Rethinking Security:
a responsible science perspective

SGR responsible science

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Peace Lecture, Bath, 5th June 2019

Rethinking

Root causes of insecurity

1. **Global Militarisation**
   Arms trade, military interventions

2. **Global env breakdowns**
   Climate; mass extinction, sea level rise >6m

3. **Competition over resources**
   Food, water, oil, minerals

4. **Inequality & Poverty,**
   1% own 50% of wealth, tax havens

Taken from ORG and Offensive Insecurity, SGR.

Later I show that this list is quite different to the Govt perspective. Military seen as a solution not a problem, climate change seen as a future problem 'from 2035' (latest version of NSS), inequality not mentioned.

Many of root causes of insecurity are as a result of the irresponsible use of science, design and technology ...

- Nuclear weapons
- Weapons and the military
- The excessive exploitation of fossil fuels and natural resources
- Modern agricultural methods leading to widespread loss of topsoil, water, biodiversity
- GMOs
- Disillusionment with science and 'experts'

- **So let's try to take a responsible science view…**

A lot of this isn't about 'science' as such – it is more about looking at facts and analysing policies vs actions.

Important to say that science can give us good information about factual issues but cannot tell us what to do about it – that is a matter of choice for society.

However, we take it as read that destruction of large numbers of people, injustice are choices to avoid.

The big question is 'why is science and technology used irresponsibly?' ...

Because systematic government and global policies and actions drive it.

'Exceptionalism'
- Nuclear weapons – owned by a minority
- Weapons and the military – mainly richer states
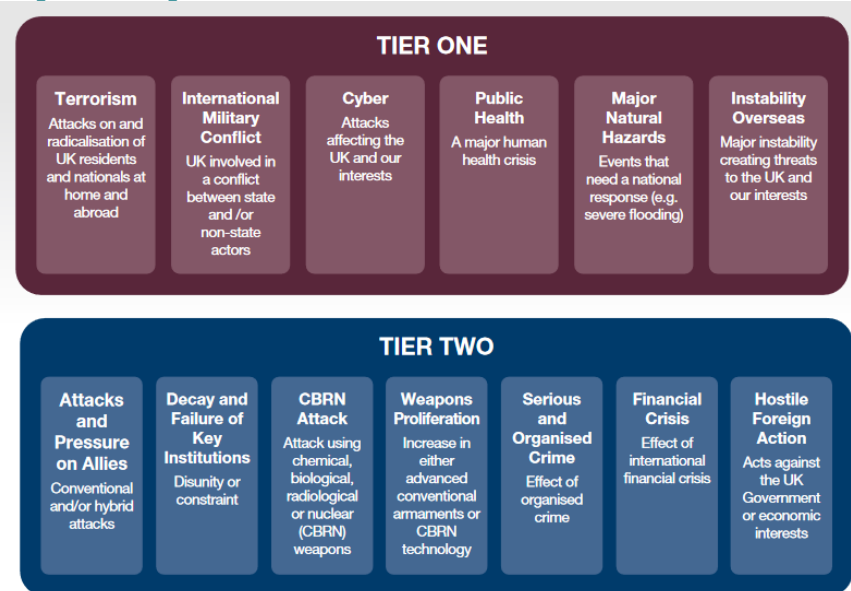
'Growth' (2%/yr = doubling every 35 yrs)
- The excessive exploitation of fossil fuels and natural resources – by richer countries
- Modern agriculture leading to widespread loss of topsoil, water, biodiversity – sold by largely unaccountable corporations
- Disillusionment with science and 'experts' - scapegoats

Exceptionalism is a widely used term often applied to the US. It applies equally to UK policies in many areas.

The UK Govt approach

How does the government view security?

By Priority Risks:

TIER ONE

Terrorism	International Military Conflict	Cyber	Public Health	Major Natural Hazards	Instability Overseas
Attacks on and radicalisation of UK residents and nationals at home and abroad	UK involved in a conflict between state and /or non-state actors	Attacks affecting the UK and our interests	A major human health crisis	Events that need a national response (e.g. severe flooding)	Major instability creating threats to the UK and our interests

TIER TWO

Attacks and Pressure on Allies	Decay and Failure of Key Institutions	CBRN Attack	Weapons Proliferation	Serious and Organised Crime	Financial Crisis	Hostile Foreign Action
Conventional and/or hybrid attacks	Disunity or constraint	Attack using chemical, biological, radiological or nuclear (CBRN) weapons	Increase in either advanced conventional armaments or CBRN technology	Effect of organised crime	Effect of international financial crisis	Acts against the UK Government or economic interests

National Security Strategy 2015

https://www.gov.uk/government/publications/national-security-strategy-and-strategic-defence-and-security-review-2015

Tier three: fuel disruption, public disorder, resource insecurity, severe weather, animal diseases, military attack on UK

main drivers of the impact and likelihood of risk are **changes in technology**, and the geopolitical and global economic context**. "Climate change** is increasingly a risk to the UK, with the full effects on UK national security more likely to be seen **after 2035" (!!) Nuclear weapons do not help this situation.**

**Government spending not in line
with their own assessment of risks**

**One example: Flooding budget:
£6bn over 5 years to 2021**

**Military budget: 30.5 times larger
£36.6bn / year: …**

https://www.carbonbrief.org/mapped-where-four-point-four-billion-being-spent-flood-protection
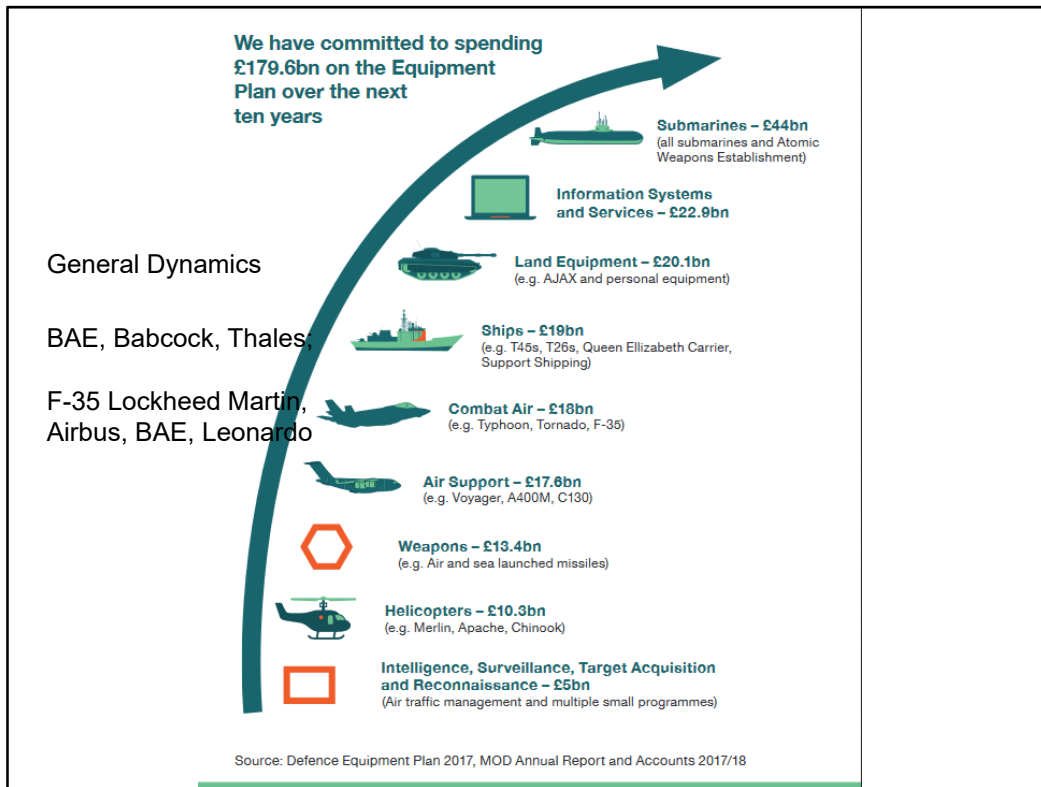
It might be useful to find other examples.

Government VERY keen on <u>military</u> spending
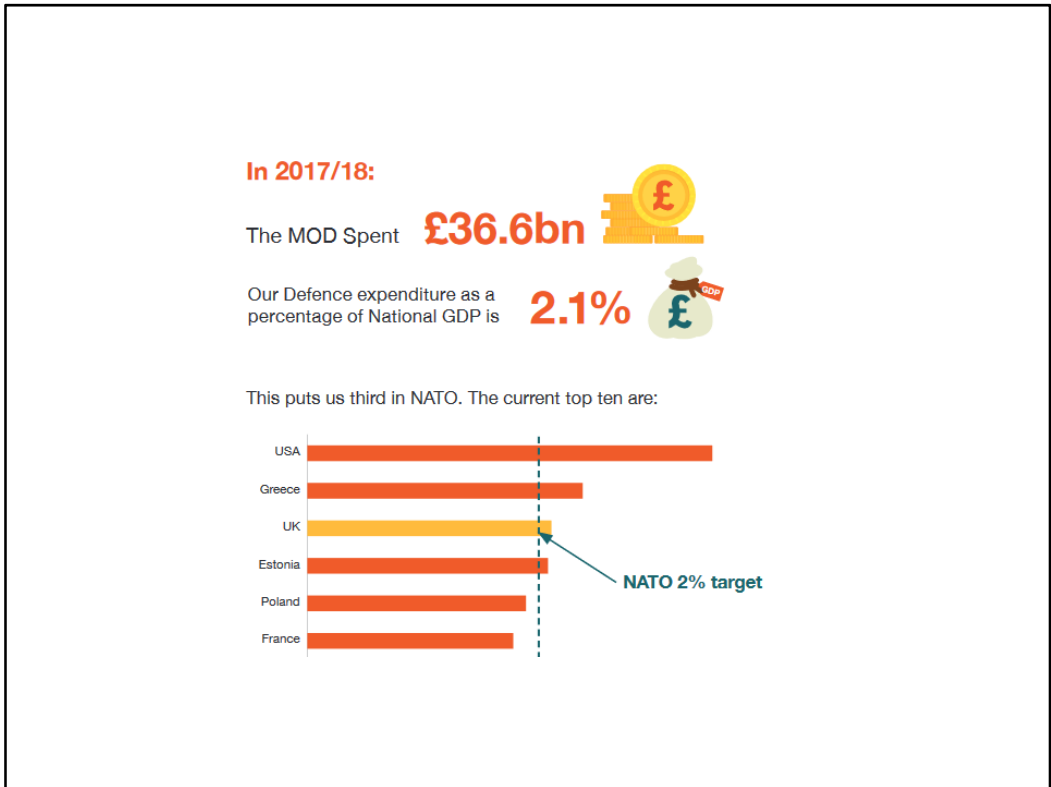
UK Defence in Numbers

October 2018

Not so much defence as offence…

Offensive in more ways than one…

We have committed to spending £179.6bn on the Equipment Plan over the next ten years

General Dynamics

BAE, Babcock, Thales;

F-35 Lockheed Martin,
Airbus, BAE, Leonardo

Submarines – £44bn
(all submarines and Atomic Weapons Establishment)

Information Systems and Services – £22.9bn

Land Equipment – £20.1bn
(e.g. AJAX and personal equipment)

Ships – £19bn
(e.g. T45s, T26s, Queen Ellizabeth Carrier, Support Shipping)

Combat Air – £18bn
(e.g. Typhoon, Tornado, F-35)

Air Support – £17.6bn
(e.g. Voyager, A400M, C130)

Weapons – £13.4bn
(e.g. Air and sea launched missiles)

Helicopters – £10.3bn
(e.g. Merlin, Apache, Chinook)

Intelligence, Surveillance, Target Acquisition and Reconnaissance – £5bn
(Air traffic management and multiple small programmes)

Source: Defence Equipment Plan 2017, MOD Annual Report and Accounts 2017/18

https://www.gov.uk/government/publications/uk-defence-in-numbers-2018

V high US company involvement

In 2017/18:

The MOD Spent **£36.6bn**

Our Defence expenditure as a percentage of National GDP is **2.1%**

This puts us third in NATO. The current top ten are:

USA
Greece
UK
Estonia
Poland
France

NATO 2% target

We are proud of our large arms spending…

https://www.gov.uk/government/publications/uk-defence-in-numbers-2018

On a rolling 10 year basis, our Defence industry is the 2nd largest defence exporter in the World

With **15%** of the global defence export value over the last 10 years, predominantly to the Middle East:
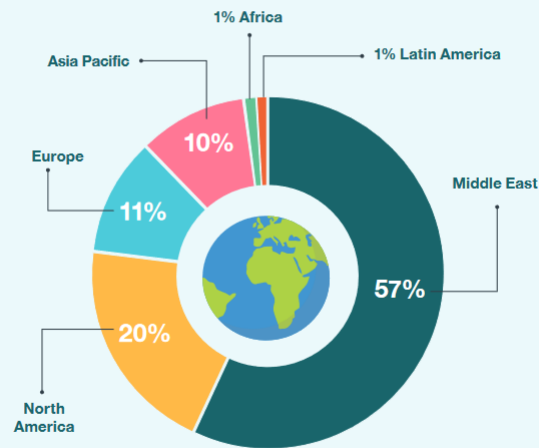
Source: UK Defence and Security Export Statistics 2017

We are proud of our arms sales…

https://www.gov.uk/government/publications/uk-defence-in-numbers-2018

Note the very large Middle east section !

HMS Queen Elizabeth, the first of 2 Queen Elizabeth Class aircraft carriers, sailing from her home in Portsmouth for the first time since being officially commissioned into the Royal Navy in December. 2nd February, 2018. © Crown copyright 2018

65,000 tonnes displacement

679 Crew rising to up to 1,600 for operations

280m length

10,000 nautical mile range

Carrier Air Wing of up to 40 aircraft, can carry up to 50 at full load

The two carriers will deliver 50 years of strategic choice for the Nation ????

Source: www.GOV.UK and the www.royalnavy.mod.uk

Not so much strategic choice as very poor value for money, force projections (eg invasions), not relevant to defence or even modern warfare, requires most of the Royal Navy to protect the carriers and forms a huge high value target vulnerable to missile attack.

Figure A. Comparison of average annual UK public spending on military R&D and sustainable security R&D, 2008-11 (cash terms)
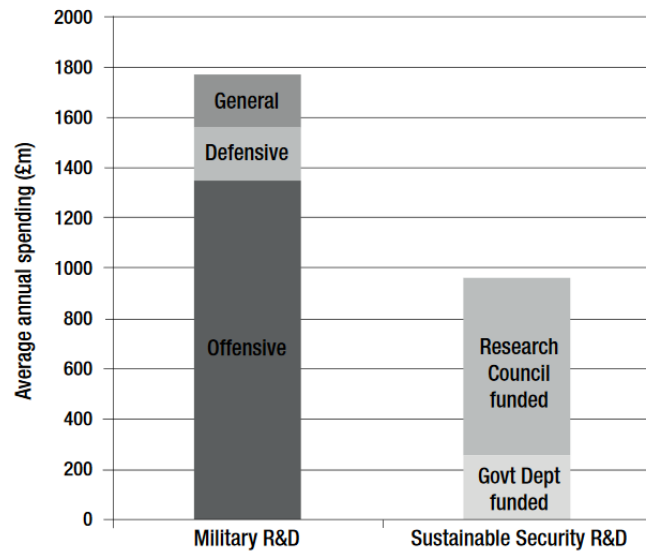
Military R&D is broken down by application; sustainable security R&D is broken down by funding source (see text).

Offensive Insecurity, SGR

Ministry of Defence spending on R&D per year approx **twice** the total public R&D spending – **seven** times civilian government departmental R&D spending helping tackle the roots of conflict.

£500m unaccounted for - 25% of the spending !!

UK government R&D spending by end use 2016
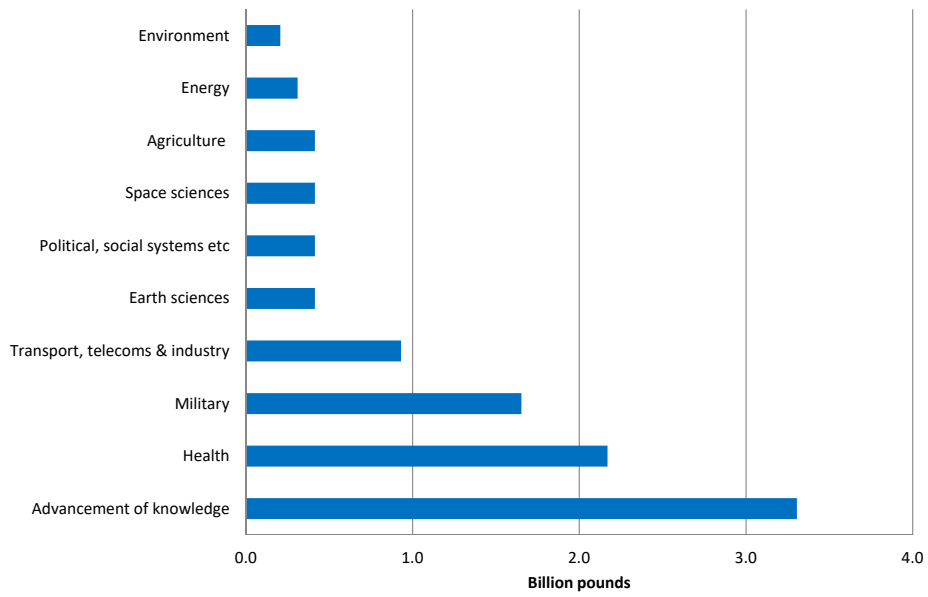
Source: Office of National Statistics (2018)

UK government-funded R&D, 2016

£ millions

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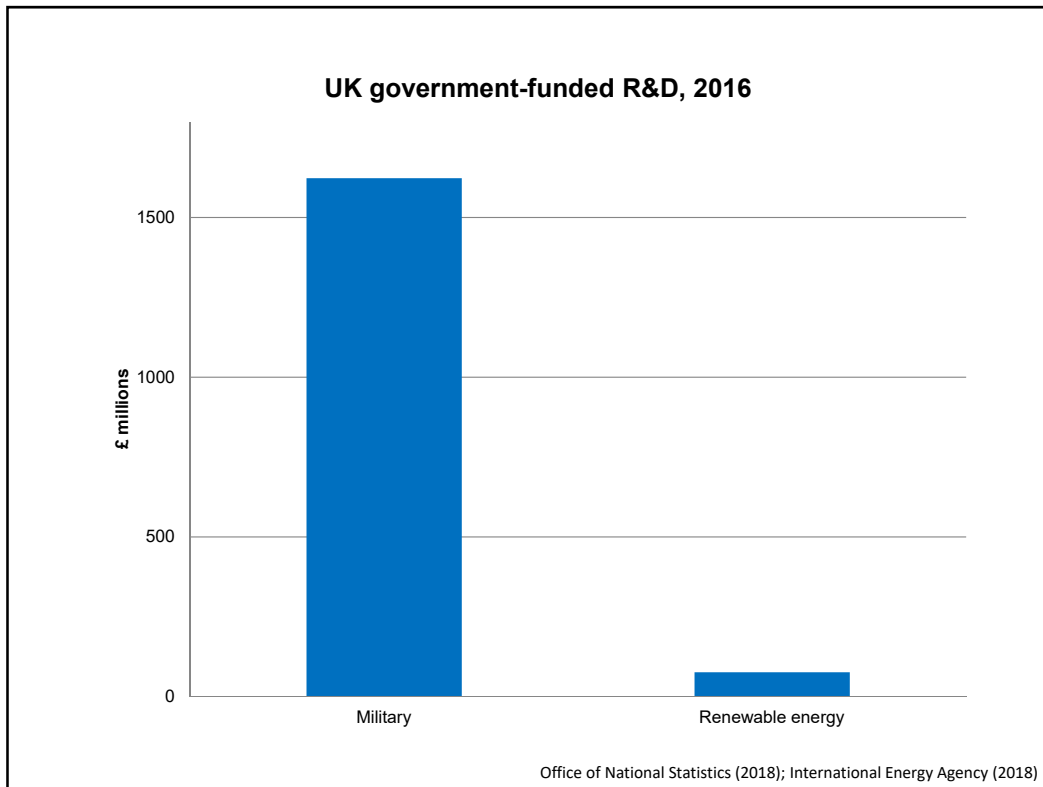
- Military spending: 2016 figures – Office of National Statistics (2018)
- Renewable energy spending: 2016 figures – International Energy Agency (2018)
- Ratio of military to renewable energy R&D spending: 21

TOP 15 MILITARY SPENDERS IN 2017
Countries with highest military expenditure
In current 2017 US$ billion

UK $47.2
Canada $20.6
Germany $44.3
Russia $66.3
France $57.8
Italy $29.2
USA $610
Turkey $18.2
South Korea $39.2
Japan $45.4
China $228
Saudi Arabia $69.4
India $63.9
Brazil $29.3
Australia $27.5
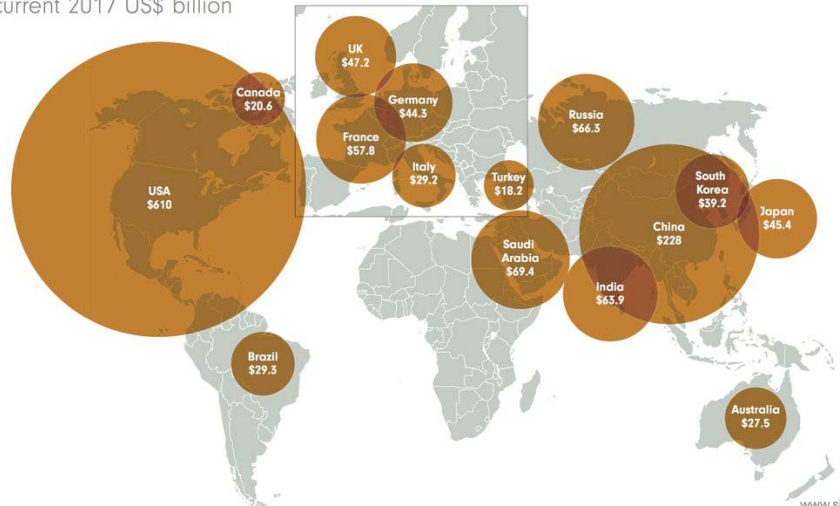
Source: SIPRI Military Expenditure Database

www.sipri.org
© SIPRI 2018

Looking at these figures one has to ask: **Why do we spend SO MUCH on arms??**

For NATO to achieve parity with Russia would mean HALVING arms spending by UK, France, Germany.

Nuclear Risks

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 we have been very 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)
- Refer to SGR 'Beginners Guide' etc

Nuclear winter scenarios

- USA-Russia scenario:

Change in SAT (°C) JJA Year 1
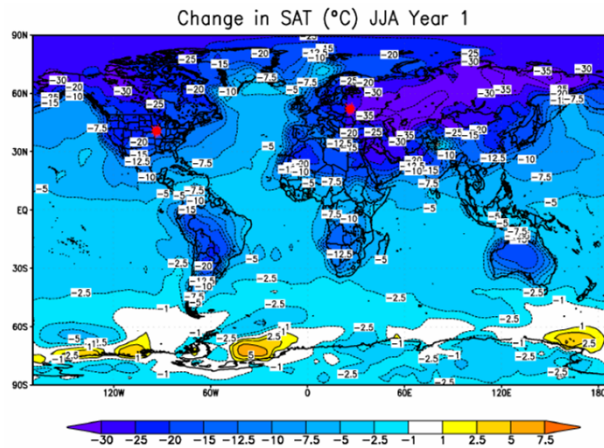
- Regional scenarios:
  - India-Pakistan; USA-Nth Korea; UK arsenal

- 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)

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

Security & the global environment

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

Source: Steffen et al (2015)
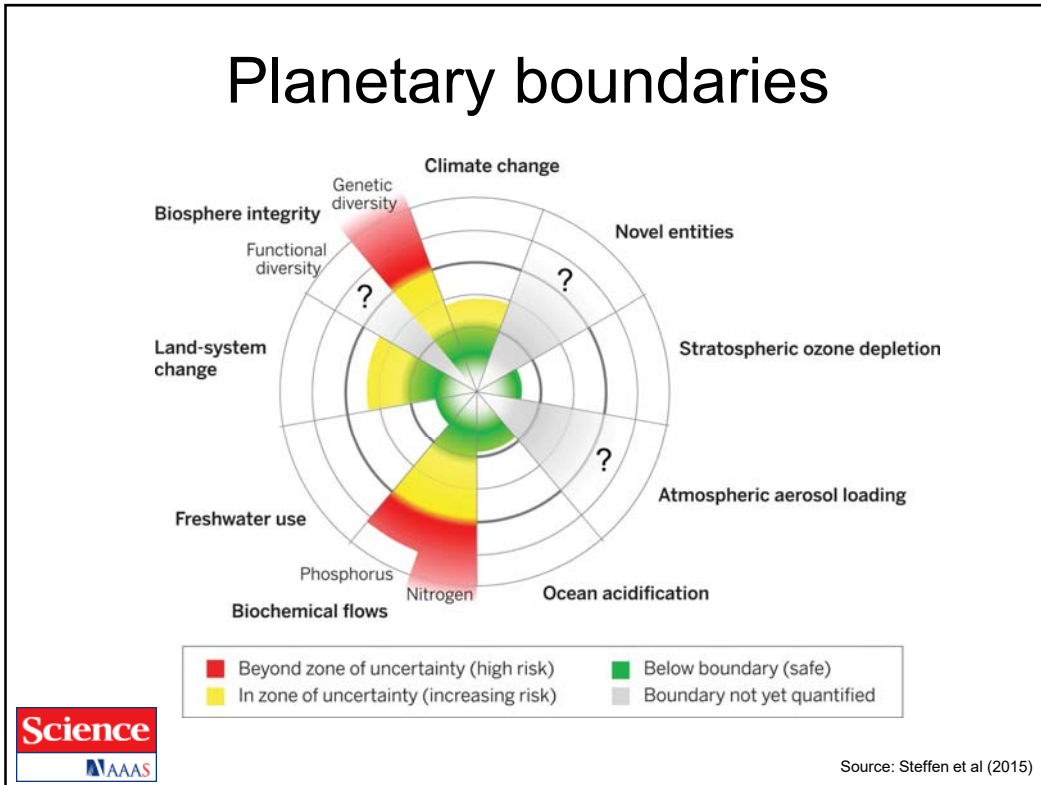
- Current status of the control variables for seven of the planetary boundaries. The green zone is the safe operating space, the yellow represents the zone of uncertainty (increasing risk), and the red is a high-risk zone. The planetary boundary itself lies at the intersection of the green and yellow 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)

Focus on the climate

Composite Antarctic CO_2 record (0-800 kyr before present) with current Mauna Loa readings
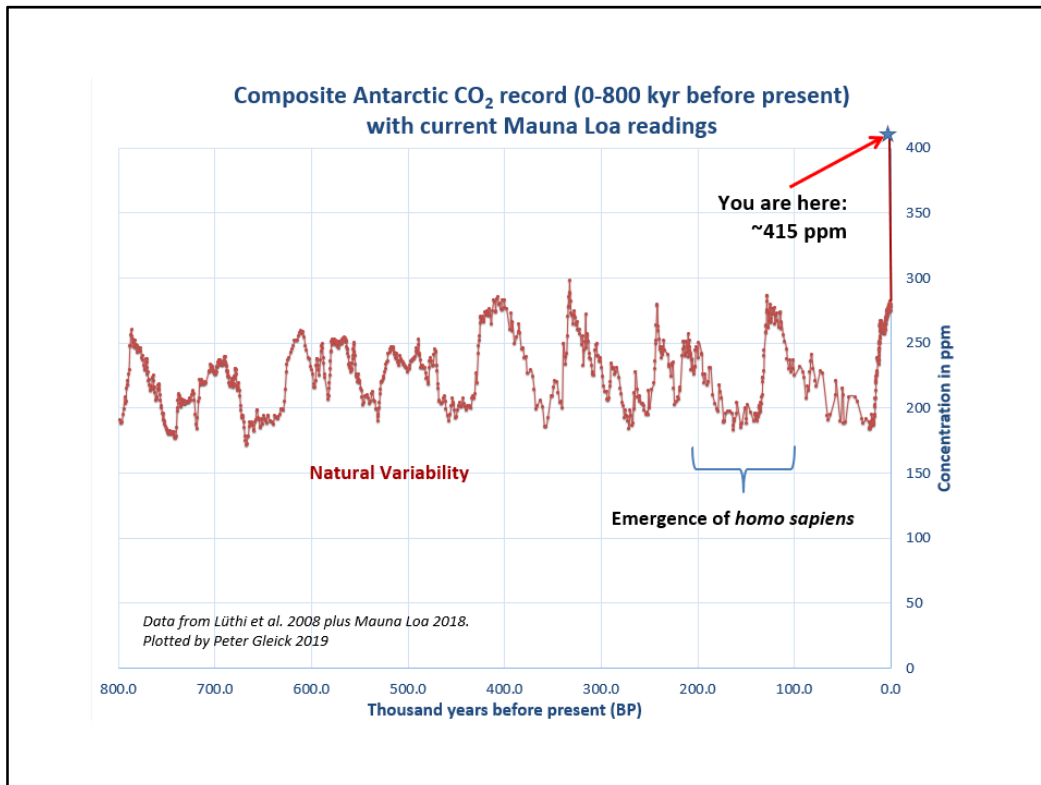
Early earth atmosphere was CO2 and ammonia. Ammonia broken down to form Nitrogen. Bacteria turned CO2 into CO2 & O2. (Over 2-3 bn years ago)

Pre-human eg Australopicethus was around about 3m years ago when CO2 was THIS high. Cyclical variations over the last 1m years largely due to perturbations in earth's orbit round sun.

We are doing/ have done in less than 75 years the equivalent of warming from ice age to temperate climate. The earth system is slow to respond but it will and the predictions are that the consequences will be very dramatic and civilisation threatening.

Figure 4 : Temporal evolution of CO$_2$ and climate forcing.

From: Future climate forcing potentially without precedent in the last 420 million years

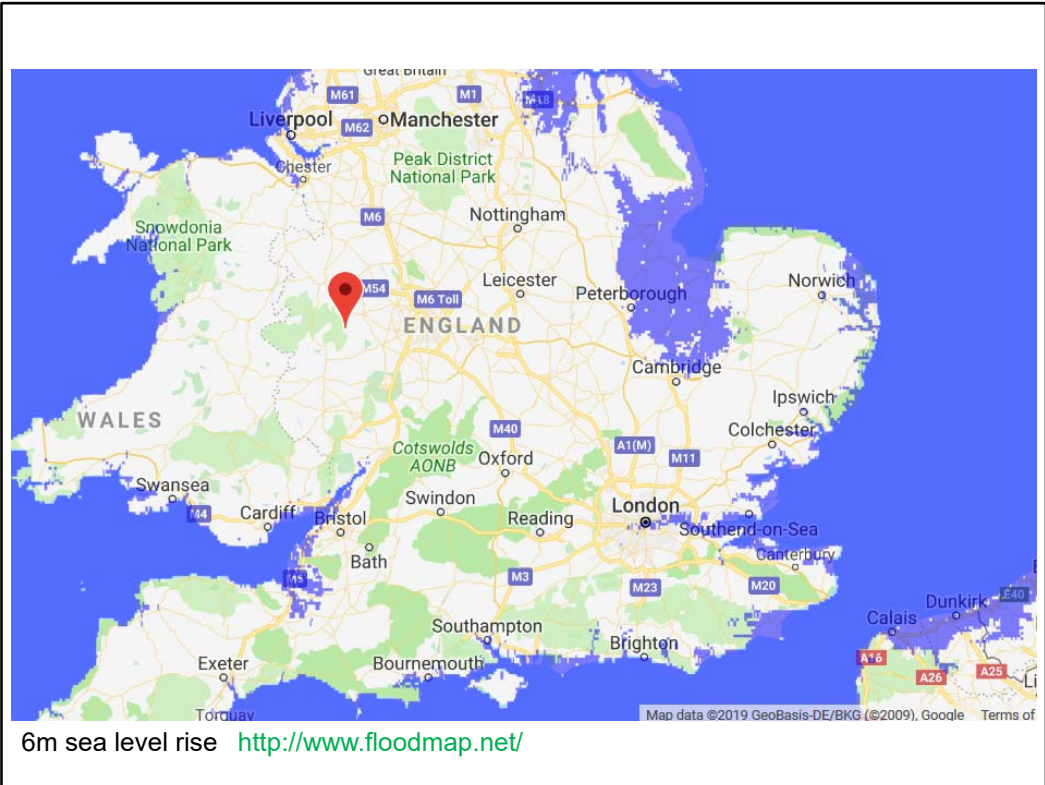https://www.nature.com/articles/ncomms14845/figures/4
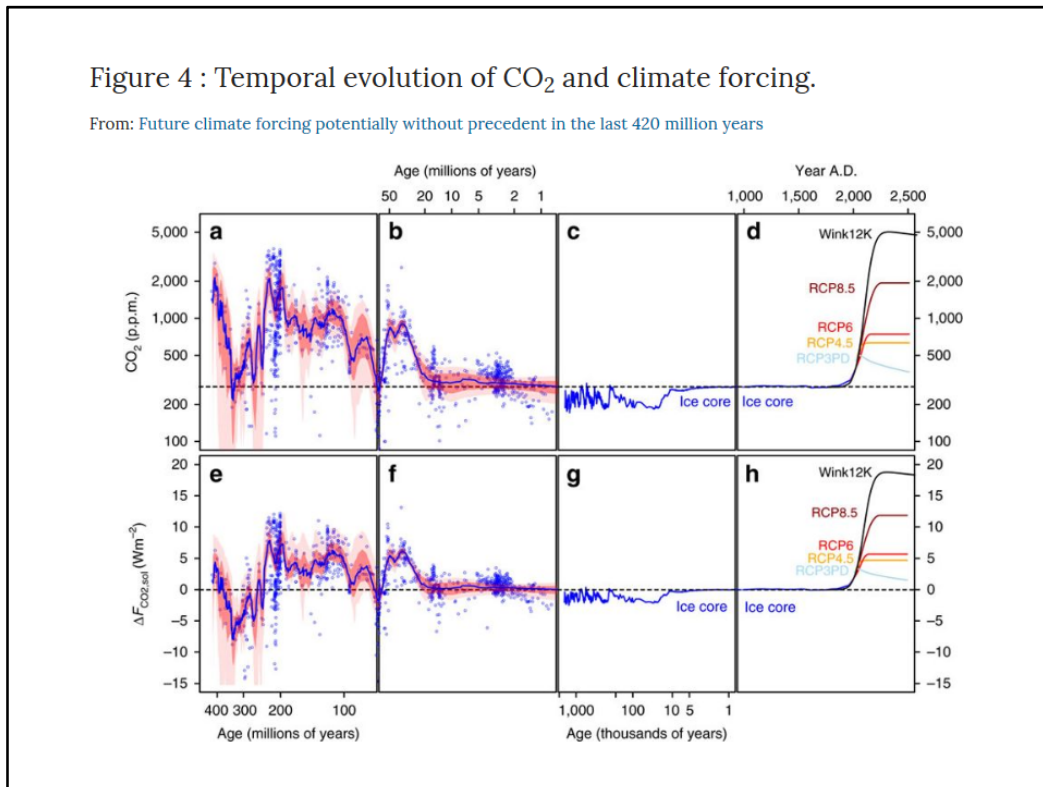
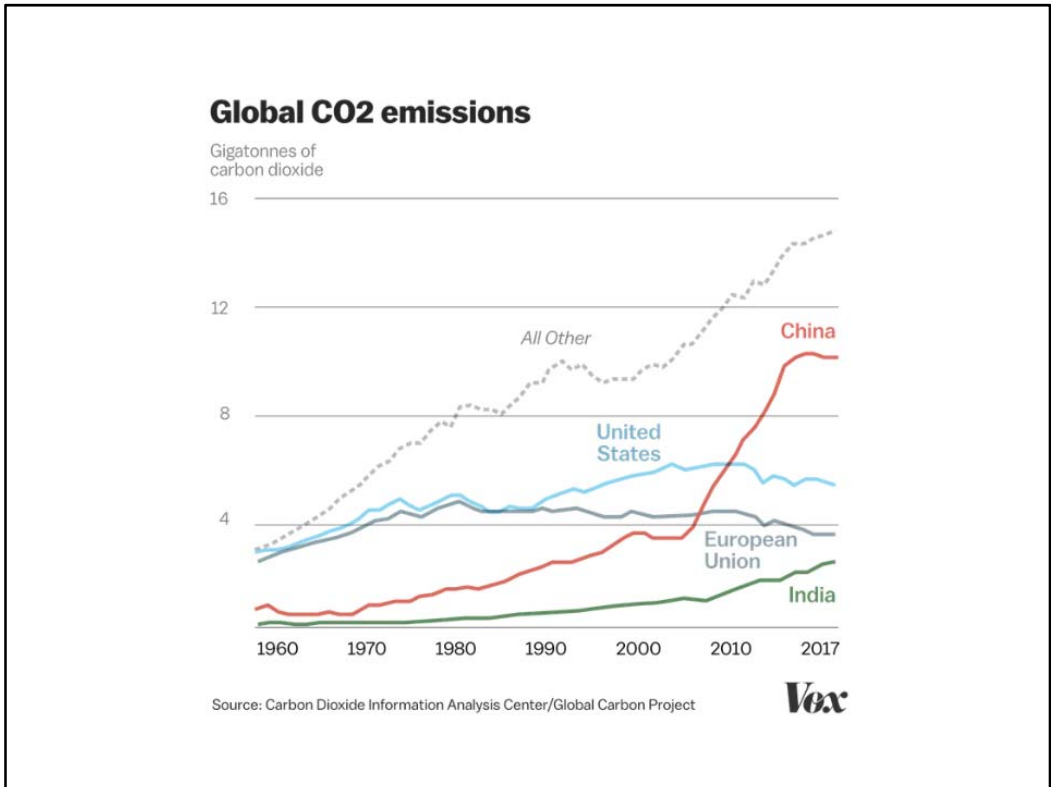*Nature Communications* **volume 8**, Article number: 14845 (2017)

Looking further back in time.

CO2 Hits 415ppm for the first time since the Pliocene 2.6-3.6million years ago

Sea levels were then 16 to 131 feet - 5 to 40 m higher !!

6m sea level rise   http://www.floodmap.net/

40m sea level rise   http://www.floodmap.net/

Global CO2 emissions

Gigatonnes of carbon dioxide

Source: Carbon Dioxide Information Analysis Center/Global Carbon Project

Vox

Who is emitting?

Why are the next 12 years so important?

To keep 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, world has 12y before 'lock in' of dangerous temp rises**
  - *(Significant uncertainties)*

- Figures from IPCC (2018)
- Uncertainties mean transition period could be significantly longer or shorter
- Emissions mostly in the last 50 years…
- Need to explain why only a small change in the average is important: hides extremes, regional variation – eg poles warm much more.
- Extremes= flooding, drought, intense hurricanes, tornados, intense cold periods, disruption of ocean currents, monsoon.

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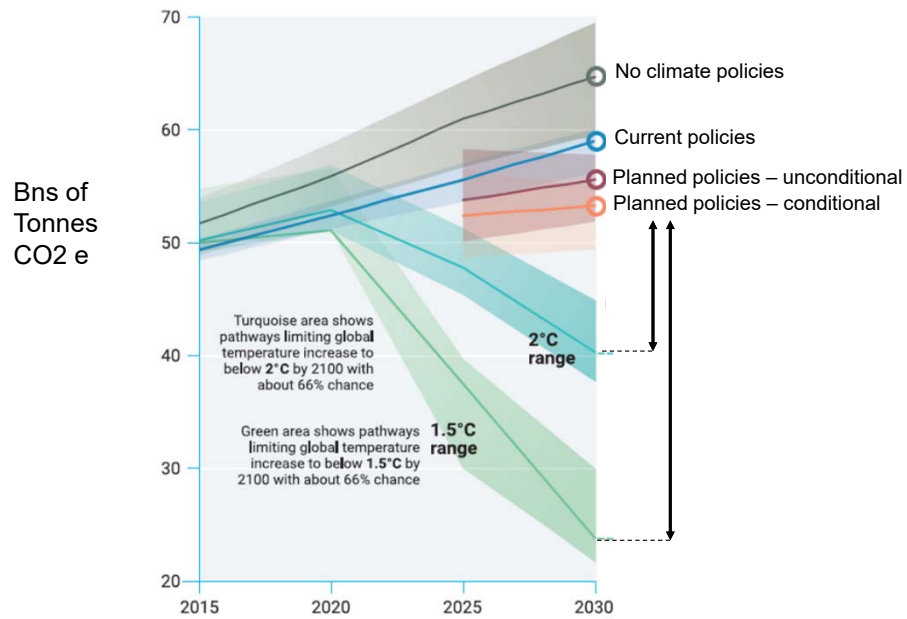
Global greenhouse gas emissions under different scenarios and the 'emissions gap' in 2030 (median estimate and 10th to 90th percentile range)

Source: UNEP (2018)

So, at 50-60 bn tonnes/year we will use up our remaining carbon 'budget' for 1.5 – 2 degrees in 10-12 years or so…

Why is a rise of only 2 degrees important?

- It is an **average**
- The average hides greater extremes
- Regional variations
- At the poles temp rises over 4 degrees
  - Disruption of ocean currents
- More energy in the system leads to more extreme events:
  - Drought, fires, floods, intense storms
 - Heatwaves, intense cold periods

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: 37,000 + supply chain

Data sources:

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

How close are we to replacing fossil fuels?

Global energy consumption
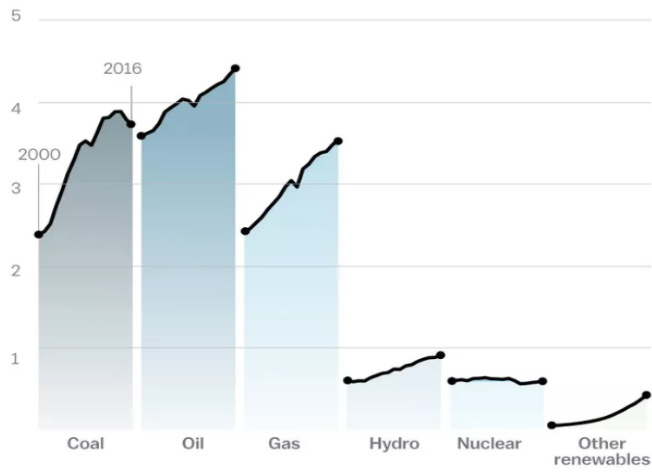
Source: BP

Not very close !

To succeed we have to get Coal Oil and Gas down to zero......

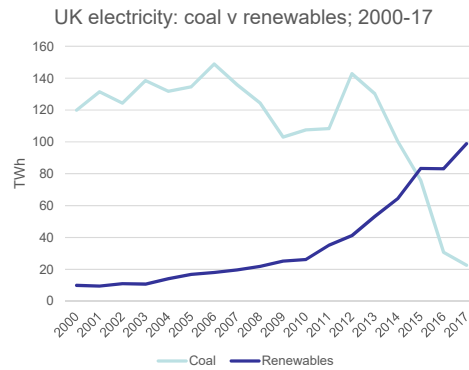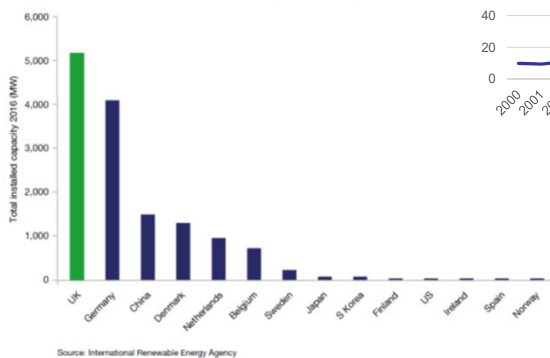## Govt claim of 40% emissions reduction since 1990

- **Creative accounting**
- **Air and maritime emissions not included**
- **Emissions due to consumption not included**
- **Reality is that UK emissions reduction ~ 25% (SGR estimate)**

But some UK climate progress

Jobs in low carbon/ renewable energy sectors:
- 210,000 + supply chain
- (bigger than MoD 123,000)

UK electricity: coal v renewables; 2000-17

Offshore wind installed capacity by country

Source: International Renewable Energy Agency

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)
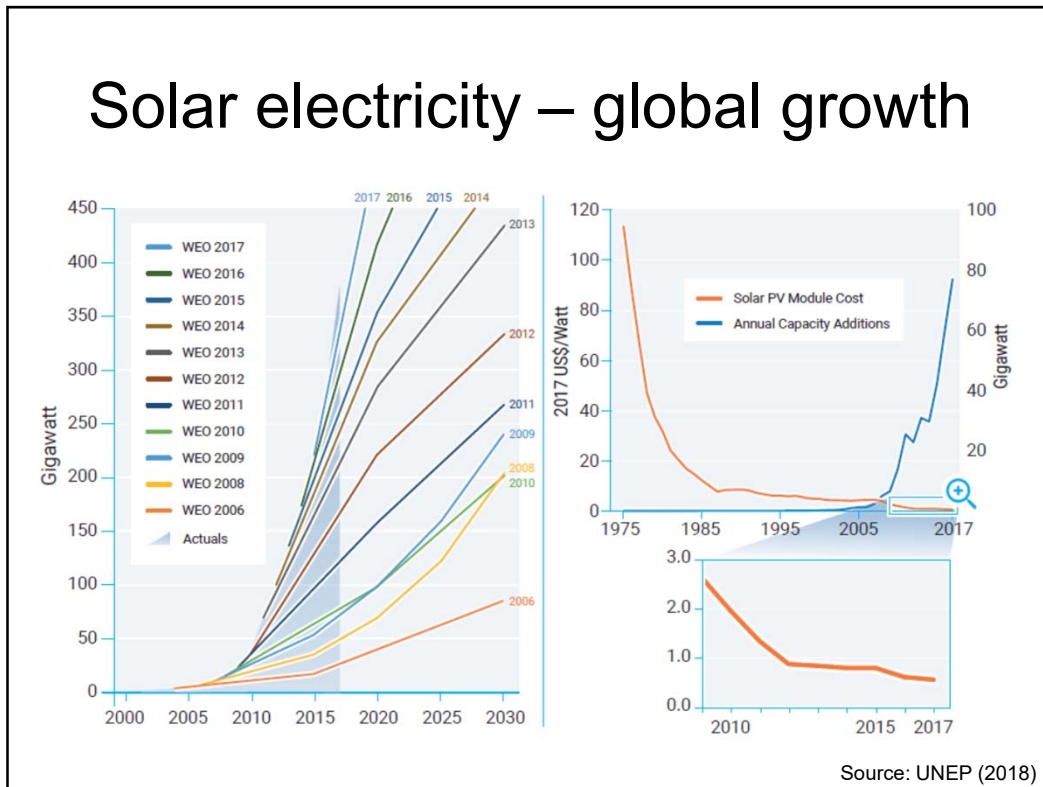
Source: UNEP (2018)

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)

Examples of the transition required

- An effort similar to that in WW-2
- We have the technology (but not so far the will to use it)
- **Low carbon infrastructure – zero C electricity & transport**
- **Some rationing eg of flying?**
- Huge changes needed
  - Major shift in transport
    - To trains, buses, cycling, walking, car-sharing
- Major areas where emissions are barely falling
  - UK examples: transport; agriculture;
    - Large reductions in meat/ dairy consumption needed
  - Fewer consumer goods

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

We have the technology – we can rebuild him: The Bionic Man / 6 million dollar man (1970s).
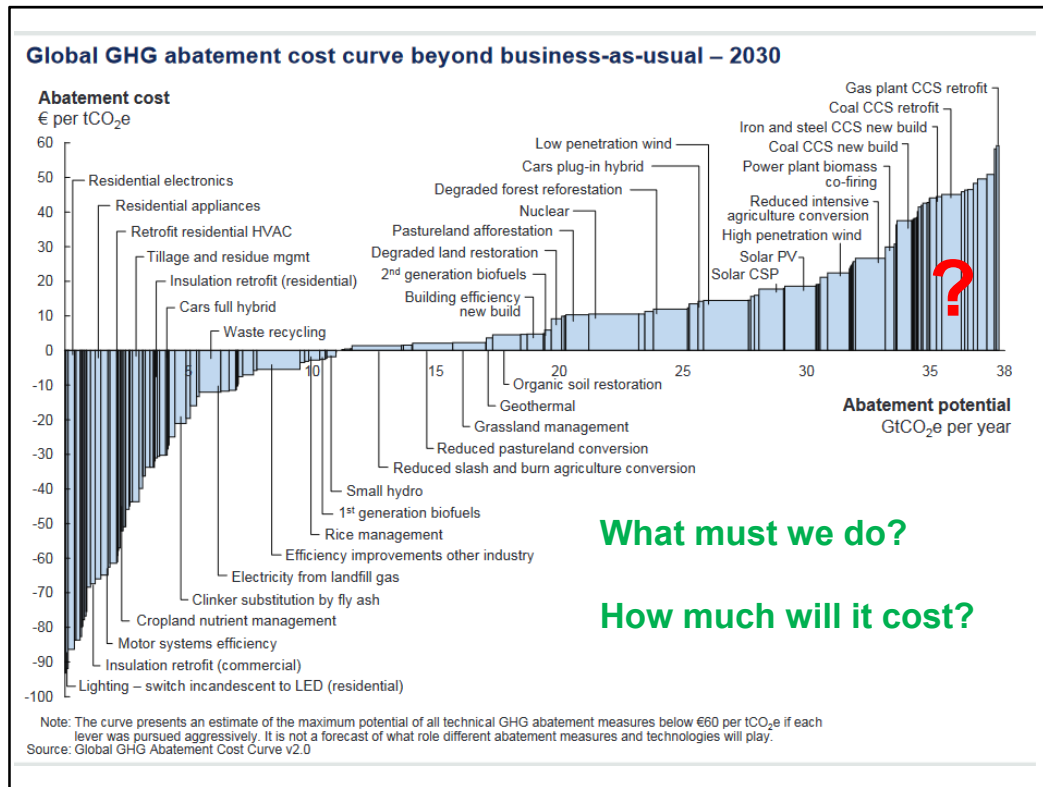
Why haven't we done this already?

- **1st IPCC was in 1990 – 28 years of failure in reducing emissions…**
- **WHY? Technocratic fraud?**
- **Offsetting – pay a poor person to diet for you**
- **Clean Dev Mechanism – state sponsored offsetting**
- **Emissions trading – too many permits**
- **Afforestation – plant a tree, expand an airport**
- **Imagined negative emission tech – (not happening)**
- **Geo-engineering – even if it 'works' not a long term solution**
- **Do as I say not as I do**
- **Highly unequal responsibility & huge asymmetry in wealth distribution embeds equity at heart of climate reductions**
- **Richest 10% produce half of global carbon emissions.**
- **If regulations forced top 10% to reduce to EU average :– 30% reductions**

Some of this from Kevin Anderson Tyndall centre.

Geoengineering is also tampering with ecosystems that we do not understand and that have evolved and become stable of millenia.

Very foolish / arrogant to think that we can safely do better.

Global GHG abatement cost curve beyond business-as-usual – 2030

https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/Pathways%20to%20a%20low%20carbon%20economy/Pathways%20to%20a%20low%20carbon%20economy.ashx

- 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)
- Tidal and marine current power
- Large red ? Indicated scepticism about these options. But we can achieve necessary reductions with well understood tech.

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Examples of spending required

- **City region £5bn (Leeds example)**
- **UK wide £100bn required (4yr payback)**
- **McKinsey: $200-350bn /yr globally**
  - **(1% global GDP)**

Precedents:

- **HS2 - £56bn +**
- **Crossrail – £17.6 bn**
- **Hinkley C - £20 bn**
- **QE £445 bn; Japan $447bn; USA $480bn/yr**

Funding low carbon cities: local perspectives on opportunities and risks, Sullivan, Gouldson & Webber, Climate Policy 2013

https://doi.org/10.1080/14693062.2012.745113

McKinsey report previous slide, Stern Reports and follow up studies.

UK science and technology policies

In brief – this talk is already much too long…

UK Industrial & Innovation plan / 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
- Defence industry policy kept separate (special treatment)
- Scientific/ university innovation plan - science increasingly tied to national economic growth policies
- Policies 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 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

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 or support SGR*

- 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).

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References (p1)

Campaign to Stop Killer Robots (2018). Fragile diplomatic talks limp forward. November. https://www.stopkillerrobots.org/2018/11/fragile/

Campaign to Stop Killer Robots (2019). Rise of the tech workers. January. https://www.stopkillerrobots.org/2019/01/rise-of-the-tech-workers/

Carbon Brief (2019). Analysis: Why the UK's CO2 emissions have fallen 38% since 1990. https://www.carbonbrief.org/analysis-why-the-uks-co2-emissions-have-fallen-38-since-1990

Carbon Tracker Initiative (2012). Unburnable Carbon: Are the world's financial markets carrying a carbon bubble? https://www.carbontracker.org/wp-content/uploads/2014/09/Unburnable-Carbon-Full-rev2-1.pdf

CDP (2017). Carbon Majors Report 2017. https://www.cdp.net/en/reports/downloads/2327

CND (2016). Trident and jobs: The employment implications of cancelling Trident replacement. Campaign for Nuclear Disarmament. https://cnduk.org/resources/trident-and-jobs/

Cogent (2011). Assurance: Skills for Nuclear Defence. https://www.cogentskills.com/media/1406/assurance-skills-for-nuclear-defence.pdf

Committee on Climate Change (2018). Reducing UK emissions – 2018 Progress Report to Parliament. https://www.theccc.org.uk/publication/reducing-uk-emissions-2018-progress-report-to-parliament/

Convention on the Prohibition of Anti-Personal Mines (2019). Convention's Facts and Figures. https://www.apminebanconvention.org/conventions-facts-and-figures/

Datoo A (2017). Could Trident be hacked? SGR website. http://www.sgr.org.uk/resources/could-trident-be-hacked

Debasers Filums Ltd (2018). Nae Pasaran. https://naepasaran.com/

Defense News (2019). Here's how many billions the US will spend on nuclear weapons over the next decade. https://www.defensenews.com/space/2019/01/24/heres-how-many-billions-the-us-will-spend-on-nuclear-weapons-over-the-next-decade/

Dept. for Business, Energy and Industrial Strategy (2017). Industrial Strategy: building a Britain fit for the future. https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future

References (p2)

Dept. for Business, Energy and Industrial Strategy (2017). The Clean Growth Strategy. https://www.gov.uk/government/publications/clean-growth-strategy

Dept. for Business, Energy and Industrial Strategy (2019). Introduction to Sector Deals. https://www.gov.uk/government/publications/industrial-strategy-sector-deals/introduction-to-sector-deals

Dept. for Business, Innovation and Skills (2011). UK Science, Engineering and Technology (SET) statistics 2011. Tables 2.2 & A2.2.

Dept. for Business, Innovation and Skills (2014). Our plan for growth: science and innovation. https://www.gov.uk/government/publications/our-plan-for-growth-science-and-innovation

Drone Wars UK (2018). Off the Leash: How the UK is developing the technology to build armed autonomous drones. https://dronewars.net/2018/11/10/off-the-leash-autonomous-drones/

Federation of American Scientists (2018). Status of World Nuclear Forces. https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/

Fossil Free (2019). Divestment Commitments. March. https://gofossilfree.org/divestment/commitments/

ICAN (2019). International Campaign for the Abolition of Nuclear Weapons. http://www.icanw.org/

IPCC (2018). Global Warming of 1.5C. Special Report. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/sr15/

IPPR (2019). This is a Crisis: Facing up to the age of environmental breakdown. Institute for Public Policy Research. https://www.ippr.org/research/publications/age-of-environmental-breakdown

International Energy Agency (2018). RD&D Statistics: online database. http://www.iea.org/statistics/RDDonlinedataservice/

Lewis P et al (2014). Too Close for Comfort: Cases of new nuclear use and options for policy. Chatham House. http://www.chathamhouse.org/publications/papers/view/199200

MOD (2017). Industry for defence and a prosperous Britain: refreshing defence industrial policy. Ministry of Defence. https://www.gov.uk/government/publications/defence-industrial-policy

References (p3)

MOD (2018). The defence equipment plan 2018. Ministry of Defence.
https://www.gov.uk/government/collections/defence-equipment-plan-reports

Move the Nuclear Weapons Money (2019). Nuclear weapons divestment: adopted policies. March.
http://www.nuclearweaponsmoney.org/legislation/

Office of National Statistics (2018). UK Government expenditure on science, engineering and technology, UK: 2016.
https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgovernmentexpenditureonscienceengineeringandtechnology/previousReleases

Office of National Statistics (2019). Low carbon and renewable energy economy, UK: 2017.
https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/finalestimates/2017

Oil and Gas UK (2018). Workforce Report 2018. https://oilandgasuk.cld.bz/Workforce-Report-2018

Our World in Data (2017). CO_2 and other Greenhouse Gas Emissions. https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

Oxford Research Group (2006). Global Responses to global threats: Sustainable security for the 21st century.
http://www.oxfordresearchgroup.org.uk/publications/briefing_papers/global_responses_global_threats_sustainable_security_21st_century

Our World in Data (2017). CO_2 and other Greenhouse Gas Emissions. https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

Oxford Research Group (2006). Global Responses to global threats: Sustainable security for the 21st century.
http://www.oxfordresearchgroup.org.uk/publications/briefing_papers/global_responses_global_threats_sustainable_security_21st_century

References (p4)

Oxford Research Group (2018). Defining Remote Warfare.(Conceptual Series)
https://www.oxfordresearchgroup.org.uk/pages/category/conceptual-series-defining-remote-warfare

People and Planet (2019). Fossil-Free Campaign. March. https://peopleandplanet.org/fossil-free

Robock A, Oman L, Stenchikov GL (2007). Nuclear winter revisited with a modern climate model and current nuclear arsenals: still catastrophic consequences. Journal of Geophysical Research, vol.112, no.D13, D13107

SGR (2011). Ethical careers programme. http://www.sgr.org.uk/projects/ethical-careers

SGR (2013). Offensive Insecurity: The role of science and technology in UK security strategies. Report. (Authors: Parkinson S, Pace B, Webber P) http://www.sgr.org.uk/publications/offensive-insecurity

SGR (2015). UK nuclear weapons: a catastrophe in the making? Report. (Authors: Webber P, Parkinson S) http://www.sgr.org.uk/resources/uk-nuclear-weapons-catastrophe-making

SGR (2018). Artificial intelligence: how little has to go wrong? Report. (Authors: Simms A, Parkinson S) http://www.sgr.org.uk/publications/artificial-intelligence-how-little-has-go-wrong

SGR (2019). Science4Society Week. http://www.s4s.org.uk/

SIPRI (2018). Trends in world military expenditure, 2017. Stockholm International Peace Research Institute. https://www.sipri.org/publications/2018/sipri-fact-sheets/trends-world-military-expenditure-2017

Steffan et al (2015). Planetary boundaries: Guiding human development on a changing planet. Science, vol.347, no.6223, 1259855

UNEP (2018). Emissions Gap Report 2018. United Nations Environment Programme. https://www.unenvironment.org/resources/emissions-gap-report-2018

Wikipedia (2019). List of weapons of mass destruction treaties [and references therein] https://en.wikipedia.org/wiki/List_of_weapons_of_mass_destruction_treaties