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The Environmental Impacts of the UK Military Sector

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Researched and written by: Stuart Parkinson, Scientists for Global Responsibility (SGR)

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ABOUT THE AUTHOR

Dr Stuart Parkinson is Executive Director of SGR, a post he has held for over 15 years, where he has co-ordinated research, education and campaigning on ethical issues across science and technology. He holds a PhD in climate change science and a Bachelors in physics and engineering from Lancaster University. He was a post-doctoral research fellow at the Centre for Environmental Strategy, University of Surrey, for five years, and has also worked in industry – including on military projects – and for other NGOs. He has also been an expert reviewer for the Intergovernmental Panel on Climate Change. He has authored/ co-authored numerous reports, academic papers and popular science articles.

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Email: info@sgr.org.uk

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Executive summary

This report assesses the key environmental impacts of the UK military, arms industry and related sectors. It provides a detailed assessment of UK military greenhouse gas (GHG) emissions – arguably, more in-depth than previously provided in a report in the public domain. It also gives an overview of other related environmental issues, especially those of particular concern, such as impacts resulting from weapons-use, the management of military nuclear waste, and the environmental impacts should nuclear weapons ever be used in war.

The report's main findings are:

GHG emissions

- The Ministry of Defence (MOD) is highly selective in the data it publishes on its environmental impacts within its annual reports. In particular, figures for total direct GHG emissions are no longer included. We estimate that the figures that are reported in the main text of the report cover less than *one-third* of the MOD's total direct GHG emissions.
- The UK military-industrial sector – including the armed forces, arms industry and related employment – is a large source of GHG emissions. There are two ways of calculating these emissions: the territorial or 'production-based' approach; and the lifecycle or 'consumption-based' approach. We estimate that:
  - The GHG emissions of the military-industrial sector in the financial year 2017–18 – using the production-based approach – were 6.5 million tonnes of carbon dioxide (CO_2) equivalent. This was greater than the direct CO_2 emissions of about 60 nations.
  - The GHG emissions of UK military spending in 2018 – using the consumption-based approach – was approximately 11 million tonnes of CO_2 equivalent. This is also known as the 'carbon footprint' and includes all lifecycle emissions, such as those arising abroad from raw material extraction. This is more than 3.5 times larger than the total direct GHG emissions of the MOD, and more than 11 times larger than the GHG figures quoted in the main text of MOD annual reports. It is also equivalent to the total CO_2 emitted by the annual average mileage driven by over six million UK cars.
  - These figures do not include the GHG emissions related to impacts of weapons use on the battlefield. Such emissions could potentially be large, but are highly uncertain.
- The UK-based company with the largest GHG emissions was BAE Systems. Its UK emissions were about 30% of the total for the nation's arms industry as a whole.
- Significant falls in the GHG emissions of the UK military seem unlikely due to: planned increases in military spending, leading to increases in activity; greater deployment of high-energy consuming vehicles, including the huge new Queen Elizabeth-class aircraft carriers; and expansion of overseas military bases.
- Any decision to mount major military operations in the future would lead to a large increase in GHG emissions.
- In terms of GHG emissions reporting, some corporations do not provide what we consider to be the minimum necessary information in their annual reports/ corporate responsibility reports. Such companies include MBDA and Elbit.

Other environmental issues

- The activities of the Ministry of Defence, including the armed forces, its civilian agencies, and its contractors, are not automatically covered by civilian environmental regulations. If the MOD decides there is a 'defence need' then they are exempt. Instead the MOD aims to 'minimise' its environmental impacts through the application of a set of environmental management systems. External verification of these systems seems to be patchy.
- The UK's military missions are likely to have major environmental impacts, but no data is publicly available on the full extent of these impacts, nor on measures taken to reduce them. Indeed, attempts to assess such impacts seem not to be undertaken routinely by the MOD.

- The MOD and its contractors have – over a period of decades – a poor record of managing their radioactive waste. There have been major delays, spiralling costs, unclear goals and, at times, prosecutions for health, safety and environmental lapses. It seems that the prosecutions would have been far more frequent had this been a civilian operation.
- The UK government fails to acknowledge, let alone address, the catastrophic global environmental impacts should it ever launch its nuclear weapons.
- The MOD's reporting on a number of environmental impacts in its annual reports is especially poor: hazardous waste; environmental impacts of war-fighting; and the exemptions from environmental law granted to the UK military and its contractors.

Broader policy issues

- Only a major change in UK military strategy – away from one based on deploying UK military forces with the capability for long-range 'force projection' to forces focused only on territorial defence and UN peace-keeping – is likely to lead to low levels of environmental impacts, including low GHG emissions.
- Such a change in military policy would go hand-in-hand with broader changes to the UK's wider security policies. This would allow a major shift in spending and other resources – for example, in science and technology – from military activities to tackling non-military threats, such as climate change and pandemics, and the broader roots of armed conflict, which include a range of economic, social and environmental problems.

Recommendations

The report makes a series of recommendations to deal with these issues. These include straightforward actions, such as improvements in the ways the MOD and arms corporations report on their GHG emissions and other environmental impacts. Other recommendations call for an end to arms exports to governments with a poor record on environmental protection and human rights, a military focus on replacing the use of fossil fuels and nuclear propulsion with efficient use of renewable energy, and an end to the deployment of nuclear weapons.

However, the overarching priority should be a major shift in the UK's security policies to a 'human security' approach which prioritises tackling poverty, ill-heath, inequality, and environmental crises, while minimising the deployment and use of armed force. This should include a comprehensive 'arms conversion' programme including all relevant UK companies, including funding for retraining of workers. Particular emphasis should be given to a shift to developing and deploying technologies for renewable energy generation and energy conservation.

1. Introduction

War and the preparation for war inevitably cause numerous, often severe, environmental impacts, including pollution of land, water and air. Military ships, aircraft and land vehicles are resource intensive to manufacture and fuel intensive to use. Maintaining military bases and deploying troops are generally energy intensive activities. Weapons use – apart from causing human deaths and injuries – also cause considerable damage to the natural environment.

The UK is a leading military power. Its budget is among the top ten largest in the world,[1] it is nuclear-armed, and it is one of the world's top exporters of weapons and other military equipment.

This report is an examination of the key environmental impacts of the UK military and related industrial sectors. It attempts to provide a detailed assessment of UK military greenhouse gas (GHG) emissions[2] – in more depth than has previously been achieved in a report in the public domain. It also gives an overview of other related environmental issues, especially those which cause particular concern, such as impacts resulting from weapons-use, the management of military nuclear waste, and the environmental impacts should nuclear weapons ever be used.

The report draws on a wide range of data, especially from government and corporate sources, but also from academia and non-governmental organisations. Some data was straightforward to access, but often national security or commercial confidentiality considerations restricted access. At times we found major gaps, in other instances the data was simply of poor quality. Hence a significant part of this report is the examination of data quality issues and how to manage them.

Specifically, the military bodies and industrial sectors that we examine in this report are:

1. the Ministry of Defence (MOD), including UK armed forces and civilian agencies, whether operating in UK territories or abroad, and whether operating during peace-time or in war;
2. UK-based MOD suppliers, including the British arms industry and other private sector businesses supplying the MOD;
3. UK-based exporters of weapons and other military equipment;
4. Lifecycle environmental impacts of (1), (2) and/or (3), including those due to arms production abroad, supply-chain industrial activities (both in the UK and abroad), and raw materials extraction and processing (both in the UK and abroad).

The report is structured as follows. Section 2 compiles estimates of the GHG emissions of the UK military-industrial sectors – for the MOD, the arms industry and other military suppliers, as well as estimating a 'carbon footprint' for the whole sector. Section 3 examines wider environmental impacts, including from weapons-use, military nuclear waste, and nuclear weapons. We draw conclusions in section 4, and make a series of recommendations in section 5.

1 SIPRI (2020). Military expenditure database. https://www.sipri.org/research/armament-and-disarmament/arms-and-military-expenditure/military-expenditure

2 Often commonly referred to as 'carbon emissions'.

2. Greenhouse gas emissions of the UK military-industrial sectors

A major focus of this report is the GHG emissions of the UK's military and arms industry, including estimating their total carbon footprint.

Many of the activities of the armed forces are obviously very energy intensive – including deploying combat planes, warships and tanks – and most of that energy comes from burning fossil fuels, especially oil, leading to large-scale GHG emissions. Military bases can also be very energy intensive, again using fossil fuels for much of their heating, cooling or electricity generation. Manufacturing arms and other military equipment is also energy- and resource-intensive, utilising specialist production facilities, complex international supply-chains, and (often rare) minerals, which themselves are energy intensive to extract and refine. Furthermore, the military is a unique sector, in that the use of its products, i.e. weapons, often leads to considerable further GHG emissions, including fires from burning buildings, fuel depots and vegetation, healthcare for civilian and military survivors, and post-conflict reconstruction.

Given the potentially large GHG emissions of the military – both in the UK and internationally – the scientific literature on the size of such emissions is surprisingly limited. For example, the reports of the Intergovernmental Panel on Climate Change (IPCC), the UN's scientific advisory body on the issue, have barely mentioned the sector.[3] National security restrictions have considerably limited access to data, with very few nations reporting separate figures for military GHG emissions, and many not compiling them at all. This situation became embedded in international reporting standards following a demand from the USA that the targets agreed as part of the 1997 Kyoto Protocol excluded emissions related to military activities.[4] The advent of the 2015 Paris Agreement, which has led to a more flexible approach to military-related emissions,[5] has opened the door to greater recognition of the issue.

Hence, a key aim of this report is to compile as complete a picture as possible using the available data on the GHG emissions of the UK military – looking not just at direct emissions from the fuel burnt by military craft, but also the wider 'carbon footprint' which includes the full lifecycle, from the extraction of raw materials through industrial manufacture of the equipment and consequent use to disposal of waste products. In addition, we consider the extent to which the emissions arising from the impacts of weapons use can be included.

We begin this section with a short summary of the key methods we use to estimate GHG emissions, followed by their application to the UK Ministry of Defence, including the armed forces, and the UK arms industry and associated sectors. We then consider total figures for the combined UK military-industrial sector, an estimate of its carbon footprint, and its significance within UK GHG emissions as a whole. Finally, we consider a range of overarching issues – including GHG emissions arising from the use of weapons, exemptions from national targets to reduce emissions, and future trends in military emissions.

2.1 Calculating GHG emissions: key methods

This report makes use of several key methods in its compilation and reporting on GHG emissions of the UK military-industrial sector.

3 For example, in the most recent (fifth) in-depth 'assessment' report – published in 2013-14 in four volumes totalling nearly 5,000 pages – military GHG emissions were only mentioned once in an annex. See p.1304 of: IPCC (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the IPCC. Cambridge University Press. https://www.ipcc.ch/report/ar5/wg3/

4 Lorincz, T. (2015). Demilitarization for Deep Decarbonization. Presentation at SGR conference, 4 November. https://www.sgr.org.uk/resources/demilitarization-deep-decarbonization

5 *The Guardian* (2015). Pentagon to lose emissions exemption under Paris climate deal. 14 December. https://www.theguardian.com/environment/2015/dec/14/pentagon-to-lose-emissions-exemption-under-paris-climate-deal

Firstly, GHG emissions are reported in 'tonnes of carbon dioxide equivalent' or tCO_2e. This is a standardised measure which takes account of the fact that there are a number of different GHGs – carbon dioxide (CO_2) being the most prevalent[6] – with each gas having different physical properties, meaning that each traps different amounts of heat in the atmosphere, molecule for molecule. All emissions figures given in this report are for single years (often the financial year, 2017–18), except where otherwise indicated.

Secondly, there are two main approaches to compiling and reporting on GHG emissions:

- territorial or 'production-based' emissions; and
- lifecycle or 'consumption-based' emissions.

The production-based emissions of a nation or organisation are those from sources within the national (or organisational) territorial boundaries. Such emissions may also include those from sources that are deployed internationally, but are owned by the national government (or organisation), for example, military ships and aircraft. National GHG inventories – as discussed below – are the most common form of production-based emissions. This approach is the simplest of the two to accurately apply in practice.

The consumption-based emissions of a nation or organisation are those that occur as part of the lifecycle of activities necessary to support that consumption. Hence, these activities include extraction of raw materials through manufacture and use to disposal of waste products, regardless of where in the world they happen or who owns them. This is commonly known as the 'carbon footprint' of a nation of organisation. This approach is argued to be more appropriate in that emissions are assigned to those nations or organisations whose consumption is responsible for driving them.

National assessments of GHG emissions are compiled by government bodies using the Guidelines for National GHG Inventories published by the IPCC.[7] All nations that are signatories of the UN Framework Convention on Climate Change are required to compile such assessments.[8] These are used as the basis for emissions reduction targets. Some governments, including the UK, have started to publish figures for their national carbon footprint.[9] Countries which import high levels of goods, rather than producing them domestically, tend to report much larger carbon footprints than their production-based emissions. The UK is one of those countries.

In this study, we compile total GHG figures for the UK military-industrial sector using both the production-based approach – in sections 2.2–2.4 - and the consumption-based approach – in section 2.5. We then compare the results in section 2.6.

There is a third methodological issue to be aware of. At an organisational level – including businesses and government departments – the IPCC reporting guidelines have been developed further by an international body called GHG Protocol.[10] It has defined an assessment standard whereby organisations report their emissions in three main categories – Scopes 1, 2 and 3 – as described in Table 2.1.

To meet the standard, organisations must rigorously measure and report their emissions for Scopes 1 and 2, but are also encouraged to assess Scope 3 emissions, on which they will have a significant influence, especially if they are a large body.

6 The other major GHGs are methane (CH_4), nitrous oxide (N_2O) and a group known as the 'F' gases.

7 IPCC (2020). Task Force on National Greenhouse Gas Inventories Programme. https://www.ipcc-nggip.iges.or.jp/index.html

8 UN Framework Convention on Climate Change (2020). What is transparency and reporting? https://unfccc.int/process-and-meetings/transparency-and-reporting/the-big-picture/what-is-transparency-and-reporting

9 DEFRA (2020). UK's carbon footprint. https://www.gov.uk/government/statistics/uks-carbon-footprint

10 GHG Protocol (2020a). https://ghgprotocol.org/

Table 2.1. GHG emissions reporting by organisations – definition of Scopes 1, 2 and 3[11]

Category	Sources
Scope 1: Onsite GHG emissions	From sources that are owned/ controlled by the organisation, e.g. from combustion in owned/ controlled boilers, furnaces, vehicles, etc.
Scope 2: GHG emissions from purchased offsite energy	From purchased or acquired electricity, steam, heat and cooling, where source is not owned/ controlled by organisation.
Scope 3: Other offsite GHG emissions	Resulting from activities of a company, but sources not owned/ controlled by that organisation, e.g. extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services.

This reporting standard uses elements of both production- and consumption-based approaches, which can lead to confusion and double-counting if care is not taken. In this study, organisations including the Ministry of Defence and many arms corporations, utilise the framework shown in Table 2.1, so we highlight this where necessary, and take account of it when compiling total figures.

In the assessment that follows, we have compiled the available GHG emissions data from the Ministry of Defence – which obviously includes the British armed forces – as well as from businesses that operate in the UK supplying weapons and other military equipment, other UK businesses that provide services for the British military, and indirect employment that is dependent on such activities. We have also gathered additional data necessary to estimate the total carbon footprint of the UK military – which includes the overseas supply-chain – and other relevant data where available. We were able to gather significant amounts of data, but there were notable gaps, and a number of assumptions had to be made in order to make estimates of total GHG emissions levels. These are also explained in the sections that follow.

2.2 Ministry of Defence

The Ministry of Defence includes the UK's armed forces – the British Army, the Royal Navy (including the Royal Marines), and the Royal Air Force – as well as numerous civilian agencies. In reporting its environmental impacts, the MOD tends to classify its activities into two broad areas:

- Estates – which includes military bases (both on UK territory and in other countries), and civilian buildings; and
- Capability and Equipment (or Capability, for short) – which includes marine vessels (warships and submarines), aircraft (planes and helicopters), and land vehicles (tanks and other armoured vehicles).

Transport for civilian activities is generally grouped with Estates, while transport for military activities is generally categorised with Capability.

The MOD currently reports on its GHG emissions in a section of its annual report entitled *Sustainable MOD*.[12] However, in the main text of the report, the figures discussed only cover Estates (including business travel) and not Capability, the latter only being revealed in an annex and only for two years behind the reporting year. The disclosed figures indicate that the GHG emissions of Capability are over 60% of the total for the whole MOD. Hence, relegating this

11 Based on: GHG Protocol (2020b). Corporate Standard. https://ghgprotocol.org/corporate-standard

12 For the most recent example at the time of writing, see pp. 91-99 of: MOD (2019a). MOD Annual Report and Accounts 2018-19. https://www.gov.uk/government/publications/ministry-of-defence-annual-report-and-accounts-2018-to-19. From 2010 until 2018, *Sustainable MOD* was published as a stand-alone report.

Table 2.2. Estimate of total direct GHG emissions of the Ministry of Defence, 2017–18.

Category	GHG emissions (thousand tCO_2e)
Estates:	
MOD reported level (80% of estate)	942
MOD unreported level (20% of estate)	236
International business travel	40
Capability and Equipment:	
Aviation fuel	1,165
Diesel	544
Gas oil/ petrol	98
Total	**3,025**

to an annex, we view as a serious shortcoming in transparency. Indeed, the annex does not even provide a total figure for the MOD's GHG emissions – another serious shortcoming. We also noted further data gaps in the reporting of GHG emissions by the MOD related to the use of certain fuels (under Capability) and the coverage of MOD facilities (under Estates). This pattern of flawed reporting seems to be a feature of *Sustainable MOD* over a number of years. To give an example of the problems in more detail, we have documented data omissions, ambiguities, inconsistencies and errors from *Sustainable MOD 2017–18* in Appendix 1. To try to achieve clarity on overall figures for GHG emissions, we submitted a request under the Freedom of Information Act to the MOD but it did not respond within the statutory period of 20 days, and we were unable to pursue the case further because of the COVID-19 crisis.

In view of these shortcomings, we decided to compile our own estimate of the total direct GHG emissions of the MOD, and this is shown in Table 2.2. The estimate for Estates takes account of the fact that the reported figures only cover 80% of the emissions[13] and, while they do include domestic business travel within the UK, they do not include international business travel.[14] The estimate for Capability is calculated from data on fuel use provided in the MOD annual report for aviation fuel (aircraft) and diesel (mainly marine vessels and land vehicles),[15] multiplied by appropriate GHG emissions factors as used by the government in compiling its national inventory.[16] Figures for the emissions from the use of gas oil and petrol (mainly land vehicles) were estimated based on usage in previous years.[17]

In terms of the reporting categories given in table 2.1, this total covers Scopes 1, 2 and a very limited coverage of Scope 3, business travel. This total does not include all the other lifecycle emissions discussed earlier related to the arms industry, other military suppliers, their supply-chains, or extraction and processing of raw materials. These will be examined in the following sections.

In summary, we estimate the total direct GHG emissions for the MOD in 2017–18 to be 3.03 million tCO_2e. This is similar to the direct emissions of the UK's vehicle manufacturing industry.[18] It is more than three times the GHG emissions level reported and discussed in the main body of the MOD annual report, 0.94 million tCO_2e.[19]

In our view, it is misleading for the MOD to report its GHG emissions in such a selective and partial way. Indeed, MOD ministers do not seem to appreciate this problem. For example,

13 Note 10, Annex C of: MOD (2018a). *Sustainable MOD Annual Report 2017–18*. https://www.gov.uk/government/publications/sustainable-mod-annual-report-2017-to-2018

14 See Appendix 1.

15 Annex D of: MOD (2019a). *Op. cit.*

16 BEIS (2019a). Greenhouse gas reporting: conversion factors 2019. https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

17 Annex A of: MOD (2018a). *Op. cit.*

18 Figure 4.2 of: Committee on Climate Change (2019). Net Zero – Technical Report. https://www.theccc.org.uk/publication/net-zero-technical-report/

19 P. 94 of: MOD (2019a). *Op. cit.*

in answer to a recent parliamentary question on the carbon emissions of the UK armed forces, the then Parliamentary Under-Secretary of State for Defence simply referred to the partial figures in main text of that year's *Sustainable MOD* and not the total figures (which were given that year) in the annex.[20]

Comparing this figure to the available data on historic GHG emissions of the UK military shows that it has fallen markedly. For example, the earliest data we could find for the GHG emissions of the UK military was for 2007–08, ten years earlier.[21] This provided a total figure of 6.0 million tCO_2e – twice the 2017–18 figure. The reductions since then seem to have been achieved through a combination of reduced war-fighting, closure of unneeded military bases following cuts in national military spending, and energy efficiency programmes.[22]

2.3 Arms industry and other military suppliers

We now turn to the GHG emissions of the UK arms industry and other companies which supply the MOD. To estimate the total direct emissions, we first compiled data on 25 private sector companies operating in the UK with large military sales – as shown in Table 2.3 overleaf. These companies were chosen because they or their parent company are either:

(a) listed in the SIPRI Top 100 arms-producing and military services companies in the world;[23] or

(b) listed as having a contract with the Ministry of Defence worth over £200 million;[24] or

(c) both (a) and (b).

Many of these companies publish data concerning their GHG emissions in annual reports and other official documents. A full list of sources used is given in Appendix 2. Such data is, in general, company-wide – and so includes emissions from both from UK and non-UK operations, and from both civilian and military-related work. To calculate the emissions specifically related to UK military-industrial operations, we used two further sets of data:

- percentage of total company sales which are military – available from the SIPRI Top 100;[25]
- percentage of total workforce[26] based in the UK – available from annual reports and other company documents.

We then simply multiplied the company-wide GHG emissions by the military sales percentage and by the UK workforce percentage.

Using the calculation makes four key assumptions. Firstly, the revenue per employee is assumed to be similar for military and civilian divisions of the businesses. Secondly, the proportion of employees carrying out military work is assumed to be similar in the UK as in the rest of the company. Thirdly, the GHG emissions per unit of military sales is assumed to be similar to that for civilian sales. Fourthly, the GHG emissions per employee in the UK is assumed to be similar to that outside of the country. Obviously, these are significant simplifications but, in the absence of more detailed company data, we think this is the best available method. Indeed, given the shortcomings in the company data which we discuss later on, we do not think these assumptions markedly reduce the quality of the

20 Lancaster, M. (2016). Armed Forces: Carbon Emissions. Ministry of Defence written question and answer. 1 February. https://www.theyworkforyou.com/wrans/?id=2016-01-25.23962.h. We attempted to ask a similar parliamentary question during the research phase for this report, but the COVID-19 crisis intervened.

21 MOD (2011). *Sustainable Development Annual Report, 2009–10*. https://www.gov.uk/government/publications/sustainable-development-report-2009-10

22 This conclusion is based on information provided in *Sustainable MOD* over the past ten years as well as wider sources. We could find no evidence that the MOD has tried to quantify the effects of each of the different factors.

23 Data for 2018 from: SIPRI (2019). SIPRI Arms Industry Database. https://www.sipri.org/databases/armsindustry

24 Table 3a (annex) from: MOD (2018b). MOD trade, industry and contracts: 2018. https://www.gov.uk/government/statistics/mod-trade-industry-and-contracts-2018

25 SIPRI (2019). *Op. cit.*

26 We used workforce rather than sales in this situation to avoid uncertainties introduced by currency conversion.

Table 2.3. UK-based GHG emissions from 25 leading corporations which manufacture military equipment and/or supply goods and services to the UK military, 2018

Company	Country of parent company	UK employees (military sales only)	UK military-related GHG emissions (ktCO2e)	Military GHG emissions intensity (tCO2e per employee)	% military sales	Includes Scope 1, 2 emissions?	Includes Scope 3 emissions?
BAE Systems	UK	32,250	440.4	13.7	95%	Yes	Limited
Babcock International	UK	11,100	92.9	8.4	46%	Yes	Limited
Serco	UK	5,970	38.4	6.4	29%	Yes	No
Rolls-Royce	UK	5,230	36.6	7.0	22%	Yes	No
Leonardo	Italy	4,760	67.8	14.3	68%	Yes	Medium
MBDA[i]	Joint venture	3,420	46.9	13.7	100%	Not stated	Not stated
QinetiQ	UK	3,750	31.4	8.4	75%	Yes	No
Thales	France	3,170	13.9	4.4	50%	Yes	Limited
Airbus	Trans-European	2,090	19.8	9.4	15%	Yes	Medium
Lockheed Martin	USA	1,490	11.7	7.8	88%	Yes	No
Raytheon Systems (Parent: Raytheon)	USA	1,460	8.5	5.8	87%	Not stated	Not stated
Amey UK[ii] (Parent: Ferrovial)	Spain	1,450	19.3	13.3	21%	Yes	No[iii]
Boeing Defence UK (Parent: Boeing)	USA	1,190	8.9	7.4	100%	Yes	No[iv]
General Dynamics UK[v] (Parent: General Dynamics)	USA	1,160	9.0	7.8	100%	Not stated	Not stated
Cobham[vi]	UK	1,150	21.3	18.5	64%	Yes	Medium
EntServ UK[vii] (Parent: DXC Technology)	USA	1,130	7.2	6.4	24%	Yes	Limited
Meggitt	UK	980	9.6	9.8	35%	Partial[viii]	No
BT	UK	880	42.5	48.2	1%	Yes	Extensive
AirTanker[ix]	Joint venture	690	9.4	13.7	100%	No data	Not stated
Elbit[x]	Israel	480	6.9	13.7	95%	No data	Not stated
GKN[xi] (Parent: Melrose)	UK	450	1.0	2.2	8%	Yes	No
Northrop Grumman	USA	350	2.0	5.7	87%	Yes	Limited
Leidos Europe[xii] (Parent: Leidos)	USA	180	1.1	6.4	100%	No data	Not stated
Rheinmetall[xiii]	Germany	80	2.7	33.0	52%	Yes	Limited
WFEL[xiv] (Parent: Krauss-Maffei Wegmann)	Germany	70	1.0	13.7	95%	No data	Not stated
Totals		**84,920**	**910.4**[xv]	**10.7**[xvi]			

General notes:
In most entries in the table, the parent company is listed – and the data provided for the percentage of total sales that are military, and the military GHG emissions intensity, is that for the parent company. Where a UK subsidiary company is listed, the parent is listed in brackets, but figures for percentage of total sales that are military is for the UK subsidiary only. Any exceptions are listed in the notes on p.11.

Employment numbers are full-time equivalent.

Scope 3 emissions: 'Limited' includes business travel only; 'Medium' includes business travel and some other sources; 'Extensive' includes wide range of sources, including supply chain. Some companies report figures for Scopes 1, 2 and 3, but given prominence to only to their Scope 1 and 2 figures. Any reduction targets are generally set for Scopes 1 and 2 only.

Several companies did not clearly state in their annual reports/ corporate responsibility reports whether figures for GHG emissions were in 'tCO_2' or 'tCO_2e'. The latter has been assumed in all cases.

Numbered notes:

i. MBDA did not provide figures for its GHG emissions in its corporate responsibility/annual reports so an emissions intensity of 13.7 tCO_2e/emp was assumed – see main text.

ii. During 2018, Carillionamey companies were renamed Amey UK companies, as they were taken over by Ferrovial following the collapse of Carillion.

iii. Ferrovial, the parent company of Amey UK, does report extensively on its Scope 3 emissions, but it is not clear how these emissions might be allocated to subsidiaries.

iv. Boeing's environmental report claimed to report on Scope 3 emissions, but no figures could be found in this or its annual report.

v. GHG emissions figures based on 2017 data.

vi. We have excluded 90% of the Scope 3 emissions as it seems – from information provided on Cobham's website – that these emissions occurred in Australia.

vii. During 2017, Enterprise Services Defence and Security UK was renamed EntServ UK following a takeover by DXC Technology. The figure for '% military sales' was estimated from MOD contract data and overall company data.

viii. Meggitt stated that its emission figures do "not include GHG emissions generated from Meggitt-owned and operated vehicles or refrigerant gases as these emissions are not material to the Group's emissions". Our view is that this is not consistent with standard GHG reporting practice.

ix. AirTanker did not provide figures for its GHG emissions in its annual report so an emissions intensity of 13.7 tCO_2e/emp was assumed – see main text.

x. Elbit did not provide figures for its GHG emissions in its annual report so an emissions intensity of 13.7 tCO_2e/emp was assumed – see main text.

xi. GHG emissions figures based on 2017 data. We could not find more recent figures on the website of GKN's new parent company, Melrose.

xii. Leidos Europe did not provide figures for its GHG emissions in its annual report so an emissions intensity of 6.4 tCO_2e/emp was assumed – similar to EntServ as they operate in similar areas. No GHG figures could be found either via the website of its parent company, Leidos.

xiii. GHG emissions figures based on 2016 data.

xiv. WFEL did not provide figures for its GHG emissions in its annual report so an emissions intensity of 13.7 tCO_2e/emp was assumed – see main text. No GHG figures could be found either via the website of its parent company, Krauss-Maffei Wegmann.

xv. Figures for total GHG emissions does not include BT's Scope 3 emissions – see main text.

xvi. This is an average figure for the 25 companies – again not including BT's Scope 3 emissions.

Full references are provided in Appendix 2.

information. We also note that estimates for GHG emissions will be most accurate for companies with a high percentage of military sales and/or a high percentage of UK operations. Notably, the company with by far the highest emissions in table 2.3 – BAE Systems – fits into both categories, and other large emitters fit into at least one. Also, in a few cases – as given in Table 2.3 – more specific company data was available, and this was used.

The 25 companies we examined varied markedly in the way they published data about GHG emissions.

Seven companies did not meet what we regard as the minimum necessary standard for GHG emissions reporting in their annual reports, corporate responsibility reports or environmental reports. Five of these published no data on their total emissions that we were able to access, these being MBDA, AirTanker, Elbit, Leidos Europe and WFEL. Estimates in Table 2.3 for their GHG emissions were therefore calculated based on the assumption of 13.7 tCO_2e per employee[27] – the same as that for the largest company in the table, BAE Systems, which also had a similar proportion of military sales as these companies. The other two companies – Raytheon and General Dynamics – did give figures for total emissions, but did not specify which activities were or were not included within their estimates in their corporate responsibility reports.

The other 18 companies achieved a higher standard of reporting. Eight companies – including Serco, Rolls-Royce and Qinetiq – specified their emissions for Scope 1 and Scope 2 activities. As discussed earlier, this includes all GHGs directly emitted by company-owned buildings, industrial plants, and vehicles, as well as emissions due to the production of electricity, heat and cooling for those activities. Eight companies – including BAE Systems, Leonardo and Babcock – went further, publishing some data on their Scope 3 emissions, mainly due to business-related travel in non-company-owned vehicles. However, only two companies, BT and Ferrovial[28] – parent company of Amey UK –

27 Except for Leidos Europe – see notes in Table 2.3.

28 It should be noted that – in the case of Ferrovial – there was no indication of how its Scope 3 emissions might be allocated among its subsidiaries.

published comprehensive data on its Scope 3 emissions, including those due to its supply-chain.

The wide range of values for the GHG emissions per employee of the 25 companies is striking. The lowest figure in the table is 2.2 tCO_2e/emp., for GKN, while the highest figure is 48.2 tCO_2e/emp., for BT. GKN only declared Scope 1 and 2 emissions, while BT, as mentioned, included a comprehensive assessment of Scope 3. BT's figure for Scope 1 and 2 only was 3.2 – showing just how large indirect emissions can be – over 90% in this case. We explore indirect emissions – as a stepping stone to estimating the total UK military carbon footprint – in the next section. Also notable is that GKN is a predominately civilian company (92% by sales) and similarly BT (99% by sales), while companies with higher proportions of military sales tend to have significantly higher emissions per employee. This indicates the more capital-intensive nature of military work, and also indicates that our assumption above – that military and civilian work has a similar GHG intensity – is likely to lead to an underestimate for the total sector figures presented in this sub-section.

Given the variable nature of the emissions data we were able to compile, we have simply added together – with one exception – the figures in table 2.3 to give an estimate for the GHG emissions of these 25 companies of over 900,000 tCO_2e. The one exception is BT, where we have only included their figures for Scope 1 and 2 emissions, to avoid possible double-counting of supply-chain emissions.[29]

In order to estimate the total direct GHG emissions for all MOD suppliers, we then simply scaled up assuming the same average GHG emissions per employee (10.7 tCO_2e/emp.). Altogether, the 25 companies in table 2.2 directly employed approximately 85,000 employees in the UK to carry out military work in 2018. According to MOD data, in total, 115,000 jobs were created by MOD spending in the private sector in that year.[30] Hence the total direct GHG emissions of those jobs were approximately 1.23 million tCO_2e.

Another way of looking at this sector is to focus specifically on companies that identify themselves as part of the 'defence industry', through membership of the trade body ADS, which lobbies for the "aerospace, defence and security industries". This would allow us to include UK-based GHG emissions related to arms exports, in addition to UK military expenditure, while excluding more civilian-orientated companies. Hence, we now focus only on the companies listed in table 2.3, that are also listed as ADS members.[31] This is 22 of the 25 companies, i.e. excluding Amey UK, EntServ and BT. We then follow the same steps as above to estimate the total GHG emissions, using a figure for average GHG emissions per employee (10.8 in this case) and total employment in the sector. According to ADS, the UK arms industry employed approximately 135,000 in 2018.[32] Hence the total direct GHG emissions of the UK arms industry are approximately 1.46 million tCO_2e. For comparison, this is similar to the direct GHG emissions of all domestic flights in the UK.[33]

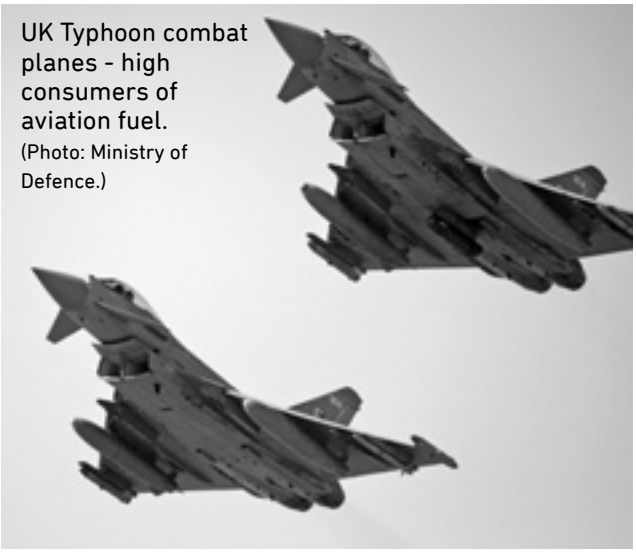
29 It could be argued that all Scope 3 emissions should be excluded from this total to provide a more accurate estimate of direct GHG emissions. We have not done this due to (a) some companies not providing a breakdown of their emissions by Scope, and (b) most companies which included Scope 3 emissions only included business travel using non-company-owned vehicles, which we think is reasonable to count within the total as this is not double-counting and is also essential to business function.

30 MOD (2018c). MOD regional expenditure with UK industry and supported employment: 2017–18. https://www.gov.uk/government/statistics/mod-regional-expenditure-with-uk-industry-and-supported-employment-201718

31 ADS (2020). Our member companies. https://www.adsgroup.org.uk/members/

32 ADS (2019). Facts and figures. https://www.adsgroup.org.uk/industry-issues/facts-figures/
Note that this figure for employment is significantly less certain than that for MOD suppliers, which is approved by the Office of National Statistics.

33 Figures include travel to overseas UK territories. Table 3 of: BEIS (2020). Final UK greenhouse gas emissions national statistics: 1990 to 2018. https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018



UK Typhoon combat planes - high consumers of aviation fuel. (Photo: Ministry of Defence.)

Another useful figure to estimate is the direct GHG emissions of the UK arms export industry. We can obtain this by estimating the fraction of the emissions from MOD suppliers that is for military equipment and that for civilian goods and services, then subtracting the former from the total for the arms industry as a whole. MOD data on its supplier contracts[34] reveals that about 75% of the value of these are with arms companies, with about 25% from companies in other sectors. Using the figures from above, this means that the direct GHG emissions of UK arms exports are approximately 0.54 million tCO_2e.[35]

We summarise the key data in this section in Tables 2.4 and 2.5.

Table 2.4 summarises the sectoral emissions calculated in the three separate but overlapping ways, while table 2.5 lists the top six corporations that are responsible for the largest share of the UK arms industry's GHG emissions, together with their emissions (from table 2.3) and the percentage of the estimated total for the industry. It should be noted that Serco and Rolls-Royce did not include any Scope 3 sources in their emissions total unlike the others.

Considering these figures in a historical context, there is little data available on the GHG emissions of arms companies before about 2010. Since then some of the larger corporations have, in common with businesses in other sectors started to report on these emissions and also implement programmes to, in particular, improve their energy efficiency. This has resulted in modest falls in emissions. For example, BAE Systems reduced its GHG emissions by 12% between 2014 and 2018.[36] We will discuss the potential for future cuts in GHG emissions from the military-industrial sector later.

Table 2.4. UK private sector GHG emissions directly related to military work, 2017–18

Category	GHG emissions (million tCO_2e)
MOD suppliers (including arms industry and other suppliers)	1.23
UK arms/ defence industry (including MOD-orientated work and exports)	1.46
Arms export industry (not including MOD-orientated work)	0.54

Table 2.5. Top 6 GHG-emitting arms corporations in the UK, 2017–18[a]

Corporation	GHG emissions (thousand tCO_2e)	% of UK arms industry total
BAE Systems	440	30%
Babcock International	93	6%
Leonardo	68	5%
MBDA[b]	48	3%
Serco	38	3%
Rolls-Royce	37	3%

Notes:

a. All figures are rounded to the nearest whole number.

b. GHG emissions are estimated – see notes in Table 2.3 and main text.

34 Table 3a (annex) from: MOD (2018b). *Op. cit.*

35 For clarity, the calculation is: 1.46 - (1.23 x 0.75) = 0.54.

36 BAE Systems (2018). Corporate Responsibility Summary 2018. https://www.baesystems.com/en/our-company/corporate-responsibility

2.4 Indirect employment

As we have discussed, there is a supply-chain of companies which provides goods and services to the UK arms industry and the other major military suppliers, including components, raw materials etc. In order to provide a rough estimate of the GHG emissions of this supply-chain within the UK, we follow a simplified version of the approach taken in the previous section. In short, we multiply an estimate of the number of employees with an estimate of the GHG emissions per employee. However, there is a difficulty in that the supply-chains are complex and often involve the same companies which we have already counted as part of the arms industry and/or other MOD suppliers. Hence, we need to take care to avoid double-counting.

As data becomes progressively more uncertain the further along the supply-chain we go, we confine ourselves to two simple estimates based on 'indirect' employment related to (i) MOD spending and (ii) arms exports.

Up until 2008, the MOD compiled such figures and its latest estimate of the number of indirect jobs created by its military spending for each direct job created was 0.94.[37] Multiplying this by the current private sector employment level generated by MOD spending – 115,000 (see previous section) – gives a figure of just over 108,000 jobs.

For GHG emissions per employee, we use the mean figure derived in table 2.3, labelled as 'military GHG emissions intensity'. This figure is 10.7 tCO_2e/emp.

Multiplying these two figures together leads to an estimate of the UK-based GHG emissions for indirect employment due to UK military spending of 1.16 million tCO_2e.

If we assume that GHG emissions related to arms exports scale in a similar way,[38] then the UK-based GHG emissions for indirect employment due to these exports are 0.51 million tCO_2e.

Table 2.6 summarises these two key estimates.

Table 2.6. UK-based private sector GHG emissions related to indirect employment arising from military work, 2017–18

Category	GHG emissions (million tCO_2e)
MOD suppliers – indirect	1.16
Arms export industry – indirect	0.51

Note, however, that they do not include elements of the supply-chain outside the UK including much of the raw materials extraction. They are also significantly more uncertain than the figures in the previous sections because of the difficulties in estimating the number of indirect jobs and the emissions intensity of those jobs. We should also acknowledge that, when comparisons are made of emissions between different sectors, this tends to be carried out on the basis of direct emissions – to reduce both uncertainties and the potential for double-counting (see next section). Nevertheless, estimates of indirect employment are useful to highlight additional emissions that would fall to zero if military spending were halted.

2.5 Carbon footprint of UK military-industrial sector

Now we turn to the carbon 'footprint' of the UK military-industrial sectors. As discussed earlier, this includes the full lifecycle from the extraction of minerals through use to disposal of waste products.

In the sections 2.3-2.4, we revealed evidence that the GHG emissions of the arms industry and other MOD suppliers, as well as other indirect activities such as the UK-based supply-chain, can be substantial. We also pointed out the increasing difficulty of assessing emissions the further down the supply-chain we go. In order to deal with such problems and try to assess the total impacts on the climate of organisations, government spending patterns and whole economic sectors, researchers have developed a number of assessment tools. For example, to estimate the carbon footprint of government

37 In 2007-08, military spending created 155,000 direct jobs and 145,000 indirect jobs. Table 1.10 of: MOD (2009). UK Defence Statistics 2009. https://webarchive.nationalarchives.gov.uk/20101213135526/http://www.dasa.mod.uk/modintranet/UKDS/UKDS2009/chapter1.html

38 In fact, this is an underestimate as both the GHG emissions intensity and the indirect employment are higher.

Table 2.7. Carbon footprints of UK military spending and UK arms exports

Category	GHG emissions (million tCO_2e)
UK military spending (2018)	11.0
UK arms exports (2017–18)	2.2

spending in a particular area – in this case, of the military – they use 'input-output' economic models, together with emissions data.[39] Using this methodology, researchers at Lancaster University have estimated that for each pound sterling of UK military spending, 0.244 $kgCO_2e$ are emitted.[40]

According to the MOD annual summary, Defence in numbers, Britain's military budget stood at £36.6 billion in 2017–18.[41] However, the UK reports markedly higher military spending figures to NATO – £45.2bn for 2018.[42] These include a number of other elements such as military pensions and funds provided for UN peacekeeping – in compliance with NATO reporting standards.[43] Hence, we use this latter figure for total UK spending. This yields an estimate for the total carbon footprint for the UK military of approximately 11.0 million tCO_2e.[44] This is approximately double the total gained by summing the emissions for the Ministry of Defence, its private sector suppliers including the arms industry, and indirect employment.

Note that these figures do not include the export of weapons and other military equipment from the UK. ADS has compiled figures for these exports and, for the latest year available (2017–18), these were estimated to be worth £9.0bn.[45] Assuming a similar carbon intensity to UK military spending,[46] this means that UK arms exports had a carbon footprint of 2.2 million tCO_2e. However, these emissions would be counted in the carbon footprints of the countries importing the military equipment, not the UK.

The two headline figures for carbon footprints are summarised in Table 2.7.

2.6 How do military-industrial emissions compare with other GHG emissions?

In this section, we carry out some comparisons between the total GHG emissions of the UK military-industrial sector calculated using a territorial or production-based approach (sections 2.2-2.4) and that using a lifecycle or consumption-based approach (section 2.5) and other GHG emissions, including the UK's national GHG emissions, and those of other nations and other UK sectors.

39 See, for example: Berners-Lee M (2010). *How bad are bananas? The carbon footprint of everything*. Profile books.

40 Berners-Lee M (2020). Personal communication, 16 March. Lancaster University. Note this is a significant fall from figures from ten years earlier (pp.169 & 226 of: Berners-Lee; 2010. Op. cit.) due to factors including reduced war-fighting, MOD energy efficiency improvements, and an expansion of UK electricity from renewable energy sources.

41 MOD (2018d). UK defence in numbers 2018. https://www.gov.uk/government/publications/uk-defence-in-numbers-2018

42 NATO (2019). Defence Expenditure of NATO Countries (2013-2019). Press release, 29 November. https://www.nato.int/nato_static_fl2014/assets/pdf/pdf_2019_11/20191129_pr-2019-123-en.pdf

43 A critical review of the different systems of accounting used by the MOD is provided in: Perlo-Freeman S (2020). Fighting the wrong battles. Campaign Against Arms Trade. https://www.caat.org.uk/resources/publications/government/fighting-the-wrong-battles-feb2020.pdf

44 While a case could be made that the carbon intensity of spending on these other areas of military activity might be lower, without further data it is difficult to justify using a different figure.

45 ADS (2019). *Op. cit.*

46 Given that a sizeable proportion of the lifecycle emissions occurs in the UK, this seems a reasonable assumption.

Table 2.8. Total UK-based military sector GHG emissions and percentage of national emissions, 2017–18 – territorial or 'production' basis

Category	GHG emissions (million tCO_2e)
Ministry of Defence	3.03
MOD suppliers (UK only)	1.23
Arms exporters (UK-based)	0.54
Indirect employment (UK only)	
- due to MOD spending	1.16
- due to arms exports	0.51
Total	**6.46**
UK total GHG emissions[47]	**451.5**
% military-related sectors	**1.4%**

Note: figures do not add exactly due to rounding

Table 2.8 summarises the total UK military sector GHG emissions using a production-based approach. In short, it is the sum of the emissions from the Ministry of Defence – including deployment of military ships, aircraft and land vehicles (both within UK territory and overseas), as well as all UK-owned military bases (again, both within UK territory and overseas) – as well as from the UK-based suppliers and related indirect employment, and UK-based arms exporters and related indirect employment. It does not include any of the supply-chain outside the UK. This gives a total of approximately 6.5 million tCO_2e. This is more than the territorial carbon dioxide emissions of about 60 nations, including Uganda, Madagascar, Iceland, Namibia and Zambia.[48] It is also equivalent to the carbon dioxide emissions of the average mileage driven by over 3.5 million British cars.[49] As a proportion of Britain's nationally-reported GHG emissions, the UK-based military sector is 1.4%.

We can also make comparisons with the GHG emissions of other UK industrial sectors.[50] In short, the military-industrial sector has larger direct emissions than nine others, including vehicle manufacture, plastics, water and waste management, and glass and ceramics.[51]

Table 2.9 summarises the total UK military sector GHG emissions using a lifecycle or consumption-based approach – using the calculations in section 2.5. As mentioned, this is the carbon footprint of UK military spending, and so includes emissions from raw materials extraction to waste disposal, regardless of where in the world they happen or who owns them. It does not include emissions related to arms exports which, as mentioned, would be counted in the carbon footprint of the importing nations. So, we can make some further comparisons between the estimate of 11.0 million tCO_2e for the carbon footprint of the UK military, and other figures as shown in Table 2.8. For example, it is more than *3.5 times* the direct emissions of the UK military, i.e. the MOD. It is also 70% larger than the figures for the wider UK-based military-industrial sectors, which demonstrates just how much pollution depends on sources overseas, and how important it is to consider the whole lifecycle. It is also more than *11 times* larger than the figure for GHG emissions quoted in the main text of the equivalent MOD annual report (0.94 million tCO_2e), which we discussed in section 2.1.

47 BEIS (2020). *Op. cit.*

48 Based on national carbon dioxide emissions from fossil sources for 2018 from: Crippa et al (2019). Fossil CO_2 and GHG emissions of all world countries. Publications Office of the European Union. https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/fossil-co2-and-ghg-emissions-all-world-countries-0 Arguably, this is a more appropriate comparison than with national GHG emission totals which include biogenic sources, i.e. those from agriculture and land-use changes, which are not comparable with the military-industrial sector.

49 The average UK car – assuming average mileage and fuel consumption – emits approximately 1.8 tCO_2 per year. Calculation based on figures from: RAC Foundation (2020). Motoring FAQs (Environment, A6; Mobility, A25). https://www.racfoundation.org/motoring-faqs

50 To allow comparisons with commonly used figures, we need to subtract the GHG emissions due to Scope 2 activities (mainly electricity), Scope 3 and indirect employment from the total in Table 2.8.

51 Comparisons with data in Figure 4.2 (p.108) of: Committee on Climate Change (2019). Net Zero – Technical Report. https://www.theccc.org.uk/publication/net-zero-technical-report/

Table 2.9. Total UK military sector GHG emissions and percentage of national emissions, 2017–18 – carbon footprint or 'consumption' basis

Category	GHG emissions (million tCO_2e)
UK military spending	11.0
UK total GHG emissions[52]	772.5
% military sector	1.4%

In recent years, the UK government has also started to publish annual estimates of the UK's carbon footprint, with the most recent data being for 2017. This is given in Table 2.9. It is markedly higher than the GHG emissions compiled under a territorial approach, as the UK imports a great deal of products and materials from abroad. Hence, using the figures above, the carbon footprint of the UK military is also 1.4% of that for the total UK. Comparisons with the carbon footprints of other nations or other UK sectors are not straightforward due to limited comparable data. However, we can make a comparison to the direct carbon dioxide emissions of the average mileage driven by British cars each year: it is equivalent to over six million cars.[53]

2.7 GHG emissions: overarching issues

Now that we have compiled estimates for the GHG emissions of the UK military-industrial sector, there are a number of overarching issues that are worth exploring briefly:

- the GHG emissions related to UK weapons use;
- exemptions for UK military GHG emissions from national reduction targets;
- future levels of GHG emissions from the UK military.

'Carbon boot-print' of the UK military

As we highlighted earlier, the military is a unique sector in terms of the GHG emissions that it is responsible for. Through the use of its products, i.e. weapons, considerable further GHG emissions can result, including from fires from burning buildings, fuel depots and vegetation, healthcare for civilian and military survivors, and post-conflict reconstruction. Arguably, a complete analysis would include such emissions within its total. Such a total we term the 'carbon boot-print' of the military.

To our knowledge there have been very few attempts to try to estimate such GHG emissions, and data in this area is unsurprisingly sparse. One indicator which could be used as a starting point is the amount of weaponry used in a given year. So, for example, in 2017, the UK military launched over 1,000 bombs and missiles in Iraq and Syria (see section 3.1). The typical size of such a weapon was 230kg (500lbs). In certain cases, the mass of the GHG emissions arising from the use of such a bomb could be many thousands of times the mass of the weapon. For example, a bomb this size could cause the concrete columns of a building to fail within a 20m radius of the explosion, and badly damage them for tens of metres beyond this.[54] Reconstruction of such a building would lead to GHG emissions of hundreds or possibly thousands of tonnes of carbon dioxide, depending on whether the building was small (a house or similar) or large (military building or office block), and especially if it used a lot of concrete – which is a very high carbon, commonly used construction material.[55] These emissions would, of course, occur months or years after the bombing – but they would undoubtedly be a consequence of it. Other bombs could hit fuel depots or other highly combustible targets – leading to immediate, large emissions, but likely to be lower than those related to building reconstruction. Some would cause much lower levels of emissions. In practice, of course, it is difficult to

52 DEFRA (2020). *Op. cit.*

53 Using figures from: RAC Foundation (2020). *Op. cit.*

54 Figure 4.2 (chapter 4) of: FEMA (2003). Primer for Design Safe Schools Projects in Case of Terrorist Attacks. Manual 428. https://www.fema.gov/pdf/plan/prevent/rms/428/fema428_ch4.pdf

55 The carbon footprint of building even a small two-bed house is around $80tCO_2e$. Berners-Lee M (2010). What's the carbon footprint of … building a house. *The Guardian,* 14 October. https://www.theguardian.com/environment/green-living-blog/2010/oct/14/carbon-footprint-house

say with certainty the GHG emissions arising for a bombing campaign as a whole.

Based on this very brief assessment, our ball-park estimation is that a military engaged in the level of war-fighting that the UK was during 2017–18 would cause GHG emissions due to weapons use of perhaps an extra 10% above the total figures given in section 2.6. A higher level of war-fighting would of course lead to more.

At the moment such estimates are highly uncertain, so we have decided not to add them to our final totals. Nevertheless, they should not be forgotten. We discuss the issue of war-related environmental impacts further in section 3.1.

Exemptions for military GHG emissions

As we discussed earlier, there has been a long-standing international convention which has caused most governments in the world not to report on the GHG emissions of their militaries, let alone include them within national targets. To its credit, the UK has not strictly followed this convention for at least ten years, but it remains unclear exactly what practice it does currently follow.

As we will examine in the next section, the activities of the Ministry of Defence are not automatically covered by civilian environmental regulations. If the MOD decides there is a 'defence need' then it is exempt. So, to what extent is the Ministry exempt from legal obligations to report and reduce its GHG emissions?

In section 2.2, we saw that the MOD prominently reports on the emissions from Estates in *Sustainable MOD*, but only 'quietly' reports on emissions from Capability and Equipment in an annex, providing no overall total for GHG emissions. Reduction targets for 2020 have been set – for Estates only – under the Greening Government Commitments, and met early. However, for Capability, there are no such targets – although there are modest 2020 targets for energy use, which acts as a de facto limit on emissions. Beyond 2020, no targets have yet been set for either category, despite a revised national target having been recently agreed under the 2008 Climate Change Act (CCA) of zero net GHG emissions by 2050.[56]

In *Sustainable MOD*, there have been no clear statements on whether Capability or Estates are exempt from CCA targets, but there have been some comments which imply that Capability emissions probably are. For example, in the 2017–18 report, it says, "MOD secured an agreement with Defra to exempt flights taken by FLCs [Front Line Commands], as these are often for reasons outside of business as usual, and therefore cannot easily be reduced without compromising military capability." [57] Conversely, an inspection of the UK's national GHG inventory[58] shows inclusion of a category for 'Other mobile: Military aircraft and shipping' whose figure for emissions in 2018 is similar to that for 'Capability and Equipment: Aviation fuel/ diesel' given in Table 2.2. This implies UK targets do include such emissions and, if these increased, extra reductions would be required elsewhere in the UK economy. Indeed, in a parliamentary answer in late 2019, the then Parliamentary Under-Secretary of State for Defence stated that "The Ministry of Defence (MOD) is committed to supporting and playing its part in the UK Government intent to tackle climate change by transitioning to net zero carbon emissions by 2050." [59]

We asked the MOD – via a Freedom of Information request – to clarify which emissions were exempt. They did not reply within the statutory 20-day period, but we were unable to pursue the case further due to the COVID-19 crisis.

Future levels of GHG emissions from the UK military

As we highlighted in section 2.1, the direct GHG emissions of the MOD fell by about 50% in ten

56 BEIS (2019b). UK becomes first major economy to pass net zero emissions law. (News story.) 27 June. https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law

57 P.44 of: MOD (2018a). *Op. cit.*

58 Table 3 of: BEIS (2020). *Op. cit.*

59 Trevelyan, A.-M. (2019). Ministry of Defence: Energy Supply. Written question and answer. 22 October. https://www.theyworkforyou.com/wrans/?id=2019-10-15.533.h&s=carbon

years from 2007-08 to 2017–18. One key reason was that the UK reduced the size of its military operations in Iraq, Afghanistan and elsewhere. Another was the closure of unneeded military bases following spending cuts ordered by the Cameron government as part of its 'austerity' policies. A third reason was the energy efficiency programmes pursued by the MOD as part of the Greening Government Commitments, which were helped significantly by the rapid increase in the proportion of UK electricity generated from renewable sources. GHG emissions of UK arms corporations also seem to have fallen in recent years as they also pursue energy efficiency measures – although not nearly as quickly as the MOD fall.

Will these reductions continue? And if they do, will they be compatible with the UK climate targets which, as stated earlier, the MOD says it supports? Government policy – before the COVID-19 crisis – was for UK military spending to increase markedly in the next few years,[60] so the associated carbon emissions would have been likely to rise as well, despite ongoing energy efficiency programmes. Indeed, the deployment of two huge new Queen Elizabeth-class aircraft carriers and the expansion of a large military base in Bahrain seemed to underline this. They are illustrative of the UK's prioritisation of military forces which are capable of 'force projection' far from British shores. However, such spending plans will have to be rethought given the biggest economic shock since World War II unfolding as this report goes to press. Indeed, some UK arms companies are converting part of their production to the manufacture of medical devices such as ventilators.[61] Nevertheless, an unexpected military crisis in, for example, the Middle East could lead to a UK government decision to launch a major military operation – and this would lead to an associated jump in GHG emissions, reversing many of the reductions of the last decade.

Regarding plans for GHG emissions reduction among arms companies and other MOD suppliers, these are fairly common. Two companies which seem to have ambitious targets are BT[62] and Rolls-Royce.[63] Nevertheless, most corporations in this sector have modest aims which, given the urgency of the climate crisis, is deeply problematic. Indeed, the potential of a wider shift from military to civilian production – for example, to environmental or medical technologies – has simply not been considered by most of them. It remains to be seen whether the COVID-19 crisis will lead to a major rethink.

Such concerns lead to the consideration of a more radical alternative path – one based on redirecting resources to tackle the roots of insecurity and conflict rather than focusing on the deployment of major military forces. Indeed, the current health crisis is challenging conventional thinking on resource allocation for tackling threats to national security. We discuss this in more detail in section 3.4.

In short, it seems that only a concerted change in the UK's national defence and security policies – away from a reliance on militaristic approaches to security to ones which take a broader approach – offers any real hope of the UK's military GHG emissions being brought down to a level consistent with tackling the climate crisis.

60 P.17 of: Perlo-Freeman S (2020). *Op. cit.*

61 *BBC News* (2020). Coronavirus: Defence firm Babcock to make 10,000 ventilators. 6 April. https://www.bbc.co.uk/news/business-52059084

62 BT Group (2018). Annual Report and Form 20-F, 2018. https://www.btplc.com/Sharesandperformance/Financialreportingandnews/Annualreportandreview/index.htm

63 Rolls-Royce Holdings (2018). 2018 Annual Report. https://www.rolls-royce.com/investors/annual-report-2018.aspx

3. Other environmental impacts

War and the preparation for war inevitably causes numerous, often severe, environmental impacts, including pollution of land, water and air. Some data on these environmental impacts is publicly available, but often there are serious gaps, restrictions on access, or significant quality issues. In this section, we examine the available data, as well as looking at some of the government's efforts to reduce the non-climate-related environmental impacts of the UK military.[64]

As discussed in section 2.2, the Ministry of Defence includes within its annual report a section entitled *Sustainable MOD*, which reports on a range of environmental impacts in addition to GHG emissions.[65] It has targets to reduce its impacts – set as part of the Greening Government Commitments related to UK sites and activities – in the following areas: flights taken by civilians; waste sent to landfill; paper use; and water consumption. It has met or is on course to meet 2020 targets for waste and water, but not for flights and paper. It also reports on: energy use of 'Capability and Equipment' – i.e. military operations; reducing the environmental impacts of its construction projects; work to improve the resilience of the armed forces to climate change; and efforts to improve biodiversity at its UK sites. Regarding other impacts, either they are not reported upon, or the information is minimal, even if the impacts are potentially large. We shall return to these shortly, but first it is necessary to consider how environmental laws apply to the military.

Management of military environment impacts is different to other areas of government activity. The MOD's activities are, in general, exempt from most civilian environmental regulations. As the Environment Agency told us in response to a Freedom of Information request:

> *"It should be noted that the MOD and its subordinate bodies, including most civilian contractors working for the Ministry and its subordinate bodies, fall under the provisions of Crown Immunity and are therefore not subject to the enforcement regime of the Environment Agency."* [66]

Instead, the Secretary of State for Defence signs a regular statement which commits to "minimising" military environmental impacts.[67] To put this into practice, the MOD runs several interlinked Safety and Environmental Management Systems (SEMS)[68] which, in many areas, mirror civilian regulations but, when there is perceived to be a defence "need", then practice will deviate, sometimes markedly. Examples of its processes are contained in its handbook of Sustainability and Environmental Appraisal Tools (SEAT)[69] to be used by its staff, partner organisations and contractors when developing policies or managing programmes and projects. In procuring military equipment, the MOD applies an Acquisition Safety and Environmental Management System (ASEMS).[70] For individual projects, it stipulates the use of a Project Oriented Environmental Management

64 Due to space constraints and data limitations, we do not examine the UK arms industry separately in this section.

65 Pp.91-99 of: MOD (2019a). *Op.Cit.*

66 Environment Agency (2020). FOI response, no. NR164426. 6 March.

67 MOD (2018e). Secretary of State for Defence policy statement on health, safety and environmental protection. July. https://www.gov.uk/government/publications/secretary-of-states-policy-statement-on-safety-health-environmental-protection-and-sustainable-development

68 MOD (2020a). Implementation of defence policy for health, safety and environmental protection (DSA01.2). https://www.gov.uk/government/publications/implementation-of-defence-policy-for-health-safety-and-environmental-protection-dsa-012

69 MOD (2019b). MOD sustainability and environmental appraisal tools handbook. https://www.gov.uk/government/publications/mod-sustainability-and-environmental-appraisal-tool-handbook

70 MOD (2020b). Defence acquisition safety and environment management. https://www.gov.uk/guidance/acquisition-safety-and-environment-group

System (POEMS). Indeed, even within the MOD's guidance on military conduct during hostilities – entitled the UK Manual on the Law of Armed Conflict (LOAC Manual) – there are included some provisions concerning the environment.

While such initiatives and documents do provide evidence that some environmental impacts are being managed and reduced, it is clear that there are major shortcomings. Targets to reduce paper use and increase recycling at UK sites may be beneficial, but they are major areas where impacts are large but little or no data is published – let alone details about mitigation actions. In section 2.1, we pointed out that the MOD no longer publishes total figures for its GHG emissions in its annual report – instead, simply reporting progress on reducing the emissions from its Estates, while figures for emissions from Capability and Equipment are buried in an annex and not up to date. Disturbingly, even more selective reporting is pursued regarding some of its other environmental impacts. There are three areas in which we have particular concerns:

- environmental damage caused by military missions;
- management of hazardous waste;
- environmental impacts should UK nuclear weapons ever be used.

These are discussed in more detail in the following three sections, with overarching issues considered in a fourth section.

3.1 Environmental impacts of UK military missions

As we have mentioned, the MOD uses environmental management systems including some which can affect how it carries out its military missions, including training exercises and combat operations. Using ASEMS can lead to the procurement of military equipment which has a lower environmental impact, while POEMS "has the ability to identify, monitor and manage any environmental aspects and impacts related to the use of defence equipment".[71] The environmental provisions of the LOAC Manual can, in theory, lead to reduced impacts during armed conflict.

So, is there any evidence that these measures have led to a large reduction in the environmental impacts of UK military action? Or even that they affected decisions to launch military action?

The Conflict and Environment Observatory, a non-governmental organisation, has investigated the UK's policies and practice on the protection of the environment in relation to armed conflicts.[72] It has highlighted significant shortcomings in relation to warfare using conventional weapons, including the following.

- The LOAC Manual only stipulates that 'regard' must be given to the natural environment during the conduct of military operations, rather than 'care' or 'protection'.
- Beyond reviews of specific weapons and weapon systems, the MOD has argued that "it does not think it appropriate for States to be obliged to prepare environmental impact assessments as part of military planning."
- While prosecution is theoretically possible if the UK committed an environmental war crime, the definition used in international humanitarian law is so vague that in practice this would be unlikely to happen.
- While the MOD acknowledges that environmental effects should be considered when deciding whether a particular type of weapon should be deployed, it qualifies this by saying, "weapon reviews inherently deal with classified material relating to the performance and use of weapons. Accordingly, any trend towards openness will always be bounded by important concerns of national security."
- While the MOD's POEMS is based on internationally recognised standards, its application in practice is not independently certified.

To put these issues into a practical setting, we consider the recent cases of UK military action in Iraq and Syria against Daesh/ Islamic State combatants. During the five years of the war, approximately 4,200 bombs and missiles were

71 Conflict and Environment Observatory (2019). The United Kingdom's practice on the protection of the environment in relation to armed conflicts. https://ceobs.org/report-the-united-kingdoms-practice-on-the-protection-of-the-environment-in-relation-to-armed-conflicts/

72 *Ibid.*

launched by UK aircraft.[73] Table 3.1 lists numbers of weapons used in each year. In two-thirds of the air-strikes, the weapon used was the Paveway IV, a 'guided bomb' weighing 230kg.[74] Based on the available data, we estimate that a total of nearly 1,000 tonnes of ordnance was used.

Table 3.1. Number of weapons fired by UK aircraft in Iraq and Syria, 2014-2019[75]

	Iraq	Syria	Total
2014	142	0	142
2015	707	23	730
2016	1,466	183	1,649
2017	707	371	1,078
2018	48	464	512
2019	41	63	104
Totals	**3,111**	**1,104**	**4,215**

Apart from the human cost, the environmental impacts of such action would be enormous. For example, we made a brief attempt to estimate the consequent GHG emissions in section 2.7. The MOD would doubtless argue that behaviour of 'the enemy' was far worse, but this data provides more evidence of the need to put much greater resources into tackling the roots of conflict and so preventing war.

In summary, the MOD does not publish any environmental data on specific military missions for reasons of national security, nor as far as we can gather does it submit to third party verification of any efforts to reduce these impacts. Hence it is very difficult to assess what difference the use of environmental management systems have made in practice to its actions. The Conflict and Environment Observatory was only able to uncover a small amount of evidence of very limited reductions in impacts.[76] In particular, we found no evidence to demonstrate that any past decision to take military action has ever been rejected because of the potential environmental costs. Given that these can be extremely large, at minimum, we argue that historical damage should be assessed, and this analysis published, so that an informed public debate can take place regarding future action.

3.2 Hazardous waste

The MOD in the course of its activities handles and disposes of large amounts of hazardous waste. From the data published in the annexes of its reports, this can vary considerably from year to year.[77] So, for example, in 2009/10 it disposed of 14,000 tonnes and in 2014/15 it disposed of 19,000t. Meanwhile, in 2012/13 the amount fell to 4,000t, while in 2017/18, it reached zero. This illustrates the cyclical nature of managing large amounts of military equipment and large numbers of military bases.

Discussion of the management of hazardous waste has been virtually absent from *Sustainable MOD* since it was first published in 2009/10, and no explanation has been given for this. Given the importance of this issue, this is a serious omission.

To illustrate the concerns, we include two case studies in this section.

Box 1 examines the dismantling of the UK's retired nuclear submarines – which currently number 20. In particular, it points out that they contain about 4,500 tonnes of hazardous radioactive waste, and that the dismantling programme has been very poorly managed, meaning that much of this waste will not even be placed in long-term storage – let alone what the government classifies as 'final disposal' – for decades.

Box 2 looks at the equally disturbing case of the management of the radioactive waste from Britain's nuclear weapons programme. Alarmingly,

73 The data was obtained from the MOD by Drone Wars UK using Freedom of Information requests. See: *The Guardian* (2020). UK's air war against Isis ends after five years. 16 March. https://www.theguardian.com/world/2020/mar/16/uk-air-war-isis-ends-five-years

74 Armedforces.co.uk (undated). RAF weapons. http://www.armedforces.co.uk/raf/listings/l0038.html

75 Drone Wars (2019). UK Drone Strike Stats. https://dronewars.net/uk-drone-strike-list-2/ See also: *The Guardian* (2020). *Op. cit.*

76 *Ibid.*

77 For example, see Annex B of: MOD (2018a). *Op. cit.* This source gives rounded figures in kilotonnes.

up until the 1980s, this waste was simply dumped at sea. Following international agreement, this practice was stopped and the UK began storing the waste at the Atomic Weapons Establishment at Aldermaston. Since then, the high risk waste has accumulated in aging containers, with about four million litres now held on site. Following 16 years of pressure from nuclear regulators, a programme of action has at last been agreed to improve the safety and security of waste storage, although this is only another interim stage until final disposal towards the end of the century.

The MOD's programme for dismantling its submarines has yet to complete disposal of any vessel. (Photo: iStockphoto.)

BOX 1 – DISMANTLING THE UK'S NUCLEAR SUBMARINES[78]

The MOD has retired 20 nuclear-powered submarines from service since 1980, all containing large amounts of hazardous radioactive waste. It has not yet completed disposal of any of the vessels. Hence it now has double the number of submarines in storage that the Royal Navy currently deploys at sea.

To dispose of the craft, the MOD must undertake a complex series of inter-related tasks, all of which need to meet health, safety and environmental (HSE) standards related to the management of radioactive materials. Submarine disposal includes removing the irradiated nuclear fuel (defueling), removing the radioactive parts (dismantling), and then breaking up and recycling the boat – with storage of the submarines being carried out in between these steps (including continuous cooling of the reactor, if it has yet to be removed, to prevent a major radiation incident occurring). So far, only 11 of the 20 submarines have completed the defueling stage. The hazardous material in each vessel is summarised in Table 3.2. Thus, in total, the MOD still needs to dispose of over 4,500 tonnes of hazardous material from these submarines, with over 1,000 tonnes being especially dangerous.

Efforts to defuel, dismantle and dispose of the submarines have been repeatedly and extensively delayed since they began in the 1990s, leading to considerable increases in costs. Some of the delays have been needed to attend to HSE risks, while others have been due to organisational problems. These latter delays have themselves added to the HSE risks. No specific end date has yet been set for the completion of disposal of these submarines, the MOD only estimating that 27 vessels currently retired or in service will be dismantled by the late 2060s – a disturbingly long time period. Dates have, however, been set for re-starting

78 All the information in this section (unless indicated otherwise) is derived from: National Audit Office (2019). Investigation into submarine defueling and dismantling. https://www.nao.org.uk/report/investigation-into-submarine-defueling-and-dismantling/

Table 3.2. Hazardous material contained within one retired UK nuclear submarine

Type of material/ waste	Amount	Disposal/ storage site[a]
Irradiated nuclear fuel[b]	tens to hundreds kgs[c]	Sellafield, West Cumbria (storage)
Intermediate-level radioactive waste	50 tonnes[d]	URENCO, Cheshire (storage)
Low-level radioactive waste	176 tonnes	Low-Level Waste Repository, West Cumbria (disposal)

Notes:

a. Depending on the level of radioactivity, the material will either be disposed of or stored pending further management (which will be decades in the future).

b. Technically, the MOD do not classify this as waste because of the possibility that it might be re-used – which remains unlikely.

c. The specific amount is classified.[79]

d. This is mainly the reactor pressure vessel.

key parts of the process following the most recent delay. Hence, defueling of the remaining nine submarines is planned to begin in 2023, while the dismantling of all submarines is due to be rolled-out from 2026, following the trial dismantling of one submarine. Any further delays could cause even more problems as three more submarines are due to retire this decade, but the storage docks – at Devonport in South-west England and Rosyth in Scotland – are already approaching their maximum capacity.

There are also serious concerns about the performance of at least one of the companies involved in the submarine dismantling programme. In 2019, Devonport Royal Dockyard Ltd (a subsidiary of Babcock International) was fined nearly £670,000 for a safety incident "where a worker narrowly escaped serious injury".[80] The company had also been served with Enforcement Notices related to worker safety issues in 2017 and 2015.[81]

Furthermore, it should be noted that completion of submarine disposal is not the end point for the most hazardous types of radioactive waste. These will require safe transportation to further storage at specialist facilities in North-west England (see table 3.1), before being placed deep underground in a 'geological disposal facility' (GDF) which is not due to open before 2050. Indeed, many aspects of the GDF itself are still to be developed and are controversial, while one of the companies – Sellafield Ltd – has a history of environmental and safety problems, including a £380,000 fine for worker safety breaches in 2019[82] and a £100,000 fine for breaching radioactive substances regulations in 2014.[83]

In terms of overall costs for this programme, the MOD included a £7.5 billion liability in its 2017–18 accounts for maintaining and then disposing of its out-of-service submarines. This figure is only an estimate, with large uncertainties and the potential to increase further.

79 Ritchie, N. (2015). *The UK Naval Nuclear Propulsion Programme and Highly Enriched Uranium*. University of York. https://fas.org/wp-content/uploads/2015/03/2015-FAS-UK-NNPP-HEU-final2.pdf

80 ONR (2019a). Fine issued to Devonport Royal Dockyard Ltd. 27 August. Office of Nuclear Regulation. http://news.onr.org.uk/2019/07/devonport-royal-dockyard-ltd-pleads-guilty-to-health-and-safety-breach/

81 ONR (2020). Enforcement action. http://news.onr.org.uk/enforcement-action/

82 ONR (2019b). Sellafield Ltd fined in case brought by ONR. 2 April. http://news.onr.org.uk/2019/04/sellafield-ltd-fined-in-case-brought-by-onr/

83 Environment Agency (2020). Environment Agency Prosecutions. https://data.gov.uk/dataset/6f06910a-8411-4117-9905-6284f1997c33/environment-agency-prosecutions

The MOD's programme for dealing with radioactive waste has been beset by major problems (Photo: iStockphoto.)

BOX 2 – MANAGING THE RADIOACTIVE WASTE FROM THE UK'S NUCLEAR WEAPONS PROGRAMME

The Atomic Weapons Establishment (AWE) is the facility where UK nuclear warheads are designed, assembled and maintained. Its main site is at Aldermaston, 70km from London, which has been the home of Britain's nuclear weapons programme since it began in the 1950s. Up until 1983, the MOD simply dumped the nuclear waste from its weapons programmes at sea. Since 1983, it has stored onsite the radioactive waste arising from its operations and decommissioning activities. However, the Office of Nuclear Regulation (ONR) and its predecessor organisations have expressed serious concerns about the ability of AWE to manage its waste safely.[84] Many details about the situation at AWE have not been released into the public domain, but some information has been compiled by the Nuclear Information Service (NIS) based on official documents.[85,86]

At present, AWE stores about 19,500 drums of radioactive waste – in total, about four million litres – at its Aldermaston site.[87] The deteriorating condition of some of the containers – which "are well beyond their normal design life" – is such that 'repackaging' of the waste is necessary in the near future. 5,000 of these drums are considered at greatest risk because they contain a combination of intermediate-level radioactive waste, which is very hazardous despite its innocuous name, and fissile material, which is particularly dangerous as it is capable of sustaining a nuclear chain reaction. After 16 years of pressure from regulators, a plan has at last been agreed whereby these 5,000 drums will be transported by road and rail to Sellafield in North-west England where the radioactive waste will be 'compacted' and repackaged at a specialist facility there. The compacted waste will then be returned to Aldermaston where it will be stored in a new purpose-built facility until final disposal in an underground GDF (see Box 1) towards the end of the century. The other 14,500 drums of radioactive waste – which contain unknown amounts of intermediate-level waste – are unlikely to repackaged until the late 2030s, when a further waste treatment facility is due to open at Sellafield.

84 See, for example: ONR (2015). Improvement Notice served on AWE. 13 July. http://news.onr.org.uk/2015/07/improvement-notice-served-on-awe-2/

85 NIS (2017). AWE's radioactive waste plan is sixteen years overdue, but is it realistic? https://www.nuclearinfo.org/blog/david-cullen/2017/04/awe%E2%80%99s-radioactive-waste-plan-sixteen-years-overdue-it-realistic

86 NIS (2019). AWE's 'do minimum' waste plan: more details emerge. https://www.nuclearinfo.org/article/waste-awe-aldermaston/awe%E2%80%99s-%E2%80%98do-minimum%E2%80%99-waste-plan-more-details-emerge

87 More details on AWE's waste holdings can be found at: Radioactive Waste Management (2013). Upstream Optioneering: Optimised Management of Orphan Wastes. https://rwm.nda.gov.uk/publication/upstream-optioneering-optimised-management-of-orphan-wastes/

3.3. Environmental impacts should the UK launch its nuclear weapons

Security analysts estimate that the UK currently has 215 nuclear warheads, 120 of which are "operationally available".[88] The Royal Navy deploys four nuclear-armed Vanguard-class submarines, which each carry 40 of these warheads, launched using Trident missiles. At any given time, one submarine is always on patrol. Each warhead has an explosive power ('yield') of 100,000 tonnes (100kt) of TNT equivalent.[89] This is approximately seven times the yield of the nuclear bomb dropped on Hiroshima at the end of World War II. Table 3.3 summarises the key data regarding the UK's nuclear arsenal.

While there is broad public awareness about the devastation that can be wrought by a nuclear explosion, the details are generally not well known, especially those related to large-scale environmental impacts.

Table 3.3. UK nuclear weapons arsenal – key data[90]

UK arsenal of nuclear warheads	
Operationally available	120
In reserve	95
Total	**215**

Nuclear weaponry of one Vanguard-class submarine	
Nuclear warheads	40
Trident missiles	8
Yield of each warhead	100,000t
Total yield per submarine	**4,000,000t**

A nuclear explosion destroys by a combination of extreme heat, blast and ionising radiation. For example, a 100kt warhead would completely destroy a circular area of radius 1.8km, with progressively less destruction up to about 8km.[91] While much damage would be caused very quickly – in milliseconds to seconds – a considerable amount of damage would also occur in the hours to years afterwards. For example, fires would rage emitting large amounts of toxic and radioactive 'fallout' over very large areas. In a major nuclear conflict, the fires would be so intense that they would inject dense smoke high into the atmosphere above the clouds, such that it would start to block out incoming solar radiation leading to widespread climatic cooling and major damage to the ozone layer. This would in turn cause major crop failures leading to famine.

Following on from early research in the 1980s on the possibility of a 'nuclear winter', scientists have since the mid-2000s used more sophisticated mathematical models to investigate the climatic effects of nuclear war scenarios. In a series of academic studies,[92] they have analysed three scenarios: regional nuclear war between India and Pakistan; 'medium-sized' war between the USA and Russia using 'high alert' nuclear weapons; and 'large-scale' war, using all available weapons. In all scenarios, a rapid, global-scale, climatic cooling was found to occur, large enough to severely damage crop-growing areas. Even the smaller of the three scenarios would cause effects so severe than *two billion people*, nearly a third of the world's population, would be threatened by famine. SGR has compared the effects of this scenario with the situation where the 40 warheads carried by a single UK nuclear-armed submarine were launched.[93] We concluded that

88 Federation of American Scientists (2020). Status of World Nuclear Forces. https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/

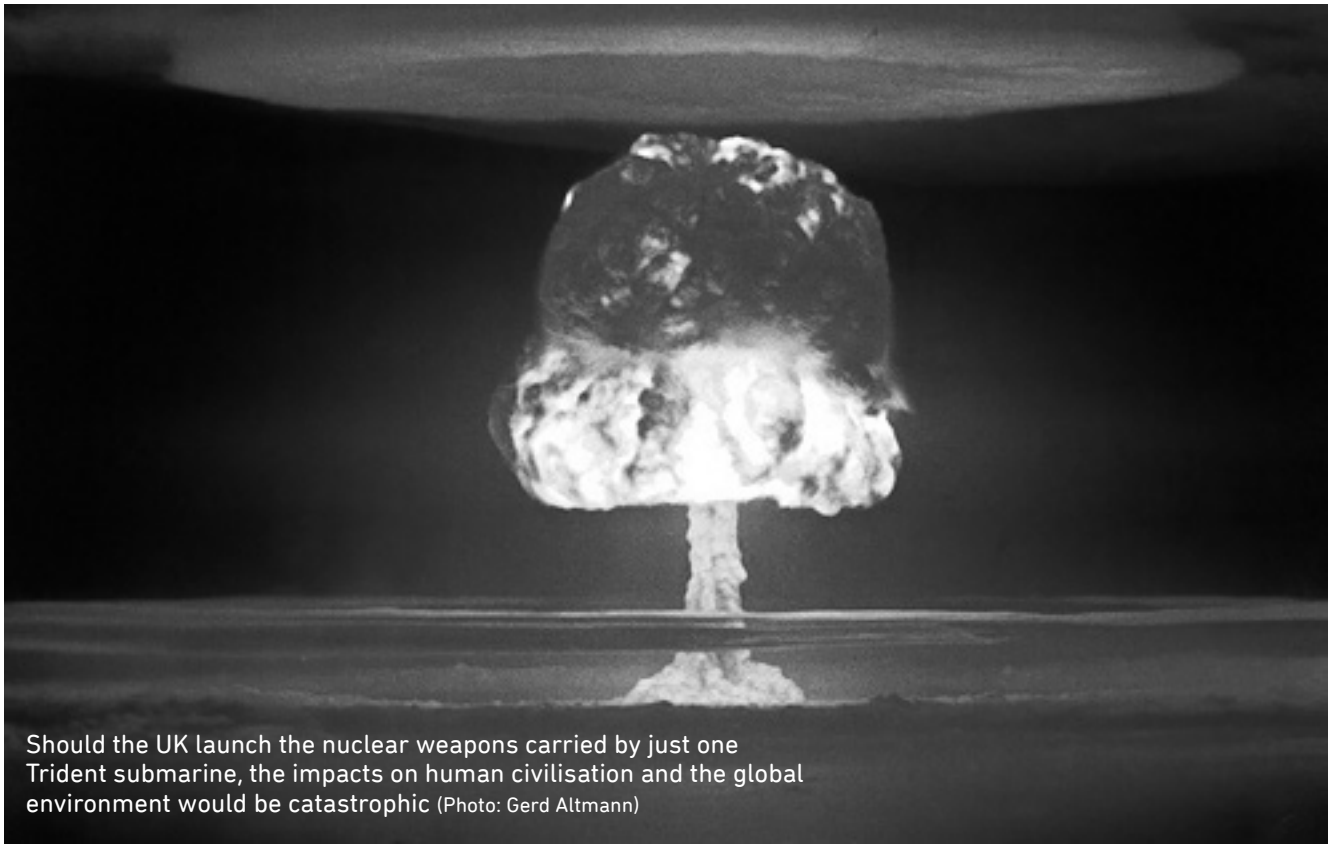
89 Webber, P. and Parkinson, S. (2015). UK nuclear weapons: a catastrophe in the making? SGR. https://www.sgr.org.uk/publications/uk-nuclear-weapons-catastrophe-making

90 Federation of American Scientists (2020). *Op. cit.*; Webber, P. and Parkinson, S. (2015). *Op. cit.*

91 Webber and Parkinson (2015). *Op. cit.*

92 See, for example: Robock, A., Oman, L. and Stenchikov, G.L. (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. For details of other studies, together with references, see: Webber, P. and Parkinson, S. (2015). *Op. cit.*

93 Webber, P. (2013). The climatic impacts and humanitarian problems from the use of the UK's nuclear weapons. SGR. https://www.sgr.org.uk/publications/climatic-impacts-and-humanitarian-problems-use-uk-s-nuclear-weapons



Should the UK launch the nuclear weapons carried by just one Trident submarine, the impacts on human civilisation and the global environment would be catastrophic (Photo: Gerd Altmann)

the UK launch scenario – depending on which targets were chosen – could generate similar levels of fires and smoke, leading to similarly catastrophic global cooling effects and a 'nuclear famine'.

The devastating effects of any potential future use of nuclear weapons – on both human society and the natural environment – clearly challenge the arguments used in favour of continued deployment. Indeed, there are major questions as to whether any such use would be contrary to international humanitarian law, including its environmental provisions.[94] Although we do not have the space in this report for an in-depth discussion of the legal issues, it is clear that the UK – in common with all other nuclear-armed nations – are on very dubious legal ground simply by continuing to deploying these weapons of mass destruction.

3.4 Environmental impacts: overarching issues

It is clear from the preceding analysis that the MOD is, at best, selective in its efforts to reduce its environmental impacts, and in its reporting on those efforts. Some might argue this is inevitable, given the nature of war and the deployment of military technologies. However, such a position is based on the perspective that the UK has no other options than continuing to deploy a large military, with major capabilities for long-range 'force projection' far from British shores. The UK government chooses to deploy a 'blue water' navy – with two aircraft carriers much larger than any in British maritime history, and nuclear-powered submarines, with ranges measured in the thousands of kilometres. It chooses to maintain a network of military bases around the world. It chooses to have one of the world's largest military budgets, while allowing the export of weapons to governments with very poor human rights records. It chooses to take part in major military operations in, for example, the Middle East. It chooses to be one of only nine nuclear-armed nations. Most other countries do not choose such roles – even ones with similar sized economies.

The government argues that such choices are necessary for security – but this is widely disputed. It is beyond the remit of this report to analyse these arguments in any depth, but we will point to a number of environmental implications.

94 Chapter 12 of: Wallis, T. (2017). *Disarming the nuclear argument.* Luath Press: Edinburgh.

Britain's continued deployment of a military with a large capability for long-range force projection makes it difficult to keep energy use low. We have seen this especially in the high consumption of petroleum fuels by military aircraft and ships, and their associated GHG emissions (see section 2.2). For marine vessels, one alternative is an expansion in the use of nuclear power. However, we have also seen the burgeoning problem of radioactive waste from Britain's submarines (see section 3.2). Technology trends indicate a greater use of smaller, more energy efficient robotic craft – and a greater role of artificial intelligence. However, that would bring a range of other risks.[95]

Regardless, there are virtually no good environmental options once war does break out (section 3.1) and, if a British Prime Minister did choose to launch the nation's nuclear weapons, then the risks of global climate disruption leading to a 'nuclear famine' would be very high (section 3.3).

There is an alternative path, however. The United Nations has long advocated an approach based on the concept of 'human security' – which is a much broader interpretation of security, taking into account threats arising from poverty, epidemics, inequality, environmental damage and other threats.[96] The UK think-tank, the Oxford Research Group, argues for a complementary approach, which it calls 'sustainable security',[97] which argues that an international combination of militarisation, economic marginalisation, and environmental destruction, such as that through climate change, are combining to make the world an increasingly insecure place. SGR has used these frameworks to argue that the UK should reprioritise its use of science and technology – in particular, shifting resources away from the development and deployment of long-range, 'offensive' military technologies to technologies that can reduce GHG emissions or provide health and social benefits.[98] Indeed, the COVID-19 crisis demonstrates that such an approach could have profound benefits. In recent years, the UK government has started to recognise the value of considering security in a broader way, so much so that in the 2015 National Security Risk Assessment, it rated pandemic influenza as a 'Tier One' threat.[99] Unfortunately, it did not reallocate sufficient resources to deal with such a threat, with consequences that are now obvious to all. Other non-military threats – such as those from climate change, mass extinction of wild species, or microbial resistance – are similarly grave.

In summary, only a concerted change in the UK's security policies – away from a reliance on militaristic approaches to ones which tackle the full range of threats – offers lasting hope for society.

95 Simms, A. and Parkinson, S. (2019). Artificial Intelligence: How little has to go wrong? SGR. https://www.sgr.org.uk/publications/artificial-intelligence-how-little-has-go-wrong

96 UN Trust Fund for Human Security (2018). What is human security? https://www.un.org/humansecurity/what-is-human-security/

97 ORG (2020). Sustainable Security Programme. https://www.oxfordresearchgroup.org.uk/Pages/Category/sustainable-security

98 Parkinson, S. *et al* (2013). Offensive Insecurity: The role of science and technology in UK security strategies. SGR. https://www.sgr.org.uk/publications/offensive-insecurity

99 Summary of the National Security Risk Assessment 2015. Annex A of: HM Government (2015). National Security Strategy and Strategic Defence and Security Review 2015. https://www.gov.uk/government/publications/national-security-strategy-and-strategic-defence-and-security-review-2015

4. Conclusions

In this report, we have examined the key environmental impacts of the UK military and the related industrial sectors. We have presented a detailed assessment of the GHG emissions of these sectors – one that we think is more in-depth than any that has been published before in the open literature. We have also provided brief assessments of other key environmental impacts of the military – focusing especially on areas that we think are being neglected by decision-makers and environmental managers.

We present here the main conclusions of this report, grouped under four headings: transparency; GHG emissions; other environmental impacts; and broader policy issues.

Transparency

- The Ministry of Defence is highly selective in the data and related information on its environmental impacts that it publishes in its annual reports, under the heading *Sustainable MOD*.
    - Figures for total GHG emissions are no longer included, and figures for emissions related to use and deployment of military equipment have been relegated to an annex and not referenced in the main text. The figures that are reported in the main text, we estimate, cover less than one-third of the MOD's total direct GHG emissions.
    - Reporting in relation to the management of hazardous waste is minimal, despite it being a serious problem for the organisation.
    - Reporting in relation to the environmental impacts of war-fighting is virtually non-existent, despite the many serious impacts this has.
    - The presentation of environmental data in *Sustainable MOD* has often been error-strewn and/or lacking in clarity in recent years.
    - There is minimal explanation of the exemptions from environmental law and reporting requirements that apply to the UK military and its contractors in *Sustainable MOD*.
- There is a wide variation in the level of environmental reporting by private companies supplying the MOD and the UK arms industry in general.
    - A few companies do not provide the minimum necessary information in their annual reports/ corporate responsibility reports concerning their GHG emissions. These include MBDA and Elbit.
    - Only one company supplying the MOD – out of 25 examined – provides an in-depth assessment of its GHG emissions in its annual report, including those in its supply-chain. This company is BT.

GHG emissions

- The UK military-industrial sector – including the armed forces, arms industry and related employment – is a large source of GHG emissions. There are two ways of calculating these emissions: the territorial or 'production-based' approach; and the lifecycle or 'consumption-based' approach. We estimate that:
    - The UK-based GHG emissions of the sector in the financial year 2017–18 – using the production-based approach – were 6.5 million tonnes of CO_2 equivalent. This was greater than the carbon dioxide emissions of about 60 nations.
    - The GHG emissions of the UK military spending in 2018 – using the consumption-based approach – was approximately 11 million tonnes of CO_2 equivalent. This is also known as the 'carbon footprint' and includes all lifecycle emissions, such as those arising abroad from raw material extraction. This is more than 3.5 times larger than the total direct GHG emissions of the MOD, and more than 11 times larger than the GHG figures quoted in the main text of MOD annual reports. It is also equivalent to the total carbon dioxide emitted by the annual average mileage driven by over six million UK cars.
    - The carbon footprint of UK exports of military equipment in the financial

year 2017–18 was approximately 2.2 million tonnes of CO_2 equivalent. (These emissions would be counted within the carbon footprints of the importing nations.)

- These figures do not include the GHG emissions related to impacts of weapons use on the battlefield. Such emissions could potentially be large, but are highly uncertain.

- The UK-based company with largest GHG emissions was BAE Systems. Its UK emissions were about 30% of the total for the nation's arms industry as a whole.
- The direct GHG emissions of the UK military have fallen by about 50% over a 10-year period, mainly due to a reduction in war-fighting, sell-off of unneeded military property, and energy efficiency improvements.
- Further significant falls in GHG emissions of the UK military seem unlikely due to: planned increases in military spending, leading to increases in activity; greater deployment of high-energy consuming vehicles, including the huge new Queen Elizabeth-class aircraft carriers; and expansion of overseas military bases.
- Any decision to mount major military operations in the future would lead to a large increase in the GHG emissions of the UK military.
- GHG emissions from UK military operations do not seem to be limited by the Climate Change Act, but there is a lack of clarity over this issue.

Other environmental impacts

- The activities of the Ministry of Defence, including the armed forces, its civilian agencies, and its contractors, are not automatically covered by civilian environmental regulations. If the MOD decides there is a 'defence need' then these are exempt. Instead the MOD aims to 'minimise' its environmental impacts through the application of a set of environmental management systems. External verification of these systems seems to be patchy.
- The UK's military missions are likely to have major environmental impacts, but no data is publicly available on the full extent of these impacts, nor on measures taken to reduce them. Indeed, attempts to assess such impacts seem not to been undertaken routinely by the MOD.
- The MOD and its contractors have – over a period of decades – a poor record of managing their radioactive waste. There have been major delays, spiralling costs, unclear goals and, at times, prosecutions for health, safety and environmental lapses. It seems that the prosecutions would have been far more frequent had this been a civilian operation.
- The UK government fails to acknowledge, let alone address, the catastrophic environmental impacts should it ever launch its nuclear weapons.
- Recent scientific evidence on the catastrophic effects should UK nuclear weapons ever be used seriously undermines their credibility as a 'deterrent'.

Broader policy issues

- Only a major change in UK military strategy – away from one based on deploying UK military forces with the capability for long-range 'force projection' to forces focused only on territorial defence and UN peace-keeping – is likely to lead to low levels of environmental impacts, including low GHG emissions.
- Such a change in military policy would go hand-in-hand with broader changes to the UK's wider security policies. This would allow a major shift in spending and other resources – for example, in science and technology – from military activities to tackling non-military threats, such as climate change and pandemics, and the broader roots of armed conflict, which include a range of economic, social and environmental problems.

5. Recommendations

Following on from the conclusions, we make a set of key recommendations.

Transparency

We strongly urge the MOD to:

- report its total direct GHG emissions – i.e. the sum of all those under the headings of 'Estates' and 'Capability/ Equipment' (Scopes 1, 2 and 3 (business travel) – as a headline indicator in its annual report.
- provide an estimate of its carbon footprint in its annual report.
- report more comprehensive information on its management of hazardous waste, including annual figures for the amounts: (i) produced; (ii) stored; and (iii) disposed – as well as documenting efforts to reduce these amounts.
- publish annual figures of the amount of ordnance used in (i) military exercises and (ii) war-fighting, as well as documenting efforts to reduce these amounts. We also urge the publication of assessments of the environmental impacts of military exercises and military operations.
- make greater use of external auditing of its environmental reporting, especially *Sustainable MOD*.
- include clear explanations of which emissions of pollutants are currently exempt from environmental regulations and/or national targets within *Sustainable MOD*.

We strongly urge arms corporations which operate in the UK to:

- report clearly on their annual GHG emissions, following the GHG Protocol, indicating which are Scopes 1, 2 or 3.
- report on their wider ('Scope 3') GHG emissions, especially related to their supply-chains.

We strongly urge research scientists – and the IPCC, in particular – to:

- carry out more studies of military GHG emissions in the UK and internationally, and publish their work in the open literature.

GHG emissions and other environmental impacts

Pending the reforms to UK defence and security policies discussed below, we strongly urge the MOD to:

- shift all energy use at military bases to renewable energy sources, and continue with efforts to reduce consumption levels.
- carry out and publicly publish assessments of the environmental impacts of past UK military actions over at least the last ten years.
- rapidly accelerate efforts to dismantle the UK's retired submarines, repackage existing radioactive waste into more secure containers, and secure the waste in more secure facilities, pending agreement on long-term options.
- phase out the use of nuclear-propelled submarines.

Pending the reforms to UK defence and security policies discussed below, we strongly urge arms corporations which operate in the UK to:

- end exports of weapons and other military equipment to governments with poor records in the protection of the environment and human rights.
- put in place plans to minimise GHG emissions consistent with the Paris Climate Agreement.

Broader security reforms

We strongly urge the UK government to:

- carry out major reforms to its national defence and security policies.
    - In the first instance, this should involve rapidly phasing out the deployment of UK military forces with the capability for long-range 'force projection' – instead focusing on forces only for territorial defence and UN peace-keeping.
    - In the second instance, this should involve a major shift in spending and other resources – for example, in science and technology – from military activities to tackling non-military threats, such

The Queen Elizabeth class aircraft carriers are the largest warships ever built for the Royal Navy – and are powered by a combination of natural gas and diesel. (Photo: Contains public sector information licensed under the Open Government Licence v3.0.)

as climate change and pandemics, and the broader roots of armed conflict, which include a range of economic, social and environmental problems. This should include a comprehensive 'arms conversion' programme including all relevant UK companies, including funding for retraining of workers. Particular emphasis should be given to a shift to developing and deploying technologies for renewable energy generation and energy conservation.

- rapidly phase out deployment of nuclear weapons due to the catastrophic effects – on both human civilisation and the natural environment – should they be ever used.

All policy actions should be consistent with the Paris Climate Agreement and other UN environmental treaties.

Appendix 1: Flaws in Sustainable MOD Annual Report 2017/18

The following are examples of omissions, ambiguities, inconsistencies and errors in *Sustainable MOD Annual Report 2017/18*.[100]

Section 3.1.1 – Capability and Equipment Energy (pp.25-28)

- No data is provided in this section on GHG emissions, despite this data being provided in Annex A and it amounting to over 60% of total MOD GHG emissions.

Section 3.1.2 – Estate Energy and Greenhouse Gas Emissions (pp.28-29)

- Para. 1 includes the sentence, "Current consumption equates to 1,117,098 MWh compared to a usage of 4,333,897 MWh for the baseline year." Totalling the relevant figures in Annex A leads to a total of 3,297,973 MWh for the current year (2017–18), nearly three times the stated figure. (The figure for the baseline year, 2009-10, is correct.)
- *Table 4*
  Title is given as "Total GHG emissions – Comparison against 2009/10 baseline". The table only includes GHG emissions due to 'Estate Energy' and 'Domestic Business Travel' – leaving out 'Capability and Equipment Energy'. Hence, it is misleading to label it 'Total GHG Emissions'.

  Final row is labelled as "% change compared to 2015/16 baseline" when it is actually % change compared to 2009/10 baseline.
- *Figure 2*
  Title is given as "Total GHG emissions – Comparison to 2009/10 baseline". Again, this is misleading as it does not include 'Capability and Equipment Energy'.

  Bar for 2017/18 leaves out figures for 'Domestic Travel' provided in Table 4.

  Blue dashed line for '30% Baseline reduction target' should be at 1.002 MtCO2e – but it is shown significantly higher than this.

Section 3.5.3 – Business travel (pp.43-44)

- *Table 10*
  GHG emissions figure for 'GGC reportable Business Travel' matches that for 'Domestic Business Travel' in Table 4 (Section 3.1.2) for 2009/10,[101] but not for the other three years. No explanation is given for why.

  Figures for 'Other Business Travel' (i.e. international) do not appear to be included in any of the total GHG emissions figures.

Annex A - Energy and Carbon Emissions data 2009/10 – 2017/8 (pp.55-56)

- The header row of the table includes the title 'Greenhouse Gas Emissions' despite only one of the five sections of the table being figures for such emissions.
- In the first part of the table (covering GHG emissions), five rows of data are provided. In three of the rows, the labelling does not indicate whether the figures for GHG emissions are for 'Estate' or 'Capability'.
- In the second section of the table, it is not stated that this energy consumption is for Estates. The reader is left to deduce this.
- No explanation is provided for the sudden switch from non-renewable energy to renewable energy for electricity in 2012/13 then back again in 2015/16 – nor how this affects (or does not affect) the total figures for GHG emissions.
- No explanation is provided for the use of only the GHG emission figures for Estates in the Normalisation section of the table.

Annex B - Water and Waste data 2009/10 – 2017/18 (p.57)

- Total waste for 2014–15 reads '1631' when the correct value (calculated by adding the appropriate figures in the table) is '164'

100 MOD (2018a). *Op. cit.*

101 Virtually - 89,747 compared with 89,748.

Appendix 2: List of sources for UK arms industry data

Company	Sources
BAE Systems	**Corporate responsibility summary 2018** https://www.baesystems.com/en/our-company/corporate-responsibility **Annual report 2018** https://investors.baesystems.com/~/media/Files/B/Bae-Systems-Investor-Relations-V3/PDFs/results-and-reports/results/2018/annual-report-2018.pdf **Basis of reporting: CR review 2018** https://www.baesystems.com/en/download-en/20190312114152/1434627978339.pdf
Babcock International	**Annual report and accounts 2018** https://www.babcockinternational.com/investors/annual-reports/ **Annual report and accounts 2018 (CH)** https://beta.companieshouse.gov.uk/company/02342138/filing-history
Serco	**Annual report and accounts 2018** https://www.serco.com/investors/results-reports-events
Rolls-Royce	**2018 Annual report** https://www.rolls-royce.com/investors/annual-report-2018.aspx
Leonardo	**Main environmental data and information: 2018 data** https://www.leonardocompany.com/documents/20142/5334341/principaliDati_ENG.pdf?t=1556646799987 **Annual report 2018** https://www.leonardocompany.com/en/investors/results-and-reports
MBDA	**Corporate and social responsibility report 2018** https://www.mbda-systems.com/about-us/corporate-responsibility/ **UK subsidiary: Directors report and financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/03144919/filing-history
QinetiQ	Annual report and accounts 2018 **https://www.qinetiq.com/Investors/Results-Archive**
Thales	**2018 Integrated report: corporate responsibility** https://www.thalesgroup.com/en/global/corporate-responsibility/key-corporate-responsibility-documents **2018 Registration document: including the annual financial report** https://www.thalesgroup.com/en/investors **UK website:** https://www.thalesgroup.com/en/countries/europe/united-kingdom

Airbus	**Annual report 2018** https://www.airbus.com/company/corporate-governance/governance-framework-and-documents.html#Orga
Lockheed Martin	**2018 Sustainability report** https://sustainability.lockheedmartin.com/sustainability/index.html
Raytheon Systems (Parent: Raytheon)	**Raytheon: 2018 Corporate responsibility report** https://www.raytheon.com/responsibility/approach/corporate-responsibility-strategy **Raytheon: 2018 Annual report** http://investor.raytheon.com/annual-reports **Raytheon Systems: Annual report 2018 (CH)** https://beta.companieshouse.gov.uk/company/00406809/filing-history
Amey UK (Parent: Ferrovial)	**Ferrovial: Climate strategy 2018** https://www.ferrovial.com/en/sustainability/environment/carbon-footprint/ **Amey UK: Annual report and financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/04736639/filing-history **Amey Defence Services: Annual report and financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/05428762/filing-history **Amey Defence Services (Housing): Annual report and financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/05428732/filing-history
Boeing Defence UK (Parent: Boeing)	**Boeing: 2019 Global environment report** https://www.boeing.com/principles/environment/index.page **Boeing Defence UK: Annual report and financial statements (CH)** https://beta.companieshouse.gov.uk/company/01290439/filing-history
General Dynamics UK (Parent: General Dynamics)	**General Dynamics: Corporate sustainability report 2018** https://www.gd.com/responsibility **General Dynamics UK: Annual report and financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/01911653/filing-history
Cobham	**Annual report and accounts 2018** http://www.cobhaminvestors.com/ **Corporate Responsibility and Sustainability: Performance data** https://www.cobham.com/the-group/corporate-responsibility-and-sustainability/performance-data-policies/performance-data/
EntServ (Parent: DXC Technology)	**DXC Technology: 2018 Corporate responsibility and sustainability report** https://www.dxc.technology/cr/ds/88734-corporate_responsibility_report_archives **EntServ UK: Annual report and financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/00053419/filing-history
Meggitt	**Annual report and accounts 2018** https://www.meggitt.com/investors/

BT	**Annual report and Form 20-F 2018** https://www.btplc.com/Sharesandperformance/Financialreportingandnews/Annualreportandreview/index.htm
AirTanker	**Annual report and financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/06279646/filing-history **Website:** https://www.airtanker.co.uk/
Elbit	**Form 20-F 2018 (Annual report)** http://ir.elbitsystems.com/financial-information/annual-reports **UK website:** https://www.elbitsystems-uk.com/about-us/vision-mission
GKN (Parent: Melrose)	**Annual report and accounts 2017** http://www.annualreports.co.uk/Company/gkn-plc
Northrop Grumman	**2018 Corporate responsibility report** http://investor.northropgrumman.com/ **UK website:** https://www.northropgrumman.com/who-we-are/northrop-grumman-in-the-uk/
Leidos Europe (Parent: Leidos)	**Leidos: Responsibility & Sustainability** https://www.leidos.com/company/responsibility-and-sustainability **Leidos Europe: Annual report and financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/09351724/filing-history **UK and Europe website:** https://www.leidos.com/company/global/uk-europe
Rheinmetall	**Rheinmetall: Corporate responsibility report 2017** https://www.rheinmetall.com/en/rheinmetall_ag/corporate_social_responsibility/csr_report/index.php **Rheinmetall: UK website** https://www.rheinmetall-defence.com/en/rheinmetall_defence/company/divisions_and_subsidiaries/rheinmetall_defence_uk_limited/index.php **Rheinmetall Defence UK: Consolidated financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/06802649/filing-history **Rheinmetall MAN Military Vehicles: Annual report and financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/09037895/filing-history **RTP-UK: Financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/06460497/filing-history **RFEL: Financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/02389307/filing-history **Mechadyne International: Filleted financial statements 2018 (CH)** https://beta.companieshouse.gov.uk/company/01834088/filing-history
WFEL **(Parent: Krauss-Maffei Wegmann)**	**WFEL: Annual report and financial statements 2018** https://beta.companieshouse.gov.uk/company/00310308/filing-history **Krauss-Maffei Wegmann: Website:** https://www.kmweg.com/company.html

Notes:
CH – as submitted to UK Companies' House
URLs correct as of 19 April 2020

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Glossary

ASEMS	Acquisition Safety and Environmental Management System
AWE	Atomic Weapons Establishment
BEIS	UK Department for Business, Energy and Industrial Strategy
CCA	UK Climate Change Act
CO_2	carbon dioxide
COVID-19	coronavirus disease 2019
DEFRA	UK Department for Environment, Food and Rural Affairs
FLC	Front Line Command
GDF	Geological Disposal Facility
GHG	greenhouse gas
HSE	health, safety and environmental
IPCC	Intergovernmental Panel on Climate Change
$kgCO_2e$	kilograms of carbon dioxide equivalent
kt	kilotonnes
lbs	pounds (imperial weight)
LOAC	Law of Armed Conflict
MOD	UK Ministry of Defence
NATO	North Atlantic Treaty Organisation
NIS	Nuclear Information Service
ONR	Office of Nuclear Regulation
POEMS	Project Oriented Environmental Management System
SEAT	Sustainability and Environmental Appraisal Tool
SEMS	Safety and Environmental Management System
SGR	Scientists for Global Responsibility
SIPRI	Stockholm International Peace Research Institute
tCO_2e	tonnes of carbon dioxide equivalent
TNT	trinitrotoluene
UN	United Nations

SGR
responsible science

The Environmental Impacts of the UK Military Sector

War and the preparation for war inevitably cause numerous, often severe, environmental impacts, including pollution of land, water and air. This report assesses the key environmental impacts of the UK military, arms industry and related sectors. It provides a detailed assessment of UK military greenhouse gas (GHG) emissions – arguably, more in-depth than previously provided in a report in the public domain. It also gives an overview of other related environmental issues, especially those of particular concern, such as impacts resulting from weapons-use, the management of military nuclear waste, and the environmental impacts should nuclear weapons ever be used in war.

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