

responsible science

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The journal of Scientists for Global Responsibility (SGR)

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

Calling science to account on the climate emergency

Interview with Kevin Anderson Lorraine Whitmarsh Bill McGuire Rebecca Willis Farhana Yamin Andrew Simms

The carbon boot-print of the military

Stuart Parkinson

News from SGR

New SGR report on fossil fuel/ arms industry financing of professional institutions

Science4Society Week 2020

One Planet – One Life

Obituary: Edward Cullinan



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Editorial

Walking the talk on the climate emergency

Do you want the bad news or the good news? asks Responsible Science's **Andrew Simms**

At the launch of the UK government's plans for COP 26, the next critical international climate conference, the Channel 4 news chief correspondent tweeted that the media were "wondering why we were here". The UK's proposed chair for the conference. Clare O'Neill, had just been sacked with the prospect of her suing the government for her removal, written a bitter letter denouncing the failure of government climate policy, and no replacement was announced. A proposed ban on petrol and diesel-engined cars was criticised as being too late, and the Prime Minister referred to carbon emissions, oddly, as being like a 'tea cosy' on the planet, leading several to guestion his choice of metaphor, if not basic grasp of science. The launch was in the shadow of a general election result that pointed towards fossil fuel, arms and nuclear industries being potential policy beneficiaries.

Such national concerns were echoed by much broader international prospects after the Bulletin of the Atomic Scientists declared that their Doomsday Clock was at 100 seconds to midnight, closer than ever in its history. The combined threats from nuclear weapons, climate change, biodiversity loss and new technology conspired to greater risks. All these issues are at the heart of what SGR does, and what we work to overcome. This edition of *Responsible Science* covers many of these multiple emergencies, and positive ways ahead. We have voices too, like those of Professors Lorraine Whitmarsh, Kevin Anderson, Bill McGuire, Becky Willis, and Farhana Yamin who challenge the science and technology community itself to be more serious and realistic about the depth of the crises, and face up to their individual and institutional responsibilities to act more in accordance with what we know.

SGR director, Stuart Parkinson, contributes to the growing awareness of the climate impact of the military, and the irony that they contribute significantly to the very insecurities that they are then called on to address. In this issue we say goodbye to our patron, Edward Cullinan, the RIBA Gold Medal architect who sadly died in 2019, but we are also delighted to welcome as a new patron Prof Alice Larkin, an expert in the climate impacts of aviation and shipping, Head of the School of Engineering at the University of Manchester, and a Professor in Climate Science and Energy Policy as part of the Tyndall Centre for Climate Change Research.

Alice joins us after a year in which SGR has explored and exposed how fossil fuel and arms corporations are financing professional engineering and science organisations, and revealed how behaviour change to address the climate emergency is on the increase among scientists. The Intergovernmental Panel on Climate Change said that 'rapid, far reaching, and unprecedented' changes in all areas of society are needed to meet agreed climate targets and stay below 1.5°C warming. We believe it is the job of responsible science to do all it can to speed that process along.

And, some things are happening. Fracking is now effectively banned in the UK, climate protest is more visible than ever, a nuclear weapons ban treaty is likely to enter into force this year, public opinion is behind more ambitious climate action and lower carbon diets, transport and energy choices are increasingly popular and the costs of renewable energy are falling. More and more are walking the talk on the climate emergency, we hope you will join us on the journey and enjoy it.

A Set



Andrew Simms Assistant Director, SGR



News from SGR

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New SGR report on fossil fuel/ arms industry financing of professional institutions

In October, SGR launched a new ground-breaking report, *Irresponsible Science*? The report reveals a previously unrecognised pattern of financial links between

the fossil fuel and arms industries on the one hand, and some of the UK's leading professional engineering and science organisations on the other. The links revealed include funding and branding of school education programmes, sponsorship of prestige conferences and dinners, investments, major donations, and corporate membership. The professional organisations that received the most significant funding from these controversial industries were the Royal Academy of Engineering, EngineeringUK and the Energy Institute. As the report was launched, we worked with the *Sunday Times* to expose an additional revelation – that the Royal Society has at least £16 million invested in fossil fuel corporations.

A summary of the report can be found on p.16. The full report – together with detailed appendices and data – can be downloaded from the SGR website at: https://www.sgr.org.uk/publications/ irresponsible-science or printed copies can be ordered from the SGR office.

The report was authored by Stuart Parkinson and Philip Wood. Funding was via the 'peaceworker' programme of Quaker Peace and Social Witness as well as the Martin Ryle Trust.

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Science4Society Week 2020

The theme of this year's Science4Society (S4S) Week is 'TRASH' – Take Responsibility And Show How to tackle pollution – and the

main activities will take place from 7th to 15th March. As usual, in advance of the week, SGR is running a competition for young people. More information and activity packs are available to download from the project website at: https://www.s4s.org.uk/



S4S project co-ordinator Jan Maskell leads a tour for university students around an eco-housing project during the 2019 Week (Photo: SGR).

All teaching resources available on the site can be used at any time during the year.

The project is intended to provide an alternative for young people to science education activities sponsored by the arms and fossil fuel industries – such as 'The Big Bang' fair which also runs annually in March.



Prof Alice Larkin, leading climate researcher, joins SGR as a Patron

Alice is Head of the School of Engineering at the University of Manchester, and a Professor in Climate Science & Energy Policy as part of the Tyndall Centre for Climate Change Research. Alice trained as an astrophysicist at the University of Leeds, did her PhD in climate modelling at Imperial College, then worked in science communication. She returned to academia in 2003 joining the interdisciplinary Tyndall Centre to research conflicts between climate change and aviation. In 2008 she was appointed as a lecturer to direct projects on international transport and food supply scenarios within a climate change context, and was Director of Tyndall Manchester between 2013 and 2016. Alice was the lead Manchester investigator on a large consortium project funded by the EPSRC entitled 'Shipping in Changing Climates'. She also led a large EPSRC consortium examining on the Water-Food-Energy Nexus.

Climate change activities

SGR's activities challenging the threat of climate disruption have continued apace in recent months.

We have given numerous talks about the potential for rapid transition in our society to tackle the problem through the expansion of renewable energy, greater energy conservation, environmental behaviour change, and economic reform. Andrew Simms spoke at events including Extinction Rebellion protests, the Glastonbury Festival, and the Green Gathering. Philip Webber spoke at a climate emergency conference in London. Stuart Parkinson spoke at a climate strike rally in Lancaster. Jan Maskell spoke at an environmental psychology conference in London. Martin Bassant spoke at an 'eco-churches' conference in Leeds. Keith Barnham created an online video lecture outlining how an all-renewable electricity system could be established in the UK.

SGR has also been arguing for greater recognition of the link between climate change and conflict. Stuart Parkinson has compiled new data on military carbon emissions (see feature on p.18) and this has been the subject of talks he has given at conferences organised by the Movement for the Abolition of War (in London), the Campaign for Nuclear Disarmament (in London and Leeds), and Church and Peace (in Birmingham).

The renewed interest in UK coal mining has also been a focus for our activity recently. SGR is supporting an attempt to initiate a Judicial Review of the recent government decision to approve a huge new deep coal mine in Cumbria. We have also submitted an objection to a proposed extension of an open-cast coal mine in County Durham.

During the general election, SGR helped the UK Climate Student Network with a scientists' sign-on letter in support of a TV debate for party leaders on climate and environmental issues.

The campaign was successful and the debate was hosted by Channel 4 - with Boris Johnson failing to turn up and famously being replaced by an ice-sculpture!



A student participant from Pilling St John's Primary School in Lancashire (Photo: SGR).

One Planet -**One Life schools** project

SGR is halfway through its twoyear school education project, One Planet - One Life, co-ordinated by Dr Jan Maskell. The project is running inspiring workshops on climate change and carbon footprints at schools in the Morecambe Bay area in North-West England. In the first year, Jan ran 16 workshops in six schools -

with nearly 500 students participating - and feedback has been very positive. In the coming year, we're planning to reach even higher numbers!

The project is especially timely given the huge interest generated in this issue among young people by the School Climate Strikes. Jan gave older SGR members a taster of the workshop at the 2019 Responsible Science conference (see p.27).

The project is funded by Ørsted's Walney Extension Community Fund. For more information, see: https://www.sgr.org.uk/ projects/one-planet-one-life

Science and peace activities

SGR's activities challenging the militarisation of science and engineering have continued over the past few months.

When NATO leaders assembled in London for their 70th anniversary summit in November, Stuart Parkinson spoke about the threats from new weapons technologies at the countersummit organised by CND and international peace groups. Several SGR members also took part in the protest outside the state dinner held at Buckingham Palace.

On nuclear weapons, SGR has continued to highlight the links between this existential threat and that from climate change in our talks and on social media (see feature on p.24). It is important that environmental campaigners understand both that political instability caused by climate change could lead to nuclear war, and that nuclear war itself would cause catastrophic climate change, in the form of nuclear winter.

SGR is also continuing to support the campaign against the massive new EU military R&D programme. In a promising new twist, the presidency - currently held by Finland - is proposing to cut the budget for this programme by half.

In brief

In June, SGR Scotland co-ordinator Dr Keith Baker gave a talk on ethical careers for school leavers considering studying science and engineering as part of the Headstart programme at the School of Computing, Engineering and the Built Environment at Glasgow Caledonian University. The talk included an introduction to SGR, and a group exercise to encourage the students to think about what ethical dilemmas they might face in different careers.





Responsibly: new SGR report Read about SGR's survey in Scientists Behaving Responsibly: Should science walk the talk on climate breakdown?

Scientists Behaving

in which we reveal how the work patterns and lifestyles of scientists and engineers align with tackling the climate emergency and how they are changing. See feature on p. 4.



Leading climate scientist and SGR patron says it's time to resign from climate compromised bodies

SGR patron, and Emeritus Professor of climate and geological hazards at University College London, Bill McGuire, resigned in November 2019 from the Geological Society over its links with the fossil fuel industry funding.

Reported by the BBC's national news Prof Bill McGuire resigned from the Geological Society following 40 years of membership. He announced his intention to do so at the SGR Responsible Science conference in London, and explains below what made up his mind. His decision was confirmed by the findings of SGR's report on the relationships between many of the UK's leading scientific institutions and membership organisations and arms and fossil fuel companies, Irresponsible Science? (see p.16) Based on his own informed decision and the report's findings, he invited others to reconsider their membership of bodies with similar links. Here he explains why:

"I resigned from one of the UK's leading learned societies after forty years as a fellow. Here's the letter explaining why. When soaring greenhouse gas emissions are on track to send our world to hell in a handcart, it beggar's belief that the Geological Society continues to feel that it's a good idea to cosy up to the fossil fuel sector. Seventy percent of the society's patrons are fossil fuel companies, a figure that rises close to ninety percent in relation to external sponsorship of events. At a time of climate emergency, the embracing of these corporations and their money makes the society complicit in the obfuscation of climate science and support of climate deniers that is their stock-in-trade. I urge all members and fellows to think long and hard about whether or not to maintain links with the society and to take the action required if we are to prevent rapid and catastrophic climate breakdown."

Are scientists walking the talk on the climate emergency?

A survey of scientists – many working in fields related to the climate emergency – conducted by Scientists for Global Responsibility (SGR), reveals a gap between awareness of international climate goals and action to align lifestyles with them. But there are signs also that radical and rapid shifts in behaviour are now happening, writes **Andrew Simms**, SGR.

he survey features in the briefing, Scientists Behaving Responsibly: should science walk the talk on climate breakdown?1 published to coincide with the SGR Responsible Science conference 2019. Increased awareness of the climate emergency has intensified a focus on the carbonintensive activities that fuel it. Scientists, engineers and technologists, especially those with international careers, can easily find themselves among some of the world's highest per capita emitters of carbon. But much media commentary has built a debate in which it is hard to win. Those who speak about the problem without actively changing damaging behaviours are called hypocrites, while those who make an effort to reduce their climate impact, and speak about it, are also condemned for not being perfect. The argument is almost framed as if you must be either an angel or a hypocrite, even though within a fossil fuel dependent economic system it is virtually impossible to be a climate angel.

Nevertheless, psychological research shows how important and influential it is to demonstrate or 'model' behaviour change. People being seen to act differently help to validate, popularise and spread new ways of living, and therefore in this instance reduce climate and environmental impacts. New social norms emerge from the effect of positive 'social contagion'. But how far has the science community itself, even the community around climate science, gone to align its activities and own behaviour with the climate challenge?

A study at the University of Adelaide looked at academic air travel and found that, although there was a high level of concern about the climate crisis, far fewer were willing to reduce their frequency of flying due to worries about damaging their careers pointing, at least, to perceived institutional pressures to fly. Is flying to conferences linked positively to academic productivity? Separate research carried out at the University of British Columbia looked at the relationship between the frequency of flying in the course of work – for example, in travelling to academic conferences – and actual academic productivity. It found that there was no relationship between the two.

Not limited to the science and technology sector, but more broadly, the link between 'leadership, beliefs and pro-social behaviour' has been investigated. In this research, leadership figures were shown to 'strongly shape their followers' initial beliefs and contributions'. The examples set by leaders in terms of their ethical stances, and the coherence of their behaviour, were highly influential and with long lasting effects. Setting good or bad examples can create different types of self-reinforcing 'path dependency' among followers. Leadership therefore matters. A researcher's behaviour can also affect the influence and credibility of their research, and climate research appears to be particularly vulnerable. If the personal carbon emissions of climate researchers is large, and therefore seen to contradict the nature of the research, it is seen to undermine the credibility of the work itself.

The SGR survey explored many of these issues and its highlights include:

- 87% of respondents said that they had considered the implications of the climate goals for their own lives, but only around half, 52%, thought that their lives were aligned with the goals
- 71% thought their field of work's response to the climate emergency either unsatisfactory or highly unsatisfactory
- More than one in three already reject flying, with that number pledged to increase to 48%
- Over one in three (38%) do not own a car and rarely use one, and the number planning to take 'very serious' steps to reduce the impact of their car use is rising dramatically

- 72% say they are adopting largely plant based diets with a further 13% adopting vegan diets
- 76% say they are turning their back on new consumer goods

 choosing less, second hand and long-term repair options
 instead
- Nearly one in three are choosing to go child free

Nearly two thirds of the changes needed to meet the UK national zero carbon target for 2050 were recognised by the advisory body, the Committee on Climate Change UK, as involving societal and behavioural change, but many of those changes are shaped by choices made more or less available by the energy, food and transport systems we live within. That means meeting agreed international emissions targets and preventing climate breakdown needs both systemic and behavioural change.

The responsible science survey shows scientists starting to make big life changes to walk the talk on climate breakdown, including getting involved in public protest. Research on behaviour change shows that seeing people act differently matters. It is hugely influential in persuading others to make changes, creating a positive 'social contagion' effect. The lack of easily available low carbon alternatives, however, was cited as the biggest obstacle to change.

We asked scientists, technologists and researchers a series of questions about the behaviours which are responsible for the bulk of personal carbon emissions and what changes, if any, they were intending to make.

Around half believed that they are living lifestyles compatible with the 1.5°C climate target

87% of respondents said that they had considered the implications of the climate goals for their own lives. But this revealed an awareness / action gap as only around half, 52%, thought that their lives were aligned with the goals. Another 40% said no, they were not aligned and 8% said that they did not know. It is worth noting that '1.5°C compatible' lifestyles are very hard to achieve given today's energy intensive infrastructure.

Respondents were more sceptical about their areas of work as a whole: 71% thought their field of work's response to the climate emergency either unsatisfactory, or highly unsatisfactory.

More than one in three already rejected flying, with that number pledged to increase to 48%

In 2018, nearly half of the population of England (48%) took no flights at all according to the Department of Transport. Generally speaking, people in higher income brackets – such as scientists or engineers – fly more. In our poll, more than one in three, 36%, said that 'not flying' was the best description of their approach to aviation. Just over 15% took one short haul flight per year, and over 26% took the equivalent of one long haul or two short haul flights per year. There were 13% taking the equivalent of two long haul or 4 short haul flights per year and over 9% taking more than that. But when asked about their likely behaviour in the future, the number planning to not fly at all grew to just over 48%.

Over one in three (38%) did not own a car and rarely used one – while the number planning to take 'very serious' steps to reduce the impact of their car use is rising dramatically

One in five owned a car but were taking 'very serious' steps to minimise its use and impact, such as working from home, lift sharing or switching to an electric car. Another combined 37% were taking either sizeable or limited steps to reduce the impact of their car use. When asked about their car use in the future, there was a big shift upwards in the group saying they would take 'very serious' steps to the impact of their car use – from 20% to 39%.

The number of respondents who placed themselves in the lowest carbon home energy use category – based on efficient use of renewable energy – was just under 1 in 8, but when the number planning to take further action were included, this rose to 1 in 4.

72% said they were adopting largely plant based diets with a further 13% adopting vegan diets

Respondents reporting that they followed plant based vegan diets, whilst also actively seeking to minimise their food waste, stood at 7%. But a much larger 29% declared that they followed the next lowest impact diet – following a 'largely' plant based diet while reducing food waste. A slightly larger group, 32%, declared that they followed a diet which might include smaller than average amounts of meat, fish and dairy. Asked about what behaviours they would choose in the future, people opting for a vegan diet went up to 13%, and the next most low carbon option moved from 29% to 39%.

76% said they were turning their back on new consumer goods - choosing less, second hand and long-term repair options instead

Nearly one in three were choosing to go child free

We next asked how the climate issue influenced people's approaches to family life. Nearly one in three, 31%, said that the issue led them to avoid having children. Another 8% said it made them chose to plan to be a one child family, and further 15% said that it meant them 'limiting' the size of their family.

Nearly two thirds cited the lack of easily available options as the main obstacle to climate action

After considering this range of options for behaviour change, we asked what were the factors holding people back from making such changes. Respondents were offered a range of options and were able to choose more than one factor. The biggest obstacle cited was the lack of easily available alternatives, with 65% of respondents giving this reason. Cost was the next most common, but was only mentioned by 34%. About a quarter, 26% cited the belief that it was the job of government and / or industry to make the necessary changes, with 22% giving reasons to do with family life, and 11% resistance from employers.

Flying less and protesting more were commonly mentioned as good examples of 'walking the talk'

Lastly, we asked respondents to tell us about the best and worst examples of walking the talk on climate action, or not. Among the 'best' examples quoted, not flying was the most common, followed closely by taking part in protest actions. Several people mentioned shifting to plant based diets, and several also mentioned inspirational leadership from individuals making bold life choices themselves. In this case, Greta Thunberg was mentioned several times, as was the climate scientist Kevin

WALKING THE TALK ON CLIMATE CHANGE

FEATURE

Anderson. Several respondents talked of choosing to limit family size and one of the pride taken in maintaining a bicycle in use that was built before 1970.

One respondent summed up the holistic nature of the challenge writing: 'Being a role model in all aspects of life: reducing waste, sustainable fashion choices, local plant based food consumption, not buying anything new. Travelling only for research or familial purposes and being open about the fact that it's not sustainable.' Several university departments and the Met Office were mentioned for transport policies that sought to encourage more sustainable choices including taking the train from London to Vienna for a conference.

In highlighting some of the more egregious examples of examples of anti-environmental behaviour, examples were in many cases the reverse of the best, such as flying a lot. But this question also raised issues around accepting sponsorship and other funding from fossil fuel companies, driving SUVs and examples of conspicuous consumption. Waste and advertising were also mentioned. One person with courageous honesty highlighted themselves as a 'worst' example. The duplicity of oil companies who say that they acknowledge the problem but continue to explore for and develop new oil and gas fields was specified too. The consideration of a 'Space Port' by a county council in the English South West was cited. But perhaps the last word should go to the respondent who said that the worst examples was, 'saying that the present crisis has nothing to do with me.' Andrew Simms is Assistant Director of Scientists for Global Responsibility, and co-ordinator of the Rapid Transition Alliance.

References

1 https://www.sgr.org.uk/publications/scientists-behaving-responsibly

WHO WAS POLLED?

This was a straw poll disseminated to specialist scientific audiences including SGR's own membership and those who follow the international climate negotiations. There were 153 responses. In order to have a sense of the specialisms of respondents we asked them to describe the broad sectors in which they worked. Of those who replied, 47% described themselves as scientists or engineers working in a climate related field, 36% were scientists or engineers not working in a climate related field, 6% were students of science or engineering in a climate related field, 4% students in other areas of science and engineering and 7% identified themselves as non-scientists / engineers. Of all the respondents, just under 39% were professional, associate or student members of Scientists for Global Responsibility.

Turning delusion into action – breaking the bias that supports a dangerous *status quo*

SGR's **Andrew Simms** interviews one of the leading voices on climate science, **Prof Kevin Anderson** of the Universities of Manchester and Uppsala, about the responsibilities of scientists in the climate emergency.



Andrew Simms: Would you like to hear more from your fellow climate scientists now about the speed and scale of action required?

Prof Kevin Anderson: I'd like to hear much more of what many academics say in private being said in public. This is also true of many others I engage with across the climate change community – from those in NGOs to more informed policy makers,

business types, journalists, and more. Over the past two or more decades I've witnessed an emerging preference for spinning an appealing but increasingly misleading yarn about what is needed to meet our various climate commitments. Disturbingly, many of those who should know better have even begun to believe their own delusionary tales. The enthusiastic and almost unquestioning support by many academics for the Climate Change Committee's (CCC UK) 'net zero' report, or 'not zero' as I prefer to call it, exemplifies how we're prepared to forgo analysis and integrity to maintain politically-palatable fairy-tales of delivering on Paris.

AS: And what are they saying in private?

KA: Not all, but many had been telling me for years, that there's no hope of staying below 2 degrees centigrade, that we're

heading to three or four degrees. I should add that I disagreed with this view, arguing that if we're lucky on climate sensitivity and are prepared to grasp the nettle and make very difficult but doable cuts in emissions, then a thin thread of hope remained for staying below two degrees. Today, the chances are much, much slimmer and with the cuts in emissions completely unprecedented and far beyond anything in the public and political debate. What I find most disturbing, is that many of those who previously had told me, away from any microphones, that 2°C was not viable, are now coming out in support of meeting 1.5°C. Worse still, they repeatedly point to idealised technical solutions, yet often with little understanding of either the technologies or their practical delivery, let alone the timelines for making wholesale shifts in technologies and associated infrastructures.

Typically it is more senior academics and others who hold these conflicting public and private positions. Whilst such deception is often very well meant, it nevertheless reflects a deep arrogance. They are basically saying, I'm a sufficiently clever person, that I can judge what is politically or not viable, and therefore by massaging my assumptions I can provide politically appropriate conclusions. Such arrogance is widespread. Just look at the CCC UK. I have a huge respect for the CCC's secretariat, and particularly the new CEO, Chris Stark, I think he's excellent. But since its inception, the academic Commissioners who, in many

FEATURE

WALKING THE TALK

respects guide the framing of the secretariat's work, have failed to support the CCC in pursuing genuinely independent analysis.

As such the CCC have, in my view, misled parliament and the public – at least in terms of mitigation. Individually I respect the academic work of many of the commissioners, some of whom I know well and would call friends, but as soon as they don their CCC hat, academic rigour is weakened in favour of political expediency. Exacerbating all of this is repeated reference to the CCC as independent. It is not. It is basically a Quango with advisors and a secretariat more sensitive to the dominant political and economic dogma than to the implications of their science.

As I say, all this is done with good intention – and perhaps if the rest of the academic community held the CCC, and government ministers, to account, this would not be a problem. But by and large the academic community, including the funders, have abdicated this responsibility preferring to embrace the CCC as the climate oracle. I want to add here, that I have spoken to Chris Stark about this, and think it only fair to note that he strongly disagrees with my views on how the Commissioners have engaged with the secretariat – seeing their contribution in a much more constructive light.

AS: Does that mean that in effect, they've been self-editing, or self-censoring, in terms of not saying what is necessary to align the process of economic and political change to meet the Paris targets?

KA: I think that's true of the CCC, and I think it's true of a high proportion of academic work on mitigation, particularly at a senior level. Unfortunately, this invidious political expediency percolates down to some of the earlier career researchers. However, from experience, the Post Docs and the PhDs demonstrate much greater integrity with their research, and an honest recognition of the scale of the challenge we face.

I've only really become aware of the misleading and dangerous influence of some senior academics on their earlier career colleagues over the past two years. It was brought to my attention at one of the big climate negotiations (COPs) I was attending. Chatting to those without grey hair, it became increasingly clear many of them were being reprimanded for asking difficult questions by their senior colleagues and supervisors. I really found this hard to believe. But the more I asked about this the more I realised I'd been living in a naïve bubble unaware of how vibrant academic debate driven by younger academic colleagues is being deliberately stifled. And this is not something that only others elsewhere are doing. I now hear that senior colleagues I've worked with & known for years - sharing many a vibrant exchange over coffee or a beer with some of them - have also actively constrained the contributions of 'their' earlier career colleagues.

I assumed most good academics thrived on open debate and courteous but robust disagreement – Ok, put on a CCC hat, do some consultancy work etc, and there's a risk of all too easily being co-opted. But this is much worse. It's a deep institutional systemic bias towards aligning our conclusions within the boundaries of the status quo – and this extends to the funders. We've chosen to forgo our academic independence for the appeal of being relevant within a debate our own analysis tells us is irrelevant.

It's only then when a Swedish child has the courage to call out our nakedness, echoed by a similar call from our own children, that we stir from our cosy consensus. Forced to look in the mirror – it's becoming bloody obvious that we're naked and have been for a long time, but no one has had the guts to tell us. The wonderful thing about children is that they're not yet locked into our political baggage – but if they go on to become post-docs, we'll do our best to bash them into conformity.

AS: Do you think it would have been easier to bring forward political and policy proposals that were in line with the scale of the problem if the scientific community had censored what they had said less?

KA: Well, first of all, I don't think the scientific community should censor what it says at all. If it does censor, then it isn't the scientific community. There's a serious risk that we've become little more than a group of elite privileged citizens. With no expertise in processes of change in emergencies, or political economy more generally, we pontificate on responding to climate change, hiding the ignorance underpinning our expedient suggestions behind a veil of academic objectivity.

I take a straightforward view of our role as academics. We need to develop a culture of being disinterested in whether people like or dislike our work, our only interest should be in whether people agree or disagree with our analysis and conclusions – and why. Academia should not be a fashion contest, or a desperate clamour for funding, committee memberships, gongs, awards and prestige.

As for whether honesty, integrity and robust bluntness would have significantly changed where we are now - well in my judgement, yes and significantly so. I can understand the levels of measured optimism of the early 1990s; that substantial but nonetheless incremental changes to business as usual could have led to a timely decarbonised future. But by 2000 it was becoming obvious that such optimism was now misplaced. Rising emissions and more locked-in fossil fuel infrastructure and associated expectations, had kicked the potential of incrementalism into the long grass. During the subsequent two decades, the academic and climate change community has not played a straight bat when it comes to mitigation. As the years have passed, through 2005, 2010, and onto 2015 and Paris, we've adopted increasingly exotic technologies, technocratic fraud, dodgy accounting and eloquent nonsense as a salve for ever-rising emissions.

There is no group that can be singled out for this abject failure. Certainly the academic community leant credibility to the fluff and nonsense that has filled the void left by failing to mitigate. But the journalists have played their role – more spin and glossy stories than investigative reporting. The policy makers, the business community, the unions, civil service and the electorate, at least in democracies, don't come out of this any better. And nor do the climate great and good – from Gore to DiCaprio, Attenborough to Goodall, Musk to Branson – all have been party to a greening of business as usual. On mitigation and particularly cutting emissions in line with Paris, we're all players in a grand unifying delusion – we've become mitigation-deniers.

If, on mitigation (as distinct from the science), academics had collectively favoured meticulous analysis, system thinking and blunt communication over spin & well-intentioned sycophancy, then I think we could have catalysed a different and more honest debate. Whether this would have led to the profound changes to contemporary society now required by Paris cannot be known. But rigorous academic input was and still is a prerequisite of transforming the thinking, expectations, policies, and societal norms in line with 2°C carbon budgets. Of course, such input is not sufficient, but without it we will continue fail.

WALKING THE TALK ON CLIMATE CHAN

How can we mobilise society to reach net zero?

Prof Lorraine Whitmarsh, Cardiff University, argues that to encourage the radical behaviour change needed to tackle the climate crisis, we need a range of well-timed interventions.

he transformation required to reach net zero is fundamentally a social one. Analysis by the UK Climate Change Committee shows that technological change alone is insufficient to reach this goal; indeed, they calculate that the majority - 62% - of the changes required will be, at least in part, behavioural or social. Changes will be required in how (and how much) we travel, in what we eat and buy, and in how we use energy. We are exploring how to achieve these profound changes to lifestyles and broader social systems in the new UK Centre for Climate Change and Social Transformations (CAST). CAST is a collaboration between Cardiff, Manchester, York, and East Anglia Universities, and the charity Climate Outreach. We work across multiple scales (individual, community, organisational, city-region, national and global) to identify and experiment with social and behavioural routes to achieving radical and lasting cuts in emissions from mobility, diet, consumption, and heating and cooling.

Together these four areas of activity account for most of people's carbon footprint. For example, diet and travel together account for around half of our emissions. So changes like eating less meat and dairy, and driving and flying less can make a really significant difference to tackling climate change.

So, what do we already know about how to achieve this profound behavioural and social change? Previous research shows that in order to address the range of factors that shape our behaviour (e.g., attitudes, habits, norms, built environment, economic factors, cultural values), multiple interventions are required. For example, dramatically cutting levels of smoking required information campaigns, labelling, smoke-free policies, support services, price/tax increases, and bans on tobacco advertising/sponsorship. We also know that social and behavioural change is more likely if solutions provide individual or societal co-benefits – such as improved health from active travel and plant-based diets or lower energy bills. Similarly, we know that wellbeing is a co-benefit of taking low-carbon actions; for example, less materialistic lifestyles are associated with higher life satisfaction.

Timing is also critical. Often, we focus on how we intervene, but just as important is when. Habits are a major barrier to lifestyle change; when we have a strong habit, we ignore information and incentives to act differently. This means many interventions aren't strong enough to break our habits. But there are times when our habits are weakened – for example, when moving house, retiring, or experiencing infrastructure disruption (e.g., road closures, blackouts) – and these 'moments of change' represent key opportunities to intervene to change behaviour.

For example, one study found that information and incentives to encourage bus use only worked amongst those who had recently moved house, but was ineffective for those who had not recently relocated. Targeting interventions to the right time, as well as to audience's values, is essential to achieving the social transformation required to tackle climate change.

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This article is based on a presentation given at SGR's Responsible Science conference in November 2019, which can be downloaded from: https://www.sgr.org.uk/events/scientists-behavingresponsibly-should-science-walk-talk-climate-breakdown WALKING THE TALK

Global heating and climate breakdown – completing the picture

Prof Bill McGuire, University College London, argued at the Responsible Science conference that mainstream climate science reports downplay the scale of the threats currently faced, especially from sea-level rise, extreme heat, shutdown of the Gulf Stream, and increased seismic activity. Here he spells out why.

very fine line separates alarmism from what a risk expert colleague of mine likes to refer to comically as Compulsive Risk Assessment Psychosis (CRAP) – scaremongering as it is otherwise known. This distinction applies to global heating and ensuing climate breakdown as much as anything else; probably more so given the imminent and desperately serious ramifications of the climate emergency. My concern, however, is that – up until now at least – the message reaching the ears of both 'the great and the good', and the general public, is simply not alarmist enough. We have alarms for a reason, after all, they save lives. What I mean by this is that the message doesn't set the alarm bells ringing about just how bad things could get as hothouse Earth becomes an ever more likely reality.

In other words, the picture that people see and take on board, of what a broken climate will look like, is not complete. It ensures that the general view of the global heating threat is watered down, one that fails to encompass scenarios involving more deleterious impacts on society. In so doing, a sense of false security is engendered and the 'call to action' to tackle global heating, diminished.

The problem can be traced to the very top. The Intergovernmental Panel on Climate Change (IPCC) undoubtedly has done vital work in building understanding and appreciation of the global heating threat, flagging likely future scenarios, and signalling what needs to be done, and how quickly – to stave off the worst of climate breakdown. Without it we would already be in a very dark place indeed. But there are downsides too.

The IPCC's periodic reports are conservative and compiled to reflect a broad consensus. This means that they fail to address

global heating and climate breakdown scenarios that, although currently regarded by the climate science community as less likely, are – nonetheless – perfectly possible. Because the IPCC reports form the climate 'bible' that drives news stories in the press and broadcast media, this incomplete picture is – inevitably – the one pitched to the public.

The blame cannot, however, be placed at the door of the IPCC. Every report it publishes is scrutinised line-by-line by representatives of all 197 nations and groupings signed up to the 1992 UN Framework Convention on Climate Change (UNFCCC). These include the United States, Australia, Saudi Arabia, Russia and others, who have a history of playing down the climate emergency. As a matter of course, objections are raised to any elements of the text that such signatories regard as pushing too far the envelope of what global heating and climate breakdown might bring. As a consequence, much peer-reviewed climate change science fails to make the reports and, as a consequence, goes largely unnoticed by most of the media and the public.

Nowhere is this more clearly demonstrated than in the area of future sea-level rise. In its 2019 *Special Report on the Oceans and Cryosphere* (SROCC),¹ the IPPC's worst case *likely* range for sea-level rise by the period 2081–2100 is 51–92cm, with a figure of up to 110cm provided for 2100. In stark contrast, peer-reviewed research, not addressed in the report, forecasts that more rapid break-up of the West Antarctic Ice Sheet could see global sea levels 292cm higher by the end of the century.² Such an order of rise is supported by polar ice melt doubling times at the lower end of the 10–40 year range³ and by a tripling in the rate of Antarctic ice loss between 2012 and 2017.⁴ If maintained, such a

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tripling time of five years would see sea level climbing by around 5cm a year by the mid 2040s.

Another possible consequence of global heating that is underplayed in the IPCC reports is the collapse of the Gulf Stream and associated currents - known in oceanographic circles as the Atlantic Meridional Overturning Circulation (AMOC). In the aforementioned 2019 SROCC report, the IPCC recognises that "... the AMOC has weakened relative to 1850-1900..." but that there is "... insufficient data to quantify the magnitude of weakening..." or to "... properly attribute it to anthropogenic forcing." The report goes on to say that the "... AMOC is projected to weaken in the 21st century... although collapse is very unlikely." Other research, reported in a range of peer-reviewed papers is, however, more worrying. The strength of the AMOC has declined by 15 percent since the midnineteenth century and is now at its weakest for 1500 years and probably since it last collapsed 11,500 years ago.^{5,6} Shutdown. should it occur, could happen extremely rapidly, perhaps over the course of just a year or two, leading to major cooling of the North Atlantic region and serious knock-on effects on sea level and weather patterns.

In its fifth Assessment Report, published in 2014,7 the IPCC notes that "...it is very likely that heat waves will occur with a higher frequency and duration." It does not, however, say anything about the terrifying prospect of so-called humid heat waves. These arise when the wet bulb temperature - a measure of the combination of heat and humidity - reaches 35°C. Such conditions, if sustained, are unsurvivable, so that even a fit and healthy human in the shade has only about six hours to live. The required combination of heat and humidity has not been encountered in modern times, but the conditions were almost met in parts of Iran in July 2015. Looking ahead, the second half of the century is forecast to see humid heat waves affecting the Ganges and Indus valleys of South Asia,⁸ the Persian Gulf and China. Most at risk is the North China Plain, where widespread irrigation is predicted to contribute to the occurrence of humid heat waves later this century that could affect up to 400 million people under a business as usual emissions scenario.⁹

Other elements of global heating and climate breakdown research are omitted from IPCC publications too, or at least soft-peddled. The key question then, is how can this information be made generally available and how can its profile be raised so as to present a more complete picture of what a hotter world might look like. Unfortunately, there does not seem to be an easy solution. One way forward might be for the IPCC to openly acknowledge the existence of relevant and important peerreviewed research that supports non-consensus findings, and to publish this material in addenda to the main reports. This would, or course, require the agreement of the signatories of the UNFCCC, which is likely to prove difficult, if not impossible.

Another way forward could be the establishment of an independently-vetted, non-political website, perhaps validated by national academies of science, on which peer-reviewed research findings not included – for one reason or another – in IPCC publications, could be lodged.

Building a more complete picture – for both stakeholders and the public – of what global heating and climate breakdown could mean, would also benefit from more climate scientists sticking their heads above the parapet and saying in public, what they currently reserve for private conversations. Many climate scientists clearly have an issue with telling it like it is, as highlighted in a recent analysis.¹⁰ (*Editor's note: see interview with* Kevin Anderson, p.6) This showed that later observations of the climate system (e.g. ice extent and sea-level rise) were typically worse than earlier predictions made by climate scientists, and that key climate indicators were often underestimated. The study also unearthed a general feeling within the climate science community that it needed to give the impression of univocality – speaking with one voice – and a consensus outlook. The analysis also revealed that – when the world is watching – climate scientists worry about how they will be perceived.

Taken together, all this means that most researchers working on global heating and climate breakdown tend to play down worstcase scenarios, thereby presenting an unrepresentative picture of their impacts and consequences. What the climate science community should be doing is not making consensus a goal. If it exists, it will emerge in its own right. If it doesn't, then clear differences of opinion need to be acknowledged and clarified. The time for sweeping inconvenient research findings under the carpet and keeping heads down for fear of reputational damage or derision are long gone. We all have a right of access to the complete picture of the world our children and grandchildren could inherit.

Failing to provide this may well mean that the actions we take in this critical decade fall short of what is needed to avoid catastrophic, all-pervasive, climate breakdown.

Bill McGuire is Professor Emeritus of Geophysical and Climate Hazards at University College London. His novel – SKYSEED – an eco-thriller about geoengineering gone wrong, is published in September 2020.

This article is based on a presentation given at SGR's Responsible Science conference in November 2019, which can be download from: https://www.sgr.org.uk/events/scientists-behavingresponsibly-should-science-walk-talk-climate-breakdown

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WALKING THE TALK

If you're thinking about climate, talk about it too: combatting societal denial

Prof Rebecca Willis, Lancaster University, writes about the challenge of overcoming social denial of the climate emergency

hen life gets me down, I go running. I have a collection of comedy podcasts which I plug into, as the dog and I make our way round the local hills at rather a sedate pace. My favourite is a show that is as old as me: the BBC's *I'm Sorry I Haven't A Clue.* It's a panel of very clever, very funny people doing silly things. For me, it is the best medicine for climate anxiety.

To live in a time of climate crisis is to compartmentalise. If, like me, you spend many of your waking hours thinking about climate, it exerts a heavy toll. The news of what is already afoot: the wildfires, heatwaves, droughts and floods. The predictions for the future, within my own lifetime, and in the lifetime of my children. The intransigence of the response from politicians, media and many people. It goes round and round in my head, and I have to switch off. When I take time off work, I can feel myself disconnecting from climate change too, and it is a relief.

Responding to climate change is about balancing this dual reality: acknowledging the enormity of climate change, without being overwhelmed. But it is a difficult balance. Those of us who work on climate daily are stalked by it. But most people keep it at a distance, or laugh it off with quips about the end of the world.

When the anthropologist Kari Norgaard went to a Norwegian village to study understandings of climate change, she uncovered a paradox which, for me, is fundamental to understanding our responses. Villagers were aware of, and concerned by, climate change. They had noticed changes to snowfall, and to the ski season that many of them depended on for income. Yet they chose, together, to ignore it. It just wasn't something that people spoke about.

As Norgaard asked, "how could the possibility of climate change be deeply disturbing and almost completely invisible – simultaneously unimaginable and common knowledge?" She labels this phenomenon 'societal denial'.

In my own research with politicians, I have seen many examples of this. The politicians I spoke to showed a marked tendency to play down the climate threat. Like Julia (not her real name), a confident politician who expresses her views freely. As we chatted over coffee, she was deliciously unguarded in her opinions of her colleagues, criticising the vast majority of her fellow parliamentarians for not dedicating time or attention to climate. She said that just a few of her six hundred or so colleagues took the issue seriously – "you might not get into double figures".



And yet Julia knew that she must tread carefully, not for scientific reasons, but sociological ones: she has to fit in. I asked her what would happen if she tried to interject in a debate on budget issues, to persuade her colleagues that fossil fuels should stay in the ground. She replied: "I think they'd just think that they'd think you were a bit 'niche', is the way I'd put it – I say 'niche' in quotes like a bit of a lunatic fringe."

Julia wasn't the only one who worries about her 'niche' reputation. One former MP, who had been an active climate campaigner in Parliament, said "I was known as being a freak". Another told me about how he tried to avoid being seen as a 'zealot'. He said he had been arguing for better public transport in his constituency, and I asked him whether he had mentioned climate change. He said he hadn't: "I think if I had mentioned carbon emissions, there would have been a rolling of eyes and saying, 'oh here he goes again." These remarks were common in my conversations with politicians. Some went as far as deliberately avoiding any mention of climate, for fear that it would be an unhelpful label.

This shouldn't come as a surprise. As any undergraduate sociologist learns, the way people think and act is conditioned by their social world. We are heavily influenced by our social surroundings, and by implicit rules and norms.

Speaking out

This insight brings with it an important lesson for all of us who are concerned about climate. It can be summed up in one sentence: If you're thinking about climate, talk about it too.

It's not an easy thing to do, because by naming climate change you are saying a lot of difficult things about how we live our lives. In the fable of the Emperor's New Clothes, it is not a coincidence that it was a child who pointed out that the Emperor was, in fact, naked. As Greta Thunberg has demonstrated admirably, children have that enviable ability to ignore social convention, and say what they see. We could all learn from that. You won't always be thanked for it, but your courage will be noticed.

You can talk to politicians. National leaders, local councillors – any and all elected representatives. Tell them you are worried about climate change, and ask them what they think. The rest of the suggestions below will help you to think about how that conversation might go. The charity Hope For The Future has a brilliant set of resources on its website to help you through the process of asking for, and planning, a meeting.

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But don't stop with politicians. You could raise it at your workplace, talk to your friends, make it clear on social media. In short: fight socially organised denial. Last year, I took a deep breath and chatted to the parents on the touchline when my son was playing football. It was a really positive conversation. Since then, I've tried to include it in a lot of general chat. Or rather, I have stopped censoring myself.

The UK charity Climate Outreach has been encouraging people to have these conversations, and researching the impacts. They worked with volunteers who offered to start up conversations, with strangers, family members, acquaintances and work colleagues, and to report back on their experiences. Though it was sometimes hard to start with, participants were glad they had done it. As one said, "talking about it breaks down the isolated feeling, and makes me feel more supported to take action". This confirms research which suggests that taking action on climate is good for you: it helps overcome feelings of helplessness or grief that may emerge from contemplating something so all-consuming.

Practising what you preach?

This brings me to the all-important question of your own footprint. Of course, we should all be thinking about this. Your own carbon footprint is a drop in the global ocean. But every drop, like every vote, counts. It counts even more if you talk about it. What better way to talk about the need to reduce aviation than to say that you have restricted your own flying, for work and for holidays? Imagine how powerful it would be if everyone who campaigned for climate action – politicians, businesspeople, celebrities, everyone – made meaningful pledges about what they would do in their own lives. Could you be the person who prompts your organisation to change?

There is a growing band of university researchers who have pledged to stop the wasteful amounts of flying that are currently a normal part of academic life. As a result, new options are opening up. International conferences have been run without air travel – like the 2018 'Displacements' anthropology conference, where online presentations were watched at different regional hubs. When I write research grants, I factor in the time and money for train travel, not flights. I have also done some brilliant research using webinars rather than actual meetings. It's different, but it can work really well. On one memorable occasion, a workshop participant in California decided to show everyone joining from round the world his beautiful stripy knitted socks. I remember him waving his feet in front of his laptop camera.

It's not a case of all-or-nothing. My good friend Kate Rawles, an amazing adventurer and climate communicator, has set herself a budget of one flight every three years, and talks about this whenever she can. She says that people find it easier to relate to than stopping flying altogether (in rich countries, at least – it's always worth adding the caveat that most people in the world have never got on a plane). Similarly, I'm an occasional meateater – I don't think you have to choose between meat every day and a strict vegan diet. Do what you can – and tell people about it. There's research to show that it makes a difference. As my research shows, people are heavily influenced by their social world. If people they respect have changed their behaviour significantly, this has an impact.

We are now seeing higher levels of concern about climate change than ever before. This is thanks to many brave people who have decided to speak out, and confront societal denial. It's a lesson that bravery and honesty are as important as technology in the climate struggle.

This article covers themes discussed by Rebbeca Willis at the Responsible Science conference and draws on her forthcoming book, Too Hot to Handle? The democratic challenge of climate change, published by Bristol University Press, Spring 2020.

Why I swapped UN negotiations for direct action

Farhana Yamin is an international climate change lawyer who swapped negotiating rooms for street protest. Frustrated by the failure of official action to match the scale and speed of what was needed, she decided to change her own behaviour and use direct action to campaign for system change. Also a speaker at the Responsible Science conference, here she explains why she changed tactics.

ast year, I superglued my hands to the pavement outside the headquarters of the oil company Shell in London, surrounded by dozens of policemen. Once unstuck, I was arrested for causing criminal damage. I have been a lead author for the Intergovernmental Panel on Climate Change (IPCC) for three of its five assessment reports, and an adviser in the United Nations climate negotiations for almost 30 years.

Why did I, an international environmental lawyer, break the law? Having spent three decades failing to get governments to pay attention to the climate crisis through advocacy at the highest levels, I felt that activism was now crucial. I wanted to show how ridiculous it is that a law-abiding (indeed, law-making) mother of four should be handcuffed while the world's major polluters remain unaccountable for ecocide. My arrest was part of a wave of peaceful protests against the UK government in April 2019, organised by the global movement Extinction Rebellion, or XR. It uses non-violent civil disobedience to demand radical action to tackle what many of us now refer to as the climate emergency.

I coordinated XR's political strategy team for much of 2019. My role was to find ways to build momentum across the party spectrum and organise negotiations with government. I helped XR meet with various political parties and was pleased our protests lead to the UK Parliament declaring a climate and ecological emergency in May 2019.

I've now returned to my profession: helping governments of developing and developed countries to implement commitments

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under treaties such as the 2015 Paris Agreement to stay on track for the well below 2 °C and safer 1.5 °C temperature goal. Countries are due to submit new targets and plans ahead of the UN Summit on climate change in Glasgow, UK, in November 2020. But the larger countries and historic emitters are dragging their feet. My focus is on helping people understand how they can support vulnerable countries and communities fight to enhance global ambition and hold larger emitters to account. I am also working closely with activists and local authorities to set up pop-up "Think and Do" eco spaces in their communities to design new projects and policies. Bottom up action can pressure governments to act and citizens come up with faster, more effective solutions, including by testing behaviour change.

Global treaties and national laws provide a crucial framework for action. But sadly, weak legislation and tweaks to 'business as usual' practices have not prevented environmental devastation. We need new kinds of collaborations and policy frameworks to challenge endless growth and consumption-based lifestyles. The current form of capitalism is toxic for life on Earth. It is based on the never-ending extraction of nature and an unjust appropriation of resources that belong to historically marginalized communities. In their current forms, green taxes and tradeable carbon permits let polluters pay to play the same old games.

The global economy must be fundamentally reconfigured into a circular system that uses fewer resources and is based on renewable technologies. The time for half measures has run out – as made plain by the 2018 IPCC special report on the impacts of a 1.5 °C rise in global average temperatures. That's why I chose to get arrested. That's why I am working now with local communities in Camden, London, to pioneer new forms of living that are consistent with the circular economy and with deep cuts in emissions including from products we import from other countries like China and India.

Talk of injustice, devastation, emergency and the need for radical change is far removed from the neutral vocabulary used by the scientific community. But these seemingly emotional terms now fit the facts – and they effect change. I'd rather be labelled ideological than mislead the public into complacency.

Many of my climate colleagues were surprised when I became an activist. But since my arrest, they have applauded what I, and thousands of fellow rebels, did in shifting the political discourse. Many others still question whether disruptive, mass civil disobedience is really necessary.

I believe it was and remains so. In large part, this is because it is producing the sorts of positive rapid result I could only dream of in my years of committee-sitting and draft-wrangling. We need to ramp up disruption because business as usual is not changing fast enough.

Disruptive force

Representatives of UK political parties on all sides congratulated XR for its festival-like actions that shut down large parts of central London. In just a year, XR put the need for global system change on the political map at the highest levels, confounding its detractors. In the United Kingdom, where XR was founded and is strongest, public support for climate action is now at record levels.

XR's political strategy team met separately with the UK government, the Mayor of London and the opposition Labour Party. On 1 May, Parliament passed a non-legally binding emergency motion that recognized the climate crisis. A month later, it legislated a legally binding target of net zero greenhousegas emissions by 2050, making the United Kingdom one of the first countries to do so. The date is nowhere near soon enough, but this fast-tracking would never have happened without XR's disruptive protests and the global student strikes on which they built, led by campaigner Greta Thunberg.

We need to value scientists and negotiators for the work they do. But we also need sustained, widespread, peaceful disruption and direct action. We as scientists need to also model the kind of behaviour change we are asking of others, but even more important is becoming more active in our profession and our local communities. Collectively, governments are way off their Paris commitments to keep temperatures well below 2°C and safer 1.5°C goal. We need to try a diversity of new tactics.

The old forms of campaigning and advocacy aren't working fast enough. Is it any wonder that frustration is mounting?

Youth protest

Students are leading the charge, calling young people and adults to join a global climate strike. Greta Thunberg rightly lambasted world leaders gathered at a crucial UN summit in New York City, convened by UN secretary-general António Guterres in September 2019. The UK government is not on track to meet its current legal obligations to cut emissions under the 2008 Climate Change Act. (It still subsidises fossil-fuel production and supports carbon-intensive investments in infrastructure, such as for a third runway at Heathrow airport.) This does not bode well for its ability to provide leadership ahead of the Glasgow summit.

In the United States, the global Green New Deal (GND) movement is gaining traction. It is supported by US senators Alexandria Ocasio-Cortez (Democrat, New York) and Bernie Sanders (Democrat, Vermont), as well as the youth movements Zero Hour and Sunrise, which share XR's demand for a break with current politics. It is also gaining traction in Europe.

These campaigns can only succeed if more people join in - including professionals, such as scientists. It is harder to

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dismiss protests that have a broad base of support. Long-sought change can come about unexpectedly quickly under the right conditions.

Understandably, many professionals are wary of endorsing campaigns, let alone taking direct action. I still share some of their trepidation. Being an activist can be emotionally and physically draining, requiring long meetings and careful coordination of strategies, tactics and systems of support. But the same can be said of working on UN negotiations: I've lost count of the number of all-night meetings I've attended, with some negotiations turning into 48-hour marathons.

Plus, activists can risk their lives, as so many do in highly illiberal nations. And being an activist can threaten livelihoods: in law, as in science, a person's credibility rests on perceived impartiality built through offering knowledge and advice in the form of books, peer-reviewed articles, policy reports and expert testimony. Not glue and placards.

For all these reasons, I anguished for a long time before thinking about getting arrested. For me being an activist is about much more than getting arrested. It is more about taking a stance and showing up for climate justice. It means not putting my identity as a migrant, a mother, a lawyer and concerned citizen into separate boxes and silos but tapping into all those identities and standing up for justice. And that means also lifestyle changes involving food, fashion, finances and flights for holidays

Deeds not words

The trigger for my leap into direct action was the release in October 2018 of the IPCC's grim special report comparing the impacts of a 1.5 °C change in global average temperatures with higher rises. It landed during a time of personal, political and professional despair, brought about by bereavement, burnout, Brexit, Trump's withdrawal from the Paris agreement, and more.

For so long, I'd trusted that government actions are essentially evidence-based, and that our 'normal' electoral cycles are messy but ultimately safeguard long-term national and planetary interests. Like every other scholar, I'd churned out papers and policy reports in the hope that these would be used by campaigners and heeded by politicians.

On behalf of the small island states, I had worked since 2008 to get the UN climate negotiations to acknowledge that a 2°C rise was too dangerous, and that it needed to enshrine the 1.5°C threshold demanded by the world's most vulnerable countries and ecosystems. Still emissions rise; still the rhetoric is "well below 2°C"?

Rethink and reset

What we need is not system change or personal change - it's both. Not street circus or government and industrial overhaul, but both. Not reform through revolution or the ballot box. Both.

The climate emergency we face now requires every one of us to question how we compartmentalize our professional, personal and political choices. That means acting differently in all three spheres and rethinking how to become audacious leaders in all aspects of our lives. Climate devastation demands us to be upstanders, not bystanders.

The era when we limited our jobs to researching, writing, presenting and throwing our reports over the 'policy fence', leaving it to campaigners and activists to implement their

conclusions, is over. Is working in silos and factions and fretting only about tenure, citations and the next research grant really the best we can do? Professionalism and impartiality must not require us to be indifferent to the fate of the world.

Now that I am 54 years old with considerable capital – economic, social and reputational – I have the freedom to speak out, as a lawyer, an activist and a mother. Like all parents, I'll do whatever it takes to keep my children safe. Right now, that means rebelling against a way of being that is destroying their future and by supporting activists, especially global youth strikers and frontline communities, to intensify their movements. Having power and status in the current system and refusing to challenge the rules hampers the co-creation of a better world. Building regenerative political communities – in which humans and nature co-exist – needs committed, courageous people to stand up for what they believe in, repeatedly, or a long time to come. I hope you join your local groups and set up your own 'Think and Do' space.

Set up your own Climate Think and Do Pop-Up!

I am often asked what are the most important steps individuals can take against the climate emergency? I say: join a movement, become an activist and get involved in politics. I am setting up Think and Do spaces to enable people to come together to make individual and collective change easier.

I think people should not be guilt tripped for not being able to live a zero-carbon life in a world that is saturated by carbon. I want industry and government to take responsibility for making it easier for me to live a greener, cleaner, healthier life based on climate justice principles. Having said that, I have made lifestyle changes focusing on the four 'Fs': Finance, Food, Flights and Fashion. I have switched my pension to ethical accounts. As a family, we have cut down on leisure flights and now travel by train and ferries. We have all switched our food to a mainly plantbased diet. I love fashion but no longer buy new clothes and get pleasure from upcycling and clothes swaps. I have found it easier to do these things as part of a local community that is thinking and doing things differently.

Setting up Camden's Think and Do Climate Pop-Up is helping create bonds and projects to create a nicer and more convivial local environment. The creation of a new civic space is a direct follow on from Camden's Citizens' Assembly on the Climate Crisis held in July 2019 which resulted in 17 recommendations. At its Full Meeting on 7th October, the Council unanimously agreed to take forward all these recommendations.

Phase one of Think and Do from October to December 2019 has seen a disused café on Kentish Town Road converted into a welcoming space accessible to all, including families and school children. Around 80 events, talks and workshops, ranging from tree giveaways to clothes swaps and talks on climate justice have been held to support climate action in Camden. Phase 2 is about spreading the Think and Do model to other communities in the UK and worldwide. You can find out more at: https://www.thinkanddocamden.org.uk/

Farhana Yamin is an international climate change lawyer. She was a lead author of three IPCC assessment reports from 1994–2007 (Working Groups II and III), and a lead negotiator for the Alliance of Small Island States helping to formulate the Paris Agreement in 2015.

Holding the UK to account for its role in the war in Yemen

Prof Anna Stavrianakis, University of Sussex, explains how UK arms exports to Saudi Arabia have helped fuel the world's worst humanitarian crisis, and examines efforts to stop these exports.

s US-Iranian relations take a dramatic turn for the worse with the US government's killing of Qassem Soleimani, and as British politics remains preoccupied with the results of the general election and Brexit, the prospects for the war in Yemen are looking increasingly bleak – and look set to continue to be ignored in mainstream British media and political debate.

Yemen death toll continues to mount

The latest round of war in Yemen, which has lasted nearly five years so far and shows little sign of abating, has a death toll that now exceeds 100,000 according to ACLED, the Armed Conflict Location and Event Data Project.¹ The Saudi-led coalition is responsible for the highest number of reported civilian fatalities - mostly from direct targeting in air strikes, conducted primarily with US- and UK-supplied weapons and accompanied by military and diplomatic support and advice. The latest UN Panel of Experts report² said individuals in the Saudi Arabian and UAE governments, as well as Houthi leaders, may be individually criminally liable for war crimes; and that arms-supplying states including the UK may be legally responsible if standards for complicity are met. The blockade of Yemen has pushed millions into famine, created an unprecedented cholera crisis, and helped destroy the infrastructure of Yemeni society. Despite strenuous UK government claims not to be a party to the war, the UK has long been intimately involved.³

Legal efforts to end UK arms exports

Where might accountability for the UK's involvement in the world's worst humanitarian disaster come from? One route is the law. Campaign Against Arms Trade (CAAT) launched a judicial review of government arms export policy, arguing that the government had failed to implement its policy that states it will not grant arms export licences where there is a clear risk that they might be used in serious violations of international humanitarian law. The case was first heard in the High Court in February 2017; in July of that year, the judges found in favour of the government. CAAT appealed, and a second hearing was heard at the Court of Appeal in April 2019. This time, the appeal judges found in CAAT's favour, deciding that the government had failed to assess whether there was a past pattern of breaches of international law, and therefore that its policy was "irrational".⁴ The government was ordered not to issue any new licences for arms exports to Saudi Arabia, and to re-take its past decisions. The government tried to downplay the verdict, presenting it as an administrative technicality; it also appealed, and won the right to an appeal, so the case will be heard in the



Bombing in the city of Sanaa, Yemen (Photo: iStockPhoto).

Supreme Court at some point in the future. The government has also since admitted "inadvertently" issuing new licences for weapons exports to the Saudi-led coalition that could be used in the war in Yemen.⁵ Pledging an internal investigation and a review by the Department of Work and Pensions, Secretary of State for International Trade Liz Truss also conceded that it is possible that more cases will come to light. No further word has come from government about its internal review of its processes, nor its legally mandated task of re-taking its past arms export decisions. The legal route is therefore rocky but ongoing.

Parliamentary efforts

In Parliament meanwhile, the announcement of a general election put an end to the last iteration of the parliamentary Committees on Arms Export Controls (CAEC). This is a socalled super-committee made up of members of the Defence, Foreign Affairs, International Development and International Trade Committees. The CAEC has not met formally since May 2019 and in the 2017-19 Parliament had refused to put the war in Yemen on its agenda, relying on a handful of active MPs to shoehorn Yemen and UK support for the Saudi coalition into the discussion at any available opportunity. The last Chair of the CAEC, Labour MP Graham Jones, was unashamedly pro-Saudi and pro-UAE in ways that stymied any reasonable interpretation of impartiality. The MP for Hyndburn, a Lancashire constituency that is home to many BAE Systems workers, Jones lost his seat in the election to Conservative Sara Britcliffe. The CAEC has yet to be re-established since the Conservative Party victory in the general election.

The role for engineers, scientists and campaigners

So the law and Parliament are ambivalent routes for accountability for Britain's involvement in the war in Yemen. They also sometimes feel remote to us as citizens, residents, workers and political beings. There are other routes that we can take as individuals – supporting organisations like Scientists for Global Responsibility and Campaign Against Arms Trade is one obvious

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example. There are also things scientists and engineers can do in a professional capacity: work as part of a trade union to break the link between arguments about jobs and government support for manufacturing and for STEM subjects in education and the uncritical support for military spending, military production, and arms exports that usually accompanies them. Conversations with colleagues and friends about what problems scientists' and engineers' considerable talents and skills should be oriented towards can repoliticise what has become depoliticised, namely the question of the end to which we apply our skills. These can be less formal actions, but alongside more traditional actions like writing to MPs to raise the profile of the war in Yemen, they can be effective in facilitating accountability for the UK's role in the war and the ensuing humanitarian disaster. Anna Stavrianakis is Professor of International Relations at the University of Sussex.

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Irresponsible engineering and science? How the fossil fuel and arms industries finance professional engineering and science organisations

Dr Stuart Parkinson summarises SGR's new report on the extensive financial links between some of the world's most controversial corporations and leading UK professional bodies in engineering and science. He argues that those links need to be severed if such bodies are to play a leading role in tackling the world's environmental and security crises.

The 'Big Bang Fair' – Britain's largest science and engineering event for young people – attracts 80,000 people a year. It is organised by EngineeringUK, the professional body charged with the promotion of engineering. So far, so good. But there's a catch. The 'lead sponsor' for 2020 – and indeed for *every year* since the fair's inauguration in 2009 – is BAE Systems, the biggest arms corporation outside of the USA, a leading supplier of strike planes to the Saudi Arabian military – whose bombing raids have killed so many civilians in Yemen (see p.15) – and the lead contractor for the new UK's new nuclear-armed Dreadnought submarines.

Sadly, this is not an isolated case of significant financial links between some of the world's most controversial corporations and the UK's professional bodies in engineering and science. Other examples are provided by the school education programmes run by the Royal Academy of Engineering, the nation's most prestigious engineering body. Data published in the academy's own annual report showed that over 70% of the external funding it received for its recent school education programmes was from fossil fuel corporations. Furthermore, almost all of the downloadable teaching resources provided by the academy on its website involved arms corporations, the armed forces and/or promoted military technologies.

Then there's the Energy Institute, the professional body for those working across the energy supply and demand sectors. Its most high-profile activity each year is 'International Petroleum Week' - one of the world's biggest events for the oil and gas industry, generating income for the institute measured in the millions of pounds. Recent sponsors included Rosneft, Russia's controversial state-controlled oil company.

These are some of the findings of SGR's new report¹ on the financial links between the fossil fuel and arms industries on the one hand, and some of the UK's leading professional engineering and science organisations on the other. The range and extent of the links has not been acknowledged or recognised until now.

The scope of SGR's research

Professional engineering and science organisations (PESOs) – which include professional institutions and learned societies – play a very important role in modern society, setting standards of conduct and providing leadership for scientists and engineers. As such, PESOs help the world gain a wide range of important social and environmental benefits. Yet society is also facing enormous threats created by the irresponsible use of science and technology. These threats include the global climate and air pollution crises, as well as the resurgent nuclear arms race, increasingly brutal conventional wars fuelled by the international arms trade, and growing risks from cyber and robotic weapons. At the centre of these problems lie very powerful fossil fuel and arms corporations. Yet the financial and institutional links between these industries and PESOs have rarely been investigated in depth.

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SGR's study sought to fill this gap. We uncovered a wide range of financial relationships between PESOs and the fossil fuel and arms industries, and critically examined these links. To do this, we investigated a sample of 20 leading PESOs, all based in the UK, but many having international memberships. We focused on four main financial links – funding of school education programmes; investments; event sponsorship; and corporate membership schemes – as well as other areas in which we could find data. We also looked at relevant organisational policies, especially charters, mission statements, investment policies, and environmental statements. We used publicly available sources, such as annual reports, financial statements, and organisational websites. We found in many key areas that transparency was very poor, which was especially disappointing given that openness is a cornerstone of scientific work.

We rated the degree of financial involvement of the PESOs with the fossil fuel and arms industries from 'none' to 'very high' in each of the main areas of the PESO's work. The rating was based on the how the proportion of funding in these areas compared with the proportion of UK engineering and science professionals directly employed by those two industrial sectors. (The report discusses the methodology in more depth.)

Numerous financial links

The main findings of our study are as follows.

School education programmes

Nine PESOs in this study published teaching resources or ran school education activities that were sponsored by or otherwise directly involved fossil fuel or arms corporations. In most cases, details of the relationships were not transparent and we could only find very limited information on the specific financial links between those education programmes and the corporations concerned.

We concluded that three PESOs ran school education programmes which had 'high' or 'very high' levels of involvement with either the fossil fuel industry, the arms industry or both – the Royal Academy of Engineering, EngineeringUK, and the Energy Institute. In addition to the examples above, EngineeringUK has received funding of at least £1m from Shell for its programme, 'Tomorrow's Engineers'. Meanwhile, the Energy Institute has a history of providing education materials sponsored by fossil fuel companies.

Investments

As we were launching the report, *The Sunday Times* helped us extract data on the investments held by the Royal Society (which they had failed to provide us when asked). The Society admitted that it held a minimum of £16 million in the fossil fuel industry, and that the actual holdings could be a lot higher.²

We also concluded that four PESOs held 'very high' levels of investments in the fossil fuel industry – the Energy Institute; EngineeringUK; the Institute of Physics; and the Royal Statistical Society.

The transparency of investments was generally very poor. Indeed, the disclosure was so inadequate that we were unable to determine whether any PESOs held high levels of investments in the arms industry.

Of 20 PESOs studied, only one - the British Psychological Society - had an ethical investment policy which restricted investment in the fossil fuel or arms industries. Five other PESOs held no investments in these industries due to their practice of not holding investments listed on stock exchanges or similar. These five were: the Association for Science Education; BCS - The Chartered Institute for IT; the Institution of Environmental Sciences; the Institution of Structural Engineers; and the Science Council.

Events sponsorship

We concluded that:

- three PESOs received a 'very high' level of events sponsorship from the fossil fuel industry - the Energy Institute; the Geological Society; and the Royal Academy of Engineering. Apart from the Energy Institute's International Petroleum Week discussed above, other examples included: BP being a sponsor of the Royal Academy of Engineering's prestigious annual dinner for at least three years in a row; and nearly 90% of the external sponsors of the Geological Society's events being from the fossil fuel sector.
- five PESOs received a 'high' or 'very high' level of events sponsorship from the arms industry – the Institution of Engineering and Technology, the Royal Academy of Engineering, the Institute of Physics, the Institution of Mechanical Engineers, and EngineeringUK. Industrial sponsors of these organisations' most prestigious events included some of the largest and most controversial corporations including BAE Systems, the Atomic Weapons Establishment, and Lockheed Martin.

Corporate membership and other relevant links

We concluded that:

- three PESOs had 'high' or 'very high' levels of other financial or institutional links with the fossil fuel industry – the Energy Institute; the Geological Society; and the Royal Academy of Engineering. For example, 70% of the Geological Society's corporate members were from the fossil fuel sector, while the Engineering Teaching Fellowships run by the Royal Academy of Engineering were funded by ExxonMobil. The Energy Institute's president was, until 2019, a former managing director of Shell.
- three PESOs had 'high' or 'very high' levels of other financial or institutional links with the arms industry – the Institution of Engineering and Technology; the Royal Academy of Engineering; and EngineeringUK. For example, among the Institution of Engineering and Technology's major donors were BAE Systems, Thales and Airbus.

Other relevant issues

Seven PESOs in our study stood out due to the *positive* extent of their environmental policies and practices: the Chartered Institute of Environmental Health; the Engineering Council; the Institute of Physics; the Institution of Civil Engineers; the Institution of Environmental Sciences; the Institution of Mechanical Engineers; and the Royal Meteorological Society.

Virtually none of the PESOs in our study regarded the ethical issues related to arms industry and peace issues more broadly as worthy of policy or activity – not even in relation to school education programmes.

Further detail is provided in the main report, with in-depth material given in a set of 20 case studies – one for each PESO – available as appendices to this report on the SGR website.

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Next steps for PESOs

For ethical and reputational reasons, we argue that professional bodies should both be much more transparent about their income from corporations, and take concerted action to eliminate their financial links with the fossil fuel and arms industries. A priority should be to immediately end all sponsorship of school education programmes by these controversial corporations. Another priority is to commission educational materials which discuss the full range of ethical issues related to the exploitation of fossil fuels and the development and use of military technologies. Some of the PESOs do provide educational materials which discuss environmental issues relevant to their profession, but there are many gaps. A further step which could be taken is to examine the extent to which the policies and practices of their organisation and profession are consistent with the Paris climate targets.

These actions would allow the professional organisations to properly fulfil their goal of providing responsible leadership for the science and engineering community, and help accelerate urgently needed action to tackle the enormous environmental and security problems currently facing the world.

Signs of change

One thing I've noticed in the more than 30 years that I've worked in the science and engineering professions is that PESOs do not tend to act quickly. However, there are recent signs of change. After pressure from members, the British Psychological Society published, in late 2018, an ethical investment policy which excludes fossil fuel companies and most arms companies.³ In early 2020, the Royal College of Physicians announced it would accelerate its divestment from fossil fuel companies.⁴ The Royal Statistical Society recently agreed to increase its investments in 'globally sustainable' companies (although it has yet to exclude fossil fuel companies from its portfolio).⁵ Also, following the publication of our report, Prof Bill McGuire – a member of the Geological Society for over 40 years – resigned in protest at the organisation's continued financial links to the fossil fuel industry, and urged other members to follow suit.⁶ He became a patron of SGR shortly afterwards (see p.3).

We are planning more campaigning to reform PESOs over the coming months. If you are a member of a professional engineering or science organisation and want to help, please get in touch via email – **info@sgr.org.uk**

Dr Stuart Parkinson is Executive Director of Scientists for Global Responsibility, and lead author of the report, Irresponsible Science?

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Dr Stuart Parkinson, SGR, assesses the latest data on the huge carbon emissions of the world's militaries – and argues that only reductions in military spending will lead to the necessary cuts in this form of pollution.

n 1997, international climate negotiations led to the agreement of the Kyoto Protocol, which set carbon emission reduction targets for industrialised nations for the first time. However, one of many compromises made to bring this treaty into being was that the emissions of military forces would be excluded from these targets. As US lead negotiator, Stuart Eizenstat, later stated, "We took special pains, working with the Defense Department... to fully protect the unique position of the United States as the world's only super power... We achieved everything they outlined as necessary to protect military operations... At Kyoto, the parties, for example, took a decision to exempt key overseas military activities from any emissions targets, including exemptions for bunker fuels used in international aviation and maritime transport and from emissions resulting from multilateral operations." In 2015, negotiations led to Paris Climate Agreement, which limits the carbon emissions of all signatory nations. Under the operating rules of the treaty, military carbon emissions may be excluded – but the decision is left to individual countries.²

With military vehicles such as warships, fighter planes, tanks etc being major consumers of fossil fuels – see Table 1 – this leaves a significant hole in the control of greenhouse gas emissions. But how large are military emissions in total?

Table 1 – Carbon emissions of selected military vehicles³

Vehicle	Fuel efficiency (miles per gallon)	Carbon emissions per mission (use only)
HUMVEE (armoured truck)	6 mpg	260 kgCO ₂ e
F-35 (combat plane)	0.6 mpg	27,800 kgCO ₂ e
B-2 (nuclear-armed plane)	0.3 mpg	251,400 kgCO ₂ e

For comparison, the average new UK diesel car is rated at nearly 60mpg.⁴

Estimating US military carbon emissions

With there being no requirement to control military carbon emissions at a national level, many governments adopt the position that it is not necessary even to calculate them. This means it is very difficult to estimate how large the problem is – which is convenient for the world's militaries. However, some countries do publish data on the energy consumption/ fuel use of their militaries, and some even publish data on the carbon emissions of their military activities. From this, it is possible to start to estimate the size of the problem.

The place to start is the world's largest military - that of the USA. While the government does not publish data on military carbon emissions, data on military energy consumption - both fuel consumption of vehicles and energy consumption of military installations - is available. Using this, Prof Neta Crawford, in a report published recently by Brown University, has estimated total carbon emissions of the US military from 2001 to 2017.⁵ So, in 2017, these stood at 59 million tonnes of carbon dioxide equivalent (tCO₂e) - equivalent to the total emissions of an industrialised country like Sweden or Switzerland.⁶ Military bases and other installations were responsible for 40% of the emissions, with fuel use in military operations being responsible for 60%. These emissions included those from the network of hundreds of military bases that the USA operates around the world - although there is serious concern that the quality of data from many of these bases is poor. Crawford concluded that the US Department of Defense (the Pentagon) was the largest institutional consumer of petroleum products in the world.

But these emissions are only part of the story. We also need to count the carbon emissions of, for example, the arms industry that produces all the military equipment, the extraction of the raw materials used by this industry, and the impacts when the military equipment is used, i.e. in war. Table 2 summarises what I define as the 'military carbon boot-print', that is, the total emissions including all aspects related to military operations.

Data on the full range of military carbon emissions is much more sparse, and that which is published is more uncertain. Methodologies in some areas – such as war-related impacts – have yet even to be clearly defined. Some data does exist though for the arms industry and its supply chain. Again, Neta Crawford has produced estimates for the USA.⁷ For 2017, she calculated a total of 280 million tCO_2e (although this is only a rough estimate).

Table 2 – Components of the 'military carbon boot-print'

Roi act dor	utine ivities – mestic bases	Routine activities – foreign bases	War- fighting	War impacts (key examples)
	Production of military equipment 1. Raw materials 2. Supply chain 3. Final assembly			Post-conflict reconstruction
	Milii 1. 3. Was	ta ry bases etc Energy use 2. Food te management		Health care for survivors (civilian/ military)
	2. M 3. L	/ehicle use 1. Aircraft larine vessels .and vehicles		(Oil) fires caused by weapons-use Deforestation during conflict

Hence, we have a total of nearly 340 million tCO_2e for militaryrelated carbon emissions for the USA, approximately 6% of the national total.⁸ This figure includes a majority of the categories in the left-hand columns of Table 2, but none of those in the righthand one.

What about UK military carbon emissions?

The UK publishes much more data on its military carbon emissions than the USA. Direct emissions from 'military aircraft and shipping' are also included as a category in the national inventory, and thus the country's reduction targets include the sector.⁹ Carbon emissions data can be found in the annual government publication, *Sustainable Ministry of Defence*.¹⁰ The latest issue – for 2017–18 – provides a number of figures for the carbon emissions of different components of the UK military, but unfortunately does not give an over-arching total. Based on the data provided in the report, I have calculated this total to be 3.2 million tCO₂e.

In order to assess the emissions of the arms industry and its supply chain, we could look at the 'corporate responsibility' reports of the main suppliers – such as BAE Systems and Rolls-Royce. However, this would only include the direct emissions of those companies themselves and not the supply chain or raw materials. To estimate a total figure, I drew upon a carbon footprint methodology used by one of the leading researchers in this field, Prof Mike Berners-Lee of Lancaster University. He has used input-output economic models to estimate the carbon footprint of industrial sectors and areas of governmental spending.¹¹ In the case of the UK military budget, this leads to a total carbon footprint of 13 million tCO₂e, or 3% of the national total.¹²

The global military carbon boot-print

Estimating a global total for military carbon emissions is even more difficult. Nations which are members of the Organisation

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for Economic Co-operation and Development (OECD) – which includes most of the world's industrialised democracies – routinely publish data on energy consumption and economic activity. This can be used to estimate military carbon emissions, if the governments concerned have not compiled their own estimates. Many of these countries tend to spend a lower proportion of national income on their militaries than higher spenders like the USA or UK. However, many of the world's other large military spenders – such as China, Saudi Arabia, Russia and India – are much less transparent. And these are the economies which are also often heavily based on fossil fuels. Hence their military spending is likely to be significantly more carbon intensive.

Based on the data that I have examined and the calculations that I have carried out for this article and previous SGR outputs on this issue,¹³ I estimate that the carbon emissions of the world's armed forces and the industries that provide their equipment are in the region of 5% of the global total. But this does not include the carbon emissions of the impacts of war – the right-hand column in Table 2 – covering sources such as fires, deforestation, health care for survivors, and post-conflict reconstruction. In a high emissions year – such as 1991 when fires raged in the Kuwaiti oil fields – this could be as high as 1%.¹⁴ So the total military carbon boot-print could be 6%. As such, this would make it a more polluting sector than, for example, civil aviation. And, of course, we should not forget all the other profoundly negative impacts of war...

At this point, it is worth asking what the Intergovernmental Panel on Climate Change (IPCC), the UN's scientific advisory body, has to say on the subject of military carbon emissions. The answer is: nothing of significance. In its latest in-depth assessment report, published in 2014, the only mention of the carbon emissions of the world's armed forces, or the industries that manufacture their weapons and other equipment, was in an annex which mentioned military activities which emitted some minor greenhouse gases – without giving any figures.¹⁵

Reducing military carbon emissions

While detailed data on military carbon emissions is distinctly lacking, it is noticeable that there are numerous military initiatives – at least in North America and Western Europe – which are helping to reduce these emissions. These include improving the energy efficiency of military vehicles, increasing the military use of electricity from renewable sources, and/or reducing carbon pollution more generally. Indeed, the current shift towards greater use of smaller, more fuel-efficient robotic aircraft – drones – as replacements for crewed military aircraft can lead to a reduction in military emissions.

Neta Crawford's data indicates that a significant proportion of the recent reductions in US military carbon emissions has been due to these types of changes, as well as a (current) reduction in large-scale overseas operations. It should also be understood that the arms industry and its supply chain are, in standard carbon emissions accounting, classified as part of the civilian economy, and hence subject to national targets.

However, while reductions in the carbon emissions of some armed forces and some arms corporations are welcome, we should be wary of a reliance on initiatives such as these. The title of a recent report by the US Defense Science Board gives away the real intention of such programmes – *More Fight, Less Fuel.*¹⁶ If the motivation is mainly to fight war more

efficiently, the rationale of these programmes is dangerous and misguided.

According to the IPCC, "Climate change can indirectly increase risks of violent conflicts by amplifying well-documented drivers of these conflicts such as poverty and economic shocks".¹⁷ The key to real reductions in military carbon emissions is thus to shrink the huge military budgets around the world – which totalled more than \$1,800 billion in 2018.¹⁸ And the key to shrinking these budgets is to reduce military tensions. So, rather than looking for new, lower carbon ways to fight wars, our governments should be prioritising measures such as diplomacy, international disarmament treaties, fair trade, poverty alleviation and, of course, reductions in carbon emissions right across the economy. Only then can we confidently achieve a more secure world.

Dr Stuart Parkinson is Executive Director of Scientists for Global Responsibility. He holds a PhD in climate science, and has been an expert reviewer for the IPCC.

This article is based on a presentation given at a conference organised by the Movement for the Abolition of War in June 2019.

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Bio-methane: a sustainable future for gas?

With the government having announced a moratorium on fracking, attention is at last turning to alternative sources of methane in the UK. **Wiebina Heesterman** outlines the science and technology of anaerobic digestion, while **Stuart Parkinson** gives a brief overview of the potential of bio-methane to meet UK demand for gas.

Anaerobic digestion: power from waste

High on the Malvern Hills in central England stands a street lamp, powered by dog poo. It is an area favoured by walkers, many of whom bring their four-footed companions. Actually, it is the methane obtained from the dog waste that fuels the light.

Any organic material can be turned into methane by the action of microbes. If all discarded food waste were to be used as feedstock for the anaerobic digestion (AD) process, hopefully sufficient methane would be generated in the UK to make the resumption of fracking unnecessary. This latter process is rightly condemned as wreaking havoc on people's living space and the environment in general, while reportedly leading to large methane leaks.¹ As methane is a potent greenhouse gas, as well as being highly flammable, minimisation of such leaks is essential.

Many facilities already utilise methane derived from organic waste. Instead of needlessly and dangerously venting from landfill (as shown in the picture), bio-methane is being used to drive buses, heat homes and provide power for all kinds of activities.

Generation of gas by AD is an old technology, forgotten and long regarded as obsolete because of the availability of cheap fossil gas. However, in recent years the situation has reversed. By late 2019, 102 digesters out of 661 in the UK were equipped to refine biogas generated from organic waste into methane suitable for injection into the national gas grid – a more than 13-fold rise from 2017.² As to the future of AD, corporate members of the World Biogas Association have expressed their commitment to reduce global carbon emissions by 12%. According to a report from the Anaerobic Digestion and



Biogas from landfill is often vented (Photo: Wiebina Heesterman).



Biogas-fuelled street-light (Photo: Wiebina Heesterman).

Bioresources Association (ADBA), UK emissions have fallen by 1% because of the activities of the AD sector, and the association estimates that given government support a further 5% by 2030 would be achievable.³

Bio-methane is widely used in transport, especially in Sweden where a train and well over 38,000 other vehicles run on bio-methane.⁴ Bristol too has its methane buses.

The range of potential feedstock is vast. Farm waste was the first substance to be subjected to the digester treatment. Soon many sewage companies began to make use of bio-digestion to fuel their operations and sell the left-over methane to the grid. All kinds of food waste, even rather unexpected liquids such as whey and ice cream residue, are being used as input. To date just 50 local authorities in the UK include kitchen waste in the weekly refuse collection as well as green waste, which tends to be composted rather than given the AD treatment. So far local authorities are reluctant to include pet poo in their regular collections because of potential parasite contamination. Nevertheless, a Canadian town is able to power 13 homes with it, collected separately from receptacles in local parks.

How does AD work?

After an initial stirring to remove any contaminants, the mixture of organic waste is decanted into an oxygen-excluding digester vessel. Then it is heated to a temperature of 30 to 50°C, and sometimes higher. The real work is done by microbes, generally part of the original input, although others may be added to speed the process.⁵

These microbes consist of bacteria and archaea: both unicellular microbes lacking a nucleus.⁶ Archaea differ in that they are able to thrive in extreme temperatures⁷ and conditions of high acidity and salinity.

There are four stages to the process of generating biogas:⁸

Hydrolysis: water molecules break the bonds which hold organic polymers together thereby exposing the substances to bacterial action.

Acidogenesis: certain bacteria convert sugars and amino acids into carbon dioxide, hydrogen, ammonia and organic acids.

Acetogenesis: these substances are converted into acetic acid, plus some more ammonia, hydrogen and carbon dioxide by different kinds of bacteria.

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Methanogenesis: archaea convert this mixture into biogas.

The result is a mixture of methane (50 to 75%),⁹ carbon dioxide, water vapour and pollutants such as ammonia and hydrogen sulphide (H₂S). Biogas may be used to provide combined heat and power for inclusion in the electricity grid or to manufacture power cells.

Further treatment is necessary to separate the constituent parts of the biogas to produce methane for injection into the gas grid. The International Energy Agency (IEA) describes different methods.¹⁰ In essence it involves the use of mechanical means to remove any impurities, such as the carbon dioxide, which may still be put to some use or sequestered underground.¹¹ In the end a solid residue is left, the digestate, which is in high demand as an organic fertilizer.

Biogas and energy crops

One energy provider intends to provide 'green gas',¹² generated from grass clippings from clover-rich meadows. As these will be rotated with fields sown with food crops, it results in the stimulation of food production as well as providing energy. Similarly, making use of grass for AD, cut from roadside verges once wildflower seed has been allowed to disperse,¹³ serves to enhance biodiversity.

The advantage of transforming waste into energy, is patently obvious: replacement of fossil fuels as well as the reduction of the energy footprint of waste treatment plants, thereby forming an important part of a zero-waste initiative. Regrettably several European AD plants still run on specially grown energy crops, a fact that gives the term 'biofuel' a bad press. Fortunately measures to restrict the practice are being introduced.¹⁴ We might wonder whether composting food waste and using

The potential for bio-methane

Bio-methane – derived from anaerobic digestion of organic waste and processed as described in the main article – has a very large potential as a fuel for power stations, homes and businesses in the UK. For example, a 2017 industry study concluded that enough biogas could been generated potentially to heat 15 million homes.¹⁶ The energy company Ecotricity estimated a similar potential from digesters fed only by sustainably-harvested grass cuttings.¹⁷ Approaching the issue from a different direction, Professor Keith Barnham, Imperial College London, argued that simply using the bio-methane that could be produced from the 200 tonnes of food wasted in the UK each year due to inadequate refrigeration would be enough to back up a UK electricity grid otherwise supplied by wind and solar power.¹⁸

Some large-scale scenarios, however, rely on the use of energy crops and there are potential land-use conflicts with food crops and wildlife habitats. A key solution here is to rotate food crops with clover and/or grass. Then, for example, the grass cuttings can be fed into a digester and the solid by-product be returned to the land as fertiliser for the next season's food crops.¹⁹ A similar rationale applies to grass cut from roadside verges after wildflowers have been allowed to set seed.²⁰

Dr Stuart Parkinson is Executive Director of SGR, and has written widely on energy and environmental issues.



Ecotricity's 'Green gas mills' (Photo: Ecotricity - with permission).

roadside hay cuttings to restore wildflower meadows¹⁵ could be preferable to converting them to fuel? But why not do both? Personally, I'm infinitely cheered by the thought that my shower is being powered by grass clippings when my solar thermal panel doesn't oblige.

Dr Wiebina Heesterman is co-author of the book Rediscovering Sustainability: Economics of the Finite Earth and has written widely on environmental issues.

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Is your pension fund wrecking the planet?

Dr Emily Heath, Ethics4USS, appeals to academics and others to support the campaigns to divest our pension funds from fossil fuels and other unethical industries.

alf of all the money in the world is invested via pension funds: £3 trillion in the UK alone.¹ Diverting these funds from harmful to beneficial uses is a powerful way to change the world. What progress has been made by divestment campaigns, and how can we apply more pressure to unethical pension funds, such as the Universities' Superannuation Scheme (USS)?

USS holds assets worth £70 billion on behalf of its 420,000 members from mainly pre-92 universities.² More than £1.1 billion is invested in fossil fuel extraction, and USS also has significant holdings in airports and airlines.³ The retirement savings of university staff are exacerbating the climate crisis, putting lives at risk.

The global fossil fuel divestment movement is growing rapidly, stigmatizing the world's biggest polluters and accelerating the transition to a low-carbon society. By September 2019, 1,115 institutions worldwide, worth over \$11 trillion, had broken their ties with the fossil fuel industry.⁴ These institutions include sovereign wealth funds, banks, insurance companies, local authorities, pension funds, universities, charitable trusts and faith groups. This is a fantastic achievement!

However, USS remains resistant to divesting, despite a longrunning campaign for it to invest ethically. The Ethics4USS campaign is led by academics, and has close links with organisations such as ShareAction, National Union of Students, University & College Union (UCU) and People & Planet. Recent tactics have included petitions, formal complaints, meeting with USS representatives and protesting at USS AGMs.

USS's approach to responsible investment doesn't exclude investment in unethical industries, but aims to influence companies through shareholder engagement. However, USS's voting record is worrying. At the Royal Dutch Shell AGM in 2018, USS voted against a shareholder request to publish targets consistent with the Paris Climate Agreement goal of limiting global warming to no more than 2°C. At the Lundin Petroleum AGM in 2017, USS voted for the reappointment of two senior executives who were, and still are, under investigation for aiding and abetting war crimes in Sudan between 1997–2003.⁵

In the past, fossil fuel companies have been attractive for pension funds, producing high levels of dividends even if the value of the company (the share price) is relatively static. However, the rapidly growing climate emergency changes everything. Uncontrolled climate change brings social and economic chaos, increasing levels of risk for all investments. And as the world transitions away from fossil fuels, companies like Shell will lose value, as they will be lumbered with stranded assets and, perhaps, made to pay compensation for their reckless pollution and history of funding campaign groups which have undermined climate science.⁶

USS has a main 'Defined Benefits' (DB) fund, and in 2016 it launched a suite of 'Defined Contributions' (DC) funds. Members who are making additional voluntary contributions, or who are earning more than £59k, can choose which of these to pay into. A very good ethical investment policy is applied to some of these optional DC funds. They are performing well, suggesting that a wider roll-out of USS's ethical investment policy would benefit USS members as well as the planet. So far, only a small proportion of USS members have actively chosen to invest in an ethical fund⁷ rather than the default (unethical) DC fund, although a large majority of members say that they are interested in ethical investment in USS member surveys.

USS has a poor track record of listening to its members. Only three of USS's twelve non-executive trustees are nominated by UCU, directly representing the employees and pensioners for whom USS exists. Around a quarter of USS staff are paid in excess of £100k, with annual pay and bonuses of £1.75m for each of the two highest-paid executives, and an appalling gender pay gap of 41%.⁸ USS recently sacked a UCU-nominated trustee - Prof Jane Hutton - after she blew the whistle on the lack of transparency in the pension fund valuation.⁹ This valuation lies at the heart of an ongoing dispute which prompted UCU members to strike for 14 days in 2018 and eight days in 2019, with more strikes likely in 2020.¹⁰ Ethics4USS supports UCU in calling for USS to reform its governance and be more accountable to its members.

Ethics4USS is campaigning for USS's main (DB) fund, and the default option for the DC fund, to be invested ethically. We are determined to succeed in 2020!

What you can do

If you are a USS member, please support the Ethics4USS campaign and get active:

- Join our newsletter mailing list at https://divestuss.org/
- Follow @DivestUSS on Twitter
- Contact ussdivest@gmail.com to join our steering group.
- If you have any DC ('Investment Builder') funds, choose one of the ethical options – this is easy to do via My USS, http://www.uss.co.uk
- You can also join USS's discussion forum: http://www.uss. co.uk/members/members-home/member-voice - and use every opportunity to demand an ethical pension.
- In a different pension scheme? Find out where your money is invested and what you can do to make it ethical: https://shareaction.org/pensions
- Check whether your bank and electricity and gas providers are funding the climate crisis – and switch if they are: https://campaigncc.org/timetoswitch

Dr Emily Heath is the University and College Union branch secretary at Lancaster University and a steering group member of Ethics4USS.

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Challenging the demise of nuclear arms control

Key nuclear weapons treaties are being discarded, as the world's nuclear powers 'modernise' their arsenals. Where should campaigning be focused? asks Stuart Parkinson, SGR.

In the last two years, two major nuclear arms control treaties have effectively been discarded. In 2018, the USA pulled out of the Iran nuclear accord and, in 2019, the USA and Russia withdrew and thus dissolved the Intermediate-range Nuclear Forces (INF) treaty. Treaty negotiations between the USA and North Korea have also stalled. In 2021, we could see the demise of New START, the only remaining treaty restricting US and Russian nuclear weapons, if negotiations don't proceed this year. Furthermore, hopes for a positive outcome to this year's review conference of the Nuclear Non-Proliferation Treaty (NPT) are not high. The US government – often backed by the British – is keen to blame others for the resulting increase in the threat of nuclear war, but the evidence shows that Donald Trump's damaging role has been central.

Trump and nuclear weapons

One of the most disturbing aspects of the Trump presidency is his attitude to nuclear weapons. He has insisted that the USA should be "at the top of the pack" in terms of nuclear capability and has criticised and undermined safeguards preventing potential use of these weapons.¹ This has led to four very dangerous effects. Firstly, US spending on nuclear weapons – already huge – has further increased. Secondly, American policy on the use of these weapons – as laid out in the 2018 Nuclear Posture Review² – has expanded the circumstances in which they might be used. These two effects have combined to generate a third problem – that smaller "more usable" nuclear weapons are now being developed and deployed. Hence, at the end of 2019, a new 'low-yield' warhead, the W76-2, was carried for the first time on a US submarine.³ Fourthly, the Trump government has sought to dismantle nuclear arms control treaties.

Trump first took aim at the Iran nuclear accord – more formerly known as the Joint Comprehensive Plan of Action (JCPOA).⁴ This treaty greatly restricted Iran's ability to produce fissile material that could be used in nuclear weapons in return for relief from economic sanctions. The deal was agreed in 2015 between Iran, USA, Russia, China, France, Germany and the UK. Iran's compliance was being certified by the International Atomic Energy Agency which reports to the UN. But the USA withdrew in 2018 – Trump having called it a "very bad deal" – and re-imposed sanctions. The other parties disagreed and initially sought to protect the deal. However, following the US assassination of Iranian general Qassem Suleimani in January, the Iranian government decided it no longer had anything left to gain by sticking with the controls set out in the deal. Boris Johnson has since supported Trump's position that a new agreement is needed.

The INF treaty was agreed in 1987 between Presidents Reagan and Gorbachev, and led to the elimination of an entire class of ground-based nuclear weapons – those with ranges of between 500 and 5,500km.⁵ Nearly 2,700 missiles were removed and destroyed under the auspices of the treaty – famously including US cruise missiles deployed at Greenham Common, as well as their Russian equivalent. However, the treaty had been under strain due to NATO's expanding ballistic missile defence system and new Russian 'SSC-8' cruise missiles. The treaty included a dispute resolution mechanism designed to deal with such problems, but this was not enough for Trump who ordered US withdrawal – and this was completed in August 2019. Russia immediately followed suit. NATO, including the UK, supported Trump's decision.

The only treaty left which restricts the size of US and Russian nuclear forces is the New Strategic Arms Reduction Treaty or 'New START'.⁶ This was signed in 2010 by Presidents Obama and Medvedev, and limits the numbers of deployed warheads and bombs held by each side to 1,550. It will expire in February 2021 if agreement on an extension is not reached by then. President Putin has publicly stated his support for an extension – but Trump has not.

Challenging the nuclear weapons states

The behaviour of the president of the country with the world's largest military is setting the standard for the other eight nuclear weapons states. Nuclear weapons 'modernisation' programmes are in full swing in all of them, including obviously the UK with its Trident renewal programme. Furthermore, all eight are showing little enthusiasm for nuclear arms control treaties.

However, non-nuclear weapons states are challenging this highly dangerous situation – as are a growing number of regional and local governments, campaigners, scientists, engineers and others. At the time of writing, 35 nations have ratified the 2017 Treaty on the Prohibition of Nuclear Weapons (TPNW).⁷ This treaty will come into legal force when 50 nations have done

⁸ Ibid.

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so - which is expected later in 2020. A total of two-thirds of the world's nations now support the TPNW.⁸ Regional and local governments are also endorsing the treaty. In the UK so far, eight local councils have pledged their support, including Edinburgh, Manchester and Oxford.⁹ While the TPNW obviously won't apply to countries that have not agreed to join it, the treaty nevertheless establishes a strong new legal norm against nuclear weapons. Furthermore, signatory nations are also forbidden from providing support - including financial - to nuclear weapons states. This will, for example, restrict some banks from investing in or lending to arms corporations involved in nuclear weapons programmes.

Public support for nuclear treaties – including from scientists and engineers – is crucial. This includes writing letters to science magazines and politicians, taking part in demonstrations, and excluding arms corporations from your pension and other investments. ICAN is leading the international campaign in support of the TPNW – and its UK partners, including SGR, are building support here. In the short term, we also need to pressure Boris Johnson into supporting the Iran nuclear accord and New START. The time for action is now! Dr Stuart Parkinson is executive director of Scientists for Global Responsibility, and has written widely on nuclear weapons issues.

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OBITUARY: Edward Cullinan, 1931-2019

Leading architect, Edward (Ted) Cullinan, patron of SGR and, before that, sponsor of Architects and Engineers for Social Responsibility (AESR) and Architects for Peace (AfP), has sadly died aged 88. Ted was very influential in his profession, being awarded the Royal Gold Medal by the Royal Institute of British Architects (RIBA) in 2008, followed later by a CBE, for his ground-breaking work in architecture.

In 1951, Ted began his studies at Cambridge University, followed by periods at the Architectural Association School of Architecture in London, and the University of California at Berkeley. He set up in private practice in 1959, then converted this into a co-operative six years later. Following his socialist principles, no one in the office was to earn more than three times the salary paid to anyone else.

In the early 1960s, he and his wife, Roz, built by hand what was to be their life-long family home in Camden, north London. The design put great emphasis on energy conservation, long before it was fashionable, and they effectively created an early example of a passive solar house. The house is now a listed building.

His early career involved work on buildings at the University of East Anglia and Cambridge University. Later he broadened out into a wide range of other architectural work, including houses, schools, conference centres, care homes, museums and commercial buildings. Among his most noteworthy buildings were:

- Minster Lovell Conference Centre, Oxfordshire;
- Uplands Conference Centre for the Nationwide Building Society, Buckinghamshire;
- Fountains Abbey Visitor Centre, North Yorkshire;

- University of East London, Docklands Campus;
- Downland Gridshell, Weald and Downland Living Museum, West Sussex;
- Centre for Mathematical Sciences, Cambridge University;
- Maggie's Cancer Care Centre, Newcastle.

Several of these are now Grade II-listed.

One building that has attracted particular praise is the Downland Gridshell, a 21st-century 'organic cathedral', shaped in a Sussex dell from oak and red cedar. It has been described as follows. "A workshop for conservation and training in the preservation of historic timber-framed buildings, this low-energy and wholly enchanting building was a work of engineering, craft, architectural and landscape sorcery. Small wonder festivals and weddings are held there."*

As well as being a socialist, Ted was a keen supporter of the Campaign for Nuclear Disarmament. He joined and became a sponsor of AfP in the early 1980s, and continued his support throughout the future mergers which eventually led to his role as a patron of SGR. In 2012, his offices hosted SGR's 20th anniversary 'strategy day', and he personally introduced the day, inspiring all who attended.

Ted's exemplary professional work was recognised with the awards of the RIBA Royal Gold Medal and a CBE, but his belief that architecture should provide a range of social and environmental benefits, while also supporting a more peaceful world, are every bit as important. He will be sadly missed.

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The ice at the end of the world: an epic journey into Greenland's buried past and our perilous future

Jon Gertner; Icon Books; 2019; ISBN: 978-178578-567-2; 418 pages

Review by Wiebina Heesterman

The first thing that strikes the eye in the introduction to this book is the shadow of a plane. It's a photo of an IceBridge flight over southeast Greenland. It clearly shows how important 'the view from above' is to understanding the behaviour of the Greenland ice and snow mass, the largest body of ice after Antarctica.

The 'Explorations' part of the book describes the utterly unimaginable difficulties of the early explorers, such as the Norwegian Fridtjof Nansen, the American Robert Peary and the Greenlander Knud Rasmussen, who travelled across Greenland's ice-sheet in the late nineteenth century on foot, on skis or by dog sled. Other explorers came to Greenland, several fated to freeze to death, among them Alfred Wegener, the 'father' of plate tectonics. For many of these explorers, reaching some specific geographic location on Greenland was not enough. They wanted to understand the behaviour of its ice and snow: observations were recorded, ice cores drilled and pits dug in order to study the various ice layers and learn about past climates. But real understanding only became possible with observation from the air, as described in the 'Investigations' section.

In 1929, forty years after crossing south Greenland, Nansen advocated the use of aerial photography of the Arctic, as its weather and ice would have profound effects on Europe and the lower latitudes. The view from above allowed the mapping of Greenland, but 'remote sensing' of the ice masses, using planes and satellites fitted with microwave and infrared sensors, did not commence until the late 1960s. As some scientists at that time thought that a new ice age was coming, a big question was whether the ice cover was really growing. However, just observing from the air would be insufficient. Ice-penetrating radar would be used to spot locations where level rock and ice layers might be drilled and pits dug to put any findings from the view from above into meaningful context. The use of laser altimeters which send pulses down to a body of water (ice in this instance) and then reflected upward is yet another way the height of the ice mass could be measured. Doing so over time at exactly the same location, which could now be done combined with GPS technology, would show whether the mass was growing or thinning. A later programme called ICESat failed when the three lasers on board all suffered technical problems. Eventually similar measurements were carried out by aircraft in an operation called IceBridge, intended as a stopgap but still active at the time of writing. Here, research planes routinely fly an eight-hour stint, for three months in the Arctic in the autumn and three in the Antarctic during our spring.

Other research methods depended on the joint US-German GRACE programme, in operation until 2017. Gravity at different



locations is measured, carried out by two small satellites flying in tandem in a circumpolar orbit at a distance of 220km from each other. GRACE stands for 'Gravity Recovery And Climate Experiment' as the instrumentation measures the gravity fields of different locations: dense objects, such as mountains or lakes exert more of a gravity pull than other bodies of matter. In this case, it might be stretches of ice, where some might be larger and more densely packed than others.

The difference in density between two locations would pull the satellite passing over the larger mass forward by an infinitesimal amount. The two satellites are linked by a permanent microwave communication, allowing them to beam the difference down to NASA's Jet Propulsion Laboratory. Over time the programme showed that the ice-sheet was increasingly losing mass, from 137 to 286 billion tonnes in seven years, while sea levels were steadily rising by small amounts. A new and improved GRACE programme was initiated in 2018. Another programme is aimed at measuring the rate of melting of the ice sheet's surface. Researchers were baffled when an instrument called a scatterometer (which exploits the fact that ice and water scatter radio waves back to the spacecraft in different ways) showed up the entire surface of the Greenland ice-sheet as red (meaning 'something fluid'). This melting led to extensive flooding of the nation's infrastructure. In addition, researchers make use of sensors attached to seals and halibut which tend to dive deep below the ice and so provide measurements from different ocean depths.

The book introduces technical details of measurement methods I didn't know existed. The gist of the 'sensing' chapters is that Greenland's several mile-thick ice-sheet has been shrinking, with meltwater finding its way into the ocean. The next question was 'how' – how does the water flow, from the top, from underneath or seeping through cracks? Clearly, the steady and relentless calving of massive glaciers, such as the fast moving, miles-wide Jakobshavn in West Greenland, makes a major contribution to sea level rise. A total melt of this particular glacier might in fact raise sea level by about 30cm. At the other end of the globe, the even larger Thwaites Glacier's melting would raise it still more, by about 60cm.

While the large number of Greenland (and West Antarctica) glaciers steadily dispatch their icebergs into the oceans, surface melting accelerates too. This leads to a darker, less reflective surface which retains more heat, leading to further melting in a feedback loop. This effect is also accelerated by the growth of increasingly dark algae on the ice-sheet's surface – not to forget micro-plastics contamination. While study to solve the many remaining puzzles still goes on, clearly the oceans – and the world's coastlines – will be transformed by the erosion of the massive ice masses of both Greenland and Antarctica, still several kilometres thick today. Despite these disturbing revelations, the book including the 'Investigations' sections, reads like a fast-paced, gripping adventure story. It's a terrific read!

Scientists behaving responsibly: should science walk the talk on climate breakdown?

SGR Conference and AGM; 16 November 2019; The Gallery, Farringdon, London

Summary by Stuart Parkinson

With public and political recognition of the threat of climate disruption reaching high levels during 2019, SGR's conference on the issue was especially timely. Leading researchers highlighted not only the scale of the threat, but also the importance of behaviour change in helping to tackle it, and the leading role that scientists and engineers could and should play in this realm. The conference attracted 90 participants – a sell-out event for SGR for the first time in many years! To coincide with the event, SGR launched a new briefing on the issue. The briefing and other materials from the conference can be downloaded from: https://www.sgr.org.uk/events/scientists-behaving-responsibly-should-science-walk-talk-climate-breakdown



Scientists behaving responsibly - survey results

A key focus of SGR's briefing was a survey of 150 people, mainly of scientists and engineers interested in the climate issue, about what steps they had taken, or were planning to take, to reduce their carbon footprint. Andrew Simms, SGR's assistant director and author of the briefing, presented some of the key highlights which showed that: more than one in three had already rejected flying; 38% did not own a car and rarely used one; 13% had adopted a vegan diet; and nearly one in three had chosen to go child free. In all categories, pledges on future action showed a large increase in the numbers taking action. More results can be found on p.4.

Although only a straw poll, the survey nevertheless showed that there is marked interest among the science and engineering community for taking a leading role in environmental behaviour change. This was important, Andrew stated, as academic research points to the need for respected members of society to set a 'good example' in order to accelerate behaviour change.

Andrew also gave a few highlights from SGR's other new report Irresponsible Science? which uncovered a wide range of financial links between professional engineering and science organisations and the fossil fuel and arms industries (see p.16).



Transforming delusion into action on climate change

Kevin Anderson, professor of energy and climate change at the Universities of Manchester and Uppsala, gave a presentation which highlighted the enormous scale of action needed to bring down carbon emissions, but also offered hope about how that action could be made to happen.

Firstly, he pointed to how the UK – which claims a leadership role in tackling climate change – is really failing to address the problem. Latest examples include the opening of massive new oil and gas fields in the North Sea and airport expansion, but the key problem is misleading accounting for its carbon emissions. So, while the UK's official carbon emissions showed a 44% reduction between 1990 and 2018, the nation's carbon footprint has only shrunk by about 10%. Many other industrialised and industrialising countries have similarly failed. Kevin argued that, in order to meet the Paris climate targets in an equitable way, emissions in the leading industrialised nations like the UK need to fall by at least 10% per year from now on.

Could we transition this fast? Kevin argued there were recent examples showing we can, including the mobilisation of capital following the 2008 global financial crisis, the very rapid growth of social media, and the plummeting price of renewable energy technologies over the past decade. He argued that there were three key areas where rapid transition needs to happen. The first is that the wealthiest 10% of the global population – who are responsible for about 50% of global carbon emissions, and includes many scientists and engineers – need to make profound changes in their lifestyle. Secondly, very stringent energy efficiency standards need to be applied to all major end-use equipment. Thirdly, heavy investment is needed in zero-carbon energy supply technologies, including major electrification of key sectors.

He concluded that such a transition would be enabled by new narratives reframing our values to care much more about equity and environmental protection. An interview with Kevin Anderson can be found on p.6.



Reducing our carbon footprints

Throughout the day, interspersed with the other presentations, SGR vice-chair Dr Jan Maskell led sessions on carbon footprints. These showcased exercises and materials from the SGR school education project 'One Planet – One Life' (see p.3) and gave conference participants an insight into calculating and reducing their own carbon footprints. Jan used 'food cards' to show the different carbon footprints of common foods, showing especially how animal foods had a higher impact than plant foods. Another exercise involved estimating which of a selection of transport options had the highest impacts. Other exercises introduced home energy choices and the impacts of different consumer goods. She also told of some of her experiences in delivering the workshops to hundreds of children in schools in north-west England – who were mainly around 12 years old – and how it helped give them broader knowledge about the world, but also inspired them to think in different ways about how they lived.



Political action on the climate crisis

The final speaker of the morning session was Farhana Yamin, a leading environmental lawyer-turned-

activist. She spoke of her personal and professional journey which has included being a lead author of reports for the Intergovernmental Panel on Climate Change (IPCC) and being part of the negotiating team for nations particularly vulnerable to climate change during the Paris climate summit. She talked of her frustration with the slow pace of work as an academic and negotiator, and her recent activity helping Extinction Rebellion (XR), including being arrested at a protest. She argued in a recent article for the journal *Nature* that the climate crisis has become so acute that more scientists and other academics need to become active in environmental campaign groups, including XR, and risk arrest (see feature on p.12).

Farhana also pointed to the achievements of climate campaigners which – even though they have not been successful enough yet – have still been critically important in shifting attitudes. She especially paid tribute to activists in developing countries who have been killed for their efforts.

Farhana also pointed to the democratic deficit on climate issues, arguing that an international 'fossil fuel dictatorship' exists which prevents transformative action which is actually popular with most of the public. In particular, she highlighted the deceitful behaviour of major oil companies whose collective expenditure on renewables is only about 3% of their total, despite a very different impression being given by their public relations campaigns.



Global heating and climate catastrophe

Bill McGuire, emeritus professor of geophysical and climate hazards at University College London, focused his

presentation on the potential of climate-related hazards to be a lot worse than the central projections of the IPCC. He pointed out that the decision-making processes within the IPCC tend to lead to conservative headline estimates of the impacts.

He outlined examples in four key areas: sea-level rise; seismicity; 'switch-off' of the Gulf Stream; and extreme heat. For sea-level rise, he pointed to academic studies which projected worse case scenarios of three metre rises by 2100 – three times the upper end of the IPCC's 'likely' range. On seismicity, he summarised research indicating that melting ice-sheets could lead to increased earthquakes and volcanic eruptions on the exposed, more unstable land. On the Gulf Stream, he pointed to work showing a marked weakening in the ocean current already, which could lead to a sudden rapid cooling of northern Europe. On extreme heat, he highlighted how vulnerable the human body is to extreme heat combined with humid conditions – which has received little attention outside academic circles.

Bill concluded by arguing that climate scientists are often too reluctant to stick their neck out when research reveals results

that are significantly worse than central estimates. This, he said, urgently needs to change (see feature on p.9).



Environmental behaviour change

Lorraine Whitmarsh, professor of environmental psychology at Cardiff University, focused on the importance of behaviour change in helping to tackle climate change. She began by pointing to

research from the Committee on Climate Change concluding that 62% of measures to tackle the problem involved some form of behaviour change. This change required action at scales from the individual up to the international level, and she said that large-scale changes had the best chance of success when the co-benefits of action – e.g. for health – were recognised. A combination of interventions was needed – including providing information on the environmental impacts of different actions, modelling pro-environmental behaviour, using economic incentives, and increasing the available choices through new products and services (see feature on p.8).

Of particular interest for SGR was research on the behaviour of scientists. Lorraine pointed to evidence that climate scientists who reduced their own carbon footprints were more likely to inspire action by the public than those that didn't. Yet research also showed that climate scientists tended to fly more than other scientists as part of their work, with senior climate scientists flying the most!



Overcoming social denial of climate change

The final main speaker of the day was Rebecca Willis, professor in practice at Lancaster University. She spoke of her

work aiming to "create better climate politics". From interviews with politicians about climate issues, she had detected 'organised social denial'. Politicians with a keen interest in climate issues were taken less seriously by their peers and were therefore less likely to rise to senior levels, while the issues themselves were regarded as niche. She argued that politicians in general underestimate the level of public support for climate action (see p.11).

She concluded with three recommendations for politicians and other policy-makers: speak out on the climate crisis; listen to the public's concerns; and take political action.

A range of issues were raised in the question and answer session which followed the main speakers. These included how the IPCC might change its decision-making processes, engaging with the wealthy – including scientists and engineers – to encourage behaviour change, and structural flaws in the capitalist system which undermine individual action.

SGR's Annual General Meeting

SGR chair Dr Philip Webber introduced the AGM, and executive director Dr Stuart Parkinson summarised the highlights of the past financial year, with treasurer Alasdair Beal covering the finances. The new National Co-ordinating 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, Dr Paul Marchant CStat, Simon Reed FIAP, Dr Gillian Smith CEng

Participants at SGR's Responsible Science conference.



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SGR is an independent UK-based membership organisation promoting ethical science, design and technology. Our work involves research, education, lobbying 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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EDITORIAL ISSUES

The editorial team for this issue of *Responsible Science* was: Andrew Simms, Stuart Parkinson and Vanessa Moss.

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Copy deadline for next issue: 30 September 2020

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