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Energy Self-Sufficient Military Installations: Rewards and Obstacles

JOHN R. DENI, PHD[1],
Research Professor of National Security Studies,
Strategic Studies Institute, US Army War College

On 27 March, 2013, more than 580 cadets at the U.S. Military Academy in West Point, New York participated in a day-long Army Energy Summit. The venue was particularly relevant, considering West Point is one of several U.S. Army installations chosen to participate in a pilot program to reduce energy consumption, increase overall energy efficiency, re-purpose waste energy, and make key investments in renewable capabilities. The Assistant Secretary of the U.S. Army for Installations, Energy and Environment, Ms. Katherine Hammack, spoke to the future leaders on the difficulty of developing technologies to enable military installations to become net zero users of energy as well as the arguably more formidable challenge of building an energy-informed culture that will enable the U.S. Army to focus on developing energy opportunities and eliminating vulnerabilities.

Prospects versus impediments: whether and how

The prospect of turning military installations into net zero consumers of energy is, at first glance, intuitively appealing to policy-makers, military practitioners, and the general public. In an era of defense budget austerity on both sides of the Atlantic, the cost savings that might be achieved through completely self-sufficient military installations alone would appear to be extremely compelling. However, despite the potentially significant benefits of self-sufficient military installations, there remain important impediments in Europe and the United States to achieving net zero use of energy on military installations. Whether and how the transatlantic community can overcome these obstacles and thereby achieve a host of benefits individually and collectively remains to be seen – in some instances, greater public-private collaboration as well as greater collaboration among countries within and through the Atlantic alliance may prove fruitful.

Reasons to turn to alternative energy sources

The opportunity to turn existing military installations into net zero users of energy through the use of alternative energy sources would seem to be of great interest to military entities across the transatlantic community, their civilian leaders and policy-makers, and the tax-paying publics that support them for at least three reasons. First, self-sufficient military installations reduce defense costs.

Defense austerity has come to both sides of the Atlantic, a response to both the winding down of conflicts in Iraq and Afghanistan and the broader debt crisis. If history is any guide – particularly the drawdowns following the Korean War, the Vietnam War, and the Cold War – defense spending in the United States and among its allies may drop as much as 30 percent in real terms over the coming decade. At the same time, energy costs show

[1] The views expressed here are the author's alone and do not necessarily reflect those of the United States, the U.S. Department of Defense, or the U.S. Army.

The U.S. Department of Defense (DoD) pays roughly $4 billion per year in installation energy costs today, an enormous sum by any measure and reflective of the fact that DoD remains the single largest consumer of energy in the United States.

no sign of falling significantly despite the unconventional fossil fuel revolution unfolding across North America. For instance, the United Kingdom's Ministry of Defense estimates that by 2015, at least 3.9 percent of the UK's defense budget will be spent on energy, rising to 7 percent in 2020.[2]

Through both energy efficiency and alternative energy development efforts though, military entities are striving to save money and cut costs.[3] The U.S. Army, for example, is attempting to turn eight installations into net zero users of energy by 2020 and thereby reduce the Defense Department's energy costs. So far, this 'Net Zero' initiative has seen some success. For instance, from 2003 to 2012, the U.S. Army reduced installation energy consumption by 13 percent even though the number of active Soldiers and civilians on installations increased 20 percent over that same time period.[4] The U.S. Navy has set ambitious future clean energy goals, including having half of the energy used by the Navy come from alternative sources by 2020 – all in an effort to reduce costs to the U.S. Navy and the U.S. Defense Department.[5] At Nellis Air Force Base in Nevada, the U.S. Air Force began operating a massive solar array in 2008 that resulted in $1.2 million in energy cost savings in the first year of operations alone.

A two-megawatt solar array at Fort Carson, Colorado produces enough energy for 540 homes.
Photo credit: U.S. Army.

2 "Energy Efficiency and Optimisation for Defence," UK Ministry of Defence, August 28, 2012, available at www.science.mod.uk/events/event_detail.aspx?eventid=178.

3 Alexandra Hemmerlybrown, "Army launches 'Net Zero' pilot program," ARNEWS, April 20, 2011, available at www.army.mil/article/55280/.

4 Katherine G. Hammack, testimony delivered before the Senate Armed Services Subcommittee on Readiness and Management Support, March 12, 2012.

5 Eric Wesoff, "US Bancorp Funding SolarCity's Solar-Strong Military PV Roof Program," Greentech Media, March 13, 2012, available at www.greentechmedia.com/articles/read/U.S.-Bancorp-Funding-SolarCitys-SolarStrong-Military-PV-Roof-Program/.

Second, self-sufficient military installations reduce military exposure to civilian energy networks, which is potentially beneficial for several reasons. In many cases, civilian grids are increasingly antiquated. Older equipment is naturally subject to increasingly frequent and lengthy power outages, particularly during periods of peak demand such as the summer months. At the same time, aging civilian energy grids are becoming more susceptible to increasingly severe weather patterns resulting from climate change. The so-called 'superstorm' Sandy in October 2012 left seven million people and an unknown but similarly large number of businesses and government offices in the densely populated mid-Atlantic section of the United States without power for several days. Hurricane Katrina in 2005 and the 'Snowmaggedon' storm of 2010 similarly caused civilian power grids in the United States to shut down for days, forcing military installations that rely on them to resort to local fossil-fuel generators.

When power lines go down for whatever reasons, military organizations turn to such generators, increasing cost, burdening the military with additional logistical fuel delivery tasks, and contributing to man-made climate change. In order to alleviate these problems, some military entities are attempting to develop the ability to disconnect from the civilian grid. For instance, at the Twentynine Palms military base in California, the U.S. Marine Corps has developed a 'microgrid' that includes an independent power plant and a solar panel field, which together permit the base to disconnect from the civilian grid.

A promising example of energy consumption reduction - exploitation of the eight installations: Fort Bliss (TX), Fort Carson (CO), Fort Detrick (MD), Fort Hunter Liggett (CA), Kwajalein Atoll (Marshall Islands), Parks Reserve Forces Training Center (CA), West Point (NY), and statewide facilities of the Oregon Army National Guard on the basis of 'Net Zero' pilot program of US Army.

Disconnecting from the civilian power grid has the added benefit of reducing exposure to efforts by state or non-state actors to wield energy as a political weapon. Certainly since the 2006 and 2009 Russian-Ukrainian gas disputes, and arguably as early as the 1970s, many in Europe and North America have feared European overreliance on Russian energy supplies. If Russia were to turn off those energy supplies during a crisis, the military forces of European allies reliant on civilian power grids might find themselves confronted with debilitating challenges. Non-state actors – particularly those capable of implementing cyber-attacks on critical energy infrastructure – provide another reason for military entities to limit reliance on civilian power grids. Energy self-sufficient military installations mitigate the risks associated with the efforts by individual hackers or collectives to harm or disable critical civilian energy infrastructure.

Finally, self-sufficient military installations allow military organizations to potentially reinvest harvested savings into current operations, modernization, or other national security priorities. During these times of budget austerity, there are certainly many national treasuries and finance ministries that are instead intent on funneling any funds saved through energy efficiency and self-sufficiency toward other pressing domestic budgetary priorities. But in other instances, defense agencies or services are permitted to retain or reallocate funds saved through efficiency measures.

Confronting up-front costs

Despite these and other seemingly obvious benefits of developing and maintaining energy self-sufficient military installations, there are significant hurdles as well. For instance, there can be major up-front budget or fiscal costs to convert existing installations into self-sufficient ones or to remove military bases from the civilian power grid. To achieve the U.S. Army's Net Zero goals – which will include water and waste initiatives as well – the Army will reportedly award $7 billion in contracts over 30 years. The U.S. Army is attempting to mitigate the costs of achieving energy self-sufficiency through greater public-private collaboration. For example the Army has a program that encourages the private sector to install alternative energy generation capabilities on bases in the United States, and then the

Army buys the energy produced by those alternative generating sources. To date, the Army has secured about $1.5 billion in these types of third-party investments on Army bases[6].

Challenging scale restrictions

However, these kinds of cost-reducing initiatives may be out of reach for many U.S. allies because of problems of scale. Given its massive size and budget, the U.S. Department of Defense can command market attention from technology entrepreneurs, helping to shape and drive technological advances in energy efficiency and self-sufficiency. For example, the U.S. Department of Defense owns 300,000 buildings across 5,000 installations in the United States alone – in contrast, the United Kingdom's Ministry of Defense owns roughly 45,000 buildings worldwide. DoD uses these buildings and installations as a kind of distributed 'test bed' to demonstrate and validate energy-related (and other) technologies in a real-world, integrated building environment.

Smaller allies with smaller defense establishments lack that kind of market-driving capability and are therefore somewhat more hampered when acting individually. The North Atlantic alliance can play perhaps a critical role here, in helping at least the European allies to collectively address this subject and perhaps attain market-driving capabilities similar to that enjoyed by the U.S. Department of Defense. Although the United States still spent more on defense than all of its European allies combined in 2012, European NATO defense spending amounted to over $400 billion last year[7], a not insignificant amount of money and a potential force for shaping and driving technological innovation.

In addition to the up-front budgetary challenges of achieving energy self-sufficiency, there are also physical and/or environmental constraints. The chief alternative energy power sources at U.S. military facilities include geothermal sources, which require particular geologic characteristics, or vast solar arrays, which require consistent sun exposure and substantial excess acreage. For example, the 72,000 solar modules that comprise the Nellis Solar Power Plant at Nellis Air Force Base mentioned above covers 140 acres (57 hectares) – and even that large size only supplies 25 percent of the power used at the base. Meanwhile, the region gets an average of 292 sunny or partly sunny days per year. Smaller, more densely populated European countries lack the vast expanses found in the United States and most lack the sun exposure possible at a place like Nellis Air Force Base.

Changing cultural perceptions

Finally, there are also challenges in terms of inculcating a greener culture within military entities. Installation energy self-sufficiency is defined as creating as much energy as is consumed in a year – hence, at least theoretically, energy efficiency is not necessarily *required* for self-sufficiency. However, greater efficiency is a key enabler – it can help an installation reduce its overall energy needs and hence enable the installation to meet its energy needs more easily through the generation of less energy. What is necessary then is a two-track approach that embraces efforts at *both* self-sufficiency and efficiency. This is more easily said than done though, especially in the United States. European military entities – especially those in Western and Northern Europe – exist within a broader culture that promotes energy efficiency, and so achieving self-sufficiency would arguably be easier. On the other hand, American culture has developed over the last several decades in an

[6] Lisa Ferdinando, "Army sees efficient energy use as mission critical," ARNEWS, April 10, 2013, available at www.army.mil/article/100761/.

[7] "Military Expenditure Database, 1988-2012" Stockholm International Peace Research Institute, available at www.sipri.org/research/armaments/milex/sipri-military-expenditure-database.

environment characterized by relatively cheap, easily accessed, seemingly infinite energy[8]. Per capita energy use over the last 30 years bears this out, with the average American using roughly twice the energy per year as an average European. The U.S. Defense Department recognizes the challenges of a relatively 'immature' American energy culture, and has begun several initiatives to inculcate a 'greener' energy culture within the U.S. military. Whether these will succeed over time – and thereby make it easier for the United States to achieve installation energy self-sufficiency – remains to be seen.

Policies and politics convergence – promising perspective

In sum, energy self-sufficient installations are not simply a worthy goal. They are in many ways a compelling necessity for managing budget cuts, reducing risks from hostile state and non-state actors to military infrastructure, limiting Mother Nature's impact on military operations, and augmenting operational capability today and tomorrow. Energy self-sufficient military installations therefore represent a wise policy choice. Standing in the way of this seemingly obvious way ahead are some rather significant impediments though, including up-front investment costs, land requirements, and cultural hurdles. Hence it is not clear whether the wise policy choice represented by military installation self-sufficiency also makes for a wise political choice, at least it the short run. Nevertheless, the task for leaders on both sides of the Atlantic is to work individually as well as collectively toward a convergence of both the policies and the politics of installation energy security.

8 See David E. Nye, Consuming Power: A Social History of American Energies (Cambridge, MA: MIT Press, 1998).

Strategy Options For Installation Of Modern Energy Technologies Into Military Bases

VYTAUTAS KERŠIULIS
NATO Energy Security Centre of Excellence

On May 22, 2013 the US Army has released the Net Zero Pilot Installation Initiative Progress Report for 2012,[1] describing results in terms of consumption reduction, increase of energy efficiency and renewable energy sources application. It also plans to issue a policy this year focused on expansion of the Net Zero Initiative to all permanent Army installations. Half a year ago on the other side of the Atlantic the EU Defense Ministers opened the portal to the world of renewable energy within Armed Forces with the launch of the ad-hoc Category B project GO GREEN, to be implemented by seven European Defence Agency's nations. On the smaller scale NATO ENSECCOE initiated a project "Energy Management of Expeditionary Environment: Towards Smart Energy Base" where main goals are to evaluate the energy needs of the combat battalion and propose solutions contributing to energy efficiency and better use of renewables. What are the available options to turn all these good intentions into the reality: self-sufficient or at least less energetically vulnerable military bases?

"Micro grids" technologies show really high potential when talking about energy efficiency: recent studies have shown, they can result in cutting off the conventional fuel usage by 37 percent[2].

It was estimated that the marginal cost of electricity produced by wind power is less than 1-cent per kWh. Constant improvements of the wind turbine technology, which encompass more efficient wind turbine blades, the performance itself and increased power generation efficiency, result in further price reductions[4].

Technological innovations as enablers

Currently most of the military bases rely on electric energy sources provided by nearby local grids and in case of black-out these bases would purely depend on backup diesel generators. Good news in this context is that today there is an opportunity of using alternative energy sources instead of diesel in the emergency situations. However, for achieving success, several conditions have to be fulfilled.

First of all, it requires so called "micro-grids" to make military bases fully self-sufficient. By introducing micro-grids in military bases, the overall electricity load can be controlled according to the demand, thus enabling the use of the available alternative energy sources, reduction of conventional energy sources and achieving self-sufficiency.

Second, according to the International Energy Agency, deployment of renewable technologies usually increases the diversity of electricity sources and, through local generation, contributes to the flexibility of the system and its resistance to central shocks[3]. However, it is well known, that renewable electricity sources, like wind power, solar power or geothermal energy, are not constant energy sources and depend on location as well as weather conditions. Therefore, only combined together they can become a reliable and consistent energy source with a certain balancing capacity.

Finally third, technology advancement usually requires significant investments and in order to become widely used it should bring not challenges but solutions for budgetary concerns related to the cost of renewable energy sources. In this context it is worth to notice that researches are coming up with more and more efficient solar cells, enabling

[1] "Net Zero Pilot Installation Initiative Progress Report for 2012", Assistant Secretary of the Army, May 2013 http://www.army.mil/article/103842/Army_releases_2012_Net_Zero_Progress_Report/

[2] Adam Stone, "Project Studies Army Base Camp Self-Sufficiency", 2012, http://www.defensenews.com/article/20120710/DEFREG02/307100011/Project-Studies-Army-Base-Camp-Self-Sufficiency

[3] "Contribution of Renewables to Energy Security IEA Information Paper", International Energy Agency, p. 5.

[4] Mukund R. Patel, "Wind and Solar Power Systems – Design, analysis and Operation" (2nd ed., 2006), p. 303

solar power to pay off even faster in the future[5]. For instance as far as solar cells prices are concerned, in 2012 it was estimated that the cost per watt was about $0.60[6], which was 250 times lower than the cost in 1970 of $150. The price is expected to decrease by another 5-10% in 2013, experts say. Wind power costs have reached the level of traditional power prices in some areas of Europe and US around 10 years ago. On the other hand, the electricity price from renewables still depends on various alternatives, like location (onshore or offshore), transmission capabilities, weather conditions and other.

Important progress

During the past few years the main efforts both in the US and Europe have been directed towards increasing of self-sufficiency and reducing of vulnerability of energy supply within military bases. Those efforts have been translated into number initiatives, such as US *Net Zero Pilot Installation Initiative*, EU initiatives *Military Green* and *Go Green*.

Source: Mojave Desert News at: http://radio-weblogs.com/0105910/2004/05/28.html

The solutions that have been proposed by such initiatives usually focus on combinations of different energy sources and links among complementary policies of armed forces, private business and local communities through different forms of cooperation. Strategies linking energy efficiency initiatives, green/renewable energy sources and technological innovation from electricity to transportation fuels towards military applications as a possible response to contemporary challenges vary from establishment of better communication among stakeholders from different sectors for conflict resolutions to engagement into Public Private Partnerships (further – PPP) meaning close collaboration among them in implementing relevant projects of common interest.

Net Zero projects are evolving in US military bases, where the main goal is described as ability of a military bases to produce as much energy as it consumes during a year. For these projects portable solar, wind power, geothermal, water power plants, biomass generators and other alternative energy sources can be used. For instance at Fort Bliss (the US Army post in New Mexico and Texas) the military has invested over $50 million to reach net zero status and during the first year after establishment they got their energy bill down between 10 and 15 percent for the military installation[7].

Further spread of innovations: assumptions for success

Military bases usually depend to some extent on the conventional energy sources and most of the time military installations are connected to local electricity grid. Therefore, in a number of cases military is willing to cooperate with developers and private investors and start mutually beneficial projects for building solar, wind and other renewable power plants on lands owned by the military. The idea would be to lease military land to the interested party which could develop alternative energy source projects, while the military could buy some or all of the power from each project manager for its own use, while any unused power could be sold for local utilities.

Two main scenarios of public-military-private sectors' cooperation could be distinguished depending on what is meant to be achieved: 1) a single base with its own energy resources (self-sufficient military base) or 2) a collective system where nearby

5 "From 40.7 to 42.8 % Solar Cell Efficiency", RenewableEnergyAccess.com, Newark, Delaware 2007, http://www.renewableenergyworld.com/rea/news/article/2007/07/from-40-7-to-42-8-solar-cell-efficiency-49483

6 "Small Chinese Solar Manufacturers Decimated in 2012", ENF, 2013, http://www.enfsolar.com/news/Small-Chinese-Solar-Manufacturers-Decimated-in-2012

7 "US Army trials off-grid living", TECHSTAR, July 2010, http://www.off-grid.net/2010/07/09/us-army-trials-off-grid-living/

- *Military Green* is European Defence Agency's (EDA) vehicle for the EU Member States to make an environmental difference and is used as a strategic tool supporting the mitigation of adverse effects to the climate and ecology while strengthening defense and crisis management capabilities. It deals with environmental values in the Defense and Crisis Management Community by promoting development and implementation of novel environmentally responsible technologies.
- *Go Green* is a novel business model proposed by EDA that cuts costs through implementation of renewables in the homeland. Implemented by seven EU Member States (Austria, Cyprus, Czech Republic, Germany, Greece, Luxembourg and Romania), the project sees access rights to rooftops and land in military premises brought together via EDA. Pooled in one business case, they are offered to the market for electricity production using photovoltaic technology. The target of the project is to demonstrate the deployment of new alternative energy sources for faster, cleaner, more sustainable and cheaper ways to meet Armed Forces' growing energy needs.

communities are integrated in the common energy system. A single military base with its own energy resources or so called "islanded micro-grid operation" is based on the ability to operate independently from the larger electrical grid. In this case the power is produced on the base and can reliably maintain operations. Recent reports from US Defense Science Board (DSB) recommend exactly to "island" military grids from surrounding communities[8]: micro-grid energy management for self-sustainable military base with limited or no connection to the local grid, according to DSB, is a must in case of emergency operation when reliable and uninterruptable energy source is necessary.

On the other hand, as the practice shows the self-sustainable military bases very often face difficulties in form of investments payoffs. Therefore, an assessment planning needs to include possible financing options and pay-off period. Besides that, planning of self-sufficient military bases should follow certain rules which include:

- Mission accomplishment should be always the top priority and any power generators or energy sources must be compatible with the installation's main mission.
- Energy security must be maintained – the energy source must be reliable and physically safe.
- New energy installation should not jeopardize overall budgetary constraints and should function in an economically viable way.
- The ability of an installation (as a whole or its separate sections) to operate independently from the outside electrical grid should be evaluated and ensured.

Best patterns

A recent concept introduced by DSB is "resilient communities", which covers the understanding of how development of reliability and sustainability for military systems should look like. As it was concluded by DSB, important assumption for the effective collaboration among military, local government, public, and commercial stakeholders is a development of deep understanding of important processes, relationships and possibility of mutual benefits. Presence of such understanding makes sharing with the local municipalities the energy efficiency related investments for military needs possible. Besides that, good communication and efficient information systems regarding existing and planned power plants allow to reduce the proportion of projects rejected by the military and to mitigate risks for conflicts.

Good example of mutually beneficial project on the basis of very close cooperation among stakeholders from public and private sectors is the one established in Municipality of Bruchsmühlbach-Miesau, Germany, where US Army's "Ammunition Center Europe", largest American ammunition depot outside the US is located. A successful cooperation resulted in a 1 MW solar PV plant installation on the roof of storage buildings inside military base, as well as biogas cogeneration plant and additional wind turbines in nearby area. This project is expected to ensure 290% production of electricity demand in the area and huge savings for the military base[9].

[8] Department of Defense's Defense Science Board Energy Task Force http://www.terrapinbrightgreen.com/experience/snapshotindepth.php?snapshotid=LN9YHfWy2MYeh61saVaW

[9] Thomas Gerke, "290% RENEWABLE BRUCHSMÜHLBACH-MIESAU", 2012, http://goo.gl/soxhf

Importance of PPP

The implementation of projects addressing complexity of issues related to renewable energy sources, security and safety of energy supply and economic viability of functioning of military bases depends on different variables such as location, technologies available, local communities, related industry interests and other. In addition, budgetary restrictions usually become major choice making factor. In this context one of the best known ways to leverage public and private competencies through the new and innovative arrangements is the application of the so called PPP model: an agreement between a government entity and one or more private industry, or other, entities to perform work or utilize facilities and equipment. The primary intent of the PPP initiative in case of Armed Force (AF) involvement (meaning military's collaboration with local communities and private sector) is to stimulate private sector's investment in AF facilities and equipment in order to sustain its core maintenance capabilities, facilities, and technical expertise in the workforce.

It must be noticed, that PPPs that include sharing of investments can benefit both the public and private sectors. For instance, utilizing the same facilities and equipment used to produce new systems to provide non-core depot maintenance may result in savings based on a best value assessment. In addition to that, the sharing of facilities, either commercial or government owned may result in savings by reducing overhead costs. Capitalizing on the investment in production start-up equipment through sharing and transfer offers as well as access to technical data (for ensuring that the government retains the option to change or adjust the roles and responsibilities within the partnership over time as circumstances dictate[12]) are also not of the less importance. All in all, the PPP which links military energy efficiency initiatives with civil developers' energy policies and technological innovations can be regarded as a promising alternative.

For instance in Sweden military aviation and wind power developers both wanted to gain from open areas with low population density and entered into unexpected conflict as wind turbines are physical obstacles for air units[10]. Another reason is that wind turbines sometimes interfere with the military radars as they show similar signals as air planes[11].

As an example, in case of *Go Green* project PPP aims at analyzing and unleashing the Armed Forces' renewable energy potential, starting in the field of Solar Power generation, by developing a common approach and sharing the generated benefits. The estimated value of the overall project is from 200 to 300 M€ investment. Through the *Go Green* project the participating European Armed Forces will develop and demonstrate a generic renewable energy exploitation models that could be used later for European-wide implementation.

10 Fredrik Lindgren, Bengt Johansson, Tomas Malmlöf, Fredrik Lindvall. "Siting conflicts between wind power and military aviation–Problems and potential solutions", Land Use Policy, Volume 34, September 2013, Pages 104–111.

11 Andrew Shchuka, Inderbir Sandhu. "Air Traffic Control Wind Farm Interference Mitigation at Raytheon", Technology Today, 2012 issue 2.

12 Handbook of ARMY PUBLIC-PRIVATE PARTNERING, United States Army Materiel Command http://www.commercecenterseiowa.com/P3Handbook.pdf

How Relevant are Today's Energy Efficiency Technologies to Deployed Military Bases?

TOM BARKER[1],
DES D TECH (Ministry of Defence of the United Kingdom),
NATO Smart Energy & UK Energy Prog Bd Project Manager: Power Systems & Interoperability

UK's Base Integration & Efficiency Forum held in Portsmouth on March 20th demonstrated a number of emerging technologies that offer efficient power generation & storage, water independence for troops (generation & purification) and power interoperability. This event also marked a small part in the move towards a holistic view of energy and resource management in Defence.

Top priority - military effect

Defence organisations - much like the general public - are developing a desire to become more energy efficient. A better understanding of changing climatic conditions, the increasing price of fossil fuel and political pressure have encouraged Defence organisations across NATO to *investigate* (but not yet *employ*) all manner of energy efficiency technologies. Defence procurements must fall within the budgets allocated by Government, and so any prospect for future savings can be a key motivator for investment. The sole purpose of Defence spending is the delivery of military effect and it is therefore the other benefits - i.e. removing *dependence* on fossil fuel and improved *operational flexibility* - that can be offered by recent developments in energy technology, that have drawn government interest. So, **can we save money, enhance military effect and deliver sustainable energy to support military operations all at once?** This article discusses the advantages and disadvantages of Defence spending on energy efficient equipment for land-based military installations.

Seeking reduction in the use of fossil fuels

Crucially, it is reduction in the use of fossil fuels that we seek to achieve through developing energy efficient military installations. The availability of these fuels may represent a single point of failure for military operations in the future. Although energy is as important as the equipment that it powers, it is not managed with the care and resource of a vehicle or aircraft project. It is forecasted that the UK MOD's fuel bill could account for 7% of the entire UK Defence budget by 2020 - a concerning prospect to be faced by all nations if the current predictions for the global demand of fossil fuel continue. If we choose to ignore this, it is clear that we will have to accept a considerable forfeit elsewhere to continue to pay for fuel. Recognising this, the UK will soon formally handle energy as a capability - to be managed as a critical enabler of our operations. Of course, we want to reduce our need for fuel without limiting the use of our equipment, to a limited effect by changing culture, but principally we look to improving our military **technology**.

Permanent establishments: building on analogy

Commercially, energy technology is maturing rapidly. Fortunately, the energy needs of permanent Defence establishments can be managed much like any large commercial property - the advantages of building management systems, efficient insulation, heating,

[1] The views expressed here are the authors own and should not be taken as representative of any body or organisation that they may be affiliated.

lighting etc are all well understood, highly developed, predictable and reliable. Such technologies are easily compared and selected to suit a building's specific construction and use. The behaviour of energy in buildings can be accurately and easily modeled, allowing investors to proceed with high confidence in practical and financial payback. So, **for permanent establishments, gathering the evidence to make a decision is simple** - a well prepared investment appraisal gives the answer.

Energy in Buildings		
Type	**Upfront Cost**	**Payback**
Fit Insulation	Low	Fast
Fit a GS Heat Pump	High	Med
Fit Solar PV	Med	Med/Slow
Decision Complexity: LOW!		

Figure 1: A fictional example of the simplistic nature of selecting energy efficient systems for permanent buildings

Deployed military installations: searching for innovative approach

However, *deployed* military installations are entirely different. Mobile, temporary, volatile, expensive and unpredictable - they represent unproven territory for energy efficiency technology. There is complex interaction between building, equipment and transport energy. Furthermore, military operations are not confined to any particular climate, scale or duration. This makes the selection of energy technology difficult. Perhaps, with an unlimited budget, specific operations could be supported through the selection of appropriate technologies from a broad mix of energy types. However, in the real world, with budget constraints, our military forces have very limited opportunity with which to carefully select operational energy sources. Hence, most military equipment is powered by fossil fuel - and it is hard to improve on diesel for power density, applicability, and reliability.

Furthermore, such is the challenge of *replacing* fossil fuel, to concentrate on using solely alternatives, would be to lose focus on the purpose of operations. Lower fuel consumption should offer a corresponding reduction in resupply - a favorable prospect in energy technologies when minimising risk to our soldiers will always be a top priority. However, supporting complex equipment can require considerable manpower and therefore such a system - even if highly efficient - may offer no net operational benefit at all. So, **for deployed military installations, the decision is not simple.** There are no easy answers.

Energy efficiency systems in permanent buildings become *financially* viable through the accumulation of *small savings* over a long period of time (typically, **years**). Military operations are seldom intended **from the outset** to remain unchanged for such a period. Also, permanent building systems - such as heat pumps - are finely *tuned* to their *specific* installation - whereas military equipment must fit all scenarios. In commercial energy technologies, low upfront costs are crucial to keep the payback period short and therefore designs focus on high power production at the expense of other considerations, including mobility and robustness. This is highly appropriate for commercial buildings, but unfortunately it is generally necessary to *ruggedise* equipment destined for military service in the deployed environment. Invariably, this increases cost (see Figures 2 & 3) - so, the fragile economics of typical energy efficiency technologies fail when considered for a military environment with the usual approach to military procurement.

Figure 2: The Panasonic "toughbooK" currently used by the British Army, ruggedized - but well above the cost of it's the commercial equivalent, available at just is £285.

Figure 3: A 40KW UK FEPS, military spec generator currently in-service at considerably higher cost than its commercial equivalent which is available at only £9,000([2]).

One strength of a deployed energy system may lie with its ability to take electrical power from a wide range of sources, appropriate for the location and situation - much like a national grid does (Figure 4)[2]. With this approach comes the need for *interoperability.* The UK's Land Open System Architecture (LOSA) defines common standards for the interconnection of all land equipment. As energy is a key capability within the Land domain, LOSA includes the provision and exchange of electrical power between all power producing and power consuming equipment - minimising energy waste and maximising flexibility. The idea has been developed and tested by the PowerFOB *(see Journal Vol 3, Nov 2012)* project, which investigated the merit of Microgrid systems, renewable energy and energy management in reducing fuel consumption at operating bases. PowerFOB utilises intelligent power management in an open system design to support the principals of LOSA, and hence offers the flexibility of accepting power input from any source that the available technology can exploit - suited to the unpredictable conditions of operations already discussed.

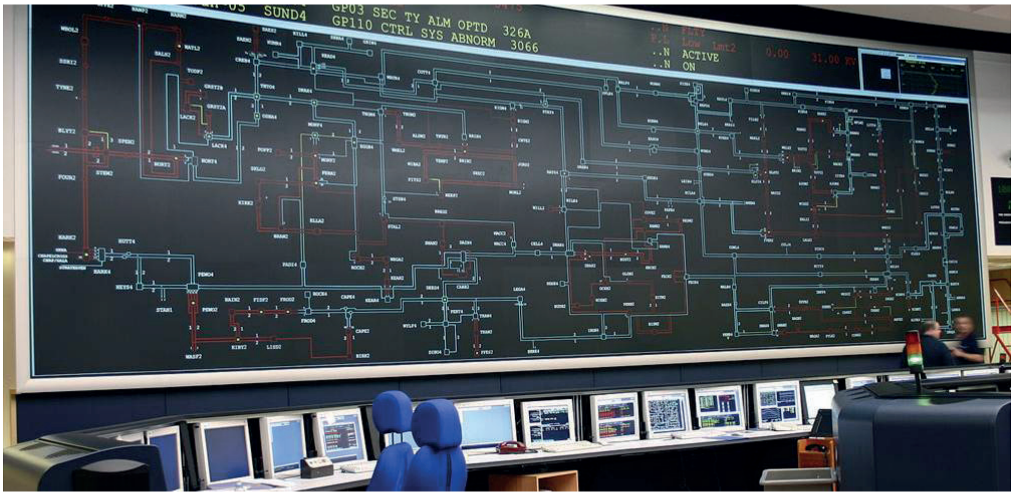

Figure 4: The UK's National Grid Control Screen: A Power Network that gains flexibility and efficiency through interoperating all kinds of energy sources

Progress requires not only new technologies, but new approaches. The more 'popular' renewable technologies *(solar, panels, wind turbines)* are easily viewed as the answer to energy efficiency. However, most solar panels would never save sufficient energy to repay their investment with a cost outlay scaled up in the manner generally observed for military equipment. Nonetheless, neither are they entirely useless, the more realistic research programmes recognise that whilst such technologies are reliable, they can deliver a wealth of other benefits (PowerFOB also delivers uninterruptible power, silent running and fuel independence) *and* they do *aid* in the construct of a robust, flexible and diverse energy network. The kind of holistic energy system outlined by PowerFOB and LOSA can offer fuel savings of around 30% for deployed bases. Of course this saving comes at the expense of higher technical complexity, investment and increased training burden.

We know then, that technical projects of many kinds can make headway in fuel efficiency at deployed bases, enhancing, rather than jeopardizing operational outputs. However, by what means can we see through the delivery into service of such equipment? I am a member of national and international committees that meet with the ambition of gaining commitment to tackling this problem. Unfortunately, whilst the participants are keen and supportive of the cause, they are often specialists in other fields, and are working under budgets that are allocated to the delivery of core Defence objectives. Hence, even as a collective, such groups can be slow to secure the *investment* necessary for progress without commitment at strate-

[2] Commercial Generator: http://www.dieselgenerators.co.uk/Three_Phase.php

gic level. Despite some confusion between *'going green'* and securing operational capability for the future, the need for progress is accepted and widely understood, but without investment shown in more projects like the UK's PowerFOB, change is slow.

Armed Forces' competence and motivation – the key enablers

With today's priorities, energy efficiency should not cloud the outputs of a deployed military base. However, the projection of fossil fuel availability dictates that some form of energy management will need to be embedded in the military operations of the future. Whilst there are many technologies developing today, their costs and benefits trade off are complex. Still, technology has a part to play and although few projects have yet delivered real impact, small successes are apparent all the time. The improvement and development we are seeing now must continue if we are to maintain the freedom of our Armed Forces to operate effectively in the future. The commercial world may be slow to adopt the changes necessary but perhaps the capable and highly motivated people employed in our armed forces - with such important outputs - are well placed to lead the way?

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NATO Energy Security Centre of Excellence

ŠILO G. 5A, LT-10322 VILNIUS,
LITHUANIA

Phone: +370 706 71000
Fax: +370 706 71010
Email:info@enseccoe.org