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Electrification and Hybridization of Land Military Equipment

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Service Paper

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Electrification and Hybridization of Land Military Equipment

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AIM

1. The aim of this service paper is to provide a better understanding of allied army electrification and hybridization initiatives which could inform the development of an eventual Canadian Army (CA) decarbonisation program that will be in line with other western militaries around the world. Decarbonisation goals must be developed with those of our allies and be in unison with current and evolving industry wide electrification technologies. This service paper will provide recommendations on how the CA can best align with and/or leverage allied army electrification and hybridization initiatives. It will also provide an understanding of technological obstacles that must be overcome to enable decarbonisation of the CA's logistic vehicles, camp sustain assets (power generation/heating) and fighting platforms that must be understood in order to map the way forward to achieving decarbonisation.

INTRODUCTION

2. In June 2021, the Government of Canada (GoC) announced that it will require all new car and passenger truck sales to be zero-emission by 2035 in Canada.[1] The GoC will also implement targets for 2025 and 2030 to ensure that this initiative meets the planned timeline which will be in line with other developed countries around the world.[2] In addition to this, the National Capital Commission (NCC), a federal Crown corporation, along with several municipalities have started to implement a ban on the use of small gas powered tools that will come into effect in 2023.[3]

3. The Department of National Defence (DND), and the CA, operate a vast amount of equipment, passenger vehicles, transport vehicles and combat vehicles that run solely on gas or diesel. The equipment and vehicles generally operate for extended periods of time during field training and during operational deployments leading to a significant amount of emissions into the environment. As DND is a leading department within the GoC, it is necessary that the department abides by the new targets set out by the GoC when procuring new equipment and vehicles to curb these emissions.

DISCUSSION

4. The DND as set out in Defence Administrative Orders and Directives (DAOD) 3015-0 requires all new procurements to incorporate environmental considerations "in the material acquisition and support process, including requirement identification and

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[1] Government of Canada - Transport Canada, "Building a green economy: Government of Canada to require 100% of car and passenger truck sales be zero-emission by 2035 in Canada," last modified 29 June 2021, https://www.canada.ca/en/transport-canada/news/2021/06/building-a-green-economy-government-of-canada-to-require-100-of-car-and-passenger-truck-sales-be-zero-emission-by-2035-in-canada.html

[2] Ibid.

[3] National Capital Commission, "NCC banning gas-powered small tools," last modified 17 November 2021, https://ncc-ccn.gc.ca/news/ncc-banning-gas-powered-small-tools?utm_source=twitter&utm_medium=social

definition, planning, procurement, operation and maintenance, disposal of goods, and closure activities in respect of acquired services and facilities" as part of green procurement.[4] This DAOD is going to continue to increase in importance as DND moves towards 2035 as part of the GoC.

5. The electrification and hybridization technology of small equipment and passenger vehicles continues to evolve quickly while electrification and hybridization of larger vehicles is taking longer to develop. Nevertheless, this technology offers several advantages in a land military context as outlined in a Defence Research and Development Canada Reference Document:

a. Stealth – Hybridization technology in vehicles often allows vehicles to operate in an electric only mode. This results in less noise than an internal combustion engine (ICE) when the vehicle is operated in this mode and can result in a lower thermal signature;[5]

b. Logistics – Fuel is often one of the largest requirements for a land force component of a military during training and operations. Electric or hybrid powertrains have an increased range because they do not burn fuel when they are in electric only mode which offers better fuel economy than their gas or diesel counterparts do. This can be further increased with the use of regenerative braking technologies which recharge vehicle batteries when brakes are applied;[6]

c. Reconnaissance Tasks – The use of large capacity batteries as part of a battery pack can be used to power optics, communication systems, and the vehicle itself. This will allow for a more silent reconnaissance capability that would be able to operate for several hours until the batteries need to be recharged;[7] and

d. Camp Power – An ICE in a camp setting can be used in conjunction with an electrical generator to charge a large battery pack. This ensures any surplus energy is stored and not wasted in the power grid. This will allow the camp to run off battery power during non-peak times and help to reduce emissions associated with generators.[8]

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[4] Government of Canada – Department of National Defence, "DAOD 3015-0, Green Procurement," last modified 13 June 2017, https://www.canada.ca/en/department-national-defence/corporate/policies-standards/defence-administrative-orders-directives/3000-series/3015/3015-0-green-procurement.html
[5] J.Giesbrecht, "Feasibility of Hybrid Diesel-Electric Powertrains for Light Tactical Vehicles," Defence Research and Development Canada, Government of Canada, Reference Document DRDC-RDDC-2018-D049, June 2018, 1-28.
[6] Ibid., 1.
[7] Ibid.
[8] Ibid.

6. Current electrification and hybridization technology does have some drawbacks compared to the present ICE technology. A number of these disadvantages for military use are outlined in the same Defence Research and Development Canada Reference Document that identified the advantages above. The disadvantages are:

a. There is often a reduced payload for the platform due to the weight of the electric or hybrid drive system and batteries;[9]

b. With the current technology, there may not be enough space in smaller vehicles for battery packs to provide a suitable enough range for a vehicle like a one or two person all-terrain vehicle (ATV);[10]

c. When operating in colder climates, the range is often reduced in electric and hybrid vehicles.[11]

d. Hot and cold climates have an impact on charging times;[12]

e. Hybrid powertrains are often more complex due to the presence of an ICE and electric powertrain. This will increase the training requirements for technicians; and

f. In a combat situation, there is an increased risk from having battery packs present. These battery packs can be an explosive risk, fire risk, or spread acid on occupants of a vehicle.[13]

7. When looking at small equipment, there are several manufactures that currently produce equipment that can be used in combat and non-combat settings. In addition to the equipment, a sufficient supply of batteries will need to be procured especially for combat units to ensure that tasks can be completed efficiently without the need to wait for batteries to be charged. As part of future battle procedure for units, they will need to ensure that batteries are charged prior to conducting operations. The equipment that is currently available includes small hand tools, lawn mowers, ride-on lawn mowers, trimmers, and chainsaws.

8. Civilian pattern vehicle hybridization is on-going within DND and within other departments of the GoC. The use of electric vehicles should be added to this initiative as a number of automobile manufacturers now offer electric models. These electric models would be efficient for local, shorter-range requirements and they offer zero emissions. The electric vehicle offerings by manufacturers is continuing to advance with a number of manufactures offering passenger cars, sport-utility vehicles (SUVs), and light-duty trucks.

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[9] Ibid., 2.
[10] Ibid.
[11] Ibid.
[12] Ibid.
[13] Ibid.

9. Small vehicles such as all-terrain vehicles (ATVs) and utility terrain vehicles (UTVs) or commonly referred to as side-by-sides, are now available in all electric models. These models would benefit reconnaissance units and light forces due to their quieter operation in addition to their zero emissions and lower thermal signature.[14] In addition to this, electric ATVs and UTVs do not have an exhaust pipe which often becomes coated with mud. In dry conditions, the debris in the mud can ignite and fall off onto the ground thus causing a fire.[15] A popular model currently in use within the CA, the Polaris Ranger UTV, is available in an all-electric version.[16] The all-electric version is similarly priced as its gas-powered counterpart and provides all of the advantages that have been described previously. A larger platform is currently in development by General Motors (GM) Defense that is called the electric Light Reconnaissance Vehicle (eLRV) that is based off the new electric GM Hummer platform.[17] This vehicle could replace other reconnaissance vehicles that the CA employs once it is available for commercial purchase.

10. The electrification and hybridization of military transport vehicles or commonly referred to as B-fleet vehicles is continuing to develop. The United States (US) Army is a key driver of this initiative and selected six companies to either develop new transport vehicles or retrofit previously acquired vehicles.[18] The project called the Next-Generation Combat Vehicle (NGCV) will develop options for a fleet of around 225 000 electric vehicles operating in a field environment.[19] The British Army is also developing options to move to a fleet of combat support vehicles that are either electric or hybrid drive over the next 15 years.[20] Some of the options being considered would fit the needs of the CA whether it is a hybrid drive or an electric drive system. That eLRV that is currently being developed by GM Defense could spawn other Hummer vehicle platforms that could eventually replace all of the US Army fleet of diesel powered High Mobility Multipurpose Wheeled Vehicle (HMMWV) or Humvee for short.[21] There has been significant research and development by the US Army on the use of hybrid systems as an interim measure prior to moving to an all-electric fleet, based on tests by the US Army, they anticipate a hybrid system fitted in a HMMWV could use up to 68% less fuel than a

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[14] Ibid.
[15] Greg Baxter, "All terrain vehicles as a cause of fire ignition in Alberta forests," Advantage, vol. 3, no. 44 (2002): 2. https://wildfire.fpinnovations.ca/39/AD-3-44.pdf
[16] Polaris Off Road, "Ranger EV," last modified 2021, https://ranger.polaris.com/en-ca/ranger-ev/
[17] Michael Wayland, "GM Defense plans to produce military vehicle based on Hummer EV in 2022," CNBC, 11 November 2021, https://www.cnbc.com/2021/11/09/gm-plans-to-produce-military-vehicle-based-on-hummer-ev-in-2022.html
[18] Jen Judson, "US Army picks 6 companies to tackle how to power electric combat vehicles in the field," Defense News, 22 April 2021, https://www.defensenews.com/land/2021/04/22/us-army-picks-6-companies-to-tackle-how-to-power-electric-combat-vehicles-in-the-field/
[19] Ibid.
[20] Ministry of Defence – British Army, "Army announces battlefield vehicle electrification plans," last modified 17 September 2021, https://www.army.mod.uk/news-and-events/news/2021/09/army-announces-battlefield-vehicle-electrification-plans/
[21] Michael Wayland, "GM Defense plans to produce military vehicle based on Hummer EV in 2022," CNBC, 11 November 2021, https://www.cnbc.com/2021/11/09/gm-plans-to-produce-military-vehicle-based-on-hummer-ev-in-2022.html

normal diesel powertrain.[22] Canada should leverage already completed research and development by either the United Kingdom (UK) or the US. Collaborating with one of these nations will allow the CA to equip the CA fleet with hybrid or electric technology more cost efficiently.

11. The hybridization of combat vehicles or A-fleet vehicles is progressing by the US. Since these vehicles are generally large and have a significant weight, electrification technology is not currently at a stage to allow the production of an all electric vehicle, however, hybridization technology is at a point where it can influence A-fleet vehicle drivetrains. A major accomplishment by the US military is retrofitting a hybrid system in to a Bradley Infantry Fighting Vehicle (IFV) that is expected to start testing in January 2022.[23] The US has developed two prototypes of the Bradley IFV with hybrid technology that they will test throughout the year in conjunction with the regular Bradley IFV to compare the two different drivetrains.[24] If the testing is successful and does not show any performance loss, it could pave the way for the hybridization of the fleet and could allow for testing on other A-fleet vehicles.[25] The lessons learned from this could be of benefit to the CA and allow the CA to start looking at a hybrid drive system on the Light Armour Vehicle (LAV) 6 in conjunction with the original equipment manufacturer (OEM) General Dynamic Land Systems (GDLS). It would also serve as a first step while waiting for technology for the electrification of A-fleet vehicles to progress to an acceptable and cost effective level.

12. The hybridization and electrification of camp sustainment equipment such as generators and heaters also need consideration. The use of solar power and a power bank to store energy in conjunction with generators would be a more efficient way to power camp infrastructure as the technology becomes available. Manufactures like Tesla are currently developing this space and offer residential and commercial solutions that would work in a military context.[26] During non-peak times and during non-adverse weather conditions, camp sustainment equipment could run off the battery power bank while it is powered by solar panels thus eliminating the need to continuously run gasoline or diesel-powered generators. During peak times and during adverse weather conditions, the generator would supply power to the camp and any excess power would be stored in the power bank to be used later. Heating and cooling options currently exist in the form of heat pumps. Heat pumps can use 60% less energy during heating than other means, 30% less energy during cooling, and there is no requirement for ductwork.[27]

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[22] Denise M. Kramer and Gordon G. Parker, "Current state of military hybrid vehicle development," International Journal of Electric and Hybrid Vehicles 3, no. 4 (2011): 378.
[23] Andrew Eversden, "Army plans to turn on first hybrid electric Bradley in January," Breaking Defense, 29 November 2021, https://breakingdefense.com/2021/11/army-plans-to-turn-on-first-hybrid-electric-bradley-in-january/
[24] Ibid.
[25] Ibid.
[26] Tesla, "Powerwall," last modified 2022, https://www.tesla.com/en_ca/powerwall
[27] Government of Canada – Natural Resources Canada, "Ductless heating and cooling," last modified 10 January 2019, https://www.nrcan.gc.ca/energy/products/categories/heating/heat-pumps/air-source/ductless/21316

CONCLUSION

13. Electrification and hybridization of military equipment is inevitable. The current advantages outweigh the current disadvantages for several the different categories discussed above. A few the disadvantages identified in the discussion portion of this service paper will continue to be mitigated as electrification and hybrid technology evolves which is why a phased approach should be adopted when upgrading and/or replacing the current fleet of equipment in the CA. This will allow technology to develop and will likely allow procurement at a reduced cost. In addition to this, international partners are developing hybridization and electrification options to replace their current fuel burning fleets of military vehicles that can be leveraged. There are several options ranging from retrofitting a hybrid drive system into current vehicle fleets, developing a new hybrid vehicle, or developing a new electric vehicle platform. Current technology allows for the hybridization and electrification of smaller vehicles that are in use across the CA, however, only hybridization options exist for large combat vehicles due to their weight and the battery packs that would be required to pursue an all-electric drive system. The CA should look to leverage technology that is already in place in either the US or the UK to allow the CA to meet emissions standards that have been put into place by the GoC and other western nations around the world. The CA should look to implement hybridization and electrification of vehicles and equipment in line with the recommendation below.

RECOMMENDATION

14. The recommended phased approach for the upgrade and replacement of vehicles and equipment is as follows:

a. Phase 1 – Present. All small equipment used by bases for grounds maintenance should be phased out at the end of their life cycle and replaced with battery powered equipment. Equipment used during the conduct of combat tasks within combat units should also be replaced when ICE equipment comes to the end of its life cycle. Enough batteries would need to be procured to ensure combat units can continue to complete tasks without interruption due to charging requirements.

b. Phase 2 – Present. All civilian pattern vehicles (Blue fleet) should continue to be replaced with electric or hybrid vehicles. The electric vehicles can be used for short local distances while the hybrid vehicles can be used when an increased range is required.

c. Phase 3 – Present. Small vehicles that are used for reconnaissance and transporting light forces should be replaced with electric or hybrid vehicles.

d. Phase 4 – Future. As technology develops and further options are available commercially, B-Fleet transport vehicles should be replaced with electric or hybrid vehicles.

e. Phase 5 – Future. Camp sustainment equipment like heaters, generators, solar panels, and power banks should be procured when the cost of acquisition decreases and the technology evolves.

f. Phase 6 - Future. As technology develops and further options are available commercially, A-Fleet combat vehicles should be replaced with electric or hybrid vehicles.

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