Energy Security Forum: IESMA 2016 Special Edition

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Editorial

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In November, 2016 NATO Energy Security Centre of Excellence (NATO ENSEC COE) had an opportunity to host yet another successful conference and exhibition "Innovative Energy Solutions for Military Applications" (IESMA 2016). The primary motivation behind IESMA 2016 was to provide a forum for the military energy efficiency "community of interest", as well as to review past experiences and outline future paths. We are glad to acknowledge that since 2011 and 2014, the event has grown both in size and influence. This year it was attended by over 400 representatives across governmental, military, business and academia sectors.

Needless to say, energy is a key enabler for successfully achieving the mission objective. Therefore, increasing the energy efficiency of our armed forces can lead to both boosted capability and reduced size of the logistical chain. Alternative energy sources such as solar power and biofuel are beginning to be used in the military domain, although often technologies are not yet fully mature and projects are in an experimental phase. Because of this, the most effective short and medium term strategy is to improve the energy efficacy of our military equipment through innovation.

That being said, several aims could be defined in the process of organising and executing IESMA 2016. First of all, we were aiming at innovation and its stimulation capabilities in the NATO armed forces. As sharing of knowledge is becoming more important within the organisation, we created an opportunity for participants to exchange good practices and learn from Allies and Partners. In order to make use of the knowledge gained, IESMA 2016 incorporated exclusive outlook to the future projects and strategies. Most importantly, IESMA 2016 was established and carried out as a unique forum of military innovation, where government, armed forces, academia and industry could interact, exchange ideas and produce a common strategy.

> We are glad to acknowledge that since 2011 and 2014, the event has grown both in size and influence

During IESMA 2016 a special technology exhibition was set up, where the variety of innovators ranged from start-ups to large corporations with a multinational reach (such as BAE Systems, G&G Partners, Pfisterer and companies represented by the Virginia Economic Development Partnership). As innovations were on display throughout the whole

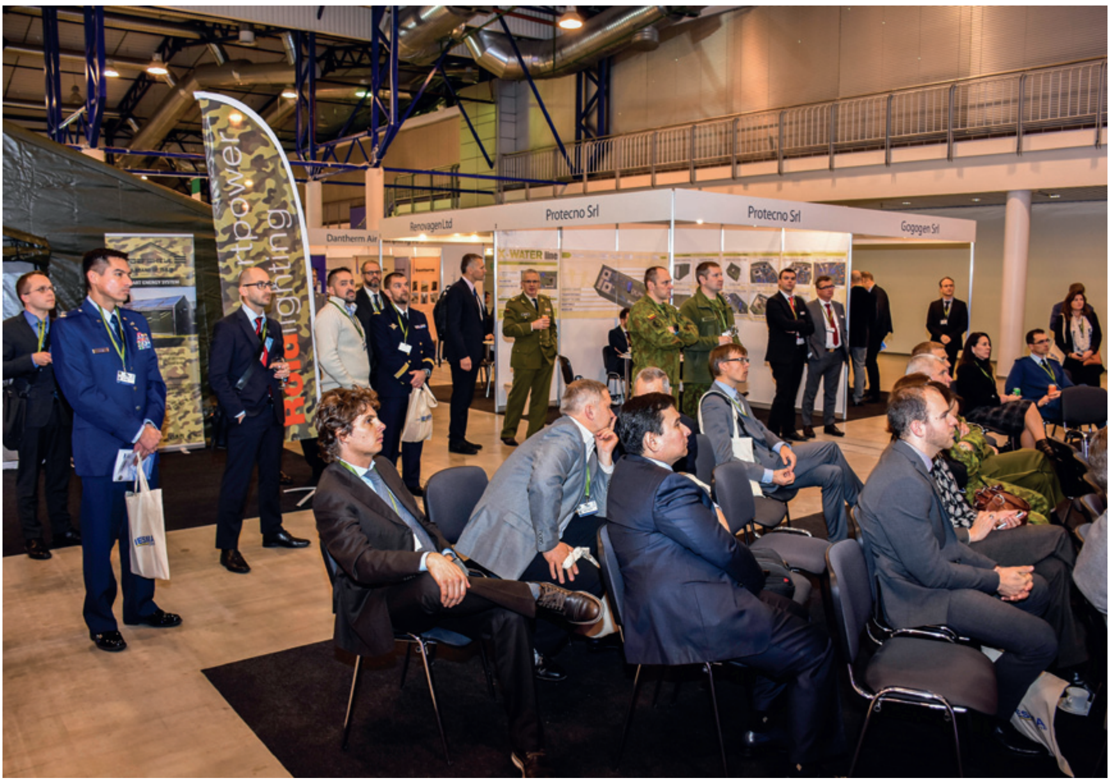
event, participants had an opportunity to acquaint themselves with a range of edge-cutting new technologies, such as rollable solar power, "swarm" microgrids, vehicle hybrid power or novel methods of insulation.

The event was greatly supported by NATO ENSEC COE partners, including Georgian State Military Technical Centre "Delta" and the NATO Science for Peace and Security

energy is a key enabler for successfully achieving the mission objective

Programme (NATO SPS). Lithuania's strategic priority over energy security proved as an excellent environment for the event, supported by the commitment expressed in keynote speeches of Lithuania's Minister of Energy Rokas Masiulis, Lithuania's Minister of Defence Juozas Olekas and in a letter from Lithuania's President Her Excellency Dalia Grybauskaitė.

While the operational and financial drivers are certainly important motivations for sharing past experiences, we should also look for a new environment suitable for more exten-



sive cooperation. Sharing vision and ideas in IESMA 2016, has enabled greater awareness between governments as well as made aligning plans and exploiting synergies possible. The collaboration of the "Golden Triangle", namely military, industry and academia, plays an important role in the future military capabilities, therefore IESMA 2016 is an exceptional approach to strengthen cooperation in the military field.

SAVE THE DATE: IESMA 2018 will take place on 14 – 15th November, 2018 in Vilnius, Lithuania

Introductory remarks
Enhancing Energy Efficiency in the Military: NATO's Way Forward

Ambassador Sorin Ducaru's Introductory Remarks at IESMA, 16 November, 2016

Ministers,
Excellencies,
Ladies and Gentlemen,
It is good to be back.

Two years ago, at the previous IESMA, I focused my speech on the rationale for enhancing energy efficiency in the military. This rationale is as clear as it has ever been. The former Chairman of the Joint Chiefs of Staff, Admiral Mullen, put it well, when he said: "We cannot think about energy after we get there — wherever "there" may be." Questions of energy consumption and energy supply are not just afterthoughts to prudent military planning. They have to be left, right and centre of military planning.

Until 2014, we looked at energy efficiency in the military largely in the context of operations outside of Europe. Our frame of reference was the experience we had gathered in Afghanistan or Mali. In these operations, fuel supply was often a major challenge. Consequently, reducing fuel consumption would minimize supply problems, but it would also reduce risks for the soldiers who had to transport the fuel to its destination. Another area we looked at was humanitarian relief operations. Deploying into an environment where an earthquake or a tsunami has literally wiped out all existing infrastructure requires forces that can operate as autonomously as possible, including in energy terms. These were pretty strong arguments in favour of enhancing the energy efficiency of our armed forces.

But "Smart Energy" is not just relevant for crisis management and humanitarian operations. It also relevant for our collective defence. A good example is our "Enhanced Forward Presence" – four battalions in the Baltic States and Poland. It is a sea change in NATO's strategy since the end of the Cold War. But while it enhances NATO's deterrence, it also creates new challenges. One of them is resilient energy supply. To reinforce our deployed forces in a crisis, for example through our "Spearhead Force", requires sound and resilient energy logistics. This Force needs to move fast and be able to operate in a contested environment, where access to the civilian supply lines may already be disrupted as a result of hybrid warfare.

In other words, even when it comes to defending our own territory, an energy efficient and resilient military will be a strategic advantage. Even when it comes to our core business of collective defence, we need to invest in energy efficiency as well as sustainable, innovative and interoperable energy generation solutions in the military.

What have we achieved so far, and where are we going? Let me outline a three-step approach.

First, we need to continue to mainstream "smart energy" into NATO's policies and activities. "Smart energy" cuts across a wide range of subjects, and it is important that we cover them all.

Clearly, a major issue is standards. Standards are key to ensuring interoperable forces. They are key to NATO's unrivalled military competence. Standards are necessary when building new fighter planes or tanks. But standards are also necessary when integrating technologies into micro grids to power a field camp.

Now, building fighter planes or tanks might be more exciting than putting together a micro grid. But the importance of being interoperable for producing the energy for a camp must never be underestimated. Even the most simple diesel generator in a camp needs standards, so that one nation can plug-and-play its equipment with that of another. That's why standards are the "invisible force multiplier", and why Standardization Agreements – or "STANAGs" – have been a trademark of NATO almost since the very beginning of this organisation.

As far as "smart energy" is concerned, NATO has started the process of updating existing policies and standards. The updated documents are being prepared by national experts, for example members of the Environmental Protection and of the Military Engineering Working Groups. They will submit their proposals early next year to the relevant NATO Committees.

But we are also looking into new standards, notably regarding smart micro grids for field camps. It is widely agreed that smart micro grids are a "quick win" for reducing fossil fuel consumption with relatively little effort and cost. As more nations are planning to procure technologies for micro grids, some of the experts involved have asked us to help them with agreeing standards. Standards are needed for the accurate measurement and logging of data, for example, or for enabling the smooth integration of different technologies into the energy management system of a camp.

This is why we have prepared a proposal for a NATO Smart Defence project. It will aim at developing and testing a new standard for integrating technologies into micro grids in a so-called Smart Energy Training and Assessment Camp – or SETAC. My staff member Dr. Susanne Michaelis will explain this project tomorrow.

To help us understand the challenges of integrating technologies, NATO's Science and Technology Organisation (STO) has put together an exploratory team that had its first meeting just last week. I believe our colleague from the Office of the Chief Scientist, Ben van Hecke, will tell you more about this later.

Yet another area of mainstreaming pertains to the NATO Defence Planning Process (NDPP). Energy efficiency should be recognised as a so-called "Minimum Capability Requirement", and be integrated into the NDPP. Judging from my experience in cyber defence, establishing a connection to the NDPP will make a real difference. Because it raises the importance and visibility of the subject, and it does so across the entire Alliance.

And then there is the environmental dimension. The "Green Defence Framework" championed by Lithuania and Denmark adds more visibility to the nexus of energy efficiency and environmental protection. But let me be clear: We are not "going green" in the faint hope that anti-military critics will suddenly love us. That's not likely to happen. We are "going green" because it makes sense operationally, logistically, financially, and in terms of security for our soldiers. And we are "going green" because we want to send a strong signal that the military has understood that it cannot be just an innocent bystander in the global effort to reduce the burden on our environment. That is why we have the "NATO

Military Principles and Policies for Environmental Protection" – and why this policy is being updated to take account of our progress in military energy efficiency.

Second, we need to further broaden the exchange of information and best practices. Our stakeholder community in "smart energy" is far larger today than it was when we started a few years ago. We have more experts involved. We have more interested nations engaged. And we have created supporting tools, such as the "NATO Smart Energy LibGuide". Through extensive networking we have built a stakeholder community that has been instrumental in achieving many important milestones: the Green Defence Framework, the Policy of Power Generation for Deployed Force Infrastructure, and the Military Advice on NATO's Role in Energy Security, to name but a few.

We recently succeeded in convincing the Nations to de-classify several overarching policy documents, so that they can be published on the Internet. You will find a number on the aforementioned Smart Energy LibGuide. With this move we hope that our stakeholder community will expand even further.

Just a few weeks ago we concluded the second Energy Security Strategic Awareness Course at the NATO School in Oberammergau. The course was developed by my energy team, the Energy Security Centre of Excellence, and the Naval Postgraduate School in Monterey. It was also strongly supported by ACT and ACO. Needless to say, this course devoted considerable time to the challenge of enhancing energy efficiency in the military; and the participants' feedback showed that the subject really "caught on". I am also happy to note that the Energy Security Centre of Excellence is organising additional courses specifically devoted to operational energy issues, and I can only encourage you in these efforts.

Third and finally, we must continue to bring relevant industry on board. NATO is only a facilitator between industry and nations, but we are determined to play our role well. A very good example was the exercise "Capable Logistician", held last year in Hungary. CL-15 featured 14 companies who demonstrated their energy efficient solutions. Some of these companies are here today, and I urge all of you to have a close look at what they offer.

In the past, technological solutions were developed in the military and later became available for the civilian consumer. When it comes to "smart energy", however, the roles may well be reversed: the civilian sector may often have the solutions that the military is looking for. Trusting and trustful relations between NATO and the private sector are therefore more important than ever. CL-15 is a prime example that our efforts in this regard have borne fruit. Again, we cannot do more than "matchmaking" between nations and industry. Whether our matchmaking actually leads to any marriages is beyond our control. But we will continue to do our utmost to create an atmosphere that is conducive to progress.

Ladies and Gentlemen,

These are testing times for the transatlantic community – with challenges to NATO's East and South. But the transatlantic community will prevail. Not only because it represents the world's strongest and most successful community of democracies. And not only because it remains one of the major engines of the world's economy.

The transatlantic community will prevail because it also remains the nexus of technological innovation. Just look around this exhibition: you see creativity, you see out-of-the box thinking, and you see skilful engineering. That is why, to me, IESMA is more than an exhibition of military hardware. IESMA epitomises the very characteristics that have made our transatlantic community great: the will and the ability to adapt to a changing environment. If we preserve these characteristics, we can meet any challenge and resist any threat.

Thank you.

Integrated Camp Energy Technologies: A Simulation Tool to Predict and Evaluate Power and Energy Requirements of a Deployed Camp

Martin Kegel (Natural Resources Canada)
Captain David Thibaudeau (Department of National Defence of Canada)
Major Ross Franklin (Department of National Defence of Canada)
Ed Andrukaitis (Defence Research and Development Canada)
Eric McDonald (Natural Resources Canada)

In an effort to support the Canadian Armed Forces' (CAF) energy conservation targets, a multi-department collaborative effort between the Department of National Defence of Canada (DND) and Natural Resources Canada (NRCan) has been undertaken to give the CAF the tools, training and mentoring required to address this challenge. Along with the delivery of various camp energy metering systems, a simulation tool was developed and recently validated at an exercise (Ex), giving the CAF a better method to predict the power and energy requirements of a user-definable camp in any climatic region. The results of several years of metering and simulation—mostly on domestic exercises—have raised important questions. Will these hardware and software tools help the CAF reduce diesel dependency on operations overseas? Will they help confirm the viability and suitability of energy efficient technologies and strategies? Can they be used with Canada's NATO partners to address energy security? The next step is to deploy the metering and simulation tools to forward logistics hubs and multinational mission bases, with concomitantly higher stakes for operational energy security, environmental compliance, and force protection.

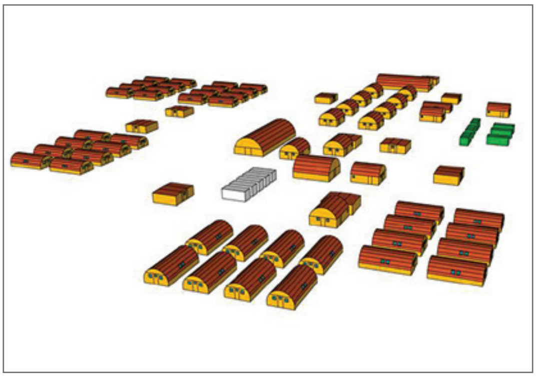
MULTI-DEPARTMENT COLLABORATION TO ADDRESS ENERGY SECURITY CHALLENGES

Deployed camps (camps) are widely used by the CAF to support a range of operations, including training, northern sovereignty, humanitarian aid, disaster relief, and conflict prevention. To sustain operations from the Arctic to hot/humid climatic regions, there is a heavy reliance on diesel fuel, which can impose significant burdens (convoy escort, route clearance, force protection, purchasing

[1] http://www.forces.gc.ca/en/about-org-structure/canadian-joint-operations-command.page
[2] http://www.drdc-rddc.gc.ca/en/index.page
[3] http://www.nrcan.gc.ca/energy/offices-labs/canmet/5715
[4] Cassolato, S., Chubbs, L, Andrukaitis, E., Lefebvre, V., Kegel, M., Operational Energy: A Multi-Faceted Government Approach, NATO Energy Security Centre of Excellence Vol 7, 2014, Lithuania, ISSN 2335-7975.

fuel among others). Thus motivation exists to search for alternative power and energy solutions for camps.

To support the CAF energy conservation targets, in 2012 Canada's DND – Canadian Joint Operations Command (CJOC)[1], Defence Research and Development Canada (DRDC)[2] and NRCan – CanmetENERGY[3] have collaboratively worked together in developing a five year strategy to:



(a)

- Better understand and better measure a camp's energy use.
- Better predict a region specific camp's power and energy demand.
- Demonstrate the use and benefit of energy efficiency technologies.

In 2012, realizing that very little information was available on a camp's energy demand levels, consumption rates and end uses, an energy monitoring study was undertaken for Operation (Op) NANOOK 2012 (a summertime exercise in the Canadian Arctic) to acquire detailed data for the first time and develop a validated energy model to identify and assess potential energy reduction strategies (Figure 1). Additional details of the study can be found in the NATO Energy Security Journal[4].

Given the long-term vision of the CAF to be able to predict, measure, and demonstrate viable energy efficiency strategies, a strong focus from 2013 onward has been the transfer and mentoring on the energy monitor-

(b)

Figure 1: Op NANOOK 2012 (a) Aerial View (b) Simulation Model

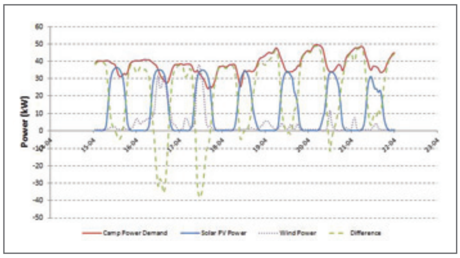
ing and prediction technology. So equipped, the CAF would have the resources and tools available to better understand and evaluate a camp's energy and power demands. Moreover, armed forces personnel could continue to collect data on the energy performance of new shelters or new shelter technologies independently, with minimal need for reach-back. This would ultimately lead to more rational camp designs featuring alternative power sources and energy efficient technologies, and would result in reduced logistical and environmental footprints on even the smallest operations.

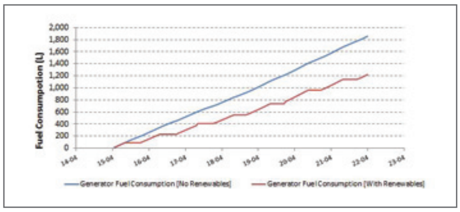
DEPLOYED CAMP ENERGY SIMULATION

In order for the camp designers of the CAF to better predict and understand the power and energy requirements, the use of an energy simulation tool was identified as a potential solution. The challenge with this solution was ensuring that the simulation would be capable of predicting the power and energy requirements reliably while remaining simple enough for any designer to use requiring little training.

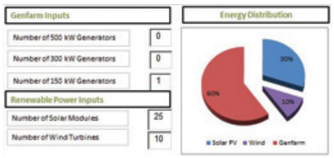
To overcome this complexity, a user interface was developed and linked to a simulation studio. The new interface reduces the number of inputs required, while still giving the designer the flexibility to predict the energy performance of a user-customizable camp through an unlimited range of pre-developed selectable shelter energy components. The database of available shelter energy models in the simulation tool can be expanded as more information is collected on existing or future shelter systems. Globally, the user inputs the location of the camp, operating period and the total design occupancy. The user then models the camp by selecting shelters and inputting key criteria such as the temperature set-points, lighting loads, convenience loads, heating or cooling equipment, and schedules. Default inputs from the energy monitoring studies are available to the user for hasty calculations.

Camp Electical Energy Power Draw and Renewable Integration Potential





Genfarm Parameter Selection



Renewable Systems Integration

	Camp Peak Power Draw		Camp Energy Consumption	
	Date and Time	Peak Power Draw (kW)	Total Energy Consumption (kWh)	Fuel Consumption (L)
No Renewables	20-04 (04:59)	50	6,407	1,856
With Renewables	20-04 (04:59)	49	4,081	1,221

Figure 3: Simulation Tool Power and Energy Output Results

The simulation tool outputs the energy consumption and temperature profile results to Microsoft Excel for further analysis. Key results, such as the peak power draw, total electricity consumption and the total fuel consumption are immediately highlighted after selecting a suitable power generating source. Additional details are provided in the form of the peak power draw of specific shelter groups and an energy end-use break-

(a)

(b)

Figure 4: Energy Metering Study at Ex Maple Resolve 2016 (a) Generator Farm Electrical Metering (b) Kitchen Hot Water Usage Metering

down for the entire camp. Through the time-varying electric load profiles, the user has a much better estimate on the anticipated peak power draw of the entire camp, which is important for selection of petroleum-fuelled generators and renewable energy equipment alike (Figure 3). The user can then run a wide variety of parametric studies evaluating different camp configurations or parameters.

SIMULATION TOOL VALIDATION

As the simulation tool utilized pre-developed shelter energy models validated from previous energy monitoring exercises, it was important to compare simulated power and energy predictions to actual data on a subsequent exercise or operation. In May 2016, Ex MAPLE RESOLVE, the annual Canadian air–land task force pre-deployment exercise, was selected to provide energy monitoring equipment training to personnel from 1 Engineer Support Unit (1 ESU)—the CAF's highreadiness military engineering unit. 1 ESU performed a camp energy metering study (Figure 4) and validated the power and energy prediction of the simulation tool. The camp was occupied by 700 soldiers and located in Wainwright, Alberta. Energy monitoring was conducted for seven days (May 15th to May 21st).

The total electricity consumption over the one-week period was measured to be 10,639 kWh with a peak electrical demand of 116 kW. The simplified energy simulation tool predicted a total energy consumption of 10,928 kWh (+2.6%) and a peak electrical demand of 131 kW (+12.9%). Differences can be attributed to the fluctuating camp population and wide diversity of convenience loads and operating schedules. This also shows the importance of continuously monitoring the energy consumption at camps, so as to quantify the anticipated diversity. The simulation tool demonstrates that a validated camp power and energy prediction strategy is significantly more reliable than using published design factors for capacity (e.g. 3 kW/person[5]), which would have significantly oversized the power generating requirements.

> Moreover, armed forces personnel could continue to collect data on the energy performance of new shelters or new shelter technologies independently, with minimal need for reach-back.

GOING FORWARD

Finding affordable alternatives to reduce the diesel dependency of military operations is critical. Through a collaborative effort between CJOC, DRDC and NRCan the CAF have been given the tools, training and mentoring required to address this challenge. Energy metering kits give the CAF the ability to monitor and better understand a camp's energy use while in operation. A simplified camp energy simulation tool has been transferred, giving designers the ability and standardized methodology to better predict a camp's power and energy demand. The energy monitoring kits were recently deployed at Ex MAPLE RESOLVE 2016, validating the power and energy prediction capabilities of the simulation tool. The CAF have recently demonstrated the potential interoperability of the tools by using them to help diagnose power generation issues at an operational support hub in Kuwait with a mixture of equipment standards. This latest development could encourage energy monitoring interoperability on NATO missions.

Going forward, collaboration will continue to support the CAF in achieving their energy reduction targets. The simulation tool will continue to be validated through energy monitoring of operations and exercises in both cold and hot/humid weather locations. Continued monitoring will also provide insight into shelter and deployed camp energy profiles, which can in turn be implemented into the simulation tool to help designers anticipate loads. The tool will be maintained by adding new shelter types as they enter CAF inventory, as well as promising energy efficient technologies. To meet energy reduction targets and realise other benefits, the CAF must field test new technologies. The CAF now have the tools and resources available to monitor and quantify these energy savings, and can draw upon continuing support from other government departments to identify promising technologies and strategies.

[5] National Defence, Engineer Field Manual Volume 12- Accommodation, Installations and Engineering Services, DND, 2005, Canada, Doc No B-GL-361-012/FP-001 page 83.

Drones and Alternative Energies: mixing technologies to achieve a new model?

The views expressed here are solely those of the author. They do not necessarily reflect the views of IRSEM or any other organization.

Océane Zubeldia

In the last two decades, we have seen the increasingly widespread use within the military of drones under the acronym RPAS (Remotely Piloted Aircraft System). As highly effective tools for joint, combined and coalition operations, drones are deployed in all types of environments; there is no longer a military dimension where this device cannot be employed. Extant studies on these machines have generally focused on their military use, with the debate focused on armed drones in the US and in Europe. However, the issues concerning autonomous and eco-compatible systems use are still a core concern. There is greater awareness of environmental issues on the international stage, which is not exclusively linked to drones. We have progressed from realization of the problem to the urgent need to take action. In a context where various challenges must be dealt with (terrorism, cyber threats, global

Could alternatives energies enhance drones' flying autonomy?

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Drone powered by electromagnetic induction.

warming, and defense budgets cuts), managing efficiency, scarcity and energy security becomes a strategic imperative. In this perspective drones have their own role to play and have both human and economic advantages.

What levers should be used as a priority? What future applications could be considered? The ambitions of fossil fuel-consuming countries are concerned with the diversification and the development of new sources of energy. Diversifying and protecting the raw materials industries, in compliance with environmental regulations, is therefore one of the challenges facing technological development in the Defence Industry. There are different possible pathways to develop clean drones. Sustainable biofuels, mechanical, thermal, electrical and solar energies could enable the development of green energy and in particular strategic autonomy. Significant progress has been made in the implementation of nanotechnologies, providing the technological capability to achieve new models. This process takes time; meanwhile, the industry wants to remain competitive in the exports market which means environmental performance often comes second. Finally, sustainable development aspects can be perceived by procurement agencies as additional constraints in a process that is already difficult.

> Technology will play a major role in making drones and alternative energies a reality; more mobile, intelligent, and autonomous and with low energy consumption for the same level of performance during various modes of locomotion.

Technology will play a major role in making drones and alternative energies a reality; more mobile, intelligent, and autonomous and with low energy consumption for the same level of performance during various modes of locomotion. This trend is becoming is particularly visible, especially in the civil sector. Dual-use technology and innovative applications may contribute to new developments and overall changes. According to the statistics, civilian application in 2015 showed that the surveillance of infrastruc-

AutoNaut is a marine drone for ocean surveillance, partially printed in 3D and which function by wave energy and solar panels.

tures was the leading domain just ahead of agriculture. This situation can be explained by high demand for surveillance and the diversity of sites and sources of supply (nuclear power stations, onshore/offshore oil installations, photovoltaic power stations, gas reserves, wind farms, etc.). Because of their great potential, drones may enhance new economic projects. To address these we can imagine new processes and policies.

In conclusion, the search for substitutes to petroleum products is imperative in the short term to guarantee our independence of supply, reduce CO^2 emissions and ensure interoperability with our allies. Additionally, a clear definition of the aims, as well as the resources to be mobilized through various stakeholders, should be set; protection and security, environmental compliance, budget constraints, and autonomy. Nikola Tesla's pioneering work affirmed that "this new power for the driving of the world's machinery will be derived from the energy which operates the universe, the cosmic energy, whose central source for the Earth is the sun and which is everywhere present in unlimited quantities" (Device to Harness, 1933).

Predicted value of drone powered solutions in key industries - global view ($ bn)	
Infrastructure	45.2
Agriculture	32.4
Transport	13
Security	10
Media & Entertainment	8.8
Insurance	6.8
Telecommunication	6.3
Mining	4.4
Total	**127.3**

Drone and surveillance of pipeline infrastructures.

Leveraging Industry to Reduce the Military's Energy Needs and Promote Operational and Installation Energy Security

Theodora E. von Hohenstaufen Noll
Defense Program Manager, Virginia Economic Development Partnership

The military-industrial complex, by its very name, highlights the interdependence the military and industry have with each other. While the 34th President of the United States, Dwight D. Eisenhower, noted in his farewell address that "our arms must be mighty, ready for instant action, so that no potential aggressor may be tempted to risk his own destruction,"[6] (Eisenhower, 1961). He also warned that "we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex."[7] His sentiments acknowledged the need for a strong defense, but cautioned of the perils for government to engage too closely with the defense industry. Decades later, and after the global financial crisis of 2008, we continue to face threats to our common security. Militaries worldwide are being challenged to do more with fewer resources. This fiscal constraint has made it necessary for militaries to find more cost effective ways of carrying out their mandates. By leveraging energy advancements found in industry, the military is able to realize energy savings, both operationally and at installations, as well as strengthen its energy supply chain.

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Since the Eisenhower days, due in large part to industry, technology has advanced in ways perhaps unimaginable back then. Unfortunately, defense acquisition and fielding new technologies has not kept up with the pace of this advancement. At a recent conference on Defining the Offset Strategy held by the Center for Strategic and International Studies, the role of the Department of Defense, in terms of advancement of technology, was described as such: "DoD is NOT organized for innovation, the system is set up that when it sees a compelling threat it adapts, but there has to be a mindset shift: innovation on the micro level should not threaten the institution."[8] According to the Office of the Undersecretary of Defense's Year 2017 Budget request, there needs to be an "emphasis on taking more advantage of the technical innovation within private industry."[9]

Energy security, as defined in the 2012 National Defense Authorization Act, "assures energy access, reliable supplies, and sufficient energy to meet mission essential requirements."[10] Energy security must be evaluated from a cost perspective, both economic and otherwise. Analysis indicates that the cost of delivering a single gallon of fuel to a forward operating base (FOB) in Afghanistan cost $400 with one in 50 fuel convoys experiencing serious injury or fatalities.[11] Thus, the need to find easily deployable, affordable and reliable power generation is critical. The American Council on Renewable Energy (ACORE) noted that renewable energy isn't just a policy issue; it is an "operational imperative, and that "by enabling technologies like microgrids [there will be] tremendous implications for the safety, security and effectiveness of the military."[12]

The DoD is the largest consumer of energy in the United States, spending billions of dollars on energy each year.[13] The Office of the Undersecretary of Defense for Energy, Installations and Environment reports that in Fiscal Year 2014, DoD required close to "87 million barrels of fuel, at a cost of nearly $14 billion."[14] The DoD is also "the largest single consumer of energy in the world."[15] The majority of energy consumption is used for operational energy (OE). Installation energy (IE), however, still accounts for a substantial part, nearly 30 percent[16] of DoD's energy consumption, at a cost of approximately $4 billion annually.[17] The overwhelming majority of DoD's energy consumption is fossil fuel based. This high-level of energy consumption, according to numerous DoD studies, has created a strategic risk which requires the U.S. military energy strategy "to redouble its work with DoD to accelerate the deployment of advanced energy technologies that improve the military's ability to fulfill its core mission."[18] For several reasons, including, but not limited to, fluctuating fuel prices, supply chain concerns as well as the environmental impact of fossil fuel dependence, the DoD has set a goal of deriving 25% of its energy from renewable sources by the year 2025.[19] The U.S. Army even has a goal to "reach net-zero energy consumption by 2030."[20] Such a goal will only be achieved in collaboration with industry.

While being mindful of Eisenhower's admonition to be wary of unrestricted influence by the military-industrial complex, the reality is that when industry and the military are able to collaborate on common interests, both benefit. In the past, DoD drove much of the research and development that ultimately benefitted the commercial sector as well. Defense dollars funded programs to benefit troops which resulted in significant advances in computers, robotics and healthcare which

[6] Eisenhower, Dwight, Eisenhower Farewell Address, 1961, retrieved from https://www.eisenhower.archives.gov/all_about_ike/speeches/wav_files/farewell_address.mp3
[7] Ibidem
[8] Porkolab, Imre, "Assessing the Third Offset Strategy," in LinkedIn Pulse, October 31 2016, retrieved from https://www.linkedin.com/pulse/assessing-third-offset-strategy-imre-porkolab
[9] United States Department of Defense, "Defense Budget Overview: United States Department of Defense Fiscal Year 2017 Budget Request," Washington, February 2016, p. 9-2
[10] Samaras, Constantine, Willis, Henry H., Capabilities-Based Planning for Energy Security at Department of Defense Installations, Calif: RAND Corporation, Santa Monica, 2013, p. xii
[11] ACORE, AEE, "U.S. Department of Defense & Renewable Energy: An Industry Helping the Military Meet Its Strategic Energy Objectives," Washington, January 2012, p. 3
[12] ACORE, "Renewable Energy for Military Installations: 2014 Industry Review", American Council on Renewable Energy, Washington, February 2014, p. 4

ultimately had crossover applications in commercial sectors. Now, however, private industry is investing significant amounts of their own research and development resources to serve commercial sector demands which can benefit the DoD's quest for energy security as well.

From the Installation Energy perspective, efforts focus on reducing energy demands and increasing efficiency of existing structures as well as increasing the amount of renewable and on-site generated electricity. DoD installations depend predominantly on commercial power generation which is "vulnerable to disruption from aging infrastructure, weather-related events and direct attack."[21] Out of market-driven necessity for their own core business models, industry has already developed many resilient and sustainable technologies that facilitate effective energy management solutions. These technologies can be adapted also to military applications.

Out of market-driven necessity for their own core business models, industry has already developed many resilient and sustainable technologies that facilitate effective energy management solutions.

Additionally, industry and the military can work together to reduce energy consumption and costs through power purchase agreements (PPA) and energy savings performance contracts (ESPC). With a PPA, the energy infrastructure asset is owned by industry and it can take advantage of renewable energy tax credits to achieve cost savings. With an ESPC, the energy infrastructure asset is owned by the military and is financed by a third party. With an ESPC, industry assumes the risk through performance guarantees. During the implementation stage of an ESPC, the private sector company implements energy saving measures and as a result of the energy savings measures, those savings generated are being used to pay for the loan to implement the improvements. Once the project is paid off, the government owns the infrastructure asset AND retains the savings. DoD is able to meet its energy goals at no increased cost to the DoD in the process. In the DoD's White Sands Missile Range case, not only did the ESPC photovoltaic project meet a portion of the base's energy needs, but it also produced an estimated $930,000 in annual savings.[22] Since this project, DoD has engaged in a number of other PPAs and ESPCs, saving DoD millions of dollars each year.[23]

From an Operational Energy perspective, DoD "will pursue a range of materiel and non-materiel initiatives that improve energy use in the near-term."[24] In addition to standard renewable energy solutions already familiar to most people, kinetic energy is a growing field that has significant size, weight and power implications to lighten troops' heavy loads. There are now shoes that capture kinetic energy created while walking.[25] Kinetic energy generating backpacks and knee braces have been field tested by the U.S. Army and U.S. Marine Corps, with full-scale prototyping to occur in 2017.[26]

[13] Ibidem, p. 21
[14] Office of the Assistant Secretary of Defense, "Operational Energy," Under Secretary of Defense Acquisition Technology Logistics, Washington, 2017, retrieved from http://www.acq.osd.mil/eie/OE/OE_index.html
[15] Holland, Andrew, Cunningham, Nick, Huppmann, Kaitlyn, Joyce, William, "Powering Military Bases: DoD's Installation Energy Efforts", Washington, July 2013, p. 1, retrieved from http://americansecurityproject.org/ASP%20Reports/Ref%200128%20-%20DoD%20Installation%20Energy%20Fact%20Sheet.pdf
[16] Office of the Assistant Secretary of Defense, "Department of Defense Annual Energy Management Report Fiscal Year 2015", Washington, June 2016, p. 7
[17] Office of the Assistant Secretary of Defense, "Installation Energy (IE)," Under Secretary of Defense Acquisition Technology Logistics, 2017, retrieved from http://www.acq.osd.mil/eie/IE/FEP_index.html
[18] ACORE, AEE, "U.S. Department of Defense & Renewable Energy: An Industry Helping the Military Meet Its Strategic Energy Objectives", op.cit.
[19] ACORE, "Renewable Energy for Military Installations: 2014 Industry Review", op.cit., p. 4
[20] Op.cit., p. 5

Another energy advancement where industry is leading the way is in liquid metal batteries (LMB). This technology offers the capability "of storing electricity at the grid level with almost perfect efficiency"[27] and it "has been designed from the beginning to have a low cost and a long lifespan, while being operationally flexible and safe."[28] These LMB, also called liquid flow batteries, are intended to make power grids more efficient and resilient, with the ability to store large amounts of energy for later delivery.[29] It could minimize disruptions that might impact critical missions. Initial testing indicates these batteries have better performance than solid-state batteries and could perform for decades with little degradation.

> While it is possible to point out numerous additional ways in which industry is developing innovative, disruptive, renewable energy technologies that could positively impact military energy security, fundamental hurdles remain. Procurement regulations themselves need to be more streamlined."

While it is possible to point out numerous additional ways in which industry is developing innovative, disruptive, renewable energy technologies that could positively impact military energy security, fundamental hurdles remain. Procurement regulations themselves need to be more streamlined. DoD recognizes the need to "make the requirements, acquisition and budget process better suited for innovation"[30], and is making changes to the acquisition process. There may also be regulatory considerations that impact what is possible in a particular country. As is the case with PPAs, if there is no renewable energy tax credit or some other incentive, this may restrict the range of what is possible.

There are federal defense and energy organizations focused on innovative energy solutions, such as the Defense Innovation Marketplace, Defense Innovation Unit-Experimental, or DIUx, the Small Business Innovation Research (SBIR) programs, the Energy Excelerator (EEx), funded in part by Department of Defense, or the Advanced Research Projects Agency – Energy (ARPA-e), funded by the Department of Energy. However, companies with innovative solutions might not come from the traditional defense contractor pool. Cutting edge technology companies may originate in STEM programs at universities, business incubators and backyard-garage inventors. For that reason, it is critical for the military to connect with academia and non-defense industry organizations to tap into the wealth of hidden potential industry offers to help improve energy security for the military.

[21] Office of the Assistant Secretary of Defense, "Installation Energy (IE)", op.cit.
[22] WSMR Public Affairs, "White Sands Home to Army's Largest Solar Power System", January 17 2013, retrieved from http://www.army.mil/article/94412/White_Sands_home_to_Army_s_largest_solar_power_system
[23] US Department of Energy, "Renewable Energy Projects at Federal Facilities | Department of Energy", 2017, retrieved from https://energy.gov/eere/femp/renewable-energy-projects-federal-facilities
[24] Office of the Assistant Secretary of Defense, "Operational Energy", op.cit.
[25] Beach, Greg,"InStep NanoPower Shoes Harvest Kinetic Energy While You Walk", in Inhabitat, February 16 2016, retrieved from http://inhabitat.com/step-into-the-future-with-instep-nanopower-shoes-that-harvest-kinetic-energy/
[26] Versprille, Allyson, "Military Tests Energy Generating Backpack", August 2015, retrieved from http://www.nationaldefensemagazine.org/archive/2015/August/Pages/MilitaryTestsEnergyGeneratingBackpack.aspx
[27] Register, Chip, "A Preview Of Innovations That Could Upend The Energy Sector," in Forbes Magazine, May 15 2014, retrieved from http://www.forbes.com/sites/chipregister1/2014/05/15/mit-shines-light-on-coming-attractions-in-global-energy/#7018ef1a6a39

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[28] Analysis Group, Ambri, "Project Imua: An Economic Analysis of the Impacts of Ambri Storage and Varying Levels of Renewables in Hawaii for Utilities and Select Customers," Boston, November 2015, p. III
[29] Stauffer, Nancy, "A Battery Made of Molten Metals," MIT News, January 12 2016, retrieved from http://news.mit.edu/2016/battery-molten-metals-0112
[30] Lyle, Amaani,"DoD Seeks Industry Collaboration in Technology Development," U.S. DEPARTMENT OF DEFENSE, September 5 2014, retrieved from https://www.defense.gov/News/Article/Article/603189/dod-seeks-industry-collaboration-in-technology-development

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