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# Low-carbon warfare: climate change, net zero and military operations

DUNCAN DEPLEDGE\*

Defence has a carbon problem. The vast quantities of fossil fuels that are being burned in the name of national security are increasingly difficult to ignore. Calculating the exact contribution of the world's militaries to global climate emissions is exceedingly challenging, given the limited accounting and reporting to date. Still, it has been estimated that the total carbon emissions of the world's armed forces—their 'carbon footprint'—and the industries that equip them could contribute up to as much as 5 per cent of global carbon dioxide emissions.<sup>1</sup> This figure is broadly comparable to the combined total emissions from civil aviation and shipping, globally. In 2021, the International Military Council on Climate and Security acknowledged that defence is the 'largest single institutional consumer of hydrocarbons in the world'.<sup>2</sup>

In 2015, the international community agreed to limit the increase in global average temperature to 1.5°C above pre-industrial levels. For a reasonable chance of limiting warming to 1.5°C, global greenhouse gas (GHG) emissions need to reach 'net zero' by around mid-century.<sup>3</sup> Meeting these targets will require every sector, including the military, to reduce reliance on fossil fuels massively. In response, western defence ministries are beginning to accept that burning carbon to create 'firepower' is no longer sustainable if the international community's climate change commitments and net-zero targets are to be met and worst-case security scenarios avoided.<sup>4</sup> As NATO Secretary-General Jens Stoltenberg warned

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<sup>1</sup> Mohammad Ali Rajaeifar, Oliver Belcher, Stuart Parkinson, Benjamin Neimark, Doug Weir, Kirsti Ashworth, Reuben Larbi and Oliver Heidrich, 'Decarbonize the military—mandate emissions reporting', *Nature*, vol. 611, 2022, pp. 29–32.

<sup>2</sup> International Military Council on Climate and Security, *The World Climate and Security Report 2021*, <https://imccs.org/wp-content/uploads/2021/06/World-Climate-and-Security-Report-2021.pdf>, p. 5.

<sup>3</sup> IPCC, 'Summary for policymakers', in Valérie Masson-Delmotte, Panmao Zhai, Hans-Otto Pörtner, Debra C. Roberts, James Skea, Priyadarshi R. Shukla, Anna Pirani, Wilfran Moufouma-Okia, Clotilde Péan, Roz Pidcock, Sarah Connors, J. B. Robin Matthews, Yang Chen, Xiao Zhou, Melissa I. Gomis, Elisabeth Lonnoy, Tom Maycock, Melinda Tignor and Tim Waterfield, eds, *Global warming of 1.5°C: an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global GHG emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (Cambridge: Cambridge University Press, 2018).

<sup>4</sup> On the concept of 'firepower', as I use it here, see Simon Dalby, 'Firepower: geopolitics cultures in the Anthropocene', *Geopolitics* 23: 3, 2018, pp. 718–42; UK Ministry of Defence, *Climate change and sustainability strategic approach* (2021), [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_)

at the UN Climate Summit (COP26) in Glasgow last year: 'There is no way to reach net zero without also including emissions from the military.'<sup>5</sup> Seemingly convinced that militaries must decarbonize, Stoltenberg also told the conference:

We cannot choose between either green or strong armed forces, we need strong and green at the same time. But I'm absolutely confident that in the future, the most effective, the best planes, the best ships, the best military vehicles, they will be fuelled by something different than fossil fuels. They will not emit.<sup>6</sup>

Nor was Stoltenberg alone in his assessment. As early as 2019, the then UK Chief of the General Staff, General Sir Mark Carleton-Smith, suggested that the current generation of military equipment would be 'possibly the last to be dependent on fossil fuel engines'.<sup>7</sup> Such claims anticipate that the armed forces of the future will, as the UK's 2021 Integrated Operating Concept set out, 'be markedly less dependent on fossil fuels', with far-reaching implications for how militaries operate.<sup>8</sup>

The central argument of this article is that as the world turns away from fossil fuels, the implications for military operations warrant urgent consideration. As the article sets out, scholarship grappling with the changing and future character of war and warfare in the twenty-first century has yet to reckon with the military's excessive reliance on fossil fuels and the resultant carbon costs of warfare. Nor has it addressed the implications of growing pressure on militaries to decarbonize, how this might affect the character of military operations and what this 'low-carbon warfare' will mean in practice.

The term *low-carbon warfare*, as I use it here, is employed to accentuate the prospect of changes in how militaries operate, as governments increasingly factor carbon costs into military decision-making. As such, low-carbon warfare addresses a gap in the existing scholarship by expanding the conceptual terrain of the study of warfare to include a regard for the pressures that are building on armed forces to decarbonize, as well as what the implications might be for where, when, with whom, with what and for what ends those forces are deployed. Although not warfare in strictest sense, this also includes a regard for military operations short of war-fighting, including, for example, training and exercising, humanitarian

data/file/973707/20210326\_Climate\_Change\_Sust\_Strategy\_v1.pdf; Ministère des Armées, *Climate and Defence Strategy*, April 2022, <https://www.defense.gouv.fr/sites/default/files/ministere-armees/Presentation%20Climate%20ans%20defence%20strategy.pdf>; NATO, *Climate change and security impact assessment*, 2022, [https://www.nato.int/nato\\_static\\_fl2014/assets/pdf/2022/6/pdf/280622-climate-impact-assessment.pdf](https://www.nato.int/nato_static_fl2014/assets/pdf/2022/6/pdf/280622-climate-impact-assessment.pdf); Jacqueline Feldscher, 'Lawmakers ask Biden to make sure DOD follows climate rules', *DefenseOne*, 28 Jan. 2022, <https://www.defenseone.com/threats/2022/01/lawmakers-ask-biden-make-sure-dod-follows-climate-rules/361340/>.

<sup>5</sup> Mark John, 'NATO chief: armies must keep pace with global climate efforts', *Reuters*, 2 Nov. 2021, <https://www.reuters.com/business/environment/nato-chief-armies-must-keep-pace-with-global-climate-efforts-2021-11-02/>.

<sup>6</sup> NATO, 'Remarks by NATO Secretary General Jens Stoltenberg at the high-level roundtable "Climate, peace and stability: weathering risk through COP and beyond" in Glasgow, UK', 2 Nov. 2021, [https://www.nato.int/cps/en/natohq/opinions\\_188262.htm?selectedLocale=en](https://www.nato.int/cps/en/natohq/opinions_188262.htm?selectedLocale=en).

<sup>7</sup> Kim Sengupta, 'British army says it must get green to protect environment and maintain recruitment', *Independent*, 12 Sept. 2019, <https://www.independent.co.uk/climate-change/news/dsei-british-army-green-environment-climate-change-mark-carleton-smith-a9103096.html>.

<sup>8</sup> UK Ministry of Defence, *Integrated operating concept*, 1st edn, 2021, [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/1014659/Integrated\\_Operating\\_Concept\\_2025.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1014659/Integrated_Operating_Concept_2025.pdf).

assistance and disaster relief, military aid to civil authority, and tackling illicit activity (smuggling, trafficking, poaching, illegal fishing, etc.).

At this point I should enter some caveats. So long as war remains materially destructive, engaging in warfare will continue to carry a high carbon—and environmental—price, especially if the fighting becomes drawn out, and/or existential for one or both sides.<sup>9</sup> This much has been made plain in Ukraine following Russia's attempt at a full-scale invasion in 2022.<sup>10</sup> Low-carbon warfare, then, is not (yet) about the total decarbonization of warfare, or indeed of war. Nor should a concern for low-carbon warfare be confused with a normative impulse to 'green' defence or rein in the use of military force. Although such sentiments will continue to form a vital part of debates regarding the climatic and environmental consequences of militarism and war, low-carbon warfare is primarily about how scholars and practitioners contend with the challenges and opportunities that will arise as militaries grapple with the question of how to retain operational capability in a net-zero—or carbon-constrained—world. Whether this leads to greater restraint around the use of war as an instrument of policy, a radical reconfiguration of the military apparatus and/or a transformation of prevailing geopolitical cultures remains to be seen.<sup>11</sup>

The remainder of this article is arranged as follows. The first section situates contemporary military thinking about carbon within the existing scholarship on the military implications of environmental change. It also makes an important distinction between normative efforts to 'green' the armed forces and emerging imperatives to decarbonize military operations, which reflect the growing intensity of the climate emergency. The second section draws attention to key political, economic and societal trends that are driving a resurgence of defence interest in 'low-carbon warfare' and why military transformation is becoming easier to imagine. The third section demonstrates how the conceptual terrain of the study of military operations, war and warfare can be—indeed, needs to be—expanded to include a regard for the global energy transition and mounting pressures to decarbonize defence. The fourth section advances a tentative research agenda for scholars wanting to grapple with the opportunities and challenges of low-carbon warfare.

## **From greening defence to decarbonizing military operations**

It is broadly acknowledged that the climate emergency has implications for national and international security. However, among western allies these concerns have primarily been expressed through the prism of 'climate security': the idea that climate change will lead to, or at the very least exacerbate existing levels

<sup>9</sup> Eoghan Darbyshire, *How does war contribute to climate change?*, Conflict and Environment Observatory, 14 June 2021, <https://ceobs.org/how-does-war-contribute-to-climate-change/>.

<sup>10</sup> Eoghan Darbyshire and Doug Weir, *Ukraine invasion: rapid overview of environmental issues*, Conflict and Environment Observatory, 25 Feb. 2022, <https://ceobs.org/ukraine-invasion-rapid-overview-of-environmental-issues/>.

<sup>11</sup> Dalby, 'Firepower'; Neta C. Crawford, *The Pentagon, climate change, and war: changing the rise and fall of US military emissions* (Cambridge: The MIT Press, 2022); Oliver Belcher, Patrick Bigger, Ben Neimark and Cara Kennelly, 'Hidden carbon costs of the "everywhere war": logistics, geopolitical ecology, and the carbon boot-print of the US military', *Transactions of the Institute of British Geographers* 45: 1, 2019, pp. 65–80.

of, instability, insecurity and violent conflict around the world.<sup>12</sup> Such thinking corresponds with earlier attempts, originating in the 1960s and 1970s, to reconceptualize environmental degradation as a threat to security.<sup>13</sup> Since the 2000s, the impact of climate change on military operating environments, and the subsequent requirement for militaries to adapt their operations, has garnered interest as well.<sup>14</sup>

While environment–conflict linkages and changing mission requirements have arguably attracted the most interest, the ‘environmental footprint’ of military activity has also received scholarly attention. Alongside the obvious environmentally destructive effects of war-fighting, such scholarship has highlighted the damaging ‘peacetime’ impacts that armed forces have had on the environment, both within and beyond areas of national jurisdiction.<sup>15</sup> The implications of environmental legislation for armed forces have been discussed too, even though militaries have tended to be exempt from key provisions on national security grounds.<sup>16</sup> All this nevertheless contributed to early calls to ‘green’ the military during and after the Cold War, while also prompting a backlash from scholars critical of the idea that militaries should address environmental challenges.<sup>17</sup> Still, the idea of ‘greening defence’ continued to gain traction: for instance, in the late 1980s and early 1990s, the US Department of Defense (DOD) was progressively engaged in addressing a range of environmental challenges, from research into non-ozone-depleting substances, to the clean-up of contaminated former Soviet bases in east and central Europe, to a more general concern for environmental safeguards wherever the US military might be operating.<sup>18</sup> In 1993, the first Deputy Undersecretary for Defense for environmental security, Sherri Goodman, was charged with ‘incorporating environmental awareness into every aspect of the Defense mission’.<sup>19</sup>

Concern for the environment eventually extended to include defence’s GHG emissions, or ‘carbon footprint’. Notably, the question of military emissions was raised during the negotiation of the 1997 Kyoto Protocol.<sup>20</sup> Although the United States failed to secure a blanket exemption for all military emissions, those emissions resulting from UN-authorized multilateral operations, international aviation

<sup>12</sup> Joshua Busby, *States and nature: the effects of climate change on security* (Cambridge: Cambridge University Press, 2022).

<sup>13</sup> Richard Falk, *This endangered planet* (New York: Random House, 1971).

<sup>14</sup> CNA Corporation, ‘National security and the threat of climate change’, 2007, [https://www.cna.org/archive/CNA\\_Files/pdf/national%20security%20and%20the%20threat%20of%20climate%20change.pdf](https://www.cna.org/archive/CNA_Files/pdf/national%20security%20and%20the%20threat%20of%20climate%20change.pdf); Michael T. Klare, *All hell breaking loose: the Pentagon’s perspective on climate change* (New York: Metropolitan Books, 2019); Kate Cox, Anna Knack, Martin Robson, Neil Adger, Pauline Paillé, Jon Freeman, James Black and Ruth Harris, *A changing climate: exploring the implications of climate change for UK defence and security* (RAND Europe and University of Exeter, 2020), [https://www.rand.org/content/dam/rand/pubs/research\\_reports/RR400/RR400i487-1/RAND\\_RRA487-1.pdf](https://www.rand.org/content/dam/rand/pubs/research_reports/RR400/RR400i487-1/RAND_RRA487-1.pdf).

<sup>15</sup> Arthur Westing, ‘The impact of war on the environment’, in Barry S. Levy and Victor W. Sidel, eds, *War and public health*, 2nd edn (Oxford: Oxford University Press, 2008), pp. 69–84.

<sup>16</sup> Sarah E. Light, ‘The military–environmental complex’, *Boston College Law Review* 55: 3, 2014, pp. 879–946.

<sup>17</sup> Daniel Deudney, ‘The case against linking environmental degradation and national security’, *Millennium: Journal of International Studies* 19: 3, 1990, pp. 461–76.

<sup>18</sup> Sherri Goodman and William Center, *Military capabilities and possible missions related to environmental security*, Environmental Change and Security Project Report no. 2 (Washington DC: Woodrow Wilson Center, 1996), pp. 98–101.

<sup>19</sup> Goodman and Center, *Military capabilities and possible missions*, p. 98.

<sup>20</sup> Axel Michaelowa and Tobias Koch, ‘Military emissions, armed conflicts, border changes and the Kyoto Protocol’, *Climatic Change*, vol. 50, 2001, pp. 383–94.

or the use of marine bunker fuels were excluded from national emissions inventories.<sup>21</sup> Nevertheless, the 2000s saw western defence ministries coming under increasing pressure to cut emissions, especially from domestic facilities and non-tactical vehicle fleets.<sup>22</sup> The UK offers an illustrative case in this regard: even before the signing of the 2008 Climate Change Act (the first legislation anywhere in the world to set binding emissions targets), it was becoming clear that the Ministry of Defence was expected to support the UK's agenda on sustainable development and climate change mitigation.<sup>23</sup> Such behaviour suggested a continuation of post-Cold War willingness among western governments to try to reduce the environmental footprint of 'defence' and ameliorate some of the Cold War's most harmful environmental legacies—but only so long as this 'greening' did not impinge on the effectiveness of military operations.<sup>24</sup> However, scepticism that 'greening' could be anything other than a constraint on military effectiveness may well have discouraged any serious consideration by scholars in this period of whether initiatives to reduce environmental—or carbon—footprints would ultimately be transformational in terms of the overall character of military operations.

For western governments, it was the energy demands of the campaigns in Afghanistan and Iraq, combined with rising oil prices, that arguably brought the cost of fossil-fuelled militaries into sharper focus.<sup>25</sup> While western-led forces faced a general problem regarding the security of supply lines, more specifically there was mounting alarm at the number of casualties being suffered by units protecting fuel convoys.<sup>26</sup> As well as the human losses, the vulnerability of these convoys was adding to the 'hidden costs' of transport and force protection, which could be some 15 times higher than the actual purchase cost of the fuel.<sup>27</sup> All this unfolded against a backdrop of record high energy prices, which further increased the pressure on NATO and other coalition forces to reduce their energy consumption.<sup>28</sup> This resulted in a marked drive among western militaries to improve energy efficiency further, as well as the development of new initiatives that would explore and experiment with alternatives to fossil-fuelled forces.<sup>29</sup>

<sup>21</sup> Michaelowa and Koch, 'Military emissions, armed conflicts'.

<sup>22</sup> Stacy Closson, 'The military and energy: moving the United States beyond oil', *Energy Policy*, vol. 61, 2013, pp. 306–16; Daniel Fiott, 'Reducing the environmental footprint? Competition and regulation in the greening of Europe's defense sector', *Organization and Environment* 27: 3, 2014, pp. 263–78.

<sup>23</sup> UK Ministry of Defence, *Defence plan including the government's expenditure plans, 2008–2012*, June 2008, [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/27165/defence\\_plan\\_2008.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/27165/defence_plan_2008.pdf). For further discussion, see Clive Murgatroyd, 'Defence in a changed climate', *RUSI Journal* 153: 5, 2008, pp. 28–33.

<sup>24</sup> Rita Floyd, 'The environmental security debate and its significance for climate change', *International Spectator* 43: 3, 2008, pp. 51–65.

<sup>25</sup> Closson, 'The military and energy'; Fiott, 'Reducing the environmental footprint?'.

<sup>26</sup> Closson, 'The military and energy'; Fiott, 'Reducing the environmental footprint?'.

<sup>27</sup> On the costs of fuel, see Deloitte, *Energy security: America's best defense*, 2009, [https://www.offiziere.ch/wp-content/uploads/us\\_ad\\_EnergySecurity052010.pdf](https://www.offiziere.ch/wp-content/uploads/us_ad_EnergySecurity052010.pdf); on casualties, see Steven M. Anderson, 'Save energy, save our troops', *New York Times*, 12 Jan. 2011, <https://www.nytimes.com/2011/01/13/opinion/13anderson.html>.

<sup>28</sup> Constantine Samaras, William J. Nuttall and Morgan Bazilian, 'Energy and the military: Convergence of security, economic, and environmental decision-making', *Energy Strategy Reviews*, vol. 26, 2019, <https://www.sciencedirect.com/science/article/pii/S2211467X19301026>.

<sup>29</sup> Katarina Kertysova, 'Towards a greener alliance: NATO's energy efficiency and mitigation efforts', in Louise van Schaik, Pierre Laboué, Katarina Kertysova, Akash Ramnath and Douwe van der Meer, eds, *The world*



The West's initial efforts to drive down military consumption of fossil fuels during operations were striking in at least two respects. The first is that they were framed primarily in terms of an operational imperative to save lives and improve the mobility and endurance of military forces.<sup>30</sup> Even amid growing international attention to the climate crisis, GHG emissions were of secondary concern, if indeed they were mentioned at all. For instance, the DOD's 2011 Operational Energy Strategy, despite emphasizing the operational and financial benefits of decarbonization, did not explicitly refer to climate change.<sup>31</sup> Similarly, the UK Ministry of Defence's 2011 Sustainable Development Strategy tied its objective of reducing the armed forces' reliance on fossil fuels in the provision of operational energy to mitigating operational and financial risks.<sup>32</sup> A separate objective to reduce GHG emissions significantly only addressed the defence estate and non-tactical vehicle fleets.<sup>33</sup>

A second striking feature of these early efforts to address military fossil-fuel consumption was that, despite the concerns that had emerged around fuel use in Afghanistan and Iraq, much of the focus remained on addressing so-called 'installation energy', typically comprising the built estate, fixed installations and non-tactical vehicles.<sup>34</sup> The 'operational energy' used in military operations up to and including war-fighting—which has been estimated to account for more than half of the military emissions produced in the UK, EU and US<sup>35</sup>—proved harder to address, not least because of the lead times required to design, procure and test alternatives to fossil-fuelled forces. However, the lack of focus on these activities also seemed to reflect a continuation of the long-held view that forcing militaries to decarbonize their operations would be detrimental to national security. Other factors may also have contributed, including the weakening of operational and economic imperatives to move away from fossil fuels as western forces were withdrawn from Iraq and Afghanistan, and later, the sharp drop in global oil prices in 2014.<sup>36</sup> Within NATO, progress towards bringing together initiatives to reduce fuel consumption in a 'Green Defence Framework' reportedly stalled following Russia's annexation of Crimea as the alliance sought to shore up its conventional defences in the Euro-Atlantic area.<sup>37</sup> Consequently, despite some notable initiatives and targets to decarbonize military operations in the early 2010s, the United States and its allies remained firmly tethered to fossil fuels.

*climate and security report 2022: decarbonized defense—combating climate change and increasingly operational effectiveness with clean military power, the need for clean military power in the age of climate change* (Washington DC: Council on Strategic Risks, 2022), pp. 24–31.

<sup>30</sup> Crawford, *The Pentagon, climate change, and war*.

<sup>31</sup> US DOD, *Energy for the warfighter: operational energy strategy*, 2011, <https://www.acq.osd.mil/eie/Downloads/OE/Operational%20Energy%20Strategy.%20Jun%2011.pdf>.

<sup>32</sup> UK Ministry of Defence, *Sustainable development strategy*, 2011, [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/27615/20110527SDStrategyPUBLISHED.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/27615/20110527SDStrategyPUBLISHED.pdf).

<sup>33</sup> UK Ministry of Defence, *Sustainable development strategy*, 2011.

<sup>34</sup> Closson, 'The military and energy'.

<sup>35</sup> For US figures, see Crawford, *The Pentagon, climate change, and war*; for combined UK and EU figures, see Stuart Parkinson and Linsey Cottrell, *Under the radar: the carbon footprint of Europe's military sectors: a scoping study*, Conflict and Environment Observatory, 2021, [https://ceobs.org/wp-content/uploads/2021/02/Under-the-radar\\_the-carbon-footprint-of-the-EUs-military-sectors.pdf](https://ceobs.org/wp-content/uploads/2021/02/Under-the-radar_the-carbon-footprint-of-the-EUs-military-sectors.pdf).

<sup>36</sup> Belcher et al., 'Hidden carbon costs'.

<sup>37</sup> Michael Ruehle, *Scoping NATO's environmental security agenda*, NDC policy brief, no. 06-20, 6 April 2020, <https://www.ndc.nato.int/news/news.php?icode=1426>.

## Anticipating low-carbon warfare

The initial wave of western interest in decarbonizing military operations was relatively short-lived and appeared to have limited impact in terms of how scholars and practitioners viewed the future character of military operations. Despite the concerns raised around energy use in Iraq and Afghanistan, it remained an open question whether militaries could, as Stacy Closson asked, ‘move beyond oil in a significant way’.<sup>38</sup> Crucially, in terms of looking to the future, what had been revealed by the campaigns in Afghanistan and Iraq was that militaries could be persuaded to decarbonize if it was in their self-interest to do so. However, much of the early momentum towards decarbonizing military operations was lost as the operational and economic imperatives shifted. While interest in ‘greening’ defence did not dissipate entirely, the carbon cost of military operations remained largely unaddressed.

So what changed? How is it that low-carbon warfare—and the transformation of military operations that it would entail—now seems more imaginable? What new imperatives have emerged? To answer these questions, we need to start with the Paris Agreement signed by 195 nations on 12 December 2015. To summarize briefly, the agreement committed signatories to pursuing efforts to limit the average rise in global temperature to 1.5°C above pre-industrial levels, and for the first time required all countries to set ambitious emissions-reduction pledges that would be further strengthened over time.<sup>39</sup> Crucially, military emissions were no longer automatically exempt, although reporting would be voluntary.<sup>40</sup> Three years later, the UN’s Intergovernmental Panel on Climate Change (IPCC) concluded that global GHG emissions must reach net-zero by around mid-century if the world is to have a reasonable chance of limiting average warming to 1.5°C.<sup>41</sup> In short, a commitment to limit average global warming to 1.5°C, which the international community reaffirmed in Glasgow in 2021, also meant committing to a low-carbon future.<sup>42</sup>

The tightening of international commitments has had several important consequences. According to Net Zero Tracker, at the time of writing some 88 per cent of GHG emissions, 90 per cent of GDP and 85 per cent of the population globally are now covered by net-zero commitments.<sup>43</sup> Within the transatlantic community, international targets have started to translate into national- and regional-level commitments. In 2019, the UK became the first country to write its net-zero commitment into law. Canada, Denmark, France, Hungary and Sweden have since followed suit. So has the EU. Although the measure is somewhat weaker than congressional legislation, in December 2021 President Joe Biden signed an executive order committing the US federal government to reach carbon neutrality

<sup>38</sup> Closson, ‘The military and energy’, p. 306.

<sup>39</sup> UN, Paris Agreement, 2015, [https://unfccc.int/sites/default/files/english\\_paris\\_agreement.pdf](https://unfccc.int/sites/default/files/english_paris_agreement.pdf).

<sup>40</sup> Parkinson and Cottrell, *Under the radar*.

<sup>41</sup> IPCC, ‘Summary for policymakers’.

<sup>42</sup> UNFCCC, ‘Glasgow climate pact’, 2021, [https://unfccc.int/sites/default/files/resource/cop26\\_auv\\_2f\\_cover\\_decision.pdf](https://unfccc.int/sites/default/files/resource/cop26_auv_2f_cover_decision.pdf).

<sup>43</sup> Net Zero Tracker, *Post-COP26 snapshot*, 28 Oct. 2022, <https://zerotracker.net/analysis/post-cop26-snapshot/>.



by 2050. China has committed itself to reaching net zero by 2060, while India has set a target of 2070.

The international community's targets are also having impacts on the commercial sector. In 2022, McKinsey & Co. reported that more than 5,000 companies have set their own net-zero goals as part of the UN Race to Net Zero Campaign.<sup>44</sup> On top of this, new emissions standards are being set for individual sectors: for instance, across most of Europe, all new cars will need to be zero emission from 2035. Trade bodies such as the International Air Transport Association (IATA), which covers around 82 per cent of global air traffic, are committing their members to achieve net zero by 2050. Pressure is growing on the global shipping industry to do the same.<sup>45</sup>

Although public opinion is difficult to assess, a major survey conducted by the United Nations Development Programme (UNDP) and the University of Oxford in 2021 suggested that all this government and private-sector action has broad support around the world, with approximately two-thirds of under-60s reporting that they view climate change as an emergency.<sup>46</sup> The survey also found strong support across western Europe and North America for more renewable energy (68 per cent) and more investment in green business and jobs (61 per cent).<sup>47</sup> In sum, across governments, the private sector and the wider public, especially in the West, there are good reasons to anticipate that one way or another the future will be low-carbon, even if there are still serious questions to be answered about how rapidly decarbonization can be achieved.<sup>48</sup>

What western defence officials presently appear most concerned about is whether militaries can afford to be left behind if the rest of the world continues to decarbonize.<sup>49</sup> Two issues stand out: the first is economic/technological, while the second is societal/political. To start with the economic/technological, demand for fossil-fuelled technologies, investment in research and development, the availability of supporting infrastructure and the associated skills base are likely to decrease because of the global transition to net zero. This means that, over time, carbon-burning technologies could become increasingly challenging to develop, more costly to fuel and harder to crew, especially if the defence industrial base is decarbonizing as well. Put simply, a military structured primarily around fossil-

<sup>44</sup> McKinsey & Co., *The net-zero transition: what it would cost, what it could bring*, 2022, <https://www.mckinsey.com/business-functions/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring#>.

<sup>45</sup> Ship & Bunker, *Net zero shipping emissions by 2050 target rejected by IMO member states*, 25 Nov. 2021, <https://shipandbunker.com/news/world/819452-net-zero-shipping-emissions-by-2050-target-rejected-by-imo-member-states>.

<sup>46</sup> Over half (58%) of those aged over 60 also agreed that climate change was an emergency. See Cassie Flynn, Eri Yamasumi, Stephen Fisher, Dan Snow, Zack Grant, Martha Kirby, Peter Browning, Moritz Rommerskirchen and Inigo Russell, *The peoples' climate vote* (UNDP and University of Oxford, 2021), <https://www.undp.org/publications/peoples-climate-vote>.

<sup>47</sup> Flynn et al., *The peoples' climate vote*.

<sup>48</sup> International Energy Agency, *World energy outlook 2022*, <https://www.iea.org/reports/world-energy-outlook-2022>; UN Climate Change, *Climate plans remain insufficient: more ambitious action needed now*, 26 Oct. 2022, <https://unfccc.int/news/climate-plans-remain-insufficient-more-ambitious-action-needed-now>.

<sup>49</sup> See Charlotte Owen-Burge, 'MOD climate chief: inaction will lead to a "more expensive, weaker military"', *Race to Zero*, 25 May 2021, <https://racetozero.unfccc.int/mod-climate-chief-inaction-will-lead-to-a-more-expensive-weaker-military/>; NATO, 'Remarks by NATO Secretary General'.

fuelled forces is likely to be much more expensive to maintain in a net-zero world, requiring a larger share of national resources.

Concerns have also been raised that public expectation is now such that governments, defence ministries and armed forces risk mounting reputational damage if they are not seen to be taking action to address emissions: indeed, they face being seen as a climate pariahs by the very societies they are supposed to serve. This is especially evident in the UK, but it is striking that in the US the DOD has been keen to stress that it does not want to be seen as exempt from the Biden administration's federal government net-zero emission targets.<sup>50</sup> Parts of the defence industry have expressed similar concerns about reputation, especially in Europe, where failure to progress towards decarbonization could affect the sector's ability to gain future investment.<sup>51</sup> General Richard Nugee, the main architect behind the UK Ministry of Defence's 2021 Climate Change and Sustainability Strategy, has warned that the implications could be severe in terms of public support for the military, and perhaps even recruitment if future generations are unwilling to serve in a high-carbon sector.<sup>52</sup> Embracing low-carbon warfare may be the only way to respond.

The prospect of a transition towards low-carbon warfare is not only a preoccupation of western militaries. While detailed information is difficult to obtain, observers have speculated for some time that the Chinese military has also faced pressure to cut GHG emissions and improve energy efficiency.<sup>53</sup> This seemed to be confirmed by the Chinese Ministry of Defence as recently as June 2022, when it shared news that the People's Liberation Army was 'resolutely following President Xi's instructions' to take 'faster steps to build a secure, efficient and sustainable modern military energy system evidenced by strongly promoting the use of new energies such as solar power, wind power, ocean energy, and hydrogen energy for military purposes'.<sup>54</sup> Similarly to the UK and the US, these efforts are now being framed as supporting Beijing's efforts to meet China's national emissions and net-zero targets. India, another of the world's top defence spenders, has also been exploring ways to reduce military carbon emissions. Indeed, experts argue that 'climate mainstreaming' is gaining momentum within the Indian military, and strengthening the argument for the armed forces to contribute more to national climate change mitigation efforts.<sup>55</sup>

<sup>50</sup> UK Ministry of Defence, *Climate change and sustainability strategic approach*; Feldscher, 'Lawmakers ask Biden to make sure DOD follows climate rules'.

<sup>51</sup> Sylvia Pfeifer, 'Rise of ESG adds to pressure on European defence companies', *Financial Times*, 1 Dec. 2021, <https://www.ft.com/content/e14ea515-a6f3-4763-9def-7bc40d3b2e4a>. See also Karen Bell, Vivian Price, Keith McLoughlin, Mijin Cha, Lara Skinner, Karen Simpson, Rosie Jones, Anita Raman and Zach Cunningham, *Decarbonising and diversifying defence in the United Kingdom and the United States: a workers' enquiry for a just transition*, British Academy, 2022, <https://www.thebritishacademy.ac.uk/documents/4197/Just-transitions-decarbonising-diversifying-defence-uk-usa.pdf>.

<sup>52</sup> Owen-Burge, 'MOD climate chief'.

<sup>53</sup> Michael Brzoska, 'Climate change and the military in China, Russia, the United Kingdom, and the United States', *Bulletin of the Atomic Scientists* 68: 2, 2012, pp. 43–54.

<sup>54</sup> Ministry of National Defense of the People's Republic of China, *PLA expedites construction of new military energy support system*, 7 June 2022, [http://eng.mod.gov.cn/news/2022-06/07/content\\_4912468.htm](http://eng.mod.gov.cn/news/2022-06/07/content_4912468.htm).

<sup>55</sup> Dhanasree Jayaram, '"Climatizing" military strategy? A case study of the Indian armed forces', *International Politics*, vol. 58, 2021, pp. 619–39.

While it is important not to overstate the rhetoric—or confuse it with concrete action—it is nevertheless notable that four of the world's biggest defence spenders, along with NATO and the EU at a regional level, have all recently tied their interest in military decarbonization to climate change and net-zero goals. All this suggests that western defence ministries, along with the defence industry, are coming to recognize a new imperative for decarbonization, acknowledging that the unfolding global transition towards a low-carbon future has left militaries exposed. More than that, the climate crisis is having adverse impacts on a wide range of other national security and defence concerns. Militaries are being forced to adapt accordingly, but the risks involved would be reduced if militaries addressed their own GHG emissions as well.<sup>56</sup> Thus, whereas in the past decarbonization has been seen as a goal that must be balanced against the need to maintain operational effectiveness, in the years ahead, operational effectiveness may well come to depend on decarbonization. Scholars need to catch up with this important shift.

### Low-carbon warfare and the future character of military operations

Scholarship on war and warfare in the twenty-first century has yet to come to terms with the implications of the climate crisis and the unfolding energy transition for the future character of military operations. For instance, notable recent works such as Major-General Mick Ryan's *War transformed: the future of twenty-first century great power competition and conflict*, and Rob Johnson, Martijn Kitzen and Tim Sweij's edited collection on *The conduct of war in the 21st century*, despite anticipating an era of rapid technological change ahead, appear to have little to say about how militaries will contend with the challenge of reducing their reliance on fossil fuels, or what the implications of that could be.<sup>57</sup> Nor were these issues much discussed in the 2019 special issue of this journal on 'Re-visioning war and the state in the twenty-first century'.<sup>58</sup> Conceptualizing recent developments through the lens of 'low-carbon warfare' offers a useful way of addressing this absence. The key point, of course, is not to suggest that decarbonization will be the defining feature of future military operations, warfare or war. Rather, to reiterate, the argument here is that the term 'low-carbon warfare' expands the conceptual terrain of the study of war and warfare to include a regard for the implications of decarbonization. This conceptual expansion is essential if scholars are to remain relevant to emerging policy debates about how militaries should respond to the climate crisis, the global energy transition and growing pressures to decarbonize defence.

At present, much of the discussion around military decarbonization has been driven by a handful of scholars, generally writing from outside the mainstream of work addressing the changing character of war. This includes notable research

<sup>56</sup> Crawford, *The Pentagon, climate change, and war*.

<sup>57</sup> Mick Ryan, *War transformed: the future of twenty-first century great power competition and conflict* (Annapolis, MD: Naval Institute Press, 2022); Rob Johnson, Martijn Kitzen and Tim Sweij, eds, *The conduct of war in the 21st century* (Abingdon: Routledge, 2021).

<sup>58</sup> See the collection of essays forming the special issue on the theme 'Re-visioning war and the state in the twenty-first century', *International Affairs* 95: 4, 2019.

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on the prospects for military decarbonization,<sup>59</sup> and more recently, on the scale of the military emissions problem.<sup>60</sup> Despite the importance of this work, up to now there has been very little consideration of the implications of ‘low-carbon warfare’ for where, when, with whom, with what, and to what ends armed force is deployed. Indeed, the scepticism described earlier about the ability of militaries—and especially the world’s largest militaries, most notably the US—to decarbonize remains engrained in much of the literature, leading several scholars to conclude that the only real solution is massively to reduce the scale of military operations.<sup>61</sup> For these scholars, decarbonization points to the reduction rather than the transformation of military power. As a result, it is perhaps unsurprising that their interventions have up to now have apparently had little impact on scholarly debates about the changing character of war.<sup>62</sup>

Evidently, expanding the scholarly debate to incorporate the prospect of low-carbon warfare remains a challenging task, but it does not necessarily require a radically different approach. Indeed, from a western perspective at least, emerging interest in low-carbon warfare dovetails with a longstanding preoccupation with trying (despite often failing) to conduct the business of war through a combination of self-restraint, risk transference and a reliance on technological ‘fixes’, all girded by a persistent belief in the utility of force to as a means to securing political ends.<sup>63</sup> Such thinking was on display in the post-1945 period during which, despite the looming threat of interstate nuclear war in Europe, most of the actual fighting involving NATO allies and the Soviet Union occurred through indirect confrontation with irregular, insurgent and proxy forces in the peripheries of Euro-Atlantic–Soviet space. However, these ‘small wars’ generated pressures of their own on western societies, leading publics to ask why so many lives and resources were being expended in faraway places that posed no existential threat. Governments were increasingly challenged not only to justify these ‘wars of choice’, but also to minimize the costs borne by the societies they served, whether those costs were exacted in terms of ‘blood’ (referring to casualties, both military and civilian) or ‘treasure’ (referring to economic expenditure).<sup>64</sup> Efforts to curb the human costs of war were also being pursued through the creation of a

<sup>59</sup> Closson, ‘The military and energy’; Fiott, ‘Reducing the environmental footprint?’.

<sup>60</sup> Crawford, *The Pentagon, climate change, and war*; Belcher et al., ‘Hidden carbon costs’.

<sup>61</sup> Crawford, *The Pentagon, climate change, and war*; Belcher et al., ‘Hidden carbon costs’.

<sup>62</sup> Although, notably, in recent years several think-tanks and NGOs have started to grapple with this challenge. See e.g. Ben Barry, Shiloh Fetzek and Caroline Emmett, *Green defence: the defence and military implications of climate change for Europe*, International Institute for Strategic Studies, 2022, <https://www.iiss.org/blogs/research-paper/2022/02/green-defence>; Louise van Schaik, Dick Zandee, Tobias von Lossow, Brigitte Dekker, Zola van der Maas and Ahmad Halima, *Ready for take-off: military responses to climate change*, Clingendael Institute, 2020, [https://www.clingendael.org/sites/default/files/2020-03/Report\\_Military\\_Responses\\_to\\_Climate\\_Change\\_March\\_2020.pdf](https://www.clingendael.org/sites/default/files/2020-03/Report_Military_Responses_to_Climate_Change_March_2020.pdf). See also the Royal United Services Institute (RUSI)’s Greening Defence programme: <https://rusi.org/explore-our-research/projects/greening-defence>; Chatham House’s Environment and Society Programme: <https://www.chathamhouse.org/about-us/our-departments/environment-and-society-programme>.

<sup>63</sup> Martin Shaw, *The new western way of war* (Cambridge: Polity, 2005); Christopher Coker, *War in an age of risk* (Cambridge: Polity, 2009); Rupert Smith, *The utility of force: the art of war in the modern world* (London: Penguin, 2019); Warren Chin, ‘Technology, war and the state: past, present and future’, *International Affairs* 95: 4, 2019, pp. 765–83.

<sup>64</sup> Smith, *The utility of force*; Shaw, *The western way of war*.

new body of international law (such as the 1949 Geneva Conventions). This added further weight to the western ideal that military force needed to be—indeed, should be—wielded in a more restrained, if not lawful, manner. These trends became even more pronounced after the Cold War as the threat of existential interstate war receded, and the costs of the West's 'wars of choice' were brought to the fore.

The broader point to make here, though, is that, as scholars of war have long acknowledged, societal changes influence the ways in which militaries organize, equip, train, fight and ultimately go to war.<sup>65</sup> Moreover, as scholars such as General Sir Rupert Smith and Christopher Coker have observed, the costs which societies are prepared to bear have also changed over time, usually depending on the nature of the threats they face and their readiness to use military force in response.<sup>66</sup> And as Thomas Waldman has pointed out, no society has ever completely subordinated social life to the demands of raising and using armed force precisely because 'war is mostly unproductive, consumes precious resources, and diverts the labour force away from production and other tasks essential to human livelihoods'.<sup>67</sup> In other words, war is generally unsustainable and societies will always have to make difficult choices about what—and how much—they are willing to sacrifice to remain in the fight. Traditionally these sacrifices have been measured in terms of blood and treasure. However, as recognition of the costs of burning fossil fuels has grown, the interest of government and military elites in the prospect of decarbonizing armed forces suggests that the carbon costs of military operations—and ultimately of war—are already starting to weigh more heavily. Scholarship has been slow to recognize the significance of this development and its potential implications. Conceptually, low-carbon warfare remedies this gap by expanding the terrain of existing debates around restraint beyond questions of blood and treasure to include also consideration of the carbon costs of military operations, and whether, amid a deepening climate crisis, this will demand even more restraint in the future.

Of course, the West's preoccupation with restraint has not been unproblematic. Nor is it the only aspect of military operations to which low-carbon warfare is related. As Stephanie Carvin has observed, one of the difficulties with restraint is the paradox that it creates for military planners, by creating duelling imperatives to win at all costs, but to do so in way that is consistent with liberal values.<sup>68</sup> According to Carvin, the United States (and arguably western militaries more generally) has been trying to solve this problem for decades using technology.<sup>69</sup> Indeed, Warren Chin has described the West's pursuit and exploitation of technological innovation and, ultimately, superiority as a 'vital agent of change' in how it has approached the business of war since 1945.<sup>70</sup> For instance, the advent of new precision-strike

<sup>65</sup> Smith, *The utility of force*; Johnson et al., eds, *The conduct of war in the 21st century*; Thomas Waldman, *Vicarious warfare* (Bristol: Bristol University Press, 2021).

<sup>66</sup> Smith, *The utility of force*. See also Coker, *War in an age of risk*.

<sup>67</sup> Waldman, *Vicarious warfare*, p. 30.

<sup>68</sup> Stephanie Carvin, 'How not to war', *International Affairs* 98: 5, 2022, pp. 1695–716.

<sup>69</sup> Carvin, 'How not to war'.

<sup>70</sup> Chin, 'Technology, war and the state', p. 766.

capabilities which came to prominence in the 1990s seemed to promise a mode of warfare that would be 'a precise, clinical, spatially and temporally *discrete* affair without fundamental ramifications for society and politics'.<sup>71</sup> At the very least, the ability to engage in war from a distance seemed to minimize the need to put large numbers of soldiers and materiel in harm's way. Such thinking eventually unravelled in Afghanistan and Iraq as what were initially intended to be short, sharp military interventions became quagmires that resulted in a far greater commitment of 'boots on the ground' to try to contain the insurgency and terrorism that followed. Other critics of what is perceived to be a kind of technological fetishism include David Kilcullen, who has argued that the limits of high-end and remote warfare have been exposed.<sup>72</sup> Tim Sweijts, Rob Johnson and Martijn Kitzen similarly suggest that western military superiority is fading as power dissipates across an increasingly multipolar international system and states lose their monopoly on violence. As a result, 'the Davids of this world [now] stand a better chance against the Goliaths'.<sup>73</sup> This, General Mick Ryan has argued, has contributed to a discounting of human ingenuity and organization as a decisive factor in the outcome of wars.<sup>74</sup> Others question whether the West can even afford to maintain its technological superiority, as innovation produces ever more exquisite, but also ever more expensive capabilities, which outstrip the resources available for defence.<sup>75</sup> Smith makes the point that a technologically advanced force may be rendered irrelevant if political leaders and societies more broadly are unwilling to carry the political, financial, moral, legal or indeed the environmental costs of employing it.<sup>76</sup>

Conceptually, low-carbon warfare extends in important ways this debate about the role and relative importance of technological superiority to military operations. Indeed, there are many who persist in presuming that military decarbonization demands a trade-off between operational effectiveness and reduced emissions. This strong proclivity for fossil-fuelled forces can be read as another instance of technological determinism, or, put differently, as a conviction that fossil-fuelled forces are and will always be superior and must therefore be retained at all costs. Proponents of low-carbon warfare, on the other hand, point to decarbonization as an opportunity not only to sever military dependence on fossil fuels for operational as well as strategic advantage, but to also support action to mitigate the climate crisis, reduce costs and shore up the armed forces' 'green' credentials within the societies that they serve.<sup>77</sup>

Irrespective of who turns out to be correct, the crucial point is this: pressure to decarbonize military forces is not occurring in isolation, nor should it be

<sup>71</sup> Shaw, *The new western way of war*, p. 2.

<sup>72</sup> David Kilcullen, *The dragons and the snakes: how the rest learned to fight the West* (London: Hurst, 2020).

<sup>73</sup> Tim Sweijts, Rob Johnson and Martijn Kitzen, 'Conclusion: assessing change and continuity in the character of war', in Johnson et al., eds, *The conduct of war in the 21st century*, p. 3.

<sup>74</sup> Ryan, *War transformed*.

<sup>75</sup> Paul Barnes, 'The West: a unified concept of war?', in Peter Roberts, ed., *The future conflict operating environment out to 2030* (London: RUSI, 2019), pp. 69–74.

<sup>76</sup> Smith, *The utility of force*.

<sup>77</sup> Richard Nugee, 'Climate change: maintaining freedom of manoeuvre', *Wavell Room*, 15 Sept. 2021, <https://wavellroom.com/2021/09/15/climate-change-maintaining-freedom-of-manoevure/>.



treated as if it were. Rather, it is emerging within a broader debate about whether western societies have put too much faith in specific technologies to win their wars, locking militaries into certain modes of operating that are proving costly not only in terms of blood and treasure, but, as is increasingly acknowledged, also in terms of carbon. The idea of low-carbon warfare, then, not only expands scholarly debates around restraint; it also adds to the debate around technology and warfare by posing fundamental questions about what the unfolding energy transition will mean for how military forces are powered in the future. The answers to these questions are likely to affect the development, procurement and deployment of next-generation platforms. It will also test assumptions about the future role of those technologies that have hitherto attracted the most interest from scholars—namely, artificial intelligence, quantum computing, robotics, directed-energy weapons, hypersonics, space technology and additive manufacturing—in a carbon-constrained or net-zero future.

Of course, none of the above debates can be divorced from the even bigger question of what kinds of military operations western societies should expect to be involved in, the capabilities that their forces will need, and the extent to which they will be deployed with restraint. For much of the post-Cold War period, the general assumption was that western forces would mostly be deployed on expeditionary operations against supposedly military inferior states or irregular opposition.<sup>78</sup> However, more recent work highlighting trends towards ‘proxy’, ‘remote’ and ‘vicarious’ forms of warfare has argued that public support for these ‘wars of choice’ was proving harder to sustain, especially as casualties and financial costs mounted.<sup>79</sup> In response, operating at a distance, in the shadows or through local proxies were all strategies used to minimize, or perhaps even hide from public scrutiny, the real costs of military intervention.<sup>80</sup> Growing pressure to decarbonize military operations promises to reinforce preferences for ‘lighter footprint’ operations involving technological surrogates, special forces and local proxies by drawing greater attention to the carbon costs of deploying mass forces around the world.

A key question remains, however, over whether the way western countries have approached the business of war over the past few decades will persist in the years ahead. Russian aggression and violence in eastern Europe, which in 2022 turned into an intense and bloody war against Ukraine, and the deepening strategic competition between the United States and China, has heightened the risk of western allies being drawn in to fight a major—possibly even nuclear—interstate war in Europe and/or the Indo-Pacific. Although the likely intensity of any such conflict continues to be debated, Russia’s war in Ukraine has prompted questions about whether the West needs to rebuild its military-industrial capacity

<sup>78</sup> Smith, *The utility of force*.

<sup>79</sup> Waldman, *Vicarious warfare*; Andrew Mumford, ‘Proxy warfare and the future of conflict’, *RUSI Journal* 158: 2, 2013, pp. 40–46; Tom Watts and Rubrick Biegon, *Defining remote warfare: security cooperation* (London: Oxford Research Group, 2017), <https://www.oxfordresearchgroup.org.uk/Handlers/Download.ashx?IDMF=0232e573-f6d6-455e-9d34-0436925002d4>.

<sup>80</sup> Waldman, *Vicarious war*.

in preparation for large-scale war.<sup>81</sup> Following Russia's attempted full-scale invasion, European nations announced increases of nearly €200 billion to their defence budgets.<sup>82</sup> While spending on this scale could be used to accelerate decarbonization, the pressure to spend quickly threatens to entrench further Europe's dependence on burning carbon for defence at precisely the moment when policy-makers are seeking ways to make the shift away from fossil-fuelled forces.

On the other hand, even as the prospect of interstate war in Europe and the Indo-Pacific commands attention, it is important to recognize that instability and intrastate violence in parts of the global South are likely to persist as countries continue to grapple with economic inequality, poor governance, insurgency, terrorism, environmental degradation, demographic shifts and the legacies of colonialism. For as long as western interests continue to be put at risk, the era of expeditionary operations—whether for the purposes of humanitarian aid and disaster relief, peacekeeping, counter-insurgency or counterterrorism—is unlikely to be over. Indeed, as during the Cold War, it is possible that the much of the confrontation between the West, Russia and China will also play out in other countries, especially in the global South (as we have seen in places such as Mali and Syria).<sup>83</sup> As Yee-Kuang Heng has argued, scholars and practitioners therefore should exercise caution over whether the looming prospect of a large-scale confrontation between major powers means the West's risk-management/risk-transfer approach no longer resonates.<sup>84</sup> Indeed, as Heng also notes, the need to conserve resources for potential great power conflict could actually accentuate demand for more 'vicarious' forms of warfare.<sup>85</sup> Similarly, faced with growing public scrutiny of emissions, the West's willingness to burn carbon may also begin to fluctuate depending on the nature of the military operations involved, with the aim of preserving defence's carbon 'budget' (whether this is perceived or one day made real) for when it is really needed.

## Low-carbon warfare: advancing the research agenda

Climate change is asking us to look at the very basics, which we have taken for granted for at least 100 years.<sup>86</sup>

If pressure to decarbonize military forces continues to build, western societies will need to confront future threats to defence and security with a much smaller carbon footprint than they do today. Quite how this can be achieved remains an

<sup>81</sup> Timothy R. Heath, Kristen Gunness and Tristan Finazzo, *The return of great power war scenarios of systemic conflict between the United States and China* (Santa Monica, CA: RAND, 2022), [https://www.rand.org/pubs/research\\_reports/RRA830-1.html](https://www.rand.org/pubs/research_reports/RRA830-1.html); Alex Vershinin, *The return of industrial warfare*, RUSI, 17 June 2022, <https://www.rusi.org/explore-our-research/publications/commentary/return-industrial-warfare>.

<sup>82</sup> Ann Finkbeiner and Richard van Noorden, 'Will war in Ukraine mark a new era for European defence research?', *Nature*, 17 Aug. 2022, <https://www.nature.com/articles/d41586-022-02185-x>.

<sup>83</sup> Tarak Barkawi, 'On the pedagogy of "small wars"', *International Affairs* 80: 1, 2004, pp. 19–37.

<sup>84</sup> Yee-Kuang Heng, 'The continuing resonance of the war as risk management perspective for understanding military interventions', *Contemporary Security Policy* 39: 4, 2018, pp. 544–58.

<sup>85</sup> Heng, 'The continuing resonance of the war'; see also Waldman, *Vicarious war*.

<sup>86</sup> Nugee, 'Climate change'.

open question. Indeed, warnings abound about the perils of trying to predict the future. As Rob Johnson wrote, 'there is no guarantee that patterns and trajectories are reliable'.<sup>87</sup> In other words, we should be cautious about attempting to divine the future character of military operations: the prospect of a shift away from fossil-fuelled forces alone cannot tell us much about the future character of military operations.

What we can do, however, is begin to identify and address questions that will be raised by strengthened commitments to low-carbon warfare, particularly as western forces seek to confront their adversaries across the entire spectrum of conflict and in different parts of the world, while at the same time addressing growing demands for other kinds of military operations short of war. One set of questions that needs to be addressed concerns how quickly military forces can realistically decarbonize, and whether defence ministries have sufficiently thought through the implications.<sup>88</sup> Related to this, there is another set of questions to be answered about whether decarbonization should be treated primarily as a technological challenge, requiring a technological fix, or if sufficient consideration is being given to alternative pathways to decarbonization, based, for instance, on exercising greater restraint around the use of force, or radically rethinking force design and structure to reduce reliance on heavy platforms such as tanks, planes and warships. Given that the design and procurement of new capabilities can take years, if not decades, and given also that some capabilities may simply prove too difficult to decarbonize, it is perhaps most likely that some combination of technology, force redesign and restraint will be required. Either way, decarbonization will pose difficult questions to the defence sector and wider society in terms of the costs they are prepared to bear to transform the military for low-carbon operations.

A third set of questions arises around the problem that, for the West at least, decisions about future force design will be difficult to take alone. Within militaries, individual services may draw different conclusions regarding the most appropriate way to decarbonize, with implications for joint operations. Looking outwards, only a handful of countries have written decarbonization into their defence strategies or set any kind of targets for their armed forces.<sup>89</sup> While more countries may be expected to tighten their climate change and net-zero targets, progress towards reducing military emissions will be uneven: indeed, 'decarbonization gaps' are likely to emerge. These decarbonization gaps will need to be monitored and assessed in terms of their potential impact on some allies' ability to operate as part of coalitions. For instance, during the International Security Assistance Force operation in Afghanistan, the use of national caveats by some allies to restrict their forces' engagement in certain types of missions or modify their rules of engagement created significant divisions within NATO.<sup>90</sup> In the future, armed forces

<sup>87</sup> Robert A. Johnson, 'Predicting future war', *Parameters* 44: 1, 2014, pp. 65–76.

<sup>88</sup> For a recent review of alternative fuels and alternative propulsion systems being developed for military use, see Barry et al., *Green defence*.

<sup>89</sup> Barry et al., *Green defence*.

<sup>90</sup> Stephen M. Saideman and David P. Auerswald, 'Comparing caveats: understanding the sources of national

may find themselves similarly constrained by caveats intended to minimize their carbon footprint. Decarbonization gaps also need to be evaluated in terms of their ability to erect barriers to host-nation support. This might include denial of access to basing rights or port facilities to 'high-carbon' military forces, in much the same way that nuclear warships and submarines have been denied access in the past.<sup>91</sup> More research is needed to understand and track how national commitments to military decarbonization are evolving, and what potential there is for allies and partners to be locked into divergent energy pathways that could put the integrity of alliances and coalitions at risk.

Adversaries also have a vote. What happens if peer and near-peer competitors choose not to decarbonize their armed forces? The issue here is that the prospect of confronting high-carbon adversaries on the battlefield remains a daunting one. One recent study by a British officer concluded that based on current capabilities and ways of fighting, an electrified land force (in this case, 3rd [UK] Division) would be unable to match the levels of firepower, protection and mobility enjoyed by a fossil-fuelled force.<sup>92</sup> Put simply, if adversaries persist with deploying fossil-fuelled forces, countries turning towards low-carbon warfare will need to rethink fundamentally their assumptions about how to fight.

Amid all this discussion of the prospects and promise of military decarbonization, scholars must also be attentive to the possibility that the pursuit of low-carbon warfare could return us to some of the paradoxes that lie at the heart of predominantly western ideals of war in the twenty-first century. As other scholars have shown, the pursuit of 'riskless', 'precise' and 'remote' forms of warfare has yet to put an end to death and destruction, even if it has served to salve consciences regarding the human and financial costs of military interventions.<sup>93</sup> In the same vein, it would be wise to anticipate that low-carbon warfare in its maximalist form could be read as promising states a way to wage 'carbon-neutral' wars, at least to the extent that states are absolved from responsibility for the emissions that result from their military interventions. This raises the question of whether it is enough to count only the direct emissions resulting from military operations involving a state's own forces and materiel, or whether low-carbon warfare should also be extended to include a concern for the carbon burned by proxies and other surrogates in support of that state's interests. What other emissions

restrictions upon NATO's mission in Afghanistan', *International Studies Quarterly* 56: 1, 2012, pp. 67–84.

<sup>91</sup> Michael Pugh, 'Nuclear warship visiting: storms in ports', *The World Today* 45: 10, 1989, pp. 180–3. Indeed, in 2021, New Zealand reiterated its decades-long ban on nuclear-powered vessels entering its waters in response to Australia's decision to develop a nuclear submarine fleet: see 'Australian nuclear subs will be banned from New Zealand waters: Ardern', *France 24*, 16 Sept. 2021, <https://www.france24.com/en/live-news/20210916-australian-nuclear-subs-will-be-banned-from-new-zealand-waters-ardern>.

<sup>92</sup> Chris Adams, 'Two shades of green: can the British Army's warfighting division fight and win without fossil fuels in 2050' (Fort Leavenworth: US Army Command and General Staff College, 2022), <https://cgsc.contentdm.oclc.org/digital/collection/p4013coll2/id/4059/rec/1>.

<sup>93</sup> Paul W. Kahn, 'The paradox of riskless warfare', *Philosophy & Public Policy Quarterly* 22: 3, 2002, pp. 2–8; James Rogers, 'Drone warfare: the death of precision', *Bulletin of the Atomic Scientists*, 12 May 2017, <https://thebulletin.org/2017/05/drone-warfare-the-death-of-precision/>; see also Jolle Demmers and Lauren Gould, 'The remote warfare paradox: democracies, risk aversion and military engagement', *E-International Relations*, 20 June 2020, <https://www.e-ir.info/2020/06/20/the-remote-warfare-paradox-democracies-risk-aversion-and-military-engagement/>.

need to be considered? The Military Emissions Gap project argues that we are nowhere near to addressing the full scope of emissions that result from military operations.<sup>94</sup> Which emissions are counted, and which are defrayed onto others or simply ignored, matters greatly when it comes to determining exactly what is being put on the table when we invoke terms such as *low-carbon* warfare or *green* militaries or *net-zero* defence.

Just as Jolle Demmers and Lauren Gould have asked of remote warfare,<sup>95</sup> the pursuit of low-carbon warfare also raises uncomfortable questions about whether, if low-carbon warfare became a reality, it would actually make western countries—or indeed any other countries—less cautious about going to war. To put the question differently, is the pursuit of low-carbon warfare simply another way of perpetuating the use of war by extending the utility of military force into a net-zero future? Modifying Demmers and Gould again, might we care less about violence that is conducted in a low-carbon way? Does military force executed with fewer emissions become invisible to and unimportant for those who wield it? Such questions remind us that in the pursuit of military decarbonization, we must be careful to not normalize low-carbon warfare in such a way as simply to normalize the use of violence in the pursuit of political ends.

## Conclusion

Whereas most scholarship on war and climate change up to now has been preoccupied with the question of whether climate change will exacerbate insecurity and lead to more armed conflict across the world, this article has argued that the deepening climate crisis is now also provoking new thinking about the carbon costs of wielding military force, and whether the future character of war is still fossil fuelled. In doing so, this article anticipates that in the years ahead we will see greater interest in what I have termed ‘low-carbon warfare’. Key to recognizing this nascent turn is understanding that as societies change, so too do their views of where, when, how, to what ends and at what cost military force should be wielded. As this article has shown, the escalating climate crisis and the global energy transition away from fossil fuels is already provoking defence ministries—as well as NATO and the EU—to think carefully about how governance, societal expectations and the industrial base will evolve in the coming years, and what this will mean for the future character of military operations.

As a concept, low-carbon warfare promises a great deal by way of response. Above all, it expands the conceptual terrain of the study of military operations, warfare and war. It also draws much-needed scholarly attention to questions of how to retain or even enhance military operational effectiveness while supporting action to mitigate the climate crisis, reducing a costly reliance on fossil fuels (as well as on petro-states such as Russia), and maintaining the support of societies

<sup>94</sup> A research project by the Conflict and Environment Observatory, and Lancaster and Durham universities, that monitors military emissions data reported to the UNFCCC. For more information, see <https://militaryemissions.org/>.

<sup>95</sup> Demmers and Gould, ‘The remote warfare paradox’.

increasingly concerned about environmental issues. However, low-carbon warfare is no panacea for policy-makers. In practical terms, military decarbonization represents a significant challenge. Decisions about how, how far and how quickly to decarbonize will be shaped by a wider range of factors from political will to public support to gaps between allies and partners. It is welcome that defence ministries are beginning to recognize the need to transform how their armed forces are powered. However, decisions must follow quickly if such thinking is to have any significant bearing on the character of military operations in 2050 (the current target date for most emission-reduction targets). This leaves little time for consideration of what the pursuit of low-carbon warfare will mean for the future character of military operations, how it might intersect with other trends such as advances in automation and AI, or how it could be affected by major ruptures in the international security environment (such as the ongoing war in Ukraine). Further research on this topic is therefore a matter of urgency.

All the while, scholars and practitioners must be alert to the darker side of low-carbon warfare and the possibility that reducing the carbon burn of military forces could actually contribute to the normalization of their use. This is not an argument against decarbonizing military operations. Rather, the intention here is to warn scholars and especially practitioners that the turn towards low-carbon warfare should not simply be about enabling more military intervention, violence and war. Turning towards low-carbon warfare may help us to resolve the problem of how to wield effective military force within the political, societal, economic and technological constraints of a net-zero world, but it should not be misunderstood as ushering in a cleaner, greener or more ethical form of violence.