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Nuclear weapons: breakthrough or breaking point?


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US B-2 Spirit nuclear-capable 'stealth' bomber which is on patrol near North Korea


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ICAN is awarded the Nobel Peace Prize for its nuclear disarmament campaigning

Stuart Parkinson, SGR, looks at the current crisis over North Korea's weapons programme and contrasts it with the new UN treaty banning nuclear weapons.

2017 was the year when the issue of nuclear weapons climbed back to the top of the political and public agendas. On the one hand, the increasingly tense stand-off between North Korea and the USA has arguably brought the world closer to nuclear conflict than at any time since the end of the Cold War. On the other hand, the resurgence of the anti-nuclear movement, led by the International Campaign to Abolish Nuclear Weapons (ICAN), has resulted in the agreement of the first UN treaty explicitly banning these weapons of mass destruction.

The threat from Kim Jong-un and Donald Trump

North Korea conducted its first nuclear weapons test explosion in 2006, breaching an international moratorium on such activities. Since then, it has conducted five more, with the latest in September 2017. This test was thought to be of a thermonuclear or 'hydrogen bomb' – a weapon which uses a combination of nuclear fission and fusion to produce a much more powerful explosion.[1]

In tandem with the nuclear tests, the North Korean military has also been developing and testing 'strategic' missiles, i.e. those designed to launch a large payload more than 300 km. The number of such missile tests has been growing over the last decade with 14 successful tests carried out in 2017. Two of these missiles were, for the first time, thought to have had an intercontinental range and therefore be capable – in theory – of hitting the US mainland.[2]

US President Trump has responded to these developments with increasingly vitriolic rhetoric, including threatening "to totally destroy North Korea" if he considered it necessary. The US and South Korea have stepped up their joint military exercises, including flying nuclear-capable bombers to the edge of North Korean airspace.[3] UN sanctions against North Korea have also been markedly tightened, with oil exports targeted for the first time. Although there have very recently been moves by both sides to reduce tensions – for example, joint Korean activities at the Winter Olympics in South Korea – the possibility of conflict, whether by intention or miscalculation, remains all too real.

But it is important to realise there is no clear evidence that North Korea has to date deployed *any* nuclear warheads on their strategic missiles – or indeed has miniaturised them sufficiently to do so. The USA meanwhile currently deploys approximately 1,800 warheads on strategic missiles, bombers and submarines, with about 2,200 more 'in reserve', and a further 2,800 retired but not yet dismantled – an overall total of about 6,800 nuclear weapons.[4]

The North Korean government justifies its actions by claiming the need for 'nuclear deterrence' to keep the country safe from military attack – exactly the argument used by other nuclear weapons states, including the USA. But the words and actions of the Trump administration demonstrate that they seem to doubt that even their huge nuclear arsenal is sufficient to deter North Korea. Such behaviour highlights basic flaws in the policy of nuclear deterrence.

(contd. on page 9)

SGR celebrates 25 years

See reports on pages 2 and 20-22

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A few words from the Director…

According to the famous 'Doomsday Clock' – maintained by the Bulletin of the Atomic Scientists – the world stands at two minutes to midnight.[1] This indicator of global threats stands at its highest level since 1953 – higher than during many Cold War crisis points. The scientific board which makes this decision has based its views on an assessment of a combination of threats from nuclear weapons, climate change and new technologies – but one person more than any other links these threats: Donald Trump.

As discussed in the front-page article, Trump's response to North Korea's accelerated nuclear weapons programme is risking a nuclear war in East Asia, whether by intention or miscalculation. And it should not be forgotten that Kim Jong-un's policies are simply following the same flawed deterrence logic pursued by the USA, UK and other such nations. But Trump's aggressive actions are also re-igniting the broader international nuclear arms race, with the new Nuclear Posture Review increasing the role that smaller 'more useable' nuclear weapons will play within US defence plans.

Trump's actions have also increased US militarism more generally. While the large increase in the USA's already bloated military budget is well known, other features have received less publicity in the mainstream media. One very disturbing statistic is that, last year, US special forces were deployed to 149 countries – that's 75% of the world's nations.[2] Their rules of engagement have also been have also been relaxed which is strongly suspected of leading to more civilian casualties in war zones.

Meanwhile, Trump's attacks on climate science and climate change policies have been largely as predicted. The notice to withdraw the USA from the Paris Agreement and the repeal of the US Clean Power Plan have received a lot of public attention. The cuts to numerous climate science programmes rather less so.

But before we get too depressed, it's worth noting just how much resistance there is to Trump's actions. The agreement in July of the new TPNW, the first treaty to completely ban all steps in the development, production and use of nuclear weapons – as discussed in the front-page article – is a very important step forward. The opposition of the UK, Germany, France and the EU to Trump's rejection of the Iran nuclear deal is also very significant. The unity shown by all other nations in support of the Paris Agreement is also striking. When Syria signed the treaty in November, the USA was left as the only country to reject it. Trump's position has been further eroded within the USA by the 'We Are Still In' movement, which represents more than 40% of the American population. Meanwhile funds divesting from the fossil fuels industry are now measured in the trillions and increasing, while the international renewables and energy storage industries continue to grow rapidly. The tide is also turning on protecting the marine environment (if you'll excuse the pun!). As we discuss on p.19 a new UN process has begun to create a 'Paris Agreement for the oceans' against the background of increasing awareness of plastic pollution and the expansion of marine protected areas.

In the UK, of course, we have to contend with the added uncertainties of Brexit – some the concerns of British academics being voiced on p.12. But the EU itself needs to confront more of its own demons – not least, the proposed new European Defence Fund, which includes a massive increase in spending on military R&D, as discussed on p.7. However, one piece of good news which came out just as the *SGR Newsletter* was going to press: UK employment in the low carbon and renewable energy sector has risen to more than 390,000.[3] These figures include direct and indirect (supply chain) jobs, and are markedly higher than those estimated for the British arms industry.

Dr Stuart Parkinson, Executive Director

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Staff changes

As the Newsletter goes to press, we are very pleased to announce that SGR's new Assistant Director will be Andrew Simms. He brings extensive experience of writing and campaigning to the post, including over a decade as Policy Director of the New Economics Foundation, and as the author of numerous reports and books, including *Ecological Debt* and *Cancel the Apocalypse*. He is also a research associate at the Centre for Global Political Economy, University of Sussex.

Philip Wood, our peaceworker funded by Quaker Peace and Social Witness, finished his one-year contract at the end of August. We wish him well in his future career.

SGR celebrates 25th anniversary

SGR celebrated its silver anniversary during 2017 by organising and participating in several events during the latter part of the year. The main ones were:

- SGR's 25th anniversary conference in London, entitled *Creating a better world: some lessons for the next 25 years* – see report on p.20
- SGR's 25th anniversary reception at the *Health through peace* conference in York. Chair Philip Webber and Executive Director Stuart Parkinson also gave presentations at the conference – see report on p.21
- The Martin Ryle Trust lecture in London, entitled *The business plan for peace* – see report on p.22

Peaceworker project

SGR's peaceworker, Philip Wood, has continued to research on the links between arms and fossil fuel corporations and science and engineering organisations in the UK. The final report of the project is due to be published later this year. In advance of this, Philip has given seven presentations about his work across the UK – especially to Quaker groups. He has spoken at local or regional events in south Cumbria, Derbyshire, Dundee and Winchester, as well as the national Quaker gathering in Warwick and the SGR conference in London (see p.20).

Nuclear disarmament activities

SGR has again been working hard on nuclear disarmament issues – especially with ICAN partners – locally, nationally and internationally.

The big success over the last year – as the front-page article describes – was the agreement in July of the UN Treaty on the Prohibition of Nuclear Weapons (TPNW). SGR was very active, both in the run-up to the formal negotiations and afterwards, in helping to publicise the new treaty. Of particular note was online publication of our six-part beginners' guide to the threats from nuclear weapons, written by Philip Webber. This has proven very popular with over 3,000 visits to date. We also signed joint letters to the Foreign Secretary and the Defence Secretary urging UK support for the treaty – but the government continues to remain hostile. One of our letters – co-signed by Nobel Prize laureate, Prof Peter Higgs – was published in *The Guardian* in August. Meanwhile, SGR's role in the ICAN campaign for the TPNW received a mention in an article in the *New Statesman*.

In parallel with these activities, SGR also supported calls for North Korea and the USA to step back from any actions which could lead to nuclear war on the Korean peninsula. In particular, we supported a CND demonstration outside Downing Street urging the UK to use its diplomatic influence to try to reduce tensions. Philip Webber also had an article published on the popular *Huffington Post UK* website in January, entitled 'This is what Earth could look like after a nuclear attack'. It was later republished on the Stop the War coalition website.

SGR speakers also discussed the threats at conferences during the autumn. Philip spoke on the possibility that a conflict could lead to a nuclear winter at the international *Health through peace* conference in York in September (see p.21). Meanwhile, Stuart Parkinson gave a presentation at the annual CND conference in London in October on the possibility that political instability brought about by climate change could lead to a nuclear war.

Finally, at the SGR office near Lancaster, we unexpectedly found ourselves in close proximity to nuclear warheads when, for the first time, a nuclear convoy spent the night at a military training camp only a mile away. We worked with local peace campaigners to highlight the risks in the local media. So far, the convoy has not returned to the base…

Science4Society Week 2018

As usual, SGR's Science4Society (S4S) Week will be running in late March, this year from 10th to 18th. Dozens of teaching resources can be downloaded free from our dedicated website – www.s4s.org.uk – so please do help us to publicise these to any science teachers you know.

New this year is a pack of 'food trump cards' – developed by project co-ordinator Jan Maskell – which can be played with like the game, *Top Trumps*. Each card has data on the nutritional qualities and environmental impacts of a commonly eaten food, helping children and adults to compare the pros and cons of each. The pack is available to download from the website, and an extension pack of further foods is planned for next year.

The competition which we have been running this year is entitled 'Am I a Good Scientist?' It has been promoted as a STEM club activity as well as for classes or individuals. If you would like further information on this, please contact Jan on <janm@sgr.org.uk>

The project and resources were again promoted via a stall at the national conference of the Association of Science and Engineering, this year held in Liverpool. Several thousand people attended the conference, and there was lots of interest in our competition and resources.

The project has recently received some additional funding from the Naturesave Trust, to whom we are grateful.

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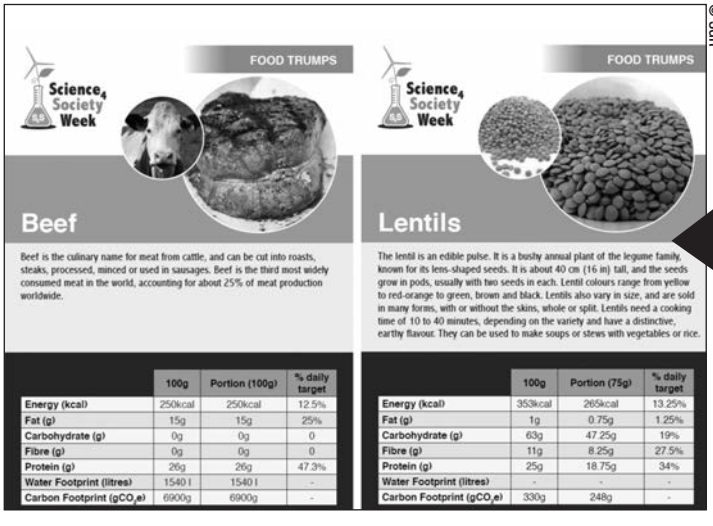
School children from Dallam School in Cumbria try out some of our classroom activities during S4SWeek 2017



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Examples of our new 'food trump cards'

Making the case for a more ethical industrial strategy

2017 was the year when industrial strategy became a key political issue, especially in the UK, but also further afield – and SGR took the opportunity to argue that ethical concerns needed to be prioritised.

UK activities

Early in the year, the Conservative government consulted on its draft strategy while the Labour Party also asked for input. SGR responded to both, arguing for a major shift away from military industry towards a range of sustainable technologies, especially renewable energy. We also raised the possibility of an 'eco-ship' industry as an alternative to the focus on military shipbuilding. Stuart Parkinson had an opinion article making similar points published in *The Engineer*, and was extensively quoted in an article on the *Pulitzer Center* website about the possibility of arms conversion at Barrow, where the UK's nuclear submarines are built.

Following this rationale SGR has helped set-up an 'arms conversion/ defence diversification group' – which comprises peace campaigners, environmental activists and trade unionists – to help gain wider support for these ideas. So far, members of the group have managed to pass supportive motions at both the Trade Union Congress and the Green Party national conference.

This activity fits well with our continued work to reduce military influence on science and technology. Apart from the peaceworker project (see p.2), we also pursued other initiatives. In the summer, an academic book was published featuring a chapter by Chris Langley and Stuart Parkinson on the problems of military influence on science. In the autumn, we worked with environmental and peace organisations to protest against the sponsorship of the New Scientist Live education event by BAE Systems and Shell. Stuart also spoke about the issue at the international Health Through Peace conference at York University (see p.21) and the Festival of Politics at Leeds University.

European activities

But arguably the biggest issue during the year was the announcement of plans for a new European Defence Fund, which is intended to massively expand the EU funds available for military R&D and associated activities – see the feature article on p.7. As discussed in the last SGR Newsletter, we have joined with several other campaign groups across Europe to challenge EU spending on military R&D. In recent months, we have helped set up a new website – Researchers for Peace: https://www.researchersforpeace.eu/ – with a sign-on statement which we are urging researchers across Europe to sign. We are also urging researchers to write to their MEPs letting them know of their opposition to the new Fund. For further information, see p.7.

Stuart Parkinson also took part in a seminar in Brussels in December critically examining the EU 'security' R&D programme. This programme has been running for over ten years funding research mainly on technologies for use in policing and law enforcement. This has raised many concerns about human rights issues, especially as numerous arms corporations have received project funding.

New patrons

SGR is very pleased to welcome four new patrons. They are:

- Tim Foxon, professor of sustainability transitions at the University of Sussex. He is author of a new book, *Energy and economic growth: why we need a new pathway to prosperity*. Tim was a member of SGR's National Co-ordinating Committee from 1995 to 2015, including seven years as secretary.
- Harvey Goldstein, professor of social statistics at the University of Bristol. He also holds professorial posts at both University College London and the London School of Hygiene and Tropical Medicine.
- Alastair Hay, professor of environmental toxicology at the University of Leeds. He is a leading expert on the effects of exposure to chemical warfare agents, and has served on a number of UK government and EU scientific expert advisory committees.
- Malcolm Povey, professor of food physics at the University of Leeds. He is also president of the University of Leeds University and College Union (UCU) branch and a member of the UCU National Executive.

The only problem with this list is the lack of women! If you have suggestions for potential patrons for SGR, please contact us (see back page).

Stephen Moorbath, 1929-2016

Stephen Moorbath, professor of geology at Oxford University and former sponsor/ patron of SGR, has died aged 87.

Stephen specialised in geochronology and is credited with dating the oldest rocks yet known on the Earth – more than 3,800 million years old – from west Greenland.

He was born in Nazi Germany in 1929 and brought up as a Jew. He and his father fled to Britain in May 1939, but his mother was not able to leave the country before war broke out and was murdered by the Nazis in 1942.

He left school at 16 and worked as a lab technician at Oxford University before moving to the UK Atomic Energy Authority in Harwell. He then studied chemistry at Oxford, developing a keen interest in geology.

His career progressed and, in 1956, he set up the Geological Age and Isotope Research Group at the university. Over the next 40 years, Stephen became a leading researcher in his field. He was elected a Fellow of the Royal Society (FRS) in 1977, and was also awarded the Murchison Medal by the Geological Society of London and the Steno Medal by the Danish Geological Society.

He joined Scientists Against Nuclear Arms in the 1980s and remained a staunch supporter after SGR was formed in 1992. He will be sadly missed.

Stuart Parkinson

In brief

- Richard Jennings and Gerry Lowe ran SGR stalls at careers events in Cambridge and Buckinghamshire respectively. Richard also edited a new book, *Successful careers beyond the lab*, which featured chapters by Philip Webber and Stuart Parkinson.
- Over the past few months, Gwen Harrison has been helping local anti-fracking campaigners in Lancashire to access scientific advice on their monitoring of potential pollution at a new drill site.
- SGR was a co-signatory of a statement presented to the UN's 'First Committee' on the increasing risks of armed drones. The statement urged international action to restrict the technology.

State of the Arctic heightens focus on climate policy

The deterioration of the Arctic ice cap and its climate has continued apace. Vanessa Spedding provides an update on recent developments.

Since the previous article in the *SGR Newsletter*[1] in 2013 on melt conditions and predictions for the Arctic ice cap, the decline of sea ice cover has continued with a clear and consistent trend, albeit with significant year-to-year variability.

Examining the latest Arctic observations

Latest figures from the National Snow and Ice Data Center (NSIDC) in the USA[2] show that the Arctic sea ice extent for September 2017 — the end of this year's Arctic summer — was, at 4.87 million square km, not a record low but the eighth lowest minimum of summer sea-ice cover. However the summer was characterised by localised weather conditions in the form of storms and low-pressure areas, both of which have cooling effects, and which produced a temporary rally. Conversely, winter 2016-7 *did* break a record, with measurements registering an all-time low for winter sea ice extent.[3]

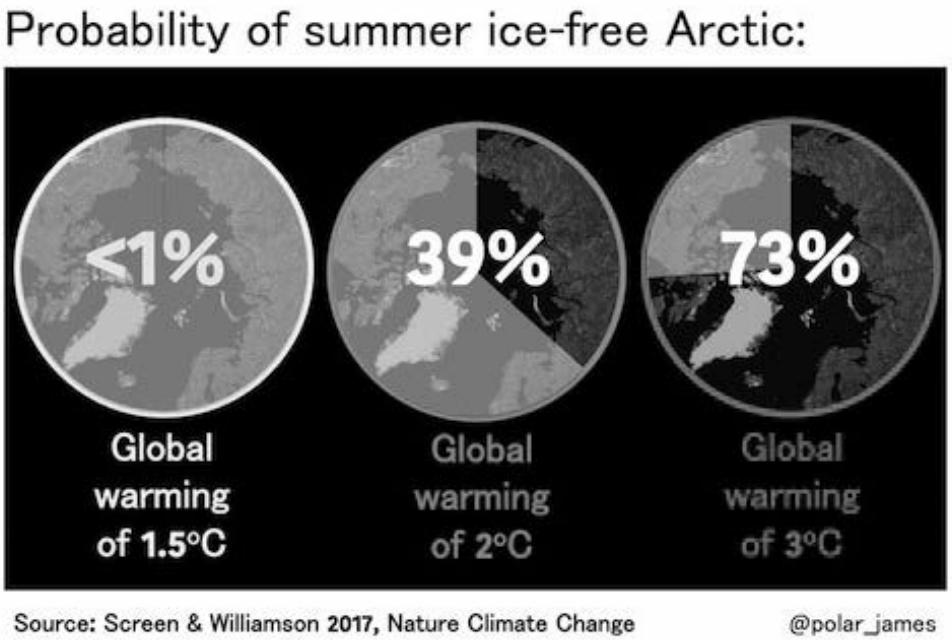
The rate of sea ice decline per decade provides a useful, longer view. For September 2017, NSIDC calculations give this figure as 13.2% per decade (relative to the period 1981 to 2010) – little changed since 2012.

Further insight into the prospects for Arctic ice is provided by assessments of its thickness, or total volume, which give indications of its quality and resilience. A rare (and dangerous) winter expedition, undertaken by Norwegian researchers in 2015, showed that winter sea ice is thinner and weaker than they expected. The scientists observed[4] that much of the older, thicker, multi-year ice is being replaced by younger ice that is thinner, more vulnerable to storms and winds, more prone to breaking up, and more likely to experience accelerating degradation, as Prof Peter Wadhams warned in our 2013 article.[1]

Overall the trends are clear and offer little comfort. A report for policy-makers published in 2017 by The Arctic Monitoring and Assessment Programme (AMAP)[5] of the Arctic Council[6] provides a comprehensive and disturbing overview of the state of the Arctic region and its prospects. The report, titled *Snow, Water, Ice and Permafrost in the Arctic* (SWIPA), is based on assessments undertaken between 2010 and 2016 and concludes that the Arctic's climate is shifting to a new state, which is warmer, wetter and more variable.

Its survey of the most recent predictions for an ice-free Arctic summer suggests this could occur as early as the late 2030s, fitting with the range of predictions made by Prof James Overland[7] and Prof Tim Lenton (referenced previously[1]) in 2013.

The SWIPA report notes that Arctic temperatures have been rising more than twice as fast as the global average for the past 50 years, that snow cover has declined steadily and that sea temperatures are also increasing.



These observations align with recent findings by a Japanese team of researchers that include Prof Kay Ohshima and Haruhiko Kashiwase, of Hokkaido University and the Japan National Institute of Polar Research respectively, which show clear evidence of the albedo effect in action.[8] This is a positive feedback loop in which reduced reflectivity resulting from receding white ice giving way to dark water causes more of the sun's energy to be absorbed as heat, in turn causing more melting. "This study was the first to quantitatively elucidate that ice-ocean albedo feedback is a primary driver of seasonal and yearly variations in Arctic sea ice retreat," Prof Ohshima said.

Links between Arctic effects and wider climate patterns

The implications of all these trends for disruptions to wider climate stability are also growing clearer. Research by Prof Florian Sévellec at Southampton University in the UK and colleagues at Yale University in USA[9] indicates that the ongoing decline of Arctic sea ice has a slowing effect on the Atlantic Meridional Overturning Circulation (AMOC). Their climate model found the AMOC to be especially sensitive to these effects in the Arctic over multi-decadal timescales (longer than 20 years).

Prof Jennifer Francis of the Institute of Marine and Coastal Sciences at Rutgers University in the USA maintains her position[10] (as described in our previous article[1]) that there is a link between a warming Arctic and a disrupted jet stream, with effects on Northern hemisphere weather patterns.

Given the importance of Arctic sea ice to maintaining stable climate patterns elsewhere, together with the enhanced sensitivity of the region to global warming, a concerted focus on preventing further degradation of the ice would seem judicious.

According to a project earlier this year, which modelled the sensitivity of Arctic sea ice to temperature increases, there may be a clear and familiar signpost to achieving that.

Reporting in *Nature* on their study into Arctic ice melt,[11] James Screen, Associate Professor in Climate Science, and Daniel Williamson, Senior Lecturer in Mathematics, both at Exeter University in the UK, conclude that summer ice cover is "virtually certain" to survive if average global warming does not rise more than 1.5°C above pre-industrial era levels. "We estimate there is a less than 1-in-100,000 chance of

an ice-free Arctic if global warming stays below 1.5°C," said Prof Screen.[12]

However, if global warming heads to 2°C (the current target maximum stipulated by the 2015 Paris climate agreement[13]), the chances of an ice-free Arctic summer rise perilously to 39% in their model.

Answering a question on the implications of the potentially inadequate 2°C target, Prof Screen commented by email, "Are we condemning sea ice to oblivion? I would say no. I would counter such a pessimistic view by saying that our work shows that the odds of ice-free summers can be significantly reduced through strong mitigation."

"We find very low chances of an ice-free Arctic for 1.5°C," he continued. "Some may say that 1.5°C is impossible and maybe it is. But the Paris Agreement text says we should pursue efforts to limit warming to 1.5°. Even if we miss that target, limiting to 1.7° or 1.8° could still pay dividends in terms of reducing the risk of a summer ice-free Arctic, compared to 2°C, or our current pathway to roughly 3°C."

If his model is correct, the difference between the current climate target of 2°C and the "stretch" target of 1.5°C is therefore far from academic.

Even accounting for ambiguity about precisely what those targets mean (in the words of Prof Screen: "Does the 1.5°C target mean we never reach 1.5°C, or stabilise at 1.5°C, or even overshoot and come back down to 1.5°?"), and allowing for the model's restriction to only one interpretation (warming to then stabilising at the target temperature), as well as other caveats that put their estimated probabilities "likely on the low side," Prof Screen is confident that "one basic message holds true […]: 1.5°C gives us a much better chance of avoiding an ice-free summer Arctic than 2°C."

In the light of that conclusion, it is encouraging that the Intergovernmental Panel on Climate Change (IPCC) is working on a special report, due for publication in September 2018, on "the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change".[14]

Thinking about public communication

It is worth noting that to date, however, targets have made little difference to global greenhouse gas emissions. Dr Christopher Shaw, researcher[15] and author of *The Two Degrees Dangerous Limit for Climate Change*[16] — despite acknowledging the great debt owed to climate researchers and modellers for their work — countered the tendency to hang all hopes on target figures, saying, "Climate change always has been and always will be a political problem. In democratic societies politicians are not likely to move far ahead of public opinion. Rather than trying to effect change through a top-down, numbers-driven approach, the momentum for ambitious climate action needs to be built from the bottom up, grounded in the values, world views and aspirations of the people."

Calling for a climate conversation that branches out beyond "the preserve of technical experts and political elites", Dr Shaw suggested that an "inclusive peer-to-peer network of dialogues" might offer the hope of sustained buy-in from the public, which could provide "a human counterweight to what is fast becoming a terminal search for the magic number that will save us."

While the IPCC teams work through the latest numbers, scientists augment their assessments, and modellers refine their predictions of how a changing Arctic ice cap will impinge on society, life in the Arctic itself is already suffering substantial challenges and depredations. The SWIPA report identifies, among other impacts, changes to the ranges of a number Arctic species, increased occurrences of algal blooms, changes in diet among marine mammals; and altered predator-prey relationships, habitat uses and migration patterns. Terrestrial ecosystems are also feeling the effects with grazing animals such as caribou, reindeer, and musk ox struggling to meet their nutritional needs, while indigenous communities experience deleterious impacts on their livelihoods.

The reality on the ground — and the ice — calls for immediate mitigation efforts, regardless of the targets. Whether this comes thanks to an upswell of coordinated public protest or to the connection being made between a particular temperature and the prospects for civilisation, or both, the Arctic sea ice remains a bellwether, or perhaps a harbinger, of profound change.

In offering "an example of a climate threshold that is highly sensitive to the amount of warming in the 1.5 - 2°C range" (to quote Prof Screen once more), Arctic sea ice provides a critical focal point for calls to act with urgency on limiting warming.

Vanessa Spedding is a writer and editor based in Herefordshire. She has degrees in chemical physics and information design, and is a former member of SGR's National Co-ordinating Committee. She blogs occasionally at http://itsvivid.wordpress.com

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EU moves into military science and technology

Stuart Parkinson, SGR, outlines plans for a huge increase in funding from the European Union for military R&D.

In December 2016, the European Parliament voted to approve a new programme which, for the first time, provided major European Union funding for military research projects. It is planned that the programme, called the Preparatory Action on Defence Research (PADR), will spend approximately 90 million euros over the three years to 2020.[1]

However, this is just the beginning. In June 2017, the European Commission officially launched a new European Defence Fund. Current proposals for this fund, if accepted by Member States and the European Parliament, would rapidly expand the EU funding available to the arms industry. Specifically, spending on military research, development and related activities would increase to at least 1,500 million euros per year (m €y) from 2021 onwards – *50 times* the current level.[2] And it is important to understand that this funding is additional to the large budgets already provided by national governments in Europe for military R&D.

How did the European Union – a civilian organisation and recipient of the Nobel Peace Prize – come to this? And how can it be challenged?

The expansion of EU funding for R&D for security and military technologies

Growing integration of the economic and political systems of EU nations in civilian areas has, over the last couple of decades, led to increasing links between the EU and European arms corporations, not least in R&D. This has taken place in two key areas: the emerging 'security' sector, which is focused on technologies for law enforcement; and 'traditional defence' work.

EU-funded R&D for security was the first area to expand. In 2003, the EU adopted a European Security Strategy for the first time. This led to the setting up of the European Security Research Programme, which initially ran from 2007 to 2013 with a budget of 200m €y. This was increased in the next budget period – which runs from 2014 to 2020 – to over 240m €y. Many of the main beneficiaries of the research fund have been arms corporations, and key areas of R&D have included surveillance and border control technologies, including drones.[3]

The growth of EU-funded military R&D has proceeded at a much slower rate until very recently. In 2004, after concerted lobbying by industry, the European Defence Agency (EDA) was founded, a formal body within the EU whose mission is "to improve European defence capabilities". Within this, the EDA is "stimulating defence Research and Technology (R&T) and strengthening the European defence industry".[4]

The EDA has run numerous small industrial collaborations since 2004. However, it was not until 2016 that it launched its first research programme, awarding 1.4m € to three projects focused on innovation in aerial drones and 'urban warfare' technology.[5] The progress made with this programme in its first few months was deemed sufficient to lead to the rapid approval of the PADR – with a *20-fold* increase in annual spending.

Then, just six months on from the approval of the PADR, the proposals for the European Defence Fund were launched including requests for further massive increases in funding.[6] The structure of the fund is shown in Figure 1. It is planned that the PADR would form the research segment of this fund. From 2021, the PADR would expanded into the European Defence Research Programme, with EU funding of 500m €y up until 2027 (the end of the next EU budget period). This funding would be focused on basic and applied research in universities, public research institutes and corporate laboratories. In tandem with this, the European Defence Industrial Development Programme would be set up, initially with EU funding of 250m €y from 2019 to 2020, rising to 1,000m €y from 2021 to 2027. The focus of this programme would be to carry out development work and assist armed forces in the EU with the acquisition of the new military technologies. Hence the total EU funding per year for military research, development and acquisition assistance would total 1,500m €y from 2021 to 2027. On top of this EU funding, Member States would be expected to provide additional direct funding to these programmes, multiplying them further (see Figure 1).

A key priority for the first research projects being funded under the PADR are robotic systems, especially military drones[7] – and the signs are that such technologies will be a priority under the European Defence Fund in general, despite their highly controversial nature.

The proposed rapid growth of EU funding for military R&D is startling, but the European Defence Agency argues it is necessary. It has compiled data showing that national governments within the EU spend, in total, approximately 8,800m €y on military R&D[8] – a very large amount. However, the EDA is quick to point out that its figures show a real term fall of 1,900m €y from the 2006 level, before the global financial crisis. Hence it is lobbying hard for the European Defence Fund to at least make up the difference. To reinforce this argument, it points especially to growing Russian militarism, not least the takeover of Crimea in 2014.

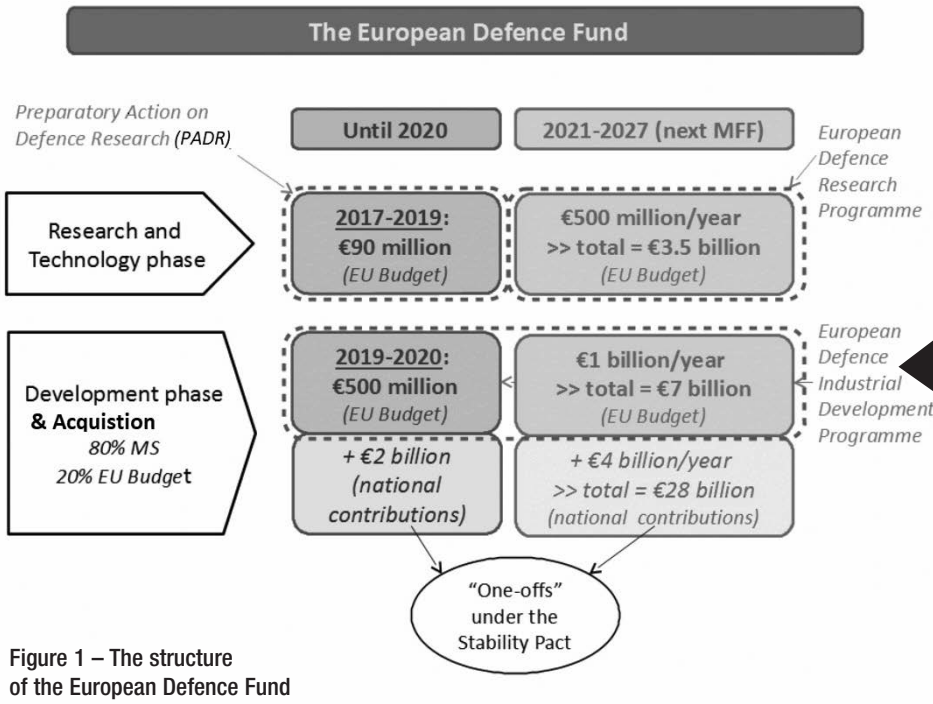

Figure 1 – The structure of the European Defence Fund

© Modified from: ENAAT (based on EU data)

Challenging the European Defence Fund

Although the PADR is now underway, there is still time to challenge the level of funding planned for other elements of the European Defence Fund. The next decision to be taken is on the size of the budget for the European Defence Industrial Development Programme for 2019 and 2020. In particular, the European Parliament is likely to vote on this in March or April 2018. Decisions on funding for programmes from 2021 onwards are likely to take place in late 2019. UK citizens will obviously be able to have a say in 2018 decisions but, if Brexit proceeds as planned, this will prevent direct input after early 2019. Nevertheless, there would be opportunities to support campaigners within the EU after Brexit happens.

Which arguments are most likely to influence MEPs and other European decision-makers?

First, let's consider national defence, especially with regard to Russia. Although Russia's military spending has increased markedly over the last decade, the total it has spent during this time has been only *one-fifth* that spent by EU countries.[9] And economic pressures – including EU sanctions following the invasion of Crimea – mean that that spending is likely to fall in the near future. This dominance is mirrored in military equipment, with the European members of NATO having force superiority over Russia in nearly all conventional weapons systems deployed – from battle tanks to warships.[10] So it is hard to see a convincing argument for the European Defence Fund based on national defence.

But, of course, the EU is a civilian alliance. Military issues are reserved to national governments, and hence decisions about key policies and funding streams are taken at that level (although some elements are co-ordinated through the EU via the EDA). So why should the EU be setting up a defence fund at all? Officials argue that funding of R&D within arms corporations is part of industrial policy, and therefore the EU has a role here. Indeed, it is notable that the officials with responsibility for the European Defence Fund have portfolios in industrial and economic policy, and use the language of efficiency and competitiveness when justifying the high level of proposed funding – and are keen to expand export markets.[11]

But the arms industry already receives numerous large subsidies from national governments – such as export guarantees and R&D funds. Furthermore, there is significant evidence that civilian industries are generally more beneficial in terms of economic performance and job creation.[12] Indeed, there is a major question mark over whether the arms industry contributes as much to the R&D activity of the EU as EDA figures indicate – see Box 1. Hence it is hard to see the economic justification for yet more public financial assistance for the military industrial sector.

Then, of course, there are the human rights issues. The EU collectively is the second largest arms exporter after the USA. Despite arms export controls, EU countries still sell weapons and other military equipment to numerous governments with poor human rights records.[13] Saudi Arabia is the largest recipient of EU arms exports, despite the equipment being used in the current war in Yemen, and despite evidence from the UN that this equipment has contributed to war crimes.[14]

Of course, the funding proposed for the European Defence Fund could be used instead for much needed civilian programmes. Indeed, in order to provide the planned 590m € to enable the creation of the European Defence Fund programmes in the current budget period (up until 2020), money is planned to be diverted from existing civilian programmes – including environmental protection, sustainable development, energy security and satellite navigation.[15] R&D in all these areas could help tackle the roots of conflict, which is arguably where the EU should focus its spending to improve global security. SGR (among others) has made this argument repeatedly over the years.[16]

Support the campaign against the European Defence Fund

To support the campaign against the European Defence Fund and its constituent programmes, SGR has joined with other European campaign groups to set up the *Researchers for Peace* website, https://www.researchersforpeace.eu/ Here, researchers from universities, public research bodies and industry are invited to sign a statement opposing the fund.

We also encourage you to write to your MEP as soon as possible, making some of the points in this article.

Dr Stuart Parkinson is Executive Director of Scientists for Global Responsibility, and has written extensively on military involvement in science and technology.

Box 1 – European military R&D spending – whose figures are right?

The European Defence Agency claims that the national governments in the EU, in total, spend about 8,800m €y on military R&D. However, Eurostat – the EU's statistical agency – has published very different figures, which are summarised in Table 1. Its total is approximately 4,600m €y – just under half the EDA estimate. Which should we believe?

Country	Military R&D spending (million euros)	Military R&D spending (% of public R&D spending)
United Kingdom	2,293	16.4%
France	1,017	7.2%
Germany	827	3.1%
Other EU countries	505	1.2%
EU (all 28 countries) (total national spending)	**4,642**	**4.8%**

Table 1 – Military R&D spending of selected European countries, as compiled by Eurostat[17] (2015 data)

In compiling its figures, Eurostat uses strict classifications of research and development, known as the 'Frascati definitions'.[18] These are internationally agreed so that robust and consistent statistics can be compiled for different organisations and countries. Unfortunately, EU defence ministries tend to compile two sets of R&D figures[19] – a Frascati-compliant set and another set which uses much broader definitions of R&D (including later stages in the commercialisation process). The second set is the source of the EDA figures. Hence their estimates are much higher. This can give the impression that the military industrial sector is more valuable in terms of R&D than other civilian sectors. This would be a misleading perception.

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Nuclear weapons: breakthrough or breaking point?

(contd. from page 1)

The need to negotiate a way out of this increasingly dangerous stand-off – and to end the nuclear arms build-up that is accelerating in other parts of the world – seems very clear.

A new UN treaty

The increasing threat of nuclear war on the Korean peninsula has spurred a very different reaction from elsewhere in the world. In 2007, anti-nuclear activists set up the International Campaign to Abolish Nuclear Weapons (ICAN) to re-energise stalled efforts at banning and eliminating these weapons of mass destruction.[5] (SGR quickly became an active supporter, and remains so – see p.3). Gathering support from sympathetic non-nuclear weapons states, notably Austria, Brazil, Costa Rica, Ireland, Mexico and South Africa, ICAN engaged a new generation of activists focusing on the 'humanitarian impacts' that the use of any nuclear weapon would have, even on countries not targeted by them. This campaign culminated, in July 2017, in the agreement by 122 nations of the Treaty on the Prohibition of Nuclear Weapons (TPNW). It became the first UN treaty to ban nuclear weapons outright, and prohibits development, testing, manufacture, possession, transfer, deployment, and threat of use, as well as actual use. Crucially, it also bans assistance, which includes financing.[6]

Although the nuclear weapons nations, and their supporters in military alliances such as NATO, have so far rejected the treaty, the TPNW is a critical step. Supporters point to the crucial role that similar UN treaties – such as those on chemical weapons or landmines – have had in pressurising even non-signatories to first reduce the numbers of weapons deployed and then, in many cases, actually joining the ban. In recognition of the importance of this advance, ICAN was awarded the 2017 Nobel Peace Prize.[7]

The next step is to convince at least 50 nations to ratify the TPNW, which will enable the treaty to enter into legal force. ICAN is campaigning for this to happen within 1,000 days of the Nobel prize award ceremony. At the time of writing, 56 governments have so far signed the treaty with five having proceeded to ratification.[8]

Nuclear disarmament is no easy task – and the risk of some sort of war on the Korean peninsula remains disturbingly real. Yet the TPNW offers a credible route by which states can choose a way out of nuclear arms races that so threaten the world's future.

Dr Stuart Parkinson is Executive Director of Scientists for Global Responsibility, and co-author of the SGR report, *UK nuclear weapons: a catastrophe in the making?*

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Cars and climate change: decarbonising passenger road transport

Rachel Freeman, University of Manchester, looks at why reducing carbon emissions in the UK transport sector is only happening very slowly, and how it can be sped up.

Most of the UK's major sectors (power, buildings, waste and industry) are making slow but steady progress towards a low greenhouse gas (GHG) emissions future – guided by the Committee on Climate Change's GHG budgets to 2050.[1] Emissions from the transport sector, however, have barely fallen against a 1990 baseline, and transport has now taken over from power as the highest emitting UK sector.[2] In this article, I will explore why transport has proved so difficult to decarbonise compared to other sectors by focusing on the largest part of transport emissions – CO_2 emissions from passenger cars. Cars were responsible for 17% of total UK CO_2 emissions in 2015 (up from 6% in 1970) and made up 58% of transport emissions.

The causes of CO_2 emissions can be formulated as a straightforward equation:[3]

> Annual emissions (grams of carbon dioxide, gCO_2) = total travel consumption per year (km) x average energy intensity of travel (megajoules/km) x average carbon intensity of energy used (gCO_2/megajoule)

Since this formula is multiplicative, a rise in one or more factors will counteract a fall in others. For example, if energy efficiency improves (i.e. the energy intensity of travel falls) but travel consumption rises at the same rate then emissions will remain the same.

Let's examine some of the key issues related to the three terms within the formula for the UK.

Travel consumption

Since the early 1970s several trends have been seen in travel consumption. Firstly, the average distance travelled by all modes, per person per year, has risen by around 70% - from 7,300 to 12,300 km/person/year. While the average number of trips per person has remained stable, the average length of trips has increased. Another change is that around 80% of personal travel is now by car, with the most common reasons for travel being shopping and personal business. Finally, the cost of car ownership has fallen by around a third and there has been a corresponding increase in the size of the UK's car fleet, rising by half since 1994.[4] Ownership of vehicles has become easier recently with Personal Contract Purchase financing, which requires no deposit and little proof of income – also linked to a trend for larger cars which have higher emissions.

There are many reasons for this normalisation of the car as the primary mode for everyday travel: it is convenient, fast (when not in traffic jams), and provides a private space. It's affordable for most people and often cheaper than public transport. It enables people to work more than one job should they need to, especially at unsociable hours, or live in places unconnected by public transport. It offers a sense of safety to concerned parents and those who feel vulnerable walking, cycling or traveling on public transport. It allows people to transport a large volume of belongings. The UK has a strong car culture, with peer pressure, personal status, and pleasure bound up with owning and driving a car that suits one's self-image.

Energy intensity of travel

A rough estimate, calculated by dividing total CO_2 emissions from cars by the total distance driven, indicates that the average energy efficiency of the UK fleet of cars has improved by around 30% since 1970, dropping from 245 gCO_2/vehicle-km to 172 gCO_2/vehicle-km. The efficiency of moving people has decreased less, however, falling from 150 gCO_2/passenger-km in 1970 to 132 gCO_2/passenger-km in 2015 – a drop of only 12%. This indicates that the utilisation rate of vehicles has decreased. Thus, some of the benefits of vehicle efficiency have been lost as cars are being used with fewer passengers. This lower utilisation is partly influenced by the volume of personal belongings people travel with and the desire for convenience and privacy.

Carbon intensity of energy

Almost all UK car travel is currently fuelled by oil-related fuels – petrol, diesel, LPG, CNG, and LNG. In 2015 electricity accounted for less than half a percent of the tonnes of oil equivalent used in road passenger transport, while bioliquids accounted for 3%.[5] Thus, the carbon intensity of fuel is basically that of fossil fuels and has not fallen.

Interactions between consumption, energy intensity and carbon intensity are important. For example, direct 'rebound' occurs when the cheaper cost of a service, achieved through an improvement in energy efficiency, leads to users consuming more of that service. Rebound erodes expected savings from energy efficiency, and for transport it has been estimated at 19% in the UK.[6]

Possible solutions: how to unstick road transport and decarbonise

Many solutions have been proposed to decarbonise transport. A study from 2007 found that a 60% reduction in transport emissions by 2030 was possible but it would require "an integrated package of technological and behavioural policy measures, ensuring that we travel in more carbon efficient ways and we travel little further than at present".[7] In the 10 years since that article was published passenger car emissions fell by 10% – a slow start towards the 60%.

One problem with considering only decarbonisation is that other negative side effects of mass privatised car use are neglected, including: urban air pollution from emissions such as particulates and NOx (especially from diesel cars); road building that takes away land from other uses; noise pollution; clogged up streets; lost economic output and human stress due to traffic congestion; social exclusion (for those without access to a car); impediments to public transport (e.g. buses getting stuck in traffic); road traffic collisions; and a lack of active travel contributing to ill health.

The reasons for the slow decarbonisation of transport are probably obvious. Car travel is just too attractive and its negative side effects are not fully valued. Energy efficiency gains have been partly offset by lower vehicle utilisation, longer trips, and larger cars.

Improvements to driving conditions, such as smart motorways, are making driving easier. Easy financing makes owning a new and impressive car more accessible to more people. The car sector and its supply chain is enjoying a boom, and the Treasury is probably not too keen on disrupting it. The general expectation seems to be that decarbonisation will happen solely through changes to vehicles and fuels. However, this may not be the quickest, most efficient or most economic route.

In addition to expanding support for public transport, cycling and walking, which have many other benefits in addition to CO_2 savings, there are several possibilities:

This Nissan Leaf electric car is operated by a car club and charged from community-owned renewable energy technologies near Lancaster. Will such options become commonplace?

1. A new business model, known as 'mobility as a service' would combine autonomous (driverless) vehicles, low-emissions vehicles (e.g. as part of a car club[8]), smart devices (e.g. apps on phones), and smart roads (e.g. live traffic data). Personal, door to door transport could be provided as scheduled or on-demand driverless vehicles (of various sizes), which are centrally coordinated to maximise road use efficiency. Many households, especially in cities, would no longer need to own cars. Imagine how much more physical space would be available for walking, cycling, and even socialising. It would reduce road traffic collisions, prevent isolation for non-drivers, reduce noise, and reduce the stress that comes with having to navigate clogged up streets. It would, however, need a huge amount of investment to make it work and it could put some public transport networks out of business.
2. An option for replacing fuel tax that would please the Treasury is dynamic road pricing. Car owners/users would pay a dynamically changing fee to use roads, which would rise as the demand for particular types or sections of roads rise.
3. An option for increasing active travel is the electric bicycle, which is becoming very popular in China and gaining market share in the UK. This offers some exercise but is not as daunting as a fully mechanical bike for those who are less fit.
4. Fully electric cars are a good option but not necessarily the best for all driving. With the current carbon intensity of grid electricity (242 gCO_2/kWh), the Nissan Leaf emits around 36 gCO_2/km (not including the high embodied emissions in a large traction battery) but with a range of only 250km. A petrol hybrid car like the Toyota Prius is rated at 70 gCO_2/km and hybrids are better as an all-round car since they have longer ranges between fuel stops. There are also many highly efficient petrol or diesel cars that are rated at less than 100 gCO_2/km. Furthermore, the implications of electrification are that deep CO_2 savings will only be achieved with a simultaneous large-scale and rapid building programme for low-carbon electricity generation. It is notable that, for example, the National Grid's 'High EV' scenario shows an increase of over 15% in electricity supply by 2050 over their 2°C scenario, some of which would come from natural gas[9] – with potential impacts on the carbon intensity of grid energy.
5. All non-electric cars still need liquid fuels, however. One option would be to replace petrol with low-carbon synth fuels, such as synthetic methanol, which can be made from low-carbon electricity and waste CO_2.[10] For example, Audi e-gas, which is produced through a two-step process of electrolysis and methanation[11], is being compressed as CNG and used in the dual-fuel Audi A5 Sportback g-tron[1]. Audi claim that the car emits "80% less CO_2/km with Audi e-gas technology purely in gas mode (CNG)"[12] compared with a similar petrol fuelled model. However, synth fuels would still require a large input of electricity from renewable sources.

A combination of the partial replacement of private cars with mobility as a service, dynamic road pricing, promotion of active travel (walking and cycling), hybridisation or electrification of cars, low-carbon synthetic fuels, and support for public transport might make a much larger dent in our car transport emissions than assuming the car fleet is going to be decarbonised through technology changes alone. Finally, we might, as a society, stop to question our high-powered lifestyles. Most of us don't think twice about taking cross country journeys in vehicles with the power of over 100 horses. Our great-grandparents might have taken such a journey only a few times in their lifetime, and certainly not at such speed. To determine whether the rewards are worth the cost, and whether there are other and better options for beneficial personal mobility, will require an engaged public debate.

Dr Rachel Freeman is a research associate at the Tyndall Centre for Climate Change Research, University of Manchester, and is funded by the UK Energy Research Centre, under the research project RACER (Rapid Acceleration of Carbon Emissions Reductions from Cars).[13]

Update

In January 2018 the CCC published an assessment of the UK's Clean Growth Strategy.[14] The study found that by 2030 the largest sectoral policy gap, when forecast emissions assuming policies in the Clean Growth Strategy are compared with those required by CCC planning, will be in the transport sector. The policy gap stands at 42 MtCO2e in 2030, twice that of the power sector. The study confirms the need for much more concerted action in reducing transport emissions.

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Will Brexit will drive UK academia over a cliff edge?

Keith Baker, Glasgow Caledonian University, looks at the prospects for British universities as the end of UK membership of the European Union approaches.

Much like the guidance from Universities UK on the government's proposals for how it intends to withdraw from the EU,[1] this article has been revised several times since it was first drafted. Back in September 2017, the guidance advised that all EU-funded activities, including those at proposal stage, would be funded to completion. Then in November researchers on projects funded by the EU's flagship Horizon 2020 programme were warned that, without an agreement being reached, funding could cease as early as March 2019.[2] This uncertainty led Prof Stuart Croft, Vice Chancellor of Warwick University, to warn that the sector could face disaster within weeks.[3]

At the time of writing, the guidance is now more optimistic, stating that all EU-funded activities will be supported until the end of the current procurement programme. UUK is also "*urging the government to confirm the UK's access to European Structural and Investment Funds (ESIF) are included in the phase one agreement as well as working to secure future association onto the successor programme, Framework Programme 9 and is contributing actively to its design*".[1]

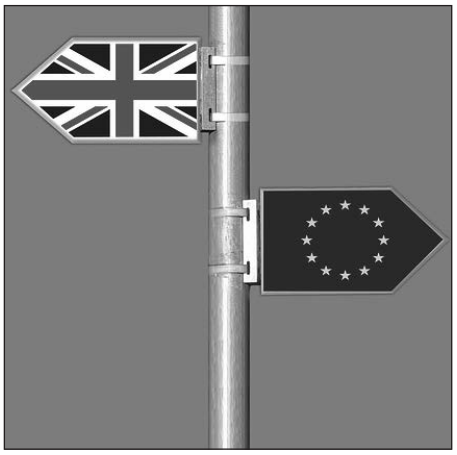
This latest guidance effectively postpones the cut-off year to 2021 but, even if these agreements are reached, the UK will of course have little or no say in the design and delivery of future funding programmes. It also seems reasonable to assume that, should such agreements be reached, UK universities would then be subject to the same basic conditions of other non-EU partners, such as receiving smaller shares of the full economic costs of activities.

But that's just the impact on research. The UK is currently the second most popular destination in the world for international students, after the USA, and in 2014-15 international students contributed over £25 billion to the economy, which is estimated as supporting over 200,000 jobs in the UK's university towns and cities.[4,5] But that income is now under serious threat. A 2016 survey by the student recruitment consulting firm Hobsons found that 30% of international students said they were unlikely to come to the UK following the referendum result, with another 6% saying they would definitely not choose to study here.[6] Assuming those figures are reasonably accurate, that's a loss of at least half of the infamous £350 million a week Boris Johnson and colleagues claimed would be saved for the NHS.

In the second draft of this article I warned that a hard Brexit, meaning leaving the EU without an agreement in March 2019, would drive UK academia over a cliff edge, and since then I've seen no reason to change that conclusion. However, we are now in a situation more akin to early 2017, so it's worth noting an analysis from the European economic think-tank Bruegel[7] which built on analysis by the Higher Education Policy Institute.[8] This found that, while the funding losses of a more managed Brexit would not necessarily be irrevocable, universities already perceive the impacts on EU staff and students a significant distortion in their human capital and international reach, and that funding benefits that do not come directly from the EU but depend on staff mobility[9] and opportunities for international collaborations, could cease.

So, while the latest news softens the blow, even a 'soft' Brexit will still have a negative impact on UK academia, and the long-term uncertainty is not going to go away. Let's not forget that nothing will be set in stone until at least late 2018, by which time pollsters and commentators are predicting we may see another general election or possibly even a withdrawal of Article 50, or that three years is a very short time for academic planning. Furthermore, here in Scotland where the need to attract immigrants to offset an ageing population is likely to remain a red line for the Scottish Government, there remains the prospect of a second referendum on independence that could attract talent from across the new border. So as things stand, the end of 2018 will see us three months away from 'Brexit Day', and while we may have retreated from the brink of disaster, that cliff edge still looks dangerously close.

Dr Keith Baker is a Researcher in the School of Engineering and the Built Environment, Glasgow Caledonian University. He has worked on EU-Funded research projects but is not currently in receipt of or applying for EU funding.



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The history of accidents in the UK's nuclear weapons programme

David Cullen and Peter Burt, Nuclear Information Service, outline the findings of a new report that reveals the frightening scale of mishaps and near-misses within Britain's military nuclear complex.

In the era of Donald Trump and Kim Jong Un there is a growing public awareness of the risks of nuclear weapons. Many fear that the escalating war of words could result in one side or other using nuclear weapons, either in a planned first strike or as a result of a misunderstanding about the other side's intentions, with catastrophic consequences.

However, there is one aspect that is often overlooked in the debate over the risks of nuclear weapons: the inherent risks that arise from simply possessing them, even if nobody ever intends to use them. No system is ever perfect, equipment becomes less reliable over time, and human error is a fact of life. These factors do suggest that even in peace-time, nuclear weapons are a risk to the public, but how large is that risk?

In the UK the Ministry of Defence has only ever published one official list of nuclear accidents in this country. Deposited in the House of Commons library in 2003 after a six-year campaign by *The Guardian* newspaper it detailed 27 incidents. However, this is far from being a complete list. The truth is that nobody really knows how many accidents and near misses there have been. There is no central record of incidents, and records prior to 1960 are particularly patchy.

Earlier this year the Nuclear Information Service (NIS) published a report compiling all of the known accidents, near misses and dangerous occurrences in the 65-year history of the UK's nuclear weapons programme. *Playing with Fire: Nuclear Weapons Incidents and Accidents in the United Kingdom*[1] lists 110 serious incidents as well as numerous other less serious incidents.

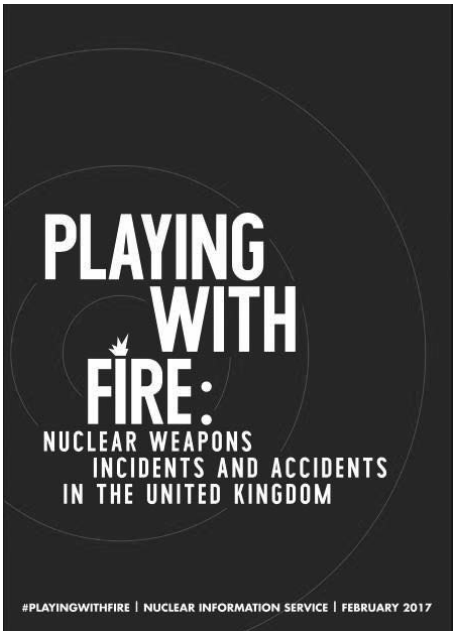
The report looks at the different stages in the production and deployment of nuclear weapons, with different chapters on manufacturing, transport, handling, and deployment on submarines, aircraft and ships. There are also separate chapters dealing with security incidents and accidents involving US nuclear weapons stationed on UK territory. Each chapter lists all of the known incidents and concludes with a detailed case study of one of the more serious incidents.

Main findings of the report

Among the serious incidents in the report are 27 fires and eight explosions, six aircraft crashes and six incidents involving a problem with a nuclear reactor. There were also 12 incidents where a nuclear weapon was damaged and seven where there was some risk of an unintended nuclear detonation.

There were several incidents that resulted in deaths. Seven workers have died at AWE Aldermaston in industrial accidents over the years, and a further nine are thought to have died due to exposure to radioactive material during their time working there. There have been no industrial deaths since 1986 and health protection standards at AWE are considerably better than they used to be, but it is a strange irony that the primary victims of the UK's nuclear weapons are the people who built them.

The most lethal incident listed in the report is the Windscale fire in 1957. The reactor where the fire occurred was part of the nuclear weapons production process – producing plutonium and other radioactive elements for nuclear warheads. In fact, the rush to produce the required materials probably contributed to the disaster. While it is not possible to directly assess the links between radiation exposure and its stochastic effects, such as cancer, an editorial in the *Journal of Radiological Protection* estimated that the radioactive release from the fire will have caused around 100 deaths from cancer.



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The patchy documentary record

There is a wide degree of variation in the amount of information in the public domain about the different incidents in the report. Some are extensively documented, like the Windscale Fire, but others do not appear to have any extant records and we only know about them from passing references in other documents, such as memoirs.

The UK government's policy on refusing to confirm or deny whether nuclear weapons were deployed on a particular surface ship and a lack of archive evidence mean that there are some very serious incidents involving nuclear-capable ships where we cannot be certain if nuclear weapons were on board at the time. These include fires and collisions with other ships.

There is documentary evidence that nuclear weapons were on ships during some incidents, for example during a collision that occurred in Hong Kong harbour in 1988 and on the flotilla dispatched to the Falkland Islands in 1982. In the latter case, the decision not to remove the weapons meant that over 65% of the UK's stock of nuclear depth charges went into war in the South Atlantic. As a consequence, they then had to be shuttled between ships in international waters in order to comply with the South American Nuclear Weapons Free Zone. This operation was done with rope and pulley system known as a 'heavy jackstay' and resulted in "significant damage" to the casing of one warhead.

West Dean convoy accident

The West Dean incident occurred on a wintry day in January 1987 when an RAF nuclear weapons convoy was moving WE177A tactical nuclear weapons from Portsmouth Naval Base to the Royal Naval Armaments Depot at Dean Hill.

The convoy was moving down a narrow country lane on the final stage of its journey when a car approaching from the opposite direction stopped to let the heavy lorries pass. As the third carrier approached the car, the driver lost control and a combination of icy road conditions and the road camber caused it to slide off the road. The verge gave way and the carrier toppled to its left, coming to a halt on its side in a field three feet below the level of the road. The fourth warhead carrier in the convoy slewed across the road on the ice as the driver braked and came to rest

precariously balanced on the verge, with its front wheels off the road.

A security cordon was placed around the site, but this was quickly infiltrated by protestors who had been monitoring the convoy. The convoy crew alerted the civilian emergency services and experts from the Atomic Weapons Research Establishment (AWRE) were called out to advise on whether the stricken trucks could be moved safely.

The fourth truck, still on the roadway, was winched back on to the road and was able to move away under its own power but the vehicle which had fallen into the field could not be moved until the following morning. At first light the truck was righted and lifted back onto the road by a 50 ton crane and then, 18 hours after the accident, it was towed into the Dean Hill base under heavy military escort with helicopters hovering overhead.

Documents subsequently released by the MoD under the Freedom of Information Act revealed that the convoy had been transporting six WE177A nuclear weapons and that each of the two trucks involved in the crash had been carrying two warheads. The four weapons involved in the accident were inspected over the next few days at the Dean Hill base by personnel from AWRE and the Royal Aircraft Establishment and were deemed to be "safe for movement and storage in the magazines", although as two of them were approaching their refurbishment date, "it would be prudent to refurbish prior to Service return".

Rough Handling at RAF Bruggen

On the 2 May 1984 a Hercules transport aircraft landed at RAF Bruggen in West Germany. The Hercules was on a 'routine logistical flight' to deliver a cargo of WE177 nuclear bombs from the UK to Bruggen. The bombs were unloaded from the aircraft later that evening and moved to the 'Special Storage Area' (SSA) at the base – the high security area where nuclear weapons were stored.

During the unloading job one of the WE177 bombs was loaded onto a flat top trailer towed by a Landrover to be driven to a storage building. As the Landrover turned a corner on its way to the bomb store the container holding the bomb "slid from the trailer; fell some 3.5 feet, and slid about 20 feet, coming to rest after rolling through 270 degrees". The container was recovered and moved into a servicing building where the bomb inside it was inspected. An impact mark three inches long was discovered on the body of the bomb, corresponding to damage to a tool box mounted inside the container. At this point the RAF decided that the weapon was unserviceable and called in experts from AWRE for advice. "They flew in a Hercules with a special decontamination unit and cordoned the whole area off", said one RAF mechanic who was serving at Bruggen at the time of the incident.

The AWRE response team took a series of radiographic images to examine the interior of the warhead, revealing a "crack-like feature" in the warhead's high explosive assembly. However, it was eventually concluded that the feature corresponded with an abutment where three explosive tile edges met and was quite normal. After three weeks of investigations the AWRE team concluded that the bomb was safe to move by normal means and it was returned to the UK for servicing.

A Board of Inquiry found that, contrary to regulations, the container had not been secured to the trailer before it was moved by the Landrover. Unsecured containers "were being moved regularly" within the Special Storage Area where nuclear weapons were stored, and personnel working in the storage area had not brought this to the attention of a higher authority. The engineering squadron responsible for explosives storage was understaffed and the practice of moving unsecured containers had been "accepted by the SSA staff as common practice for some considerable time".

The inquiry found that non-compliance with regulations directing the transport of nuclear weapons had been "directly and wholly responsible" for the damage to the bomb, and concluded that seven RAF personnel, including two officers, had been negligent in their duties. These officers knew that rules were being broken but failed to report the effects that lack of staff and equipment were having on compliance with safety procedures or to provide adequate supervision. Both were subsequently removed from their posts.

Concluding comments

The picture built up from these examples, and from the others in the report, is that it is not possible to eliminate accidents altogether. Problems and sloppy behaviour will eventually creep in at some point, equipment will break or some unforeseen circumstance will cause unforeseen difficulties. While changes such as putting the defence nuclear programme under external regulation would help to reduce the risks of an accident involving nuclear weapons, it will not be possible to eliminate the risks altogether while nuclear weapons still exist.

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UK nuclear convoys have experienced accidents and equipment failures

Air pollution: one of the greatest health challenges of our time

May van Schalkwyk and Emer O'Connell outline the neglected impacts of air pollution, and the key steps needed to tackle it.

The scale of the problem

Pollution is one of the most important public health challenges of the 21st century and, despite marked progress in policy and technology over the past decades, it continues to threaten the health and prosperity of populations across the globe.[1] Pollution is responsible for three times more deaths than the combination of those due to AIDS, Tuberculosis and Malaria and 15 times more than is caused by wars and others forms of violence.[1] While many populations experience exposure to harmful levels of pollution, the health burden falls disproportionally on the poor and vulnerable. Pollution-related disease is most prevalent among minorities and the marginalised in all countries,[1] exacerbating inequities and injustices.

Air pollution (ambient/outdoor and household) is a major contributor to this concerning picture, with 3 million and 4.3 million deaths annually being attributable to ambient and household air pollution, respectively.[2] In the European region (as classified by the World Health Organisation), exposure to particulate air pollution is estimated to reduce the life expectancy of every individual by an average of nearly 1 year, primarily due to the increased risk of cardiovascular and respiratory diseases and lung cancer.[3] In the UK, the impact of exposure to particulate air pollution in 2008 was estimated to be equivalent to almost 29,000 deaths at typical ages and an associated loss of population life of 340,000 life years lost.[4] To put these figure into context, household exposure to second-hand smoke has been estimated to account for 10,700 deaths in the UK.[5]

Unless aggressive interventions are implemented, the number of deaths attributed to ambient air pollution globally are predicted to increase by over 50% by 2050.[6] The drivers of air pollution are complex and policy solutions are not straightforward. However, the dividends from policy solutions that are designed to maximise other health benefits whilst reducing the direct burden from air pollution provide an important opportunity.

What is air pollution and what are the health effects?

The term 'air pollution' is used to refer to substances in the air that have harmful effects on human health, welfare, plant and animal life. Although there are numerous air pollutants that have been associated with significant excess morbidity and mortality, oxides of nitrogen (NO_x), ozone, carbon monoxide and sulphur dioxide for example, it is the effects of particulate matter 2.5 ($PM_{2.5}$) that has the strongest epidemiological link with health outcomes. It is the air pollutant that is most commonly adopted as a proxy indicator of air pollution exposure[4] and has been shown to be associated with a wide range of diseases in many human organ systems.[7,8] PM, a complex mixture of solid and liquid particulates of organic and inorganic substances, is categorised depending on particle size. For example, PM_{10} is used to refer to particles of diameter less than 10 micrometers (μm). The health impacts of air pollutants are dependent on the size of the particle. PM_{10}, shown to penetrate and lodge deep within the lungs, is strongly associated with short term increase in death rates and exacerbation of some common medical conditions, such as asthma. Elevated concentrations of ambient $PM_{2.5}$ are even more harmful to health as long term exposure to these smaller particles increases the risk of premature mortality from cardiovascular and pulmonary diseases.[9]

The evidence for these associations is strong with numerous large-scale studies reporting statistically significant impacts on health consistently, regardless of context. The evidence also indicates that there is no safe level of exposure for human health.[4,10] The International Agency for Research on Cancer has categorised airborne PM and ambient air pollution as proven human carcinogens.[11,12,13]

There is increasing concern about the health impacts associated with exposure to nitrogen dioxide (NO_2). In 2015, the UK Department of Health's Committee on the Medical Effects of Air Pollutants concluded that the strength of the evidence on the health impacts of NO_2 has increased significantly over recent years and, based on the findings, can be considered a cause of certain health effects.[14] This is a particular concern given the very high ambient concentrations of NO_2 in many urban areas due to high traffic volumes.

Who are exposed and what are the sources?

Air pollution affects all regions of the world and it is estimated that 92% of the world's population lives in places where air pollution levels exceed WHO safety limits.[2] There are however, marked geographical differences in exposure to air pollution. People who live in Africa, Asia or the Middle East are exposed to much higher levels of air pollutants in comparison to those who live in other parts of the world.[15] Motorised vehicles (from petrol and diesel exhaust emissions, break and tyre wear), industries and households emit complex mixtures of air pollutants, all contributing to the levels of ambient air pollution. Most PM comes from fuel combustion, both from mobile sources such as vehicles and from stationary sources such as power plants, industry, households or biomass burning.[16]

Approximately 3 billion people still depend upon solid fuels (i.e. wood, crop wastes, charcoal, coal and dung) in open fires and leaky stoves to cook and heat their homes. The majority of these people are deprived and living in low- and middle-income countries. These practices produce high levels of household air pollution that contains a suite of pollutants known to be harmful to health, including small soot particles that can penetrate deep into the lungs. Poor ventilation can lead to indoor smoke levels reaching 100 times higher than is acceptable for fine particles. Women and young children are at high risk of exposure as they spend most time near the domestic hearth.[17]

A call for action

Action is needed to prevent the huge burden of premature death and ill health attributable to air pollution annually. Addressing the detrimental effects of air pollution poses a unique opportunity for improving health and prosperity worldwide. By adopting initiatives that focus on broader health issues and equity, multiple benefits – such as reducing levels of physical inactivity, obesity and non-communicable disease, social isolation, and climate change mitigation - can be realised also.

The drivers of air pollution are multiple and complex so multi-faceted cross-sectoral initiatives are needed. We must realign the way we design and function in our cities and the way we use resources. Importantly, collaborative working across multiple

sectors, and improvement in the application of evidence to improve urban design and transport are pivotal in addressing the inter-related health issues such air pollution, climate change and non-communicable diseases. The evidence demonstrates that land use and transport policies and practices contribute substantially to such health threats.[18–20] For example, the approach to city planning with the greatest potential to produce the largest health benefits is one where walking, cycling and public transport are supported by a safe infrastructure and given prioritisation over private motorised forms of transport.[18–20]

Led by WHO, the Climate and Clean Air Coalition, and the Government of Norway, BreatheLife is a global campaign that advocates for action that prioritises: (1) knowledge sharing between cities; (2) upscaling monitoring; (3) supporting solutions; and (4) educating people and provide examples of city-wide solutions and actions that can be taken by individuals, leaders and the healthcare community.[21]

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Doctors Against Diesel

Doctors Against Diesel is a new evidence-based campaign run by the public health charity Medact, and supported by numerous doctors, nurses and health professionals. Our mission is to reduce the impacts of air pollution on children's health.

We recognise that there are multiple sources of outdoor air pollution. However, in urban areas the single biggest source is road transport. Children in particular are vulnerable to the effects of air pollution from traffic. Hence, it is of particular concern that a recent Greenpeace UK investigation revealed that more than 2,000 schools and other similar establishments are within 150m of roads emitting illegal levels of nitrogen dioxide (NO_2).

Our campaign specifically focuses on diesel because it is the biggest source of air pollution in cities, and a source of two of the most dangerous air pollutants for health: NO_2 and particulate matter (PM_{10} and $PM_{2.5}$).

Diesel cars produce more of these pollutants than petrol cars. Indeed, diesel cars produce over 40% of the NO_2 coming from roads in cities.

Following the Volkswagen 'Dieselgate' scandal in 2015 and other similar scandals, it has become apparent that many car companies have been knowingly fixing emissions tests designed to reduce emissions from diesel, and hence breaking air pollution standards.

Despite some moves to alter testing regulations and 'fix' some of the cars, two-thirds of the newest, high 'Euro 6' standard diesel cars still do not meet emissions standards in real world conditions.

Doctors Against Diesel is working for a world where:

- No child's health is adversely affected by air pollution
- Highly polluting diesel vehicles are phased out from UK towns and cities
- Policies support the choice to walk, cycle or take public transport as healthy and safe alternatives to driving

For more information or to support the campaign, see https://doctorsagainstdiesel.uk/ or phone Carla Stephan on 0207 324 4739.

Being a radical scientist: lessons from the 1980s

SGR patron Keith Barnham reflects on his work with Scientists Against Nuclear Arms investigating the military diversion of civilian nuclear materials – and considers the relevance for academics and activists today.

With Trump's election, the recent spiral of fiery nuclear rhetoric, and the continuing Western and Russian involvement in Middle East conflicts, the Doomsday Clock – that measure of how close human civilisation is to global catastrophe[1] – is moving closer to midnight. Those of us who can remember the early 1980s see parallels with the rise in Cold War intensity following President Reagan's election and Soviet Russia's invasion of Afghanistan. We also recall the remarkable rise in the global peace movement that followed. This included the founding of Scientists Against Nuclear Arms (SANA), one of the forerunners of SGR.

During and following the SGR annual conference in 2016 there was discussion about the problems of organising SGR working groups[2] given the current pressures on academics/scientists. This prompted me to set down the following recollections on an early SANA working group that I joined. I hope the similarities and contrasts with the current university situation will encourage younger SGR members as they try to balance involvement in SGR activities with the demands of an academic career – as well as informing the current and future development of working groups within SGR.

The founding of SANA

The inaugural meeting of SANA in 1981 at the Open University was a memorable experience. The hall was full of young, old, senior and student scientists from universities and industry. The epithet 'scientist' was broadly interpreted – ranging from theoretical physics to engineering and the social sciences. Equally impressive were the pages of flip-charts with suggestions for working groups. These were updated while the opening presentations were being made. The groups got underway in parallel afternoon sessions, enthused by Prof Mike Pentz – SANA's first chair – whose unforgettable exhortation was that we should provide the tools that the peace movement needed to fulfil its aims.

My choices from this cornucopia of options were easy. As my research in particle physics at Imperial College involved experiments at CERN in Switzerland, I joined the group planning to develop international links with other scientists in the peace movement. Secondly, I had recently decided that, being fortunate to have a permanent academic contract, I wanted to change my research field to solar energy (for reasons described in my book *The Burning Answer*[3]). The working group most closely related to my new field was the one on the links between nuclear power and nuclear weapons.

SANA's contribution to the CND Sizewell Working Party

The SANA 'Nuclear Links' working group started by studying the Non-Proliferation Treaty and its application worldwide. It soon focussed on the question whether the UK was setting a poor example to other signatories of the treaty through links between its civilian and military nuclear activities. We decided to challenge the UK government's insistence that there were no such links by calculating from first principles the total amount of plutonium produced in the first generation of UK civilian Magnox reactors. We would then subtract from this total the amount the government admitted had been produced since 1969 to determine the amount generated in the early years of operation. The aim was to test if one could believe government assurances that all this early-years plutonium, which would have had an isotopic purity of interest to the military, had been sent to civilian locations in the USA.

To do this we needed accurate data on reactor operation. Fortunately, the ideal mechanism for prising such sensitive information from the government was imminent: the public inquiry into the proposed Sizewell B nuclear power station (1983-1985). Under the old public inquiry system, the government was obliged to provide information requested by objectors that was pertinent to the inspector's remit.

Though the efforts of the Campaign for Nuclear Disarmament's Sizewell Working Party, informed by the scientific input from SANA, did not stop the Sizewell plant, there were a number of significant achievements. Firstly, the Inspector's final report devoted the whole of one of his thirteen recommendations to actions to enhance the separation of civilian and military nuclear activities. This included ending the practice of co-processing civilian and weapons grade plutonium, which CND uncovered during questioning of the Sellafield experts. Secondly, Prime Minister Margaret Thatcher subsequently made a rare U-turn. She amended the categorical assurances that civilian plutonium had never been weaponised by adding the caveat that it hadn't happened during her administration (i.e. only since 1979). Further details of these achievements can be found in *The Burning Answer*.[3]

Finally, and more negatively for the environmental movement, I think it likely that the CND working party's achievements were a significant factor in the government's later decision to amend infrastructure planning law so that such public inquiries were no longer required for new nuclear build.

Confirmation of the accuracy of the SANA calculations

In 1996, the authorities in the USA published a figure of 5.4 tonnes for the total plutonium they had received from the UK that was in remarkable agreement[4] with a revised figure of 5.4 tonnes we had published four years earlier. The figure for missing plutonium in our 1985 paper had to be reduced in 1992 when David Lowry, a founder member of the SANA working group, uncovered new data on plutonium in waste much higher than the official figure quoted at the time of our original paper. It was still significantly more plutonium than could be contained in the civilian locations the UK government had listed as destinations for the exchanged plutonium.

Following this lead from President Clinton's Administration, the new Labour government published an inventory of UK military plutonium as part of the Strategic Defence Review in 2000.[5] This came up with a remarkable admission. The UK had more weapons grade plutonium than it thought it had! In the words of the Ministry of Defence report, "the weapon cycle stockpile is in fact some 0.3 tonnes larger than the amount of plutonium the records indicate as available." The report admits that 0.37 tonnes of weapons grade plutonium came from 'unidentified sites'. It does not attempt to identify the origins of this 70 bombs' worth of weapons grade plutonium despite there being only one possible source. The origin must have been the low-irradiated fuel from the civilian programme that was co-processed together with the military fuel at Sellafield.

This was the final confirmation of the accuracy of the SANA calculations.[5] Our 1985 paper shows that 0.36 tonnes of weapons-grade plutonium were produced in the early years of operation of the civil reactors, again remarkably close to the 0.37 tonnes the Ministry of Defence describe as coming from 'unidentified sites'.

Relevance to current day SGR activities

I appreciate today's university environment, with research funding and permanent positions harder to obtain and increased pressure on research associates to generate their own funding, makes similar working groups difficult to establish. Some of the funding sources that supported this SANA working group, like the Greater London Council, no longer exist. But CND and our American colleagues in the Union of Concerned Scientists are still very active.

I have no quantitative evidence, but it seems to me that nowadays there are more academics with permanent contracts doing socially responsible research than in the 1980s. Hence there are more options for collaboration between these and SGR working groups. At the 2016 SGR annual conference we heard from some impressive researchers bravely persisting with their work despite the pressures from commercial interests or their surrogates.[6] However university studies in the anti-nuclear area appears to have become more acceptable nowadays. This can be seen, for example, from the impressive list of academics supporting the Nuclear Consulting Group.[7]

One formative experience of the SANA Nuclear Links group provides further evidence for a change in the attitude of the political establishment nowadays. Following the publication of our first *Nature* paper, a government scientific advisor telephoned my Head of Department to warn him that some 'chaps' in his Department had 'got it all wrong'. Fortunately, whoever had briefed the advisor hadn't done their homework properly. The Head of Department happened to be Professor Tom Kibble, then vice-chair of SANA, and one of our 'chaps' was Jenny Nelson (now an award-winning professor of physics and patron of SGR). Tom arranged for us to meet the advisor and it became very clear he had not been briefed on the contents of our paper. Following the confirmation[5] in 2000 that we had 'got it all *right*', I had the satisfaction of a telephone conversation with the advisor, now retired, in which he admitted what he had been unable to say while in post: that his experience of the Sellafield operation suggested it was highly likely that such events could well have happened.

By contrast, the recent and important work of researchers at Sussex University that has established links between the UK's new nuclear power programme and its military submarine programme[8] has already been publicly presented at a hearing of the House of Commons Public Accounts Committee.

One other related issue. Following publication of the 2000 *Nature* letter, I managed to arrange a meeting with those in the UK government responsible for nuclear safeguards. This was due to the relevance of our calculations to international discussions on the Fissile Material Cut-off Treaty as a demonstration that one could monitor the amount of weapons grade plutonium produced in a reactor. Sadly, but not unexpectedly, they did not follow up on my proposal that, were they to compare our results with their own figures, it could provide confidence that this treaty could be reliably policed by independent bodies given reactor operation information that is supplied to the International Atomic Energy Agency. If anyone in SGR is currently interested in fissile material cut-off issues, please get in contact.

Modern developments aiding SGR working groups

The research funding schemes that supported my transition from particle physics to solar photovoltaics research still exist. I was very fortunate to obtain a Royal Society Industrial Fellowship that supported a year at Philips Research Laboratory in Surrey to learn about the latest developments in semi-conductors. On my return to Imperial College, Jenny Nelson and I founded the Quantum Photovoltaic group using funding obtained from the Greenpeace Environmental Trust (a registered charity) with the help of SANA member (now leading solar energy advocate), Jeremy Leggett.

Also on the positive side, the internet and social media have made working groups far easier to organise than in the 1980s. In particular, it greatly facilitates the multinational collaboration and access to international funding that the SANA Nuclear Links working group pioneered. The other SANA working group that I joined, which developed contacts with scientists aboard, would have been able to achieve far more with modern communications. The early history of that SANA working group is relevant to an initiative that is proposed in Part III of *The Burning Answer*: an international solar laboratory. This could be organised entirely over the internet by co-ordinating the work in national hubs. But that is for another article in the *SGR Newsletter*...

Keith Barnham is Emeritus Professor of Physics at Imperial College, London, a founder member of SANA and a patron of SGR.

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Improving protection of the oceans

2017 was a year of significant progress on measures to protect the world's oceans. Stuart Parkinson and Louisa Reynolds explain.

After more than ten years of discussions, countries voted at the United Nations on Christmas Eve to begin formal negotiations on the first-ever international treaty to protect life in the 'high seas'.[1] The process is planned to take two years. The treaty would have the authority to create large marine protected areas in the high seas as many ocean scientists have been calling for.

This work builds on the progress made at the UN Ocean Conference, which took place in New York in June, and has led to over 1,400 commitments by governments, businesses, environmental organisations and scientists.[2]

The importance of ocean health

The importance of the world's oceans is hard to overstate. They govern in large part the Earth's hydrological and energy cycles, the global nutrient cycle and the biological food chain, as well as climate patterns on global and regional scales.[3] In addition, the ocean supports human industries and activities such as shipping and other transport, food, recreation and tourism, and the exploitation of offshore minerals, such as oil and gas.[4]

The marine environment was once considered too vast for its welfare to be damaged by human activity,[4] but now societies are grappling with a range of urgent oceanic problems. These include: depleted fish stocks; pollution from plastics;[5] climate change effects such as temperature rise, sea level rise, acidification and the consequent coral bleaching;[6,7] destruction and major damage to wetlands and other shore habitats;[4,6] untreated sewage and runoff from industry and agriculture leading to aquacultural effects; jelly fish swarms due to diminished predator populations; the exacerbation of disease and mortality in large oceanic mammals; and increased exposure to ultra-violet radiation due to stratospheric ozone depletion.

Of particular concern has been a lack of jurisdiction and protection of the high seas, leaving nearly 60% of the world's oceans unprotected.[8] The high seas are those parts of the oceans outside of the 200-mile exclusive economic zone (EEZ) of countries with coastlines. These areas tend to be only fished by large vessels, often huge bottom trawlers that can damage the sea floor.

It is intended that the proposed treaty would have the power to the ban fishing in some areas, enact protections from key industrial impacts, and develop rules around marine genetic resources in order to facilitate fairer sharing of 'marine services'.

The negotiations over the next two years will build upon the growing international and multidisciplinary collaboration in a range of areas related to the oceans, as demonstrated at the UN Ocean Conference.[9] Commitments made at this event included a large expansion in the size of marine protected areas (MPAs) – keeping the world on track to meet the target of 10% of the ocean covered by MPAs by 2020. Other commitments covered reducing the use of single-use plastics, reducing the amount of sewage and other pollutants entering the ocean, protecting fisheries, and expanding oceanographic research.

UK actions

At the Ocean Conference, the UK government made pledges in three areas:

- delivering a network of MPAs (which currently cover 23% of UK waters) in order to conserve the marine environment of the UK and its overseas territories, including protecting global significant biodiversity;[10]
- combating marine litter, including reducing the volume of single use plastic bags and the introduction of national litter strategies;[11] and
- strengthening its work on marine science, including improving ocean observations and data sharing, and using new technologies such as robotic systems.[12]

Since then the government has published its 25 year environment plan,[13] including commitments on protecting fish stocks and other marine wildlife as well as reducing marine plastic pollution. However, the commitments have been widely criticised as being vague or unambitious. For example, the target year for eliminating 'avoidable' plastic waste is only 2042. Separately, the government has also enacted a ban on the manufacture of 'microbeads'.[14] While the UK is one of the first countries to enact such a ban, it nevertheless only applies to certain 'rinse-off' bathing products.

Concerning the UK's research commitments on the marine environment, much of the work is being led by the National Oceanographic Centre (NOC), based in Southampton, together with a range of other collaborating organisations. News on their latest research can be found on their website.[15]

Progress but…

The recent progress on protection of the oceans at both the UN level and the national level in the UK is important and encouraging. However, the scale of the problems facing the marine environment remains huge and much more action is needed. But particularly disturbing are Donald Trump's new proposals to open up virtually all the USA's coastal waters to oil and gas drilling, in stark contrast to previous presidents.[16] However, even here there is hope as most governors of coastal states are opposed, many of them from Trump's own party.

Dr Stuart Parkinson is Executive Director of Scientists for Global Responsibility and holds a PhD in environmental science. Dr Louisa Reynolds holds a PhD in environmental science.

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Creating a better world: some lessons for the next 25 years

SGR's 25th anniversary conference; 28 October 2017; The Gallery, Farringdon, London

Summary by Martin Bassant and Stuart Parkinson

Over 60 people gathered for SGR's silver anniversary conference, which focused on how rapid progress had been achieved in the past on key security and environmental problems and how lessons from these examples could be used to help deal with current threats.

As participants gathered before formal proceedings began, members old and new took the opportunity to reflect on SGR's 25 years – helped by a montage of photos from the organisation's archives. As usual, participants came from a range of technical and campaigning backgrounds, and it was good to see younger members involved in proceedings.

Executive Director Stuart Parkinson opened the conference by remarking on both the contrasts and the similarities between the world today and the world in 1992, when SGR was formed. Wars in the Middle East and inadequate action on climate change are still key issues – although there had been important progress in some of these areas.

The potential for rapid transition

Andrew Simms, of the think-tank, the New Weather Institute, kicked off proceedings with an interesting presentation looking at situations where society had rapidly and successfully adapted in the face of major threats. He drew on diverse examples from World War II to the post-Cold War period, including the global financial crisis of 2007-8 and even the ash cloud from an Icelandic volcano which overnight grounded air travel across Europe in 2010. He used a range of interesting quotes to get across key points, the most memorable of which was, "History teaches us nothing, only punishes [us] for not learning its lessons."

Andrew argued that rapid change to a low carbon and low consumption society is "not easy but demonstrably possible" and gave several examples, especially from within the UK during WWII. Not only had British society adapted at speed to much lower consumption of some key commodities, there had also been unexpected benefits, such as improvements in nutrition and health. He also argued that quantitative easing – on a comparable or smaller scale than that used to bail out the banks in 2007-8 – could be used to transform our energy system at a much faster rate than we are currently doing. This would be more in line with the urgency demanded by the scale of the climate change threat.

During the discussion, Andrew pointed out that full consensus on an issue is not necessarily a precondition in order for major cultural change to happen. A key recent example was the rapid acceptance of gay marriage in the UK and elsewhere.

Andrew's presentation is based on a report he authored – *How did we do that?* – which can be downloaded from: http://www.newweather.org/2017/04/24/new-study-how-did-we-do-that-the-possibility-of-rapid-transition/

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Andrew Simms speaking on rapid transition

Transforming the security agenda

Philip Webber, SGR's Chair, then gave us a history lesson on the security agenda. He focused on transitions related to nuclear weapons – sometimes rapid – during and after the Cold War. He discussed the nuclear arms control treaties negotiated in the decade following the Cuban Missile Crisis in 1962. He looked at the rapid changes in the late 1980s, following the appointment of Mikhail Gorbachev as President of Soviet Russia, especially the negotiation of very large cuts in the numbers of Russian and US nuclear weapons. He also covered the very recent negotiations on the new Treaty on the Prohibition of Nuclear Weapons (TPNW). Phil interspersed these with discussion of UK civil defence – government emergency preparations in the event of nuclear attack – looking at how these transformed in response to major criticism.

Particularly interesting were the stories Phil told about his own experiences working in civil defence with the Greater London Council and as an emergency planning officer for South Yorkshire in the 1980s. He spoke about the considerable mismatch between government advice in pamphlets like 'Protect and Survive' and the warnings that he and others were able to give based on robust scientific information. He highlighted some of the key books and films that were helpful in getting the message across to the public – not least *London After the Bomb* (which he co-authored) and other reports from Scientists Against Nuclear Arms.

When discussing the campaign for the TPNW, he highlighted the importance of broadly-based grass-roots activity connected to key international decision-makers, robust scientific information on the nature of the threats, and use of few celebrities! The International Campaign to Abolish Nuclear Weapons (ICAN) combined these different aspects very effectively which is why it was awarded the Nobel Peace Prize for its leading role in the TPNW. Phil also highlighted SGR's role in ICAN, producing well-researched briefings on the threat from UK nuclear weapons which were distributed at the preparatory intergovernmental meetings as well as via the web.

Phil's presentation can be downloaded from the SGR website at: http://www.sgr.org.uk/resources/transforming-security-agenda

Update on peaceworker project

Next, Philip Wood, SGR's 'peaceworker' (a research post funded by Quaker Peace and Social Witness), gave a presentation on his preliminary findings on the financial links between engineering and scientific organisations in the UK and the arms and fossil fuel

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industries. He covered areas such as investments, funding for school education projects, and conference sponsorship. The links were, in some cases, extensive. A report on this work will be published later in 2018.

SGR's Annual General Meeting

After a refreshments break, SGR's AGM was held, chaired by Philip Webber. Stuart Parkinson summarised the organisation's work over the previous financial year – not least our involvement in the ICAN this year. Alasdair Beal then covered SGR's finances. Six members of the National Co-ordinating Committee (NCC) were then re-elected:

Chair:	Philip Webber
Vice-chair:	Jan Maskell
Treasurer:	Alasdair Beal
Secretary:	Martin Bassant

Committee Members: David Hookes, Paul Marchant

Many people were thanked for their valuable contributions over this and previous years, not least Philip Webber for being Chair for all but two of SGR's 25 years, and Vanessa Moss for managing the SGR office and compiling the accounts. Thanks were also expressed for the work of previous committee members, staff, patrons and numerous volunteers, all of which has helped make SGR the organisation it is today.

SGR members' forum

SGR Vice-chair Jan Maskell then led a members' forum which broke into small groups to discuss three questions:

- which SGR activities have been the most successful?
- what should SGR's priorities be during the next five years?
- what issues would be best for SGR working groups to cover?

The answers from the groups were quite diverse. Successful past activities included work on nuclear weapons, Science4Society Week, military science, and ethical careers. On future priorities, some argued for 'more of the same' while others argued for a greater emphasis on (for example) climate change or biodiversity. There were numerous suggestions for working group topics including economics for sustainability, military involvement at universities, biodiversity, artificial intelligence, and debunking nuclear deterrence. Some members volunteered to be involved in such groups. SGR's staff and NCC will be contacting members about these over the next few months.

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Members' forum discussions

Stuart Parkinson closed the conference by thanking all those attending on being part of an inspiring day.

Material from the conference can be downloaded from: http://www.sgr.org.uk/events/creating-better-world

Health through peace

Medact/ IPPNW conference; 4-6 September 2017; York University

Summary by Stuart Parkinson

Our colleagues in Medact – a UK organisation of health professionals which campaigns on peace, justice and environmental issues – organised this conference together with the International Physicians for the Prevention of Nuclear War (IPPNW). The event brought together several hundred campaigners, health professionals, scientists and others from numerous countries to discuss key issues linking peace and health.

Early conference sessions focused on nuclear weapons, especially the new Treaty on the Prohibition of Nuclear Weapons (TPNW). It was IPPNW which founded the International Campaign to Abolish Nuclear Weapons (ICAN) which had been so successful in galvanising action to bring about the treaty.

Other noteworthy sessions focused on how health professionals help those affected by war. There were inspiring stories of the work done by medics in war zones, and a shocking presentation describing the increasing problem of hospitals being targeted by air strikes in countries such as Syria and Yemen. Veterans for Peace talked about their work to counter the propaganda of armed forces recruitment campaigns.

SGR was a supporting partner of the event, taking part in several activities. We held a reception to mark our silver anniversary, which was attended by over 60 people. Philip Webber and Stuart Parkinson briefly summarised highlights from our 25 years of activity. Philip and Stuart also gave presentations as part of the academic panels, with Philip discussing nuclear war scenarios that could lead to nuclear winter, while Stuart outlined SGR's research and campaigning on the military influence on science in the UK. Stuart also ran a workshop with ForcesWatch on military involvement in schools and universities. Vanessa Moss ran an SGR stall distributing our reports and other publications.

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Philip Webber speaking at the Health Through Peace conference

The business plan for peace: making possible a world without war

Martin Ryle Trust lecture; 2 October 2017; Conway Hall, London

Review by Josephine Anne Stein, with input from the other Martin Ryle Trustees

In the second annual Martin Ryle Trust Lecture, Dr Scilla Elworthy made a compelling case for a 'Business Plan for Peace'. Co-sponsored by The Martin Ryle Trust and the Conway Hall Ethical Society, the lecture attracted students, people from minority ethnic groups, women in hijabs, Quakers and Conway Hall 'regulars' among others; over 100 people had registered. Good participation in Q&A and the post-lecture discussion reflected the extent to which Scilla's lecture informed and inspired the audience.

Scilla's main message was that "war is past its sell-by date" and needs to be replaced by (mainly) local peace-building responses to conflict. By now, there is extensive experience globally in successful peace-building initiatives ranging from early intervention to post-war community rebuilding. Some remarkable examples have emerged endogenously from people within conflict and post-conflict zones, some supported by expert trainers working with local people.

One example is in the Democratic Republic of Congo, where a peace-building organisation has successfully re-integrated almost 6,000 ex-combatants back into their community over the past ten years. They have trained psychosocial counsellors who provide the necessary support to ensure that ex-combatants and the community are able to heal after the ravages of war.

Another is a project to promote peace and gender equality amongst young people, started by a 16-year-old girl in a rural village in northern Pakistan. The project has grown and by now has saved the lives of over 10,000 young people by giving them an alternative to joining extremist armed groups.

The participation of women is a notable contributor to successful peace-building projects, and Scilla especially encouraged women in the audience to act on issues of concern, describing a great range of actions to support alternatives to war. Scilla pointed out the effectiveness of small steps and described the great sense of satisfaction that comes with taking action.

Perhaps the most striking part of Scilla's lecture was a comparison of the human, financial and environmental costs of war to the costs and benefits of peace-building projects. Spending on the world's militaries in 2016 amounted to just under $1,700 billion, while a fully-costed peace-building alternative would require roughly $0.2 billion per year. Considering the global human population of 7.6 billion, this equates to a cost of $220 per year to pay for war by every person on the planet – as compared to 'just under three cents' per year per person for systems that prevent conflict and build peace. A health warning applies to these numbers; it was not possible in this one lecture to fully go through the complexities associated with the structural transformation in the political economy that would be needed before expenditures could be redirected. Moreover, those factors contributing to conflict in the first place, such as climate change and economic inequality, and consequences of militarism such as migration and rebuilding or developing infrastructure to meet needs for clean air and water, and healthcare, need to be taken into account. However, there is no doubt that the costs associated with building a more peaceful world are orders of magnitude less than the costs of war.

For more information, see Scilla's recent book: The Business Plan for Peace: Building a World Without War, published by Peace Direct, London. The book is packed with facts, figures, analysis, and most importantly, ideas and inspiration for all of us to take up to help to make a world without war possible. It can be ordered online via: https://www.scillaelworthy.com/the-business-plan-for-peace/

This moment: the emergency, the opportunity

Robert Hutchison, Green House, 2017, 13pp. (free)

Review by Kate Macintosh

This compact publication has large ambitions. Although only 13 pages long, the aim is to provide a near comprehensive guide to the jungle of interests, arguments, recommendations and risks confronting those engaged in the struggle to save the Earth's climate. One particular focus is the psychology of denial, including the way individuals can simultaneously hold contradictory positions on an issue, as well as the dark forces feeding dis-information and seeking to undermine trust in climate science.

Interesting insights embedded include that "if the richest 10% of individuals were to change their lifestyles so as to reduce their emissions by half that would save a quarter of all emissions by individuals or 16% of global emissions".

This is a pretty comprehensive overview of the many thinkers in both the technical and economic fields trying to create a credible new vision for one-planet-living. As a compendium of issues and arguments, it provides a handy reference work and is greatly to be recommended.

It concludes on an optimistic note for the struggle-weary, pointing to the surge in renewable power generation, the sector now being a bigger employer in the USA than oil and gas extraction. It also offers some thoughts on human ingenuity and ability for empathy – capacities we must cultivate to reverse the present direction of travel.

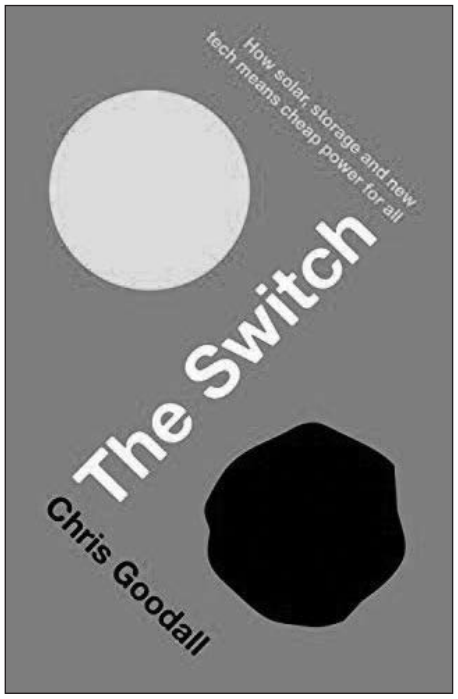
Sadly, Robert passed away only a few months after writing this briefing. His impressive track record in writing, broadcasting and campaigning will be much missed.

Available free to download from the Green House website: http://www.greenhousethinktank.org

The switch

Chris Goodall, Profile Books, 2016, £9.99, 278 pages, ISBN: 978-178125635

Review by Dr Wiebina Heesterman



This book argues that a transition to renewable energy sources makes good economic sense as well as being perfectly achievable. It reviews the activities involved in supplying the necessary renewable energy in depth. A period of sunshine as short as an hour and a half would be able to provide the world with the equivalent of a year's energy consumption. The cost of solar technologies has been rapidly declining: in September 2015 a leading energy professional predicted that solar photo-voltaics (PV), regarded as prohibitively expensive just two years earlier, would become "the dominant backbone" of the energy system across the world. The speaker in question, believe it or not, was Ben van Beurden, the CEO of Shell. The rationale for the rapid price reduction is the 'experience curve' - or 'learning by doing'. Production and installation of new technology become progressively faster while costs keep dropping. An exception to the 'experience curve' rule is nuclear power, which has not become cheaper with time.

When Goodall suggests that "the price of alternatives is tending to rise," this refers to generating costs rather than end price. He then forestalls any reservations concerning the inadequacy of power generation in periods with little sunshine or wind in countries such as Britain by referring to the need for energy storage, discussed more fully in later chapters. The book reviews a range of potential solar energy-generating materials other than silicon, such as perovskite on its own or in combination with silicon, resulting in multi-layer cells capable of capturing different wavelengths of the solar spectrum. The potential of solar for developing countries, which lack electricity networks as e.g. in Africa, is huge, especially when distributed over micro-grids. The main stumbling block for worldwide adoption of PV was – and still is – the fact that securing loans for solar projects is hard when the speed of the transition to renewable energy is constantly underestimated.

Next Goodall surveys a broad range of solar technologies, such as carbon-based molecules to be printed on a flexible backing based on PET (polyethylene terephthalate, as used for drink bottles) and CSP (concentrating solar power), which may be combined with storing the generated heat for several hours after sunset. However, its cost has not come down to the same extent as that of PV.

Then we come to means of energy generation for "when the sun doesn't shine." The most important is wind power, which would theoretically be able to provide 900 terawatts of energy per year, more than enough to provide the world population with a continuous supply of electricity. The generating price depends largely on the location of the turbines: high on landlocked sites and low on windy coastal locations. Cost of installation offshore, favoured by the public, is much higher than on land. However, wind has not benefited to the same extent as PV from the experience curve. Yet the International Energy Agency continues to predict a much steeper price decrease for wind power than for solar, by some 45 percent as against 30 by the year 2040.

Next other types of energy generating technologies are reviewed, focusing on the different techniques rather than cost calculation. Biomass is discussed in most detail, with hydroelectricity and geothermal mentioned cursorily. Plant material can be used in a dry state, for burning in former coal-fired power stations, such as Drax, or ground into a fine dust to be gasified. Plants with a high moisture content may be fed into an anaerobic digester to produce methane for the gas grid. The advantage is that gas can be stored until needed. The drawback is that it conflicts with the need for land to grow food.

Chapter 5 deals with the long-established requirement for energy backup to ensure a continuous supply. As not all processes need to be constantly active, automated power switching of equipment will help to coordinate demand and supply more accurately, thereby removing the need for duplication of energy sources.

The next topic is the ongoing development of efficient means of saving spare energy for use in countries too far north to receive much in the way of sunshine throughout the year. Pumped hydro storage in mountainous areas provides some useful longer term standby capacity, but there is not enough. Goodall states that energy storage in car batteries is so far a one way process, and it cannot easily be returned back into the grid. However, developments since the publication of the book indicate this is now becoming possible. The book also mentions other forms of energy storage such as gas or compressed/ liquid air. In addition, wood waste heated to high temperature can be turned into diesel by the Fischer Tropsch process. Finally, there is the use of genetically modified bacteria able to feed on hydrogen and carbon dioxide and produce substances for processing into liquid fuels. Examples are hydrogen converted to methane in a process called 'P2G' (power-to-gas) and microbes to produce liquid hydrocarbons, taking advantage of gas streams from power stations. While the viability of various storage methods is discussed at length, the potential of high-voltage direct current (HVDC) connections to balance out any peaks and troughs in power production does not get a mention.

New technologies are surveyed comprehensively with a focus on economic viability and the book reads well, although the many examples of research in specific renewable applications interspersed with explanatory sections tend to break the flow of the argument, especially in the last section dealing with the technical details of storage options.

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

- Stuart Parkinson
- Jan Maskell

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