STC

159 STCEES 13 E bis
Original: English

NATO Parliamentary Assembly

SCIENCE AND TECHNOLOGY COMMITTEE

NEW ENERGY IDEAS FOR NATO MILITARIES: BUILDING ACCOUNTABILITY, REDUCING DEMAND, SECURING SUPPLY

REPORT

Osman BAK (Turkey)
Rapporteur
Sub-Committee on Energy and Environmental Security

www.nato-pa.int

13 October 2013

TABLE OF CONTENTS

I. INTRODUCTION

1. Ever since the introduction of the internal combustion engine in the 1850s, energy resources have played an important role in military thinking. However, since the advent of fuel-hungry jets in the 1950s, military energy consumption has grown exponentially, rendering the provision of energy of central importance to military planners. US soldiers serving in the recently concluded Iraq mission consumed roughly 103 litres of fuel per day, compared to only 6.3 litres during World War II (Molis, 2012). At the same time, the growing energy requirements of modern soldiers' combat gear and of the sophisticated electronic devices deployed on military bases have resulted in a significant increase in the amount of electricity consumed. The ever-growing amounts of fuel and electricity necessary for powering modern warfare have also created the need for expensive logistics and supply lines, which depend on the permanent availability of aerial refuelling tankers, fuel tanker trucks, and other supply vessels.

2. Of course, the heightened use of energy has enabled NATO forces to reach unprecedented levels of effectiveness. Until recently, NATO militaries therefore paid little attention to increasing energy efficiency and to pursuing new energy sources. Plentiful, inexpensive supplies of petroleum products and electricity prompted defence planners to focus their attention on building weapons platforms that were bigger, faster, and more powerful – no matter how energy intensive. However, in recent years, it has become increasingly obvious that energy is no longer an inconsequential expense.

3. In light of the economic, environmental, and security risks posed by militaries' steadily increasing dependence on energy, this report evaluates the risks of inefficient military energy use and discusses measures taken by individual NATO member states and collectively within NATO and the European Union (EU) to address these risks. Specifically, this report undertakes to examine what new ideas have been developed across the Alliance to increase the energy efficiency of militaries. Towards this end, it provides snapshots of some of the main activities Allied militaries have carried out in recent years with regard to building energy accountability, reducing energy demand, and securing energy supplies.

II. THE NEED FOR NEW ENERGY IDEAS FOR NATO MILITARIES

4. The proposition that Allies need to formulate and implement new ideas to strengthen the energy efficiency of their militaries has been challenged on various accounts. It has been argued that the steady increase in the amount of energy militaries use has been a vital prerequisite for making NATO's armed forces as effective as they are today. In this line of reasoning, the effectiveness of military equipment and thus the achievement of strategic objectives are fundamentally dependent on the availability of unrestricted supplies of energy, specifically fossil fuels. In other words, critics of military energy efficiency initiatives fear that concerns about energy usage could trump sound strategic considerations.

5. Another argument frequently put forward against more efficient military energy consumption is that the availability of substantive amounts of new fossil energy resources, such as unconventional gas and oil, diminishes the need for greater energy efficiency. Indeed, in the United States (US), some military strategists have argued that unconventional gas and oil will provide the military with cleaner energy at lower prices on a sustained basis for decades to come. While the exploitation of unconventional energy sources still meets with scepticism in Europe, similar arguments might soon emerge among European military strategists.

6. Last but not least, some experts have argued that the costs of diversifying energy supplies are too high. This criticism is most often levelled at alternative fuel initiatives. An underlying argument is that alternative fuels have lower energy densities than petroleum and that therefore more fuel would have to be used to achieve the same power output. The bottom line is that alternative fuels fail to promise any performance advantages, which might ultimately make them

more expensive than petroleum. Moreover, doubts have been expressed about the possibility of producing biofuels in quantities sufficient to replace petroleum in military energy planning.

7. While some of these arguments may appear sound at first sight, they neglect the wider negative effects that high levels of military energy consumption can have on the fiscal health of Allies in times of austerity, on environmental sustainability, and on the security of NATO soldiers and military installations. Indeed, the generation and implementation of new energy ideas for NATO's militaries are an economic, environmental, and strategic imperative.

A. AUSTERITY

8. The costs of powering NATO militaries, both in operational theatres and at home, have increased vastly ever since the first oil crisis in the 1973 and particularly over the last decade. The main reason for soaring costs has been the growing price of energy itself, specifically petroleum. During fiscal year (FY) 2005, for example, the US Department of Defence (DOD) spent US$ 8.8 billion for 130 million barrels of petroleum supplies. During FY 2008, the DOD spent US$ 17.9 billion for 134 million barrels. In other words, for almost the same amount of petroleum purchased in 2005 the DOD paid almost twice the price in 2008 (Reichert et al., 2011). Significantly, in contrast to oil prices, the costs of renewable energies have declined rapidly in recent years, with the price of solar panels having decreased by more than 60% since 2009 (Reichert et al., 2011).

9. Another reason for the increase in military expenditures for energy has been a steady growth in the amounts of energy militaries require to power their operations. This is first and foremost a result of the increasing mechanisation of the armed forces and the rise in the number of expeditionary missions Allies have conducted in recent years. Thus, in 2010, the US DOD, for example, spent about US$ 15 billion on energy to conduct military operations (Roughead, Carl & Hernandez, 2012). US armed forces consumed nearly 5 billion gallons of petroleum in military operations at a total cost of US$ 13.2 billion, representing a 255% increase over the amount spent in 1997 (Roughead, Carl & Hernandez, 2012).

10. A third reason for the growing price of military energy supplies, which is often neglected, are the significant external costs of consuming energy in conflict theatres that arise from transport, storage, and human resource requirements. Indeed, a substantial amount of the costs associated with energy consumption in conflict theatres arises from transportation, which itself requires considerable amounts of energy. Additionally, in out-of-area operations, thousands of troops protect energy convoys and storage spaces. These troops cannot be assigned to perform other pressing tasks, raising overall manpower needs. Taking all these factors into consideration, the US DOD has estimated that the cost of petroleum consumed in theatres easily amounts to US$ 40 per gallon and in some cases even more (Reichert et al., 2011).

11. In the future, high levels of fossil energy consumption by militaries could become even more expensive because of tightening environmental regulations. Currently, NATO militaries – like most military forces around the globe – are largely exempted from meeting the costs of producing CO_2 emissions. However, as the international community and individual states formulate and implement ever stricter environmental legislation for civilian as well as military activities, the indirect costs for excessive use of oil and other carbon energy resources could also increase for militaries.

12. Finally, a range of other, less tangible costs are also associated with high levels of military energy consumption. The development and procurement of more efficient military energy capabilities can provide an economic stimulus to civil sector industries, creating new jobs and capital. Technological developments in the military sector have often provided the basis for even more ambitious commercial developments, including computers, the Internet, the Global Positioning System, and semiconductors. Existing research suggests that US military investments in new energy technologies might reach US$ 10 billion a year by 2030. Abandoning military energy efficiency efforts would therefore undermine a potential source of economic development and innovation, especially in areas where there is little civilian investment.

B. SUSTAINABILITY

13. Since the human and economic costs of military operations are high, their environmental costs are rarely taken into consideration. However, the environmental costs of high levels of military energy consumption are considerable and unsustainable in the long-term. NATO militaries produce enormous amounts of carbon emissions both at home and abroad, the impact of which has crucial global repercussions.

14. While it is always difficult, if not impossible, to fully establish the carbon footprint of large organisations, some basic estimates of Allies' carbon footprints have been provided in the past. At the end of the last decade, the United Kingdom's (UK) Ministry of Defence (MOD) estimated that it had produced approximately 5.5 million tonnes of CO_2 emissions per year, with almost two million tonnes emanating from non-operational energy use at fixed installations (RUSI, 2008; UK Ministry of Defence, 2009). An even more worrying picture emerges when examining the carbon footprint of the military operation in Iraq. The British newspaper *The Guardian* has estimated that, between 2003 and 2010, all military operations in the country taken together released about 250-600 million tonnes of CO_2 per year (The Guardian, 8 July 2010). By comparison, an EU citizen produces on average around 8.9 tonnes of carbon dioxide per year, which adds up to close to 4.5 billion tonnes of CO_2 emissions across the EU (Eurostat, 2011).

C. SECURITY

15. NATO militaries' dependence on stable energy supplies has several security implications. Steady energy supplies are a crucial prerequisite for militaries' ability to ensure national security and the security of soldiers in the field. Military installations in NATO member states host a multitude of critical systems, which require energy 24 hours a day, 365 days a year. In operational theatres, shortage of fuel and electricity could halt combat operations and disrupt support functions.

16. Another security dimension is inherent in the transport of energy. The need for large amount of fossil fuels can only be met by a large number of fuel convoys, the protection of which puts soldiers' lives at considerable risk. In 2010, there were 1,100 attacks on ISAF (International Security Assistance Force) fuel convoys in Afghanistan. It has recently been estimated that there is one casualty for every 46 convoys. When briefing an STC delegation on its June 2013 visit to Texas, John M. King, Executive Director of CleanTX, the core industry group for energy and clean technology in Central Texas which is very involved with US defence energy efforts, told Committee members that this number could be as high as one casualty per 24 convoys. Official records further show that between 2003 and 2007 the protection of fuel convoys resulted in more than 3,000 military and contractor casualties. Yet, a NATO mission can hardly be accomplished without these fuel convoys. In 2011, Pakistan closed the border with Afghanistan three times, which held down 4,000 fuel trucks at the border, causing considerable disruptions to the ISAF mission and creating higher energy costs, as fuel had to be brought in from more distant areas.

17. The considerable number of convoys necessary for providing energy and the need to protect these convoys not only divert forces from combat operations and war fighting. The need for steady energy supplies also affects those soldiers who are engaged in combat operations. Thus, it has been estimated that up to 20% of NATO soldiers' combat gear, which has a total weight of 30-40 kg, consists of batteries. For each day on mission, NATO soldiers must carry more than 3 kg of batteries. Naturally, this negatively affects mobility and ultimately survivability [see the 2013 STC General Report on *Improving the Survivability of NATO Ground Forces (158 STC 13 E)*]. Therefore, even when energy needs are met, dependence on energy supplies might still pose a risk to soldiers' lives.

III. NEW ENERGY IDEAS ACROSS THE ALLIANCE

18. Various Allies and NATO partner countries, such as Australia, Canada, France, Germany, Italy, the Netherlands, Spain, or Sweden, have pursued a proactive approach in recent years with regard to developing new energy ideas for their militaries. The French Defence Ministry, for example, is pursuing a sustainable defence development strategy, which inter alia aims at raising energy consumption awareness by introducing effective energy consumption measurement tools, reducing energy consumption by improving the energy efficiency of fixed installations, and diversifying energy supplies by exploring biomass and renewable energy sources (French Ministry of Defence, 2011a; 2011b; 2012). In the summer of 2013, Italy's Navy tested non-food biomass fuels, including algae-based biofuels, for use in its naval fleet, and Sweden is planning on performing tests in 2013 and 2014 on powering its Air Force with biofuels made from wood scraps. In 2011, the Science and Technology Committee learned first-hand about the Spanish efforts to greatly reduce the energy consumption of the roughly 170,000 MOD employees when visiting the Maranosa Institute of Technology, the MOD's main research and development institution (Science and Technology Committee, 2011).

19. Many other important military energy efficiency projects are pursued across the Alliance. However, due to the space constraints inherent in NATO PA reports, this report focuses on examining the activities of three NATO member states, namely the United States, the UK, and Turkey, as well as the efforts of NATO's most crucial non-state partner, the EU. In selecting these particular activities, attention was paid to the relative expenditures and sizes of militaries. Thus, the United States was chosen for being the largest NATO military contributor; the UK for being the biggest military spender in Europe; and Turkey for being the European NATO member state with the largest number of active military personnel. The selection of countries under review in this study also makes for an interesting comparison. While the United States and the UK have a long-standing track record in improving the energy efficiency of their militaries, Turkey has only recently begun to invest in this area, but is eager to make swift progress. The EU is NATO's most important non-state partner and very active in increasing the energy efficiency and effectiveness of its member states, many of which are also NATO members.

20. In looking at the efforts of the three Allies and the EU, the following sections discuss the three principle dimensions of increasing military energy efficiency: building accountability, reducing demand, and securing supplies. NATO's own efforts with regard to increasing the military energy efficiency of its members within these three dimensions are discussed subsequently and separately in section IV.

A. BUILDING ACCOUNTABILITY

21. Building energy accountability translates first and foremost into fostering energy awareness at various levels. Leadership on energy efficiency plays a key role in formulating overarching policy change, while energy awareness training at the individual level is at the heart of wider behavioural changes that create a sense of ownership. Both aspects are crucial building blocks of successful energy efficiency policies. However, reliable benchmarking tools for energy usage are just as important when it comes to the effective implementation of such policies. As the following sections show, leadership, ownership, and benchmarking all play an important role in the military energy accountability activities pursued by Allies and the EU.

1. United States

22. In recent years, the different branches of the US armed forces have formulated detailed energy strategies, which outline several areas for energy awareness activities. The 2009 Army Energy Security Implementation Strategy, for example, highlights the strengthening of energy leadership, ownership, and accountability (US Army, 2009). With regard to promoting energy

efficiency leadership, the US Army has mandated its senior officials to nourish an energy efficiency culture by promoting the implementation of new energy efficiency proposals into existing and future strategies, projects, and efforts. At the level of individual ownership, the Army regularly conducts energy training courses and new Army recruits receive energy efficiency instructions from the first day. Moreover, Army commands, offices, and personnel are increasingly held accountable for their energy usage, and incentives are provided for developing and implementing innovative energy solutions.

23. To make energy a consideration in all activities it carries out, the Air Force has set up a dedicated Culture Change Working Group (CCWG). The overarching aim of the CCWG is to instil an energy efficient management culture and to promote individual ownership. To this end, the CCWG pursues activities in three principle areas, namely leadership, individual training, and benchmarking (US Air Force, 2010). Thus, the CCWG encourages Air Force leaders to regularly initiate personal communications with subordinates on energy management and to demonstrate their commitment through personal actions. At the same time, a system is in place that rewards leaders for energy efficient management practices. To promote energy awareness at the individual level, the CCWG has launched awareness campaigns and new training courses. Currently, the CCWG is also developing a set of incentives aimed at encouraging energy efficiency among Air Force personnel, such as specific energy awards. In order to establish an energy efficiency benchmark, the CCWG is aiming at regularly measuring workforce motivations, alignments, and actions. In addition, surveys will be used to measure how well energy awareness and individual responsibility for energy efficiency has penetrated different segments of the work force.

24. The 2010 Navy Energy Vision for the 21st Century puts general policy change, coherent leadership, and individual training at the heart of the Navy's efforts to raise energy awareness (US Navy, 2010). Policy change for greater energy efficiency awareness primarily denotes embracing technologies that help monitor energy consumption directly and take into account the indirect factors influencing consumption, such as observed or forecast weather and ocean currents. To ensure a coherent approach to changing its energy policy, the Navy has appointed a Director of Operational Energy who is responsible for providing overall leadership. Reporting to a Senior Energy Council, the Director works with all Navy stakeholders to ensure that energy considerations are seamlessly incorporated into decision-making processes. At the individual level, the Navy has introduced energy awareness training courses as well as incentives for energy conscious behaviour.

2. United Kingdom

25. In 2011, the British MOD adopted a sustainable development strategy, which defines the promotion of energy awareness among all military branches as a key objective (UK Ministry of Defence, 2011). Recognising that overarching organisational values are of prime importance to increasing energy efficiency, the MOD has committed itself to integrating energy efficiency considerations into all future strategic documents.

26. The current MOD sustainable development strategy also highlights the commitment of defence leaders as a crucial driver of energy efficiency. Accordingly, the MOD encourages senior defence officials to personally lead by example and to demand that their staff do the same. In addition, the MOD has appointed 'sustainable development champions' who act as ambassadors for energy efficiency.

27. On the individual level, the MOD has identified training and engagement as essential prerequisites for changing behaviour. Over the last years, defence training courses have therefore been adapted to include modules on energy efficiency and effectiveness. Furthermore, mechanisms are being developed to allocate clear responsibility and accountability to individuals on their energy usage.

28. In recent years, the MOD has been at the forefront of developing reliable benchmarking tools for measuring energy consumption. Recognising that it is difficult to manage energy consumption if

the latter cannot be measured effectively, work is undertaken to improve the quality and coverage of data. In this respect, the MOD draws on a so-called Fully Burdened Cost of Energy (FBCE) model. The FBCE model provides insights into the full costs of energy at the point of usage, taking into account, among other factors, the logistics effort required to transport the energy to its point of consumption, the infrastructure to store and generate it, the cost of protecting it, and the costs produced by CO_2 emissions. The FBCE model has already generated several valuable insights. For example, although providing forward bases with electricity typically accounts for only 3% of the fuel usage in deployed scenarios, the generation of this electricity easily accounts for 20-30% of the fully burdened energy costs.

29. Incorporating not only the actual use of energy but also the costs associated with infrastructure and logistics support, the FBCE model also helps to identify where investment in energy technologies can produce cost savings in the future. Indeed, considering the fully burdened costs of energy may provide a compelling case for investing in more expensive but also more efficient energy infrastructure and transport technologies in the future.

3. Turkey

30. The energy budget of Turkey's armed forces amounts to about US$ 900 million annually. Twenty percent of the budget is earmarked for electricity, 25% for heating, and the remaining 55% for fossil fuels, which are primarily used to power aircraft and vehicles. In view of the considerable resources spent on energy, the Turkish armed forces have recently intensified their efforts to build greater energy accountability among staff members. Moreover, a committee has been set up to co-ordinate energy efficiency activities.

31. The Turkish MOD has also established a special Energy Efficiency and Environmental Management Unit, which has been tasked with providing analyses and reports on increasing energy efficiency across all military branches. The Unit also designs and implements projects that aim at promoting the systematic evaluation of strategic decisions and developing action plans in line with energy efficiency objectives. In addition, the Turkish MOD has appointed a number of energy managers who are mandated to raise energy awareness among stakeholders across the military branches.

4. European Union

32. Ever since its creation in 2004, the European Defence Agency (EDA) has been at the helm of EU efforts to promote and coordinate common European projects on increasing the energy efficiency of EU militaries. However, given its firm focus on the technical side of multinational defence capability development, the EDA has only engaged in a limited amount of awareness raising activities to date. These include two workshops, focusing on sustainable energy supplies in crisis management operations, which were conducted in 2011 and 2012 respectively (European Defence Agency, 5 May 2011; European Defence Agency, 6 February 2012).

33. Since its launch in 2011, the European External Action Service (EEAS) has also become increasingly involved in raising energy awareness among EU militaries. In September 2012, the EU Military Staff, which is part of the EEAS, presented a European Union Military Concept on Environmental Protection and Energy Efficiency for EU-led military operations. The Concept calls for organisational, behavioural, and technological changes (Council of the EU, 2012). Organisational changes primarily refer to increasing the interoperability of military resources and promoting the standardisation of equipment in line with higher energy efficiency requirements. With regard to promoting behavioural changes, the concept suggests a pragmatic incorporation of energy awareness training and education into existing programmes. In terms of technological changes, the concept calls for an ambitious modification of energy supplies. This includes the introduction of new energy generation technologies alongside conventional ones as well as the creation of efficient storage and distribution architectures. The EU's concept also calls for the reduction of energy consumption by introducing automated energy management systems and structural improvements, such as better thermal insulation. As the concept has only been adopted

recently, it is still too early to assess its impact on the energy culture of EU militaries and the conduct of EU-led military operations. However, not least due to the concept, the Lithuanian government, which is holding the EU Presidency during the second half of 2013, has announced plans to institutionalise energy security considerations as a major component in the strategic planning for future EU military operations and in the design of common EU defence procurement projects.

B. REDUCING DEMAND

34. As a result of Allies' ongoing efforts to build greater energy consumption accountability, many new energy ideas for NATO militaries have revolved around reducing demand. Reducing military energy demand has two principle dimensions: the fixed installations dimension and the operational dimension. Taking the example of the United States to illustrate the first dimension, reducing energy consumption at fixed installations means reducing the energy consumption of more than 500,000 buildings and structures at 500 major bases around the world. All of these buildings require energy for electronics, lighting, heating and cooling. While there is substantial potential for reducing energy consumption at such large facilities, it is also a challenging task with long timelines.

35. In addition to energy consumption at fixed installations, militaries require operational energy. Operational energy includes the energy necessary for training, moving, and sustaining military forces and weapons platforms for military operations. Operational energy usually constitutes a much bigger share of the energy militaries consume than the energy required for powering fixed installations. Efforts to reduce military energy consumption should therefore start with mobile assets deployed abroad. Indeed, improving energy efficiency and effectiveness of NATO aircraft, ships, and ground vehicles arguably represents the cheapest and fastest way of reducing overall military energy dependence.

1. United States

36. The DOD has pursued initiatives to increase energy efficiency at its bases for more than a decade. As a result, between FY 2003 and FY 2010, overall energy usage at both fixed and at forward operating Army bases was reduced by 11.4% (Reichert et al., 2011). Nevertheless, among all US government agencies, the Army still has the highest levels of facility energy consumption. During FY 2010 alone, US$ 1.2 billion were spent on powering bases at home and in theatre (Roughead, Carl & Hernandez, 2012). In response, the DOD has established one of the most ambitious energy efficiency programmes in the Alliance with the Installation Energy Test Bed programme (Strategic Environmental Research and Development Program, n.d.). The programme is focused on developing and testing new energy technologies in five specific areas: lighting, heating, and cooling; energy management and control; smart grid and energy storage; energy assessment and design; and alternative energy generation. While still underway, the initiative has already yielded more than 45 demonstration projects since its launch in 2009. Collectively, these projects have the potential to reduce energy demand by 50% in existing Army buildings and by 70% in new constructions.

37. During FY 2010, the Army spent US$ 2.5 billion on fuel purchases for combat and non-combat vehicles deployed in operational theatres (Roughead, Carl & Hernandez, 2012). A prime objective in reducing the Army's overall operational energy consumption has therefore been to reduce the consumption of fossil fuels. To this end, the Army has focused on promoting the development of medium- and heavy-duty electric vehicles that could replace the current fleet of 190,000 non-combat vehicles. Accordingly, in June 2011, the DOD released a call for proposals for an electric vehicle that could be deployed at a cost that is competitive with internal combustion engine non-combat vehicles.

38. The Army has also conducted work on improving the energy efficiency of current and future combat vehicles. In mid-2012, the Fuel Efficient Ground Vehicle Demonstrator (FED) was presented as proof of the feasibility and affordability of achieving significant reductions in combat

vehicle fuel consumption without sacrificing performance or capability (US Army Tank Automotive Research, Development and Engineering Center, n.d.). While the FED itself will not go into production, some of its components and technologies will be incorporated into the current fleet as well as in future designs. However, despite the recent advances, future generations of US Army ground vehicles are projected to weigh more and therefore to also burn more fuel than current models (Sarewitz et al., 2012).

39. Similarly, the future equipment of US soldiers deployed in combat theatres is likely to consume more energy. In the past, the Army has made few efforts to cut the amount of power consumed by electronic equipment, such as radios, even though it is widely recognised that readily available off-the-shelf commercial products could significantly reduce the energy needs of combat gear (Sarewitz et al., 2012). Indeed, as battery-powered systems and equipment are proliferating, US soldiers could end up carrying even more batteries in the future.

40. Like the Army, the Air Force has focused its efforts to reduce energy consumption on reducing fossil fuel consumption. The Air Force has been investing in a Versatile Affordable Advanced Turbine Engine programme, which seeks to improve fuel consumption by 25% compared with other state-of-the-art engines [see the 2013 STC Special Report on *The Future of Combat Aircraft: Towards a 6th Generation?* (160 STC 13 E)]. The Air Force is also trying to optimise fuel consumption by implementing energy management and operational initiatives, such as modifying routes, improving aircraft centres of gravity, increasing the use of flight simulators, and adjusting aircraft-to-crew ratios. Taken together, all of these activities generated savings of US$ 494 million during FY 2012 (Reichert et al., 2011).

41. To date, the Navy has arguably accomplished the greatest tangible achievements in the battle for lower energy consumption. By installing so-called stern flaps, which reduce drag and therefore the energy required to propel a ship, the Navy has achieved annual savings of up to US$ 450,000 per ship over the last few years. Recently, the Navy has also begun to introduce hybrid energy systems on board of some of its ships. Commissioned in 2009, the USS Makin Island is equipped with a hybrid electric propulsion system, which combines diesel, gas, and electric propulsion and is expected to save more than US$ 250 million in fuel costs over the course of its lifecycle. In the near future, a similar hybrid electric drive system will also be tested and installed as a proof of concept on the USS Truxtun. The Navy has also invested US$ 91 million during FY 2012 into developing more advanced materials for propellers and water jets as well as systems that allow ship hulls to eliminate biological growth, such as algae, which increases drag. Moreover, since 2010 many Navy bases have seen the introduction of a Resident Energy Conservation Programme, which offers financial rewards for military families consuming less energy than the normal usage.

2. United Kingdom

42. In recent years, the British armed forces have undertaken a wide range of efforts to reduce energy consumption. The British Army has built a particularly sound track record when it comes to making its forward operating bases more energy efficient. In 2009, for example, the MOD set an ambitious 50% reduction target for fuel consumption at its military bases in Afghanistan (Fielding, 2010; Stein, 2009). To meet this target, more efficient fuel management mechanisms have been implemented at Camp Bastion, which are supposed to reduce fossil fuel consumption by 30%. The remaining 20% are to be achieved by improving insulation and capturing waste energy through combined electricity and heat generation at other British-run bases. Moreover, in 2011, the MOD's Defence Equipment and Support Division presented the findings of a research project on saving energy in forward operating bases (Desider, 2011). The Power Forward Operating Base project demonstrated the possibility of reducing energy costs with the help of a wide range of commercially available technologies and without any major investments.

43. Attempts to reduce the fuel consumption of Army vehicles deployed in operations have met with less success so far. In July 2012, the MOD's Centre for Defence Enterprise launched an ambitious call for proposals on optimising the energy efficiency and effectiveness of existing Army

combat and non-combat vehicle platforms (Centre for Defence Enterprise, 2012). While the evaluation is still on-going, various ideas on technology insertion, such as tools that utilise waste energy, and on systems optimisation, including better utilisation of power systems, appear promising.

44. Over the last years, the Royal Air Force (RAF) has primarily explored operational and training improvements as a basis for reducing energy consumption (Fielding, 2010). For example, several operational adjustments were implemented in response to a 2009 International Air Transport Association study, which had revealed that changes to flight planning, more efficient operation of jets, and improved maintenance procedures could produce savings of £6.9 million (Stein, 2009). The RAF has also examined the possibility of more frequent use of simulator-based air training to reduce the amount of fuel consumed in exercises. On the technical side, recently signed procurement contracts for energy efficient navigation aids and more fuel-efficient aircraft for radar flight checking are expected to result in savings of more than £5 million and 1,600 tonnes of CO_2 until 2015 (Dixon, 2012).

45. The Royal Navy has already achieved several tangible energy saving results. In this respect, the installation of electric transmission gearboxes on board of its ships has been of particular importance (Hodge, 2010). Today, most warships use mechanical transmission whereby a diesel or gas turbine engine drives a gearbox which in turn powers the shaft and propeller. Such systems are most energy efficient at full power and full load. However, since warships need to be able to vary their speeds constantly and thus to be fuel-efficient at all speeds, the Royal Navy has promoted the electrification of vessel transmission systems. The result is a flexible system that can handle a range of speeds and loads without losing efficiency to the extent a traditional mechanical equivalent would. The first warship with a modern electric drive, the HMS Daring, was formally handed over in December 2008. Recognising the advantages of electric propulsion, today, the MOD's default position is that future warships should incorporate electric propulsion. Current Royal Navy plans also envisage the extension of electric drive technologies to most aircraft carriers and submarines.

3. Turkey

46. In the past, most of the Turkish armed forces' efforts to reduce their energy consumption have revolved around improvements at fixed installations. In this respect, an important first step was taken when energy managers were appointed to monitor developments at all installations that consume more than 260 MWh annually and/or that cover more than 10,000 m^2. Calorimeters at all military buildings have been replaced and more energy efficient lighting systems have been installed. The insulation of buildings has also been improved. A Committee for the Coordination of Energy Productivity also constantly reviews all technological innovations in the private sector that may help to increase the energy efficiency of military installations, focusing in particular on solar energy technologies.

47. More recently, the Turkish MOD has also begun to explore the possibility of introducing hybrid electric propulsion technologies as a means to reduce the energy consumption of combat and non-combat vehicles. In addition, solar energy solutions for powering vehicles are being reviewed.

4. European Union

48. To date, only one major EDA effort has been concerned with the development of technologies that could contribute to reducing military energy consumption. Thus, in 2009, the EDA completed an Overall Platform Energy Efficiency Study, which sought to identify the most effective means of reducing energy consumption on board naval ships (BMT Defence Services, 2009). Specifically, the study aimed at identifying new technologies, which could improve the energy efficiency of naval platforms on a whole-ship basis, exploring, for example, new hull/water

interfaces, hydrodynamic designs, prime movers and propulsion mechanisms, electrical transmission systems, and reuse of waste heat.

49. Out of over 100 candidate technologies, 16 were eventually earmarked as warranting further consideration. Detailed analyses were subsequently carried out with reference to four ship types: small and large surface combat ships, large amphibious assault ships, and fleet tanker auxiliaries. Technology roadmaps were created for the most promising technologies. The study also defined the activities necessary for the full development of some of the shortlisted technologies. Eventually, high temperature fuel cells and iso-engines were identified as the most promising technologies when it comes to conducting further research and development (BMT Defence Services, 28 August 2009).

C. SECURING SUPPLY

50. Securing military energy supplies easily translates into diversifying military energy supplies. Indeed, arguably the greatest challenge for NATO forces in overcoming energy dependence is to find a viable substitute for fossil fuels. In this respect, two overlapping types of energy are of interest, namely alternative energy and renewable energy.

51. Alternative energy describes all energy derived from sources other than fossil fuels. One form of alternative energy is alternative fuels, such as biofuels and synthetic fuels. Biofuels currently pursued by military and commercial actors include hydro-treated renewable jet fuel and hydro-processed renewable diesel fuel, both of which can be made from feedstocks, such as camelina, jatropha, rapeseed, soybeans, babassu, animal fats, or plant and cellulosic materials, such as crop residue, wood scraps, switchgrass, algae, or seaweed. Most renewable fuels are ‘drop-in’ substitutes for petroleum fuels. Drop-in substitutes require no costly additional engineering because they must be chemically equivalent and perform to the standards of the petroleum-based fuels they are replacing.

52. Falling under the heading of alternative energies, renewable energies are derived from wind, the sun, water, thermal energy, and biomass. Renewable energies have become increasingly important in powering military efforts. However, renewable energies face at least three considerable challenges. First, currently available technologies are often inefficient. Second, the availability of energy generated from renewable sources fluctuates greatly. Finally, more efficient and less bulky energy storage devices need to be developed. Indeed, the availability of alternative means of converting and storing energy, such as fuel cells and novel batteries, is becoming increasingly important for NATO militaries.

1. United States

53. The last decade has seen a steady diversification of energy supplies at US military installations. In mid-2010, the US military was implementing more than 450 renewable energy projects at bases at home and abroad. The Army, the Air Force, and the Navy are each committed to generating 1 GW of renewable energy on their bases by 2025, which would be enough energy to power 750,000 US homes. To date, one of the most prestigious US Army fixed installation renewable energy projects is a 500 MW concentrated solar power project at Fort Irwin in California (Wall Street Journal, 31 July 2009). Commissioned in mid-May 2013, the installation of a microgrid at Fort Bliss in Texas, which is fully independent of the commercial utility grid, is another ambitious Army project. Until 2017, about 50% of electricity fed into the Fort Bliss microgrid will be generated by a 65 MW solar array. The most ambitious Navy project has been the creation of a geothermal plant of more than 30MW at Fallon Naval Air Station in Nevada. The 14 MW solar array at Nellis Air Force Base constitutes one of the largest projects of its kind in the United States, and the Air Force is also developing other large-scale projects, which should produce between 250 MW and 1,000 MW each (Deloitte, 2010).

54. With regard to introducing renewable energies on forward operating bases, the most ambitious research projects to date have arguably been conducted by the US Marine Corps. In 2010, the Marine Corps initiated the Experimental Forward Operating Base (ExFOB) programme which tested the use of alternative energy technologies, inviting private firms to demonstrate new technologies for renewable energy generation, heating and cooling, shelters, and water purification. Over the course of the programme, Marines incorporated flexible solar technology into the roofs of their tents, which generated enough energy for powering radios or laptops. A group of Marines also tested ExFOB technologies in Afghanistan, operating two patrol bases with renewable energy. The energy savings achieved during the trial period in Afghanistan have prompted the Marine Corps to invest US$ 25 million to provide ExFOB technologies to all of its units in Helmand Province.

55. In addition to the activities pursued at fixed installations, the US Army has also made several efforts to diversify the power supplies of combat and non-combat vehicles and soldiers in various theatres. Thus, the Army has increasingly embraced the use of drop-in biofuels, now aiming at an annual 10% increase in non-petroleum fuel use in non-combat vehicles. Following a debate over the National Defence Authorisation Act, which took place in June 2013, the Senate Armed Services Committee reaffirmed its support for the Army's biofuels programme and the military use of biofuels more generally.

56. The Army has also undertaken considerable efforts to diversify the energy supplies of dismounted soldiers. The US Army Communications-Electronics Research, Development and Engineering Center (CERDEC) currently develops two alternative technologies to power combat gear. The first technology is based on photovoltaic energy generation (Bui, 2010). Photovoltaic technology has featured most prominently in CERDEC's Rucksack Enhanced Portable Power System (REPPS), which includes a flexible solar panel that is capable of recharging batteries and/or acting as a continuous power source. Due to its high procurement costs, its relatively heavy weight of about 4.5 kg, and the rather low efficiency of the solar panels, REPPS has not been made available for wider Army use so far. However, CERDEC staff continue to explore the use of novel photovoltaic material, production processes, and coating techniques, and the Center expects that the findings could translate into making REPPS standard equipment in the near to medium term.

57. The second technology CERDEC is developing is alternative energy fuel cells. The benefits of fuel cell systems are their portability, continuous power supply, lighter weight compared to existing batteries, reduced life-cycle costs, and renewable energy character. Indeed, a fuel cell outperforms traditional batteries by up to sevenfold. Weight savings over batteries become particularly apparent after the first 24 hours of usage, making fuel cell systems very attractive for multi-day missions. CERDEC is developing two different alternative energy fuel cells for portable applications.

58. The Air Force is the biggest operational energy consumer. Therefore, it has been aiming at using alternative aviation fuels for 50% of its domestic aviation needs by 2016. To achieve this, the Air Force successfully completed its first flight test of an aircraft powered by a 50-50 camelina-based biofuel blend in March 2010. Since late-2012, the entire Air Force fleet has been certified to fly on biofuel blends and currently several strategies are under examination to generate a steady supply of sufficient quantities of biofuels.

59. In August 2011, President Obama announced that the US Navy, along with the Departments of Energy and Agriculture, would invest up to US$ 510 million until 2014 to co-finance the construction or retrofit plants and refineries capable of producing significant quantities of advanced biofuels. In this context, the Navy issued a call for industry proposals for establishing a commercially viable drop-in biofuels industry. The initiative is expected to help reduce the cost of advanced biofuels, to ensure that supplies of these new fuels are available for military testing and use, and to spur job creation and economic opportunities in rural parts of the United States. In 2012, the US Navy also adopted a Great Green Fleet concept, which envisages alternative energy sources to meet 50% of all operational Navy energy requirements by 2020 (US Navy, n.d.). As one

of the first steps towards achieving this goal, the Navy demonstrated an F/A-18 Super Hornet (the Green Hornet) on a 50-50 blend of traditional Navy jet fuel (JP-5) and camelina-based HR-J in April 2010. In 2012, the Navy presented a carrier strike group powered solely by alternative fuels.

2. United Kingdom

60. In recent years, the MOD has pursued various alternative and renewable energy activities to diversify the energy supplies on bases at home and in theatres. A case in point has been the £ 280 million investment in Catterick Garrison, which has enabled the installation of new heat pumps, the introduction of solar thermal water heating, which now produces 75% of all hot water, and the super-insulation of buildings. The reforms carried out at Portsmouth naval base, which is one of the largest energy consumers of all fixed British military installations, constitute another example (Team Portsmouth, 2012). The base received solar powered street lamps and its own bio-mass power station in 2012. In conflict theatres, portable solar panels have been issued to British personnel at smaller bases to power electronic devices. In 2011, the MOD's Defence Equipment and Support Agency invited contractors to develop ideas on how forward operating bases could switch to renewable energy sources (see also the section on reducing energy consumption).

61. In order to provide alternative fuels for vehicles, the British Army has worked closely with the US Army on the development of drop-in solutions. Moreover, the British Army is undertaking specific research on algae-based biofuels. Since 2011, Army soldiers in Afghanistan have been equipped with solar panels, which have replaced batteries and thus reduced the overall weight of combat gear. Microbial fuel cells are another alternative to batteries the Army is currently exploring. However, research is still at an early stage, and the same applies to ongoing research on H_2 storage capabilities.

62. Among NATO Allies, the UK was one of the first countries that had its Air Force certified to fly entirely on bio-fuels. Currently, defence firms are examining the viability of producing both manned and unmanned solar-powered aircraft for the Air Force.

63. The MOD's Defence Technology and Innovation Centre explores several opportunities to broaden the range of energy supplies available for powering Navy ships. One research programme explores the possibility of fitting nuclear reactors into ships (Fielding, 2010). Another research project examines the practicability of running existing ships on biofuels and the availability of sufficient quantities of biofuels for powering all Navy ships. Last but not least, several hybrid electric propulsion technologies are being explored and calls for proposals for advanced concepts have been issued.

3. Turkey

64. The Turkish armed forces carefully monitor the emergence of new energy sources, which could contribute to increasing their energy security. They also participate in all NATO projects executed by the NATO Petroleum Committee (NPC) and other relevant sub-committees. In this respect, the Turkish armed forces also support the definition of new NATO STANAGs (NATO Standardisation Agreement) and the evaluation of existing STANAGs.

65. The Turkish armed forces also aware, like other armed forces, that fossil energy sources are limited and that they should initiate projects for new and renewable energy sources. During the last quarter of 2012, the Turkish Navy started to test the use of bio-fuels in their ships. On land, tests for damage detection and power loss detection and the evaluation of their effects are also ongoing.

66. Other bodies of the Turkish MOD, such as the Under-secretariat of Defence Industry or the Research & Development Department, administer projects on the development of Direct Methanol Fuel Cells for Portable Communication Systems as well as synthetic jet fuels. In addition, the Turkish armed forces, in co-operation with the Scientific and Technological Research Council (TUBITAK) and under the auspices of the Western European Armament Group (WEAG), currently execute the Molten Carbonate Fuel Cell project. The results of these efforts and the infrastructure

built in the context of this project are also used in the Full Electrical Ship project. Moreover, the Turkish armed forces use thermal cells for missiles and smart munitions as much as possible as a result of a successful TUBITAK project. The Under-secretariat of Defence Industry also pays close attention to Air Force efforts on promoting Filter Smoke Number -0.6 domestic motors, which consume less energy and produce lower emissions.

4. European Union

67. The EDA has promoted two major research initiatives on diversifying the energy supplies of EU militaries, which have focused on energy generation from renewable resources. Launched in 2006, the first initiative aims at developing alternative and renewable energy sources for powering the equipment of deployed soldiers. The initiative is part of a wider EDA research project on soldier equipment (European Defence Agency, 13 August 2012). The nine EDA member states participating in the project have agreed to jointly develop combat equipment from 2015 onwards. To date, the EDA has hosted two workshops on the energy supply diversification aspects of new combat gear.

68. Since mid-2012, the EDA and seven participating states have also pursued the so-called GO GREEN project. The project is based on the assumption that EU militaries are ideal sponsors of the land necessary for erecting large-scale, energy-generating photovoltaic plants (European Defence Agency, 6 August 2012). Indeed, taken collectively, EU militaries are among the largest owners of land and infrastructure of all public sector institutions, as they possess roughly 1% of the EU's total land surface. The GO GREEN project is supposed to provide a framework for pooling the ownership rights of military land possessions across EU borders and to offer them in bulk to Europe's solar energy development and exploitation industry. The ultimate goal is to enable Europe's militaries to produce the electricity they need for powering their bases at home and to generate additional revenue by feeding surplus electricity into the general electricity network.

IV. NATO'S NEW ENERGY IDEAS: TOWARDS A 'SMART ENERGY' AGENDA

69. Ever since its creation, NATO has shaped the energy supplies of its Allied forces. Indeed, during the Cold War, the Alliance had prime responsibility for ensuring the security of fuel supplies for military forces in Europe. To this end, an extensive NATO Pipeline System (NPS) was built, which, today, runs through 13 NATO countries and connects ten distinct fuel storage and distribution systems. Since the mid 90s, the NPS has also increasingly been used as an 'energy backbone' for operations in theatres outside of Europe, such as – most recently – in Libya. In the post-Cold War era, some Allies have also sought to carve out a role for NATO in energy security beyond the military realm. Thus, rather than focusing exclusively on military energy security, NATO ministerial discussions have often revolved around the energy security of the Alliance as a whole. As the first major NATO strategic document to touch upon the issue of energy security, the 1999 Strategic Concept, for example, stresses that the disruption of "vital resources" – a term that first and foremost refers to energy – could have severe negative effects on transatlantic security. The 2008 Bucharest Summit saw Allies identify a range of NATO activities with regard to protecting Allies' energy security, including facilitating information and intelligence sharing, projecting stability, advancing international and regional cooperation, and supporting the protection of critical energy infrastructure.

70. While the current Strategic Concept, which Allies adopted at the 2010 NATO Summit in Lisbon, underlines NATO's mandate in ensuring the security of its members' energy supplies, the Alliance's growing concern in recent years with military energy efficiency has become increasingly visible in other documents. Thus, the 2010 Lisbon Summit Declaration stresses that the stability and reliability of energy supplies and the diversification of supply routes, suppliers, and energy resources are of critical importance to attaining the Alliance's military objectives. Moreover,

following a number of NATO events that gave experts from academia, industry, and the military an opportunity to raise awareness about energy and environmental issues in the military, Allies agreed at the 2012 Chicago Summit to “work towards significantly improving the energy efficiency of our military forces”, effectively calling for the emergence of a NATO Smart Energy agenda.

71. The Smart Energy agenda received its latest impetus in June 2013 when the Danish and the Lithuanian Delegations to NATO presented a paper, entitled "Towards a Smarter and Greener Defence: NATO and The Green Defence Dimension – Opportunities to Be Investigated". The paper seeks to launch a process with three principle aims, namely to limit the negative environmental effects of defence activities, to make Allies’ existing defence facilities and capabilities more energy efficient, and to reduce the consumption of fossil fuels by NATO militaries. Towards these ends, the Danish-Lithuanian paper proposes several activities to increase NATO militaries’ energy awareness and accountability and to reduce military energy consumption across the Alliance. Specifically, in terms of raising energy awareness, the paper proposes a greater NATO role in conducting and supporting research and information-sharing on military energy efficiency. Moreover, the paper calls for a more visible role for energy efficiency elements in future NATO training courses and exercises. With regard to strengthening energy usage accountability, the paper suggests the creation of a comprehensive NATO database for the collection of information on energy-consumption in NATO operations. Last but not least, the Danish-Lithuanian initiative promotes the formulation of a code of conduct, outlining best practices for member states, and the integration of energy components in the NATO defence planning process. To reduce NATO militaries’ energy consumption, Denmark and Lithuania propose the definition of a set of concrete targets for reducing carbon emissions and fossil fuel consumption, including for NATO-owned structures and agencies. Currently, the NATO Defence Policy and Planning Division is drafting a food-for-thought paper on how to advance the ideas presented in the Danish-Lithuanian paper.

A. SMART INSTITUTIONAL INNOVATIONS

72. In addition to the advocacy work of several Allies, a range of NATO bodies has driven the emergence of NATO’s Smart Energy agenda. NATO's Allied Command Transformation (ACT) has repeatedly hosted events, which have highlighted the importance of energy efficiency in achieving military goals. The Danish-Lithuanian paper suggests that ACT assume an even more visible role in research on military energy efficiency in the future. The launch of NATO’s Emerging Security Challenges Division (NATO/ESCD) in 2010, which has a dedicated Energy Security Section, has also underlined the various links between military energy efficiency, on the one hand, and security, environmental sustainability, and financial prosperity, on the other hand.

73. In November 2011, NATO/ESCD initiated a conference on Innovative Energy Solutions for Military Applications, which took place in Vilnius, Lithuania. The conference brought together over 200 experts from academia, industry, and the military. The event was supported by the NATO Science for Peace and Security (SPS) Programme and organised jointly with the then national Energy Security Centre in Vilnius, which has since become the NATO Energy Security Centre of Excellence (ENSEC COE). Following the success of this event, the ENSEC COE has enhanced its portfolio to include energy efficiency in the military, while NATO/ESCD followed up with national briefings and the Smart Energy Team (SENT) concept.

74. The most recent addition to NATO’s initiatives, SENT was established in late 2012 as a two-year project with support of the SPS Programme. SENT is composed of subject matter experts from eight nations, of which six are Allies (Canada, Germany, Lithuania, Netherlands, the UK, and the United States) and two are force contributing partner countries (Australia and Sweden). The composition of SENT cannot be changed until the end of the project in 2014, when Allies will decide on future initiatives.

75. SENT’s overarching mandate is to steer national smart energy projects towards interoperability. By providing a platform for sharing information and best practices among all stakeholders, SENT draws together various ongoing national and NATO activities, which would

otherwise remain disconnected. SENT's aim is to recommend and initiate multinational Smart Energy projects under NATOs' Smart Defence framework.

76. To date, SENT's work agenda has largely revolved around improving the measurement of energy consumption on military bases, providing an overview of national Smart Energy efforts, and developing specific Smart Energy project ideas, looking in particular at microgrid systems, energy performance measurement tools, and alternative energy technologies. One of SENT's first deliverables is an Internet platform for pooling scientific knowledge and relevant data, including national strategies and results of R&D activities, which is hosted on NATO's server (www.natolibguides.info/smartenergy).

77. Based on requests from its member nations and NATO bodies, the ENSEC COE has developed a rather ambitious work programme, which includes the conduct of strategic analysis and research projects on lessons learned by other NATO bodies, member states, other international organisations, as well as third states with regard to increasing military energy efficiency; the development of new methodological and theoretical approaches to identifying and assessing energy security risks; the adaptation of civil sector energy innovations for military needs; and the latest R&D on increasing operational energy security. Moreover, ENSEC COE is aiming at assuming an implementing role in education and training by developing and delivering courses, integrating energy security aspects into other NATO-accredited courses, and conducting conferences, seminars, and workshops. Accordingly, so far, the work of the ENSEC COE has largely focused on analysis, the organisation of conferences and workshops, the conduct of exercises (such as ENERGEX 2012, which simulated a disruption ISAF's energy supplies), and concept development and experimentation (see below). Holding the EU Presidency during the second half of 2013, the Lithuanian government has suggested that ENSEC COE could assume a consultative role with regard to EU efforts to make European militaries more energy efficient.

B. SMART ACCOUNTABILITY

78. Even before the launch of Smart Energy and the creation of ENSEC COE and SENT, NATO was involved in raising awareness about military energy efficiency and effectiveness. From the mid-2000s onwards, ACT launched several projects to contribute to 'culture change' among NATO's military leaders. Specifically, ACT organised regular training courses. At the same time, ACT has been rather active with regard to documenting energy efficiency best practices in the ISAF mission (see below).

79. Moreover, NATO's SPS Programme has hosted a range of workshops on transatlantic energy security. In this context, the cross-cutting topics of environmental protection, energy efficiency and sustainability of NATO forces were frequently discussed, and the SPS Programme continues to support research activities on innovative energy solutions for NATO militaries and renewable energy solutions with military application. The SPS Programme also continues to support SENT.

80. Since its official launch in 2012, the ENSEC COE has supported NATO's effort in raising awareness about the need for military energy efficiency and effectiveness. The ENSEC COE's mission statement explicitly outlines a future role for the Centre in the development of NATO energy efficiency doctrines, standards, and procedures as well as in the development, validation, and improvement of NATO militaries' energy consumption standards and procedures.

81. However, to date, the major thrust of ENSEC COE activities with regard to building energy accountability has focused on organising and hosting training courses for NATO military commands and staff members. Over the next few years, these training courses will further increase in number and frequency and cover a wide range of topics. In addition, ENSEC COE will contribute to strengthening the quality of training within NATO member states. On the analytical side, ENSEC COE has recently launched a research project on energy management in expeditionary NATO missions.

C. SMART DEMAND

82. If, in the past, Allies have often fallen short in adequately promoting military energy efficiency on an individual level, their collective track record in NATO has been even more problematic. The standardized use of military equipment in NATO missions has repeatedly resulted in lower levels of energy efficiency and thus higher levels of energy consumption. A case in point is the fuel consumption of militaries within the framework of the ISAF mission in Afghanistan. To simplify the logistic efforts, ISAF forces operate under a 'one fuel for all capabilities' policy. This policy prescribes that all fuel-powered systems, such as aircraft, combat vehicles, or electricity generators, have to run on Jet Propellant 8, even though many of these systems were not designed to run on this type of jet fuel. Consequently, many ISAF combat vehicles are currently 10-20% less efficient than they could be. At the same time, the vehicles are more likely to experience mechanical problems and thus to require spare parts, which adds to the operation's overall logistic requirement and the amounts of energy necessary for meeting these requirements.

83. Unnecessarily high energy demand in NATO missions is not only a result of operational inefficiencies but also of inefficiencies on forward and main operating bases. Up to 70% of the fuel delivered to Afghanistan is required for cooling and heating bases. The main reason for this high fuel demand is that many ISAF forces are housed in tents, which are cooled with air conditioning units powered by highly inefficient inter-linked generators. The tents are poorly insulated and air-conditioning is often left on all day, regardless of whether troops are present or not. On top of that, energy generators are often controlled centrally, meaning that all of them are used at all times.

84. As noted in previous sections, over the last five years, US and British forces have increasingly recognised that the way tents are cooled and heated is not sustainable. Several surveys have been conducted to establish ISAF's energy consumption in Afghanistan and to explore possible improvements. The latter include the introduction of spray-on foam insulation, low energy air-conditioning solutions, and alternative electricity generation.

85. Despite these improvements, the ISAF mission has illustrated that in future operations NATO must take a much more active approach to developing energy efficiency measures from the outset. Indeed, the countries that are members of SENT have begun to explore more effective energy solutions with regard to cooling and heating tents, including load-adjustable generators, heat exchange pumps, floor-heating, heat/energy storage insulation material for tents, as well as solar power generation and smart grids. Some of these technologies were demonstrated within the framework of a Smart Energy Multinational Integrated Logistics Unit that was set up at the June 2013 Capable Logistician exercise in Slovakia. The aim of presenting the Unit was to raise awareness about energy efficiency and to showcase possible technical solutions for increasing military energy efficiency. Thus, the three participating NATO nations, namely Germany, the Netherlands, and the UK, demonstrated different technologies that reduce energy demand (for example insulated tent and LED lighting) and that diversify energy supplies (for example solar cells and hydrogen fuel cells).

D. SMART SUPPLY

86. While implementation is still in its infancy, recent years have seen NATO develop what might be labelled a Smart Supply energy strategy. The three principle areas of NATO activity outlined in the strategy are of direct relevance to securing the energy supplies for NATO militaries. First, the strategy foresees NATO establishing itself as a dialogue broker and hub for information and intelligence sharing among Allies, partner countries, and the private sector on the security of critical energy infrastructure in energy producing and transit countries, on the security of transport routes, and on the analysis of terrorist threats. Moreover, NATO aims to co-ordinate analyses of potential risks to energy transits to NATO operational theatres.

87. Second, NATO could become a more visible actor in promoting the protection of critical civilian and military energy infrastructure in member countries. Thus, at an Ally's request, NATO

can contribute to the protection of energy delivery routes which are crucial for transatlantic security, such as sea lanes or pipelines, either through civilian experts or military means. Moreover, NATO's civil emergency planning capabilities can be employed in case of a man-made or natural disaster to restore steady energy supplies to military facilities and other key civilian institutions.

88. A third and arguably less explicit area of NATO activities geared towards securing civilian and military energy supplies is the shaping of political and socio-economic reform processes in NATO's broader strategic environment. NATO's aim is thus to further strengthen political relations and military co-operation with partner countries, many of which are either energy producers or transit countries. Indeed, energy security issues have featured more frequently in recent years in NATO co-operation programmes with partner countries.

89. Notably, NATO's current Smart Supply strategy is very much focused on securing the supply of traditional energy sources, specifically fossil fuels. Indeed, the only Smart Defence project that deals with increasing military energy security, the so-called "Multinational Logistics Partnership for Fuel Handling", is aimed at optimising the provision of fuel to forces deployed in conflict theatres. At the same time, NATO's work on diversifying energy supplies for military purposes has remained limited. However, if NATO wants to play a more visible role in future debates about the energy supplies of its members' militaries, ACT, ESCD, ENSEC COE, and particularly SENT should make even greater efforts to put energy diversification on the Alliance's agenda. In this respect, initial steps could include fostering improvement of data collection on energy performance, and diffusing knowledge on microgrids and alternative power generation. However, NATO's ability to promote new energy ideas among Allies will ultimately require the support and collaboration of member states. As the summary of activities pursued by the United States, the UK, Turkey, and the EU shows, the energy record of the Alliance is ultimately defined by its constituting members.

V. NEW ENERGY IDEAS FOR NATO MILITARIES: THE WAY FORWARD

90. This report has examined the rationale for new energy ideas for NATO militaries. It has argued that the generation and implementation of such new ideas are crucial in the face of economic, environmental, and strategic challenges. The report has presented a range of new ideas on building accountability, reducing demand, and securing supply that have been developed across the Alliance to increase the energy efficiency of militaries. Special attention was paid to the activities of the United States, the UK, Turkey, the EU, and NATO.

91. Even though the report has shown that there is a compelling logic to invest money into increasing NATO militaries' energy efficiency, there is a risk that military energy programmes will be cut in an attempt to save money, as defence budgets continue to stagnate or decrease. This would be short-sighted, as many of the activities outlined in this report show that there are clear economic benefits to be gained in the long run. Therefore, NATO member states should examine new energy ideas, not only with regard to their short-term merits, but also with regard to their long-term benefits.

92. Military energy efficiency and interoperability is an area where NATO as an organisation can provide significant added value by encouraging nations to agree on standards, education, and training and on integrating technologies. Given that the implementation of new energy technologies and approaches in military settings is still at an early stage, few established interests are at stake – a fact that often hinders co-operation on other potential Smart Defence projects. Moreover, many technologies that could bolster military energy efficiency, such as mobile energy storage devices or improved tent insulations, are already available in the private sector and could therefore be bought off-the-shelf at a relatively low price. Indeed, NATO military authorities could consider identifying NATO's shortfalls and requirements in line with technologies already available, and corresponding Smart Energy projects could be developed. These projects should be relatively easy to initiate under NATO's Smart Defence agenda, especially if the first steps concentrate on quick wins.

Furthermore, if the current Smart Energy initiatives prove themselves to be effective tools of transformation, they should be firmly institutionalised. In conclusion, the Alliance would do well to pick these low-hanging fruits to increase the energy accountability and interoperability, to reduce the energy consumption, and to diversify the energy resources of its militaries.

BIBLIOGRAPHY

BMT Defence Services, "BMT completes Overall Platform Energy Efficiency Study for European Defence Agency", 28 August 2009, http://www.naval-technology.com/contractors/warship/bmt-defence/press22.html

BMT Defence Services, *Overall Energy Platform Efficiency Study Volume Three: Executive Summary*, Brussels: EDA, 2009

Bui, Tony, "Alternative Energy Solutions for the US Army", *RUSI Defence Systems*, Vol. 13, No. 1, 2010

Centre for Defence Enterprise, *Energy Efficiency and Optimisation for Defence*, UK Defence and Technology Laboratory, 11 July 2012, http://www.science.mod.uk/controls/getpdf.pdf?714

Council of the EU, *European Union Military Concept on Environmental Protection and Energy Efficiency for EU-led Military Operations,* Brussels: Council of the EU, 2012

Deloitte, *Energy Security: America's Best Defense*, New York: Deloitte, 2010

Desider, "Saving Energy in Front Line Military Bases", *UK Defence Equipment and Support*, 7 October 2011, http://sd.defra.gov.uk/2011/10/saving-energy-in-front-line-military-bases

Dixon, Maurice, "Delivering Sustainable Air Power", *RUSI Defence Systems*, Vol. 14, No. 3, 2012

European Defence Agency, "21st Century Soldier", 13 August 2012, http://www.eda.europa.eu/projects/projects-search/21st-century-soldier

European Defence Agency, "Energy Supply for EU Crisis Management – Lessons Learned and Opportunities Identified", 5 May 2011, http://www.eda.europa.eu/info-hub/events/2011/03/28/energy-supply-for-eu-crisis-management-lessons-learned-and-opportunities-identified

European Defence Agency, "European Armed Forces GO GREEN", 6 August 2012, http://www.eda.europa.eu/projects/projects-search/european-armed-forces-go-green

European Defence Agency, "Workshop on Energy & Environment and 5th Progress Meeting of Energy Supply for Camps – 22-23 March 2012", 6 February 2012, http://www.eda.europa.eu/info-hub/news/12-02-06/Workshop_on_Energy_Environment_and_5th_Progress_Meeting_of_Energy_Supply_for_Camps_-_22-23_March_2012

Eurostat, *Carbon Dioxide Emissions from Final Consumption*, 2011, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Carbon_dioxide_emissions_from_final_consumption#Carbon_dioxide_emissions_associated_with_EU_consumption

Fielding, Ray, Capability Vision: Reducing Operational Dependence on Fossil Fuel, 2010, http://www.rusi.org/downloads/assets/Ray_Fielding.pdf

French Ministry of Defence, *Stratégie de développpement durable de la défense ; rapport d'activité 2011*, 2011a

French Ministry of Defence, *Directive DEF/SGA/DMPA/SDIE/ENV du portant noveau plan d'action environment du ministère de la défense*, 2011b

French Ministry of Defence, *Strategie ministerielle de la performance energetique*, 2012

Hodge, Chris, "The Electric Warship: Using Energy More Efficiently", *RUSI Defence Systems*, Vol. 13, No. 1, 2010

Molis, Arūnas; "Fuel Supply got Military Missions and Operations – In Search for Solutions", *Energy Security Highlights*, First Quarter, 2012

Reichert, Joshua, et al., *From Barracks to the Battlefield: Clean Energy Innovation and America's Armed Forces*, Washington: The Pew Charitable Trusts, 2011

Roughead, Gary, Jeremy Carl, and Manuel Hernandez, *Powering the Armed Forces: Meeting the Military's Energy Challenges*, Stanford: Hoover Institution Press, 2012

RUSI, *RUSI Alternative Energy and Sustainability Project*, London: RUSI, 2008

Sarewitz, Daniel, et al., *Energy Innovation at the Department of Defense: Assessing the Opportunities*, Washington: CSPO, 2012

Science and Technology Committee, *Mission Report: Visit to Madrid, Spain, 21-23 September 2011*, NATO Parliamentary Assembly, 2011, http://www.nato-pa.int/Default.asp?SHORTCUT=2692

Stein, Paul, "Alternative Energy for the Military", *RUSI Defence Systems*, Vol. 12, No. 2, 2009

Strategic Environmental Research and Development Program, "Installation Energy Test Bed", n.d., http://www.serdp.org/Featured-Initiatives/Installation-Energy

Team Portsmouth, "Energy Saving on a Major Scale", 2012, http://www.teamportsmouth.co.uk/documents/Shorside%206%20Low-Res.pdf

The Guardian, "What's the carbon footprint of … the Iraq war?", 8 July 2010, http://www.guardian.co.uk/environment/green-living-blog/2010/jul/08/carbon-footprint-iraq-war

UK Ministry of Defence, *MOD CO2 Emissions 2008/09*, 2009, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/27614/MOD_CO2_0809_hyperlinked_charts_final_version_v3.pdf

UK Ministry of Defence, *Sustainable Development Strategy: A Sub-strategy of the Strategy for Defence 2011-2030*, London: UK Ministry of Defence, 2011

US Air Force, *Air Force Energy Plan 2010*, Washington: US Air Force, 2010

US Army, *Army Energy Security Implementation Strategy*, Washington: US Army, 2009

US Army Tank Automotive Research, Development and Engineering Center, "FED Bravo Vehicle Puts Efficiency on Display", n.d., http://tardec.army.mil/news/fed_bravo_debuts_at_sae.aspx

US Navy, "Great Green Fleet", n.d., http://greenfleet.dodlive.mil/energy/great-green-fleet

US Navy, *A Navy Energy Vision for the 21st Century,* 2010, http://greenfleet.dodlive.mil/files/2010/10/Navy-Energy-Vision-Oct-2010.pdf

Wall Street Journal, "Army Green: Ft. Irwin Has Builders for 500 MW Solar Project", 31 July 2009, http://blogs.wsj.com/environmentalcapital/2009/07/31/army-green-ft-irwin-has-builders-for-500-mw-solar-project