



Unfolding Green Defense

Linking green technologies and strategies to current security challenges in NATO and the NATO member states

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Denne rapport er en del af Center for Militære Studiers forskningsbaserede myndighedsbetjening for Forsvarsministeriet. Formålet med rapporten er at informere og skabe grundlag for fortsat udvikling af grønne løsninger i NATO og i NATO's medlemslande. Rapporten introducerer NATO's Green Defence Framework og skildrer, hvordan grønne teknologier og strategier er blevet udformet med henblik på at håndtere aktuelle sikkerhedsproblematikker. Med afsæt i konkrete eksempler undersøger rapporten en række politiske, militære, organisatoriske og teknologiske udfordringer og muligheder, som knytter sig til brugen af grønne løsninger indenfor forsvaret.

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This report is a part of Centre for Military Studies' policy research service for the Ministry of Defence. Its purpose is to inform and support the further development of green solutions for defence in NATO and in the NATO member states. It does so by introducing the NATO Green Defence Framework and unfolding how green technologies and green strategies for defence have been linked to current security challenges. Through specific examples the report explores political, military, organizational, and technological challenges and possibilities related to green solutions for defence.

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Abstract

In recent years, many states have developed and implemented green solutions for defense. Building on these initiatives NATO formulated the NATO Green Defence Framework in 2014. The framework provides a broad basis for cooperation within the Alliance on green solutions for defense. This report aims to inform and support the further development of green solutions by unfolding how green technologies and green strategies have been developed and used to handle current security challenges. The report, initially, focuses on the security challenges that are being linked to green defense, namely fuel consumption in military operations, defense expenditure, energy security, and global climate change. The report then proceeds to introduce the NATO Green Defence Framework before exploring specific current uses of green technologies and green strategies for defense. The report concludes that a number of political, military, organizational, and technological challenges and possibilities are related to the development of green solutions for defense. Based on this conclusion the report argues that it is essential to comprehensively describe how a green solution is linked to a security challenge to develop relevant and viable green solutions for defense. The report is concluded with seven recommendations aimed at informing and supporting the further development of green solutions for defense in NATO and in the NATO member states.

The recommendations are as follows:

- The NATO framework and the Green Defense concept should be further substantiated and should clearly describe which activities Green Defense is composed of and prioritize.
- Much research has already been done by NATO member states on green solutions for defense, and NATO should facilitate more coordinated research efforts and increased information-sharing to avoid duplicate research.
- The number of green technologies that potentially could be used by military organizations is vast and currently unmapped. This lack of overview is a hindrance to strategic political prioritization. NATO should therefore seek to develop a more comprehensive mapping of the available technologies.
- Political and military decision-makers in NATO and its member states should seek to analyze and comprehensively describe how a green solution is linked to a security challenge before deciding on a specific set of green solutions.

- Green strategies for defense should be developed in coordination with the green strategies of other state agencies.
- When selecting and developing green solutions, NATO and its member states should analytically describe how green technologies and strategies are coordinated.
- To create long-term changes in how the military uses green solutions, it will be necessary to change how new technology is developed and procured. The Green Defense concept should therefore be incorporated into the NATO Defence Planning Process.

Dansk resumé

En række af NATO's medlemslande har i de seneste år udviklet grønne løsninger til det militære område. Nye grønne strategier er blevet udarbejdet og grønne teknologier er blevet taget i anvendelse med henblik på at mindske det miljø- og klimamæssige fodaftryk samt bidrage til at håndtere en række aktuelle sikkerhedsproblematikker. I forlængelse af denne udvikling blev NATO's Green Defence Framework præsenteret i 2014, hvorved der er blevet skabt et solidt grundlag for samarbejde indenfor NATO omkring udviklingen og brugen af grønne løsninger indenfor det militære område. Rapporten fokuserer indledningsvist på de fire centrale sikkerhedsproblematikker, nemlig brændstofforbrug i operationer, medlemslandenes forsvarsbudgetter, energisikkerhed samt globale klimaforandringer. Herefter introducerer rapporten NATO's Green Defence Framework og fremfører en række centrale diskussioner i arbejdet med grønne løsninger indenfor det militære område. Dernæst præsenterer rapporten en række konkrete eksempler på grønne initiativer indenfor det militære område. Først fokuserer rapporten på grønne teknologier (biobrændsel og solenergi) og derefter på grønne strategier. Afslutningsvis konkluderer rapporten, at en række politiske, militære, organisatoriske og teknologiske udfordringer og muligheder knytter sig til brugen af grønne løsninger indenfor forsvaret. På dette grundlag anbefales det i rapporten, at sammenhængen mellem grønne initiativer og sikkerhedsproblematikker udfoldes og analyseres indgående. Dette vil være et afgørende element i udarbejdelsen af relevante, efficiente og effektive grønne løsninger indenfor det militære område. Rapporten afsluttes med syv anbefalinger, der fokuserer på den fortsatte udvikling af grønne løsninger indenfor NATO og i NATO's medlemslande.

Anbefalingerne er:

- NATO's Green Defence Framework samt konceptet Green Defense kan med fordel udbygges og defineres klarere. Et væsentligt element heri vil være at beskrive, hvilke typer af initiativer og aktiviteter Green Defense består af og bør prioritere.
- Der foregår allerede en væsentlig forskningsindsats indenfor NATO's medlemsstater i forbindelse med udviklingen af grønne løsninger til det militære område. NATO kan med fordel facilitere en øget koordination af forskningsindsatserne samt fremme mulighederne for informationsudveksling. Herved kan der skabes grundlag for, at NATO's medlemslande kan få størst muligt udbytte af forskningsindsatserne.

- Der findes aktuelt et væld af grønne teknologier, der kan bringes til anvendelse indenfor det militære område. De teknologiske muligheder er endnu ikke blevet systematisk klarlagt, hvilket vanskeliggør strategiske politiske prioriteringer indenfor det grønne område. NATO kunne mindske denne udfordring ved at udarbejde en oversigt over tilgængelige grønne teknologier med relevans for det militære område.
- Før NATO og NATO's medlemslande beslutter sig for at udarbejde og implementere specifikke grønne løsninger indenfor det militære område, kan de med fordel analysere, hvordan de grønne løsninger specifikt vil bidrage til at håndtere aktuelle sikkerhedsproblematikker.
- Grønne strategier for forsvaret bør udarbejdes i tæt koordination med grønne strategier indenfor andre politikområder.
- NATO og NATO's medlemsstater kan med fordel udarbejde analyser, der undersøger og beskriver, hvordan udviklingen af grønne strategier og teknologier er blevet koordineret.
- For at skabe vedvarende forandringer i forsvarets brug af grønne løsninger vil det være nødvendigt at ændre måden, hvorpå ny teknologi udvikles og indkøbes. Green Defense-konceptet kan derfor med fordel indarbejdes i NATO's forsvarsplanlægningsproces.

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1. Introduction

This report is about green technologies, green strategies, and current security challenges. In recent years, many states have developed and implemented green public policies aimed at various policy areas, including defense and security. Until now, the development of green policies has primarily been a national concern. However, the new NATO Green Defence Framework provides a basis for increased knowledge-sharing and research coordination, which can support the development of cheaper and more effective green solutions for defense—solutions capable of addressing a number of contemporary and emerging security challenges, in particular energy security, global climate change, defense spending, and the logistical challenge of getting energy to the battlefield.

Green defense solutions have often been introduced without clear descriptions of how these solutions will handle the security challenges in question. The report argues that in order to identify relevant and viable green solutions to contemporary security challenges, it will be pivotal to unfold how a solution is linked to a given challenge. By establishing such a link, it will be possible to assess the efficiency and effectiveness of different solutions. The NATO Framework can provide important support in unfolding both the green solutions and security challenges—and in linking the two. The NATO framework only partly defines the Green Defense concept, however, and it is linked to a number of different topics, actors, activities, and challenges. This makes Green Defense potentially relevant at many different levels but also difficult to operationalize and assess. Does it address both political and military challenges? And can solutions be found within all kinds of military activities?

The report offers a basis for strategic and political debate about green solutions for defense. It will provide an introduction to the concept of Green Defense and, based on a number of specific examples, develop recommendations for the further development of Green Defense. The examples are used in conjunction with the conceptual analysis to unfold the political, military, organizational, and technological challenges and possibilities related to Green Defense.

Initially, the report will revisit the security challenges in focus before proceeding to a presentation of the NATO Green Defence Framework. The NATO framework utilizes a number of recent analyses and insights, which the report will examine to gain a more comprehensive understanding of the challenges and potentials of Green Defense.

To further unfold the elements of Green Defense, the report will then present a number of specific examples of green defense solutions, which can be divided into two groups: green technologies and green strategies. The examples illustrate how green solutions have been developed and introduced to handle different security challenges and that a number of political, military, organizational, and technological aspects have influenced how green defense solutions have been applied.

Thus, the report covers a number of different topics. It introduces the NATO Green Defence Framework, tracks the ideas and technologies that have gone into it, presents notable green technologies and strategies, before finally making recommendations on future work with the Green Defense agenda and the Green Defense concept.

1.1 Methodology

The report is part of the Centre for Military Studies' (CMS) research-based public sector services. It is the result of academic research and follows the CMS guidelines and procedures for quality control. The analysis underlying the report was organized and conducted in the following manner.

An initial meeting was planned with the Danish Ministry of Defence to exchange understandings and ideas and to identify central organizations and persons. A number of preliminary analytical considerations were developed on the basis of the meeting: 1) Green Defense is still an emerging concept; 2) Green Defense addresses a number of different general and specific problems and solutions, some of which are linked to the global level, others to the national level, and others yet are linked to specific operations and actions; 3) a number of the elements linked to Green Defense are well-known and have already seen wide use, including concepts, technologies, and strategies. Hence, Green Defense covers and connects both new and old elements. These three analytical considerations framed how the analysis was conducted.

The first part of the analysis was done as desk research. A number of key official documents from NATO, Denmark, and the U.S. were identified, studied, and subsequently used to trace other central documents, organizations, and persons. During the autumn of 2014, the NATO Energy Security Centre for Excellence hosted a conference on Innovative Energy Solutions for Military Application. Based on the desk research already done, the conference provided beneficial opportunity to explore how Green Defense was being discussed and developed

within NATO. The conference reemphasized the validity and relevance of the three analytical considerations already identified.

The final report was drafted on the basis of the desk research, the information collected at the conference, and information provided by scholarly experts on the topic.

2. The security challenges

Fuel consumption was not considered a key military challenge while Operation Enduring Freedom–Afghanistan and Operation Iraqi Freedom were being prepared in 2001 and 2003, respectively. This changed as the military operations continued and fuel consumption evolved into a distinct operational challenge that limited operational parameters, caused inflexibility, put service personnel in harm’s way, and inflated the operational expenditures.¹

Access to fuel was essential for the forces operating on the ground in Afghanistan and Iraq. The fuel was used to power ground and air vehicles with advanced weapons and surveillance systems, which enabled the forces to monitor their surroundings, follow presumed enemies, and destroy enemy targets.² These technologies had already proven themselves important in a war characterized by few spatial, temporal, and social boundaries. The coalition forces had to be patient and maintain their presence across Afghanistan and Iraq for years—and to await an enemy who had no eagerness to engage in direct confrontations. The waiting and the use of advanced technologies increased the fuel consumption, and it became necessary in both Afghanistan and Iraq to bring in massive amounts of fuel on a weekly basis.³ Convoys brought in fuel from Pakistan and Jordan, and the large fuel consumption rendered it impossible to operate with flexible convoy schedules; they had to depart on the same days, the predictability of which made them a favorite target of the insurgency forces.⁴

The military organizations started looking for solutions capable of addressing this serious operational challenge, and a number of solutions were developed. They all targeted the increased fuel consumption but approached the challenge from different perspectives: some focused on new technologies and others on changing the behavior of the service personnel.⁵ Notable effort was made by the U.S. Marines Corps, which was able to reduce its energy consumption significantly, thereby increasing operational parameters and lowering the human and financial costs suffered from attacks on fuel convoys.

In addition to the logistical challenge of getting fuel and energy to the battlefield, green defense solutions have been pursued in connection to three other security challenges: energy

security, global climate change, and defense spending. These challenges are all linked to fuel and energy consumption but are of very different character.

Energy security has been a key state priority for more than a century.⁶ Fossil fuels have been essential for economic growth, and the oil crises of the 1970s and 1980s clearly revealed the damaging effects of petroleum shortages. Energy security will become increasingly challenging as the global population increases in the future. According to the U.S. National Intelligence Council, the demand for energy will rise by approximately 50% over the next 15–20 years.⁷ In 2030, 8.3 billion people will inhabit the earth, and a growing share of these people will be middle class consumers demanding food, water, and technological commodities,⁸ the provision of which requires energy, and energy security will continue to be a top state priority.⁹

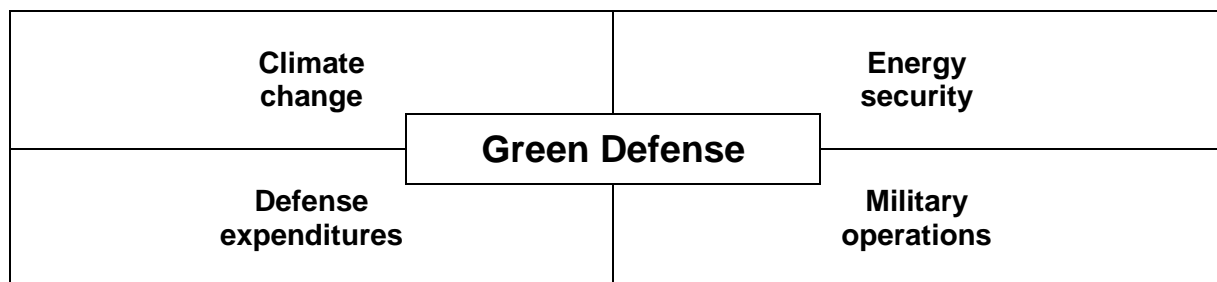
Climate change is another security challenge that has been connected to green defense solutions. The average temperature on earth increased over the course of the 20th century, and it is now widely acknowledged in scientific circles that human-induced emissions of greenhouse gases are the main driver of this increase in temperature.¹⁰ The increased average temperature has been linked to changes in rainfall, more frequent and severe heat waves, rising sea levels, warmer oceans, and melting icecaps—developments that are challenging national security across the globe, if not directly then indirectly through migration, increasing extremism and terrorism, and armed conflicts.¹¹ The massive challenge of reducing global fossil fuels consumption is an on-going discussion, and no solution or agreement appears imminent. However, the challenge has been acknowledged and is currently being addressed in the UN and numerous countries and international organizations.

Lastly, green solutions for defense have been associated with defense expenditures. With the end of the Cold War, the defense budgets of the NATO member states started shrinking.¹² The secure environment of the 1990s offered unique opportunity to reduce military spending focusing instead on domestic priorities and balancing public budgets. When the financial crisis hit North America and Western Europe in 2007 and 2008, most of the NATO member states introduced austerity measures to limit public spending, leading to further defense budget cuts.¹³ At this time, operations were still continuing in Afghanistan and Iraq and the new cuts put increased pressure on the armed forces. To address this challenge, production and production costs were revisited, and energy consumption was recognized as an area with

cost-reduction potential.¹⁴ Energy consumption was thus linked to defense spending and policy initiatives were outlined to reduce energy consumption.

Energy—and in particularly fuel—consumption has thus been discussed in connection to a number of different security challenges ranging from the highest global level to the lowest tactical level. So far, the different challenges have been addressed through different lines of policy. An important step towards developing a coherent policy for green defense solutions was taken in 2014, when NATO published the “NATO Green Defence Framework”. The Green Defense concept was introduced to describe and support initiatives aimed at these different security challenges. The Green Defense concept and the four security challenges are displayed in Figure 1.

Figure 1: The Green Defense concept and the four security challenges



While the NATO concept of Green Defense is important and has significant potential regarding NATO security and defense policy, the concept also carries a number of challenges, particularly concerning its ambiguous conceptual core, and further conceptual work is required to develop the NATO framework.

3. The NATO Green Defence Framework

This section of the report will focus on the Green Defense concept. The NATO Green Defence Framework will be introduced after which a number of analyses and insights that the concept builds upon and further develops will be considered.

In February 2014, the NATO Defence Policy and Planning Committee agreed to the NATO Framework for Green Defense. NATO had already addressed the link between security and the environment in the 1991 Strategic Concept. NATO has not, however, initiated specific initiatives aimed at environmental or climate challenge since. The importance of the Green Defense agenda was noted at the 2014 NATO Summit, and the summit declaration stated that

the Alliance members would aim to ‘further develop NATO's competence in supporting the protection of critical energy infrastructure; and continue to work towards significantly improving the energy efficiency of our military forces.’¹⁵

While environmental challenges have generally received limited attention in NATO, the energy security issue has been discussed frequently. Energy resources are essential for national security, and a continuous supply of such resources has been a key strategic priority. To address the challenge of energy security, Lithuania has established a research center on energy and security with support from numerous NATO member states.¹⁶ The center was accredited by NATO in October 2012 as a NATO Centre of Excellence (NATO Energy Security Centre of Excellence) and has since provided subject matter expertise on energy security to NATO bodies, Alliance members, and partner nations.

A number of other NATO member states have also addressed environmental and climate challenges. Denmark has emphasized the agenda for years, and Denmark and Lithuania worked together to advance the Green Defence Framework in NATO. In June 2013, Denmark and Lithuania presented a number of green initiatives at the defense ministerial in NATO. This was an initial presentation of the ideas that were later developed into the NATO Green Defence Framework. The initiatives reflected recent experiences and were intended to provide the basis for further investigations of Green Defense opportunities within NATO. The presentation emphasized that within this policy area ‘some [NATO] nations have broader experience than others in terms of formulating policies and action plans, as well as in implementing the necessary measures.’¹⁷ Consequently, it was suggested that there was a great potential for further international cooperation on Green Defense.

Thus, the 2014 NATO Green Defence Framework contained no specific targets or demands for activities, instead highlighting a number of initiatives capable of supporting or facilitating the development of green initiatives within NATO and in the member nations.

Green Defense is defined in the framework as ‘a multifaceted endeavour cutting across a wide range of activities, including operational effectiveness, environmental protection and energy efficiency.’¹⁸ The framework highlights how Green Defense involves numerous different actors and domains, including operations, logistics, engineering, and defense planning. It further emphasizes how many of NATO’s activities, in particular operations and exercises, have a significant environmental impact and that a number of new technologies provide important opportunities to reduce this impact. It is therefore suggested that NATO

can support and facilitate the closer coordination of research and information-sharing on the topic, which could potentially reduce costs, lower the risks to Allied soldiers, and reduce the Alliance's environmental footprint.¹⁹

The NATO framework consists of six main parts. The first part establishes the scope of the framework and outlines three pillars of initiatives: 1) reinforcing efforts of NATO bodies; 2) facilitating Allies' efforts; and 3) improving NATO's "green" profile.²⁰ The first part also emphasizes that the Green Defence Framework 'will be developed over time through existing structures and resources' and that NATO 'does not appear to be an appropriate venue to engage in environmental politics.'²¹ The following three parts address each of the three pillars by identifying the aims and potential areas and venues for further Green Defense activities. The fifth part addresses the path ahead and initially reads that 'the work strands depicted under the three pillars should ultimately make Green Defence integral to the Alliance's endeavors.'²² The framework then proceeds to state that:

NATO bodies will continue their efforts (...) towards making NATO a "greener organization", by incorporating relevant aspects of Green Defence in NATO training, education, and exercise activities, applying "green" standards and principles across the NATO HQ, NATO Command Structure and NATO agencies, where appropriate, and by pursuing scientific research geared towards "greener" future military capabilities.²³

In the sixth, and final part, the Green Defence Framework outlines recommendations to the Council. The recommendations are to agree the framework, to support and reinforce Green Defense efforts within each of the three pillars, and to invite the Defense Ministers to note the framework.²⁴

In summary, the NATO framework provides a broad basis for cooperation within the Alliance on green solutions for defense. It follows a more general development that puts sustainability at the top of the political agenda, building upon and further developing a number of insights recently gained by scholars and analysts.²⁵ The framework is comprehensive and speaks to the established political and military processes in NATO, thus providing a number of tangible paths forward.

3.1 Connecting challenges and solutions

However, the NATO Green Defence Framework also suffers from a conceptual ambiguity that renders it difficult to operationalize the key elements of the framework. This conceptual

ambiguity can be connected to a common green public policy challenge, namely how specifically the green solutions and general security challenges can be linked. Without clear descriptions of the link, it is difficult to assess the viability of the available solutions.

In a 2011 issue of “The Military Engineer,” Barnhart et al. discussed how the U.S. Department of Defense could utilize net-zero military installations to address the security challenges of climate change, energy security, and operational fuel consumption.²⁶ The authors concluded that net-zero installations could be an effective solution to all three challenges by lessening greenhouse gas emissions, reducing the need for foreign fuel, and improving operational fuel efficiency. While net-zero installations have significant potential in all three regards, the distinct character of the three security challenges was not addressed by the authors. Instead, the challenges were grouped to compose one general basis upon which to act. This is a common feature in the discussion of green defense solutions. It has proven difficult to describe the link between a general security challenge and the available green solutions, and it is therefore challenging to assess the viability of the solutions.

Like Barnhart et al., the NATO Green Defence Framework only provides a limited description of how the security challenges and green solutions are linked. The NATO Green Defence Framework contains few descriptions of the activities, domains, and actors that are mentioned. According to the framework, the activities include operational effectiveness, operational protection, and energy efficiency.²⁷ On a conceptual level, efficiency and effectiveness are not activities but rather measurements of how well activities are being conducted and whether they are reaching their objectives. Efficient and effective operations are vital, but the NATO Framework becomes less accessible when activities and performance measurements are mixed. For the Green Defence Framework to support the development of viable green solutions for defense, it will be important to highlight how some technologies and activities can reach some objectives efficiently and effectively while other solutions can reach other objectives.

Incomplete descriptions of the links between security challenges and green solutions can also be seen in the 2013 Danish–Lithuanian Green Defense initiative. This policy initiative aimed at three overall purposes: limiting detrimental impact, saving money, and optimizing operational effectiveness, which it then used as a general basis for discussing solutions. The initiative reads: ‘Having this in mind [the three purposes], we should ask what NATO as an organization can do to be more environmental-friendly [sic.] and more energy-efficient in the

way the Alliance is conducting its “business”.²⁸ The initiative then proceeds to present a number of concrete ways to promote the Green Defense dimension in NATO. Among the ways forward are target-setting, development of best practices, knowledge-sharing, common training, discussion in Allied Command Transformation, and data collection. While most—if not indeed all—of the initiatives are relevant and have significant potential regarding the three purposes, how they are linked to the purposes is not unfolded. Consequently, assessing the potential of the different suggestions is not straightforward.

Although the links between green defense solutions and contemporary security challenges are often rather straightforward, it is essential to describe them explicitly. This will enable policy-makers to compare the available green solutions and thus select efficient and effective solutions aimed at the most significant challenges.

3.2 Guarding resources and service personnel

While the NATO framework and the concept of Green Defense are relatively new, the concept speaks to a number of well-known challenges, particularly the logistical challenge of bringing energy and fuel to the theatre of war and the military operational challenge of using energy resources in the most efficient way. Resources are scarce on the battlefield and risks can be reduced and leverage gained by using resources more efficiently.

The delivery of fossil fuels to forward operating bases in Afghanistan and Iraq proved costly both in terms of casualties and finances. In 2011, General Allen, Commander of the International Security Assistance Force (ISAF) in Afghanistan, stated that ‘operational energy is about improving combat effectiveness. It’s about increasing our forces’ endurance, being more lethal, and reducing the number of men and women risking their lives moving fuel.’²⁹ A year later, U.S. Secretary of Defence Leon Panetta echoed this: ‘These investments in new energy technologies (...) will enable our forces to operate longer and at greater distance while enhancing our energy security at home.’³⁰ Thus, the relevance and significance of green solutions in military operations has been emphasized in recent years at the highest military level in the U.S. The remarks made by General Allen and Secretary Panetta rest on a number of analyses.

In 2006, U.S. Lt Col Hornitschek published a monograph entitled “War Without Oil: A Catalyst For True Transformation.” Hornitschek argued³¹ that the fuel consumption of the U.S. Department of Defence (DoD) was so immense that it would be forced to transform its organization and capabilities. He based his argument on statistics that depicted the DoD’s

increasing consumption of fossil fuels. By projecting this development into the future, Hornitschek expected that the DoD would be forced to develop a long-term strategy on energy consumption.

Hornitschek primarily focused on operational capacity and energy security. As oil prices increased between 2001 and 2008, the fuel consumption of the U.S. DoD was often discussed. Could fuel consumption be cut sufficiently through behavioral change or would the U.S. need new weapons platforms?

In 2007, the Brookings Institution published a research paper on the topic authored by Gregory Lengyel. His paper, "Teaching an Old Dog New Tricks," identified a number of energy challenges before presenting strategic recommendations. He focused his recommendations on leadership and cultural change, innovation and process management, technologies that could reduce demand, and increased/diversified energy sources.³²

Lengyel approached the topic by highlighting the security challenges connected to the high energy resource consumption. Two challenges were particularly in focus, namely the energy security of the United States and the military vulnerability that stems from operating with platforms and systems that require assured access to large amounts of fuel. Lengyel concluded that the challenges contained both demand and supply elements. On the demand side was global fuel consumption, of which the U.S. took a 25% share in 2007.³³ The U.S. DoD used roughly 1.9% of this energy, and in terms of electricity the DoD only used slightly less than the entire nation of Denmark and slightly more than Syria.³⁴ Fuel costs increased dramatically between 2001 and 2008, which put the U.S. DoD under financial pressure. In addition to the demand side challenge, Lengyel highlighted a challenge on the supply side: how long will the Earth's oil reserves last? According to Lengyel, 'there are so many variables that any period is largely speculative.'³⁵ In a more short-term perspective, however, the oil supply is determined by production capacity, and Saudi Arabia alone was operating with excess capacity in 2004. Much has changed since then due to falling oil prices and the development of so-called hydraulic fracking for recovering gas and oil from shale rock. The challenges identified by Lengyel are therefore of a different character and scope today. However, they remain valid in terms of stressing that carbon-based energy reserves are limited on a global level, and that we are operating with a limited production capacity on a short-term basis.

Lengyel argued further that in order to handle these challenges, the DoD would need to reorganize and develop a new culture: ‘Organizational structure can, by itself, preclude success, it cannot, by itself, ensure success.’³⁶ He echoed organizational theorist Edgar H. Schein, stating that ‘the change goal must be defined concretely in terms of the specific problem you are trying to fix, not as a “culture change”.’³⁷ The increasing consumption of energy resources would need to be handled by stressing the operational and political benefits of reduced energy consumption:

The DoD will have affected a culture change when commanders instinctively know they are accountable for energy consumption, they know efficiency is its own ‘effect’ in increasing combat capability, and they continually strive to improve efficiency because energy is a consideration in all military activities and operations.³⁸

Lengyel concluded that a new culture, in combination with new structures and technologies, could address the challenge of increasing fuel consumption.

In 2009, Deloitte’s Department of Defence Practice and Federal Government Services published a report on operational energy security. The report—and the picture on the front page of a fuel convoy in Afghanistan—has since received much attention and is commonly referred to in discussions of Green Defense. The report was published prior to the introduction of the Green Defense concept, however, and therefore contains no references to the concept.

The Deloitte report found that ‘there has been a 175% increase in gallons of fuel consumed per U.S. soldier per day since the Vietnam conflict.’³⁹ Several aspects have driven fuel consumption up: the increased mechanization of technologies, the expeditionary character of conflicts, rugged terrain, and irregular warfare.⁴⁰ This increase has occurred despite significant improvements in internal combustion and jet engines. As stressed in the report, however, the improvements have been overshadowed by ‘the higher number of vehicles and rate of use.’⁴¹ A number of different fuel-reducing means were suggested by Deloitte: new conservation techniques, renewable resources (particularly solar and wind), renewable carbon-based resources (algae and biomass), nuclear fission, hot/cold fusion, fuel cells, and more advanced electrical systems.⁴²

The Deloitte report also stressed the multiple and somewhat blurred objectives of the many green solutions.⁴³ The report stated that the initial objective was to support sustainable

development. As oil prices increased between 2001 and 2008, the economic benefits of renewable energy sources were increasingly emphasized. Based on their analysis, Deloitte added an additional objective: green military solutions can reduce the number of wartime casualties. Thus, it was argued that technologies capable of reducing fuel consumption should be ‘ranked on par with more effective weapons systems, sophisticated fuel transport tankers, more resistant armoured vehicles, and net centric sensing technologies.’⁴⁴

The conclusions of the Deloitte report were echoed by Bochman in late 2009, who argued that the U.S. DoD had neglected fuel efficiency considerations in its warfighting systems.⁴⁵ Instead, the warfighting systems had been designed and procured on the assumption that ‘fuel logistics were free and invulnerable.’⁴⁶ Bochman argued that the DoD would need to acknowledge that fuel efficiency is a key enabler of operational effectiveness and that ‘fat logistics tails incur huge costs (in both blood and treasure), tie up whole divisions hauling and guarding fuel, and create attractive targets for our adversaries.’⁴⁷ To enable lower fuel consumption, Bochman⁴⁸ pointed to the implementation of operational energy metrics. He expected that such metrics could reduce the logistics tail that slows operations, limits deployability, ties up force structure in combat support, and exposes service members to risks. Bochman therefore argued that energy efficiency should be introduced by the U.S. DoD as a key performance parameter in the acquisition process.⁴⁹ Thus, he pointed to the same problem as Deloitte. While Deloitte highlighted technological solutions, however, Bochman emphasized performance measurements.

In a strategy research project submitted to the U.S. Army War College in 2010, Baer⁵⁰ investigated the fully burdened cost of fuel as it relates to the procurement of warfighting systems. Baer’s project followed the conclusions made by Deloitte and Bochman and pointed to the financial and human costs of fuel consumption in military operations. Baer combined the conclusions reached by Deloitte and Bochman and investigated a number of different potential solutions. He investigated options for reducing theatre fuel transportation requirements, reducing fuel needs with more efficient living and work environments, and adding energy efficiency key performance parameters to the DoD’s acquisition process.⁵¹ Based on these investigations, Baer argued that operational energy metrics could increase operational flexibility.⁵²

Baer based a number of his conclusions on the 2009 report, “Powering America’s Defense: Energy and the Risks to National Security,” published by the Center for Naval Analysis. This

report ‘identified a series of current risks created by America’s energy policies and practices that constitute a serious and urgent threat to national security.’⁵³ The report took a much wider analytical perspective on energy consumption and analyzed military, diplomatic, and economic challenges stemming from increased energy consumption. As echoed by Baer, however, a key finding of the report was that ‘inefficient use and overreliance on oil burdens the military, undermines combat effectiveness, and exacts a huge price tag—in dollars and lives.’⁵⁴

Hornitschek, Deloitte, Bochmann, and Baer all engaged in a common conversation about reducing—or at least managing—the U.S. DoD’s energy resources consumption. The four analyses agree on the immediate challenge, namely that the DoD’s massive consumption of energy resources was becoming a security challenge to the U.S., on tactical, operational, and strategic levels. The four analyses did, however, outline different solutions to the challenge. The solutions can beneficially be grouped into two general categories: 1) technologies and 2) strategies aimed at creating behavioral change.

Table 1: The Green Defense concept and the associated security challenges and general and specific solutions

Concept	Security challenges	General solutions	Specific solutions
Green Defense	Military operations	Reduce energy demand	New green technologies
	Defense expenditures	Increase and diversify energy supply	- <i>More efficient combustion engines</i>
	Energy security		- <i>Solar panels</i>
	Climate change	Adjust force structure and defense planning	Green strategies and management systems
			- <i>Green strategy for defense</i> - <i>Key Performance Parameters</i>

Table 1 connects the Green Defense concept with the four security challenges and some of the general and specific solutions identified and discussed by Hornitschek, Deloitte, Bochmann, and Baer.

For green solutions to work, it will be important to change behavior along with the introduction of new green technologies. However, changing organizational and individual

behavior is a challenge; not just in military organizations but in organizations in general.⁵⁵ Organizations and individuals are said to resist change due to inertia, sunk costs, scarce resources, threats to the power base, values and beliefs, and inability to perceive alternatives.⁵⁶ To make military organizations consider, develop, and use green solutions, it will be essential to clearly show how the solutions can support military operations by improving efficiency and effectiveness.

The next section of the report will address this challenge by providing specific examples of how military organizations have introduced and used green solutions. The examples show how a number of aspects such as organizational interests, technological developments, and political goals influence the development and use of green technologies and strategies. This creates a number of possibilities and challenges that need to be taken into account by political and military decision-makers.

4. Finding inspiration in practice

A number of green military technologies and strategies have been developed, implemented, and used by NATO member states in recent years. The developments have rarely been explicitly linked to the NATO Green Defense agenda, but the policy initiatives will be important in the further development of the NATO Green Defence Framework. To unfold the technical, organizational, military, and political elements of Green Defense, the next two sections will provide specific examples of Green Defense technologies and strategies. The first focuses on green technologies and the second on green strategies. This structure reflects the distinct potential of the two categories of green solutions. The examples should not be seen as best practice, and they do not encapsulate or reflect the vast range of available technologies or the variation in green strategies. Instead, they reflect the political and military possibilities and challenges that are related to the use of green technologies and strategies. By presenting specific examples of green solutions for defense, the report sheds light on how viable solutions have been developed through the coordinated introduction of technologies and strategies.

4.1 Military use of green technologies

This section of the report will present two notable examples of green military technologies: marine biofuel and solar panels. The examples differ regarding the initial aims, research and development, use, and political support. Because of these differences, a number of different

challenges and possibilities can be connected to the introduction of the two technologies, and important insights can be gained by unfolding how the two technologies were developed and put to use.

4.1.1 The Great Green Fleet and the *Flotta Verde*

In 2009, U.S. Secretary of the Navy Ray Mabus announced that the Department of the Navy would reduce its energy consumption and outlined five specific energy goals. The second of these goals was the development and deployment of “the Great Green Fleet.”⁵⁷ The remaining four goals were to: change how the U.S. Navy and Marine Corps awards contracts; reduce petroleum use in the commercial fleet by 50% by 2015; produce at least half of the shore-based energy requirements from alternative power sources by 2020; and, by 2020, 50% of the Navy’s fuel consumption in ships, aircraft, tanks, vehicles, and shore installations should be from alternative power sources.⁵⁸ The Great Green Fleet was scheduled to be deployed throughout the calendar year 2016, using alternative sources of energy. In 2012, the Navy conducted a demonstration of the Great Green Fleet and the alternative energy sources during the Rim of the Pacific exercise (RIMPAC). Five U.S. navy vessels participated: the carrier USS Nimitz, the destroyers USS Chafee and USS Chung Hoon, the missile cruiser USS Princeton, and the fleet replenishment oiler USNS Henry J. Kaiser.⁵⁹ The participation of the five vessels successfully demonstrated the performance of drop-in replacement biofuel blends.

The ships in the 2012 Great Green Fleet demonstration were powered by alternative fuels, either nuclear (USS Nimitz) or biofuel blends. The biofuel was a 50/50 combination of petroleum-based marine diesel and third generation biofuel⁶⁰ made from used cooking oil and algae.⁶¹ From the onset of the project, it was a requirement that the bio-fuels could be ‘dropped in’ without changing the infrastructure for transportation and distribution and without making modifications to weapons platforms.⁶²

In addition to the 2012 RIMPAC exercise, the U.S. Navy successfully tested a combination of jet fuel⁶³ and alternative fuel on a number of its aircraft. In 2010 and 2011, the U.S. Navy tested a biofuel made from Ester and Fatty Acids (HEFA) on eight of its aircraft, including the F/A 18 E/F Super Hornet, MV-22B Osprey, and AV-8B Harrier.⁶⁴ The fuel change did not cause changes in performance in any of the tests.⁶⁵

By adding renewable diesel to the fuel, Secretary Mabus wanted to ‘improve operational effectiveness while increasing energy security.’⁶⁶ The Great Green Fleet was a key element in

reaching this aim. It was also emphasized that it would be necessary to reform requirements-setting, acquisition, and contracting processes to ‘incorporate energy performance criteria into decisions for new systems.’⁶⁷ This acknowledgement was formalized in 2011, when the Assistant Secretary of the Navy issued a memorandum on the use of energy-related factors in acquisition processes in relation to platforms and weapons systems.⁶⁸

The focus of the U.S. Navy on fuel efficiency and energy security was encouraged by the National Defense Authorization Acts of 2007 and 2009 and the 2010 Quadrennial Defense Review. The 2007 Authorization Act stated that the policy of the U.S. DoD was to improve the fuel efficiency of weapons platforms to enhance operational effectiveness, reduce the burden of logistics, and minimize the potential impact of rising oil prices or oil shortages.⁶⁹ In the 2009 Authorization Act, fuel efficiency key performance parameters (KPP) were introduced to the requirements developments process. Key issues to be considered were the full life-cycle costs of new systems and the requirements for, and vulnerability of, fuel logistics.⁷⁰ The policies of the 2007 and 2009 Authorization Acts were acknowledged in the 2010 Quadrennial Defense Review. The 2010 QDR stated that the DoD would ‘fully implement the Energy Efficiency Key Performance Parameter (KPP) and Fully Burdened Cost of Fuel (FBCF) methodologies’ required by the 2009 Authorization Act.⁷¹

While the U.S. Navy was able to successfully demonstrate the performance of the Great Green Fleet in 2012, the plans were still criticized at the political level, and just prior to the 2012 demonstration of the Great Green Fleet, the U.S. Congress challenged the Navy’s focus on alternative fuels. At that time, the U.S. Navy had already managed to develop and successfully use a number of alternative fuels, and aircraft and ships did not seem to lose performance by shifting to alternative fuel sources. However, the prices on alternative fuels were stilling running high. In May 2012, the price of alternative marine diesel⁷² was \$15/gallon, four times the going rate for conventional fuel.⁷³ The high price was met by political criticism. Both the House Armed Services Committee and the Senate Armed Services Committee passed amendments to the DoD budget, and the Pentagon was forbidden from paying any more for green fuels than for regular fossil fuels.⁷⁴ This would have killed the Great Green Fleet. However, the successful deployment to the RIMPAC exercise and a Navy pledge to never overpay seemed to change the picture, and the anti-biofuel amendments were erased in November 2012.⁷⁵

When Secretary Mabus launched the Navy initiative on alternative power sources, why the U.S. Navy would look into the challenge was only partly addressed. There was no direct political pressure.⁷⁶ According to Secretary Mabus, there were many reasons for the U.S. Navy to consider alternative power sources: ‘changing the way we do business, looking to an energy-secure Navy and Marine Corps of the future, and leading the federal government in energy initiatives is what we must do.’⁷⁷ To further substantiate, the Secretary outlined a number of security challenges related to fossil fuel consumption: oil is a limited resource; fossil fuels are bought from volatile areas of the world; the consumption of fossil fuels has harmful environmental effects; fossil fuel dependence limits operational independence and creates a large vulnerable logistics tail; and the high military operational consumption of fossil fuels comes at a very high price due to transportation costs.⁷⁸ For these many reasons, Mabus argued that ‘the Navy and Marine Corps have an obligation to do something now about our impact on the environment (...)’⁷⁹ Thus, Mabus and the U.S. Navy were not looking for solutions to specific current military challenges; instead, they were addressing the more general challenge of developing alternatives to fossil fuels. This general approach rendered it difficult to assess the development and strategic value of the Navy’s efforts, and the critique from Capitol Hill clearly showed that the political level did not share the Navy’s general priorities.

In January 2014, the Italian Navy took a decisive first step towards the establishment of a green fleet, a *Flotta Verde*. ITS Foscari, an offshore patrol vessel, was refueled on January 27 with green marine diesel.⁸⁰⁸¹ The biofuel was a distinct second generation biofuel produced in Venice using vegetable oils and tallow—animal fat—and could be used without having to modify the Navy’s ships and weapons systems and was compatible with the existing logistics systems.⁸² ITS Foscari made a successful 5-hour sea trial on January 29 and was certified for the Italian Navy’s *Flotta Verde*. The Italian Navy expects that it will have certified the major units of the fleet for green marine diesel before the end of 2015 and have an operational *Flotta Verde* sailing the Mediterranean in 2016.⁸³

The *Flotta Verde* project was started in close cooperation with the U.S. Navy. The knowledge and experience the U.S. Navy had gained while developing the Great Green Fleet was shared with the Italian Navy, and the two Navies signed a statement of cooperation on research of alternative fuels.⁸⁴ Based on the statement of cooperation, the Italian Navy has stated that it will look into third generation marine bio-fuel in the near future.⁸⁵

The use of biofuel to power the American Great Green Fleet and the Italian *Flotta Verde* is, however, not without challenges. While the fuels have proven to be “drop-in-replacements,” they are still struggling with limited supply and potential high costs.⁸⁶ This adds important logistical and financial challenges to the operational use of biofuels.

In addition to the financial and operational military challenges, biofuel has also been linked to a potential, serious global security challenge. Global corn prices almost tripled from 2005 to 2007, which was linked to the use of corn for biofuel.⁸⁷ To avoid food shortages and rising food prices, new ways to produce biofuel have been developed. One alternative is to use waste, for instance the stover of corn, for biofuel production.⁸⁸ Third generation biofuel, as used in the Great Green Fleet, is made from algae instead of food products. Algae-containing pond scum is highly efficient in turning incoming photons from solar light into stored chemical energy, and algae can be grown and nourished in deserts with undrinkable wastewater.⁸⁹ Thus, algae can be a more efficient and cost-effective biofuel that does not have global repercussions on food prices.

Yet, according to Biello, we should not put too much confidence in biofuels:

All the energy in crops grown today (...) comes to roughly (...) 20 percent of world energy consumption. (...) Breakthroughs remain possible, and the scientific quest for a better biofuel continues, but investors and politicians might be wise not to stake too much money or policy on a high-risk bet.⁹⁰

The U.S. and Italian experiences with biofuel are important and deserve mention. Once biofuels reach cost-effectiveness they will be a relevant fuel source to consider for military organizations. However, the case of the U.S. Navy shows the importance of comprehensively analysis and explains why green technologies should be used and how the technologies will handle the tasks and challenges they are aimed at. A precise and narrow description of challenges, tasks, technological solutions, and the links between them will reduce the risk of developing ineffective technologies and also limit the potential criticism from external actors and organizations.

4.1.2 Solar panels and battlefield bases

Solar panels are another green technology that has been widely discussed as a defense solution. Solar panels are not a novel technology and their performance has already been widely tested. The U.S. military has used solar panels in two different settings: on military

bases in the U.S. and on forward operating bases on the battlefield. The sections below will focus on the latter.

In the last week of September 2010, a U.S. Marine Corps company arrived in Helmand's Sangin district, Afghanistan, bringing a number of innovative pieces of equipment,⁹¹ including solar chargers, computers, communications equipment, solar tent shields that could provide shade and electricity, and portable solar panels that could be folded up into boxes. The Marine company was the first to introduce this kind of equipment into the battlefield.⁹²

The use of alternative energy sources was connected to a more general development in the U.S. Marine Corps. In 2011, the U.S. Marine Corps published an expeditionary energy strategy that described the energy challenges facing the U.S. Marine Corps. According to the U.S. Marine Corps Expeditionary Energy Strategy, a Marine Corps infantry battalion had seen a 200% increase since 2001 in the number of vehicles it included and a 300% increase in the amount of computer and IT equipment it utilized.⁹³ The strategy highlighted how an infantry battalion of 900–1,000 marines in 2001 used less energy than an infantry company of 125–150 marines in 2011.⁹⁴ New technologies, such as global positioning systems (GPS), thermal imaging scopes, and satellite phones, enabled the U.S. Marine Corps to operate more effectively, but the increased effectiveness came at a price. Most of the new equipment is battery-driven and requires recharging. By using solar energy systems, the Marine Corps could reduce the fuel demand of forward-operating bases, thus reducing the number of fuel convoys.

The U.S. Marine Corps company brought a number of different solar panels with them to the Sangin District; they were of different sizes and designed for different purposes. Some were developed for use within the base while others were portable and designed for patrols. Three systems were mainly used: the Ground Renewable Expeditionary Energy System (GREENS), the ZeroBase Regenerator, and the Solar Portable Alternative Communication Energy System (SPACES).⁹⁵

GREENS is a solar powered system capable of supplying electricity to electrical devices in forward operating bases.⁹⁶ The system consists of solar panels, batteries, and software capable of helping soldiers select the energy components required for a mission. The GREENS system used in the Sangin district was based on four portable solar modules that can be folded out into two large solar panels. Using photovoltaic effect, the solar panels can charge a battery that can store power over night. GREENS could provide an average

continuous output of 300 W and power four computers at a time in the Afghan sun, which is enough to power a platoon's command center. Due to its small size, the system could be transported by Humvees and was flexible and easy to set up.

The ZeroBase Regenerator is a large power source capable of running more than 20 lighting systems and 15 computers by using sunlight to produce electricity.⁹⁷ The version used by the U.S. Marines in 2010 was composed of six solar panels that funneled energy into a single battery capable of powering the electrical devices throughout the night.

The U.S. Marines used SPACES to power platoons and squad-size units operating in remote locations.⁹⁸ The system is lightweight and portable and uses solar light to recharge batteries. Marines could carry the flexible 4 m², 1 kg panel, which can be rolled up or stowed in a pack. Instead of carrying around batteries for satellite communication radios and other minor electronic devices, the Marines could use SPACES to power equipment while on extended patrols. They also brought a PowerShade, which was a large solar tarp that could fit over a Marine tent to power a lighting system.⁹⁹

The alternative power systems used by the U.S. Marines in the Sangin district have a distinct operational potential. They reduce the dependence on fuel deliveries, thereby reducing a key vulnerability, while enabling the continued use of the equipment that currently gives them an advantage on the battlefield. According to the U.S. Marines Corps, the solar modules enabled the marines operating in Sangin to reduce their daily fuel consumption significantly,¹⁰⁰ which enabled them to increase operational parameters and reduce the number of fuel convoys and thus the risks to the logistics personnel.

The average price of a solar panel system has declined by more than 40% since 2011.¹⁰¹ This makes the systems commercially competitive, and they now appear even more operationally relevant to expeditionary forces due to their flexible and lightweight construction. For the foreseeable future, however, forward operating bases will not be able to rely on solar energy alone.¹⁰² Systems based on solar energy must therefore be able to work effectively with pre-existing sources of energy, such as diesel generators.

To enhance the operational and tactical utility of alternative power sources, it will be necessary to redesign the structures and approaches currently used while preparing and planning operations. In 2011, the U.S. Marines Corps concluded that they 'need[ed] a new methodological approach.'¹⁰³ It will be necessary to revisit and redesign how operations are

prepared. New green strategies and management systems will be central in this regard. New technologies, such as solar panels, can reduce the logistical requirements of operations, which can be further enhanced by developing green strategies or management systems that support green behavior in operations.

4.2 Managing green strategies

Many states have developed green strategies aimed at environmental and climate challenges in recent decades. These strategies have described the saliency of contemporary green challenges and then framed the available policy options. Thus, green strategies are not a new creation. Green strategies for defense are somewhat new, however, and many states are still working on developing comprehensive green strategies for their armed forces. A number of green strategies have already been developed, four of which will be examined in this section: the Expeditionary Energy Strategy of the U.S. Marines Corps, the Operational Energy Strategy of the U.S. Department of Defense, the Sustainable Development Strategy of the British Ministry of Defence, and the Climate and Energy Strategy of the Danish Ministry of Defence. The four green strategies share a number of features but also differ in many ways.

4.2.1 The U.S. Marine Corps and the Expeditionary Energy Strategy

The U.S. Marine Corps developed their 2011 Expeditionary Energy Strategy as a response to the challenges they had faced in Afghanistan and Iraq. The Strategy was drafted to ‘decrease the Marine Corps’ dependence on fossil fuels in a deployed environment (...) and provide the foundational guidance for energy investments and management across the Marine Corps from Bases to Battlefield.’¹⁰⁴ The strategy describes a number of current operational challenges that are linked to the consumption of fossil fuels. The strategy highlights how over the last 10 years, the Marines’ ‘energy consumption has grown exponentially, driven by enhancements to command, control, communications, computers, and intelligence technologies; hardened vehicles; and weapons systems (...) In executing (...) prolonged campaigns, our sustainment has also increased.’¹⁰⁵ Marines today use advanced technologies on the battlefield that give them important military advantages but also limit operations due to fuel and energy constraints: ‘Over the last ten years we have become more lethal, but we have also become heavy. We have lost speed. To reset the balance, we must return to our Spartan roots – fast, lethal, and austere.’¹⁰⁶

The Expeditionary Energy Strategy was drafted to recalibrate the vision, mission, and scope of the U.S. Marines Corps and to identify specific initiatives capable of addressing current

operational challenges. The Marine Corps wanted to minimize their logistical tail and operate with less load and a reduced environmental footprint. Thus, the strategy was drafted to align expeditionary energy posture with the force called for in the “Marine Corps Vision and Strategy 2025.”¹⁰⁷

The Expeditionary Energy Strategy frames a mission containing three generic initiatives.¹⁰⁸ First, upgrade legacy equipment and procure and use more efficient equipment. Second, increase the use of renewable energy through innovation and adaptation. Third, change how energy is thought of within the U.S. Marines Corps. According to the strategy, it would be decisive for the success of the new line of thinking to equate efficient resource consumption with increased combat effectiveness.

The strategy presents a number of specific goals for bases and the battlefield, which address two general areas: technology and behavior. With regard to technology, the strategy stresses how the Marine Corps should ‘increase energy efficiency of weapons systems, platforms, vehicles, and equipment (...) [and] seek innovative renewable energy and energy storage capabilities that can be deployed in expeditionary environments.’¹⁰⁹ In terms of behavior, the Marine Corps should ‘embed expeditionary energy into the USMC ethos (...) [and use monitoring instruments to] manage expeditionary energy performance.’¹¹⁰

Thus, the U.S. Marine Corps drafted their 2011 Expeditionary Energy Strategy in response to specific operational challenges. To handle these challenges, the strategy focused on behavior and technology and developed a number of specific goals for alternative energy use, energy and water consumption, and the consumption of petroleum for non-tactical use.¹¹¹

The Marine Corps’ Expeditionary Energy Strategy was not drafted without political involvement. The 2009 National Defense Authorization Act contained directives for operational energy management, planning, requirements development, and acquisition.¹¹² Hence, the Expeditionary Energy Strategy was also drafted to align the Marine Corps with new political guidance.

The political intentions were framed in 2010, when the U.S. DoD and the Department of Energy issued a Memorandum of Understanding: ‘Energy Efficiency can serve as a force multiplier, increasing the range of endurance of forces in the field while reducing the number of combat forces diverted to protect energy supply lines, as well as reducing long-term

energy costs.¹¹³ In connection to this the U.S. DoD published “Energy for the Warfighter: Operational Energy Strategy” in 2011.

The new energy strategy was aimed at meeting the operational challenges created by increased military fuel consumption. The strategy repeatedly stated that the DoD’s main mission was ‘to protect the American people and advance the Nation’s interests.’¹¹⁴ To enable this, the U.S. Armed Forces would need to reconsider their use of resources due to a changing security environment. Hence, working for a more sustainable planet was not a primary objective of the armed forces. Yet a number of challenges meant that the armed forces needed to reduce their energy consumption. According to the strategy, the U.S. had to:

prepare for a much broader array of security challenges (...) The United States will need a broad portfolio of military capabilities with maximum versatility. (...) To build and sustain the 21st century military force (...) the Department of Defense must use its resources wisely, and that includes our energy resources.¹¹⁵

The goal of the “Operational Energy Strategy” is ‘to assure that the armed forces will have the energy they require for 21st century military missions.’¹¹⁶ To reach this goal, the strategy outlines three principal lines of effort: 1) reduce energy consumption in military operations; 2) expand and secure the supply of energy to military operations; and 3) build energy security into the future force.¹¹⁷ The three ways of reaching the goal all rely on a combination of new technologies and changed behavior. Technological development will not in itself be sufficient; it is also necessary to change service personnel behavior and the management schemes guiding their actions. Data on the consumption of energy resources was highlighted as a key element in this effort.¹¹⁸ By having valid information regarding energy resources consumption, the political and military decision-makers would be able to allocate resources to the most effective solutions and target the most significant problems.

Of the three lines of effort described in the U.S. Operational Energy Strategy, the third is the most comprehensive and long-term. The extent to which new technologies and changed behavior can reduce demand and increase supply is limited. The existing military capabilities have not been produced with lower energy consumption in mind. It will become necessary to develop and procure capabilities that have been specifically designed for low energy consumption to go beyond the limits determined by the current capabilities. Real changes in energy consumption will only be achievable by incorporating considerations of energy consumption in defense planning and procurement.

In sum, the energy strategies developed by the U.S. Marines Corps and the DoD were based on an identification and description of specific operational challenges. These analyses were used to identify specific solutions by describing the links between challenges and solutions, thus enabling comprehensive considerations of different technological and behavioral solutions.

4.2.2 The United Kingdom's Sustainable Development Strategy

The UK has had a green strategy for defense, the Sustainable Development Strategy, since 1994, which has been revised in 1999 and 2005 (HM Government, 2005). In 2011, the British government published "Mainstreaming sustainable development – The Government's vision and what this means in practice"¹¹⁹, which was developed as a shared government framework for sustainable development in the UK. In this connection, the British Ministry of Defence (MoD) published a new green strategy, the "Sustainable Development Strategy – A Sub-strategy of the Strategy for Defence"¹²⁰.

The Sustainable Development Strategy provides direction for what the British armed forces must do 'to become increasingly sustainable during the period 2011–2030.'¹²¹ It consists of two parts: a strategy looking out 20 years and a plan that identifies and outlines specific targets and actions for the first four years.

The Sustainable Development Strategy initially states that it is informed by three drivers: legislation, government, and the benefits of sustainable development to defense.¹²² The MoD published the strategy to comply with legislation and contribute to the British government's mainstreaming efforts. In addition, the strategy states that there is an 'overwhelming business case for SD [sustainable development] in Defence'¹²³ based on the assumption that 'global environmental, social, and economic pressures pose real threats to Defence's ability to meet its strategic objective.'¹²⁴ Hence, the British armed forces must consider sustainable development in their operations to ensure the security of the people of the UK and the Overseas Territories. A number of other benefits are listed to further substantiate and motivate the business case: less reliance on fossil fuels in the theatre of operations will reduce the amount of fuel that must be transported to the frontline; using fewer natural resources, less energy, fuel and water and producing less waste will save money; and acting more sustainably could reduce criticism and boost public support for defense, which could pave the way for more favorable conditions.¹²⁵ Thus, the strategy clearly distinguishes between political objectives and military operational considerations.

Based upon legislation, government plans, and the business case for sustainable development in defense, the strategy outlines one key objective and five additional objectives to be achieved by 2030.¹²⁶ The key objective is ‘to have ensured that environmental, social, and economic threats, impacts, and opportunities are fully taken into account in Defence decisions and in the management of Defence activities.’¹²⁷ The remaining five objectives focus on reducing operational reliance on fossil fuels, reducing Greenhouse Gas emissions from defense, reducing waste production, increasing waste recovery, reducing water consumption, and reducing key suppliers’ waste, water use, and Greenhouse Gas emissions.¹²⁸ While the objectives are all related to sustainable development, they are not explicitly linked to the ‘overwhelming business case’ for sustainability in defense.¹²⁹ It is therefore difficult to trace how the five objectives will achieve the prospects of the business case and whether they are the most effective ways to meet legislation, government plans, and the challenges of defense.

The limited description of the development and selection of the five objectives is reflected in how the MoD presents the benefits of sustainable development. In the “Sustainable MOD Annual Report 2013/14,” the MoD states that: ‘Environmental, social, and economic pressures on a global scale have major implications for Defence’s ability to meet its strategic objectives (...) Embracing sustainability throughout Defence will ensure that it is prepared for and adapts to these challenges.’¹³⁰ Thus, the MoD is assumed to be able to tackle the security challenges of the future, both at the strategic and operational levels, by including sustainability in military operations. However, this description leaves out an explanation of how the Sustainable Development Strategy will prepare the MoD for both levels of challenges. The objectives of the strategy are primarily linked to the strategic level—resource scarcity, climate change, and waste. Handling these challenges is a very different task than handling the operational challenges that military forces will meet in future operations. Sustainability will likely be an important element in handling the operational challenges. However, the operational challenges are asking for a distinct strategy and distinct objectives. By not substantiating how sustainability will prepare the MoD for both levels of security challenges, it becomes difficult to assess the viability of the British Sustainable Development Strategy.

To summarize, the UK has worked with green strategies for a number of years, and the MoD has acknowledged that the agenda is highly influenced by political considerations and ambitions, which is reflected in the strategy documents. This political clarity has significant

strategic potential. However, the potential is challenged by how the objectives are presented in the strategy document. While the objectives appear relevant, it is difficult to assess the distinct potential and importance of the individual objectives. In particular, their relevance to the respective security challenges at the strategic and operational levels.

4.2.3 Denmark's Climate and Energy Strategy

Like the British Ministry of Defence, the Danish Ministry of Defence (MoD) has had green strategies addressing climate and environmental challenges for a number of years. Denmark has had an Environmental Strategy for its armed forces since 1993 and an Energy and Climate Strategy since 2012. The Danish policy has been aimed at reaching both short-term improvements through technology and more long-term advances achieved via behavioral change enabled by action plans and strategies. Thus, the 2013/2014 NATO Defence Planning Capability Review stated that 'Denmark (...) [is] working to ensure that defence operates in an energy efficient way and saves resources where feasible.'¹³¹

Prior to the development of the Climate and Energy Strategy for Danish defense, energy challenges were addressed in the Environmental Strategy. The introduction of a distinct Climate and Energy Strategy reflects how the climate turned politically salient in the 1990s and 2000s. The Danish Climate and Energy Strategy followed developments in the European Union (EU) and was drafted to meet an EU agreement that stated that the EU and its member states were moving to 'a competitive low-carbon economy in 2050'.¹³² In 2011, "the European Council reconfirmed the EU objective of reducing greenhouse gas emissions by 80–95% by 2050 compared to 1990."¹³³ To reach this target, the EU member states pledged to address energy consumption in all public sectors, including defense.

The Climate and Energy Strategy of the Danish MoD initially states that green solutions are beneficial for a number of reasons. The increased use of green solutions will enable Denmark to reduce its energy consumption, save money, and gain operational benefits.¹³⁴ The components of the strategy are presented on the basis of this general description of the strategy's objectives. The strategy contains a *mission*, three *visions*, and six *focus areas*.¹³⁵

The mission is to enable the Danish armed forces to reduce their energy consumption while working for peace and security in the world at home and abroad.¹³⁶ The three visions are that, by 2020, the Danish armed forces will: 1) reduce energy consumption by no less than 20% in comparison to 2006; 2) increase the level of electricity consumption from renewable energy

to at least 60%; and 3) reduce carbon emissions stemming from activities¹³⁷ by 40% in comparison to 1990.

The strategy then identifies six focus areas: energy optimization of buildings, energy and environment in operations, renewable energy and energy conversion, climate-appropriate and energy-appropriate behavior, climate accounts, and energy management.¹³⁸ The strategy describes the background and purpose of each of the focus areas and then outlines a number of ‘tangible’ targets that will ‘give practical form to the vision of the strategy’.¹³⁹ The strategy operates with three different phases across the six focus areas.¹⁴⁰ First, to develop more and better information on energy consumption and greenhouse gas emissions in the Danish defense. Second, to analyze, identify, and set targets for activities and to identify the best and most cost-effective solutions. Third, a number of new green activities should be initiated based on the available information. In relation to each of the focus areas, the strategy presents a number of initiatives and actions, including construction standards, certification, new technologies, changed individual and collective behavior, research, new accounting schemes, and green management.

The Danish armed forces have carried out a number of campaigns to achieve long-term reductions in energy consumption through behavioral change. For instance, the Danish Defence Estates and Infrastructure Organisation has prepared a number of information campaigns, which have primarily been about changing the behavior and habits of the military personnel. The slogan for one campaign was ‘Sign up for the battle against overconsumption.’ The campaigns targeted the service’s sergeant schools, the first step in a Danish officer’s career, to have an impact on the individual officer’s behavior from an early stage.¹⁴¹

The Climate and Energy Strategy published by the Danish Ministry of Defence is both comprehensive and tangible. It includes technologies and behavioral initiatives and addresses the challenges currently stemming from limited information. The mission and the clear targets set by the visions create a solid basis for the development of concrete green policies. The clear and tangible character of the strategy’s elements also form comprehensive grounds for discussing green initiatives in the armed forces. The Danish Ministry of Defence is currently preparing a new Climate and Energy Strategy, and the new strategy will benefit from the information that has been made available by the former strategy; both in relation to

the planned information development and the implementation of the specific green policy solutions.

The new Climate and Energy Strategy of the Danish MoD would gain by providing a clearer description of how the mission, the visions, the focus areas, and the specific initiatives have been developed. While all of the initiatives described in the current strategy can contribute to reducing military energy consumption, it is difficult to assess their individual potential. An important part of such a description would be to substantiate why the different focus areas have been selected since that would create a stronger basis for assessing the viability and potential of the individual focus areas.

4.2.4 Organizations, challenges, and strategies

The content and format of the American, British, and Danish green strategies display how a number of different political, military, technological, and organizational aspects influence the development of green strategies. While the strategy developed by the U.S. Marines Corps focuses on a limited number of operational challenges, the British and Danish strategies are more general, which of course relates to different objectives, tasks, organization, and legacy equipment.

These differences mean that different countries and state agencies must formulate their own distinct green strategies. The clear mission statement issued by the U.S. Marines Corps provides a tangible basis for a green strategy. In a political organization with a wide number of tasks and more general objectives, such as the British and Danish Ministries of Defence, establishing clear links between the overall objectives and the specific initiatives and actions described in a strategy poses a greater analytical challenge. This also means that it is challenging to identify best practices beyond basic generic considerations. However, a number of lessons are still to be learned at this level, most importantly to identify the objectives, describe the challenges, and comprehensively link the challenges to the green solutions. The examples presented in this section display why this is important and how some organizations have handled the challenge.

The examples have also framed the importance of clear links between different levels of green strategies. Green strategies should be linked vertically through government agencies from the highest political level. State agencies such as the ministry responsible for defense and the armed services should develop green strategies that are clearly linked to the green strategies of higher state authorities. Many states have developed cross-government green

strategies in recent years to which green strategies for defense should be clearly linked. This will enhance coordination and provide a basis for the development and implementation of viable green strategies and technologies.

5. Linking green solutions to security challenges

When General Allen and Secretary Panetta argued that new energy technologies could improve military operational effectiveness, they were not speaking to a well-known military debate or an established research agenda. Instead, they were addressing specific contemporary operational challenges in Afghanistan and Iraq. The 2014 NATO Green Defence Framework reintroduced Allen's and Panetta's arguments while at the same time expanding the discussion by introducing a number of additional security challenges and green initiatives. Thus, the NATO framework included both new and well-known insights and experiences. By combining these elements, the NATO framework provided a basis for discussing political, military, technological, and managerial issues that have not conventionally been addressed together.

As the NATO framework and the Green Defense concept are still under development, it is too soon to review the framework. However, it would be beneficial to further substantiate the elements of the framework, particularly what kinds of activities Green Defense should consist of and prioritize.

Solutions and activities related to Green Defense can, as done in this report, be grouped into two categories, namely technologies and strategies. These two categories are linked to actors and challenges on a number of different levels. The span and variation of the two categories have not been mapped in this report. Instead, the report has presented specific examples of green technologies and green strategies. The examples were presented to display the possibilities and challenges green technologies and green strategies offer to political and military actors and organizations.

The examples displayed how it can be analytically difficult to describe the link between green military solutions and various security challenges. This analytical challenge is important to emphasize and should be addressed in future green policy initiatives. The relevance, impact, and cost-effectiveness of different solutions is difficult to assess if the links between solutions and challenges are not analyzed and described comprehensively. The link can be described qualitatively and quantitatively (or both) but should be clearly addressed. This is particularly

important in the development and selection of green solutions, since many of the security challenges will be of cross-cutting nature and involve multiple areas, organizations, and policies. Table 2 illustrates how the link between green solutions and different security challenges can be analytically unfolded.

Table 2: Linking green solutions to security challenges

		Security challenges			
		<i>Military operations</i>	<i>Defense expenditures</i>	<i>Energy security</i>	<i>Climate change</i>
Green solutions	<i>Technology_A</i>				
	<i>Technology: SPACES</i>	<i>Increase operational parameters</i>	<i>Modest reduction in theatre fuel consumption</i>	–	–
	<i>Technology: HRD-76 biofuel</i>	–	<i>Until now not commercially sustainable</i>	<i>Reduced vulnerability due to diversification in fuel consumption</i>	<i>Potential to reduce greenhouse-gas emissions from marine diesel</i>
	...				
	<i>Strategy_x</i>				
	<i>Strategy: U.S. Marine Corps</i>	<i>An agile and deployable force with limited fuel dependency</i>	<i>Significant reduction due to reduced fuel consumption on the battlefield</i>	–	–

Table 2 illustrates how green military solutions often address more than one security challenge. This multiplicity in aims makes it important to assess the distinct potential of green solutions; not because green solutions should be able to handle all security challenges but because the development, procurement, and use of green solutions should reflect the political priorities.

The examples covered in section 3 are included in Table 2 (the Solar Portable Alternative Communication Energy System (SPACES), the biofuel used by the Great Green Fleet (HRD-76), and the U.S Marine Corps’ Expeditionary Energy Strategy). Subject matter experts would be required to fill out the table comprehensively. However, the potential of the

technologies and the strategy can be assessed on a generic level to illustrate the links between the green solutions and security challenges:

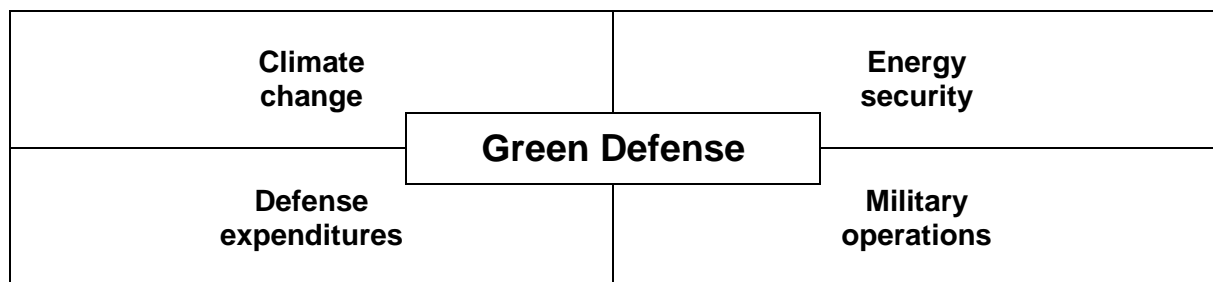
- The flexibility and portability of SPACES makes it a technology with clear potential for military operational use. However, the low energy production of SPACES also means that it has limited potential regarding energy security and global climate change.
- The research and experiences of the U.S. Navy have not yet resulted in the development of commercially sustainable marine biofuel. The Great Green Fleet initiative can potentially reduce the energy security challenge, but high costs and limited supply still makes marine biofuel a financial and logistical challenge.
- The Expeditionary Energy Strategy developed by the U.S. Marine Corps focuses on the objective and “roots” of the organization; namely to be fast, lethal, and austere. Based on this narrow organizational objective, the strategy can focus on current operational challenges and outline green initiatives aimed at specific battlefield challenges. Due to the high costs of bringing fuel to the battlefield, the strategy has significant potential for reducing defense expenditures. The strategy refers only briefly to energy security and global climate change and contains no specific initiatives aimed at these challenges.

Green military technologies and strategies can, and often do, address multiple security challenges simultaneously. This follows from the cross-cutting nature of the security challenges, and green solutions will need to cover a number of policy areas to handle the challenges.

6. Conclusions

The 2014 NATO Green Defence Framework builds upon and further develops the debate about using green defense solutions to handle current security challenges. Green solutions have previously been linked, particularly in the U.S., to military operational effectiveness. Large amounts of fuel are required to operate the advanced military technologies currently used on the battlefield, and fuel consumption in both Afghanistan and Iraq turned out to be a significant military vulnerability. The NATO framework combines this operational challenge with a number of other security challenges, namely defense expenditures, energy security, and global climate change. This is illustrated in Figure 2.

Figure 2: The Green Defense concept and the security challenges it is aimed to address



In the course of the last decade, a number of scholars and military analysts have researched and discussed how green solutions can be used by defense to handle contemporary and emerging security challenges. In 2009, Deloitte’s Department of Defence Practice and Federal Government Services published a report on operational energy security entitled “Energy Security: America’s Best Defense.” The report has been a common point of reference in discussions of green military solutions. The report emphasized how new energy technologies could reduce fuel consumption, thus limiting the need for vulnerable fuel convoys. The Deloitte report therefore argued that technologies that could reduce fuel consumption should be ‘ranked on par with more effective weapons systems, sophisticated fuel transport tankers, more resistant armoured vehicles, and net centric sensing technologies.’¹⁴²

While the Deloitte report holds a central place in the debate about green solutions in the military, a number of scholars and analysts have also made contributions, and their work and conclusions are important to note for a more comprehensive understanding of Green Defense. Contributions by Hornitschek, Bochmann, and Baer focus on the massive consumption of fossil fuels by the U.S. DoD. They identify security challenges at the strategic, operational, and tactical levels and argue that new technologies should be introduced together, and in coordination, with strategies that can change the behavior of soldiers and military organizations.

The security challenges and green solutions identified and analyzed by Deloitte, Hornitschek, Bochmann, and Baer fall into three overall clusters: challenges, general solutions, and specific solutions. It has proven difficult for policy-makers to describe analytically how challenges and specific solutions are linked. Green policy initiatives are often motivated on the basis of a general presentation of all of the security challenges. By not establishing and explaining the links between security challenges and green military solutions, it becomes

highly difficult to assess whether a specific solution is relevant, efficient, and effective and to see how it connects to political priorities.

This report has grouped green solutions into two broad categories: 1) technologies and 2) strategies that support behavioral change. This categorization is analytically beneficial because it emphasizes that neither things nor behavioral change alone can handle the security challenges. New technologies and changed behavior will need to be developed and introduced in conjunction with one another.

The report has presented a number of specific green military initiatives to unfold how green technologies can be used and behavioral change can be achieved. These examples were meant to neither encapsulate nor reflect the vast range of available technologies nor the variation in green strategies. Instead, the examples were used to shed light on the development and use of green technologies and green strategies.

With regard to technology, the report focused on the development and use of biofuel in ships and planes by the U.S. and Italian naval forces and on the use of solar technologies by the U.S. Marines Corps in the Helmand province to reduce fuel consumption. The two examples displayed how it can be difficult to develop and introduce green technologies if it is not clearly stated which security challenges the solutions are meant to solve, and how.

On the case of behavioral change, the report focused on the green strategies of the U.S. DoD, the U.S. Marines Corps, the British Ministry of Defence, and the Danish Ministry of Defence. The American, British, and Danish strategies revealed how a number of different political, military, technological, and organizational considerations contribute to influencing and forming green strategies. Differences in organization, tasks, challenges, policy programs, and legacy equipment entail that the strategies have been formulated differently. The report placed particular focus on how the green strategies identify objectives, challenges, and green solutions, and how these elements are linked in the strategies.

The examples of technologies and strategies have shown how it can be difficult to link security challenges and green solutions due to the cross-cutting nature of both the security challenges and the green solutions.

Seven recommendations can be made on the basis of these conclusions:

- The NATO framework and the Green Defense concept should be further substantiated and should clearly describe which activities Green Defense is composed of and prioritize.
- Much research has already been done by NATO member states on green solutions for defense, and NATO should facilitate more coordinated research efforts and increased information-sharing to avoid duplicate research.
- The number of green technologies that potentially could be used by military organizations is vast and currently unmapped. This lack of overview is a hindrance to strategic political prioritization. NATO should therefore seek to develop a more comprehensive mapping of the available technologies.
- Political and military decision-makers in NATO and its member states should seek to analyze and comprehensively describe how a green solution is linked to a security challenge before deciding on a specific set of green solutions.
- Green strategies for defense should be developed in coordination with the green strategies of other state agencies.
- When selecting and developing green solutions, NATO and its member states should analytically describe how green technologies and strategies are coordinated.
- To create long-term changes in how the military uses green solutions, it will be necessary to change how new technology is developed and procured. The Green Defense concept should therefore be incorporated into the NATO Defence Planning Process.

While the Green Defense concept sounds like something to strive for in times of security and prosperity, green defense solutions have proven their ability to increase operational effectiveness and limit operational costs. The concept also holds much promise with regard to energy security. Diversification in energy sources and reduced consumption of energy will be key elements in forming a policy response to future energy security challenges. NATO's Green Defence Framework should therefore not be forgotten in times of tension and great power politics. Military forces and societies will be more resilient if they have developed and implemented viable green solutions.

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