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A decarbonised defence sector: is it even possible?

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Abstract:

The world's militaries are major emitters of greenhouse gases. Although their exact contribution is unknown, estimates range from 1% to 5% of global emissions.

For the armed forces, reliability, safety and operability take precedence over sustainability factors. Despite these priorities, the defence sector is making efforts to reduce its emissions.

The transition towards the use of renewable energy technologies in the armed forces opens up great opportunities for the decarbonisation of the defence sector, but only in those systems and equipment that do not compromise reliability and operability in an increasingly demanding security environment.

Keywords:

Decarbonisation, GHGs, climate change, renewable energy…

La descarbonización del sector de la Defensa: ¿un deseo realizable?

Resumen:

Los ejércitos del mundo son grandes emisores de gases de efecto invernadero. Aunque se desconoce la contribución exacta, las estimaciones oscilan entre el 1 % y el 5 % de las emisiones globales.

Para las Fuerzas Armadas, la fiabilidad, la seguridad y la operatividad priman sobre los factores de sostenibilidad. A pesar de estas prioridades, el sector de la defensa está llevando a cabo esfuerzos en la reducción de las emisiones.

La transición hacia el uso de tecnologías de energía renovables en las Fuerzas Armadas abre grandes oportunidades para la descarbonización en el sector de la defensa, pero solo en aquellos sistemas y equipos que no comprometan su fiabilidad ni su operatividad en un entorno de seguridad cada vez más exigente.

Palabras clave:

Descarbonización, GEI, cambio climático, energías renovables.

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Introduction

The world's militaries are major emitters of greenhouse gases. Although their exact contribution is unknown, estimates range from 1% to 5% of global emissions, comparable to the aviation and shipping industries which each contribute 2%.[1] According to a recent study, the cumulative emissions in 2019 from the defence sectors of EU members were equivalent to approximately 24.8 million tonnes of CO_2 or, in other terms, the annual emissions of 14 million medium-sized cars.[2]

Given the extent of these figures, NATO has recognised that national and global emission reduction targets will not be achieved without an effort to reduce emissions within the military realm.[3]

Some argue that the best way to reduce the carbon footprint of military operations is to reduce defence budgets and focus on diplomacy, international disarmament treaties, fair trade and poverty alleviation rather than looking for new ways to decarbonise the defence sector.[4] But it also seems logical to think that, from a deterrence point of view, without a secure environment – provided by prepared, adequately equipped armed forces – countries would find it very difficult to achieve the ambitious national climate targets set out in the Paris Agreement. This was stated by NATO's Secretary General at last year's Madrid Summit: "If we fail to preserve peace, we will also fail to fight climate change."[5]

During the latest climate summit (COP27) in Egypt, the Ukrainian president declared that "there can be no effective climate policy without peace",[6] using the climate argument to get Western powers more involved in ending the war.

From the point of view of decarbonisation, the war in Ukraine has established a new framework that opens the debate between the need for the military – and thus the entire defence sector – to meet climate requirements and the need to continue to use fossil-

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1 Mohammed Ali Rajaeifa et al. "Decarbonize the military - mandate emissions reporting". Nature 611, 29-32 (2022) doi: https://doi.org/10.1038/d41586-022-03444-7
2 Stuart Parkinson & Lindsey Cottrell, Under the Radar: The Carbon Footprint of Europe's Military Sectors, (Brussels: The Left group in the European Parliament - GUE/NGL, February 2021), 7.
3https://www.nato.int/cps/en/natohq/197168.htm?selectedLocale=en
4 https://www.sgr.org.uk/sites/default/files/2020-08/SGR-RS02-Military-carbon-boot-print.pdf
5https://www.nato.int/cps/en/natohq/197168.htm?selectedLocale=en
6https://www.theguardian.com/environment/2022/nov/08/cop27-climate-summit-volodymyr-zelenskiy-ukraine-president-speech

fuelled equipment and materials to obtain adequate operational capability to win current and future wars.

Measuring emissions to reduce them

The international community has developed a variety of methods and tools to measure greenhouse gases. For example, the GHG Protocol has defined an assessment standard whereby organisations report their emissions in three main categories: scopes 1, 2 and 3.[7] This allows countries to report their emissions to the United Nations Framework Convention on Climate Change (UNFCCC).

During the Kyoto Protocol negotiations, the US lobbied for the military to be excluded from greenhouse gas (GHG) emission reporting as this information could compromise the national security of states. Although this discourse has been maintained over the years, the Paris Agreement provides for the voluntary reporting of military emissions. The lack of a minimum obligation to report these emissions to the UNFCCC means that there are significant gaps in the data sets submitted by individual countries. In these reports, some countries report defence emissions, but the data are not of adequate quality to establish the emissions from the sector, as they are incomplete, unclear or inconsistent.[8]

With growing climate awareness among the population, the security grounds exemption on reporting military emissions may be increasingly challenged.[9]

Under the premise that "what you measure can be reduced", NATO is already working on developing the first methodology for measuring NATO's civilian and military GHG emissions. It sets out what to count and how to count it, and will be available to all allies to help them estimate their own military emissions.[10]

7Scope 1 emissions are direct emissions from the emitter's combustion of fuel.
Scope 2 emissions are indirect emissions generated by the electricity purchased and consumed by the emitter.
Scope 3 emissions are indirect emissions that arise from the activity of the emitter but are owned and controlled by an agent removed from the emitter.

8 Mohammed Ali Rajaeifa et al. "Decarbonize the military - mandate emissions reporting". Nature 611, 29-32 (2022) doi: https://doi.org/10.1038/d41586-022-03444-7

9 Report: Estimating the Military's Global Greenhouse Gas Emissions. CEOBSE.2022. Available at: https://ceobs.org/wp-content/uploads/2022/11/SGRCEOBS-Estimating_Global_MIlitary_GHG_Emissions_Nov22_rev.pdf

10https://www.nato.int/cps/en/natohq/197168.htm?selectedLocale=en

In the case of the Spanish Ministry of Defence, the stock-taking of potential GHG sources and the calculation of the Ministry's carbon footprint were initiated in 2012. This calculation is divided into three different scopes:

Scope 1: Direct emissions produced by the Ministry, mainly from the consumption of fossil fuels.

Scope 2: Indirect emissions produced by electricity suppliers.

Scope 3: Indirect emissions produced by suppliers of goods and services to the Ministry and the use of external means of transport, among others.[11]

In the US, an approach is being tested to facilitate the measurement and reporting of emissions, taking into account the difficulties arising from the military's own activities. The Annual Energy Management Data Report of the US Department of Energy's Federal Energy Management Program classifies emissions into standard and non-standard operations. Standard operations generally refer to facility operations and include fuel consumption in buildings and non-tactical fleet vehicles. Non-standard operations are vehicles, ships and submarines, aircraft and other equipment used for combat support, combat service support, tactical or relief operations, training for such operations, law enforcement, emergency response and space flight (including associated ground support equipment). This is consistent with the US Department of Defense's definition of operational energy, which was defined in fiscal year 2009 as “the energy required for training, moving, and sustaining military forces and weapons platforms for military operations.”[12]

In peacetime, the main sources of CO_2 emissions from military activity include the production of military equipment (raw materials through to final production), the operation of military bases and installations (energy use for waste management) and the use of transport vehicles (aircraft, naval fleet and land vehicles).[13]

11https://www.defensa.gob.es/medioambiente/cambioclimatico/reduccionemisiones/
12https://s3.documentcloud.org/documents/22067222/usa001358-21-rtc-greenhouse-gas-emissions-levels_updated_report-only.pdf
13 https://www.sgr.org.uk/sites/default/files/2020-08/SGR-RS02-Military-carbon-boot-print.pdf

Some analysts propose that the military, in addition to reporting its Range 1, 2 and 3 emissions, should begin to explore how it can begin to track and report emissions associated with its combat activities by proposing the designation "Range 3 Plus".[14]

Accounting for emissions during conflict is much more difficult for reasons of security, mobility and confidentiality.   At present, aiming for a *low-carbon war*[15] is an impossible task whether in the combat phase or during reconstruction.

Some estimates made to assess the emissions from the future reconstruction of Ukraine after the end of a war indicate that it could easily exceed 100 million tonnes of CO_2 if the conflict has caused nationwide destruction.[16]

Despite the difficulty of determining emissions from a conflict, emissions from the Ukraine war were estimated and presented at COP27: 33 million tonnes of CO_2, of which 8.9 million tonnes were due to hostilities, 1 million tonnes due to displacement and 23.4 million tonnes due to fires. To these emissions should be added those generated in the reconstruction of the country, which could amount to 48.7 tonnes of CO_2.[17]

Progress towards decarbonisation of the armed forces

Although there are many difficulties in accurately and comprehensively measuring emissions in the military, this does not mean that actions are not being taken to help reduce emissions and move towards sustainability within the armed forces. There are currently numerous initiatives at the military level that are helping to reduce its emissions. These include improving the energy efficiency of military vehicles, the increasing use of renewable sources and the shift to more energy-efficient equipment such as drones.[18]

Emission sequestration and carbon sinks from all natural areas belonging to defence institutions also contribute to reducing the amount of emissions. In Spain, for example, the Ministry of Defence can contribute to absorbing carbon through its natural resources such as forests (more than 100,000 ha of tree and shrub vegetation), natural carbon sinks or offsetting measures.[19]

14 Report: A framework for military reporting of greenhouse gas emissions - CEOBS
15https://thefivepercentcampaign.files.wordpress.com/2022/06/military-emissions_final.pdf
16https://climatefocus.com/wp-content/uploads/2022/11/ClimateDamageinUkraine.pdf
17 https://eu4climate.eu/ukraine/
18 https://www.sgr.org.uk/sites/default/files/2020-08/SGR-RS02-Military-carbon-boot-print.pdf
19https://www.defensa.gob.es/medioambiente/cambioclimatico/absorcionemisiones/

The EU has always demonstrated its commitment to ambitious climate targets, but with regard to reducing emissions in the defence sector, the US and the UK are the countries that are trying to take the lead, given that defence accounts for 80% and 50% of government emissions, respectively. Decarbonisation of the defence sector is therefore vital to achieving the US and UK governments' net zero emissions ambitions.[20]

In the area of mitigation, NATO aims to reduce its own carbon emissions in its military equipment and operations. In line with partner countries' emission reduction targets, the alliance has proposed to reduce its emissions by around 50 percent by 2030 and to reach net zero by 2050. While NATO cannot set individual member nations reduction targets or mandate the use of a particular energy source, it does provide the cooperative framework for allies and partners to organise trials and share best practices and experience. In addition, the NATO certification scheme and STANAGs (Standard Agreement) can serve to establish common standards and promote interoperability for equipment using green energy. Even with more common funding, NATO could consider creating a "Green Fund" to help finance trials and demonstrations and to help less advanced allies make the transition to green energy.[21]

The EU has also proposed emission cuts in activities associated with the Common Security and Defence Policy (CSDP). In particular, it focuses on limiting the environmental footprint of CSDP missions worldwide and emphasises the need to reduce emissions from the defence industry as an "integral aspect" of the EU's efforts to achieve climate neutrality by 2050. These objectives are further developed in the EU's *Climate Change and Defence Roadmap*,[22] which calls for greater energy efficiency, as well as the development and use of innovative technologies and practices to minimise defence-related emissions.[23]

20https://www.thebritishacademy.ac.uk/documents/4197/Just-transitions-decarbonising-diversifying-defence-uk-usa.pdf
21 https://www.gmfus.org/sites/default/files/2022-03/Shea%20-%20NATO%20climate%20-%20brief.pdf
22https://www.eeas.europa.eu/eeas/eu-climate-change-and-defence-roadmap_en
23 https://finabel.org/wp-content/uploads/2023/05/May-2023.pdf

Decarbonisation and technologies in the armed forces

Some dual-use technologies related to renewable energy offer considerable potential for the decarbonisation of the armed forces although it must be assumed that this is not an easy or quick task. Firstly because heavy weapons systems such as combat aircraft, battle tanks or warships require a significant amount of fossil fuels for their functioning and operation.[24] On the other hand, it must also be considered that the armed forces will play a greater role in outer space, a highly polluting and greenhouse gas-producing sector, but one of growing strategic importance from both a civilian and military point of view.[25]

Another aspect to take into account that may slow down decarbonisation within the armed forces is the lengthy procurement processes and equipment lifetimes. For example, the F-16 fighter jets that entered US service in 1979 are not scheduled to be retired until 2040.[26] In such cases, the only option is to modify, if possible, existing equipment to emit fewer emissions.

The use of renewable energies in military missions can offer certain advantages, mainly to reduce the transport of fossil fuels, which is often one of the most vulnerable links in foreign missions. The advantages also include the possibility of using renewable energies to gain autonomy from electricity grids susceptible to attacks that could endanger the activity of the armed forces and the security of a nation.

With the armed forces increasingly demanding electricity through the use of quantum computers and artificial intelligence, the option of owning facilities can offer multiple advantages. In some countries, this model is even seen as an investment with a social return, as the electricity produced in a military installation could also be used by nearby communities. One such example can be found in India.[27] Also the US Department of Defense has about 30% of the microgrid market and this can have positive spill-over effects for industry and consumers.[28]

24https://www.iiss.org/globalassets/media-library---content--migration/files/research-papers/2022/green-defence---the-defence-and-military-implications-of-climate-change-for-europe.pdf
25 https://www.bbvaopenmind.com/ciencia/investigacion/vuelos-espaciales-amenaza-clima-capa-ozono/
26 Mohommad Ali Rajaeifar et al. Nature 611, 29-32 (2022)
27 Ch. Sravan and P. Paramita. "*When National Decarbonization: India's just transition with military assistance*". Energy Research &Social Science, Volume 98, April 2023
28https://www.defense.gov/News/News-Stories/Article/Article/3140223/us-should-not-surrender-clean-energy-technology-to-china-dod-official-says/

However, this type of renewable energy, such as wind or solar energy, is not free of risks that can affect the operability of the armed forces and therefore national security. Renewable energies require the use of certain critical materials necessary for their production. Switching to reliance on certain minerals such as rare-earth elements, lithium or cobalt whose production and processing is held in far fewer hands than fossil fuels raises great uncertainty about adequate supply. To avoid these problems, the Department of Defence is interested in bringing the supply chain of these strategic materials closer together to ensure safe and reliable availability.

Electric mobility, just as it is in society, is also being implemented within the armed forces, preferably for movement within military installations. Also the US Army has recently achieved positive results in this direction with the so-called Tactical Vehicle Electrification Kits (TVEK)[29] for tactical platforms, which reduce average fuel consumption by approximately 25%.[30]

The use of drones can also contribute to the decarbonisation of the military, as can 3D manufacturing, which allows for cheaper and more energy-efficient production of many of the weapons systems and components used by armies.

As far as military manoeuvre exercises are concerned, it is possible that to a large extent they could be replaced by increasingly realistic simulations. However, given the growing rivalry between the US and China in the Indo-Pacific region, such exercises are more necessary than ever to demonstrate the power of both powers in future conflict zones.

The aerospace industry, both civil and military, is one of the most challenging industries to achieve climate neutrality. Today, fossil fuels are the only viable and efficient way to fly.

The aerospace industry must focus on disruptive innovation if it is to find a more sustainable and efficient mode of propulsion compared to fossil fuels, a prerequisite for use in the military.

Part of the emission reductions in the aviation sector could be achieved by introducing innovations in aircraft design. These developments would consist of both the design of

29 U.S. Army Climate Strategy.
30 J. A, Montero Muñoz. "*Influence of climate change on land operations*". The influence of climate change on military operations. CCDC, 2022

models to make them more aerodynamic and the introduction of lighter materials and coatings.

Another option to decarbonise the aerospace sector is to look for new propulsion systems, including the use of sustainable aviation fuels (SAF) and electric propulsion. The former could offer a solution for medium and long-haul flights in both bio and synthetic versions. In fact, Boing aims to have its new aircraft using only this type of fuel by 2030.[31]

Electric propulsion, however, seems to be aimed at short-haul flights and urban air mobility, all with the long term in mind. At present, only short-range flights are possible, but if research is carried out into increasing the density of the batteries, it may be possible to use them for long-range flights in the future.

Hydrogen propulsion is also being investigated as it offers great potential for reducing GHG emissions. The main problem is storage and the need to establish a new aircraft design. Airbus is currently working on the design and development of hydrogen propulsion systems.[32]

The establishment of new, more efficient air traffic routes and the modernisation of airspace management systems are also options that would contribute to the decarbonisation of the aerospace sector.

For all these options to be realised, it is necessary to involve the entire aviation ecosystem. Related infrastructure such as airports and military bases also need to implement appropriate measures to help reduce emissions.

According to experts, all of these options are viable but to varying degrees. The use of sustainable fuels is the option with the highest decarbonisation potential at a 45% reduction in emissions. This is followed by electric propulsion (18%) and aircraft design with 8%. Improving efficiency could reduce emissions by 6% while hydrogen propulsion could reduce emissions by 5%. The infrastructure improvement option would lead to a 3% reduction in total aerospace emissions.[33]

In recent years there have been numerous attempts by partners and allies to bring their forces into line with these new trends. For example, in 2019, the US naval fleet carried

[31] https://www2.deloitte.com/us/en/insights/industry/aerospace-defense/decarbonizing-aerospace.html
[32] https://www.businessinsider.es/airbus-avion-hidrogeno-clave-descarbonizacion-1014537
33 John Coykendall. Decarbonisation of aerospace sector

out a battle group deployment around the world in which all ships and aircraft involved consumed an exclusive blend of conventional fuel (F-76 for ships and F-44 for aircraft) with a 50% proportion of bioethanol. Although biofuel has been identified as a possible area of contribution to reducing the military's pollution footprint, "the sustainability of these fuels has been called into question as a short-term solution; these fuels, along with other synthetic and nuclear fuels, will need to be competitive with respect to indirect pollution and other environmental costs". The cost associated with this pilot project proved to be unaffordable in the long term, but the process opened up a field of research, showing the existence of alternatives to the fuels currently used.[34]

For the naval sector, the choice of alternative fuel must take into account the size, mission and payload of the given ship type, the range and power demands of the military systems on board, such as radars and weapons, and the potential exposure to hostile fire. For these reasons, non-combat vessels will be early adopters of alternative fuels.

Alternative fuels sources undergoing R&D in the military naval sector include batteries, biodiesel, hydrogen, nuclear and bioethanol.[35]

In relation to the latter type of fuel, it is worth mentioning the development and manufacture of the S-80 class submarines in Spain. This is a flagship project of Spanish technology, in which the submarines will include an advanced Air Independent Propulsion (AIP) system that allows greater autonomy of operation underwater.[36] This propulsion system is based on a fuel cell powered by hydrogen produced by a bioethanol reformer. The Isaac Peral submarine is the first of four planned to be developed with this technology.

This propulsion system is an example of how the use of cleaner energy can improve some operational capabilities by significantly increasing the submarine's dive times on a continuous basis and reducing noise production, which contributes to increased safety.

34 Cottrell, L. (2021). The Military's contribution to climate change. Conflict and Environment Observatory. Available at: The military's contribution to climate change
- CEOBS.

35 https://www.dnv.com/news/dnv-white-paper-tackles-the-decarbonization-of-naval-vessels-219461

36J. del Pozo. "*The Navy facing the challenge of global warming*" Chapter 3. The influence of climate change on military operations. CCDC.

Defence industry

The military should engage with their extensive supply chains on emissions tracking as soon as possible[37]. The defence industry has started to reduce its scope 1 and 2 emissions. However, much remains to be done on scope 3 emissions, which are those that are beyond their control as they extend all the way through the production chain to their final customer.

In this context, defence companies are under pressure. On the one hand, investors are looking for companies that are also leading the way towards sustainability and are committed to high standards of corporate social and environmental responsibility. On the other hand, defence companies must do research to be able to meet the climate objectives of the defence sector while ensuring the reliability, safety and operability of new systems and products.[38] This leaves defence manufacturers between a rock and a hard place. They are caught between a market demanding products that can go further, faster and with greater capacity, and an investor/lender community that is placing significant pressure on them to decarbonise. The potential consequence of this for the defence manufacturer is a significantly higher cost of capital to meet market demand.[39]

In the new 2022 Strategic Concept, NATO countries have made a firm commitment to contribute to combating climate change by encouraging investment in research into improving energy efficiency and developing alternative fuels for use in military propulsion systems.[40] Ministries and departments of defence can lead wider technological change across society by creating sufficient demand signals to stimulate innovation and enable the private sector to bring low-carbon solutions to market.[41]

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37 Report: A framework for military reporting of greenhouse gas emissions - CEOBS
38 https://www.iiss.org/research-paper//2022/02/green-defence
39 https://kpmg.com/uk/en/home/insights/2023/01/the-decarbonisation-of-the-aerospace-and-defence-industry.html
40 Nato 2022 Strategic Concept.
41 COMMUNIQUE: Decarbonised defence: Launch of the World Climate and Security Report 2022. The Center for Climate & Security (climateandsecurity.org)

Some civilian technologies may already be relevant, but many new green technologies are not mature enough for military use. Where there is insufficient relevant civilian research, defence R&D will be required to fill the gap.[42] A stronger partnership, with sufficient capital investment and dual-use commercial exploitation, will therefore be needed to achieve net zero in the armed forces.[43]

China's military-civilian fusion model potentially gives it an R&D advantage over European models. Monitoring industry developments is not sufficient to design an R&D model with more specific application for the military but with limited commercial use. One solution to this problem could be to monitor emerging technology companies both to keep an eye on their innovations and to prevent them from being acquired or financed by potential adversaries due to their relevant results.[44]

Conclusions

Because the military has historically been excluded for security reasons from GHG reduction targets, its ability to record its emissions lags far behind other sectors. This approach is now changing as the defence sector is highly carbon intensive and therefore has an important role to play in reducing global emissions.

The first problem that needs to be addressed to reduce emissions in the defence sector is how they can be measured. Without measuring emissions, reduction targets cannot be proposed and the efforts being made to introduce decarbonisation initiatives cannot be quantified.

There is a lack of precise methodologies for calculating the emissions from military activities. Therefore, as the NATO Secretary General announced at the COP27 summit, it is necessary to create a system to measure – at least partially – the emissions of the armed forces within the alliance.

In line with the global ambition to achieve net zero emissions by 2050, the sector is expected to take decisive action on decarbonisation by investing in new green technologies.

42 https://www.iiss.org/research-paper//2022/02/green-defence
43 Ibid
44 Ibid

The decarbonisation of the defence sector poses major challenges as it must be compatible with the operational, reliability and safety priorities of equipment and systems. Armed forces using renewable energy are also likely to be much more costly to maintain in a net zero emissions world, thus requiring a larger share of national budgets.

In the future, the transition towards the use of renewable energy technologies in the armed forces opens up great opportunities for decarbonisation and the introduction of operational and security improvements. But there is a need for a strong R&D capability in the defence sector, both on the civilian and military side.

In the face of this uncertain future, defence departments could lead wider technological change across society by creating sufficient demand signals to stimulate innovation and enable the private sector to develop low-carbon, dual-use solutions.

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