responsible science

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A membership organisation promoting responsible science and technology.
Part of the campaign awarded the 2017 Nobel Peace Prize.

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Scientific responsibility at the centre of multiple crises

The challenge of scientific responsibility lies at the heart of multiple current collective perils. From the technological choices in tackling climate change that range from geo-engineering to energy generation and transport modes, to the challenge of global vaccination programmes, military technology and its human and ecological impact.

How science and technology conducts itself, and the consequences of different paths taken, is possibly more critical now than at any other stage in civilisation's history. This is to do with the scale at which it now operates; the lethal and potentially irreversible nature of consequences, the opaque nature of power and control, and the extreme difficulty of ensuring accountability for poor choices.

As the UK hosts, in some form, a vital climate conference in 2021, to help build greater responsibility among both individuals and institutions, SGR is pioneering its *Science Oath for the Climate* as a pledge of scrutiny, integrity and engagement from the science and technology community itself. We are also examining in detail the often overlooked carbon footprint of the military. And, as if an emerging issue like this is not enough, the UK is implementing the largest increase in military spending for 70 years – at the same time as cutting aid to the world's poorest – and a 40 per cent increase in its nuclear weapons stockpile as part of the so-called Integrated Review. This is the first increase since the end of the Cold War and a breach of the Non Proliferation Treaty (NPT). The same review speaks of the UK as 'science and technology superpower' – but focuses on both destructive military technology and high risk applications of artificial intelligence and nuclear power. At the same time failed domestic home decarbonisation plans and cuts to energy efficiency roll-out programmes suggest that the sustainable options most likely to 'level-up' the UK economically will lose out.

A glimmer of hope on disarmament however can be found from the entry into force of the new Treaty for the Prohibition of Nuclear Weapons (TPNW). The two treaties, the NPT and the TPNW, have also inspired global action for an agreement to end the new exploration for and production of fossil fuels, with major municipalities and over 100 Nobel Prize winners endorsing the idea of a Fossil Fuel Non Proliferation Treaty to work alongside the Paris Climate Agreement.

And at the grassroots and municipal levels a huge amount is happening to generate a socially inclusive rapid transition to more sustainable ways of living. From re-imagining former industrial areas to tackling overconsumption and changing attitudes and behaviours around highly polluting transport choices, you will see in this edition evidence that many people are no longer waiting for the governments to do the right thing. Instead, to the best of their abilities, they are doing it themselves. SGR is doing its best to help and we hope that you will continue to support us to do so.

Andrew Simms
Assistant Director, SGR

PS The eagle-eyed amongst you will notice that this issue of the journal is later and longer than usual. This is to include extra analysis of recent key policies published by the UK government, not least the Integrated Review of Security, Defence, Development and Foreign Policy.

News from SGR

Science oath for the climate gains more than 130 signatories

SGR's 'Science oath for the climate' now has more than 130 signatories – including over 40 professors – following its launch in November 2020. The signatories, who study or otherwise work on climate change, have committed to personal behaviour change and to calling out policy shortcomings related to the climate emergency.

The oath focuses on change at both an individual level and a system level, and is designed for scientists, engineers and academics working on climate issues. By signing they demonstrate their commitment to speaking out about the scale of the threat shown by the scientific evidence, and the consequent speed and scope of necessary action – despite the often politically challenging conclusions that they reach from the evidence. In order to show leadership, signatories pledge to take action to reduce their own personal carbon emissions and to lobby their professional associations and employers to align themselves with pathways compliant with the Paris Agreement's "well below 2°C" target.

"Experts working on the climate emergency should not have to look over their shoulders when describing its seriousness, and they should feel free to speak out about unrealistic technological fixes, inadequate policies or things likely to make the problem worse. Signing the oath is a public commitment to stand together in public and represent the full implications of the science without fear," says Andrew Simms, SGR's Assistant Director.

SGR's concern is that there has been self-censorship in the climate community, with some things said in private that are not said in public. These include, for example, concerns about the practicality of proposed technical solutions such as rapid, large-scale implementation of bioenergy carbon capture and storage (BECCS), and the need for stronger efforts in the policy and economic realm related to behaviour change by the wealthier groups in society. We are troubled that not enough is being said in public about climate scientists' private concerns.

To coincide with the launch, five of the signatories had a letter published in *The Guardian*[1] to raise awareness of the oath. These signatories were: Professor Chris Rapley, University College London; Professor Sarah Bracking, King's College London; Professor Jonathan Bamber, University of Bristol; Professor Bill McGuire, University College London; and Professor Simon Lewis, University of Leeds.

With the UK hosting the international COP26 climate negotiations in November 2021, a year later than planned due to the COVID-19 pandemic, SGR thinks it's vital that scientists show their support for the necessary action to meet the Paris targets.

SIGNING THE OATH

The full text of the 'Science oath for the climate' and the latest list of signatories are available at:

https://www.sgr.org.uk/projects/science-oath-climate-text-and-signing

Further background information and related articles can be found at:
https://www.sgr.org.uk/projects/why-do-we-need-climate-oath

If you're a science/ technology practitioner[2] working on some aspect of climate change, we encourage you to sign.

The climate oath initiative stems from two SGR reports:

- *Scientists Behaving Responsibly: Should science walk the talk on climate breakdown?*[3] which highlighted the potential of scientists and engineers to act as role models for behaviour change and as voices calling for system change in their sectors; and
- *Irresponsible Science?*[4] which examined the environmental and ethical track records of UK professional engineering and scientific organisations.

Next steps

In the near future, we will be publishing a list of key behaviour changes which oath signatories can sign up to in order to reduce their personal carbon emissions. We have also started contacting professional bodies with calls to action. We will also be expanding all our activities internationally.

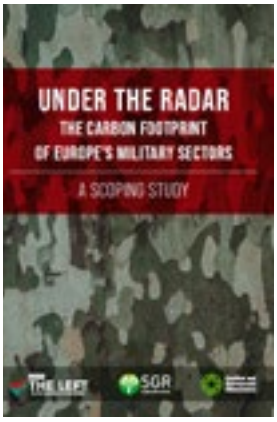
The project is funded by the Martin Ryle Trust and ClimateWorks Foundation. We are very grateful to both trusts for supporting our work.

If you're interested in helping with the campaign – especially if you're a member of a professional body – please contact Liz Kalaugher, SGR's Responsible Science Campaigner, at lizk@sgr.org.uk

References

1 https://www.theguardian.com/science/2020/nov/07/support-a-science-oath-for-the-climate
2 This includes social scientists.
3 https://www.sgr.org.uk/publications/scientists-behaving-responsibly
4 https://www.sgr.org.uk/publications/irresponsible-science

New report on the EU's military carbon emissions



In February, SGR published a new report, *Under the Radar: the carbon footprint of Europe's military sectors.* This provided, for the first time, an estimate for the carbon footprint of total military spending in the 27 nations of the European Union – including direct emissions from vehicles (combat aircraft, warships, tanks etc) and military bases, as well as indirect emissions from the arms industry and its supply chain. The estimate – which we consider very conservative – was nearly 25 million tonnes of carbon dioxide equivalent, similar to the direct emissions of 14 million average cars. The report included case studies of the EU's biggest military polluters including France, Germany, Italy and Poland. The work built upon a previous SGR report – published in 2020 – which examined the carbon footprint (and other environmental impacts) of the UK military.

The report was co-produced with the Conflict and Environment Observatory (CEOBS) and funded by the European United Left (GUE). Authors were Stuart Parkinson (SGR) and Linsey Cottrell (CEOBS). PDF copies can be downloaded from the SGR website, and you can also watch a video of the launch event there – see: https://www.sgr.org.uk/publications/under-radar-carbon-footprint-europe-s-military-sectors

SGR's wider work on the military and climate change has been used in several other ways. We input to an oral session of the UK Parliament's Environmental Audit Committee. Stuart Parkinson spoke at an international webinar attended by numerous representatives from defence ministries and arms corporations. Gillian Smith spoke at a webinar organised by a local peace group based in Oxfordshire. SGR's data has also been used in a best-selling book, *How bad are bananas? The carbon footprint of everything,* and a new report by campaign group, Tipping Point North South. More research work is planned for later in the year.

SGR's main outputs in the field of the military and climate change can be found online at: https://www.sgr.org.uk/projects/climate-change-military-main-outputs

Britain's accelerated militarism: SGR campaigning

With the news that the UK government is increasing military spending at its highest rate for 70 years, including financing a 44% jump in the size of its nuclear warhead stockpile (see *Brexit Britain's security policy* on p.27), SGR stepped up its campaigning on these issues.

In the autumn, SGR – along with many peace organisations – had submitted a response to the government's public consultation on its 'Integrated Review of Security, Defence, Development and Foreign Policy'. However, it was clear then – both because the public consultation was carried out in such a slipshod way, and because one major conclusion of the review had already been announced – that the government was not going to take critical views very seriously. However, the scale of the announcements took almost everyone by surprise. SGR joined in the immediate criticism via our social media channels, and took part in a number of other activities:

- Stuart Parkinson worked with the UK branch of the Global Campaign on Military Spending, speaking on military v climate spending at a webinar in February – and turning the presentation into a short briefing for campaigners;
- Philip Webber worked with UK affiliates of the International Campaign for the Abolition of Nuclear Weapons to publicise – including to parliamentarians – the entry into force in January of the new Treaty for the Prohibition of Nuclear Weapons (see *Nuclear weapons are now illegal*, p. 31);
- Stuart spoke at two other webinars – one organised by the Green Party and the other by London Campaign for Nuclear Disarmament (CND) – on the risks of new weapons technologies, while Phil spoke at a national CND webinar on the importance of tackling the roots of insecurity.
- SGR continues to support other peace campaign networks on 'killer robots' and arms conversion.

Other climate campaigning

SGR has supported a range of other climate-related campaigns in recent months.

At an overarching level, we joined the Build Back Better campaign, signed up to the Climate Coalition's 'ten point plan' (much more radical than the government's!), and continued to support the Rapid Transition Alliance. Andrew Simms spoke at several online events, including a local government conference on the climate emergency.

At a more focused level, we continued to support the campaign against the proposed huge new coal mine in Cumbria – with Stuart Parkinson speaking against the mine at a council planning committee meeting in the autumn. The campaign has since achieved national media coverage, leading to the government giving in to pressure to hold a public inquiry. Meanwhile, SGR also joined the new Scotland-focused '100% renewables' campaign, with Keith Baker speaking at the launch. SGR also submitted an objection to proposals for the expansion of Leeds-Bradford Airport.

COVID-19 activities

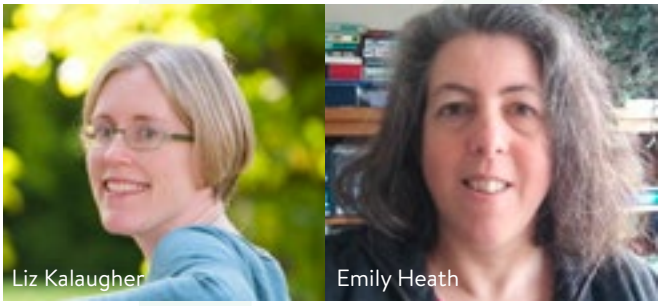
While SGR does not have the expertise/ capacity to work on the health-related dimensions of the COVID-19 pandemic, we have continued to explore areas where there is some overlap with our concerns, such as: rapid transition (see *SGR Conference summary, p.* 40); industrial conversion (see *From arms, planes and racing cars to ventilators*, p.15); and detrimental corporate influence on science (see *"Catastrophic moral failure" of vaccines not reaching the poorest*, p. 25).

Our series of COVID-19 blogs on our website has explored these and other issues in more depth – see: https://www.sgr.org.uk/search/covid-19

New staff

We have been pleased to welcome two new staff in the last few months: Liz Kalaugher and Emily Heath. Liz is our new Responsible Science Campaigner – see her update on p.2 – while Emily takes over as SGR's Office Manager, following the retirement of Vanessa Moss. We wish Vanessa well in all her future endeavours.

You can contact Liz at lizk@sgr.org.uk and Emily at emilyh@sgr.org.uk – and read their biographies on the SGR website at: https://www.sgr.org.uk/pages/staff-and-ncc



STEM education projects

Dr Jan Maskell gives an update on SGR's education work on Science, Technology, Engineering, and Mathematics (STEM).

Science4Society Week 2021

This year's Science4Society (S4S) Week took place between 6th and 14th March, and was run online due to COVID-19 restrictions.

Bryony Maskell ran two family science sessions, broadcast via the Malvern Festival of Ideas website. These were:

- Climate Kitchen! Do you know the impact of your diet?
- Do you know the environmental impact of washing your hands?

Both included practical exercises which families could try at home, such as cooking a climate-friendly meal and making eco-friendly soap. All the materials from these workshops are now available to download via the S4S website – https://www.s4s.org.uk/ – along with over 50 other fun and educational activities.

This year's competition was titled 'Be like Greta – Write a letter', and children were encouraged to draft a letter to a top decision-maker in government or industry to encourage them to take science-based action to reduce their environmental impacts. The winners were Harleen Sandhu and Martina McLeod, both based in London.

One Planet One Life

SGR's project to deliver workshops on climate change and sustainable lifestyles to children in the Morecambe Bay area was put on hold during much of 2020 due to COVID-19-related school closures. Only one school was able to participate in the autumn term, and this workshop was run with the pupils (and their teacher) in the classroom and the trainer facilitating remotely via Zoom. This worked well as the children had become used to being taught in this way.

With lockdown again preventing schools opening for much of the spring term this year, a restart to our workshops is being planned for the summer and autumn terms.

Despite the recent problems, the project has so far delivered 31 workshops to nearly 1,000 students – a very impressive total.

The project is funded by Ørsted's Walney Extension Community Fund. We have started seeking funding for a further stage of the project – in which we train new facilitators to deliver the One Planet One Life education materials in schools across the UK. We will keep you posted on how this develops.

For more information on the project, see: https://www.sgr.org.uk/projects/one-planet-one-life-about

Globally Responsible Careers

In September, thanks to grants from the Martin Ryle Trust and Scurrah Wainwright Charity, SGR began a new project to provide careers support and advice to students at university and school. The project is building on our successful ethical careers programme run during the 2000s, by producing updated and expanded web-based materials. These will cover key ethical issues related to STEM careers, a self-assessment questionnaire, and a series of career case studies. We will be launching a new section of the website containing these materials in the next few months – so look out for it.

What if we treated the climate emergency as seriously as we treated COVID–19?

In an edited version of **Prof Alice Larkin**'s presentation to SGR's Responsible Science conference, she highlights the importance of social and economic change in responding to the climate emergency.

I've learnt two important lessons so far from the pandemic. The first is that change can take place quickly and the second is that government and societal priorities can shift dramatically to tackle an emergency.

My third observation is not a lesson as such but something that has sparked my interest. It is that, in the same way that climate science and scientists find themselves scrutinised for clear facts when policy makers are faced with the need to engage with the science, so our medical colleagues find themselves and their science also thrust into this spotlight.

It is even more the case now that they too are now tackling some of the same economic questions, in the terms of the 'GDP versus science' debate that many climate researchers have been dealing with for decades.

Policy-makers don't yet consider climate change an emergency

So what can be harnessed from these lessons to tackle the climate emergency? The pandemic became all-consuming, leading to rapid policy, social and media responses that I suspect hasn't been experienced by any of us before in our lifetimes. As such, it draws attention to how little credence has been given to the term 'emergency' in a climate rather than a COVID-19 context.

First, on the speed of response and government priorities, I've spent the last 18 years trying to understand the scale of the climate emergency and how our energy systems need to transform to minimise cumulative carbon emissions. 'Energy systems' can sound technical but basically it means how you and I use energy every day, what we use it for, when we use it, how much we use, and where it comes from. The climate emergency that we are facing is so great that mitigating the damage we are doing now, and the damage that will be done in the future, requires much more than just incrementally increasing the amount of renewable energy on our national grid, for example.

We need to consider all the ways we consume energy, from travelling to heating our homes, from cooking to industrial manufacturing of goods. Critically, we need to do this rapidly because greenhouse gases are accumulating. That's why it's not just about technology. We know a wide variety of technical solutions exist for cutting CO_2 but some will take decades to be sufficiently widespread to make the difference that is needed in the next five or ten years or, indeed, was needed during the last decade.

I come from a physical sciences and modelling background, but have spent most of my career working with engineers and social scientists. That's how I know that the potential shown by modelling theoretically an idealised technology – such as bio-energy with carbon capture and storage – and how it might cut CO_2, is very different to the much more complicated, actual and widespread, rapid implementation of new infrastructure in society.

There are many examples that we are familiar with, the construction of new nuclear facilities, the retrofitting of technologies for heating in every single UK home, designing and deploying an extensive fleet of electric vehicles and charging points, and perhaps most importantly in the current debate, the largescale rollout of new, largely unproven CO_2 removal and storage technologies.

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That is why we need to pay close attention to the geographical governance and social context within which we are expecting technologies to be rapidly deployed, contexts that are much more challenging to articulate well, if at all, in a numerical model. This is also why it matters how much energy we consume in total. If we can consume less then we won't need to transform as much of our high carbon infrastructure, or indeed deploy new unproven technologies to remove CO_2 from our atmosphere that our energy consumption has put there.

The importance of behaviour change

But cutting energy consumption or demand is rarely the focus of CO_2 mitigation discussions, as the debate on decarbonising the aviation industry testifies, which at an official level rarely if ever mention curtailing our flying. Consuming less energy has taken a back seat in policy debates compared to decarbonising our energy supply. One of the reasons is that it requires changes to individual and collective behaviour, attitudes and expectations.

Another is that it requires us to make large upfront strategic investment choices for the long term, and pay more attention to issues of justice and equity. Tackling behaviour, inequality and redirecting investments for future generations are all seemingly more politically sensitive than a focus on large, scalable technologies in the short-term, capital spend and aspects that challenge the pretence of security provided by protecting GDP growth in wealthy nations. But they are also aspects where COVID-19 responses have illustrated change, and the potential willingness to shift what we do, what we invest in and how quickly this needs to happen. All these are now close to the surface of revealed possibilities.

There are probably very few who haven't changed one of their individual common practices or habits during lockdown. It might be a lower frequency of traveling to work or a way of getting in the weekly shop, or a walk taken more regularly done to boost well-being.

Collective and community-based behaviours have changed, and there are higher expectations, for example, on people being more available to attend meetings online – which might not always be a good thing! But I sense also that there is a more diverse group of people who are willing to interact in those meetings then they would in other settings.

Some of us now know more of our neighbours, and some of us might be sharing activities to avoid more individual trips to the shops. At a national level, the government's budget plans have been thrown up in the air with finance being redirected to fund schemes constructing hospitals, infrastructures or maintaining public transport systems when demand is falling through the floor.

So, we've learnt from COVID–19 that people can work and live differently. We can accept less commuting, less flying, less buying material goods and all energy consuming activities. But I'm not trying to pretend that change hasn't been extremely tough for many. We've accepted these changes because we know there is a threat to human society. If we actually recognise the climate emergency as being like the pandemic, similarly a threat to human society, then will we see action that is commensurate with the shifts that we really need?

It requires us to pause and rethink every investment made, every job created, every policy measure on the table, every descion that we find ourselves part of. But we need to take on the learning that has presented itself due to this rapid societal change. Then we can embed where we need to pay attention to societal concerns and any potential backlash or inertia. Then perhaps the trend in rising CO_2 emissions could start to be overturned and done so sustainably.

Following the science?

I turn now to what we might take or learn from the ways in which the science and the scientists associated with COVID-19 have been plunged into the spotlight. It was reported by the BBC that, early on, the government prominently flagged that it was following the science. What can we learn from how this has been playing out? Similar to climate change, there is a reasonable understanding of the short-term impacts of COVID-19 on people, just as there is a good understanding of the rising CO_2 emissions on temperatures and sea level rise.

Also, similarly, the wider societal outcomes of both rising CO_2 and the pandemic have become much less clear. There are similarities with regard to climate mitigation and tackling the virus at an early stage. The targeted test and trace systems and lockdowns led to a decline in infections. Likewise for CO_2 emissions, a reduction in energy consumption while low carbon technologies are deployed will reduce the production of CO_2 emissions. But, as mentioned, reduction of energy consumption or investing in the scaling of low carbon technology is needed, but runs into our seemingly immovable attachment with protecting GDP growth.

This is similar to our approach to tackling the virus, where there is the added complication that there are limits to medical capacity, requiring trade-offs between different health concerns, COVID-19 treatments vs cancer treatments – but isn't this the same problem? Investments in additional medical capacity could cover both, but this is chosen not to be prioritised. The other contrast between the pandemic and the climate emergency is that the science behind tackling the rise of COVID-19 infections is less advanced than the science and interdisciplinary understanding of CO_2 mitigation options.

As a plethora of climate change mitigation measures are overlooked on the basis of their potential impact on GDP growth, the academic community has even increasingly come up with evermore speculative options to feed into their models and scenarios, and technologies that paint a rosier picture and avoid wider shifts in society or, heaven forbid, a focus on equity and the distribution of high carbon activities.

At the time of writing, the COVID-19 debate doesn't appear to have reached that point yet, but perhaps there are lessons for our colleagues in medicine to be learnt from the climate field in this regard. There will always be a range of scientific views on high profile issues and they will end up being scrutinised in the popular press by policy-makers and commentators alike. But when policy-makers, for example, hold up GDP growth as a red light, suggesting it is unquestionable, our scientific understanding and judgment mustn't be clouded as a consequence. While our models can be made to show theoretically that speculative options offer ways out within the political 'red lines', we must be true to our areas of expertise and avoid our judgment being clouded by policy-makers' enthusiasm for political expediency.

Transforming society

So if we were to respond to the climate emergency with the same significance as the pandemic what should or shouldn't we be doing?

Firstly, we need to recognise the positives and opportunities presented by the large-scale societal shift we've been seeing. We need to learn the lessons from the societal concerns that have

emerged, the backlash or inertia to COVID-19-related measures, and the focus on what matters most to people: friends and family, jobs, time. Bringing our physical and social scientists and engineers together, we must build this new understanding into our dialogue with policy-makers for the benefit of the climate debate.

Secondly, we need to encourage government and decision-makers to rethink every investment made and every job created, every policy measure on the table and every decision they make or even that we find ourselves a part of, and ask does it reduce energy demand? Will it provide a sufficiently rapid transition to a low carbon energy system? Clear investment at this pivot point could positively transform systems away from fossil fuels while simultaneously improving employment, equality and health and well-being.

Thirdly, we need to challenge the impact of apparent red lines, overcoming our obsession with GDP growth in wealthy nations.

Exploring alternative measures or prosperity is essential at this moment and this debate could take on new momentum. Space to challenge this obsession has now been created. Not only has COVID-19 given us lessons that we can learn from but it has also created a flux in our everyday routines. We all need to take advantage of this flux to develop and influence a sufficiently deep, rapid but sustainable response to the climate emergency.

If we don't take advantage of this moment in a time where we have demonstrated that society can accept deep changes, then we will pass up our opportunity of a lifetime to help future generations.

Alice Larkin *is a Professor in Climate Science and Energy Policy as part of the Tyndall Centre for Climate Change Research, and Head of the School of Engineering at the University of Manchester.*

For more details of the SGR conference, including web-links to the videos and slide presentations, see p.40.

How a just transition can speed up the race to net-zero

Prof Nick Robins, London School of Economics, looks at the dynamics of a just transition away from fossil fuels.

If there is one thing that the brutality of the COVID-19 pandemic has taught us, it's the importance of shared endeavour in the face of a disruptive shock. The same is true for the existential threat of climate change, whose physical impacts are already disrupting lives and livelihoods across the world, spurring countries, companies and communities to step up the race to net-zero.

Long championed by the trade union movement, the just transition is now also becoming a shared endeavour. In 2015, the Paris Agreement recognised the imperative of placing the interests of workers and communities centre-stage so that decarbonisation brings decent work and quality jobs. All the evidence suggests that the creation of the net-zero economy offers huge potential to create both more and better jobs, thereby contributing to ending the poverty and inequality that hold back the global economy.

Looking at energy, for example, the sector employed almost 58 million people worldwide in 2017. According to IRENA, this could rise to 100 million under its Transforming Energy Scenario, which would set the energy system on the path needed to keep the rise in global temperatures to well below 2°C and closer to 1.5°C during this century. This generates 15% more jobs than IRENA's conventional Planned Energy scenario, led by renewables, energy efficiency as well as power grids and energy flexibility. This shift is already underway with renewable energy jobs growing by 500,000 to 11.5 million in 2019.

This expansion in employment, achieved in ways that provide fair incomes for workers and better prospects for communities, will not happen automatically, however. Too often, the climate agenda has been socially blind, introducing policy interventions with little regard for the impacts on employment, or indeed on consumers. As one of the *gilets jaunes* protesters in France

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memorably remarked, "You care about the end of the world; we care about the end of the month".

A critical success factor for net-zero

That is why the just transition is rising to the top of the agenda as the connective tissue that binds together climate goals with social outcomes.

First of all, it is simply the right thing to do, making sure that long-standing human rights are realised in the transition, not least the right to participate in decision-making in the workplace. Second, a just transition is essential to build the political support for the changes that are needed, overcoming the understandable anxiety of those who fear that they could lose out. Workers in high-carbon sectors tend to support green policies when they believe that credible alternatives exist. This was confirmed this year in a survey of oil and gas workers in the UK, where over 80% said they would consider moving to a job outside the sector. Given the option of retraining to work elsewhere in the energy sector, more than half said they would be interested in renewables. As one worker put it: "moving into renewables is something to feel good about."

COVID-19 is intensifying the importance of translating the just transition into a practical reality for the global energy system. Global coal production peaked two years before the Paris Agreement and 2019 looks set to be the peak for oil production. This year, oil corporations have made historic writedowns as they realise the looming risk of 'stranded assets' on the road to net-zero. Sharan Burrow, General Secretary of the International Trade Union Confederation (ITUC), has said that it is essential that this economic restructuring does not result in 'stranded workers' and 'stranded communities'.

The key ingredients of what makes for a just transition are well established: social dialogue in the workplace, along with respect for labour standards and human rights, economy-wide skills development and retraining, buttressed by social protection and safety nets. As many of the core high-carbon sectors are clustered in specific places, community renewal and regional development are crucial, along with macroeconomic strategy to connect the just transition with key climate policy levers (such as carbon pricing). In addition, a special focus needs to be placed on small and medium-sized enterprises, both along supply chains and in regional economies. Turning the just transition into everyday reality is clearly a tough challenge. Even before COVID-19, the global economy was marked by a set of 'decent work deficits' that confront the 3.7 billion people who are either employed or could be in a job.

Growing international momentum

There are growing examples, however, of leaders across government, business and society demonstrating how this challenge can be met.

In the European Union, Commission President Ursula von der Leyen has placed the just transition at the heart of its Green Deal, introducing a dedicated funding mechanism, stating that "the transformation ahead of us is unprecedented. And it will only work if it is just – and if it works for all". In South Africa, President Cyril Ramaphosa has committed to draw up a just transition plan backed with a just transition fund so that measures are in place for "workforce reskilling and job absorption, social protection and livelihood creation, incentivising new green sectors, [and] diversifying coal dependent regional economies".

In a striking departure from the previous US administration, President Joe Biden has made job creation the centrepiece of his climate strategy, stressing that these must be "good-paying jobs that provide workers with the choice to join a union", adding that he will also focus on "delivering justice for communities who have been subjected to environmental harm". This commitment has been embedded into Biden's $1.9 trillion stimulus package signed in March 2021, and in two infrastructure bills amounting to a further $3 trillion. These steps are supported by a large civil society platform calling for 40 percent of climate investment to benefit disadvantaged communities.

In business, energy utilities across Europe are signing up to a just transition pledge and a new guide has been released in the US showing how companies can incorporate the just transition into their renewable energy procurement. Investors too are starting to integrate the just transition into their climate activities. Bringing together more than 500 global investors with over US$47 trillion in assets, Climate Action 100+ has included the just transition as one of the eight areas in its Net Zero Carbon Benchmark. Development finance institutions such as the European Bank for Reconstruction and Development and CDC are also coming forward with new initiatives.

The agenda for the UK

In the UK, by contrast, the government has yet to introduce a comprehensive commitment to the just transition as part of its drive to a net-zero economy. North of the border in Scotland, a Just Transition Commission has recently recommended a raft of measures to make climate action 'fair for all'. A similar body should be established at the UK level to set out how greening our energy, homes, industry, land and transport systems can be shaped to reduce deep inequalities that have been exacerbated by the COVID crisis. For example, a just transition plan for North Sea oil and gas is required to phase out exploration and production in ways that improve the lives of workers and communities. A comprehensive Green Home funding programme is also needed, building a high-skilled and empowered workforce to retrofit every building in the country, with special focus on upgrading homes for low-income families. A strong place-based dimension will also be needed to ensure that net-zero plans respond to the different community needs: this could help to give some substance to the government's desire to 'level up' the economy. As in the US, an ambitious UK government policy around the just transition would be welcomed by civil society, as well as by many in the financial community.

Heading towards COP26

As the world heads towards COP26, the just transition will need to be part of every government's COVID recovery plan as well as their short- and long-term climate strategies. It needs to be part of every business plan and every finance strategy from banks and investors. If net-zero is the 'what', then the just transition is the 'how'.

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This article covers the ground of the contribution made by Prof Robins to the SGR Responsible Science conference 2020, and is based on a Commentary written for the Grantham Institute.

A referenced version can be downloaded via: https://www.sgr.org.uk/publications/responsible-science

Overconsumption, the climate emergency and the scientific community

In an edited version of **Prof Julia Steinberger**'s presentation to SGR's Responsible Science conference, she explores how to live well within environmental limits, and asks why questioning overconsumption is so problematic.

Why is it hard to talk about overconsumption and the climate emergency in the scientific community? In this article, I will cover 'living well within limits', and what that means. I'll also discuss some of the questions around alternatives to GDP and well-being, and how to mathematically model a very different world – one in which we're focused on reducing energy use. Then I'll cover why we need to address consumption in a direct way, and criticise overconsumption, and why that's seen as difficult.

Understanding well-being

What does 'live well within limits' mean? I begin with a view of well-being that is very different from the mainstream economic one,[1] and indeed from our own governments' perception of well-being. Typically, even when they include happiness indicators they're operating in a very individualised paradigm. But the theory of human needs from which we approach well-being is a very much social paradigm.

The overarching goal of well-being includes that someone is able to participate in society. In our COVID times, this is more difficult to do. For example, you need to make sure everyone is more connected to the internet because otherwise they'll lose out during a lockdown.

To ensure the possibility of well-being and social participation, certain 'basic needs' create a foundation. These are universal and include physical health, mental health, autonomy, cognitive understanding, and opportunities to participate. So you need to be able to understand and interact with the world around you. You also need to be able to read, to think critically and distinguish false reporting from that which is true. An obstacle to participation, for instance, is a long working day.

In order to fulfill these needs, there are 'need satisfiers' which we consider to be universal across societies. These include food, water, housing, healthcare and a safe environment. There are a finite number of satiable need satisfiers, and these are non-substitutable – for example, you cannot substitute food with housing or vice versa. These underpin the meeting of basic needs and their provision builds up well-being.

But is this actually the way human beings function? I and academic colleagues have tested this,[2] and we found that when need satisfiers like nutrition, sanitation, education, and sufficient income are provided, life satisfaction and healthy life expectancy go up. It is both a theory of how the world works, and what we can actually observe in reality. A finite number of non-substitutable, satiable, universal human need satisfiers have to be provided for us to be well. Then the question becomes how do we achieve those while operating within planetary limits?

Operating within planetary limits

We studied this within my own 'living well within limits' project, where we put all these factors together in a framework.[3] This included social outcomes (like well-being), bio-physical inputs (like energy resources), and 'provisioning systems' (such as technology and society). Probably the more important thing here is that the framework had to include not just technological and economic factors, but also culture and communities. ≫

The next question about whether we can live well within planetary boundaries is addressed by what is now referred to as 'doughnut economics', proposed by Prof Kate Raworth.[4] Can this be modelled? Taking the idea of the doughnut (see more detail below), together with the ideas of basic needs and need satisfiers, it is possible to imagine and also quantitatively model a different future.

I and academic colleagues have done this[5] and used an extra piece of the puzzle, which is the idea of 'decent living energy' developed by Prof Narasimha Rao of the University of Yale. His theory shows what human need satisfaction corresponds to in terms of minimum levels of core energy services, like thermal comfort, transportation and communication. He's not talking about energy consumption directly, but about the energy services that we get from energy consumption. It poses the question of what is the minimum level needed to have a decent life, i.e. not suffering from deprivation and being able to participate in society.

We've tried to model this and our model takes into account state-of-the-art technical efficiency. So it focuses on technologies that exist and that are proven – not speculative technologies – so we don't need to invent anything new, just learn how to roll out what we already have maximally.

Also, to be clear, we're talking about equal human need satisfaction all over the world, which means that everyone reaches a sufficient level of well-being. Furthermore, we're talking about degrowth of energy demand because we have to reduce overconsumption. So it means that everybody has enough, but nobody has more than enough. It means we're in a situation of equality globally, but where we also take into account geographical and climatic differences, whether people live in urban settings, their household size, and demographics.

Our results modelled a value for 2050 to provide an amount of energy necessary for decent living. We compared it to other models including the International Energy Agency's models and ours gets to the lowest amount of energy needed. It is pretty much a 'how low can you go' model. We believe it is possible to deliver sufficient energy for universal satisfaction in 2050 at 40% of our current consumption, and this includes the effects of population growth.

If we compare that to current energy consumption levels, it means that most wealthy countries would decrease their energy use by about a factor of 10, while many other countries are clearly in a state of 'insufficiency'.

Criticising overconsumption

We return now to the idea of 'doughnut economics'. At the centre or 'hole' of the doughnut, levels of consumption are at their lowest – so you have deprivation and poverty here, which is socially unsustainable, and means people are suffering because their consumption needs are not met. In the middle ring of the doughnut, we have sustainable lifestyles, so there is sufficiency and we are not overconsuming. On the outer edge, we have overconsumption which is environmentally unsustainable.

It's difficult to study overconsumption and it's difficult to talk about it. Mainstream media outlets are reluctant to cover this kind of work, and most coverage of our work has been on science blogs. However, one article that we wrote mapping international inequality of energy footprints[6] was covered by the BBC with the headline, "Climate change: The rich are to blame." This work demonstrated that the energy consumption categories with the highest levels of inequality tend to be within transportation, due to frequent flying and people who drive large cars a lot.

We wrote another paper titled *Scientists' warning on affluence*'[7] and it didn't receive much mainstream media coverage at all. In it, as well as energy and resource footprints, we also discussed the systemic and structural factors within our economies that drive patterns of overconsumption. One of the things we pointed out is that overconsumption is designed into our economic systems by the state, by industries, and by markets. It becomes necessary for us to overconsume because our economic system needs an outlet for growth and production, and as a result there's a deliberate lack of low consumption alternatives. Advertising pressurises us into overconsumption. As these things are designed into our systems, we need to talk about it.

There is also 'positional consumption' where the affluent drive consumer behaviour through their setting of norms and aspirations, like my Swiss compatriot and tennis champion Roger Federer who advertises big cars. We're taught to look up to these people, and aspire to their consumption patterns. It means that when we are attacking overconsumption, we are attacking the people who are trendsetters – and that creates problems within our culture.

Merely existing and surviving within unequal neo-liberal societies also compels overconsumption. If you want to keep up with what's demanded by our economies you need a private vehicle and time-saving appliances, so you're going to be pushed into overconsumption.

So, in our work, we question mainstream economic ideas and examine the alternatives. Our society needs to explore different economic schools of thought, including things like eco-socialism and de-growth. It's important to engage not only with how to resolve climate change, but to understand why so little is being done right now. And I think it has to do with our economic systems, and it has to do with our systems of production and consumption with their lock-in mechanisms. From my political economy perspective, once we understand those we can have a bigger chance of real progress, because we can better target our actions. So we need to bring economics into the picture in a very central way.

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For more details of the SGR conference, including web-links to the videos and slide presentations, see p.40.

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Hidden military implications of 'building back' with new nuclear in the UK

After speaking at SGR's 'Transition Now' conference, **Phil Johnstone** teams up with **Andy Stirling**, both of the University of Sussex, to reveal even more evidence of the unwelcome institutional links of nuclear energy.

At a time when such discussions are muted in academic enquiry, media coverage and wider energy policy, Scientists for Global Responsibility (SGR) have provided crucial analysis of the role that militaries play in influencing the direction and speed of low carbon transitions.[1] Indeed it is remarkable given the central role that war and the military have played in past energy transitions and how large global military spending continues to be,[2] that there seem only such marginal levels of academic curiosity regarding how contemporary energy system dynamics might be shaped by military imperatives. There is tendency in contemporary analysis of 'sustainability transitions' for example, to treat energy and other 'systems' as discrete and bounded, governed by their own internal properties and seemingly disconnected from wider dynamics. This leaves questions of how military ambitions shape the direction of energy policy trajectories almost entirely unaddressed.

A key example of these tendencies can be seen in conventional energy policy analysis of UK commitments to new nuclear power, the UK being one of the few OECD countries still enthusiastically pursuing the technology. As we discuss below, given the now clear disadvantages of new nuclear compared to renewables, this commitment does not make sense when considered simply within the confines of energy policy rationales. What we have outlined through research spanning several years, is that a key driver of the UK's intense enthusiasm for new nuclear reactors stems from elite imperatives to sustain the capabilities, skills, and supply chain activities necessary for Britain to build, maintain, and operate the nuclear propelled submarines that underpin its nuclear weapons system. In other words, civil nuclear channels a subsidy towards military nuclear activities. At a time when the UK Government seeks to 'build back better' following the COVID-19 pandemic and sees nuclear as playing a role in this, our analysis holds potentially significant implications for the UK's climate action, for discussions concerning the health of British democracy – and for the building of a more peaceful and less militarised world.

The oddity of UK nuclear commitments

We are currently living through momentous and global shifts in energy systems. Over the past decade, renewables have surpassed official expectations with rapid construction and plummeting costs. Renewables now increasingly offer the cheapest energy sources worldwide.[3] As highlighted by recent Lazard data, cost advantages of renewables over new nuclear now typically dwarf costs of managing intermittency.[4] Costs of batteries and other storage and grid management options are also declining rapidly.[5] Between 2010-2019 wind costs fell globally by 70% and solar costs by 89%.[4] Nuclear costs on the other hand, have risen by 26% over the past decade.[4] Indeed, global nuclear new build continues to stagnate.[6] is plagued by delays and cost overruns.[6] with leading nuclear companies face bankruptcy or potential insolvency.[7] Some are withdrawing entirely from nuclear investment, because it is no longer

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≫ 'economically rational'.[8] Much touted predictions of a global 'nuclear renaissance' since the early 2000s have simply not materialised.[6]

The UK's long running 'nuclear renaissance' has performed particularly poorly, with costs tripling.[9] delays of nearly ten years for the only new power station under construction, and new nuclear very seriously failing to contribute towards the aims of rapid emissions reductions and energy security "significantly before 2025". The National Audit Office (NAO) and Public Accounts Committee (PAC) found that the Hinkley C nuclear project could "lock in" consumers to a "bad deal" that will "hit the poorest households the hardest".[10,11] Indeed, while new nuclear was originally justified on grounds of economic benefits,[12] the government's own figures show that even when integration costs are considered, renewables are now far cheaper.[13] During this period of stark failure in initially firm nuclear policy commitments, renewables have climbed from under 10% of electricity generation in 2010 to 43% in 2020.[14]

With very few companies left investing in new nuclear worldwide, the UK government is mounting a desperate attempt to secure nuclear investment through even more extravagant financial arrangements – including forcing consumers to pay upfront for potential cost overruns under a 'regulated asset base' (RAB) or direct government financing.[15] Meanwhile, intense enthusiasm for entirely untested Small Modular Reactors (SMRs) continues despite these technologies being irrelevant for rapid climate action and almost certainly more expensive than conventional reactors.[16]

As we have documented,[17] this intense enthusiasm is particularly odd by comparison with a country like Germany, which is phasing out nuclear power. The UK has a far more abundant and cost-effective renewable resource and a nuclear industry that performs particularly poorly when compared with Germany and other countries.[18] It is the UK with its abundant renewables resource that stands in the best position to enact a transition to a non-nuclear future and reap the benefits of investment and jobs in renewables. Yet the relentless obsession for new nuclear continues. This obsession makes no sense – until we consider that Britain is a nuclear weapons state.

Civil-military nuclear interdependencies

'Material interdependencies' between civil and military nuclear infrastructures have long been well documented around fissile materials, enrichment and reprocessing.[19,20] What is new in our research, is the highlighting of hitherto neglected 'industrial interdependencies' between civil and military nuclear power particularly in relation to nuclear-powered submarines.[21,22] Maintaining the reservoir of skills, research and development, and supply chain activities necessary for nuclear submarines, is an expensive long-term endeavour. Maintaining civil nuclear construction is crucial to sustaining this reservoir of capability. What has become clear in recent years is that the countries that tend to pursue intense nuclear new build programmes tend to be established or aspiring nuclear weapons states.[22] Recent statements from high-level officials confirm the industrial interdependencies between civil and military sectors – for instance French President Emmanuel Macron's blunt statement in 2020:

> *"to oppose civilian nuclear and military nuclear in terms of production…[and]…research, does not make sense for a country like ours…without civilian nuclear, no military nuclear, without military nuclear, no civilian nuclear".*[23]

Such candour is also found in the USA, with a prominent think tank outlining that the military complex is *"tied to the fate of the commercial nuclear industry".*[24] Meanwhile, the Atlantic Council –describing a *"a mutually reinforcing feedback loop"* between the civil and military nuclear sectors – puts a value on the economic contribution of civil nuclear 'human capital' to the US defence nuclear enterprise at $26.2 billion.[25] In other words, civil nuclear underwrites considerable costs associated with the military nuclear complex in the USA. This is particularly relevant for naval nuclear propulsion including submarines, where a report by former US Energy Secretary Ernst Moniz advocating national security benefits of civil nuclear highlights the "strong overlap" between the nuclear navy and commercial nuclear industry.[26]

The smaller scale of the UK nuclear industry means these industrial pressures are likely to be even greater. Although no official statements have been made (and the issue remains almost entirely undiscussed in energy policy), UK military policy documents do provide clear evidence for these same interdependencies. For example, Rolls Royce have long emphasised that a decline in civil nuclear has *"reduced the support network available to the military programmes"* emphasising that that *"…this will especially be so if, despite renewed calls for them, a new generation of civil nuclear power stations is not constructed".*[27] As the UK considered renewal of Trident, a prominent security expert expressed concerns that ""*if the UK does not build new civil nuclear stations… the entire burden of the nuclear safety and regulatory regimes would fall on the defence budget."*[28] It was highlighted in 2009 by the Dalton Institute that *"The UK is not now in the position of having financial or personnel resources to develop both [civil and defence] programmes in isolation"*, with Rolls Royce in the same report stating that: "*a larger involvement in the broader [civil] industry will also have a spillover benefit to military capability".* A RUSI report in 2008 highlighted the benefits of "*masking"* costs of submarines in other infrastructural projects, the most related of course being civil nuclear.

In 2014, a heavily redacted formerly secret report noted that the UK nuclear submarine industry was in serious disarray due to atrophy in crucial skills and expertise exacerbated by decline in the civil nuclear industry.[29] The report recommended further 'engagement' with the civil nuclear sector as a solution to these challenges, urging that ""*the [submarine] programme seek imaginative methods to better engage with the emergent civil new-build programme…to the benefit of defence"* and that *"the Research Programme Group establish a workstrand to look at leveraging to maximum effect civil nuclear investment"*.

This advice seems to have been readily taken up. In 2017 (following evidence submitted by the authors to a Public Accounts Committee (PAC) inquiry into nuclear power[30]), it was confirmed by the Permanent Secretary of the Ministry of Defence (MoD) that civil nuclear new build presented opportunities for the submarine industry in *"…building up its nuclear skills"* but there would need to be *"…concerted government action to make it happen".*[31] This 'concerted action' can be seen in the documentation around the 'nuclear sector deal' a year later, which provided for the *"…greater alignment of the civil and defence sectors with increased proactive two-way transfer of people and knowledge".*[32] Rolls Royce also confirmed the importance of civil nuclear to underwriting costs for the submarine programme, outlining that investment in SMRs could *"relieve the MoD of the burden of developing and retaining skills and capability…free[ing[up resources for other investments".*[33]

Despite this strong evidence, there remains no official acknowledgement from the UK Government that energy strategy is being motivated in part to subsidise nuclear submarine infrastructures. Nonetheless, rare statements are made by

There is strong evidence of 'industrial interdependencies' between the UK's civil and military nuclear programmes

government officials that clearly demonstrate the inseparability of civil and military nuclear in the UK. For example, in 2018 the then Under Secretary for Energy Richard Harrington referred to the separation of civil and military nuclear as an "*artificial distinction*".[34] Yet official energy policy remains silent on the matter. This is despite acknowledgement by the National Audit Office that factors "*beyond the energy trilemma*" are influencing the government's persistent attachment to costly new nuclear.[10] The long-awaited 2020 Energy White Paper reiterated intense nuclear commitment, despite the government's own data showing severe cost disadvantages for nuclear compared to renewables – data that were conspicuously left out of the White Paper itself.[35] At the same juncture however, an interview with a senior figure at Rolls Royce, highlighted that developing SMRs would "*...help Rolls-Royce maintain UK capabilities for the country's military nuclear naval program*".[36] This continued heavy military influence on continuing UK government commitment to nuclear has significant implications for the UK's climate ambitions, the state of democracy, and for movements towards a more peaceful world.

Implications for decarbonising, democratising and demilitarising energy futures

The COVID-19 pandemic has sparked discussions around 'building back better' in ways that drive low carbon energy, providing economic opportunities and jobs. Yet the UK government continues to justify new nuclear based on climate change arguments that are no longer credible. Since Tony Blair announced that nuclear was 'back with a vengeance' in 2006, only one power station out of several proposed developments is currently underway. Eighteen years after the launch of the UK's new nuclear programme, and nearly ten years beyond its own due date, Hinkley Point C may be built by 2026. But it is extraordinarily rapid growth in renewables and energy efficiency, that has seen the UK's grid rapidly decarbonise and coal virtually eliminated. New nuclear has thus far made no contribution at all. And with government commitments to reduce emissions by 62% as soon as 2030, further new nuclear beyond Hinkley (whether large or small), cannot make any meaningful contribution. Beyond this, research shows that high costs, long lead times and institutional effects associated with nuclear, can crowd out renewables investment.[37] So, continued nuclear enthusiasm represents a considerable opportunity cost for rapid climate action: slowing investment and growth in more rapid, effective and affordable renewables, energy efficiency and grid transformation.

The matter of jobs and climate has of course been central to discussions around 'building back' after COVID-19. Yet despite the stream of rhetoric from the nuclear industry and much media coverage around nuclear jobs, it is clear there are already more jobs provided by renewables in the UK than nuclear, with the difference set to grow fast. Similar evidence in the USA highlights how more jobs are already associated with solar and wind than with nuclear, despite the USA having more nuclear reactors than any other country. So why are nuclear jobs so important to the UK government compared to other types of low carbon employment? And here we arrive back at the evidence provided above, that it is the retaining of nuclear military capabilities which makes this such a priority.

Not only are military-influenced obsessions with new civil nuclear detracting from climate action, but associated efforts at concealment are eroding the transparency, rigour, and quality of democratic UK policy making. It is on these grounds crucial that the UK nuclear debate is opened up beyond the narrow confines of now-discredited energy and climate policy rationales, so that citizens and energy consumers can make informed decisions. To see this does not imply a 'pro' or 'anti-nuclear' position. Instead, this is simply a matter of responsibility shared to a greater or lesser degree across all politicians, activists and citizens – to work towards a more vigorous, transparent and democratic debate in which rationales are not hidden, but properly scrutinised and evaluated.

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Nor is this a new issue. It chimes strongly with concerns that were at the forefront of discussion in the burgeoning progressive movements of the 1970s, in which SGR itself was born.[38] In this light, the challenge is not just the technical imperative to reach zero carbon, but a democratic question over what kind of zero carbon world we want to build? It is here that it is so crucial to scrutinise the real drivers of nuclear infrastructures. Without understanding the evident strength of military pressures on civil energy systems, these forces threaten to subvert and overpower not only the climate agenda, but democratic policy making itself. If renewable energy and energy efficiency are to realise their full promise for shifting the world onto "soft energy paths" "towards a durable peace", then it is imperative that energy debates recover some of their former rigour and vigour. With a newly accelerating nuclear arms race in which the UK is scandalously complicit, now is the time for renewed efforts to reconcile the longstanding aims of SGR between climate, peace and democracy. It is only in a world free from nuclear weapons, that nuclear distractions and obstructions can be removed from the essential goals of reaching zero carbon.

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For more details of the SGR conference, including web-links to the videos and slide presentations, see p.40.

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From arms, planes and racing cars to ventilators: industrial conversion during the COVID-19 crisis

Dr Stuart Parkinson, SGR, assesses the UK's crash industrial programme to scale up production of medical ventilators during the pandemic – and what lessons can be learned for conversion away from fossil fuels and arms.

As cases of COVID-19 accelerated in the UK in early March 2020, one of the problems that analysts in the National Health Service (NHS) realised was that there could quickly be a massive shortage of mechanical ventilators. Ventilators are machines that assist or replace a patient's breathing by moving pressurised air in and out of the lungs, and they provide life-saving care for many patients with COVID-19 and other major respiratory illnesses. Mechanical ventilators are the type used for the most severe cases. The NHS analysts estimated that, in a 'reasonable worst case' scenario, up to 90,000 beds with ventilators would be needed to care for COVID-19 patients – but only about 7,400 mechanical ventilators could be accessed.[1] The government responded both by trying to order as many units as it could from existing medical suppliers (both in the UK and internationally) and by calling on UK industry to scale up the domestic production of ventilators. In this article, we'll focus on the second of these as it offers an important case study of rapid industrial conversion to meet a social goal.

UK ventilator consortia

UK companies quickly formed numerous consortia to respond to the call – and the main ones are summarised in Tables 1 and 2, according to whether or not they went on to supply the NHS. The approaches taken by these collaborations fell into two categories:

1. Scaling up production of existing ventilator designs; and
2. Designing and manufacturing new devices.

In general, the first approach was more successful given the very limited timescale, and consortia pursuing this option were the ones which eventually went on to supply the NHS.

Table 1. New/ expanded consortia which supplied the NHS with mechanical ventilators[2]

Ventilator models	Companies involved	Numbers supplied
Prima ESO2	Ventilator Challenge UK/ Penlon consortium Key organisations: High Value Manufacturing Catapult (govt body/ lead), Penlon, Ford, Airbus, McLaren, Siemens, STI No. of companies involved: 31 No. of supporters/ suppliers: 30	11,700
Parapac 300/ 310	Ventilator Challenge UK/ Smiths consortium Key organisations: Smiths Medical, Rolls-Royce, GKN Aerospace Total numbers involved: as above	1,500
Nippy 4+/ Vivo 65	Breas Medical	2,000

One surprising element is that many of the companies involved did not have a track record in the design or production of medical devices. Significantly, they included arms corporations – such as Babcock and BAE Systems; automotive companies – both those involved in mass production vehicles, such as Ford and BMW, and motor racing teams, such as McLaren; and

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≫ aviation giants – such as Airbus. Table 3 summarises the main sectors from which these companies were drawn.

Table 2. New/ expanded ventilator consortia which did not supply the NHS[3]

Ventilator models	Companies involved
Zephyr Plus	Draeger; Babcock
Gemini	OES Medical; BMW
3CPAP (SOG)	Vobster Marine Systems
Piran Vent	Swagelok
VelociVent	Cambridge Consultants; MetLase
Mosquito	Sagentia
CoVent	TTP; Dyson
AirCare	Intersurgical; BAE Systems
EVA	TEAM Consulting; Cogent Technology
Helix	Diamedica; Plexus
OxVent	Oxford University; Kings College London; Smith & Nephew
InVicto	JFD
BlueSky	Darwood IP/ Formula 1 teams; Olympus Medical

Table 3. Sectors represented by companies in UK ventilator consortia

Sector	No of companies: Ventilator Challenge UK	No of companies: Other consortia
Medical	6	13
Automotive: Passenger cars Motor racing	 1 8	 2 4
Military technology	7	2
Aviation (civilian)	3	0
Academia/ public sector	1	3
General engineering/ other	11	6

Data is drawn from Tables 1 and 2 and references therein. Note that some companies are categorised in more than one sector.

CASE STUDY: THE VENTILATOR CHALLENGE UK / PENLON CONSORTIUM

In order to understand the level of success of the ventilators programme, let's examine the Ventilator Challenge UK/ Penlon consortium in more detail.[4] This group was the one which ended up supplying the largest proportion of new mechanical ventilators to the NHS (see Table 1). It opted to modify the design of an existing anaesthesia machine for use in treating COVID-19 patients. The existing model was being manufactured by a small Oxford-based medical device company called Penlon. To appreciate the complexity of this device, bear in mind that its construction consists of 700 individual parts, sourced from 88 suppliers. As one senior engineer involved in the project put it, each ventilator is "not quite as complex as a car". Furthermore, the device had to pass through rigorous medical and engineering certification processes before it could be made available to the NHS.

Once approval had been granted, the consortium rapidly ramped-up production of the device. The speed with which it did this was impressive. The first unit was produced just four weeks after the government issued its call for help – in mid-April – while only 12 weeks after that, about 11,700 units had been completed. Production was being doubled every few days, and the consortium went on to achieve a production volume that was 200 times the rate of the original model! It was able to achieve this transformation by converting four manufacturing sites, each one in a different company in a different sector and in a different part of the country:

- Ford in Dagenham, Essex;
- Airbus in Broughton, North Wales;
- McLaren in Woking, Surrey; and
- STI in Hook, Hampshire.

Approximately 1,500 technical staff were involved, and training was carried out at a distance using 'mixed reality' headsets. These were modified from virtual reality devices so that new templates and designs for the manufacture and assembly of components could be projected in front of the technicians' eyes while they worked. An extra complication was that, of course, all this activity had to take place under 'lockdown' conditions – so workers also had to adapt to using new personal protection equipment, social distancing protocols, and video conferencing technology.

An engineering success but medically irrelevant?

In engineering terms, the ventilator programme was a major success for British industry – but how did it fare in achieving medical goals?

Let's first consider where the programme succeeded and the reasons for this. It achieved – in a remarkably short time – a huge scaling up in the production of complex, potentially life-

saving medical devices. Over 15,000 mechanical ventilators were produced to strict medical standards in just a few months by converted or expanded manufacturing facilities.[5] Senior engineering staff involved in ventilator programmes gave a number of reasons for this success, including:[6]

- Shared social goal – with a specific and urgent health aim;
- Existing high quality manufacturing sites and staff – coupled with high quality control standards;
- Willingness to innovate rapidly – described as a 'will-do culture'; and
- Collaborative working practices – including close cooperation between regulators, businesses, and trade unions; a flat management structure; data sharing between all businesses and government; and a simple relationship with the customer, i.e. government.

However, in medical terms, the success of the programme is open to question. Firstly, the existing NHS availability of ventilator-beds was nearly twice the peak demand from patients in April 2020 – and, anyway, only 200 new ventilators had been manufactured by then.[7] The January 2021 peak in demand from COVID-19 patients was about 25% higher than the April peak[8] – not enough either to require the extra ventilators. Indeed, media reports at the time highlighted that there were local shortages in the number of *beds* in Intensive Care Units to treat COVID-19 patients – a rather different problem.[9]

A further consideration is that, in parallel with the industrial conversion programme, the NHS was able to buy an additional 11,000 mechanical ventilators through the existing global supply chain.[10] That alone more than doubled the NHS stock of ventilators, rendering the new UK manufactured devices superfluous.

However, one area where a UK industrial programme did yield significant medical benefits was in the production of new 'CPAP' machines. These simpler, 'non-invasive' ventilators are also used for COVID-19 patients, depending on their specific symptoms. In parallel with the industrial programmes listed in Tables 1 and 2, University College London partnered with Mercedes Formula 1 engineers and G-TEM to manufacture 10,000 of these devices in a plant in Northamptonshire.[11] From the information available, these seem to have been widely used by NHS hospitals.

Of course, the government could not have been sure in advance that lockdown and other measures would have been sufficiently successful to negate the need for the ventilator programme – especially given the initial reasonable worse case scenarios – so there was no choice on the need to pursue it at the time – but this demonstrates the importance of better pandemic emergency planning, following the examples seen in some other countries.

One other aspect is worth noting here. Having rapidly scaled up production, the Ventilator Challenge UK consortia were completely shut down in July once the government decided the NHS had enough new equipment. All the participating factories were then converted back to their original manufacturing processes – including military technologies, racing cars, and airliners. Hence the opportunity to establish a more permanent conversion to socially-useful production was missed.

Lessons for the climate emergency and arms conversion

There are clearly important lessons from this programme for other efforts to convert production. In particular, the argument that it is too difficult for industries to rapidly move away from reliance on fossil fuels or arms contracts has been left in tatters, as it was exactly these companies which were most heavily involved in the ventilator programme. Industrial success was achieved through a combination of: political will focused on clear social goals; rapid industrial innovation; partnership working across businesses, government and trade unions; and adequate funding for reskilling and retooling. These could and should be the focus of the industrial contribution to tackling the climate crisis and curbing international arms races.

One final lesson has also been strongly exemplified by the ventilator programme: the importance of early action. A great deal of effort was expended by the UK industrial consortia, but most probably had no medical benefit. Better emergency planning for pandemics had been recommended by numerous UK studies in recent years, but this advice had not been actioned. This echoes the slow response in implementing lockdown measures as cases started to rise. If we don't heed similar advance warnings for the climate crisis or nuclear arms control, the consequences will be even worse.

Dr Stuart Parkinson *is Executive Director of SGR. He has written widely on industrial conversion, especially related to the arms industry.*

This article is updated and expanded from a presentation given at SGR's 'Transition Now' conference.

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Hacking the Earth: what could go wrong with geoengineering?

In an edited version of **Prof Bill McGuire**'s presentation to SGR's Responsible Science conference, he assesses the risks of deliberately interfering with the climate system.

Geoengineering – the wholesale, deliberate intervention in the climate system to curtail global heating – is the wrong answer to the wrong question. Instead of asking ourselves how we can tackle the symptoms of the climate emergency, we need to throw everything at treating the causes. It's not as if we are in the dark about this. We have long known that global heating and ensuing climate breakdown are a consequence of accumulating greenhouse gases (GHGs) in the atmosphere, as a direct result of humankind's polluting activities.

The solution is simple, at least in theory: draw down the level of GHG emissions as rapidly as possible, with the aim of reaching net zero in as short a time as we can. The problem is that, in practice, this is far from straightforward. To stand any chance of keeping below a 1.5°C globally averaged temperature rise (compared with pre-industrial times) – which marks the catastrophic climate change guardrail – we need emissions to fall by at least 45% by the end of the decade. Currently, we are on track for a measly 0.5% reduction. This dreadful news should be spurring governments to work harder to slash emissions in line with what the science demands, and it may yet do so. Worryingly, the snail's pace of progress on emissions cuts also seems to be encouraging the tinkerers – those who can't wait to resort to untried and untested techno-fixes in an attempt to bring temperatures or carbon emissions to heel in short order.

Gathered together under the broad, rather ambiguous heading of 'geoengineering', today's portfolio of schemes to intentionally interfere with the climate can be traced back directly to post-World War II plans to weaponise the weather touted by Edward Teller, lead scientist of the USA's hydrogen bomb project, and others like him. Thankfully, such plans never got off the ground. It is vital that we ensure common sense prevails so that today's schemes also never bear fruit.

Broadly speaking, geoengineering technologies can be grouped together into those that seek to tackle rising global average temperatures by blocking incoming solar radiation and those that aim to slow or halt climbing temperatures by isolating anthropogenic carbon either before it reaches the atmosphere or by directly removing it. All are risky, expensive and – undertaken at scale – have the potential to be environmentally damaging. All, too, raise serious questions about accountability and the infringement of legal and human rights.

Of the various schemes being proffered today is one that probably carries some of the highest risks. It is predicated on the knowledge that major volcanic eruptions have a temporary cooling effect on the climate, and involves plans to mimic such an event by pumping particles into the stratosphere to reduce incoming solar radiation. It is true that massive eruptions do have a cooling effect, but that is not the end of it. Severe cooling linked to the biggest historical blasts was also accompanied by extreme and unpredictable weather, large-scale harvest failure, and famine. Indeed, the impact of volcanic cooling in the years following the 1815 Tambora eruption (in Indonesia), was great enough to trigger the last, great, subsistence crisis in the western world, widespread unrest in Europe, and the last armed uprising in the UK.

It is therefore extremely concerning – and depressing – that the US National Academy of Sciences, no less, has recently published a report advocating a research programme to better understand the feasibility of interventions that seek to dim the sun. This unwelcome support has added wind to the sails of the Harvard research group promoting the plan, who are itching to fly an experiment called SCoPEx (Stratospheric Controlled Perturbation Experiment) on high altitude balloons above the pristine landscape of Arctic Sweden. The first experiment was planned for summer 2021 to test the balloon and instrument gondola – and followed, later in the year, by a flight that would release small volumes of sun-dimming aerosols. At the time of writing, the test flight has been suspended pending consultation with local Swedish and indigenous populations. The fact that such engagement has only followed public outcry says it all about the arrogant attitude of the tinkerers, and their willingness to ride roughshod over the wishes of others.

This local dispute points up one of the key issues associated with the embracing of intentional climate intervention. By what right does any one group, or one country, or one economic bloc, decide that it is OK to do this? Surely, no geoengineering scheme could be allowed to go ahead without – at the very least – the agreement of all nations. And even then, what about the legal and human rights of individuals? Do they count for

nothing? The whole situation is a minefield, and one that is far better never ventured into. Almost certainly, it would be at least as difficult – if not more so – to achieve international consensus on a geoengineering plan as on an accord to slash greenhouse gas emissions in line with the science. Why then waste time, energy and money on something that does no more than address one of the symptoms of the climate crisis?

And, notwithstanding the associated risks and dangers, there are other reasons for kicking geoengineering into the long grass. It is often touted by its supporters as a 'Plan B', to be dusted off if and when Plan A (cutting emissions at a rate that circumvents catastrophic climate change) looks like failing. The problem with a Plan B, however, is that Plan A is no longer regarded as a last resort. In other words, the very existence of Plan B, detracts from the urgency with which Plan A needs to be enacted. If governments feel that a techno-fix is waiting in the wings, they are less likely to support those measures needed to slash emissions as the science demands, and more likely to champion net zero targets that are further in the future and require less effort or change to attain.

Reading Bill Gates's recent interventions on the climate crisis, it becomes apparent that what he means by 'avoiding a climate disaster' is knocking that pesky global heating on the head so that capitalism can keep moving forward in the fast lane – and so that, for example, he can keep criss-crossing the planet in his private jet. This is also how many of its supporters and advocates – not least the fossil fuel corporations – see geoengineering. Whether true or not, it seems to them to offer an opportunity to 'solve' the climate crisis without the wholesale reorganisation of society and economy that a rapid transition to a zero-carbon world would require. The bottom line, however, is that our planet is simply too small, too exploited and too damaged, to survive continued business as usual. So, if we want to save our world, and the people of it, we cannot afford to open the can of worms that is geoengineering. Instead of following what some like to think of as the easy road of the techno-fix, we must take the route that sees greenhouse gas emissions slashed and net zero carbon achieved, as soon as possible, not – as John F Kennedy said of the Moon landing programme – because it is easy, but because it is hard. And because it will change everything about our world for the better.

Bill McGuire *is a Patron of SGR and Professor Emeritus of Geophysical and Climate Hazards at University College London. His new novel,* Skyseed *– an eco-thriller about geoengineering gone wrong – is published by The Book Guild.*

The potential for rapid transition of the aviation industry after COVID-19

In an edited version of **Dr Lucy Gilliam**'s presentation to SGR's Responsible Science conference, she looks at the steps that need to be taken to prevent a resurgence of the aviation sector as we emerge from the pandemic.

Our current crisis presents an opportunity for rapid transition of the aviation industry in two different ways. One is through attaching conditions to bailouts, because the aviation industry is holding out its hand due to the financial crisis it faces. The other way is by mobilising people in institutions and corporations to make lasting changes to travel policy, which fits in very well with the pledge people make in SGR's Science Oath for Climate (see p.2).

Pre-2020, aviation growth was very high. In the EU, annual growth stood at around 5.9%, with a 26.3% increase over 5 years. Whereas other sectors within the European Emissions Trading Scheme (ETS) have been cutting their carbon, aviation has been on a very steep upward curve. Globally, the annual carbon emissions of international aviation are already about 70% higher than 2005.

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The aviation sector can be decarbonised, but it will require huge investment. The main way that it is possible to decarbonise aviation is through the scaling up of, and switching to, renewable fuels. New aircraft designs have a role, but they will take a fairly long time to have any impact on emissions. Meanwhile, alternative synthetic fuels will require huge amounts of renewable energy. So, the challenge of decarbonising aviation becomes much greater if the sector is allowed to continue to grow at pre-2020 rates. Also, the non-CO_2 impacts that planes have, such as aviation contrails, are not easily solved even with synthetic renewable fuels. For these reasons, we need additional measures to curb demand.

In the past, aviation growth has been the result of cheap tickets, indirect subsidies to the sector, and aggressive marketing campaigns that have all enabled flight prices to fall significantly compared to their levels 20 years ago.

Due to the pandemic, the airline industry is facing the worst crisis in its short history. Aviation has been seeking government bailouts from the public purse, and this is despite the fact that the industry has avoided contributing to that purse through tax exemptions.

Over €33 billion has been given in aid to airlines in Europe (at the time of writing) and they are looking for further bailouts. To put that into perspective, the industry also avoids charges of around €24 billion per year, just in untaxed kerosene alone. So, it is a critical time for the aviation industry when key decisions can be made about the structure and the financing of the sector. This will have consequences for the coming decades. In addition, in the next 30 years we need to tackle the climate crisis, and we've got to think about how we are going transition the sector to zero emissions in line with the Paris Agreement. We also have to think about a just and fair transition for workers. Currently, there is very real suffering for workers in the aviation industry with 5.6 million jobs lost in Europe in aviation in relation to COVID-19 alone.

We need to be sensitive when talking about the need for long-term reductions in the aviation industry, and to have realistic solutions for how we can manage the transition fairly. It's important to think about what limits should be placed on the size of the sector, given the difficulties of scaling up technological improvements, within the timeframes to meet the climate goals. If we don't have these conversations right now, we'll see that things very quickly will revert back to business as usual, just as they have done following other recent crises.

Something else to consider, when talking about transition of the industry, is the question of who flies? Even in Europe, flying is not that 'normal'. In the UK, for example, the top 1% took one in five of all flights abroad. About half of the public don't fly at all in a given year, and on a global level we can see that ten percent of the global income spectrum is responsible for three quarters of flight emissions. So, when thinking about bailouts, it is really important to question whether we should continue to subsidise the rich so they can fly cheaply.

Another thing to consider is the huge shifts in working and travel patterns that we've seen during the COVID-19 crisis. Behaviours shifted very rapidly due to the uptake of online technologies for meetings. We've seen a 'Zoom boom' and the resistance that used to exist towards this technology before the pandemic has perhaps been overcome. Now, we can think about what we can do to embed these behaviour changes for the long term.

Talking to people about what they expect when they return to work after the COVID-19 crisis, you can see that there has been a shift in attitudes towards home working, recruitment and business travel. It is highly likely that travelling for work will not return to previous levels and I think finance departments might also be looking at some of the recent cost savings and thinking, "well, maybe we can keep these savings and not return to how staff travelled before".

Business travel does make up a substantial part of the carbon footprint of an organisation.

Work on the carbon footprints of research organisations reveals that that more than 50% of their carbon footprint is down to business travel. Half of those are EU trips so, even though they are a smaller portion of the emissions compared to long-haul flights, because they are within Europe they could be shifted to other modes of transport if, indeed, those journeys are needed at all.

An interesting aspect of tackling the business carbon footprint relates to premium seating business travel. This type of travel leads to higher emissions per person, and makes up about 20% of flights. Three-quarters of an airline's revenue comes from selling tickets for business purposes, and premium seating is the most lucrative part of this sector. If the behaviour of this market is shifted, it will disproportionately impact on the profitability of the business models of the whole aviation sector.

This could be the thin edge of a wedge that changes the industry, if we consider travel policies within our institutions. For example, guidance could be introduced saying that a train should be taken for journeys of less than a certain timeframe or distance, or questioning whether meetings really need to take place face-to-face, rather than using online conferencing.

2021 is the European Year of Rail, so there is going to be a lot of debate around improving intra-EU rail and I'm hoping this will lead to a shift in passengers from air to rail across the continent.

Stay Grounded is a global grassroots network working to reduce aviation, and it runs a campaign to make lasting change and embed new travel norms in business institutions and universities, and empowering student networks to push for change. It produces many resources, available on their website – https://stay-grounded.org/ – and has a nine-step plan for shifting travel policies in institutions for anyone wanting to become an activist within their organisation. One Stay Grounded campaign is called 'Save people, not planes'. It started in the immediate aftermath of the first lockdown, but I think it is still relevant.

Dr Lucy Gilliam *is Aviation and Shipping Campaigner at Transport and Environment, a European NGO based in Brussels, https://www.transportenvironment.org/*

For references, see Dr Gilliam's slide presentation on the SGR website at: https://www.sgr.org.uk/resources/what-potential-rapid-transition-aviation-industry-after-covid-19

For more details of the SGR conference, including web-links to the videos and slide presentations, see p.40.

Early sparks: tales from the history of renewable electricity

In an edited version of **Dr Alice Bell**'s presentation to SGR's Responsible Science conference, she outlines some of the early history in the development of hydro-power and solar-power.

I've spent a chunk of the last few years writing a book about the history of the climate crisis – *Our Biggest Experiment*, out with Bloomsbury in July.

A key part of the book centres around the question "how did we get into this mess?" In many ways, that part of the story is a matter of how people found evermore elaborate ways to burn fossil fuels.

It's a pretty incredible story, one not just about oil, gas, coal and pollution, but the growth of globalised businesses and intricate, often hidden networks of infrastructure that connects us both to our nearby neighbours and people around the world. This side of the book relates to an issue I feel very keenly in my day job with the climate campaign Possible, that the public are almost encouraged to not pay attention to the energy they're using, where it came from or how it got to them. I often say one of the biggest challenges we have there is not building public engagement with climate science – or even the climate crisis at large – but centuries of public disengagement with the energy system.

The burning of fossil fuels at scale, as humans have been doing for the last few hundred years has transformed lives in countries like the UK, bringing all sorts of benefits alongside huge amounts of pollution and human rights abuses. Our energy system includes some incredible feats of engineering, for good and bad. The things that we have done as people together, collectively to build the energy system, is quite awe inspiring (the word "awe" here used in the sense that it can inspire a mix of fear and wonder). And yet the public has kind of almost been encouraged not to pay attention to any of it.

In some respects, it's liberating that you can just flick a switch and have light or heat or movement without having to give it much attention; that you don't have to think about everything going on behind your computer charging or hot water running because there are other clever people thinking about it for you. But now, as we're faced with the climate crisis and asked to change that system, this lack of attention can mean everyday members of the public find it hard to navigate what change might look like.

In the book I unpick some of the stories of the oil industry as well as the growth of networks for gas and electricity. One of the things I learnt from researching the book was how interesting the history of the gas industry is, how much it's shaped our lives today and might have turned out quite differently. But in this article, I want to focus on something else – the long history of renewables. Because as citizens of the twenty-first century we have inherited an almighty mess, but we also have inherited some great tools too.

Cragside is in the north of England, a little north of Newcastle. Today it's a National Trust property, but it was built by an engineer called William Armstrong in the mid-late nineteenth century. He made the bulk of his fortune and name selling guns, though his company also built the hydraulics for Tower Bridge in London. In the 1870s, he took semi-retirement to build a grand home in the North of England. As well as a home to enjoy his retirement, he also wanted somewhere he could invite visiting dignitaries who might buy his guns, and impress them. Set in 1,700 acres, it had five artificial lakes and they planted seven million trees. Inside, he displayed his prestigious art collection and fitted rooms out with the latest William Morris ≫

wallpaper. He loved to tinker as an engineer and he used this as an opportunity to try out some of his more wild inventions (and simply show off). The building was even used as the set for a mad scientist's castle in one of the Jurassic Park movies.

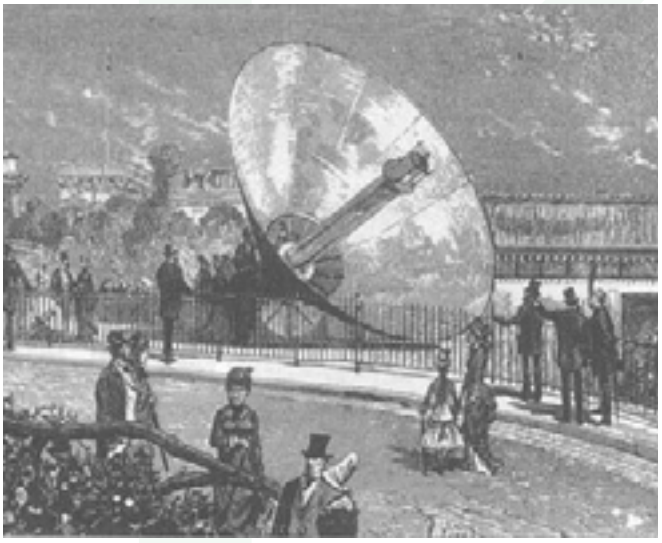
Armstrong asked his friend Joseph Swan to give him some of his new light bulbs. Electric 'arc' lights had been pioneered by people like Humphrey Davy a few decades before, but were incredibly bright, so you'd need an umbrella to shield your eyes because of the brightness. There were a few homes near Paris with arc lights because the owners liked a sense of being modern, and they were used in some theatres or positioned high up away from eye-level, as street lighting, but it wasn't really an option for the home. Swan had developed light bulbs that would produce light from heat which was much softer, and William Armstrong installed them amongst the other modern gadgets in his house.

To power these light bulbs instead of having a coal burner in the basement – which is how, decades later, Edison would first sell his electric light system to people like J.P. Morgan – he set up the first hydroelectric system of its kind, powered by one of his streams. The National Trust recently rebuilt it, so (once we can move around again and visit National Trust properties) you can visit the first, working hydroelectric system. Hydroelectricity soon started to get a lot bigger. Not just powering one person's slightly eccentric idea of home electric light, but trains and buses. Indeed, the first really big electricity system anywhere was hydro, Niagara Falls in the 1890s.

It's easy to forget that electric transport at the turn of the twentieth century was a big thing, and that this electricity didn't always come from the burning of fossil fuels. When I say to people that "electricity used to be the future for transport back a hundred years ago" people reply, "Yes, but it was all coal powered". But actually the first sparks down the line from Niagara in 1896 were for powering public transport – the trolley buses. It wasn't until several weeks later that it was powering lights. You used to be able to take an electric powered tram to the Giant's causeway in Ireland too.

Solar started around the same time Armstrong was messing about with early hydroelectricity. At the World Fair in Paris in 1878, Augustin Mouchot presented his printing press run on solar powered steam. A big funnel concentrated the sun that would heat water which would then turn into steam and turn a turbine that powered a printing press. Even on a cloudy day it would still manage to produce 500 copies an hour of a special magazine called *The Sun* (no relation to the modern British newspaper). The steam solar research was, at one point, even state funded and supported by Napoléon and Mouchot travelled to Algeria because there was more sunshine there (renewables, like fossil fuels, have a history tied to colonialism). But coal was too cheap and the project was cancelled, Mouchot returning to his old job as a maths teacher.

In the 1900s, another early solar entrepreneur, Frank Shuman, managed to build a solar thermal plant in his back garden. He used a liquid that had a lower boiling point than water, which meant it was more efficient. Shuman later took the project to Egypt, figuring the technology could be of use in parts of the world which had a lot of sun but not much easy access to coal. He received some good coverage in the press, but that project was stalled by World War I, and never really picked up again after that, perhaps because by this point oil pipelines were being built. There was renewed interest in solar thermal technology around the energy crisis in the 1970s though, with President Carter famously installing some panels on the White House roof.



In 1878, Augustin Mouchot constructed a printing press that ran on steam generated by a solar thermal collector. See https://commons.wikimedia.org/wiki/File:Mouchot1878x.jpg. Public domain, via Wikimedia Commons.

The first stages of what we call solar PV – photovoltaic cells – also dates back to the mid nineteenth century. Initially it came from a failed experiment to make better underwater cables for the telegraph network that was being built under the Atlantic. A scientist was experimenting with different materials and found selenium had a higher conductivity under sunlight and thought, "Well, that's no good on the bottom of the ocean but maybe someone else would be able to make better use of it." He wrote a paper about it in the 1870s which was picked up by a few others, but it was still years before any sort of efficient solar cell was made, by Bell Labs in the 1940s.

Again, at first this was accidental, a researcher called Russell Ohl was playing with some silicon samples and noticed one with a crack in it. But the research became the basis for the first silicon chip and the first silicon PV cells. As soon as Bell Labs presented their shiny new cells to the world, the military were excited about, and sent their head of energy research, Hans Ziegler (who'd come over from Germany after World War II with Werner von Braun). Ziegler was excited about all the different military uses of solar, and his team workshopped all the different possible things they could do with it. The realisation soon dawned that the only place that it would be really useful was in outer space. Conveniently, they were planning on launching a satellite, Vanguard One. The Americans lost the race to the Russians to get a satellite up for International Geophysical year in 1956, but when they did send one up, it was solar powered. In fact, it's still up there, the oldest bit of space junk, of human produced space rubbish, so maybe give it a wave next time you're using anything solar powered.

Dr Alice Bell *is the director of communications at the campaigning climate charity Possible, and author of the book Our Biggest Experiment.*

For more details of the SGR conference, including web-links to the videos and slide presentations, see p.40.

BP's Big Screen in Trafalgar Square, jaimelondonboy via Flickr

Lessons from the campaign to end big oil sponsorship of culture

In an edited version of **Jess Worth**'s presentation to SGR's Responsible Science conference, she reflects on the successes of, and obstacles to, the campaign to end fossil fuel sponsorship of art organisations and museums.

We need to transition rapidly away from fossil fuels, because climate science tells us that even just burning the remaining oil and gas reserves will take the world well beyond a dangerous 1.5°C temperature rise. However, oil and gas corporations have very effectively cultivated a 'social licence' that allows them to operate, to continue to drive up carbon emissions, and to lobby against effective emission control measures. That's why we've seen campaigns like fossil fuel divestment.

The aim of the Culture Unstained campaign is to work alongside the divestment campaigns, by challenging sponsorship by the oil companies of cultural activities – which are another way in which they boost their social license. Recent sponsorship deals have included:

- BP Big Screens, part of the Royal Opera House's activities;
- BP-sponsored 'blockbuster exhibitions' at the British Museum;
- The BP Portrait Awards, which has been running for over 30 years;
- Wonderlab, an interactive gallery for children at the Science Museum, sponsored by Equinor (formerly Statoil);

Most recently – in May 2021 – the Science Museum opened 'Our Future Planet', a new exhibition sponsored by Shell on technologies and other measures to remove carbon dioxide from the atmosphere.

But the campaign is really having an impact. The biggest recent success was the Royal Shakespeare Company ending its sponsorship with BP halfway through the contract, and actually giving the money back. Ever since 2016, when the Tate didn't renew its contract with BP, we've seen a lot of different cultural institutions end their relationships with oil and gas companies. The Edinburgh Science Festival was the first organisation that actually cited climate change and their responsibility as a scientific and educational organisation as the reasons to no longer accept money from Exxon and similar corporations.

The secrets of campaign success

Creativity and storytelling are powerful tools in the success of these campaigns. Activist theatre group 'BP or not BP', of which I am also part, performs in cultural spaces without permission and without warning. We take the space and we use it to talk about climate change and what oil companies are really doing, in order to catalyse conversation. We see our role as bringing debate on the actions society needs to take to prevent climate breakdown out of the science and policy spheres and into the cultural sphere – by meeting the public where they are, in cultural spaces and institutions.

We try to find campaign actions that are attention grabbing and innovative. For example, we used umbrellas to spell out the word 'NO' in the British Museum's Great Court. We try to use ways of communicating that aren't dry, but also aren't terrifying – that engage and have humour. For example, we smuggled the constituent parts of a 'BP Kraken' into the British Museum, along with some BP Pirates, when the company sponsored the Sunken Cities exhibition.

We also highlight connections to wider social justice issues, such as decolonisation and Black Lives Matter, tapping into debate within the museum sector on grappling with our colonial legacy.

Another lesson is to build coalitions beyond traditional campaigns. Oscar-winning actor Mark Rylance resigned as an Associate Artist with the Royal Shakespeare Company

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(RSC) with an impassioned article in *The Guardian*, receiving a huge amount of coverage at the time. This helped catalyse the decision by the RSC to move away from BP. Artist Gary Hume decided to speak out against BP sponsorship of the Portrait Awards on the day the awards were announced, even though he was one of the judges. He had had a moment of clarity having seen Extinction Rebellion protests, and realised he had a responsibility to talk about his concerns. He was then joined by a lot of prominent portrait painters and Turner Prize winners, as the artist community mobilised around him.

Egyptian author Ahdaf Soueif resigned as a British Museum trustee in 2019 with a heartfelt article in the *London Review of Books*, citing the museum's intransigency on BP sponsorship, but also their treatment of workers and the lack of engagement with their colonial legacy. Making links between all of these issues sent shockwaves through the museum sector, and Soueif's resignation was also supported by the British Museum branch of the PCS trade union. We then staged a 'BP Must Fall' protest, bringing a Trojan horse into the Museum forecourt, and the union branch put out a public statement supporting that too.

The link between external activism and internal advocacy has been a crucial dynamic, because activists can catalyse an internal or sector-wide conversation that might not have otherwise happened. It can make it possible for employees to have the internal conversations they want to have, but feel under a lot of pressure not to have. We work with people inside the sector to ensure that our framing of campaigns is helpful and not counter-productive.

Entrenched institutions

However, some of these institutions are still deeply entrenched with oil and gas corporations – not least, The Science Museum Group. It has had financial relationships with three large oil companies over the years, some stretching a long way back. As mentioned, Equinor sponsors Wonderlab, while Shell's current deal is the latest of several involving climate and environment exhibitions. The museum also partners with BP on STEM training for science teachers.

At Culture Unstained, we decided that we would put together a formal complaint to the Science Museum, focusing not just on these three companies' huge emissions but also their histories of disinformation on climate issues. We concluded that The Science Museum Group was breaking its own ethics policy through a lack of due diligence. The complaint was supported by an impressive list of nearly 50 scientists, including several from Scientists for Global Responsibility.[1]

How did the Science Museum respond? They completely brushed it off, and refused to engage. They didn't even give us the courtesy of a formal response, or engage with the substance of our complaint on any level. Even more than that, Ian Blatchford, the Director of The Science Museum Group, came out fighting, saying that even if the museum was lavishly publicly funded, he would still want to have sponsorship from oil companies. He wrote a letter to all staff responding to the controversy explaining that big oil and gas companies "have the capital, geography, people and logistics to find solutions [to climate change] and demonising them is seriously unproductive".[2]

This is a good example of some of the barriers to action on this issue. There are very entrenched corporate financial interests at the top of a lot of institutions that are often strongly out of step with the staff and the rest of the sector. But they hold the purse strings and the power.

We know there is a lot of discomfort among museum staff concerning oil industry sponsorship, but Blatchford's response to them was extremely forceful. He mentioned junior colleagues in his letter, ostensibly to reassure them, but I think this has left employees with very real concerns about job security if they speak out.

What needs to happen is for the scientific community to become collectively more outspoken, supporting staff who are under pressure to not rock the boat, but nevertheless are strongly opposed to the current situation.

The oil industry is in an existential crisis, at the beginnings of a death spiral. Corporations like BP, Shell and Equinor are desperately trying to rebrand themselves as leaders of the energy transition, so we have a really important role to play in debunking their spin, especially when it relates to geoengineering and carbon capture and storage. Their net zero rhetoric is breath-taking, and designed to obscure the fact that they are all still actively expanding oil and gas exploration and production – and planning to continue over the next few decades.

At the same time, the cultural sector is in an existential crisis due to the pandemic, which is heart-breaking. But big institutions shouldn't be trying to solve one problem, the problem of their financial instability, by fuelling another one, climate breakdown.

ACTION

The UK Climate Student Network and 350.org have called on people to boycott the Science Museum's 'Our Future Planet' exhibition over its sponsorship by Shell. To pledge your support, go to:

https://act.350.org/signup/boycott-science-museums-new-exhibition/

Jess Worth *is a Co-director of Culture Unstained. For more information on their campaigns, see: https://cultureunstained.org/*

For more details of the SGR conference, including web-links to the videos and slide presentations, see p.40.

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"Catastrophic moral failure" of vaccines not reaching the poorest

Andrew Simms, SGR, describes the UK's great aid betrayal, and the international moral failure of pandemic vaccines not reaching the world's poorest.

The international response to the coronavirus pandemic is not happening in a vacuum, but in the long shadow of unequal relationships between countries that have deep economic and political histories.

Nearly three decades ago in the early 1990s, sat at a desk in the anti-poverty charity Oxfam, I was writing a press release with the headline, 'Slashed, Cut, Forgotten.' It was part of a campaign against threatened cuts in the Budget to UK overseas aid which proved successful, but was playing out against the backdrop of an unjust rising debt crisis, unfair trade and human displacement due to multiple conflicts.

A target for wealth countries to allocate 0.7% of gross national income to overseas aid was set by the UN General Assembly in 1970 (compare this to the target set by NATO in 2014 for member countries to spend a minimum of 2% of GDP on the military). Back in the early '90s momentum was gathering through a series of UN conferences following the UN Earth Summit of 1992 for a set of new development goals to mark the approaching millennium, these 'millennium development goals' (MDGs) later morphed into the current 'sustainable development goals', or 'SDGs'. Behind all of them was the critical questioning of financing, and hence the important, though never straightforward question of aid spending. 'Aid' of course implies charity, when in fact this form of international redistribution might better be characterised as compensation for past and current injustices, engineered inequality and damage caused. The SDGs, which include health targets, always have and remain chronically underfunded.

Following massive civil society mobilisation against poor country debts and global poverty more generally the UK began meeting the 0.7% aid target in 2013, and in 2015 its commitment to it was made legally binding. In 2019 the Conservative party reaffirmed its commitment to keeping that level of spending in its general election manifesto. So it surprised many when in the 2020 spending review, the UK Chancellor, Rishi Sunak, announced that he was reneging on his party's legal and manifesto promises, triggering the resignation of a Foreign Office minister in protest.

The reality of these cuts emerged in early 2021 with aid to strife torn Yemen facing cuts of nearly half, and to Syria a cut of two thirds. South Sudan, Libya and Sudan also face major cuts.

Prime Minister, Boris Johnson, blamed the breaking of his manifesto promise on "current straitened circumstances."

Most global emergencies are what the international humanitarian community calls 'complex', often combining a mixture of conflict, economic and environmental instability, poverty and inequality. That could certainly be said of the countries facing sharp falls in UK aid. Not only do they suffer these and existing impacts from climate destabilisation, but with broken health services and displaced populations the conditions for the spread of coronavirus have worsened, and 'exacerbated crises' in the Middle East and Africa.

Sir Mark Lowcock, Under-Secretary-General at the Office for the Coordination of Humanitarian Affairs (OCHA), and former permanent secretary at the UK's Department For International Development (DFID), criticised the UK's decision as, "an act of medium and longer term self-harm, and all for saving what is actually – in the great scheme of things at the moment – a relatively small amount of money". He added, "The decision, in other words, to balance the books on the backs of the starving people of Yemen, has consequences not just for Yemenis now, but for the world in the long term." Lowcock previously also criticised Boris Johnson to the BBC for the UK's, "Policy inconsistency and incoherence between on one hand raising issues like climate change in the Security Council, which is a good thing to do, and on the other hand cutting back the things the UK is doing to tackle those issues."

Worse, this government's decision to cut aid is a purely political posture, and nothing to do with 'straitened' economic circumstances. Public spending, or rather in this case, potential investment in collective, international human security, is not a zero sum game. Government can, more or less, spend what ≫

it wants to, and in this case obliged itself to do so by law. As Richard Murphy, tax justice campaigner and Visiting Professor of Accounting at Sheffield University Management School explains, "Whenever the government wants to spend it can. Unlike all the rest of us it doesn't have to check whether there is money in the bank first. It knows that legally its own Bank of England must pay when told to do so. It cannot refuse. The law says so."

All this sets the scene for the current, self-defeating mismanagement of the pandemic response. A wave of almost existential relief met the initial roll-out of COVID-19 vaccines. For pharmaceutical companies, historically embroiled in a wide range of ethical and legal controversies, it must have felt like one of their finest moments. To judge by certain media coverage, it was understood as a pure, private sector victory. In a discussion about the failures of health outsourcing, on the flagship BBC Radio 4 Today Programme *(08/02/21)* it was put to the official opposition's Shadow Chancellor, the Labour Party's Rachel Reeves, that 'ownership' did not matter, because the vaccines were made by private companies. There was no mention, of course, that most scientists working for pharmaceutical companies would have been trained at publicly funded universities, that the companies made lucrative profits from public procurement contracts, or that repeated examples of drugs companies overcharging the NHS come to light.

Pfizer, praised for its vaccine work, for example was fined £84million by the Competition and Markets Authority (CMA) in 2016, one result of multiple such investigations. Another case the following year against Concordia highlighted £34 million of overcharging.

Pfizer escaped the fine on appeal, but left with the Appeal Court commenting on the "stark reality" that "literally overnight, Pfizer and Flynn (another pharmaceutical company in the case) increased their prices… by factors of between approximately 7 and 27, when they were in a dominant position in each of their markets." Critically, the CMA said as recently as March 2020, as the pandemic worsened, that it "continues to have serious concerns about the very big price increases imposed by certain drugs companies for several other generic drugs, which have cost the NHS hundreds of millions of pounds. The CMA remains committed to its work to robustly tackle any illegal behaviour by drug companies ripping off the NHS."

But an even larger, long-standing global issue overshadows recent geographical triumphs with the COVID-19 vaccine. It is a structural problem of global health that shows the degree to which private research interests, driven by the profit motive, distorts and undermines the care and treatment of the global majority.

As the British Medical Journal (BMJ) explained in a 2006 editorial, headlined, 'The Great Medicines Scandal', "The failure of pharmaceutical companies to invest in research and development of medicines for neglected diseases is long standing." Looking at new drugs developed over a 30 year period, it said that only 21 of 1556 were targeted at priority health threats in poorer countries such as malaria, tuberculosis, leishmaniasis and other key conditions. "Sick people in poor countries are deeply disadvantaged," said the BMJ, "The millions who have 'neglected' tropical diseases lack safe and effective drugs. Those afflicted with 'Western' diseases… can ill afford treatment." Western diseases usually refers to a range of illnesses, such as breast, prostate and colon cancers, and coronary heart disease.

Now, in the middle of the biggest global health crisis in living memory, the Global South is again being failed. Lack of access to essential treatments for COVID-19 mirrors the historic marginalisation of health services for poorer countries (not to mention worse health outcomes for poorer people in richer countries also being the norm).

According to the People's Vaccine Alliance, a campaign group including Amnesty International, Frontline AIDS, Global Justice Now, and Oxfam, nine out of ten people in 67 low income countries are highly unlikely to be vaccinated against COVID-19 during the whole of 2021. The reasons, according to the Alliance, are down to rich countries hoarding vaccines and drug developers being unwilling to share their intellectual property.

Rich countries representing only around one in seven of the world's population bought over half of the eight most promising vaccines. As of December 2020, the BMJ reported that "AstraZeneca-Oxford, Moderna, and Pfizer-BioNTech had received more than $5bn (£3.79bn; €4.13bn) of public funding in developing their vaccines." Campaigners for the Alliance called on the manufacturers to support World Health Organization's (WHO) COVID-19 technology access pool and share their intellectual property.

The head of the WHO, Tedros Adhanom Ghebreyesus, warned in January 2021 of the world being on the edge of a "catastrophic moral failure" as, at that point, only 25 individual doses of vaccine had been administered across all poorer countries, compared to 39 million doses given in rich countries.

In June 2020, at the Global Vaccine Summit, Gavi, a global alliance to provide access to vaccines to poor countries, underpinned by the WHO, UNICEF, the World Bank and foundations, launched the COVID-19 Vaccines Advance Market Commitment as the first step of creating the COVAX Facility. Its aim was to "make sure the most vulnerable in all countries can be protected in the short term, regardless of income level." But, judging by the conclusion of the WHO itself, it had failed to do so by early 2021.

One problem was that several wealthy countries hugely over-ordered vaccines. The US ordered double the amount needed for their whole population, the EU 2.7 times its population, the UK 3.6 times and Canada 5 times their respective populations. In an initiative that appeared like medical crumbs from the lavishly laid table of the wealthy, a February 2021 G7 meeting saw the proposal that 'surplus' vaccines held by rich nations would be distributed to poorer countries. However, it was reported that the, "decisions on when and how much of the surplus will be distributed will be made later" in the year.

Given what is known about the speed of virus transmission, and how quickly the virus is evolving, the attitude of rich nations appears still to be lethally complacent and counterproductive. If they do not wake up to the need for genuine, timely, support and cooperation at the scale needed to prevent uncontrolled suffering, something even worse could soon haunt the global community that none can hide from.

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A fully referenced version of this article can be found on the SGR website at: https://www.sgr.org.uk/resources/aid-betrayal-catastrophic-moral-failure-poorest-missing-vaccines

Brexit Britain's security policy: cutting aid to spend on weapons

A string of announcements over the past year have set out Britain's security and defence priorities in the wake of Brexit. These show an emphasis on high tech military equipment such as robotic and nuclear weapons, while the overseas aid budget is slashed and action on climate change remains inadequate. **Dr Stuart Parkinson**, SGR, assesses the situation.

In March, the UK government profoundly changed direction on nuclear weapons – revealing a decision to increase the size of Britain's nuclear weapons stockpile by 44%, ending 30 years of phased reductions since the end of the Cold War. This decision was part of the 'Integrated Review of Security, Defence, Development and Foreign Policy' [1] – many decisions from which had been released months earlier. Key among those was that funding for the military would increase by a total of £24bn over the coming four years.[2] Adjusting for inflation, this is an average rise of about 10% over the Ministry of Defence's budget for 2019/20 – and represents the largest increase since Britain's participation in the Korean War 70 years ago.[3] Conversely, it was also announced that the international aid budget would undergo a huge cut.[4] These spending decisions and policy changes were a shock to many – especially against the background of a healthcare system and a national economy in crisis due to the effects of the COVID-19 pandemic. To make matters worse, the government also decided that public sector pay would be either frozen or held to small increases because the nation could not afford it.

The focus of the MOD's spending increase is military equipment – with nuclear weapons just one of the systems set to benefit. So which technologies are favoured, and how will that influence science spending? How do these fit within the overall strategy of the UK's military policies following Brexit? And where does this leave policy and funding in other areas essential for global security, such as international development and climate change?

Military technology in the UK

Let's start by looking at the technologies. Details have been given in a Defence Paper published as part of the Integrated Review.[5] First priority for the new spending are the existing military equipment programmes that are running over-budget. The National Audit Office (NAO), a government spending watchdog, estimated that the MOD's budget shortfall in its equipment budget up until 2025 had been approximately £8.3bn before the new spending announcement (but could be significantly higher).[6] Since about £7.5bn of the £24bn increase had already been promised in the Conservative Party's 2019 election manifesto – and hence was included in the NAO's spending assessment – this means that at least two-thirds of the spending increase will be swallowed up just trying to keep current plans on track.

Of these plans, the largest is the submarines programme, which includes Britain's nuclear arsenal.[7] Central to this programme is the manufacture of the new nuclear-armed Dreadnoughts – four vessels which are scheduled to replace the Vanguards, which currently carry Trident nuclear missiles. The replacement is scheduled to begin in the early 2030s, with continuous deployment intended to continue until at least the 2060s. The March announcement means that the target level for the nuclear warhead stockpile in 2025 increases from 180 to 260.[8] This is a reversal of the previous policy which had led to continuous reductions in the stockpile since the end of the Cold War. Furthermore, the conditions under which the UK might use these weapons of mass destruction (WMDs) have been expanded to include threats from chemical or biological WMDs "or emerging technologies that could have a comparable impact".[9]

Condemnation of these profound policy changes has been widespread. Of particular note was the response from the UN Secretary General's spokesperson who stated that it breached the Nuclear Non-Proliferation Treaty (NPT) – by which the UK is legally bound.[10] It is also a challenge to the new UN Treaty for the Prohibition of Nuclear Weapons – which entered into force only in January and is supported by over 120 nations, but which the UK rejects.[11] As SGR has pointed out since 2008, launching the warheads carried by just one Trident »

submarine would be more than enough to cause a catastrophic 'nuclear winter' threatening human civilisation as we know it[12] – so it is no surprise that these weapons attract such widespread international opposition.

Another of the UK's major technology programmes is warships. With the two Queen Elizabeth class aircraft carriers – the largest ships in British naval history – now complete, construction of other warships is being ramped up. This is planned to include eight Type-26 and five Type-31 frigates – as well as developing new warships, the Type-32 and Fleet Solid Support ships. The intention is that a 'Carrier Strike Group' (CSG) will be "permanently available".[13] Regular deployment of such a group is planned for the seas around China and India as part of an 'Indo-Pacific tilt'[14] – very likely to fuel military tensions in the region. Indeed, the first deployment of the CSG began in May. This is in addition to the 20% of Royal Navy ships that are stationed in the Middle East at any one time.[15] These clearly illustrate a core intention of the Integrated Review – a major expansion of military capabilities to 'project force' far from the UK – instead of, for example, focusing on protecting national territory.

Another major area is combat planes. Again, the focus on expanding the offensive capabilities of the technology is clear. Not content with completing the deployment of the new long-range F-35 Lightning strike planes and expanding the number of Protectors – an armed drone with 'global reach' – the strategy is then to develop the Future Combat Air System (FCAS) intended to use artificial intelligence and drone technology "to defeat any adversary in air-to-air combat".[16] Planned spending on this project is £2bn over the next four years.[17]

The FCAS illustrates the critical role that the MOD sees for applying emerging technologies to a wide range of military applications. Other new initiatives include:[18]

- A 'National Cyber Force' whose mission is to "deceive, degrade, deny, disrupt, or destroy targets in and through cyberspace";
- A 'Defence Centre for Artificial Intelligence', carrying out R&D using AI for military purposes; and
- A 'Space Command' to "enhance the UK military command and control of the space domain" set up with funding of £1.4bn over 10 years. The first satellites are due to be launched in 2022.[19]

Underpinning the development of these new technologies is an extra £375 million a year aimed "to master the new technologies of warfare".[20] The wide range of research areas highlighted is especially concerning: space; cyber; quantum technologies; engineering biology; directed energy weapons; and advanced high-speed missiles.[21] The Integrated Review talks about the importance of the UK being a "Science and Tech Superpower" but the main area of extra government science spending seems to be military – with repeated references to opportunities that may be derived from 'dual-use' research which can be applied to both civilian and military applications.[22] Indeed, the new Advanced Research and Invention Agency (ARIA) – being set up with £800 million of public money to back 'breakthrough technologies' – has been inspired by the US military body, the Defence Advanced Research Projects Agency (DARPA).

The British military's rapidly growing interest in robotic warfare technologies also gives a clue as to why the government is currently opposing a new UN treaty on lethal autonomous weapons (LAWS). While it claims to object to such weapons, it argues that such a treaty may "stifle innovation" – a high risk position to take.[23]

When Boris Johnson announced the new military spending in November, he emphasised his intention for Britain to take a leading role in developing new military technologies.[24] He drew on science fiction imagery as he described British soldiers of the future being able to order "a swarm attack by drones" or "paralysing the enemy with cyber weapons", while "our warships and combat vehicles will carry 'directed energy weapons', destroying targets with inexhaustible lasers". This approach was strongly criticised by peace campaigners. For example, Kate Hudson of the Campaign for Nuclear Disarmament said, "by… boosting spending on military posturing and weapons systems, he will help increase global tensions and escalate the risk of a new arms race".[25]

The over-arching narrative of the Integrated Review is the promotion of a post-Brexit concept of 'Global Britain' – but central to this is the UK asserting itself as Western Europe's most heavily-armed nation, while championing NATO and the country's role within it. Deploying more forces to other parts of the world – whether it is the oil-rich Middle East, the Polish-Russian border, or off the coast of China – is seen as central to the concept.

Meanwhile – not mentioned in the main Integrated Review paper, but covered in the accompanying Defence paper[26] – is the fact that the UK continues to be one of the world's leading arms exporting nations. Official data – collated by Campaign Against Arms Trade – shows that the government approved export licenses for £5.1bn of military goods in 2019.[27] As SGR and our collaborators have discussed before,[28] this includes supplying Saudi Arabia with weapons which have been used to carry out war crimes in Yemen. Despite legal action to try to prevent such exports, the British government and arms corporations continue to dodge efforts to hold them to account.

Side-lining a broader approach to security: poverty and the climate crisis

The Integrated Review highlights the importance of measures that help tackle the roots of conflict – such as global poverty, climate change and other environmental degradation. Yet these have not fared as well in the government's spending plans.

Let's start by looking at the aid budget. As mentioned earlier, the government announced in November that spending on international development would be slashed. The annual budget will fall from 0.7% to 0.5% of gross national income.[29] Analysis by the Centre for Global Development (CGD) estimates that, in 2021, this will amount to a £4.5bn cut from the 2019 level – a 30% cut.[30] Some details of the cuts in the budgets for individual countries and programmes have so far been released[31,32] – and they show that many of the poorest nations will suffer the most. For example, Yemen is due to receive less than half the previous year's amount. The CGD analysis looks at the impacts of a range of cuts – for example, cuts in immunisation programmes could lead to as many as 100,000 extra deaths.[33]

When the Integrated Review itself was published in March, it stated, "we will return to our commitment to spend 0.7% of gross national income on development when the fiscal situation allows" – but gave no indication of when that might be.[34] Indeed, the reduced priority with which this government views overseas aid is exemplified by the decision, in mid-2020, to merge the Department for International Development (DFID) with the Foreign Office to form the Foreign, Commonwealth and Development Office (FCDO). The merger decision was widely criticised. For example, Richard Reeve, co-ordinator of the Rethinking Security network, stated that, "Tackling poverty and inequality are crucial steps in reducing insecurity

Figure 1.
UK Government spending, 2020-21 (£bn)

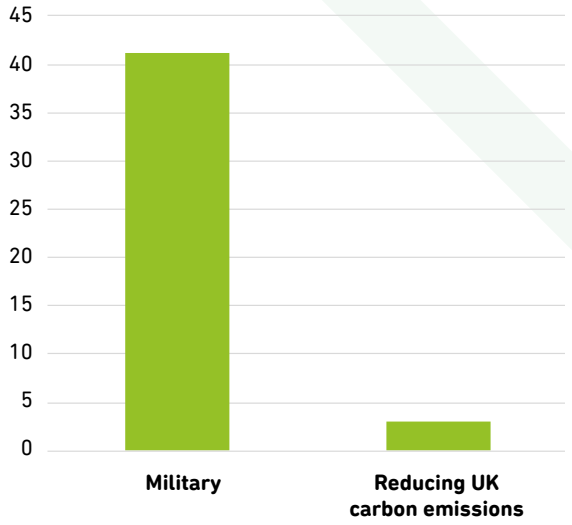
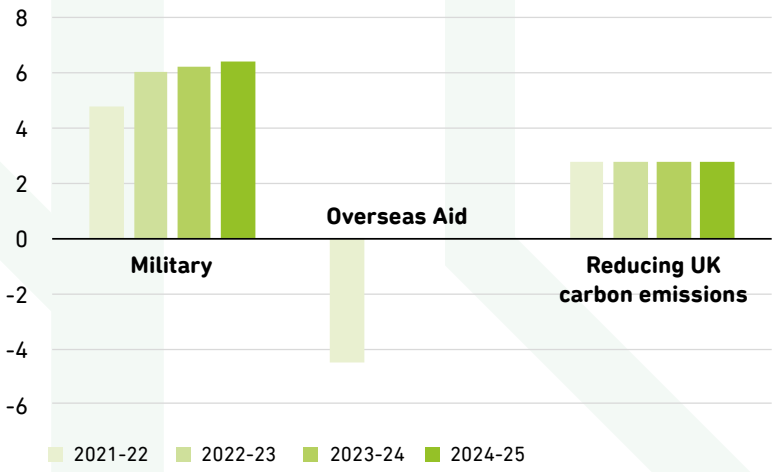


Figure 2.
UK Government spending changes relative to 2020-21 (£bn)



References for these figures are provided in the text.

and conflict. DFID has been world-leading in its focus on conflict prevention; its loss risks aid spending being diverted to narrowly defined security and trade objectives rather than global wellbeing."[35]

The growing climate crisis is another major source of global insecurity, with leading military figures regarding it as a 'threat multiplier'.[36] The government had already been planning to spend £2.9bn a year on international climate finance between 2021 and 2025 – and this at least seems to have survived the aid budget cuts.[37] On a domestic front, the autumn saw the release of a 'Ten point plan for a green industrial revolution' aimed at boosting the UK's efforts to reduce its own carbon emissions.[38] The headline figure for this plan was given as £12bn, but SGR analysis[39] of the document leads us to conclude there is a maximum of only £11bn during this parliament – so average annual spending of nearly £2.8bn, less than half the increase in the military budget. Closer examination of the plan also reveals that low-cost renewables such as onshore wind and solar photovoltaic farms are excluded, while more speculative and controversial technologies such as 'advanced nuclear' and carbon capture, utilisation and storage are to be given hundreds of millions of pounds. Furthermore, efforts to rapidly increase home insulation and domestic low carbon technologies via a 'Green Homes Grant' have already run into major problems with only 13% of a planned £1.5bn fund being spent during the 2020-21 financial year due to administrative problems.[40] The scheme has since been closed to new applicants.

In April, the UK parliament agreed a new legally-binding target of a 78% cut in carbon emissions by 2035 in line with recommendations by the Climate Change Committee (CCC).[41] However, Britain is not even on course to meet its 2025 target, so the CCC has urged the government to markedly increase domestic action.[42] Among its recommendations is that government spending on emissions reduction should increase very rapidly to between £9bn/y and £12bn/y – and that other (non-budget) measures are also needed to help switch or stimulate the rest of the UK economy to spend at least £40bn/y. This would require, for example, a doubling of the government spending planned for 2021–22. But note this is only to reach the net-zero carbon target by 2050. A growing number of climate scientists argue that we need to hit this target before 2035.

One further new UK climate strategy is worth noting here – that of the MOD.[43] However, this is severely undermined by a lack of emission reduction targets and the MOD's aim "to use the green transition to add to its capabilities".

Offensive insecurity v human security

In an in-depth SGR report published in 2013,[44] we revealed how UK research and development spending was used to help pursue a political agenda which prioritised military approaches to tackling security problems over approaches which sought to tackle the root causes of conflict. Indeed, we highlighted that, even within military R&D, technologies which had a capability for 'force projection' far from the UK were prioritised over more technologies more useful for defence of national territory. The report, we titled *Offensive Insecurity* to highlight the focus on aggressive military technologies while repeatedly underfunding efforts to tackle the root causes of conflict. Examining the spending commitments underlying the 'Global Britain' approach shows this militarisation agenda is being accelerated – despite claims that it is a balanced set of policies. One of the clearest examples is a comparison between the average annual government spending planned for the period 2021–25: for the military, it is £47bn; for reducing UK carbon emissions, it is only about £6bn (see Figures 1 and 2).[45]

A fundamental shift is needed – and this can be best exemplified by the 'human security' agenda. This is an approach championed by the United Nations which puts the wellbeing of the individual at the centre of security policy, and includes related concepts such as shared security and planetary security.[46] It defines three freedoms:

- Freedom from fear – including protection from violence and environmental crises;
- Freedom from want – including provision of decent food, healthcare, and housing;
- Freedom from indignity – including from human rights abuses.

Following this approach – rather than the traditional approach of 'national security' – the emphasis shifts from a military focus to a much broader one which prioritises, for example, spending on health, welfare and environmental protection. »

The jobs dimension

Prioritising human security would also have employment benefits for British workers. In announcements on the Integrated Review, Boris Johnson has highlighted jobs which will be created in the arms industry by the extra military spending – but these are actually much smaller in number than those which the government has estimated will be created by the extra (inadequate) spending on the 'Ten point' climate plan. For an extra £24bn of military spending, the government estimated 40,000 jobs would be created over four years.[47] Yet the much lower £11bn of government spending over the same period on the climate plan would create over 90,000 jobs in that sector, the government estimates.[48]

A more rigorous economic assessment needs to be carried out to compare the job creation potential of these different spending patterns, but previous academic analyses have shown that military spending creates significantly fewer jobs than most alternatives.[49]

A radical and ethical security review

The government's Integrated Review of Security, Defence, Development and Foreign Policy was widely trailed in the media as "the most radical reassessment of Britain's place in the world since the end of the Cold War". In reality, it mixes grand ethical aspirations with many of the most militaristic and aggressive elements of the UK's late twentieth century policies – such as 'Great Power' rivalry, technological arms racing, uncritical nationalism, and failure to give adequate help to the world's poorest. It then adds a new, high technology edge to them. Given over 125,000 British people have died in the COVID-19 pandemic, and the nation has one of the highest death rates from this disease in the world,[50] it is not hard to see how badly the government is failing to live up to its own rhetoric of protecting its citizens – let alone improving security elsewhere.

In early 2021, the Rethinking Security network[51] – of which SGR is a member – took the first steps in carrying out an 'Alternative Security Review' for the UK. This aims to do what the government failed to – follow a radical and ethical examination of the UK's approach to tackling security problems from the level of the individual to the international scale. Only approaches like these offer a chance for the UK – and other nations – to make the world a secure place.

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Nuclear weapons are now illegal

On 22nd January 2021, the Treaty on the Prohibition of Nuclear Weapons (TPNW) became part of international law. **Dr Philip Webber**, SGR, examines the implications of this new UN treaty.

When Donald Trump was US president, he withdrew the country from three major nuclear weapons treaties – the JCPOA (as known as the Iran nuclear deal), the Intermediate-range Nuclear Forces (INF) Treaty (leading to its dissolution), and the Open Skies Treaty. Although his record was particularly poor, very little progress has been made with numerous international nuclear agreements in recent years.[1] The purpose of the TPNW, agreed by 122 states at the United Nations in July 2017, is to definitively change this.[2] While, in a strict legal sense, the TPNW only applies to states that ratify or accede to it – i.e. join – the intention is to create a new international legal norm that all aspects of nuclear weapons are illegal because of their capacity to cause irreparable, catastrophic harm to people across the globe.[3] Before the TPNW, nuclear weapons had an almost protected status in international law. The treaty corrects this and puts them in the same 'taboo' class as chemical and biological weapons, along with anti-personnel mines.

For decades, the five original nuclear weapon states – Russia, the USA, China, France, and the UK (known as the P5) – and the newer nuclear states – India, Pakistan, Israel and North Korea – dominated and controlled discussions about nuclear weapons. Unsurprisingly, but hypocritically, they argued that they had unique security concerns for which they had to retain their nuclear weapons: these unique concerns simply being the other states with nuclear weapons. They also developed complicated legal justifications for their nuclear policies. For example, they variously argued that they did not intend to actually use their nuclear weapons or they would only hit military targets or they would just carry out a 'limited' strike. All these former justifications are swept away by the TPNW and a wealth of scientific evidence of immense nuclear harms, including key materials published by SGR and its predecessor organisations.[4] In response, Russia, the US, France and the UK actively coordinated their opposition to the TPNW, even at one point staging a protest outside of the UN chamber. It appeared to be clear that the only thing greater than the nuclear states' fear of nuclear annihilation was a fear that they would no longer be able to threaten it.

What difference will the TPNW make?

The nuclear states and their allies – a further 30 or so countries – mainly in NATO or the former Soviet bloc – argue that the TPNW does not apply to them. They haven't signed it. They also argue that the TPNW undermines the likelihood of progress towards disarmament under the Nuclear Non-Proliferation Treaty (NPT). In disarmament terms, the NPT has been undermined by the nuclear states for at least 25 years, so it is hard to take such arguments seriously. In reality, the TPNW text was carefully written to complement the NPT and, by setting out a clear path for disarmament for signatories, represents a substantive contribution to the nuclear disarmament clauses of the NPT.

At the time of writing, the TPNW has been ratified by 54 countries.[5] These include some of the world's most populous nations such as Nigeria, Bangladesh, Mexico, the Philippines, Vietnam and South Africa – as well as smaller industrialised nations including Ireland (now on the UN Security Council), Austria, and New Zealand, and Pacific islands states, some of which were victims of nuclear testing. The combined population of these countries has passed one billion people. Over 30 more countries have so far signed the treaty, including Brazil and the Democratic Republic of Congo. More are expected to join in due course. Roughly two thirds of all countries have expressed their opposition to nuclear weapons, by supporting the new treaty during UN negotiations and/or by being part of existing nuclear weapon-free zones.

The TPNW has already changed the ethical status of nuclear weapons within the international financial system. Following detailed research published in the 'Don't Bank on the Bomb' reports,[6] several large pension funds and other financial bodies have withdrawn investment from companies involved in the manufacture of nuclear weapons. The treaty bans all such support, and hence this is influencing the ethical investment screening in this sector.

A further effect is that some NATO countries, for example, Spain,[7] have started considering subtle changes to their stances on nuclear weapons policy.

The treaty is also re-invigorating civil society opposition to nuclear weapons. Many polls in European countries show increased support for the elimination of nuclear weapons – in particular, there is growing opposition to the continued deployment of US nuclear bombs on the continent. Over 400 cities have also declared their support for the treaty – including many in nuclear weapons states – for example: Barcelona, Paris, Berlin, Washington DC, Manchester, Edinburgh and Leeds. These cities are in turn pressing their national governments to sign up to the TPNW.

What next?

The TPNW should be seen as a step towards a safer world.

While the new US Biden Presidency will not recognise the TPNW, there are some signs of limited progress. For example, one of Biden's first actions in office was to agree with Russia to extend New START, the only treaty left limiting the numbers of nuclear weapons in these two most heavily-armed nations. There is also hope that the US will re-join the Iran nuclear deal and the Open Skies Treaty. The second impeachment of Trump has reminded ≫

the American people that he, like all other US presidents, had the sole authority to launch a nuclear strike, hence proposals to ensure that any such order would require multiple authorisation have been revived. In addition, a new bill has been introduced into the Senate proposing that the USA adopts a 'no first use' policy.[8] From the point of view of those desiring a world without nuclear weapons – to get rid of nuclear weapons before they get rid of us – requiring multiple permissions to destroy the world would represent very limited progress. But it would at least remove the possibility of a sole crazed leader initiating a nuclear strike.

Turning to the UK, PM Boris Johnson shocked opponents and allies alike in March when he unexpectedly announced an increase in the nation's nuclear weapons stockpile for the first time since the end of the Cold War.[9] The stockpile ceiling for 2025 is to be increased from 180 to 260 warheads – a staggering 44% rise.[10] This increase was widely condemned as breaching international law,[11] especially as it was accompanied by a broadening of the UK threat to use nuclear weapons to deter potential attacks by ill-defined non-nuclear "emerging technologies", including via cyber-space.[12] A UN spokesperson said Britain's actions were "contrary to its obligations under article six of the NPT and could have a damaging impact on global stability and efforts to pursue a world free of nuclear weapons".[13]

In contrast, there is a realistic prospect for change in nuclear weapons policy arising from the Scottish National Party (SNP). Not only are they completely opposed to Scotland's 'hosting' of UK nuclear weapons – at the Clyde Naval Base not that far from Glasgow – they currently form Scotland's government. Having been re-elected in May with a larger number of parliamentary seats, and opposition to hosting these weapons fuelling support for a referendum on independence in the near future, things could change significantly in the coming months and years.

The central problem, of course, remains the commitment of the governments of the nine nuclear weapons states to nuclear deterrence – and the consequent huge expenditures that all have recently allocated for nuclear 'modernisation', including new destabilising technologies such as hypersonic missiles, widespread satellite surveillance, and new nuclear 'fuses'. All of these seriously undermine the NPT, let alone the TPNW.

Nevertheless, the entry into force of the TPNW opens a new phase in the history of nuclear weapons, offering a more hopeful path for the future. It came about through concerted campaigning by civil society – especially the International Campaign for the Abolition of Nuclear Weapons (ICAN), highly deserving of its award of the Nobel Peace Prize – and will continue to focus minds on a more international perspective and away from dominance by the nuclear powers. There are already majorities across both governments and civil society which recoil from the dangerous doctrine of nuclear deterrence – the idea that security can be achieved by endlessly threatening annihilation despite the possibility of human or machine failure – and accept that real security can only be gained through cooperation and compromise. Common, real, human, security.

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Are UK universities being drawn into developing autonomous weapons?

The UK government refuses to support a treaty to regulate lethal autonomous weapons systems, preferring instead to expand military R&D, including at universities. But, argues **Leyla Manthorpe Rizatepe**, these same universities could become a further focus of protest.

Since 2012, the Campaign to Stop Killer Robots has advocated the pre-emptive ban on the development, production and use of lethal autonomous weapons systems (LAWS). Persuasive moral, ethical, security, legal, and technological concerns have seen the Campaign gather widespread support, including from Scientists for Global Responsibility. The global coalition comprises over 140 non-governmental organisations. In addition, 30 countries, as well as the Non-Aligned Movement, have declared their support for a legally binding instrument to regulate LAWS, and over 4500 experts in artificial intelligence (AI) and robotics have called for a treaty to prohibit LAWS.[1] Even UN Secretary-General Antonio Guterres has described LAWS as 'morally repugnant and politically unacceptable'.[2]

The UK's obstruction of an international ban on LAWS

Despite evidence of growing global consensus, action at the international level is underwhelming. The Group of Governmental Experts at the UN Convention on Certain Conventional Weapons (CCW) affirmed 11 guiding principles on LAWS, which led to discussion of the development of a 'normative and operational framework' for LAWS. This may look like progress, but the principles were only intended to guide deliberations and not to carry legal force, while talk of a framework is intentionally vague and falls far short of the concrete legal regulation which is urgently required.

The UK is one of a handful of states standing staunchly in the path of an effective treaty ban on LAWS.[3] The UK Campaign has been especially disappointed with the UK government's half-hearted support for any kind of regulation of automated weapons. In 2019, Boris Johnson pledged at the UN General Assembly that the UK would be a 'global leader' in setting standards to guide the development of emerging military technologies. But, as with so many of our PM's grand public statements, the reality of the UK's position is far less impressive. During that year's discussions at the CCW, UK representatives denied the need for concrete legal regulation, and repeatedly asserted that a new legal framework is neither necessary nor desirable. Existing regulations in international law, however, were drafted many years ago by officials who could not have envisaged weapons systems with full autonomy. This makes these provisions ill-suited to govern LAWS. The Campaign maintains that a treaty is necessary to stipulate certain obligations (such as setting minimum standards for equipment reliability) in addition to a prohibition on development, production, acquisition and use, in order to maintain meaningful human control over the deployment of lethal force. Furthermore, once an international agreement is presented in the form of a treaty, significant stigma attaches to parties who breach its terms, providing another reason why this new legal framework *is* desirable.

In response to a letter written by the UK Campaign in late 2020, the Ministry of Defence suggested that autonomous weapons systems should be embraced in order to 'support compliance with International Humanitarian Law', and claimed that it would be 'counterproductive' to introduce a 'legally binding instrument which hampers the legitimate development and use of such technologies'. Such arguments present a false dichotomy between the virtues of compliance with IHL and scientific advancement on one hand, and against a legally binding instrument on the other. The MOD apparently fails to recognise that it is possible to have a well-drafted treaty which would prohibit unacceptable uses of AI and autonomous robotics, while permitting those technological developments which are permissible under IHL (such as the use of autonomous systems to perform dangerous tasks like disposing of explosives). Arguments such as these suggest that the UK government is making excuses for its continued investment in autonomous technologies. Most likely, the real reason for the UK's continued opposition to binding legal regulation of LAWS is that they fear falling behind in an arms race for these weapons. Few states currently have the resources to conduct the research necessary to develop the component code and robotics that would ultimately be used in LAWS, and states like the UK must fear giving up that advantage.

A robot army for the UK?

The UK's pursuit of autonomous weapons was evidenced in November 2020 in the Chief of Defence Staff's comments that the UK will 'absolutely' avail itself of autonomous systems, and that in the near future 'we could have an army of 120,000, of which 30,000 might be robots'.[4] Autonomy is indeed a priority for the MOD, and their pursuit of AI and machine-learning technology to facilitate autonomous weapons is extensive. The MOD runs an Autonomy programme which seeks to enable 'next generation autonomous military systems'.[5] As part of this, its research arm, the Defence Science and Technology Laboratory (DSTL) often uses its Defence and Security Accelerator (DASA) programme to hold competitions for awards of contracts for certain projects to private arms companies. In March 2020, HORIBA MIRA and QinetiQ were awarded contracts to develop a fleet of autonomous ground vehicles.[6] These awards were described as 'a demonstration of the continued commitment to progressing autonomous systems as innovative approaches for developing future Land force logistic capability' by the DSTL's Autonomy lead, illustrating the DSTL's earnest attitude to developing autonomous weapons. In January 2021, the DSTL unveiled its latest progressions towards autonomous systems: managing a swarm of 20 unmanned drones of different sizes and operations capabilities,[7] and its award of a contract to Northern Ireland's Spirit AeroSystems to design and manufacture a prototype of the UK's first uncrewed fighter aircraft.[8] Then, in March, the government launched its 'Integrated Review of Security, Defence, Development and Foreign Policy', confirming

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» the central role it sees for robotics and artificial intelligence in UK military policy (see Stuart Parkinson's article on p.27).

The rapid, determined development of technologies with autonomous capabilities beckons an era of fully autonomous weapons. While fully autonomous lethal weapons do not yet exist, clear regulation is needed *now* to ensure that humans retain meaningful control of decisions to deploy lethal force. Convincing the UK government to change its position, and support the introduction of a Treaty, will require considerable pressure from influential actors. One source of such pressure could be UK universities.

UK university involvement in military AI and robotics research

Universities play a key role in the government's and MOD's pursuit of autonomous systems. Academics and university research departments often team up with private arms companies to work on DSTL projects. The DSTL funds an Autonomous Systems Underpinning Research (ASUR) programme, led by BAE Systems with support from universities including Cranfield and Loughborough, while the industry team for the swarming project referred to above included Durham University. Imperial College London provides a hub for DASA, to promote 'collaborative working between the Government, academia and the private sector'.[9] More evidence of collaboration between academia, government and industry in this field is GCHQ's strategic partnership with the Alan Turing Institute, the UK's institute for data science and AI, which was established by five UK universities (Oxford, Cambridge, Edinburgh, Warwick and University College London). The Institute's activities include a 'defence and security' programme, with one project pursuing large-scale coordination of autonomous swarm robotics.

Furthermore, individual universities often receive substantial funding for research projects from private arms companies. While it can sometimes be hard to deduce the full contribution to autonomous systems that a project may have from its title alone, a freedom of information (FOI) request submitted to Oxford University in late 2020 did reveal that its Engineering Department had received £129,000 from Rolls-Royce for Project TEMPEST. This is being conducted in conjunction with the RAF, BAE Systems, Leonardo and MBDA and which is designed to support 'scalable autonomy'.[10] Looking at the bigger picture, further FOI data revealed that Oxford has received over £6 million from Rolls-Royce since 2016, and over £6 million from the DSTL in the three financial years from 2016. Over the past decade the university has received well over £100 million in total from the DSTL and private companies with a prominent arms-focus, including Rolls-Royce, Lockheed Martin, Airbus, QinetiQ, BAE Systems, and Thales. Even if only a tiny proportion of these sums were used for projects relevant to autonomy or LAWS, the figures demonstrate that the military and private companies rely heavily on academic institutions to conduct research.

University campaigning

The importance of universities in pursuing the MOD's autonomy agenda was the impetus for the launch of the University Stream of the UK Campaign to Stop Killer Robots in September 2020. Initially, Amnesty International and Pugwash student groups at 13 UK universities with identifiable links to the MOD and private arms companies took part, and in January 2021 the campaign was extended to all UK universities where there are active student groups. Students seek to challenge their universities on their funding sources and research projects, with the aim of establishing university-wide policies demanding transparency and ethical consideration of permissible research outputs.

UK universities could take inspiration from 'Civil Clauses' signed by 20 German universities since 1986 in which they promise to conduct only civilian research, or similar no-military-research policies adopted by some Japanese universities. A more targeted approach would be to seek contractual guarantees from those funding certain projects specifying that the research conducted by the university must not be used for LAWS. This would likely be easier to achieve than a complete ban on the receipt of funding from military interests, but would nevertheless be an important step – and could be used as a stepping stone to broader ethical goals.

Representatives of the UK universities campaign also form part of the Global Campaign's Youth Network – an important and powerful voice alongside the diplomats, NGOs and scientists who have already featured prominently in the campaign.

Universities have long been sites of activism and protest, and their unique position in this campaign gives them potential to send a strong message to the UK government to reconsider its support for a legally binding treaty.

ACTION

If you're studying or working at a university and want to help with the Campaign:

- Ask your department to sign the Future of Life Institute's Lethal Autonomous Weapons Pledge[11] or Open Letter.[12]
- Get in touch with the Amnesty International Society on your campus, if there is one, to see if they are already campaigning on this issue. You can explore Amnesty UK's Stop Killer Robots Activism Toolkit at: https://www.amnesty.org.uk/files/2020-08/Stop%20Killer%20Robots%20Activism%20Toolkit.pdf?xPcBuAZX_UoV_XSsYKOQ_gkjh_luRDep=
- Contact Maiara Folly, the UK Coordinator for the Campaign to Stop Killer Robots, at robotsuk@una.org.uk
- Visit https://www.stopkillerrobots.org/ for more information.

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UK space ports: supporting the further militarisation of space

Prof David Webb, Leeds Beckett University, examines the links between the UK's military and civilian space sectors.

The huge increase in the UK military budget – see Stuart Parkinson's article (p.27) – includes £1.4bn over ten years to set up a British Space Command. The aim of this body is "to enhance the UK military command and control of the space domain, assist in coordination of commercial space operation and lead the development of new space-based capability".[1,2]

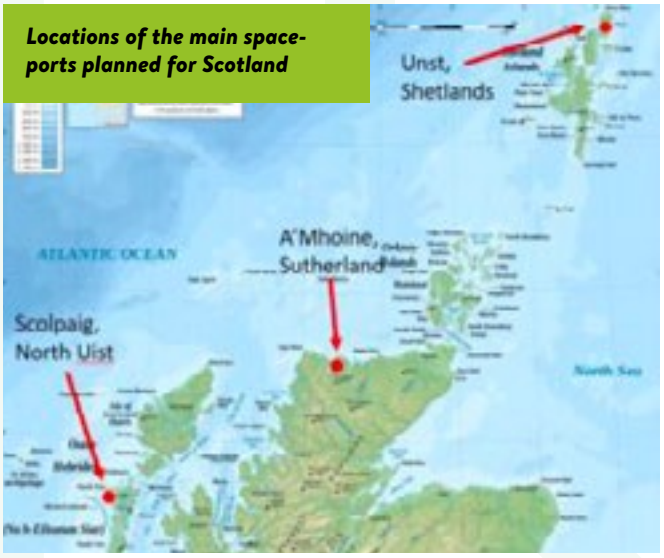
In 2019, the Ministry of Defence (MOD) announced a £30 million military space programme supported by a team working closely with the USA, to launch a small satellite demonstrator which would beam high-resolution video directly into the cockpit of fighter jets. Miniature satellites are relatively cheap to produce, launch and place in Low Earth Orbit and are being increasingly deployed for commercial and military purposes. Government grants totalling nearly £40 million have been awarded to enable the launch of small satellites from UK spaceports, and the government has paid Lockheed Martin – the world's largest arms corporation – £23.5 million to identify suitable UK spaceport locations. Scotland is well positioned geographically for the launch of satellites into orbits suitable for communications and earth-observations and rockets are planned to be launched from there by 2022. The Edinburgh-based Skyrora Ltd carried out the first successful test launch of its Skylark nano-rocket from the Scottish Highlands in June 2018 and is keen to become the go-to UK launch company.

The UK is also focussing on the production of miniature satellites through *Surrey Satellite Technology Limited* (SSTL). Elon Musk's *SpaceX* company bought a 10% share in SSTL in 2005 and the European Aeronautic Defence and Space Company (now Airbus) acquired another 80% in 2008. SSTL has since captured 40% of the global small satellite market and received over £4 million from the MOD to develop a small, low-orbit satellite called Carbonite 2, which was launched in 2018 to provide high-resolution reconnaissance.

Space is now big business and seen by the government as one potential path to recovery from the economic havoc caused by COVID-19. Forecasts suggest it could be worth over $1 trillion by 2040 and the UK aims to capture 10% of the market by 2030. A consortium of Local Enterprise Partnerships which bring together local authorities, academic institutions, research groups and businesses are establishing several regional space-hubs around the UK to ensure that space is a priority for regional economic growth. Among them is 'AstroAgency' which operates across Scotland on behalf of the Scottish Space Leadership Council.

Lockheed-Martin has chosen Unst – one of the Shetland islands – to develop its own Shetland Space Centre (SSC) for vertical launch operations. Situated at a high latitude, Unst is well placed for launching satellites into polar orbits – often used for reconnaissance, weather, or communications satellites. There are plans for other spaceports in Scotland (see map) – on the A'Mhoine Peninsula in Sutherland County in the Highlands and on an island in the Outer Hebrides, along with two others from which to conduct plane-based horizontal launches – at Prestwick

Locations of the main space-ports planned for Scotland



and Argyll. All of these spaceports have joined together under the Scottish Space Leadership Council to form the Spaceports Alliance and others planned for Cornwall and Wales look likely to become members in the near future.

The Scottish spaceports are promoted by Highlands and Islands Enterprise (HIE) and the UK Space Agency (UKSA) and welcomed by the Scottish Minister for Trade, Investment and Innovation. But there has been opposition from environmental groups, heritage bodies and local residents, so these plans are still not settled.

Space activities are usually presented to the public as having significant commercial value and the promise of new jobs, but the military dark side is always present. Space operations are often useful to both commercial and military sectors and UKSpace, the trade association of the British space industry, works closely with the RAF through the Commercial Integration Cell at the MOD's Space Operations Centre (SpOC). A similar set up in the USA sees the Space Force and the Combined Space Operations Centre at Vandenburg Air Force Base working to improve interoperability between member nations of Operation Olympic Defender (OOD). OOD was established to build international partnerships to 'deter adversaries and hostile acts in space' and the UK was the first to join in 2019. The UK is also the first to gain access to the US Standardized Astrodynamics Algorithm Library (SAAL) which contains information to help predict the locations and trajectories of satellites and objects in orbit. Access to SAAL enables the streamlining of multinational military operations across the globe and will also increase the ability of the SpOC to collaborate and share data with the US Space Force.

So, the UK is now well on the way to being directly involved in US plans for space domination.

***David Webb** is Emeritus Professor of Engineering at Leeds Beckett University, Chair of the Campaign for Nuclear Disarmament, and a Director of Global Network Against Weapons and Nuclear Power in Space.*[3]

References, further reading and campaign groups

1 Overarching details of the UK military's space activities are given in: MOD (2021). Defence in a competitive age. Defence paper. March. https://www.gov.uk/government/publications/defence-in-a-competitive-age

2 Further analysis of the issues covered in this article (including references) is given in: Webb D (2021). No Space for Peace in the Integrated Security Review. Yorkshire CND. May. https://yorkshirecnd.org.uk/no-space-for-peace-in-the-integrated-security-review/

3 http://space4peace.org/

Out of thin air: from gas boiler to heat pump

Following an installation in her home, **Wiebina Heesterman** explains how heat pumps – set to be an important alternative to fossil gas for home heating – actually work.

This paper owes as much to personal experience as to technical literature. The day that the Centre for Alternative Technology (CAT) newsletter captioned 'Heat pumps: their role in our zero carbon future' fell through the letterbox, *The Guardian* contained an article about the technology: 'West Midlands canals to help heat hospitals in renewable energy drive'.[1] Then our boiler started to behave erratically. Should we invest in a heat pump ourselves? I was reading up on the background when COVID-19 struck – not an ideal time to have a major appliance installed.

There are claims that adoption of heat pump technology might help result in a zero carbon economy. With the UK pledged to ban gas heating in new-build homes by 2025,[2] there have been alternative calls for the conversion of gas appliances to hydrogen. Some wonder whether this might be due to lobbying by fossil fuel companies rather than hydrogen's allegedly clean, green character.[3] Heat pumps could be a better solution for space heating and hot water supply in temperate zones. But how do they work?

These pumps transfer heat from one area to another and are based on the fact that compressing a gas heats it, while an expanding gas cools. There are three types, depending on where the heat is drawn from – air-, ground- and water-source heat pumps. Ground- and water-source pumps are regarded as more effective than air-source pumps. However, the installation of a ground-source heat pump entails major disruption – weeks rather than days. Without a source of water at hand, our only realistic choice was an air-to-water heat pump, even if that meant replacing a number of radiators.

Heat pumps circulate a refrigerant – a chemical that needs only a small amount of energy to change from a liquid into a gas[4] – through an evaporator, a compressor, a condenser and an expansion valve. The fluid changes temperature and pressure as it travels. Depending on the refrigerant's boiling point, it may start its journey as a liquid as cold as -30°C, becoming a cool, low-pressure gas when a fan (see photo) inside the collector/evaporator blows slightly warmer external air towards it. Next, either outside or inside the building depending on the system, the gas is subjected to compression, creating high pressure and warmer temperatures. A condenser containing a number of heat exchanger coils transfers the refrigerant's new heat to the building's heating system.[5,6] The heat may be delivered in the form of hot air, via under-floor heating. Perhaps more common is the 'air-to-water' system like ours, with hot water delivered from the tap as well as flowing through radiators. Finally, an expansion valve returns the refrigerant to its original temperature and pressure so that it's a cold liquid and ready for the process to begin again. Pumping the refrigerant around the system requires electricity, which should ideally be from renewable sources. In any case, running a heat pump uses far less electrical energy than heating a house straight from the socket.

Heat pump working properly at below 0°C

Ground- and water-source heat pumps use the same principles but the evaporation and compression of the refrigerant magnify heat contained in the soil or water rather than in air. A ground-source pump's collector unit sits in a pit dug into the soil, with its coils looping around at a shallow depth inside an extensive collection area, possibly a hundred square metres or so. An alternative is to dig one or more collection probes vertically a hundred metres deep. For water-source heat pumps, the collecting coils are laid out in circles on top of the water, then pressed down. The collector/evaporator usually sits in a pit on the shore.

Hot water tank and associated units

The installation of our heat pump took place in late August 2020, when COVID-19 appeared to be in abeyance. A patch of concrete a metre from the kitchen wall provided a firm, horizontal surface for the pump unit. We are entitled to a seven-year pay-out from the Renewable Heat Incentive (RHI). The first £300+ instalment appeared in February, to be followed by quarterly instalments for the next six and a half years. Since we are on a renewable energy tariff, we have hot water and a warm house carbon-free all year round – and we can still use the airing cupboard to dry washing and propagate seedlings.

Wiebina Heesterman *is a Dutch national and co-author of* Rediscovering Sustainability: Economics of the Finite Earth. *She holds a PhD in Law/Human Rights, an MSc in IT and a BA Lib.*

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2 Ideal Home (2021). Your boiler could be extinct by 2025. 22 January. https://www.idealhome.co.uk/news/gas-boiler-ban-223229

3 Vaughan, A. (2021). Hope or Hype? *New Scientist*. 6 February. pp.45-49.

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5 Evergreen Energy (undated). What is a heat pump condenser? What do they do? https://www.evergreenenergy.co.uk/heat-pumps/what-is-a-heat-pump-condenser-what-does-it-do/

6 Davies, T. (undated). Notes on compression refrigeration. University of Exeter. https://people.exeter.ac.uk/TWDavies/energy_conversion/notes%20on%20refrigeration.pdf

OBITUARIES

Dr Frank Barnaby, 1927–2020

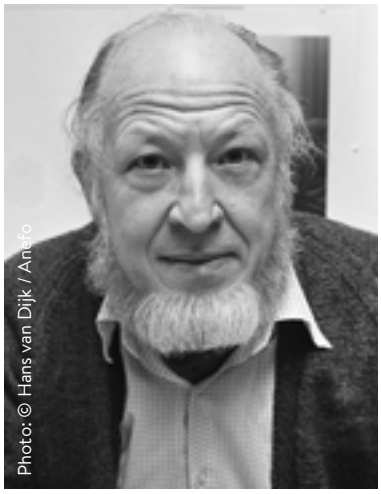
Photo: © Hans van Dijk / Anefo

Dr Frank Barnaby, leading nuclear scientist, peace campaigner and member of SGR, has died aged 92.

Dr Barnaby was "one of the most effective critics of the nuclear arms race" during the Cold War and afterwards,[1] publishing numerous articles, reports and books, and holding senior positions in international peace organisations and academia. He helped SGR on multiple occasions, including speaking at our annual conference.

Born in Hampshire, he was conscripted into the RAF, before leaving to undertake a science degree and then a doctorate in nuclear physics at the University of London. From there he went to work at the Atomic Weapons Research Establishment (now AWE) at Aldermaston in Berkshire.

He quit Aldermaston in 1957, becoming a lecturer at University College London. He also joined the Pugwash Conference on Science and World Affairs, which facilitated contact between scientists on both sides of the Iron Curtain and helped in the creation of several nuclear arms control treaties. He became its Executive Secretary in 1967. For a decade from 1971, he was director of the influential Stockholm International Peace Research Institute, writing numerous articles and reports on the growing threat from nuclear weapons and their proliferation. He then became professor of peace studies at the Free University of Amsterdam until 1985, including warning of the increased dangers of US deployment of cruise missiles in Europe. Following this, he became a visiting professor at the University of Minnesota and a consultant to the think-tank, the Oxford Research Group. His work expanded to warn of the risks of nuclear terrorism and links between the military and civilian uses of nuclear technology.

In 1986 he authenticated a *Sunday Times* article based on revelations by a technician, Mordechai Vanunu, that Israel had a secret nuclear weapons programme – and testified a year later at Vanunu's trial in Israel. Four years later he flew to Columbia to assist in the decommissioning of weapons by an insurgent group.

Dr Barnaby worked with SGR on several occasions. In 2003, he spoke at our conference *Nuclear Weapons – Issues for UK Policy*[2] highlighting, for example, the catastrophic consequences should a plane crash into the radioactive waste storage facilities at Sellafield in Cumbria – something of particular concern following the 9/11 terrorist attacks. In 2007, he authored a front-page article in the *SGR Newsletter*,[3] examining the potential for Iran to divert its nuclear power programme to weapons production. He skilfully argued how diplomacy offered a way out of the problem – something that came to fruition with the agreement of the 2015 Iran nuclear deal (although Donald Trump's subsequent rejection of the deal has considerably undermined this progress). Dr Barnaby also helped SGR lobby the Royal Society to try to take a more critical stance on nuclear power (something which they continue to resist).

In my dealings with Frank, I found him to be extremely knowledgeable and helpful, and we like many others will miss both him and his expertise.

Stuart Parkinson

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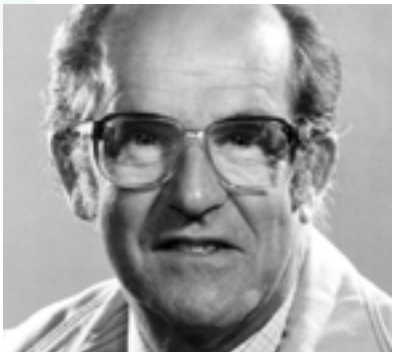
2 https://www.sgr.org.uk/events/nuclear-weapons-issues-uk-policy
3 https://www.sgr.org.uk/resources/iran-s-nuclear-strategy-civil-or-military

Professor John F. Nye FRS, 1923-2019



Professor John Nye FRS was a patron of Scientists for Global Responsibility from its foundation in 1992 until his death, shortly before his 96th birthday in 2019.

Dr Nye was my tutor in the second year when I was an undergraduate in the physics department of Bristol University, 50 years ago. He struck my then 20-year-old self as a serious, rather reserved yet kindly man, possessing great knowledge. I do remember when he quizzed me on why I had missed one of his tutorials, and I replied that it was the result of a hangover, he seemed aghast and asked me to let him know in advance if I ever was not going to attend any in the future. I didn't miss another!

John Nye was born in Hove in 1923. He won a scholarship to Kings College Cambridge, gained his PhD in 1948 and was subsequently invited to take on a demonstrator role. He then travelled to the USA and worked at Bell Telephone Laboratories. In 1953 he came back to the UK to join the physics department of Bristol University, where he was to be involved for 66 years up until his death, latterly as an emeritus professor.

His first major scientific contribution was concerned with dislocations in crystals. This work gave birth to his book *Physical properties of crystals: their representation by tensors and matrices*. He then developed an interest in glaciology, applying his skills to modelling glaciers. He built on the work of John Glen so as to generalise the latter's eponymous law. His work enabled greater understanding, leading to being better able to predict the

≫

trajectory and speed of glacial flows. He was not just desk-bound however as he was also active on field trips to remote places all over the world.

His research interests in waves began as a result of measurements of the thickness of glaciers by radio echo sounding. The returning pulse had interesting characteristics, due to the roughness of the rock surface a long way below. He noticed the changes in waveform could have characteristics reminiscent of dislocations within crystals. His interest and research in the field of waves carried on until the time of his death. Along the way he wrote the book *Natural focusing and fine structure of light: caustics and wave dislocations*. He published a technical paper on the theme of electromagnetic waves in his last year of life.

In his obituary from the Royal Society, written by his Bristol colleague Prof Sir Michael Berry FRS, it mentions his ready willingness to help scientists in difficulties. It recounts the visit he and Bristol colleague John Ziman FRS (also an SGR patron) made in the 1980s to speak at seminars in the small flats of scientists who had fallen from favour with the Soviet authorities and who were thus very limited in their ability to participate in science.

Paul Marchant

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Prof John Nye: Royal Society obituary: https://royalsocietypublishing.org/doi/10.1098/rsbm.2020.0002

Bristol University obituary: http://www.bristol.ac.uk/news/2019/march/john-nye.html

Letters

Child-bearing and carbon footprints

In response to the article 'Are scientists walking the talk on the climate emergency?' *(Responsible Science, no.2)* while I applaud the motives of those who think going child-free will help, I wonder if this is actually the case. It is a small proportion of the total population who are highly intelligent conscientious scientists and this generation is fortunate to have them as leaders, but where will succeeding generations source such a resource if it is deliberately reduced? Is it assumed that they will automatically arise from the less talented majority? In these days of universal free education, surely most potential talent is already able to operate, though no doubt improvements in the supply could be made. It is recognised that scientific ability is usually inherited and possibly so is conscientiousness. (Has any research been done into this?) Perhaps this noble gesture needs to be re-considered.

Dorothy Woolley

Speaking out on climate change

Kevin Anderson said in his interview in *Responsible Science, no.2*, that some colleagues in the climate field compromise their integrity to conform to what is politically palatable. He accused them of self-deception and deceit. But one could argue that such deliberate misrepresentation in science is more normally called fraud.

Meanwhile, in 'Global heating and climate breakdown' *(RS, no.2)*, Bill McGuire draws attention to the 'incomplete picture' of climate change given by the IPCC. That the IPCC should have inherent bias and be susceptible to political lobbying is unsurprising, but that some researchers should take their lead from so compromised an authority is a different matter altogether, and similar to the point made by Kevin Anderson.

Pragmatism and concealment are common within politics, and are no doubt present at the interface of science and policy. But science and other systematic scholarship is antithetical to politics. For reputable practitioners there is no such thing as scholarship influenced by vested interest; or as Kevin Anderson puts it, if the scientific community censors what it says then it isn't the scientific community.

Non-scientists have often accused scientists of navigating a safe passage between the constraints of physical evidence on the one hand and their personal interests on the other. But it is less common and more telling for prominent scientists to accuse immediate colleagues of 'massaging assumptions'. Yet instead of the condemnation one might have expected, Kevin Anderson refers to deception that is often well meant and sycophancy that is well-intentioned. If even senior academics widely admired for being outspoken feel obliged to offer excuses for what amounts to a major reason for climate change inaction, then something is wrong.

Jared Diamond in his latest book, *Upheaval*, pointed out that the preconditions for transformative change are to openly acknowledge the need for it, then to make an honest appraisal of what needs to be done. Self-deception and deceit, particularly among academics, explicitly prevents that. We rely on their clear sight and plain speaking. And of all those in the world who can speak plainly and be taken seriously, Kevin Anderson and Bill McGuire are among the foremost.

Dr Philip Wilson

Entangled life: How fungi make our worlds, change our minds and shape our futures

Merlin Sheldrake, Bodley Head, 2020,
ISBN: 9781847925190, 368 pages

Review by Wiebina Heesterman

Reading this book's subtitle, one's first thought is how pretentious and earth-shaking such a claim is. Surely something growing out of sight beneath our feet could never be that powerful?

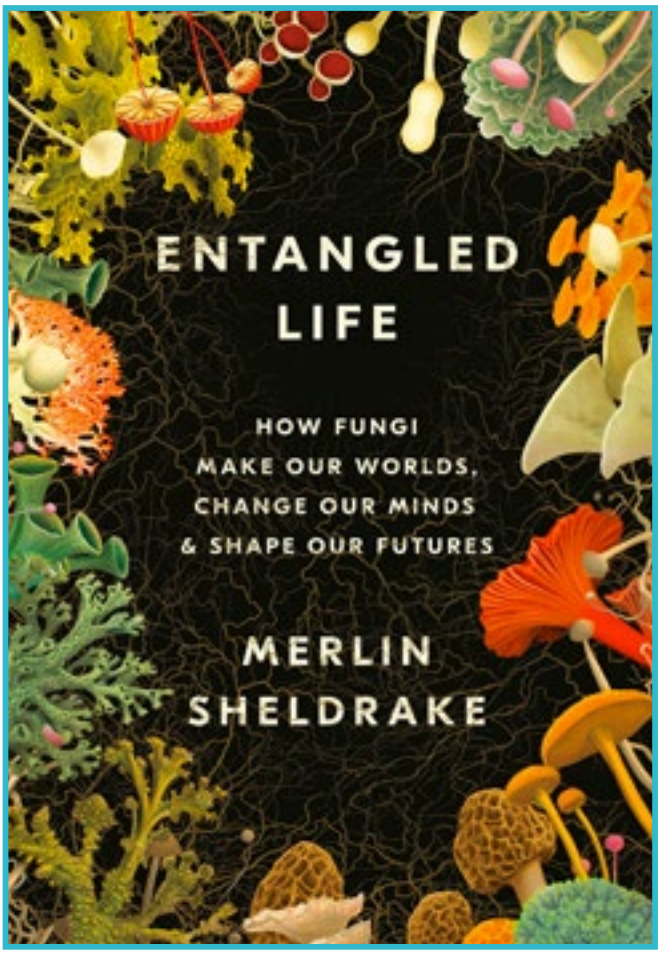
Sheldrake uses the introduction to present all the basic facts, explaining that the mushrooms and toadstools visible on the soil surface are but the fruiting bodies of fungi that propagate by releasing their spores to the wind. The fungi proper consist of fast-growing hollow shoots as thin as a tenth of a human hair. These hyphae form a network, or 'mycelium' that spreads far and wide in complex patterns, and may intermingle with the hyphae of other fungi while penetrating the roots of plants.

Fungi are neither plants nor animals, they are a kingdom in themselves. Many live in soil, others can be found deep inside rocks, others again dwell inside plants and animals, including humans. Without fungi we wouldn't be the individuals we are. Some fungi spoil our food or enhance its taste: just think of yeasts giving us yoghurt, and vinegar giving us bread and beer.

In the chapter, 'Intimacy of strangers', Sheldrake looks at lichens. Until recently people assumed lichens comprised just one fungus and one alga. Even defining a lichen as a close arrangement of one fungus with one or more algae and/or bacteria turned out to be incorrect. More realistically, a lichen is a fusion of one or more fungi and one or more algae and/or bacteria, an arrangement depending on the ability of the individual organisms to perform complementary functions useful to the whole. Lichens grow everywhere, including the most inhospitable places imaginable: in the ice-cold dry valleys of Antarctica, scorching dry deserts and around hot, acidic thermal vents. Lichens sent into space survived cosmic radiation; the only action they didn't outlive was being hurtled through space unprotected, as if stuck on a meteorite.

Later chapters discuss how fungi exploit other living life forms to reproduce and spread themselves. Certain fungi lure man and beast with their irresistible smell and taste, spreading by being consumed and excreted. Pigs and dogs, with their acute sense of smell, are so attracted by truffles that they immediately start digging. Magic mushrooms also use their smell to attract mammals, including humans, offering them 'beatific' visions or out-of-body experiences. Other fungi spread by hijacking ants, forcing them to take control of large numbers of additional ants.

In those fungi that form a mycelium, this network appears to follow a definite route and to know what it is aiming for – generally, food. Unlike plants, fungi don't photosynthesize to make their own food. The hyphae branch if they encounter an obstacle such as another mycelium, then fuse again, perhaps multiple times, or split over and over again. Remember that this may take place in just a teaspoon of soil.



Sugars and lipids pass through mycelial networks, not only for the benefit of fungi, but also for other plants, including trees. Plants and fungi complement each other in what they need and can provide, both gaining by the relationship. Carbon, nitrogen and phosphorus also pass from plant to plant through fungal networks. What's more, even if mycelial networks are deliberately kept separate, signals seem to pass between them. Scientists speculate whether these might be chemical signals that pass through the air rather than through the mycelial networks themselves.

Unfortunately, modern agriculture disrupts the alliances between fungi and plants, harming soil fertility. Fungal networks hold soils together, preventing the topsoil from washing away, while increasing the amounts of nutrients and water that soils can absorb. Soils preserve twice as much carbon as plants and the atmosphere combined, tied up in organic compounds produced by mycorrhizal fungi.

While these paragraphs may give you some idea of the substance of *Entangled Life*, it's the way Sheldrake approaches his subject that makes the book such an entrancing read. You could classify it as garrulous and self-indulgent, constantly branching out into interesting details. This habit of going off at tangents would be irritating in someone less enthusiastic.

Can fungi really shape our futures? Even this doesn't seem unthinkable. Keeping the mycorrhizal networks intact is likely to be of major benefit to agriculture, while the ability of fungi to neutralise polluting substances is certainly useful. They can even break down the explosive TNT and plastics, turning them into useful materials. Perhaps they can restore degraded habitats as well?

Transition Now: Recovering from COVID-19, will responsible science and technology be tools of rapid change?

SGR Conference and AGM – 4 & 7 November 2020 – ONLINE

Summary by Stuart Parkinson

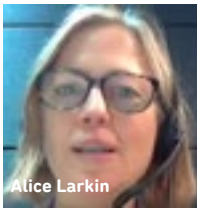
With many COVID-19 restrictions in place, SGR held its first online conference last autumn. The event took place in two parts. The first, on Wednesday 4 November, included four speakers on the theme of 'Responsible science and the climate emergency'. Meanwhile, the second part, on Saturday 7 November, included our AGM preceded by five speakers on the theme of 'Responsible technology and the climate emergency'. The first session drew an audience of over 65, while the second was attended by over 60.

The presentations are available in a number of formats:

- Eight videos can be viewed individually or in sequence on SGR's YouTube channel at: https://www.youtube.com/user/ResponsibleScience
- Seven 'powerpoint' slide-shows can be downloaded from SGR's website at: https://www.sgr.org.uk/events/transition-now-part-i https://www.sgr.org.uk/events/transition-now-part-ii
- Nine articles summarising or expanding upon the presentations can be found in this journal on pages 5 to 24.

With all these other outputs, we therefore provide only a brief summary of the event here.

PART I – Responsible science and the climate emergency


Alice Larkin

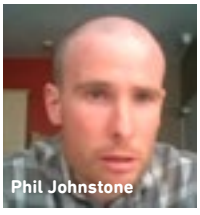
Andrew Simms, SGR's assistant director, introduced and chaired the first session. The first speaker was Prof Alice Larkin, University of Manchester, who looked at how things would be different if our society treated the science of the climate crisis as seriously as that of the COVID-19 pandemic. Prof Julia Steinberger, now at the University of Lausanne in Switzerland, then discussed how tackling overconsumption could lead to numerous rapid benefits – but unfortunately faced significant obstacles from both the scientific community and the wider public. Following this, Prof Bill McGuire, University College London, surveyed the scientific information concerning leading geoengineering proposals and warned of the dangers of relying on these speculative, uncertain, and highly risky technologies to avoid major cuts in carbon emissions. Finally, Jess Worth, of the advocacy group Culture Unstained, summarised successful campaigns which have persuaded several British cultural organisations to sever their financial ties with major fossil fuel corporations. One that is resisting, however, is the Science Museum and the session discussed how we might convince them to stop promoting and taking sponsorship from 'Big Oil'.


Jess Worth

PART II – Responsible technology and the climate emergency


Nick Robins

Andrew Simms also chaired the second session. Dr Lucy Gilliam, of the advocacy organisation, Transport and Environment, began by examining the possibilities for rapid transition of the aviation industry after COVID-19. Prof Nick Robins, London School of Economics, then looked at lessons for rapid and equitable transition from some case studies in the finance sector. Following this, Dr Philip Johnstone, University of Sussex, argued that plans to 'build back' with civil nuclear power were being strongly driven by military interests and, by following this path, cheaper and more sustainable energy options were being side-lined. Dr Alice Bell, of the campaign group Possible, took a whirlwind look at the history of renewable energy, highlighting some little-known stories. Finally, Dr Stuart Parkinson, Scientists for Global Responsibility, summarised industrial conversion during the COVID-19 crisis. In particular, he looked at how UK engineering facilities in the arms, aerospace and automobile sectors were converted to manufacture mechanical ventilators for treating patients.


Phil Johnstone

SGR's Annual General Meeting

SGR's vice-chair, Dr Jan Maskell introduced the AGM, and executive director Dr Stuart Parkinson summarised the highlights of the past financial year. He also summarised the accounts as treasurer Alasdair Beal was unable to take part due to ill-health. Dr Liz Kalaugher, SGR's new responsible science campaigner, summarised our new 'Science oath for climate' (see p. 2) and the associated project work. Questions and comments were then taken from members.

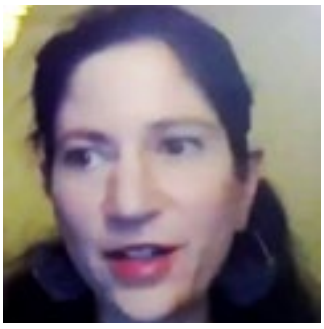
Finally, retiring Office Manager, Vanessa Moss, was thanked for her valuable contribution to the organisation over the past six years.

THE NEW NATIONAL COORDINATING COMMITTEE WAS ELECTED AS FOLLOWS:

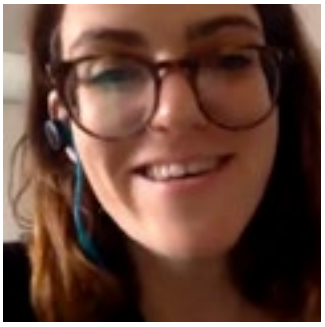
- Chair: Dr Philip Webber
- Vice-chair: Dr Jan Maskell
- Treasurer: Alasdair Beal CEng
- Committee members: Steve Ballard; Dr David Hookes; Simon Reed FIAP; Dr Gillian Smith CEng

Other speakers at SGR's Transition Now conference included:

Stuart Parkinson



Julia Steinberger



Alice Bell

Join SGR – as a Member or an Associate

SGR is an independent UK-based membership organisation promoting responsible science and technology. Our work involves research, education, campaigning and providing a support network for ethically-concerned professionals in these areas. You can join SGR as a member if you are or have been a science/design/technology professional in the broad meaning of the words: our members come from many disciplines including natural sciences, social sciences, engineering, computing, architecture and design, and interdisciplinary areas. They work in research and development, manufacturing, teaching, science writing, or are students or retired. Members are invited to contribute their expertise to help make SGR even more effective. If you are not a science/design/technology professional, but want to support our work, you can help us by becoming an associate.

Please consider joining by standing order as this will save us time and money, and help us to campaign more effectively.

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The editorial team for this issue of *Responsible Science* was: Andrew Simms, Stuart Parkinson & Liz Kalaugher.

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Copy deadline for next issue:
15 October 2021

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