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Operational Energy

A Multi-Faceted Government Approach

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IMPORTANT INFORMATIVE STATEMENTS

Operational Energy: A Multi-Faceted Government Approach





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Recent analysis of the results achieved during consequent simulation exercises of 2013 and 2014 aimed at reducing diesel dependency at military deployable camps and stations in Canada demonstrates the potential of new technologies and the scope of possible savings: a 50% reduction can be achieved in total fuel consumption of cold weather operations. Will those achievements be translated into real-life technology demonstrations using actual military exercises? Will they be interoperable with Canada's NATO partners as they move towards new energy technologies?

Response to challenges through interagency cooperation

The Canadian Department of National Defence (DND) operates in remote locations in Canada for training and sovereignty operations, as well as globally under natural disaster conditions or in foreign territories with conflicts. To sustain operations from the Arctic to hot climatic regions, the DND depends heavily on long logistics lines of communications to supply fossil fuel (primarily diesel) as the main supply of power and energy for static (such as main operating bases, forward operating bases, etc.) and for mobility requirements. The transport of fuel represents a heavy logistics and financial burden to operations.

In non-permissive locations, fuel transport also requires route clearance, convoy escort and force protection. In eco-fragile remote areas such as the Arctic, the risk of fuel spills is also increased by the storage and transport of fuel, thereby adding to environmental issues such as greenhouse gas (GHG) emissions.

In support of DND's military operations and environmental objectives, Defence Research and Development Canada (DRDC)[1] has engaged in a power and energy Technology Demonstration (TD) project called Integrated Camp Energy – Technologies (ICE-T). The ICE-T TD project was initiated by reducing diesel dependency at military deployable camps and stations, both nationally and abroad. The project's main focus was Arctic operations.

The scarcity of existing Canadian Armed Forces (CAF) data for camp energy demand levels, consumption rates and purposes prevented the analysis and pre-selection of technologies for optimum operational impact. To mitigate this problem and to leverage their energy

1 http://www.drdc-rddc.gc.ca

R&D expertise, the Natural Resources Canada – CANMET Energy laboratory was mandated by DRDC to conduct energy audits and later determine suitable technologies that would maximize operational benefits.

Operation Nanook 2012

The data collected revealed a total camp consumption of 32,086 kWh for both diesel and propane for a typical week. The monitoring also showed that 85% of the total amount of diesel delivered to the camp was used by the generator farm to produce electricity and domestic hot water heating. A peak electrical demand of 247 kW and a total energy consumption of 22,279 kWh were recorded.

NRCan's CanmetENERGY monitored Canadian Armed Forces Operation NANOOK held in Inuvik (NWT), from July to September, 2012. The fuel, electrical energy consumption and climatic data of a 350-person camp were monitored.

The largest electric load during the exercise went to provide space heating for soldier accommodations. This load represents 33% of the total electricity generated on site. The kitchen, food preparation and ablution as well as the refrigeration units (i.e. reefers) took another 23%, while the Tactical Operations Centre and the offices required 19%. The vehicle fuelling station, transport and Electric Mechanical Engineers (EME), vehicle washing station and Central Material Traffic Terminal (CMTT) required 12%. The remaining loads were for the Reverse Osmosis Water Purification Unit (ROWPU) and sewage, which accounted for 9%, and a single ablution which required 4%.

Fuel Reduction Technology Demonstration

Using this energy profile for a typical Canadian Armed Forces cold climate deployed camp, CanmetENERGY-Varennes[2] was tasked with developing and demonstrating power and energy technologies capable of providing fuel consumption reductions for military operations deployed to cold climates. Preliminary analysis of the energy profile for Operation NANOOK 2012 clearly demonstrates that fuel reductions would be substantial if energy used for office and accommodation space heating and domestic hot water heating could be diverted from generator sets and provided as thermal energy recovery. Renewable energy sources were not evaluated because the significant expected fuel reductions achievable by thermal recovery did not justify solar panel and wind turbine introduction at this moment. Although thermal recovery has existed for quite a while, the camp demonstration task represented a special R&D challenge in that DRDC requested that the developed technology be "transportable" to meet expeditionary requirements in Canada's vast wilderness or abroad.

To achieve these goals, a mini-camp was erected by CanmetENERGY-Varennes at the site of Hydro-Québec's Institut de recherche électricque du Québec (IREQ). IREQ provided the site facilities near Montréal as well as their expertise with power management systems and cold weather *battery technology*[3]. Figure 2 presents an overview of the demonstration camp mechanical system. All of the mini-camp's electricity was produced by a variable speed generator (see GENSET in the schematic). The variable speed generator (CVT Corp.[4]) is designed to provide up to 125 kW of power while automatically adjusting its engine speed to minimize losses as electrical load demands vary. This generator was fitted with a heat recovery system to capture heat expelled by the engine-cooling jacket into the environment. The heat captured is transferred to propylene

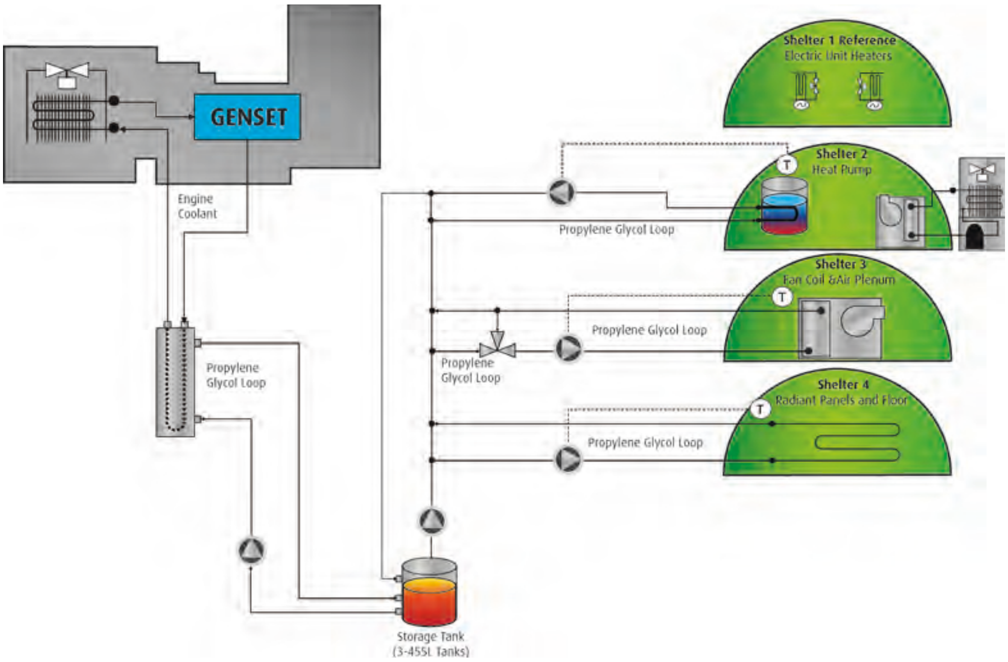
2 http://www.nrcan.gc.ca/energy/offices-labs/canmet/varennes/5761 , dated 27 May 2014. CanmetENERGY Varennes (QC) Research Centre.

3 http://www.hydroquebec.com/innovation/en/index.html, dated 27 May 2014 . Institut de recherche électricque du Québec (IREQ).

4 http://www.cvtcorp.com/powergeneration.html, dated 27 May 2014. CVT Corp. Designed for Power.

glycol, stored in a tank system (i.e. three 455-litre tanks), and distributed by pumps to the various shelters for space heating or to preheat domestic hot water (DHW). The camp demonstration was held in March 2013 with outdoor temperatures averaging between -8º and -15º Celsius.

Figure 1:
ICE-T Demonstration Overview



Shelter 1 was the Reference Shelter and was heated using two standard DND 5 kW electric convective heaters. Shelter 2 featured the DHW water system as well as an energy efficient cold weather air-source heat pump. The remaining space heating configurations using heat recovered from the generator were as follows: a fan coil system (half of Shelter 3), a floor air plenum (the remaining half of Shelter 3), and a radiant floor and panel system (Shelter 4). In order to operate the heat recovery system, a maintenance shelter (not shown in the schematic) was required to house the propylene glycol storage tanks and the various pumps used to circulate the propylene glycol throughout the camp.

The shelters' energy consumption was individually monitored and the results are presented in Table 1. Also, this table includes the energy required for the additional pumps to operate the heat recovery system and the total energy reduction when comparing the proposed solution to the Reference Shelter. The energy reduction is considerable: compared to the reference shelter, a 47% reduction was achieved using a cold climate heat pump, while a 65% reduction was measured by using heat recovered from the generator and then used to provide heating by means of the fan coil or the under floor air distribution system. Finally, a 70% energy reduction could be achieved by installing a radiant floor heating system and using heat recovered from the generator.

Table 1: Energy Consumption for Space Heating Solutions

SHELTER ENERGY CONSUMPTION COMPARISON (Based on 21 Days of Data)					
Shelter Number	Description	Energy Consumption (kWh)	Energy Consumption including PUMP PENALTY (kWh)	Energy Consumption per Day including PUMP PENALTY (kWh/day)	**Energy Reduction (when compared to the Reference)**
1	***Reference***	2,791	2,791	132.9	-
2	Heat Pump	1,468	1,468	69.9	**47%**
3	Fan Coil & Under Floor Air Distributed	661	976	46.5	**65%**
4	Radiant Floor	427	820	39.0	**71%**

The camp demonstration proved that considerable energy reductions are achievable through the integration of a heat recovery system.

Modeling

In order to determine the impact of implementing a heat recovery strategy to provide space heating or DHW heating, a camp model was created using TRNSYS version 17. The equipment and physical characteristics for each type of shelter were used. Energy data was collected during Operation NANOOK and during the camp demonstration so that the model could be used to simulate the camp's energy requirements for different geographical locations and weather profiles. The mini-camp demonstration was operated for approximately 3 weeks in temperatures ranging from 0º to -22º Celsius.

The camp energy model was used to simulate the energy requirements for a camp with the same configuration as Operation NANOOK but operating in Edmonton (AB) for the month of January with an average temperature of -12ºC. The simulation showed that a camp built using standard DND equipment would require a peak electric demand of 1,359 kW and 145,000 litres of diesel fuel to operate.

The same energy model was used to simulate the impact of using recovered heat (from the generators) to satisfy some of the space heating and domestic hot water heating requirements of the camp configuration (see Figure 3). Once again, the energy model determined the impact of operating this camp in Edmonton (AB) for the month of January.

In this scenario, fan coils using heat recovered from the generator farm replaced the electric unit heaters used in the office shelters, the dining hall, the kitchen and the medical hospital. Also, the electric space heaters in the accommodation shelters were replaced with cold weather air-source heat pumps. Finally, the domestic hot water requirements for the ablutions were primarily provided by the recovered heat from the generator farm.

Figure 2: Camp Equipment Configuration

The camp configuration shown above using the heat recovery equipment is forecasted to require a peak electric demand of 922 kW and 70,000 litres of diesel fuel to operate. It must be noted that the heat recovery configuration requires a storage capacity of 10,000 litres to ensure proper supply of space heating and DHW heating.

Comparing the standard camp configuration to the heat recovery camp configuration shows that a ***50% reduction*** can be achieved in total fuel consumption of cold weather operations.

Going Forward

Fuel represents 50% of supplies transported into theatre to sustain deployed camps.[5] The reduction of fuel consumption will provide the military with environmental and operational benefits such as: reduced vulnerability to supplies; reduced vulnerabilities of deployed forces and increase in autonomy; reduced casualties related to supply convoys[6]; and ensuring future interoperability with NATO partners as they move towards new energy technologies. In addition, this scenario can provide a cost-effective energy supply. The Fully Burdened Cost of Energy ranges from $5/L to $105/L depending on convoy protection, distances, terrain, air coverage and hostility levels[7,8,9,10]. The fuel dependency reduction will also free assets and infrastructure and redirect them to other priorities, thereby increasing operational resiliency.

Finding affordable alternatives to how operations are sustained is critical to future operations. With the present set of data and using conservative assumptions, this study indicates that significant fuel consumption reductions can be achieved for a large deployed cold weather camp.

The long-term vision for the Canadian Armed Forces is to take the data collected during Operation NANOOK and the ICE-T camp demonstration and to translate them into real-life technology demonstrations using actual military exercises. It is only through the fielding and testing of new technologies that the actual benefits will be seen and the necessary resources allocated. The end state will see modern camps with alternative energy powering them as well as a reduced logistic and environmental footprint on operations.

5 http://www.army-technology.com/features/feature77200/, dated 26 Feb 2010. Casualty Costs of Fuel and Water Resupply Convoys in Afghanistan and Iraq.

6 Eady,D.S.; Siegel, S.R., Bell,R.S.,Dicke,S.H., Sustain the Mission Project: casualty Factors of Fuel and Water Resupply Convoys, Army Environmental Policy Institute, September 2009.

7 http://thehill.com/homenews/administration/63407-400gallon-gas-another-cost-of-war-in-afghanistan-, dated 31 January 2011, $400 dollar per gallon gas to drive debate over cost of war in Afghanistan, Roxana Tiron.

8 Dr. Melendez, G.J., Advancement in Power Management and Intelligent Distribution, IDGA Tactical Power Summit, January 2010, Slide no 5.

9 Geary, C., Approaches to more Efficient Power Generation, IDGA tactical Power Summit, January 2010, Slide no 10.

10 Deloitte, Defence: New realities, Innovative response.

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