can be huge. Personally, I think that the primary reason for the new government approach is a narrow ideological focus on market-base 'solutions' regardless of the evidence. In my view, the very clear benefits of domestic sustainable energy programmes make them a prime candidate for direct government support at scale.

City-level low carbon programmes

At the start of this article, I discussed the role of MACC curves in guiding investment in carbon reduction measures. While they have to be used with care because of the practical limitations, they are still very valuable in helping to guide energy policy. Recent MACC-based analysis has estimated what could be done using finance at commercial rates across the housing, business and transport sectors for several large city regions in the UK. These studies have yielded intriguing results. For the Leeds city region (with a population of three million), funding of £5bn would pay for itself from energy savings over four years. Funding of £13bn would pay for itself in eight years – and generate nearly 9,700 jobs while leading to carbon reductions of 19% by 2022.[9] Scaling this to the UK, low carbon initiatives in the region of £100bn to £260bn would be self-funding over periods of four to eight years and create about 200,000 jobs.

This scale of spending dwarfs government low carbon plans by 30 times or more but is comparable to the scale of spending that government identify as required for more conventional infrastructure investment (such as Crossrail). Government is beginning to offer direct funding for such projects. The city-level studies show that there is a strong case for government to offer direct funding for at least one city region to pilot this concept. It would be, and should be, part of a comprehensive infrastructure modernisation programme for the UK – especially given the major potential to create jobs in the local economy.

But finance in the £100bn-£300bn range *is* out there in the economic system outside of government, and looking for somewhere to invest. Ironically, the continuing financial crisis and extremely low interest rates mean that pension funds, which routinely look for investment packages of £500m a time and which have several billion looking for a good home, are struggling to secure safe long-term returns. They would settle for a rate of return as low as 2-3%. Low carbon programmes can easily deliver rates around 12%. I am part of a Leeds-based group of researchers and practitioners who are currently exploring ways to link the city-level studies and the finance together so that investment will be forthcoming. Apart from the Leeds city region, big local authorities such as Birmingham, Manchester and Southampton are also designing low carbon programmes.

If even one of these schemes happens, it might start to change the current government's less than enthusiastic position on the potential of green economy, as well as addressing some negative attitudes within the public at large. I see this as the only positive light on the green horizon in the UK at present.

Philip Webber was head of the Environment Unit at Kirklees Council from 1990 to 2011. He is Chair of SGR and a visiting professor at the University of Leeds.

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Slowly boiling the frog? Reasons for disquiet over synthetic biology

Helena Paul and Ricarda Steinbrecher warn that the rapidly developing field of synthetic biology – which proposes releasing artificial living organisms into the environment – is running ahead of the necessary precautionary controls.[1]

Synthetic biology is presented as a potential means of addressing challenges and bringing economic benefits for society.[2] Underlying this is the unstated proposition that perhaps science can help politicians sidestep political and economic problems through new technologies. There is no agreed definition of what exactly synthetic biology is, and how it differs from genetic engineering used to produce GM organisms so far. However, the definition provided by the UK Royal Society is one place to start: "the design and construction of novel artificial biological pathways, organisms or devices, or the redesign of existing natural biological systems."[3] The language of 'synbio' is that of computing and the images are concepts from engineering, with talk of building new assemblies of DNA on the hollowed out chassis of a cell, while the practice is still largely cut, copy, mix and paste.[4]

Although the presentation of synthetic biology is becoming more nuanced, the image of biological components as pieces in a game is developing through iGEM, a series of international student competitions focused on the issue.[5] Some are tempted to believe that we will use synbio to 'improve nature', for example, through the creation of organisms that are more 'efficient', with functions that do not serve a human purpose being deleted and those that do being enhanced.

Uncertain science

However, first attempts have revealed that we do not understand enough about gene functions and interactions to build new organisms from scratch, or even decide which genes to leave out of a 'minimal' genome. It is largely a hit and miss process, useful for learning but not ripe for release. Few genes and/or their products are involved in only a single function or activity. Most have several functions and interact with each other in complex and subtle ways in response to circumstances. This demonstrates that genomes are dynamic systems.

To some extent, synthetic biology is an extension of genetic engineering and it can be difficult to differentiate between the two especially where they overlap. Synbio ranges from synthesising known genes from sequence data to designing completely new genes, working with entire genetic systems instead of single genes and proceeding at a much faster pace and broader scale.

Can policy and regulation keep up?

We therefore need to ask whether current analysis, regulation, and risk assessment models are equipped to deal with new and emerging challenges posed by both genetic engineering and synbio, especially as the technologies move further away from genetic engineering, as we assume they will. How can we update regulation, oversight and mindsets to deal with this?

Beyond oversight and regulation, there are wider considerations. The development of new and the refinement of existing technologies raise new scientific, ethical and socioeconomic questions, but these are rarely addressed under current forms of risk assessment and decision-making. The public almost never has the opportunity to debate these issues, or whether certain technologies should continue to develop, and if so how. There is currently no mechanism to halt a technology the public does not want and views as dangerous. The problem is compounded by the fact that equipment is increasingly cheap and almost anyone can access and use DNA sequences, unsupervised, for any purpose, with potential for deadly mistakes and aggressive applications.

There are thus major tensions between promoting synthetic biology to address political and economic problems and the need for extreme caution when considering the potential environmental impacts of releasing novel organisms. One proposed technical solution is to develop strategies to prevent the survival or reproduction of these organisms. For example, with bacteria, certain fungi (including yeast and moulds) and small algae, strategies considered include changing their genes to prevent them from producing or metabolising vital nutrients, so theoretically they could not survive in the 'wild'. However, horizontal gene transfer, a survival and evolutionary tool highly developed and utilised amongst micro-organisms, enables them to share information and quickly replace missing or faulty genes. Biological containment – including Genetic Use Restriction Technologies (GURTs), also called 'Terminator Technologies' – intended for plants and animals, is a flawed strategy and an unreliable practice. Every organism has a clear interest in reproduction and survival and will tend to adapt. The UN Convention on Biological Diversity has established a moratorium on Terminator Technologies and is considering a similar moratorium on the environmental release and commercial use of organisms produced through synthetic biology. These provide a vital opportunity to pause and consider the implications before releasing the products of such technologies into complex and still little understood environments.

And this is the most important point of all. While genetic engineering is useful for research, our understanding of the ecosystems into which genetically engineered organisms and the products of synthetic biology could be released, either deliberately or accidentally, is still in its infancy. Ecosystems are highly complex, dynamic webs of interrelationships that we are barely beginning to understand and we urgently need more research. We should observe and try to understand better the systems we depend on before we risk releasing synbio products into them. We cannot allow political expediency, facilitated by technology, to take precedence. We must beware of becoming like the proverbial frog in the slowly heating water – it does not perceive the gradual change in temperature, fails to jump out while it still can, and is finally boiled.

Helena Paul and Dr Ricarda Steinbrecher work for EcoNexus, a public interest research organisation analysing developments in science and technology and their impacts on environment and society.
http://www.econexus.info/

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Fallout from Fukushima: the impacts so far

18 months have passed since the massive earthquake and tsunami off the east coast of Japan triggered the Fukushima nuclear accident. Ian Fairlie and Stuart Parkinson give an overview of why the nuclear disaster happened, why it is still occurring, and its implications to date.

New information about the Fukushima nuclear accident is still emerging on a frequent basis, and so this article will necessarily only give a snapshot of the evidence to date. Nevertheless, there is much about the disaster and its effects that has become clearer in recent months, so this is a good time to take stock.

The nuclear accident[1]

Following the earthquake on 11 March 2011, the three operating reactors at the Fukushima Dai-ichi nuclear plant[2] automatically shut down because of huge lateral vibrations caused by the quake. But the quake also disconnected the reactors from the national grid, meaning power to the cooling pumps was lost. Emergency diesel-powered pumps kicked in but these were unwisely located in reactor basements, which were flooded by the tsunami arriving 20 minutes later. The result was inexorable rises in nuclear fuel temperatures until the fuels melted.

Because of the paramount need to remove the large amounts of 'decay heat' from nuclear fuels, both in the reactors and in the ponds containing the spent fuel, cooling failures resulted in a compound, cascading series of explosions and other events, which are still being unravelled. The major events were as follows:

- core meltdowns occurred in the reactors of Units 1, 2, and 3;
- explosions destroyed the reactor buildings of Units 1, 3, and 4;
- an 'explosive event' damaged the containment structure inside reactor 2;
- several fires broke out at Unit 4 (luckily, reactor 4 was offline at the time of the earthquake);
- spent fuel stored in the pools of Units 1–4 overheated as their water levels dropped;
- many workers suffered high radiation exposures and often had to be evacuated;
- machinery for reactors 1–4 damaged by floods, fires and explosions remained inoperable.

On 12 March 2011, a probable hydrogen explosion at Unit 1 exposed its spent fuel pool to the open air, released radioactive matter into the environment and caused delays in cooling Unit 3. The ensuing huge explosion at Unit 3 a day later damaged seawater injection lines and vent lines for Unit 2, producing delays in its cooling. It is likely this caused the 'explosive event' on March 15 inside the reactor at Unit 2. A few minutes later, a fourth explosion badly damaged the rooftop area at Unit 4 that contained the spent fuel pond. In other words, explosions at one unit hampered responses to the damage at others, leading to a chain-reaction of explosions and radiation releases. No wonder staff members at the plant were often terrified and TEPCO (the electricity utility) wanted to withdraw all personnel from the plant at one stage.

Within about six hours of the Japanese earthquake, it appears that full or partial nuclear fuel meltdowns had occurred within Units 1, 2 and 3 at Fukushima due to the inexorable heat from radioactive decay inside the fuel. This was quickly followed by the molten fuel (at ~2,000 °C) melting its way through the steel pressure vessels into secondary concrete containment vessels. It is now thought these containment vessels have cracked and much fuel is now in the basement areas of the reactors. At the same time, the water in the spent fuel ponds above the reactors also began to boil, causing their water levels to drop and thus exposing spent fuel to the atmosphere.

So within a few days of the earthquake and tsunami, four major explosions had occurred: one at each of the relevant Fukushima Dai-ichi Units. These explosions caused massive damage, with the result that the reactor building at Unit 1 and the spent fuel pond at Unit 4, in particular, may collapse. It is important to note that the reactor malfunctions, resulting core meltdowns and explosions were due to the earthquake as well as the tsunami, contrary to the explanations given by TEPCO and the Japanese regulators, which only mentioned the tsunami.[3] The point is that the many Japanese nuclear reactors near fault lines are considerably more vulnerable to earthquakes than to tsunami.

The continuing disaster

18 months later, the accident is still continuing in slow motion and will do so for years. Major efforts are still being made to keep the reactor fuel cool to stop it from melting through the bottoms of the reactor buildings into the soil below (although the concrete bases are about 10 m thick). If this were to occur, Japan would be deep in uncharted areas: further explosions would likely occur. Water is also still being pumped into the storage pools to keep the spent fuel covered.

A major headache is the structural instability of the wrecked reactor buildings, which may still collapse due to the massive weight of the storage ponds situated, again unwisely, on top of the reactors. This would spill thousands of tonnes of dangerous spent fuel and radioactive water over the site. Indeed, there have been warnings that the pond at Unit 4 – which contains over 1300 spent fuel assemblies – is especially vulnerable.[4]

When we look further afield, the situation is no better, as very large amounts of radioactivity were emitted to the atmosphere and released into the sea. The former resulted in much land being contaminated with fallout, and large amounts of agricultural produce also being contaminated. In addition, it is known that many nuclear fuel fragments were blasted throughout the plant and even as far as the large town of Iitate over 30 km away. About 100,000 people have had to be evacuated from their homes, most possibly for decades. These effects are on top of the estimated 20,000 people killed by the earthquake and tsunami themselves. The situation is truly numbing and our hearts go out to the Japanese people struggling with the horrible consequences of the earthquake and tsunami and of the Fukushima disaster.

How long will this dire situation continue? It is hard to say, but officials from the International Atomic Energy Agency privately talk of years: other scientists say decades.

Health and ecological effects[1]

Death and serious injuries so far due to the Fukushima accident are certainly small in comparison to the thousands caused by the earthquake and tsunami. About seven deaths to military personnel and plant operators were apparently caused by the site explosions. Nearly 600 deaths have been certified as "disaster-related" – mainly due to ill-effects caused by the evacuation.[5] None of these deaths was due to radiation exposure. But fears remain about longer-term effects, as radiation has decades-long latency periods before most solid cancers appear. Increased incidences of thyroid cancers – a prominent effect after Chernobyl – are unlikely to appear for another three years.

The first main projection of radiation-related deaths was by Professor Frank von Hippel at Princeton University in September 2011.[6] Hippel estimated an


Digital Globe

Satellite image of the damaged Fukushima Dai-ichi reactor buildings, 16 March 2011

additional 1,000 fatal cancers would arise from Fukushima. A more detailed study by Mark Jacobson and John Ten Hoeve, researchers at Stanford University, was published in July 2012.[5] They used an atmospheric model to estimate the dispersion of the main radioactive materials released by the accident, together with the 'linear no-threshold' model for radiation effects. Estimates for internal radiation from contaminated food were added. Their best estimate was 130 additional cancer-related deaths, and 180 non-fatal cancers to the year 2061. The uncertainty in the number of deaths ranged from 15 to 1,300. The researchers pointed out that two key factors meant that the exposure of the population to the release of radioactivity – and therefore the estimated death rate – was much lower than it could have been. Firstly, over 80% of the radioactive material was deposited over the Pacific Ocean and, secondly, the Japanese authorities did take major preventative actions – including large-scale evacuations and bans on contaminated food.

Studies of the ecological impacts have also started to be carried out. For example, data on the contamination of fish in coastal waters (within 20 km of the site) has been published by TEPCO.[7] Of 50 samples, over half were contaminated above the levels allowed for human consumption, and one was 50 times above this level. Another study, this time on butterflies, has highlighted both physical and genetic damage resulting from the radioactivity, and pointed out that the damage has increased in later generations.[8]

Further assessments

Fukushima is clearly a major disaster but not as serious as Chernobyl. Radioactive air emissions are much more important than radioactive sea discharges in terms of their resulting radiation doses to people, and the dispersed radioactivity to air from Fukushima has been estimated to be about 10% to 40% of the amount dispersed from Chernobyl. About 1,000 square kilometres near the Fukushima plant were seriously contaminated, but at Chernobyl the corresponding area was over 200,000 square kilometres throughout Europe, according to the European Commission.

The Japan Centre for Economic Research has estimated the full cost of the nuclear disaster, including compensation and decommissioning all six of the Dai-ichi plant's reactors, at 5.7 to 20 trillion yen or $70-$250bn.[9] This is a enormous amount, and is surely having a huge impact on Japan's already weakened economy.

A Japanese parliamentary panel – the Nuclear Accident Independent Investigation Commission – published a report in July 2012 that was very outspoken in its criticism of the government, the nuclear regulators and TEPCO.[10] It commented that Fukushima "was a profoundly manmade disaster – that could and should have been foreseen and prevented." It highlighted many institutional failures, both in advance of the accident and during it, cataloguing "a multitude of errors and wilful negligence." The lack of preparedness shown by the organisations involved was caused by the myth that the risk of major nuclear accidents is vanishingly small, which nuclear power proponents had nurtured over decades.

Perhaps the simplest of the lessons to be learned from Fukushima is that nuclear power is a supremely unforgiving technology. When things go wrong, they can go very wrong with consequences that are extremely difficult to remedy, even in advanced industrial nations. But nuclear power is merely a complicated way of boiling water and, after Fukushima, many countries have begun to examine safer energy policies, especially Japan itself which appears to be moving to phase out its nuclear industry by 2030.[11]

Ongoing political fallout in Europe

The political response to the Fukushima disaster in the months immediately following the disaster was discussed in *SGR Newsletter no.40*.[12] While many countries – including Germany, Switzerland and Italy – opted to phase out nuclear power or cancel proposed programmes, some – notably the UK – vowed to continue with their plans. This stark divide was perhaps best illustrated by two parliamentary votes taken within weeks of each other in summer 2011. In the UK, only 14 out of 650 MPs voted against the government's Nuclear Policy Statements, which proposed new development, while the German parliament voted by 513 to 79 to phase out all nuclear power by 2022.

In the months since then, historically pro-nuclear France has elected a new President, Francois Hollande, who has pledged to reduce the share of French electricity derived from nuclear power from its current 75% to 50% by 2025.[13] Government support for renewable energy will also be increased.

With Austria, Denmark, Greece, Ireland, Norway and Portugal all non-nuclear, and phase-out programmes also in Belgium and Spain, European support for nuclear power is on a clear downward path. Add to this the major problems in the construction of new reactors in France and Finland,[14] and it is little surprise that French nuclear companies are looking to the UK as a safe haven for new nuclear projects – with the Coalition government offering enthusiastic support. Yet, even here, plans for new nuclear are looking decidedly shaky. German companies have pulled out of the Horizon consortium, which had been proposing nuclear plant for two sites, while the government seems in disarray over its Draft Energy Bill which proposes major new financial support being provided to nuclear developers.[14]

It is a sobering thought that on the nuclear power issue after Fukushima, the UK appears to be increasingly out on a limb in comparison with most other European countries.

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This article is an updated version of one published on the SGR website on 7 March 2012.

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   These sites are kept up-to-date, are well-informed, and with good sources. Collectively they cite around 1000 references. Most important, they are pretty even-handed. These sites represent a vast amount of work: it seems they are maintained by a team or teams of Japanese academics.
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Letters

Tidal reef

In response to the letter in *SGR Newsletter 40* by Andrew Ferguson, and the editorial reply, we at the Green World Trust are wholeheartedly in favour of optimising all of our renewable resources including those of sun and wind. However there is another source which can provide energy which is predictable, constant, reliable and would operate for at least 20 hours in every 24. I refer to the tidal energy available in the Severn Estuary, in particular to the harnessing of this energy by means of a 'reef' which would be sited between Minehead in Somerset and Lavernock Point in South Wales.

There is more information regarding this project on the Green World Trust website, see
http://www.greenworldtrust.org.uk/Energy/Tidal/ReefCompared.htm

William Acland, Chair, Green World Trust

Peak oil or climate change?

Mandy Meikle's article 'Why we must prepare for a low energy society' (*SGR Newsletter 40*) addresses the concerns of people who foresee the end of cheap fossil fuels and she rightly describes the ways in which we could manage with much lower energy consumption. However, the *BP Statistical Review of World Energy* published in June 2011 claims that proven reserves at the end of 2010 would be enough oil to last the next 46 years, if global production remain at the current rate. Long before the end of this time frame, all fossil fuel emissions of carbon will need to have been drastically reduced to prevent escalating climate change.

So the vital question is not how long fossil fuels will last but how soon will we begin to treat them as dangerous pollutants?

Dr Morris Bradley, Edinburgh

Technology and control

Bronislaw Szerszynski's article 'Emerging technologies and risk' (*SGR Newsletter 40*) reminded me of three propositions I advanced some time ago, while teaching Environmental Impact Assessment:

- The benefits and dis-benefits of any technology are symmetrical but they may manifest themselves at different levels of organisation and have to be managed so that the consequences do not fall disproportionately on one sector of society, economy or culture;
- Technology cannot negotiate absolute physical thresholds, and as these thresholds are approached the solutions have to be 'ethical' rather than technological;
- Technology may accelerate the rate at which we approach an 'absolute threshold' rather than ameliorate the basic problem.

They are essentially restatements of the Laws of Thermodynamics but as I listen to politicians and economists it seems that they are being encouraged in the belief that there will always be a timely technology to save them in the face of serious long term hazards. Over the years I have tried to refine the model to take account of accessibility, intensity and frequency and the distinctions between electronic technology and all preceding technologies, but the stark truth is that globalism is the creation of a technology that confuses information with knowledge and both with wisdom, which is a function of human control. The admission that actually this technology imposes an inhuman logic remains the issue, and makes us victims of an exogenous authority which we hardly understand let alone control and it makes the very term 'technology' a dubious and a dangerous term.

Bénédict Cowell, Builth Wells, Powys

How influential are the climate change sceptics?

Stuart Parkinson looks at the factors that have led to the prominence of climate change sceptics over the past two decades and asks whether they are as influential as they seem.

In July, the Berkeley Earth Surface Temperature (BEST) project concluded that global temperature had risen 1.4°C over the past 250 years and that "essentially all of this increase results from the human emission of greenhouse gases".[1] The thing that made this conclusion so significant was that the analysis was carried out by a group of scientists initially sceptical of climate change, and was part-funded by one of the Koch Foundations, which are major funders of US climate change sceptic groups.[2]

This could be the death knell of the mainstream public debate over whether global climate change is happening and whether humans are the main cause. But the debate has seemed settled many times before – not least when the Intergovernmental Panel on Climate Change (IPCC) published their second, third and fourth 'assessment reports' in 1995/96, 2001 and 2007 respectively – and the sceptics have proven stubbornly resilient.

Powerful friends

SGR reviewed the influence of climate change sceptics in its report *Science and the Corporate Agenda* in 2009.[3] In it we looked at how large-scale funding by the fossil fuel industry, starting in the USA in the late 1980s, had brought the doubts of a small number of climate scientists into the public realm and had kept them there long after the issues had been settled within the scientific community. As the scientific evidence solidified, support from some corporations (e.g. Shell and BP) fell away while that from others (e.g. Exxon) continued, often via third parties such as public relations organisations and think-tanks.

These think-tanks were generally those espousing free-market views – such as the Heartland Institute – and so the political alignment with right-wing politicians and parties grew. Academics have pointed out that the overwhelming majority of climate change sceptic commentators in the USA have links with free-market/right-wing think-tanks.[4] This political alignment became more deeply entrenched with the rise in prominence of former Democratic vice-president Al Gore as a climate change advocate in the mid-2000s. US opinion polls show that the views of Republican and Democrat supporters on this issue began to diverge strongly from that time onwards.[5] And, of course, the political divergence in views has been reflected in the media, with right-wing outlets increasingly taking a sceptical position.

Hence, the large-scale industrial, political and media support have proven to be a powerful combination for raising the profile of the climate change sceptics despite the lack of scientific backing for their views.

How influential are the sceptics really?

While the public profile of sceptics may be high in countries like the USA and UK, and the political influence within the USA is undeniable, it would be a mistake to assume this is universally the case.

For evidence, consider a recent analysis of media coverage of climate change scepticism which suggests that the sceptics' high profile is largely an 'Anglo-Saxon phenomenon', being much more prominent in English-speaking countries.[6] Coverage – even in right-leaning media – in countries such as France, India, Brazil and China gives considerably less attention to sceptics' views. One possible explanation could be the type of economic system pursued in Anglo-Saxon nations. Academics Peter Hall and David Soskice have pointed out that such nations have historically pursued a stronger free-market approach, having been quicker to liberalise and de-regulate their economies.[7] This culture may have increased political resistance to concepts of 'environmental limits' that are so central to tackling the problem of climate change.

It is also instructive to look at international opinion polls conducted between 2007 and 2010.[8] These show high levels of concern across the major countries, with the average at around 85% considering climate change a 'serious' problem. Even in the USA – which polls the lowest levels of concern among the most powerful nations – this figure stands at about 70%. Concern has grown recently in China, India and Russia, but has fallen somewhat in some Western countries, including the UK. Are the sceptics to blame for this fall? More detailed analysis shows that it is actually more likely to be the cold winters that Europe and elsewhere have experienced recently.[9]

Indeed, the idea that the public's direct experience of extreme weather has a more powerful influence over their views on climate change than criticisms of the science is given further credence by the latest opinion polling in the USA.[10] This shows that belief in, and concern about, climate change is growing in the wake of record-breaking droughts in the country.

Waning support?

In the last year, the sceptics' credibility has been dealt major blows – both by the BEST studies mentioned above and by the behaviour of leading climate sceptic think-tank, the Heartland Institute.[11] Firstly, there were revelations about Heartland's secret strategies to undermine climate science. Then, Heartland launched a series of aggressive adverts including one that likened climate change believers to terrorists. Ashamed of this sort of campaigning, many of its corporate funders withdrew their financial support.

So are climate change sceptics finally a spent force? That view would be premature given their industrial, political and media support. Clearly, their political influence still needs to be challenged, especially in the USA and UK, but neither should we over-emphasise their limited importance.

Dr Stuart Parkinson is Executive Director of SGR. He holds a PhD in climate science.

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The decline of UK military R&D

Continued from p.1

Nevertheless, the trend towards privatisation continued. The Strategic Defence Review of 1998 – carried out by the incoming Labour government – accelerated the process of breaking up and part-privatising the Defence Evaluation Research Agency, the MoD's science and technology facilities. This led in 2001 to the creation of the Defence Science and Technology Laboratories – which remained in public hands – and a major new company, QinetiQ.[5]

A major driver of these initiatives was a desire for industry to fund more of the military R&D spend in the UK, as well as to 'increase innovation'. Numerous new collaborations – such as Defence Technology Centres and Defence and Aerospace Research Partnerships – were started with universities to tap into their expertise. Such initiatives were especially controversial as they attempted to draw in increasing numbers of civilian researchers, especially in engineering, computer science and physics.[6,7,8]

This period of rapid change coincided with the early years of the 'War on Terror' following the September 11th attacks in 2001. With UK forces deployed first in Afghanistan and then Iraq, the UK military budget grew rapidly. However, apart from a brief spike in 2002-3 (which could have been a data collection error[9]), the MoD spending on R&D slowly began to fall again in real terms.

At the end of 2005, the government launched its Defence Industrial Strategy, aiming to improve collaboration between the MoD and the UK arms industry in the procurement of military equipment. This was followed – in late 2006 – by the Defence Technology Strategy, which outlined key areas for military R&D. These ranged from counter-terrorism to robotic aircraft (drones), submarines, and fighter aircraft.[10]

However, for the UK arms industry and its sympathisers, including the House of Commons Defence Committee, these programmes were not enough and they called for greater spending.[11,12] They argued that the public spending on civilian R&D had increased considerably under Labour, and that extra money should also be made available for military R&D. This was despite the MoD's budget still representing 25% of the total public R&D spend.

These calls went unheeded and, of course, the economic situation has deteriorated drastically in the years since. In 2010, with the incoming coalition government – and especially the MoD – facing a financial crisis, major cuts were announced across the public sector over the following five years. It remains to be seen how far this squeeze will eventually affect the MoD's science and technology spending, but the latest figures show that the R&D budget fell to £1.7 bn in 2009-10, this being 17% of total public R&D spend.

SGR's programme on military influence on science and technology

SGR decided to increase its research and campaign work on the military influence on science and technology in the early 2000s, as the 'War on Terror' mentality took hold of policy-makers in the UK and elsewhere.

We began a new research project in 2003, which led to the publication of the in-depth report *Soldiers in the Laboratory*, launched at a parliamentary event in early 2005. With the situation changing rapidly, we followed up with a short update entitled *More Soldiers in the Laboratory* in 2007, and then focused on military influence within UK universities – using data gathered under new freedom of information legislation – for our third report *Behind Closed Doors* in 2008.[13] We carried out numerous education and campaign activities based on the evidence in these reports (see p.5).

Our latest project in this area began at the start of 2012 and is focused on developing specific proposals for shifting public R&D spending away from militaristic ends towards tackling the roots of insecurity and conflict (see p.3).

At this point, it is worth considering 'recommendation 1' from *Soldiers in the Laboratory*. In it, we called on the government to "begin a rapid and significant shift of funding from military R&D to civil R&D". In particular, we recommended "a shift in funds of the order of one-third to one-half of the current military R&D budget in the near term". The actual fall up until 2010 was approximately 37%.[14] In real terms, this fall amounts to £1.0 bn in annual spending. Notably this is similar to the increase in the civilian budget over the same period, which amounts to approximately £0.8 bn. In terms of the proportion of the total public R&D spending that goes towards military projects, this has fallen from 29% to 17% during this period.

So, from this data, one could argue that the government has followed our recommendation closely!

Analysing the decline

Obviously, there are a range of factors at work that have led to the decline since the end of the 1990s. Although military spending increased considerably as the UK government chose to join the 9/11 wars, a significant consequence of the extended wars in Afghanistan and Iraq coupled with spiralling costs on major new military equipment programmes – including the Typhoon fighters, Astute submarines and Nimrod aircraft – was unanticipated budgetary pressures. Military spending could have been increased further to allow an increase in R&D spending, as called for by the arms industry and its supporters, but it was not. Meanwhile spending on civilian R&D was increased markedly, as it was seen by the government as key to the economy and quality of life. Official statistics reveal that the consequence was that total public R&D spending (civilian and military) as a fraction of GDP rose significantly.[15] This was a key science policy goal – as stated in the UK ten year 'science plan'.[16]

This analysis indicates that, despite the Labour government's enthusiasm for the 9/11 wars and a militaristic approach to security more generally, in practice, it still accepted SGR's basic argument that civilian R&D – with its multiple benefits – should be prioritised over military R&D.

It is worth noting, however, that for a few years in the mid-2000s, business and overseas spending on military R&D carried out in the UK did rise.[17] This briefly offset the fall in MoD R&D spending during this period, but by 2008, these other sources of funding had fallen back as well.

Will the decline continue?

With the MoD's budget planned to contract by 8% between 2010-11 and 2014-15,[18] the contraction in R&D spending seems set to continue, at least in the near term. However, in February 2012, the MoD published its latest White Paper on military technology, creating a new target that its spending on 'science and technology' (which is predominantly scientific research) will not fall below 1.2% of its total budget.[19] As Figure 1 shows, the MoD's research spending has long been significantly smaller than its spending on technological development. However, the fall in the former in real terms has been smaller. This new target is intended to slow that fall but, since it is a relative target, absolute spending by the MoD on research is likely to continue its downward trend until at least 2015.

Comparing current public R&D priorities

In presenting its research and development programmes to the public, the MoD often focuses on projects that attract widespread public support, such as medical prosthetics for injured soldiers or body armour. However, recent freedom of information requests to the MoD made by SGR reveal a very different set of priorities, which have hitherto not been clear from publicly released statistics.[21] The MoD's R&D spending is dominated by the five programmes shown in Box 1.

Box 1 – Ministry of Defence – current major R&D programmes

- Future Submarines
- Nuclear Propulsion (for warships/ submarines)
- Typhoon (fighter aircraft)
- Joint Combat Aircraft
- Lynx (helicopters)

All are obviously major weapons systems and some have clear – and highly controversial – export markets. Government-funded R&D on nuclear warheads is also large-scale.[21] It is clear that the UK is still using its R&D in ways that contribute to international arms races. More information about these R&D programmes will appear in SGR's forthcoming report on the issue.

SGR has repeatedly argued that many important areas of civilian R&D programmes are underfunded, especially when compared with the MoD spend. Renewable energy is a case in point. Public funding of R&D in this area stood at £166 million[22] in 2010 – equivalent to less than one-tenth of the military spend.

Further reform is needed

Public funding of military R&D in the UK has fallen considerably in the last 25 years. Notably the fall has continued in the last ten years despite major increases in total military spending and civilian R&D spending. SGR has played an important role in challenging military R&D spending during this time.

Nevertheless, the MoD's R&D spending continues to be focused on developing major new offensive weapons capability, and remains considerably larger than numerous other areas of R&D that are needed to tackle severe problems such as climate change. Clearly, a more fundamental change in the UK's R&D priorities is needed.

Box 2 – International comparisons

The Organisation for Economic Co-operation and Development (OECD) publishes annual data on the public spending on R&D by many industrialised nations. The data shows that most of the top spenders have markedly reduced the fraction of their R&D budget spent for military purposes since the end of the Cold War. The one major exception is the USA, which has maintained the level at near 55% – a huge fraction. In absolute terms, the USA's military R&D spending dwarfs all other OECD members – see Table 1. Nevertheless, it is clear that the UK spending is still significantly higher than that of some other key nations, such as Germany and Japan.

Country	Public R&D spending for military purposes ($bn)*	Proportion of total public R&D spending for military purposes
USA	76.7	57%
France	2.4	15%
UK	2.2	17%
South Korea	2.1	16%
Japan	1.4	5%
Germany	1.3	5%

* base year of 2005, purchasing power parity

Table 1. Public funding of military R&D in 2010: international comparison of leading spenders in the OECD[20]

Dr Stuart Parkinson is Executive Director of SGR, and co-ordinator of SGR's programme on military influence on science and technology.

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SGR's 20th anniversary – thoughts and memories

Active members of SGR over the years contribute their personal thoughts and memories of the organisation to mark our 20th anniversary.

Dr Philip Webber, Chair (1992-2001, 2003-present)

SGR matters to me because it is a place where I know I can talk safely to other professionals who care about the impact of their work and the fate of the Earth. It is where groups of us can develop an intelligent, rational way forward based on our collective knowledge and experience. Humanity needs people with expertise to challenge the decision-makers and the vested interests in society, and to support a more open, democratic and rational way to manage the resources we share.

I cannot pretend that SGR has more than a small influence on the ways things are. But it has consistently spoken with conscience about things that matter deeply, and has shone a bright light into the darker recesses, such as weapons of mass destruction, or environmental problems. If SGR didn't already exist, someone would have to create it. It is one of a few vital beacons of sanity against over-consumption, war-mongering, irrationality and the misuse of engineering, science and technology. I think SGR will continue to grow and contribute to debates and decisions, and be part of developing and communicating a positive practical agenda for the future.

Kate Macintosh MBE, Chair of Architects for Peace (1981-1991), Chair of Architects and Engineers for Social Responsibility (1991-2005), Vice-chair of SGR (2005-2011)

I was chair of Architects and Engineers for Social Responsibility (AESR), and in 2002 we organised a committee meeting to coincide with an SGR meeting at the Bradford University Department of Peace Studies. Our two groups came together at the close of business to discuss matters of common interest, and I was impressed by the range of issues SGR was covering and the expertise represented on its National Co-ordinating Committee. In the following years, we continued to build up our links until formally merging in 2005.

Prior to this Architects for Peace had merged with Engineers for Social Responsibility to form AESR in 1991. The merger with SGR was a bigger step. We had observed SGR's strength and authority with awe and envy, and some of our engineer members held joint membership. Chris Langley spoke at our 2004 AGM to tell us about his research for the SGR report *Soldiers in the Laboratory*. The major reports are projects that I hugely admire, and they confer authority to SGR members when they respond to invitations to speak or to press enquiries.

In the UK the public debate on the major issues facing humankind has regressed since the last general election. But I take comfort from the fact that there are more hits on our excellent web site from the USA than the UK. SGR must stick in for the long haul as a voice of sanity when the establishment has turned away from a rational examination of options for policy guidance.

Dr Stuart Parkinson, Chair (2001-03), Executive Director (2003-present)

SGR helped me to discover how my skills in science and engineering could be reconciled with my deep concern about ethical issues. Until then my skills and interests had taken me in various directions – some of which conflicted with one another.

A childhood interest in computers led to a bachelors' degree in physics and electronic engineering, and to student placements in industry, including projects with military applications. At first, this seemed exciting, but serious doubts about the ethics of arms exports and militarism in general made me turn away from this career path.

After graduation, a growing concern about environmental issues led me to embark on a PhD in climate change modelling. My science skills made me a strong candidate for such work. I also got involved in student campaigning on green issues. More conflicts arose. Did my ethical concerns mean I would have trouble being a 'disinterested scientist'? And did flying to academic conferences mean I wasn't serious about the threat of global warming?

After completing my PhD, I moved to research on policy issues related to climate change and other environmental problems. But the research centre where I worked was a close collaborator with industry – and the pressure from large industrial partners with a keen eye on their profits came to bother me.

During this time, I discovered SGR – and its combined concern about scientific and ethical issues immediately excited me. Here was somewhere you were encouraged to openly discuss military projects or pressure from industrial funders, and speaking publicly about broader ethical concerns – from climate change to nuclear weapons – was considered essential.

Given my early career experiences, I began to help with SGR's ethical careers work. Over the following years, we wrote ten publications providing information on environmental or peace-related careers or inspiring case studies of science and technology professionals. Later I coordinated project work focused on the distorting influence of narrow, powerful interests – such as the military and large corporations – on science and technology. These projects have raised considerable interest and I'm very pleased to have been involved in them.

Prof Tom Kibble CBE, Chair of Scientists Against Nuclear Arms (1985-1991), SGR Sponsor (1992-present)

I joined Scientists Against Nuclear Arms (SANA) almost as soon as it was formed in 1981, primarily out of concern about the dangers of nuclear war. I was on the National Coordinating Committee for most of the 1980s, and chair from 1985 to 1991. This was at the height of the Cold War, with a terrible arms race underway between the two superpowers and their allies. SANA did some excellent work highlighting the risks of nuclear weaponry, including a study of the likely

effects of a bomb on London and the idiocy of the government's plans for civil defence.

There was a SANA presence at several of the big anti-nuclear demonstrations; we had a homemade, awkwardly designed banner that lived for some years in my garage. We also hosted an international conference *Ways Out of the Arms Race* at Imperial College, London in 1988, which was a great success. Since the collapse of the Soviet Union, SANA has shifted to become SGR and has broadened its concerns to the impact of science, which I welcome.

Prof Keith Barnham, Member of National Co-ordinating Committee, Scientists Against Nuclear Arms (1981-82), SGR Sponsor (2009-present)

I recall the inaugural meeting of SANA in 1981. There was an impressive attendance and a large number of working groups were set up. I was a particle physicist at CERN, so one of the groups I joined was that looking at links between nuclear weapons and nuclear power.

This was a very constructive experience. We backed up CND's case at the inquiry into the proposed Sizewell B nuclear power station. This was a rare opportunity to obtain information about the links to weapons. CND discovered that, at the Sellafield nuclear facilities, reprocessing of spent fuel from the military as well as civil reactors was being carried out in the same reprocessing line at the same time without safeguards. Data from the inquiry enabled us to calculate the plutonium produced by civil reactors. We found that more plutonium was missing from the UK inventory than the amount the government admitted sending to the USA under defence agreements.

Our calculations were criticised at the enquiry suggesting we had used the wrong reactor burn-up curves, even though we had taken them from an official publication. In a fine example of SANA/SGR networking, David Caplin introduced me to Jenny Nelson who wanted a challenging project before starting her PhD. Jenny calculated the burn-up curves from first principles, and found results that were consistent with the official curves. We published our research in *Nature* in 1985. We were vindicated when the USA published its plutonium inventory in 1998: their figure for the material in the exchanges agreed with ours. In 2000, the UK government admitted that 0.37 tonnes of its weapons grade plutonium had come "from unidentified sites". Our 1985 figure for weapons grade from civil reactors was 0.36 tonnes. Thus 11% of the plutonium in UK warheads had come from civil reactors.

Prof William Powrie, Sponsor of Architects and Engineers for Social Responsibility (1994-2005); SGR Sponsor (2005-present)

I came to SGR through AESR when the two organisations merged in 2005. I had become involved with AESR shortly after my arrival at the University of Southampton in the mid-1990s as a professor of geotechnical engineering. For a couple of years we ran a successful undergraduate lecture series with visiting speakers giving talks based on AESR position papers on topics such as energy, waste, transport and sustainable housing. This was quite radical for engineering at the time, but nobody would consider it strange now for an engineering faculty to be engaged in research and teaching that encompasses the environmental and societal benefits and impacts of technology.

Over the last 20 years we have seen quite a change in the aspirations of engineering students, they now have a far greater understanding of the role engineers and scientists have to play in creating a better society, and a desire to make a difference. It is easy to think you can't make a difference, but this shows that if enough like-minded people push consistently in the same direction, little by little, you can. I am proud to be associated with SGR, and I hope that over the next 20 years it will be as successful as the first.

Prof Pauline Harrison CBE, SGR Sponsor (2011-present)

To be a scientist is a great privilege. Scientific advances such as the determination of the structure of DNA and the first observation of the Higgs boson give scientists a huge sense of excitement – as indeed do many of the findings of their everyday research. Privilege brings with it responsibilities: to explain the science, discuss the implications with the public, and to try to ensure that governments fund scientific research adequately and ethically and use the fruits of scientific research wisely.

To fulfil these responsibilities scientists need to work together. That is why an organisation like SGR is so important. It provides a forum for enquiry into and rational discussion of the ethical and practical applications of scientific research, topics ranging from nuclear power to genetic modification. It publicises the effects of climate change and population growth on the world's ecosystems and tries to persuade people and governments to take appropriate action. It campaigns against the corporatisation of science.

I am happy that the SGR is both a gatherer of information and an active pressure group. I am proud to be a member and wish it every success in its next twenty years.

Prof Jenny Nelson, Treasurer (1992-2005), Sponsor (2011-present)

I first became involved with SGR (or Scientists Against Nuclear Arms, as it was then) when I had the opportunity to work with Keith Barnham in 1985 on calculations of the amount of fissile nuclear material generated by civil UK power stations (see left). I was a physics graduate with experience of computer programming, it was the middle of the Cold War, and I was very motivated to find a way to apply my skills to problems of relevance to society and especially in the interests of peace. I then joined SGR while a PhD student and later I spent two extended periods working as a volunteer in the SGR office (in the welcome company of SGR's long-term administrator, Kate Maloney), first building a membership database and then working on a range of projects and events. I later served on the National Co-ordinating Committee as Treasurer for several years.

I gained a huge amount from my involvement with SGR, from the excitement of being involved in politically sensitive investigative studies, to learning

how to file annual tax returns, to meeting eminent, inspiring and outspoken scientists, and most importantly how to keep driving towards goals in the face of apathy or opposition.

I was honoured when I was invited recently to become a sponsor of SGR, though I haven't quite noticed the time passing. Now as a scientist active in the development and promotion of new solar technologies I am delighted and encouraged to see that SGR's work continues with the same objectives, of harnessing the knowledge of scientists to bring about a secure, fair and peaceful future.

Vanessa Spedding, Member of National Co-ordinating Committee (2002-2005)

I found SGR more than a decade ago, while looking for a safe place in which to express and share concerns about aspects of science that had been troubling me; and also for ways to help work towards a useful correction to those aspects. At the time, there was little opportunity even to start such conversations in my work environment.

SGR provided both haven and opportunity, on several levels. Here I found experienced scientists, who understood the depth and breadth of the issues to a degree far beyond my own understanding. It was a relief and a delight to meet them. And as it happened, there was no shortage of editing work to be done at the time (I am a science writer), so I was very pleased to help out – especially with the ethical careers publications. This was so satisfying that if it had been possible to quit my job and work full-time for SGR at that time I would have done so! As it was, I joined the committee, and served from 2002-2005, since when I have remained an active member.

In my view, SGR is an unusual and important organisation. It speaks truths that others either dare not speak or do not have the expertise to assert. It combines the analytical rigour for which science is respected with courage and compassion. SGR has my heartfelt congratulations for 20 years of dedication, hard work and consistently high-quality, powerful outputs. A society that puts ultimate trust in science is vulnerable to opportunist forces that abuse that trust – with grave consequences, as we see today. Recognising, naming and exposing those forces from a position of strength provides a critically important service to us all. Awareness of this is growing and my hope for SGR is that ever-increasing numbers will turn to the organisation for its wisdom and foresight.

Prof David Webb, SGR Sponsor (2007-present)

I am really pleased to have contributed to the much needed work by SGR on ethical careers, and I have been particularly impressed by the excellent research on the influence and impacts of military funding on universities. These issues and others are so important and are yet almost totally ignored by the professional science and engineering institutions. It is so important that SGR is there to provide an essential critical – and hopefully influential – analysis.

Gabriele Krauskopf, Executive Secretary International Network of Engineers and Scientists for Global Responsibility (INES)

SANA and AESR were two founding members of the International Network of Engineers and Scientists for Global Responsibility (INES). INES came into being in 1991 at the international congress *Challenges - Science and Peace in a Rapidly Changing Environment* held in Berlin.

From the start, SGR has been a valuable and well-respected member and supporter of the international INES community. We appreciate and marvel at the comprehensive expertise that SGR offers, and value its contributions, be it as speakers at international conferences, authors of articles for INES publications, and reliable fulfilment of their financial commitment to INES.
We are thankful for the past and look forward to future cooperation and mutual support.

Longer versions of these pieces can be found on the SGR website at:
http://www.sgr.org.uk/pages/sgrs-20th-anniversary-thoughts-and-memories

Obituary: Alfred Oppenheimer, 1923 – 2012

SGR has lost an outstanding member with the death on 17th July this year, just short of his 90th birthday, of Alfred Oppenheimer, scientist, engineer, humanitarian and wonderful human being.

Born in Cologne, and automatically under threat with the advent of Hitler, the whole family, Jewish and secular, moved to the UK, where the internment of Alfred and his father on the Isle of Man was not time wasted: Alfred began there the studies that led to a successful career as a production engineer. The Colston washing machine was brought into production by Alfred, who refused an invitation to work on Concorde, following the principles that marked his whole life: was this machine socially useful, environmentally acceptable, and designed for ordinary people rather than for the privileged? He held senior positions as science and technology advisor to local authorities, and of course found a natural home in SGR.

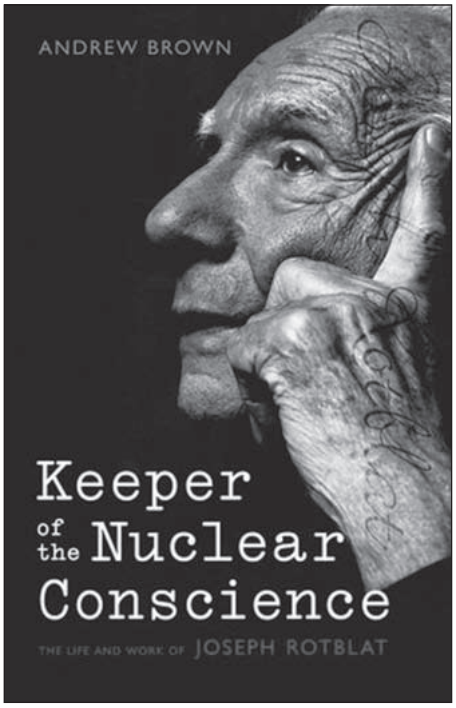
He let us all know how lucky he considered himself in his two marriages, to Rhoda, who died after a long illness, and to Jacquey, who survives him. Alfred and Rhoda's four children, and Jacquey's three, have become especially close during and after Alfred's last illness – testimony to the wise and loving embrace of this exceptional man.

Mike Koefman

Keeper of the nuclear conscience – the life and work of Joseph Rotblat

Andrew Brown - Oxford University Press, 2012, 368pp., £18.99, ISBN 978-0199586585 (hardback)

Review by Philip Webber



This biography gives a fascinating and personal insight into Joseph Rotblat's dynamic life and work, from the development of the nuclear bomb at Los Alamos, USA, and his reasons for leaving the project after Germany left the war, to his founding of the Pugwash organisation and his work at St Bartholomew's Medical School, where he researched the effects of radiation and pioneered its use for medical purposes.

Rotblat had little conventional education, growing up in extreme poverty in a Jewish ghetto in Warsaw. He largely taught himself electrical engineering, and secured a degree at the Warsaw Free University. He worked at the Warsaw radiological institute measuring neutron fluxes and was one of a few scientists to realise that neutron fluxes could break up a nucleus, creating a chain reaction of neutrons with a huge release of energy – the atomic bomb.

Shortly before the war, he married and then secured a contract at Liverpool University to develop the early cyclotron with James Chadwick. Tragically, he never managed to bring his wife to the UK. He was then recruited to the Manhattan project in Los Alamos to develop the atomic bomb. During these war years, he had no news from his family in Poland. As the war in Europe drew to a close, he realised that Germany had not developed an atomic bomb, and his earlier doubts about the validity of the bomb project returned. This view was compounded when he overheard General Groves, the US project leader, say to Chadwick, the lead UK scientist, that the bomb's real purpose was to counter the Russians, rather than defeat the Germans. Rotblat thought this was completely wrong. He and Niels Bohr foresaw the arms race that would grip the world for the next four decades.

Rotblat decided to leave the project. His secret service file alleged that he planned to parachute into Russia to give them the bomb secrets to create a balance of power! He persuaded the project to release him if he agreed not to speak to any other scientists, even at Los Alamos, and to say that his reason for leaving was to find out what had happened to his family. On 7 August 1945, he was shocked to hear that the atomic bomb had been detonated on Hiroshima the day before. Later he discovered that many of his close family, including his wife, had been murdered in a concentration camp or had died in the extreme privations of the ghetto.

Having seen the danger of uncontrolled science and technology, Rotblat decided to work only on science that is useful and socially responsible. This was a critical aspect in his founding of the Pugwash Conferences on Science and World Affairs, which still continue today. In the last years of his life, Rotblat came to the view that war itself had to be abolished, as war "turns us all into beasts". He still worried what he would do if the same circumstances presented themselves today. Would he work on a bomb? He still did not honestly know the answer about himself.

Andrew Brown has accurately captured the spirit of the man. The many personal observations throughout the book bring the past to life vibrantly, making it easier to grasp the tensions and undercurrents that Rotblat grappled with throughout his long life.

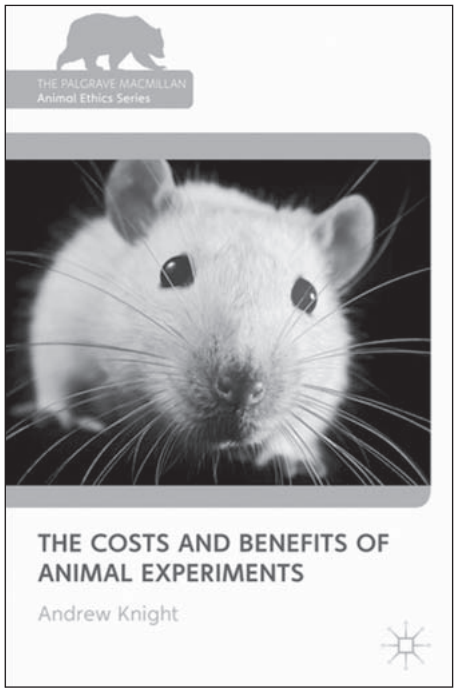
From a personal perspective, I first met Rotblat in 1982, when he was kind enough to read the entire draft of our book *London after the Bomb*, and made several useful comments. I worked with him on a World Health Organisation assessment of the global impact of nuclear war and we co-authored a letter to *Nature* with Patricia Lindop on the impact of a nuclear attack on a major city. I remember being impressed by how he re-plotted my data, and asked me to explain some puzzling trends that this revealed. He was unfailingly helpful and down to earth, and had immense reserves of energy. He seemed to be constantly on the move, jetting off around the world. His range of contacts was truly extraordinary. At one of the Pugwash conferences, I came into contact with Russian and US scientists, five-star generals, and key policy advisors talking freely and privately. I think his friendship with President Gorbachev was influential in helping to provoke a change of attitude in the Soviet Union, which culminated in 'perestroika' and the cessation of the Cold War. For that alone he deserved a Nobel Prize.

Dr Philip Webber is Chair of SGR.

The costs and benefits of animal experiments

Andrew Knight – Palgrave Macmillan, 2011, 256pp., £18.99, ISBN: 978-1137289681 (paperback)

Review by Chris Langley



The use of animals in teaching and research, and the many ethical and pragmatic questions regarding their use, is of wide concern within the science and technology communities. Although significant progress has been made in the use of non-animal alternatives in medical research and teaching, there remains a core of unexamined prejudice supportive of the continued use of animals. This is despite grave concerns about their validity in understanding biological processes in humans, including the quality of the experimental method and design being used.

The Costs and Benefits of Animal Experiments is a highly readable, extensive and rounded review of the many aspects of the experimental use of animals and the alternatives available. It critically examines the validity of animal models for devising treatment regimes for human disease, and for creating robust protocols for regulatory purposes. It fills an important gap in the literature, making it a must-read for those who use animals in teaching and research, policymakers, students, those in science governance and the growing numbers of people interested in the philosophy of science.

Andrew Knight takes a medical and ethical perspective to examine four themes of experiments on animals: the animal costs; the human benefits; alternative strategies; and the educational use of sentient organisms and its impact on students. Each theme is tackled over two or three chapters, and a closely argued fifth section draws together the four themes with conclusions and policy recommendations. The book is concisely written and the arguments rely heavily upon evidence-based literature. The breadth of references is very impressive – 29 pages including extensive citation of peer-reviewed articles and reviews.

Knight has published widely on the use and validity of using animals in research and testing, and this book joins a long list of titles from the Ferrater Mora Oxford Centre for Animal Ethics,[1] of which he is a Fellow. It collects together the many issues that the use of animals for research entails, supplying ample material for both graduate and postgraduate courses in experimental design, bioethics and philosophy of science. Many of the chapters draw upon the latest data concerning animal cognition and awareness, and this material challenges us to look again at how we view animals. An especially valuable thrust of the book addresses how animal use in research and teaching influences students' thinking in practical ways, such as in the training of veterinarians and experimentalists but also among those who go on to be involved in the governance of science and technology.

I have a number of small quibbles about the book. It would benefit from a more comprehensive index and, although the coverage of alternative methodologies is good, there are no links to web-based resources. It is also a shame that the author, while making detailed reference to governmental and intergovernmental initiatives, underplays the role of biomedical charities in supporting the development of alternatives to the use of animals.

The evidence that Knight has collected clearly weighs against the use of animals, putting the onus on society to rethink its attitudes toward and the treatment of animals, and to move away from the entrenched positions about how science should be undertaken. The author also provides some thoughtful pointers to how those involved in experimental research might devise better experiments without reliance upon the questionable use of sentient organisms.

Dr Chris Langley is a science consultant who has been principal researcher for SGR and currently operates ScienceSources.

Notes

1. The Ferrater Mora Oxford Centre for Animal Ethics – http://www.oxfordanimalethics.com/ – was established by Professor Andrew Linzey, a theologian with a passionate interest in bioethics. The Centre, an independent and scholarly think-tank, examines in a balanced fashion our often confused attitudes to animals. It was established in the face of a total lack of interest from Oxford University.

Back issues of the SGR Newsletter

Back issues of the SGR Newsletter are available to download from the SGR website at: http://www.sgr.org.uk/publications/sgr-newsletters

We also have a small supply of *printed* copies of Issue Nos 33 to 39 inclusive.

If you would like any of these - perhaps to fill a gap in your own collection, or to pass on to a friend or colleague - please let the SGR Office know (contact details on back page). They are free to members.

Changes at the Martin Ryle Trust

The Martin Ryle Trust – the registered charity that works in partnership with SGR – has moved. The new address is:

The Martin Ryle Trust
PO Box 876
Lancaster LA1 9HR

The Trust also has a new administrator, Debbie Mace.

SGR's 20th Anniversary Annual General Meeting and Strategy Forum

19 May 2012, Edward Cullinan Architects, London

Review by Stuart Parkinson and Alasdair Beal

SGR members gathered for the organisation's 20th anniversary AGM and strategy forum in London in May. Over 30 people attended, including long-standing members (some of whom had first been active with either Scientists Against Nuclear Arms or Architects and Engineers for Social Responsibility) as well as recent joiners. SGR sponsor and host Edward Cullinan welcomed members to the event, with impassioned words arguing that the science, design and technology professions need to put much more focus on wider social and environmental concerns, rather than just financial priorities.

Annual General Meeting

SGR Chair Philip Webber opened the formal proceedings of the AGM pointing to the achievement of SGR reaching its 20th birthday. Matters arising from the minutes of the previous AGM included a short discussion on the carbon emissions of the military and possible future SGR work in that area.

Executive Director Stuart Parkinson then presented the annual reports for 2010-11[1] and 2011-12. Focusing on 2011-12 activities, Stuart highlighted how SGR had continued to be influential and active on science, design and technology issues. A particular focus had been on linking the peace, environment and economic reform agendas and promoting diversion of military spending to energy conservation and renewable energy. Thanks to funding from the Network for Social Change, SGR had begun a new project critically examining the government's spending on military and security R&D programme, with a view to promoting radical reform (see below). This built on SGR's previous reports in this field, which themselves continued to be popular, with thousands of downloads from the website. Other activity during the year included a conference on emerging technologies, 10 external lectures on issues such as arms conversion and climate change, numerous opinion articles and other appearances in the media, and campaign activities especially focused on energy issues. The organisation published the 40th issue of the respected *SGR Newsletter*, and the website continued to be well visited. Stuart also reported that the latest three-year development plan – funded by the Joseph Rowntree Charitable Trust – had come to an end during the reporting period. SGR had achieved much during the plan, including an expansion of the membership and high levels of activity.

Treasurer Alasdair Beal then reported on the SGR accounts. Finances continued to be tight, not least because of wider economic problems.

Researcher Barnaby Pace then discussed SGR's new research and advocacy project in more depth. He reported that he had had some notable successes in obtaining new and detailed data on the R&D spending of the Ministry of Defence – via freedom of information requests – and had begun analysing it. He expected more data soon. Discussion followed about the potential implications of the research so far, including the degree of emphasis on 'offensive' military technologies versus 'defensive' technologies, and the benefits that could be achieved by more research focus on tackling the roots of conflict, including the growing competition over natural resources.

The meeting then moved to the election of this year's National Co-ordinating Committee. The elected candidates are listed on p.2. Retiring members Roy Butterfield and Genevieve Jones were thanked for all their work for SGR over the years.

Stuart Parkinson then gave an update on recent activities, including an SGR presentation at a side event at the nuclear non-proliferation treaty negotiations in Vienna, and evolving plans for the SGR office to move to Lancaster in coming months.

The formal business was concluded with a heartfelt vote of thanks to Kate Maloney, SGR's Office Manager, who will be retiring this year having been with the organisation from its beginning.

Strategy Development Forum

The second part of the meeting was a strategy development forum led by occupational psychologist and SGR member Jan Maskell. Jan began by explaining that her approach to organisational development was based on identifying the positive aspects of organisations and individuals within those organisations. She then led the group through three exercises.

The first was a discussion in small groups of SGR's key successes during the last 20 years. Members identified a range of activities including events (such as past SGR conferences), project work (such as the SGR report, *Soldiers in the Laboratory*) and high-profile media coverage (such as contributing to a front-page article in *The Independent* on opposition to UK nuclear weapons).

The second exercise – in the same small groups – gave members an opportunity to identify their skills and the activities they enjoy the most. This led into the final exercise where members were asked to come up with ideas for future SGR activities and commitments that they personally were willing to make – based on their skills and interests. This led to offers of voluntary help, including fundraising, writing articles, and commenting on drafts of the new SGR report, for which we are very grateful.

Stuart Parkinson closed the meeting with thanks to all involved.

1 Only a summary of 2010-11 report had been available at the previous AGM, so it needed to be formally approved at this event.

SWIIS 2012: international stability & systems engineering

11 -13 June 2012; Waterford, Ireland

Review by Marion Hersh and Alan Cottey

This was one of the most energised and stimulating conferences we have attended. Like SGR, SWIIS (which has been renamed International Stability, Technology and Culture[1]) discusses the wider context of science and technology, but focusing on technology rather than science. It is a technical committee of the International Federation of Automatic Control. SWIIS was originally set up to apply systems engineering, control and associated approaches to the study of international stability. Since then its focus has expanded to cover the wider context in which technology is applied and developed, to include culture, ethics, human factors, power dynamics and spirituality. SWIIS also stresses the importance of perspectives from outside Europe. All these elements were evident at the conference. There was no gatekeeping, and challenging of established wisdom was encouraged. The conference was also marked by very lively discussion, which spilled over into the breaks and was only curtailed by the time constraints.

We were both involved in a session entitled *Roles and Responsibilities of Engineering in Achieving a Just and Sustainable World* which Marion Hersh organised and chaired. Alan Cottey's presentation was entitled *Don't Worry, Cynthia, No One's in Charge*, a reference to an anecdote in *Making Weapons, Talking Peace* by Herbert York, who was director of the Lawrence Livermore Laboratory at the University of California and oversaw research that led to the development of the hydrogen bomb. Alan's paper reflected on the tension between control and management on the one hand and the individual's need for autonomy on the other.

Marion Hersh discussed some of the issues that affect ethical behaviour by engineers, including the need to do more than just comply with the law. She highlighted barriers to ethical behaviour, power dynamics and the importance of including minority perspectives. She also considered the importance of both individual and collective responsibility and the dynamic between them. Another paper in the same session, by engineer Bogdan Lewoc, discussed his experiences of developing early control and automation technology in Poland and how he resisted power structures and attempts to co-opt him.

Alan Cottey also chaired a session on *Systems Engineering in Human Contexts*, which included a presentation on the human context from an Indian cultural perspective by Karamjit Gill.

The next SWIIS Conference will be from 6-8 June 2013 in Pristina, Kosovo. More information can be found at http://www.ubt-uni.net/swiis2013/.

Dr Marion Hersh is a senior lecturer in biomedical engineering at Glasgow University. Dr Alan Cottey is an Associate Fellow at the University of East Anglia and a former Secretary of SGR.

1 The acronym SWIIS originally stood for Supplementary Ways of Improving International Stability.

Geoengineering: the geo-politics of planetary modification

2 May 2012; Lancaster Environment Centre, Lancaster University

Review by Simon Mair

Geoengineering, once the realm of science fiction, is increasingly being presented as a credible 'Plan B' in the fight against climate change. Much current research is rooted in the natural sciences, but geoengineering raises social as well as technical issues. Moreover, it is not a new concept: there is much to learn from its chequered past as a military tool. This seminar brought together speakers from the humanities and social science to start the conversation.

Proceedings kicked off with a stark proposition from Phil Macnaghten of Durham University. He argued that Solar Radiation Management – where large-scale technical measures are used to reduce the amount of solar energy that reaches the Earth's surface – cannot be contained democratically. Macnaghten noted that current research is framed by the 'Oxford principles'. These state that geoengineering should be regulated as a public good, including a transparent research process, public consultation, independent assessment of impacts, and an emphasis on governance before deployment. He argued that even these limited principles are often violated. A timely example is the UK-based Stratospheric Particle Injection for Climate Engineering (SPICE) research project, whose field tests were cancelled due to conflicts of interest caused by the filing of patents by a private consultant involved in the project.

Two science historians added their perspectives: James Fleming of USA-based Corby College argued that current research and policy framings are dominated by the concerns of the global north and ignore geoengineering's militarised history, while Vladimir Jankovic of the University of Manchester discussed the use of small-scale geoengineering in various cities. The restructuring of air flow in Japanese cities stood out as an example in contrast to the Oxford principles: in Japan, the landowner controls the local atmosphere.

In the final presentation, Bronislaw Szerszynski and Maia Galarraga, both of Lancaster University Sociology Department, suggested that in geoengineering the social sciences are used to hold natural science to account. However, Szerszynski and Galarraga posited that this often amounts to little more than a box-ticking exercise, and instead advocated a more critical, self-reflective model of interdisciplinary study.

Personally, I believe the mixed history of geoengineering serves as warning to researchers. A truly holistic interdisciplinary approach is required, and I was struck by the lack of natural scientists present at this seminar. The problem may not be a lack of the historical or sociological understanding of geoengineering, but rather a refusal to acknowledge it.

Simon Mair is a PhD student at the Centre for Environmental Strategy, University of Surrey.

Joint conference of ARC-PEACE and ASF International

12-15 April 2012; Copenhagen

Review by Tom Woolley

The 25th anniversary assembly of ARC-PEACE (International Architects Designers Planners for Social Responsibility) was held in Copenhagen in April 2012. The event was organised to coincide with the general assembly of Architecture Sans Frontières (ASF) International, and included a conference, *Building Resilient Futures*, which consisted of three sessions:

- Social responsibility and sustainable buildings
- Architects working for development
- Managing disasters in urban areas

The conference was attended by 150 people from over 30 countries as far afield as the Democratic Republic of Congo, India, Nepal, Peru and the USA. I attended as a representative of SGR.

Much of the ARC-PEACE assembly was concerned with its future role. Some key members have been involved since its beginning and were presented with veteran certificates! The organisation has limited funds and depends on the unpaid work of the general secretary and free facilities in Stockholm. A new working group was tasked with fundraising and attracting more members. While a key issue for ARC-PEACE remains its opposition to nuclear weapons and the arms trade, a stronger focus for the organisation seems to be its involvement in development projects in Africa and South America, and its close relationship with ASF International.

ARC-PEACE also debated, at some length, a statement about architectural education, as there was a shared concern from many countries that architecture schools are placing a greater emphasis on style and aesthetics and have drifted away from social responsibility. While many schools play lip service to sustainability, design is often taught as something detached from building technology, planning, social processes, sustainability and other aspects of social policy.

In particular, the statement urged "professional schools to develop curricula and train instructors to teach the architectural and planning skills necessary to create healthy, socially sustainable environments and create buildings and plan cities with smaller carbon footprints that reduce consumption and conserve energy."

The full text of the statement can be accessed on the ARC-PEACE web site (see below). It was agreed that all ARC-PEACE members would actively promote the education statement, in the belief that many students are unhappy with the current ethos of many university courses and would prefer a stronger emphasis on social action and sustainability.

The conference *Building Resilient Futures* included speakers and projects from Canada, Denmark, Haiti, Palestine/Israel, Peru, Serbia, Sudan, Tanzania, Thailand and more. They showcased research into building development, including its political dimensions, as well as initiatives to empower the oppressed at a local level. There was a great deal of debate about how this could be done.

The ASF International general assembly concerned organisational business but included an extensive discussion about how ASF International might develop training to equip socially engaged architects and volunteers in projects throughout the world. ASF International is active in the UK and is looking to expand its membership.

Tom Woolley is an architect with Rachel Bevan Architects and member of SGR's National Co-ordinating Committee.

For more information about ARC-PEACE, see: http://www.arcpeace.org/

For more information about ASF International, see: http://www.asfint.org/

In my lifetime

Documentary film by Robert Frye, The Nuclear World Project, 2011

Review by Joanna Bazley

This feature-length documentary by award-winning US director Robert Frye is an impressive attempt to present the complexity of issues surrounding nuclear weapons, and while the anti-nuclear message is clear, this is not simply anti-nuclear propaganda. Rather, it is the product of detailed research and interviews gained through a long career as a TV journalist. Frye is obviously good at persuading people to talk to him.

The film's starting point is Hiroshima, and archive footage from 1945 is juxtaposed with moving interviews with surviving victims and the annual ceremony in the Peace Park. It then explores the UK's underground Cold War bunkers, providing a chilling insight into the mentality of the time. From there it follows disarmament campaigner Rebecca Johnson as she revisits Greenham Common and reflects on the historical significance of the Peace Camp.

Most remarkably of all, Frye gained permission to film inside the UN building in New York during the Non-Proliferation Treaty Review Conference of 2010. The 'fly on the wall' footage brings the debates to life, and mercilessly reveals the collusion between nuclear states intent on preserving the status quo.

His copious use of archive footage vividly recreates the past and shows how the world entered the nuclear age through interviews with the Manhattan scientists and military personnel of the time. The clinical detachment of the medical experts examining the first recorded cases of radiation sickness is chilling, while the naivety of a military establishment that exposed troops to nuclear weapons for their entertainment is almost unbelievable.

Frye refuses to take a simplistic approach to moral issues. Two laughing US sailors are photographed in front of the ruins of Nagasaki in 1945, but we are reminded that these photographs were taken in a historical and emotional context that we cannot hope to understand fully. He explores political context through contemporary media coverage: a North Korean TV announcer bursting with pride reports the first successful nuclear test.

In My Lifetime was four years in the making and is a very thorough analysis of the issue. Its title is a quote from Rebecca Johnson, offering some hope that nuclear disarmament is a realistic and achievable goal. Distribution arrangements in the UK are being finalised with CND.

Joanna Bazley is Secretary of Wimbledon Disarmament Coalition/CND

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You can join SGR as a member if you are or have been a science/design/technology professional in the broad meaning of the words: our members come from many disciplines including natural sciences, social sciences, engineering, computing, architecture and design, and interdisciplinary areas. They work in research and development, manufacturing, teaching, science writing, or are students or retired. Members are invited to contribute their expertise to help make SGR even more effective.

If you are not a science/design/technology professional, but want to support our work, you can help us by becoming an associate.

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Editorial Issues

The editorial team for this issue of the SGR Newsletter was:

- Stuart Parkinson
- Sophie Hebden
- Kate Maloney

The opinions expressed within, including any advertisements or inserts, do not necessarily represent the views of SGR.

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Copy deadline for next issue: 31 April 2013

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