Science for a secure and sustainable future

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Bristol Quakers Peace Lecture, Bristol University, 9 March 2019

We'll focus on two questions…

- What **are** the roles played by science and technology in our society?
- What **should be** the roles of science and technology in our society?

Two future scenarios

Pessimistic scenario

- Authoritarian/ nationalist leaders become more common/ powerful
  - Use social media to spread ‘fake news’ and intolerance
  - Cut welfare and aid spending
  - Dismantle regulation and international treaties
  - Increase military spending and use of force
  - Undermine environmental science
  - Obstruct environmental industries

Optimistic scenario

- Enlightened leaders, communities and industries become more powerful
  - Use communication to encourage understanding, tolerance and co-operation
  - Economic reform, including social ‘safety nets’
  - Support multilateral regulations/ treaties
  - Shift from military spending to tackling underlying causes of conflict
  - Shift subsidies/ support from polluting industries/ lifestyles to environmental options

Case study 1: Sustainability

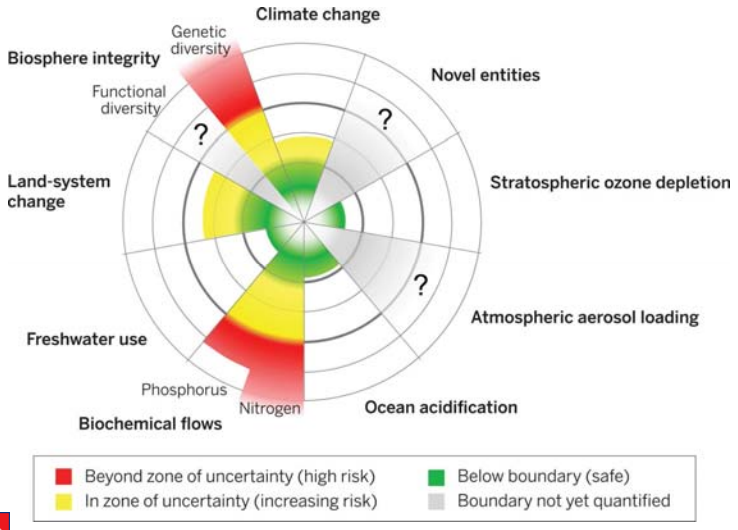
Global environmental threats

- Climate change/ disruption
- Biodiversity loss/ mass extinction
- Soil erosion/ desertification
- Air pollution/ low air quality
- Freshwater & marine pollution

➢ *Misuse of science and technology has helped create these problems, but careful use can help solve them*

- For a summary of global environmental threats see, for example: IPPR (2019)

Planetary boundaries

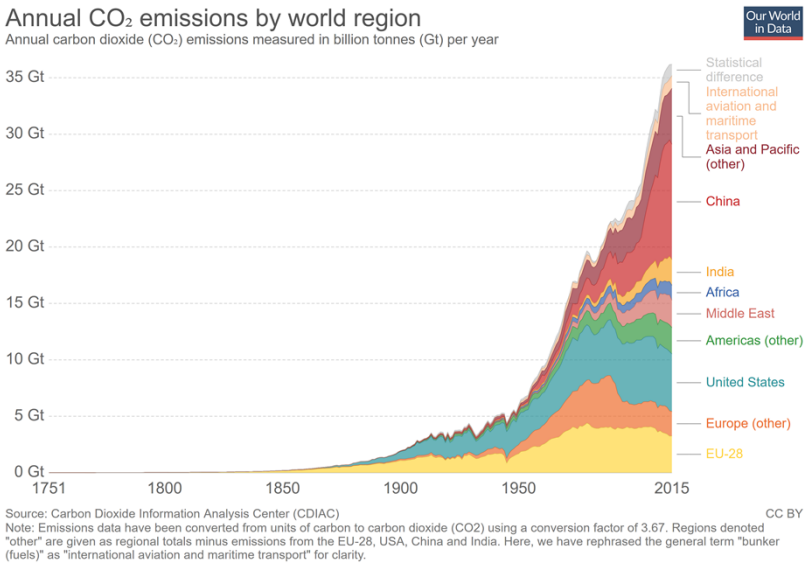


Science AAAS

Source: Steffen et al (2015)

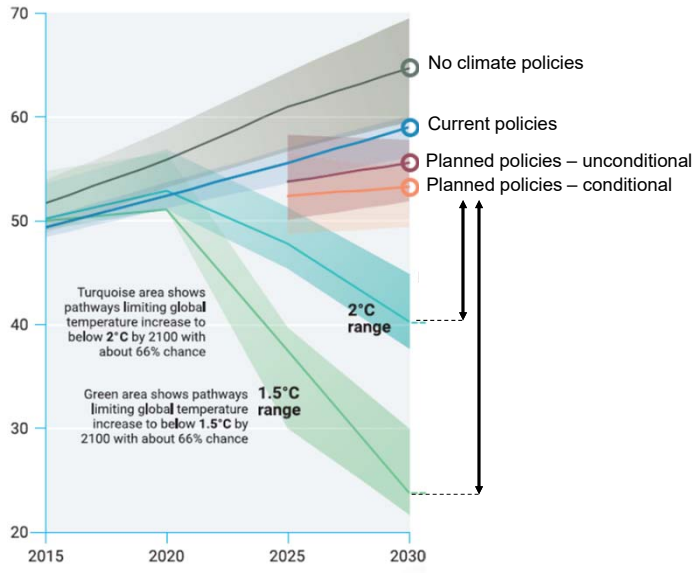
- Current status of the control variables for seven of the planetary boundaries. The green zone is the safe operating space, the yellow represents the zone of uncertainty (increasing risk), and the red is a high-risk zone. The planetary boundary itself lies at the intersection of the green and yellow zones. The control variables have been normalized for the zone of uncertainty; the centre of the figure therefore does not represent values of 0 for the control variables. The control variable shown for climate change is atmospheric CO_2 concentration. Processes for which global-level boundaries cannot yet be quantified are represented by grey wedges; these are atmospheric aerosol loading, novel entities, and the functional role of biosphere integrity.
- Source: Steffen et al (2015)

Climate change/ disruption



Graph can be downloaded from: Our World in Data (2017)

Greenhouse gas ‘emissions gap’



Source: UNEP (2018)

Global greenhouse gas emissions under different scenarios and the ‘emissions gap’ in 2030 (median estimate and 10th to 90th percentile range)

Source: UNEP (2018)

Keeping below 1.5C

- Keeping below 1.5C global temperature rise requires keeping within ‘remaining carbon budget’
  - Approx. 2,200 billion tonnes carbon emitted since Industrial Revolution
  - Approx. 600 bn tonnes left before world committed to 1.5C
  - At current annual emissions level, we have about 12y left
  - *(Significant uncertainties)*

- Figures from IPCC (2018)
- Uncertainties mean transition period could be significantly longer or shorter

Fossil fuel industry

- Proven reserves of coal, oil and gas:
  - Equivalent to approx. 2,500 bn tonnes carbon
  - Over 4 times remaining carbon budget
- Just 25 corporate/ state entities responsible for over 50% of industrial carbon emissions
  - UK: Shell; BP; all actively exploring for more
- Scientific/ engineering expertise central
  - UK jobs in oil/gas extraction: 37,000 + supply chain

Data sources:

- Total reserves based on: Carbon Tracker (2012)
- Corporate emissions: CDP (2017)
- Employment: Oil & Gas UK (2018)

Key technologies for low carbon transition

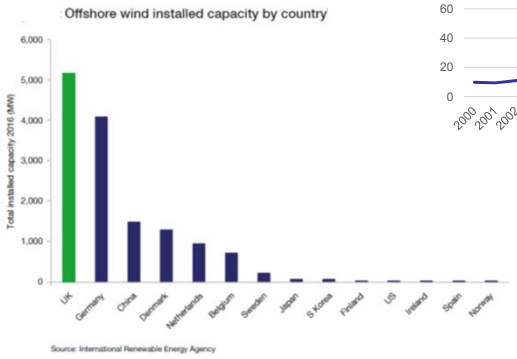
- Energy efficient tech
  - e.g. home insulation; LED lighting; A++ appliances; heat pumps
- Renewable energy tech
  - e.g. wind, solar, hydro, marine, (bio)
- Energy storage tech
  - e.g. batteries, hydrogen, hot water tanks
- Electric vehicles
  - Including cars, buses etc

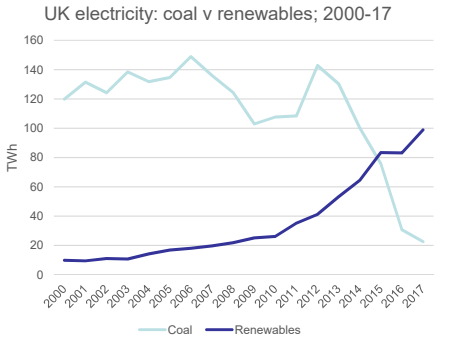
- Important progress is being made in all these areas in many parts of the world – although many opportunities still being lost due to poor policy choices
- For example, UK has recently cut back its policy support for home energy efficiency, onshore wind and solar – see: Committee on Climate Change (2018)

UK climate progress – examples

Jobs in low carbon/ renewable energy sectors:

- 210,000 + supply chain





Source: Carbon Brief (2019)

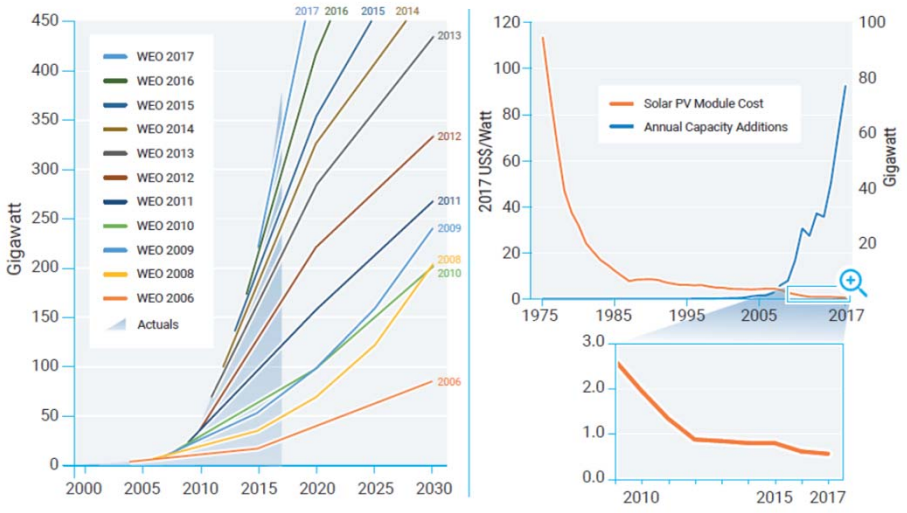
UK carbon emissions down (but not as much as official stats indicate)

- Low carbon employment stats from: Office of National Statistics (2019)
- Offshore wind stats from IRENA, quoted in: Dept. for Business, Energy and Industrial Strategy (2017), p.35
- UK electricity stats from: Carbon Brief (2019) – coal generation has fallen 85% in 5y; renewable generation is five times the level of 10y ago

Other notable progress:

- UK electricity demand – reduced by about 15% from peak in mid-2000s, with much of the reduction due to energy conservation measures
- UK GHG emissions reduction: 42% (1990-2017) – however, UK carbon footprint (including net emissions from imported goods) down much less – my rough estimate is that it is only down about 26% (using figures from Carbon Brief, 2019)

Solar electricity – global growth



Source: UNEP (2018)

Left hand graph: Cumulative solar PV installations compared to forecasts from various IEA World Energy Outlooks (WEO).

Right hand graphs: Historical price reductions and annual installations, 1975–2017

Source: UNEP (2018)

Wider uses of science for transition

- Major areas where emissions are barely falling
  - UK examples: transport; agriculture
- Behaviour change needed
  - 'Modal shift' in transport
    - From planes/ private cars to trains/ buses/ car-sharing/ cycling/ walking
  - Shift to plant-based meals
    - Large reductions in meat/ dairy consumption needed
  - Fewer consumer goods
  - Psychology research
    - Using experience from public health campaigns

See, for example: Committee on Climate Change (2018)

Case study 2: Security

Global security threats

- Nuclear weapons
- Increasing militarisation
  - High military budgets; international arms trade
  - New weapons, e.g. use of robots/ AI
- Cyber security threats
- Global inequality/ environmental threats

➢ *Misuse of science & technology has helped create these problems, but careful use can help solve them*

- For more discussion, see, for example, Oxford Research Group (2006)
- Fervent nationalism/ religious fundamentalism are also key in fuelling security problems

Nuclear weapons

- ‘Modernisation’ programmes
  - 9 nuclear weapons states
  - Approx. 14,500 nuclear weapons
  - All 9 nations are ‘modernising’
- Breakdown of treaties
  - Negotiations stalled: CTBT; FMCT
  - Being dismantled: ABMT; JCPOA; INF Treaty
  - Vulnerable: New START; NPT

- Data on nuclear weapons programmes from Federation of American Scientists (2018).
- Treaties
  - CTBT – Comprehensive Nuclear Test Ban Treaty; agreed in 1996; global ban on nuclear weapons testing; 184 signatories; widely observed, but yet to come into legal force due to USA and some other nations failing to ratify
  - FMCT – Fissile Material Cut-off Treaty – currently only proposals
  - ABMT – Anti-Ballistic Missile Treaty; US-Russian treaty restricting ‘defensive missiles’; in force from 1972 to 2002; withdrawal initiated by George W Bush administration
  - JCPOA – Joint Comprehensive Plan of Action commonly known as Iran nuclear deal; agreed 2015 between China, France, Iran, Russia, UK and USA; aimed to limit Iran’s nuclear programme; US withdrew 2018
  - INF – Intermediate-range Nuclear Forces Treaty; US-Russian treaty agreed 1987, banning land-based missiles with ranges of 500-5,500km; US and Russia suspended treaty in February 2019
  - New START – Strategic Arms Reduction Treaty; US-Russian treaty agreed in 2010; will automatically expire in 2021 without further agreement
  - NPT – Nuclear Non-Proliferation Treaty; agreed in 1968; aimed to prevent spread of nuclear weapons beyond first 5 nations, while encouraging the 5 nations to eventually disarm; 190 signatories; now under challenge by non-nuclear weapons states due to lack of disarmament by the 5 nations
- Main source: Wikipedia (2019)
- [image: Trident missile]

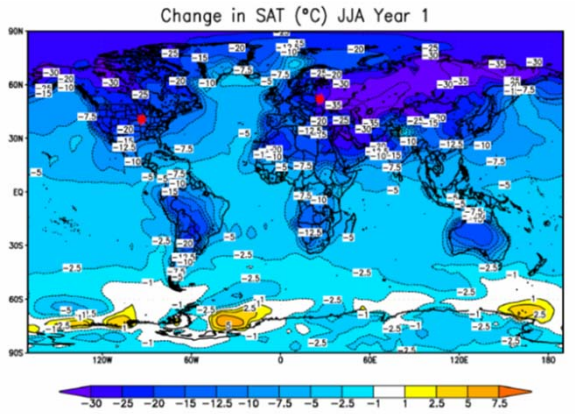
New research on dangers

- Accidental nuclear war
  - Historical evidence shows world has been lucky
  - Average of 1 ‘near miss’ every 3 years
- Nuclear winter
  - Recent climatic research shows higher vulnerability to global cooling from smoke from any nuclear conflict
- Cyber security threats
  - These increase risk of launch in a crisis

- Average of 1 ‘near miss’ every 3 years from 1962 to 2002 (Lewis et al, 2014)
- For a summary of recent research on nuclear winter, see: SGR (2015)
- For examples of cyber security threats to nuclear weapons systems, see: Datoo (2017); SGR (2018)

Nuclear winter scenarios

- USA-Russia scenario:



- Regional scenarios:
  - India-Pakistan; USA-Nth Korea; UK arsenal

- Graph: Surface air temperature changes (degrees Celsius) for the '150 Tg case' – i.e. a major nuclear war between USA and Russia leading to emissions of 150 million tonnes of black carbon into the upper atmosphere, mainly in the form of smoke – averaged for June, July, and August of the year of smoke injection and the next year. Effects are largest over land, but there is substantial cooling over oceans, too. The warming over Antarctica in Year 0 is for a small area, is part of normal winter interannual variability, and is not significant. Also shown as red bursts are two example locations for nuclear weapon explosions. Source: Robock et al (2007);
- Regional scenarios would also cause catastrophic cooling for a decade – see Robock (2007); SGR (2015)

Remote warfare

- Wealthy nations moving towards 'remote warfare'
  - Greater use of private military organisations/ local forces
  - Greater use of special forces in secret
  - ***Greater use of robotic technologies***
    - Including weapons, e.g. armed aerial drones
    - Concerns include: lowering the threshold for war; use for targeted assassination

Oxford Research Group (2018)

Robotic weapons

- Growing use of ‘autonomous’ or ‘cognitive’ systems (artificial intelligence)
- Serious problems
  - Hard to predict
  - Poor legal controls
  - Serious potential for abuse
- Global arms race starting
  - UK involved

- For summary of UK-related developments/ issues, see: Drone Wars UK (2018)

[image: BAE Mantis]

Arms industry

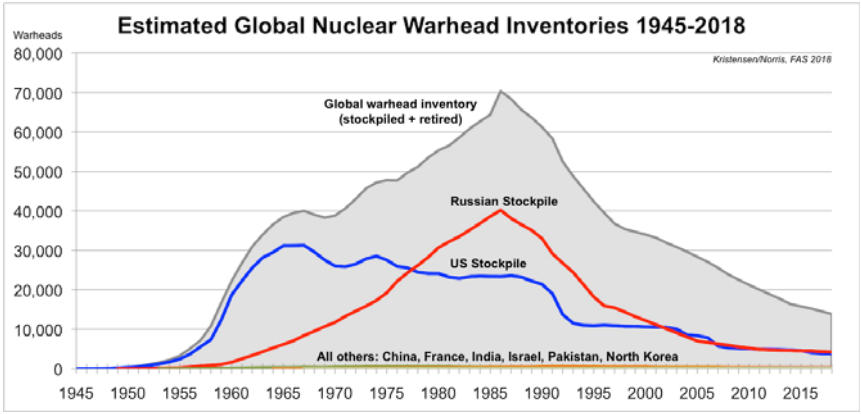
- Global military spending
  - Approx. $1,700,000,000,000 each year
  - USA dominant
- Nuclear weapons: US: $50bn/y; UK: £4bn/y
- UK arms corporations
  - Largest involved in R&D on nuclear weapons and/or military robotics
    - e.g. BAE Systems; Rolls-Royce; Babcock; AWE
- Scientific/ engineering expertise central
  - UK jobs, nuclear weapons: 12,000 + supply chain

- Like fossil fuel sector, small number of governments and corporations responsible for most spending
- Global military spending figures from SIPRI (2018) – USA spends 35% of total (10 times more than Russia); top 10 nations spend nearly ¾ of total
- Nuclear weapons spending – US figures from Defense News (2019); UK figures from MOD (2018); total for all nuclear weapons states is estimated at £100bn/y by campaign group, Move the Nuclear Weapons Money
- UK jobs in nuclear weapons: Cogent (2011) estimated 15,000 direct jobs for all 'defence nuclear' projects, which includes Astute and Trafalgar submarines (not nuclear-armed); CND (2016) estimated 11,500 direct jobs for Trident programme only.
- UK jobs in military robotics – specific figures unknown, but perhaps one or two thousand + supply chain – but growing rapidly

Key policies and technologies for arms control

- International treaties are essential and have had some important successes
  - e.g. weapons of mass destruction; conventional weapons; emerging technologies
- Technical support work
  - drafting text; monitoring; verification
- Social science research supports reconciliation and peace-building
- Targeted aid programmes can help

Nuclear disarmament



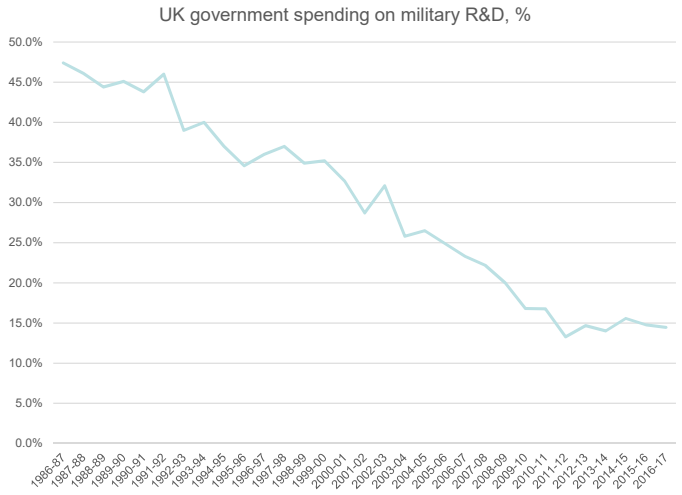
- Large reductions were implemented at the end of Cold War (but have stalled recently)
- Between 1987 and 1997, approx. 35,000 nuclear weapons decommissioned by US/Russia (about half peak level)
- Data from: Federation of American Scientists (FAS) (2018)

Disarmament treaty success

- Mine Ban (Ottawa) Treaty, 1997
  - Ban on all anti-personal landmines
  - Campaign led by civil society
  - 164 nations now ratified treaty
  - 52 million mines have been destroyed
  - Of 63 countries with mine fields:
    - 31 declared ‘mine-free’; 32 have action plans to eliminate mines
  - Large drop in numbers killed by landmines
    - But casualties now rising due to ‘improvised’ mines

- Figures from: Convention on the Prohibition of Anti-Personal Mines (2019).

UK R&D spending shift from military to civilian



Sources: Dept. for Business, Innovation and Skills (2011); Office of National Statistics (2018)

- Large fall since end of Cold War (but has recently stabilised at a level significantly higher than comparable countries, e.g. France, Germany)

Further uses of science for disarmament

- Treaty for the Prohibition of Nuclear Weapons (TPNW)
  - Supporting progress towards ‘entry into force’
  - Supporting compliance
- Ban on Lethal Autonomous Weapons (LAWs)
  - Support either through existing or new treaty
- Military to civilian spending/ skills shift
- R&D for ‘sustainable security’

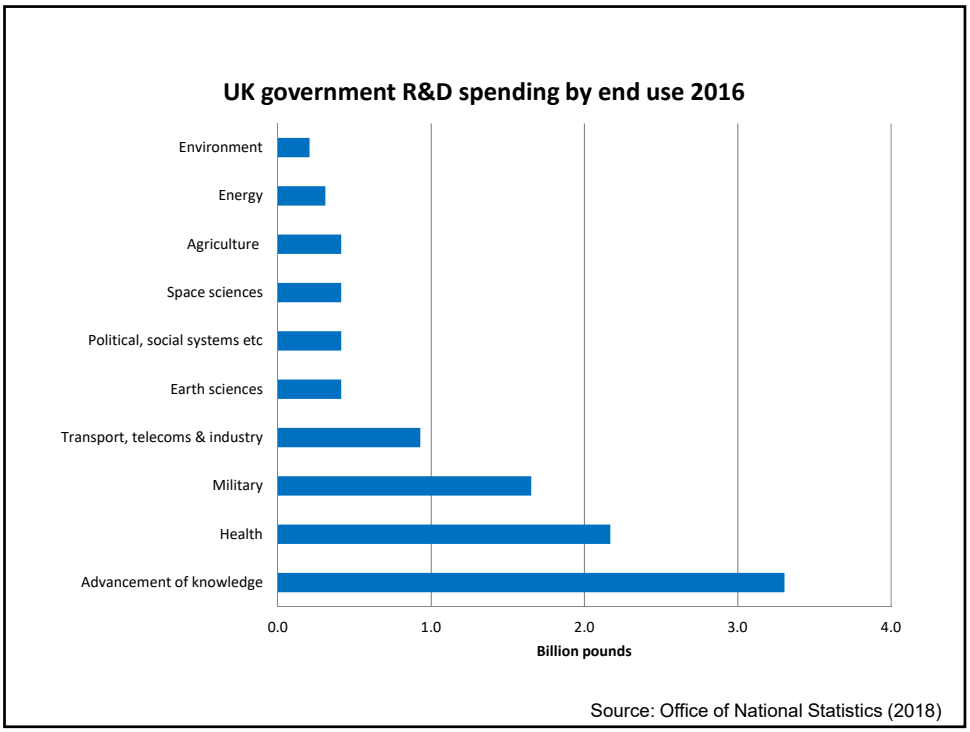
- TPNW text adopted in July 2017 by over 120 nations – will ‘enter into force’ when 50 nations have ratified, probably in early 2020; 22 nations ratified so far (ICAN, 2019)
- Negotiations on a ban on LAWs currently being conducted through UN Convention on Conventional Weapons (CCW). However, this is currently being resisted by several leading arms-producing states including UK. An alternative route is through a new stand-alone treaty, similar to the Mine Ban Treaty. (Campaign to Stop Killer Robots, 2018)
- A shift from military to civilian spending would free up numerous skilled workers for use in, e.g., renewable energy sector.
- R&D on sustainable security would include understanding and tackling the roots of conflict, including global environmental problems/ inequality militarism. (SGR, 2013)

UK science and technology policies

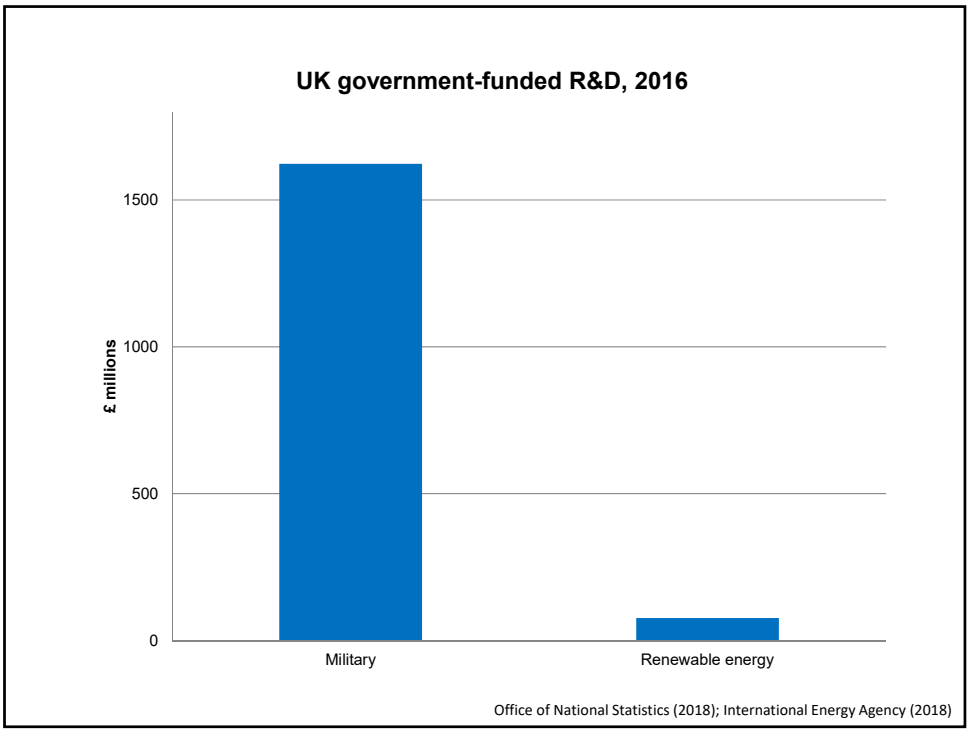
UK Science/ Innovation Plan

- Main elements include:
  - Nurturing scientific talent; scientific infrastructure; supporting research; catalysing innovation; global participation – increase in gov funding
- Scientific/ university research increasingly tied to national economic growth policies
  - Why aren't wider social/ environmental goals given more priority?
  - Where is the critical analysis of economic goals?
- UK military R&D programmes continue

- Dept. for Business, Innovation and Skills (2014) – includes targets up until 2021
- Military R&D programmes run separately by Ministry of Defence



Source: Office of National Statistics (2018)



- Military spending: 2016 figures – Office of National Statistics (2018)
- Renewable energy spending: 2016 figures – International Energy Agency (2018)
- Ratio of military to renewable energy R&D spending: 21

UK Industrial Strategy

- 4 ‘Grand Challenges’
  - Artificial Intelligence and Data Economy
  - Clean Growth
  - Future of Mobility
  - Ageing Society
- 9 ‘Sector Deals’ (so far)
  - Life sciences; Automotive; Creative industries; AI; Construction; Nuclear; Aerospace; Rail; Offshore wind
- Military industry – separate ‘Industrial Policy’
- Are these consistent with social/ environmental challenges?

- UK Industrial Strategy White Paper includes targets up until 2027 – its 4 ‘Grand challenges’ are defined as:
  - Artificial Intelligence and Data Economy – “We will put the UK at the forefront of the artificial intelligence and data revolution”
  - Clean Growth – “We will maximise the advantages for UK industry from the global shift to clean growth”
  - Future of Mobility – “We will become a world leader in the way people, goods and services move”
  - Ageing Society – “We will harness the power of innovation to help meet the needs of an ageing society”
- Offshore Wind Sector Deal only announced on 7 March 2019
- Defence Industrial Policy separately launched by Ministry of Defence

Sources: Dept. for Business, Energy and Industrial Strategy (2017; 2019); MOD (2017)

A few recommendations

Nations

- Government
  - Joined-up policies supporting rapid economic shift to sustainable/ equitable economy
    - e.g. align Grand Challenges/ Sector Deals with 1.5C climate target/ UN Sustainable Development Goals
  - Security policies focused on tackling roots of conflict and treaties banning key weapons
    - e.g. based on Sustainable Security concepts; support for TPNW and LAWs ban
  - Economic diversification agencies to support 'just transition' from fossil fuels/ arms to sustainability sectors

- Including rapid phase-out of fossil fuel subsidies
- Including 'climate emergency' declarations – e.g. at local government level

Organisations

- All
  - Divest from fossil fuel/ arms corporations
- Universities/ Professional Science Bodies
  - More research/ teaching programmes on environmental technologies & lifestyles, peace-building
  - Endorsement of (e.g.) 1.5C climate target; UN Sustainable Development Goals
- Trade Unions/ Eco-industries
  - Build supportive links

Fossil fuel divestment

- Numerous campaigns being run by, for example: Fossil Free; People and Planet
- Globally, over $8 trillion of divestment commitments made to date (Fossil Free, 2019)
- 72 divestment commitments made by UK universities to date (People and Planet, 2019)

Nuclear weapons divestment

- Campaigns being run by: Move the Nuclear Weapons Money; Don't Bank on the Bomb
- Numerous divestment commitments to date (Move the Nuclear Weapons Money, 2019)

Individuals

- Scientists/ engineers etc
  - Choose career focused on sustainability principles/ tackling roots of conflict
    - See SGR's ethical careers/ S4S web-pages
  - Conscientious objection
    - e.g. Nae Pasaran, Project Maven boycott
  - Shortages of scientists/ engineers means you are powerful!
- All
  - Divest your pension etc from fossil fuels/ arms
  - ➢*Join Scientists for Global Responsibility*

- SGR's ethical careers programme: http://www.sgr.org.uk/projects/ethical-careers
- SGR's Science4Society Week: http://www.s4s.org.uk/
- In 1974, Scottish trade unionists at Rolls-Royce refused to carry out maintenance work on jet engines destined for use by the Chilean Air Force controlled by dictator, General Pinochet. This led to the grounding of some planes and release of human rights campaigners. Story is told in film, 'Nae Pasaran' (Debasers Filums Ltd, 2018).
- In 2018, 4,000 workers at Google refused to work on Project Maven, a project funded by the US military to aimed at incorporating AI in military drones. Google consequently terminated the contract and adopted a policy not to 'design or deploy' AI for use in weapons (Campaign to Stop Killer Robots, 2019).

Final thought

Compassion-based science and technology

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