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THE FIFTH FUEL:
A CASE FOR ENERGY CONSERVATION PRACTICES ON OPERATIONS

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> In transporting provisions for a distance of one thousand li, twenty bushels will be consumed in delivering one to the army…. If difficult terrain must be crossed even more is required.
>
> -Sun Tzu, *Sun Tzu and the Art of Modern Warfare*

AIM

1. The aim of this paper is to illustrate how simple low cost solutions can reduce energy consumption in deployed camps. Two easily implemented energy reducing initiatives will be considered in this paper; modifications to user behaviour and better alignment of electrical production to demand.

INTRODUCTION

2. Consistent energy supply is essential to support warfighting and sustainment capabilities on operations. Conservation of energy thus provides greater operational capability and resiliency to military operations. In his Masters' Thesis Lean, Green and Mean: An Operational Imperative, Major David B Moore, defines the problem with inefficient energy practices in deployed camps as;

> Fuel that is transported at great risk, great cost in lives and money, and substantial diversion of combat assets for convoy protection, is burned in generator sets to produce electricity that is, in turn, used to air condition un-insulated and even unoccupied tents.[1]

Resupply convoys serve as lucrative targets in asymmetric warfare. Force protection costs account for as much as 90% of the fully burdened cost of fuel (FBCF).[2] Despite the considerable force protection measures, one casualty occurred for each twenty-four US

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[1] David B Moore, "Lean, Mean, and Green: An Expeditionary Imperative," (master's thesis, Marine Corps University, 2010), 5.
[2] *Ibid*., 6. "Fully burdened fuel costs are the true cost of fuel once it is delivered to battlespace forces after applying all the costs of getting it there."

fuel resupply convoys in Afghanistan during 2007.[3] The saving of resources achieved by a reduced dependence on energy significantly increases resilience of the force.

3. The intent of this paper is to highlight two simple measures capable of minimizing energy waste in deployed camps. The paper will first review the increase in energy demands of North Americans at home and on operations to highlight the importance of energy security. Key energy conservation and security concepts will be presented to establish relevant foundational principles. The potential savings from two simple conservation initiatives will subsequently be explored. First, data from literature and recent metering initiatives on CAF operations will be used to demonstrate the sizeable costs associated with wasteful user behaviour. Second, the limited ability of the CAF to effectively link electrical generation to demand will be highlighted.

DISCUSSION

North American Energy Demands, Conservation and Energy Security

4. North Americans have become accustomed to consuming a disproportionate amount of the worlds energy. Even when energy consumption rates are normalized to account for variations in climate, Canadians consumed more energy per capita than the United States.[4] Average homes sizes in Canada have more than doubled since 1950 despite significant reductions in the number of occupants per household.[5] Similar increases in energy consumption and accommodations standards have occurred on

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[3] David S. Eady, Steven B. Siegel, R. Steven Bell, and Scott H. Dicke, "Sustain the Mission Project: Casualty Factors for Fuel and Water Resupply Convoys," *Army Environmental Policy Institute*, 2009, i.

[4] Meredith Gray and Jay Zarnikau, "Chapter 9 - Getting to Zero: Green Building and Net Zero Energy Homes," in *Energy, Sustainability and the Environment*, ed. Fereidoon P. Sioshansi (Boston: Butterworth-Heinemann, 2011), 232, https://doi.org/10.1016/B978-0-12-385136-9.10009-9.

[5] Gray and Zarnikau. "Chapter 9 - Getting to Zero…, 234.

operations. The gallons of fuel burned per soldier each day doubled between Operation *Desert Storm* and Operation *Iraqi Freedom*.[6] More fuel is now consumed by electrical generators than tactical vehicles or aircraft during combat operations.[7] The increasing dependence of military operations on fuel supply warrants attention.

5. The Canadian Army has postulated that energy supply will serve as one of the key factors in the future operating environment.[8] The relevance of energy security in modern conflict is exemplified by the magnitude of dependency most eastern European nations have on Russian energy supplies.[9] Modern militaries must be prepared to operate in environments where the adversary can influence, or potentially control, some or all of the fuel supplies from outside the area of operations. The case for reducing energy demand should resonate strongly with military professionals.

6. The CAF employs particularly wasteful practices on operations despite exceptional costs as well as a mandate to improve. The Defence Scientist Ahmed Ghanmi measured the FBCF to CFS Alert and various FOBs in Afghanistan as roughly 800% and between 120 and 320% respectively.[10] During the Op PRESENCE Theater Opening, the JTFSC Comd was approached by the German Camp Commander on more

[6] General Charles F. Wald (USAF Ret), "Energy Security - Americas Best Defense. A Study of Increasing Dependence on Fossil Fuels in Wartime, and Its Contribution to Ever Higher Casualty Rates" (Deloitte LLP, 2009, 3.

[7] Moore, "Lean, Mean, and Green: An Expeditionary Imperative…, 22.

[8] Canada, Department of National Defence. Canadian Army Land Warfare Centre, *Canada's Future Army, Volume 1: Methodology, Perspectives and Approaches.*, 2015, 22. http://publications.gc.ca/collections/collection_2017/mdn-dnd/D2-354-1-2015-eng.pdf.

[9] Julijus Grubliauskas, "WHY SHOULD NATO'S MILITARY CARE ABOUT ENERGY?" *NATO Emerging Security Challenges Division*, 2017, 17-19.

[10] Ahmed Ghanmi, "Fully Burdened Cost of Energy in Military Operations," in *2012 First International Conference on Renewable Energies and Vehicular Technology*, 2012, 22, https://doi.org/10.1109/REVET.2012.6195304.

than one occasion to address the excessive consumption of electricity, water and food by Canadian soldiers.[11] Furthermore, Target 9 of the Defence Energy and Environment Strategy (DEES) mandates a 50% reduction in petroleum-generated electrical energy consumption at deployed camps by 2030.[12] There are strategic, operational, and tactical benefits linked to reducing the sizeable and costly wastes occurring on operations.

7. Energy conservation is often referred to as the fifth fuel after coal, hydrocarbons, nuclear and renewables.[13] Although the terms efficiency and conservation are often used interchangeably, efficiency is strictly a subset of conservation. Energy conservation initiatives, such as cooling to 23ºC instead of 20ºC, create realized energy savings. Conversely, improved efficiency is susceptible to the 'rebound effect' or Jevons Paradox where savings are subsequently consumed elsewhere.[14] For example, the savings from more efficient air conditioners are often used to cool to a lower standard. Realized savings increase energy security through improved resiliency and reduced dependency.

8. The Canadian Joint Operational Command (CJOC) Integrated Camp Utilities Technology (I-CUT) program was established to meet the requirements of DEES.[15] The first decisive point of the program is the establishment of a systematic energy metering

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[11] LCol Tom Murphy, "RE: Op PRESENCE Waste," October 15, 2019.
[12] Canada and Department of National Defence. Defence Energy and Environment Strategy*: Harnessing Energy Efficiency and Sustainability : Defence and the Road to the Future,* Ottawa: National Defence, 2017, 14. http://publications.gc.ca/collections/collection_2018/mdn-dnd/D2-394-2017-eng.pdf.
[13] M G Burbage-Atter, "36 - Energy Conservation," in *Plant Engineer's Reference Book (Second Edition)*, ed. Dennis A. Snow (Oxford: Butterworth-Heinemann, 2002), 36–3, https://doi.org/10.1016/B978-075064452-5/50091-2.
[14] *Ibid*.
[15] BGen C.M. Harding, "Update 002 - FY 19/20 Implementation Plan Integrated Camp Utilities Technologies (I-CUT)" (CJOC, August 26, 2019).

and reporting capability.[16] The program will evolve towards promoting energy awareness and subsequently targeted interventions to reduce energy consumption.[17] Proper metrics are required to identify problematic user behaviours and measure the impact of behaviour interventions. With the installation of electrical meters on multiple operations, the initial framework is in place to support energy conservation measures on operations. However, the $200k of annual funding towards I-CUT is only sufficient to meter small portions of a few missions. Data and proper metrics are essential to identify and confirm the magnitude of wasteful behaviour in order to implement targeted interventions.

Wasteful User Behaviour

9. Highly wasteful practices present opportunities to conserve energy on an enormous scale. Canada postulates that one third of the 2030 green house gas emission reductions can be achieved from energy conservation practices alone.[18] Conservation strategies already in place in the Province of Ontario's have resulted in a 6% drop of electrical consumption between 2007 and 2014.[19] Sizeable savings have been demonstrated within a sub-set of the Canadian population without a reduction in the

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[16] LGen S. Bowes, "CJOC Implementation Plan Integrated Camp Utility Technologies (I-CUT)", CJOC, 2017, 2.
[17] *Ibid*., 3.
[18] Merran Smith and Linda Coady, "Canada's Energy Transition Getting to Our Energy Future, Together," *Generation Energy Council Report*, 2018, 23.
[19] Environmental Commissioner of Ontario, "2015/2016 Energy Conservation Report – Conservation: Let's Get Serious | Environmental Commissioner of Ontario,"2016, 20. https://eco.auditor.on.ca/reports/2016-lets-get-serious/.

standard of living. A similar effect should be reproducible on operations where user controls are easier to enforce.

10. Implementation of energy efficient technologies have been observed to create negligible savings, or even cost increases, when implemented without engaging the users.[20] Engaging users can be as simple as reminding personnel to turn off lights or equipment at the end of the day. When users of government buildings were engaged via energy management plans, savings of up to 16% were realized without employing any technological changes.[21] These results demonstrate the importance of engaging the user in energy conservation initiatives.

11. The Hawthorne effect is defined as "the alteration of behavior by the subjects of a study due to their awareness of being observed."[22] A recent study involving Virgin Airline pilots demonstrated the positive impact of making users aware their energy behaviours were monitored.[23] Four groups of 83 pilots were randomly selected from the overall population. All groups were informed that fuel consumption would be tracked during their flights. A control group was required to follow existing SOP and was not provided monitoring results. The three test groups were encouraged to reduce the number of engines used during taxiing and perform better fuel calculations in order to carry less fuel weight. Each test group was provided feedback on fuel consumption from

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[20] Natural Resources Canada, "Who Creates Savings", *Good Practice Guide 84 Managing and Motivating Staff to Save Energy*, Ottawa: Government of Canada, 2012.
[21] *Ibid*.
[22] Google Dictionary. "Hawthorne Effect," last modified [or accessed] accessed October 22, 2019, https://www.google.com/search?client=firefox-b-d&q=hawthorne+effect.
[23] Greer Gosnell, John List, and Robert Metcalfe, "The Impact of Management Practices on Employee Productivity: A Field Experiment with Airline Captains", Cambridge, MA: National Bureau of Economic Research, February 2019, https://doi.org/10.3386/w25620.

their flights. Targeted reductions were given to two of these groups with one group also provided minor incentives for reaching the target. All groups proved considerably more fuel efficient than the overall population. Remarkably, the simple fact pilots were aware of the monitoring was credited with creating over $6 M (1%) of savings in fuel costs over an eight-month period.[24] The extra measures of feedback, targets and incentives were identified to have contributed an additional $500k in fuel savings.[25] Monitoring combined with engaging users was the more effective method in reducing energy consumption.

12. A "phantom" electrical load occurs when a device continues to draw power while not in use. Such as a computer that has been "logged off" versus a turned off or unplugged. Although comparatively small to other wasteful practices, phantom electrical loads can account for as much as 10 percent of a homes energy use in Ontario.[26] Phantom loads are simple to eliminate via an energy management plan or the installation of smart power bars.

Wasteful User Behaviour on Operations

13. Relocatable temporary camps, comprising Weatherhaven MTS Lite tents and Mobile Expandable Container Configuration (MECC) Ablutions, are used to house CAF and NATO personnel in support of the Enhanced Forward Presence (EFP) Battle Group in Adazi, Latvia. Although the camps were heated by external diesel fueled heaters, the

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[24] Gosnell, List, and Metcalfe, "The Impact of Management…, 16.
[25] *Ibid*.
[26] HydroOne. "Residential Tools and Tips – Phantom Power,"last modified [or accessed] accessed October 22, 2019, https://www.hydroone.com/saving-money-and-energy/residential/tips-and-tools/phantom-power.

remainder of the electrical consumption of the camps has been metered intermittently. The total electrical energy consumed in the camp at Life Support Area 1 (LSA1) during the month of October 2018 was 134,000 kW-hr.[27] Using an average generator efficiency value of 1 L of fuel to produce 3.5 kW, over 38,000 L of diesel fuel was required to power the camp. The 400 personnel in the camp were not aware of the metering nor was an energy management plan in force. Assuming the impact of engaging the user observed in the Virgin Airlines (1%) and government building studies (16%) are achievable, savings would be in the range of 380 to 6,000 L of fuel per month. Considering the LSA constitutes a small fraction of the infrastructure used to support the operation, the overall savings of engaging the user through an energy management plan would be significantly greater.

14. The majority of current CAF operations employ large headquarters that utilize large amounts of electronic devices. At present, roughly 900 computers are deployed on CAF operations.[28] The annual fuel requirements to support the phantom power consumption of these computers is approximately 5,600 L.[29] This example does not consider the sheer volume of other office, convenience and personal devices employed on operations that also draw phantom power. An energy management plan or employment of smart power bars would eliminate the entire phantom power load.

Electrical Supply Versus Demand

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[27] LCol T. Murphy, "Annual Energy Monitoring Report FY 18/19", 1 ESU, 2019.
[28] Simon MacDonald, "RE: Computers on Operations," October 21, 2019.
[29] HydroOne. "Residential Tools and Tips – Phantom Power,"last modified [or accessed] accessed October 22, 2019, https://www.hydroone.com/saving-money-and-energy/residential/tips-and-tools/phantom-power.

15. The electrical demand rates in doctrine are highly conservative possibly accounting for the inefficiencies associated with tented structures. The peak electrical requirement for accommodations and ablutions has been defined as 3 kW/person.[30] The peak electrical demand measured in the accommodations area of LSA1 on Op REASSURANCE and Ali al Salem Air Base on Op IMPACT were 1.02 and 1.34 kW/person respectively.[31] The doctrinal planning value is therefore in the range of two to three times the actual requirement. Additional metering data will be instrumental to refine electrical demand rates which vary significantly with climate, type of operation and infrastructure employed.

16. The CAFs only fleet of large deployable generators is composed of inefficient single speed generators. Single speed generators are geared to operate at a constant engine speed and thus produce consistent power. As an example, a 150 kW single speed generator will run efficiently when the demand in the system is roughly 150 kW. If a lower demand is applied, the generator will run outside the optimal speed resulting in greater fuel consumption and significant wear and tear. A variable speed generator is designed to be able to efficiently vary the speed of the engine matching output power to the electrical demand. The limitations of the single speed generators are addressed by employing load banks. Load banks increase resistance in the system so the generator will operate closer to the optimal speed. The concept is analogous to converting fuel into heat in order to reduce wear and tear on the system.

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[30] Department of National Defence, B-GL-361-012-FP-001, Engineer Field Manual Volume 12 Accommodations, Installations and Engineering Services. (Ottawa: DND Canada, 2005), 83.
[31] LCol T. Murphy, "Annual Energy Monitoring…, 6.

17. A load bank functions adequately in a well designed system with a consistent demand. Two key factors prevent this from occurring in deployed camps. First, the demand varies considerably by season and throughout the day based on the occupant's activities. Second, the current planning factor of 3 kW/person results in generators sized to at least double the peak requirement. The net effect is a tremendous abundance of power generated on operations without any requisite capacity to store the power. The load bank employed at LSA1 consumed 50% of the electrical power produced during the month of October.[32] It is estimated that removal of the load bank would have reduced fuel consumption by approximately 19,000 L of fuel per month without a decrease in the standard of living.

CONCLUSION

18. Energy demand on operations continues to increase at a rapid rate. The dependence of the military on fuel has strongly reinforced the importance of energy security. The energy consumption data available, although limited, suggests the CAF is highly wasteful on operations. Counter to intuition, efficiency initiatives rarely produce savings as demand typically increases following technological improvements. Conservation thus presents a remarkably simple and effective solution to reduce the energy dependency within deployed camps. The continuation of these trends will render conservation practices applicable to overall operations not simply deployed camps.

RECOMMENDATIONS

[32] LCol T. Murphy, "Annual Energy Monitoring…, 7.

19. The following initiatives are recommended.

a. Conservation. Wasteful consumption of electricity, water and food should be identified and minimized on operations.

b. Metering. Metering capabilities on operations should be expanded to monitor electrical, water and fuel consumption in order to;

(1) Identify wasteful practices; and,

(2) Update planning factors and doctrine.

c. Fully Burdened Fuel Cost. The FBCF should be assessed for each operation to inform better support decisions.

d. Energy Management Plan.

(1) Energy management plans should be developed for major operations to include;

(a) Additional reporting of consumption data. Receipts or invoices for utilities, water delivery, wastewater recovery and fuel deliveries are easily accessible and transferable;

(b) Methods to inform users of energy monitoring should be employed; and,

(c) Phantom power should be eliminated through checks by duty personnel or use of smart power bars.

(2) Energy management activities should be highlighted during Key Leader Engagements during rotation changes.

(3) Energy management and conservation principles should be instructed on the Engineer Operations, Construction Engineer Supervisor, and Environmental Officer courses.

e. <u>Electrical Generation</u>.

(1) Load banks should not be employed on operations;

(2) Electrical generation farms should be designed to better match demand through the employment of multiple different sizes of generators or variable speed generators; and,

(3) CJOC should identify the requirement for efficient variable load power generation equipment to the CAMP SUSTAIN project.

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