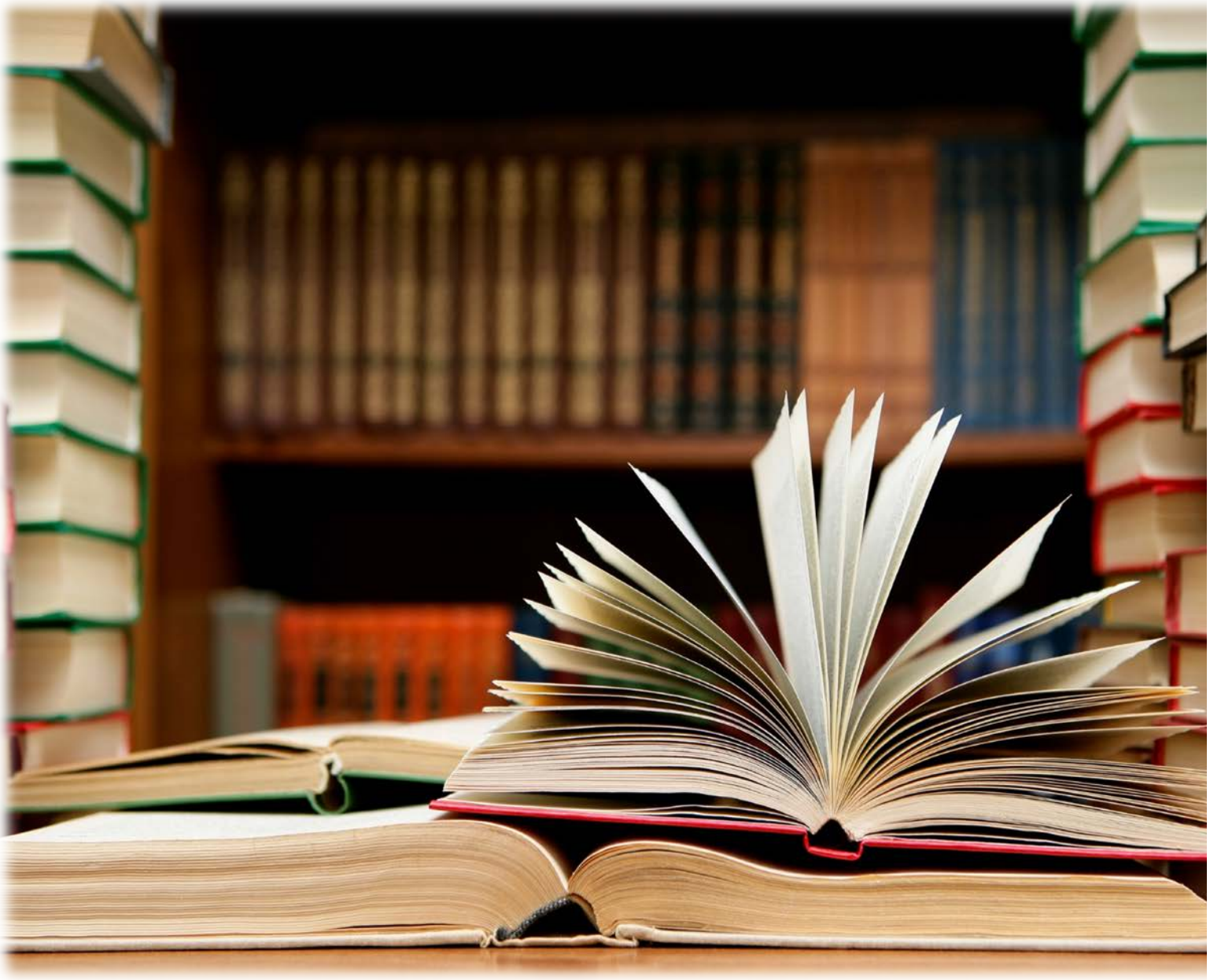
Propane-Fuelled Vehicles and Multi-Residential Building Storage Risk

Examining the Frequency of Propane-Fuelled Structure and Vehicle Fires



Jennifer Armstrong M.A., Joseph Clare Ph.D, and Fire Chief Len Garis

January 2013

UNIVERSITY OF THE FRASER VALLEY
SCHOOL OF CRIMINOLOGY & CRIMINAL JUSTICE

UNIVERSITY OF THE FRASER VALLEY
CENTRE FOR PUBLIC SAFETY & CRIMINAL JUSTICE RESEARCH

Executive Summary

1. Although it is estimated that less than 0.3% of Canadian vehicles currently on the roads are fuelled by propane, there is a growing policy concern regarding the fire-and-safety risks posed by storing these vehicles in the common parking areas of multi-residential buildings.

2. To this end, the current research undertakes a retrospective analysis of the fire risks posed by the parking of propane-fuelled vehicles in underground parking areas of multi-residential buildings. The analysis was performed on a data set containing 37,492 fires reported to the British Columbia Office of the Fire Commissioner between October 2006 and October 2011. Of these cases, 2,542 fires occurred in multi-residential structures and 8,933 cases involved vehicle fires. The analysis examined fires stemming from propane, and also examined gasoline fires by way of a comparison group.

3. There were no instances in the multi-residential structure fire dataset where the fuel/energy was propane, the material first ignited was propane, and the area of origin for the fire was the engine or fuel area of a vehicle. In comparison, there was one instance where this combination was observed with respect to gasoline.

4. Overall, however, multi-residential structure fires involving propane as the fuel/energy were 5.7 times more frequent than gasoline fires. Subsequent analysis indicated that a large percentage of these fires where the fuel/energy was propane are likely the result of cooking and/or recreational use, with these fires 4.5 times more likely to have originated from external areas (balconies/court yards/patios) when compared to gasoline fires.

5. The frequency of vehicle fires involving propane was 11.6 lower than for gasoline fires. This rate difference increased to 34.8 times when the fuel/energy and material first ignited were gasoline, and the area of origin for the fire was the engine of fuel area of a vehicle. In addition to this, propane-fuelled vehicle fires were 2.7 times more likely to have occurred in the engine area, 2.1 times more likely to originate from the passenger area, and 5.0 times more likely to originate in the cargo area, when compared to gasoline fires.

6. Overall, based on the dataset analysed here, there does not appear to be support for the notion that propane fuelled vehicles pose an increased fire risk in underground parking areas of multi-residential buildings when compared with gasoline fuelled vehicles. Two interesting findings that did emerge include:
   (a) There appears to be an issue associated with propane-fires on the outside areas and balconies of multi-residential buildings.
   (b) There is suggestion that vehicle fires related to propane are elevated as a function of the storage and transportation of propane within vehicles.

Paper Overview

There are 2.7 million vehicles on the road in British Columbia [1], and 99.7% of them are fuelled by either diesel or gasoline. The remaining 0.3% of the vehicles on the road are fuelled either by electricity, natural gas, propane or an 85% ethanol/gasoline blend. Historically, propane-fuelled vehicles have served a variety of occupational roles; such as equipment used in farming, police vehicles, busses, and other government agency fleets, i.e.; Canada Post. In the last decade however, there has been an increased interest in propane as an alternative fuel source, reflected by greater production of propane vehicles and, in some cases, the conversion of privately-owned vehicles to being propane-fuelled. Understandably, the primary reason for the increase in conversions is due to the rising price of gasoline. Generally, it is understood that from both an economic and environmental perspective, the use of propane-fuelled vehicles offers additional short- and long-term benefits.

Importantly, while there are many reasons to support the use of propane as an alternative fuel, the focus of this report is based on an on-going matter of policy regarding the parking of vehicles that are fuelled by propane in underground parking areas. There is a concern over policy in North America associated with fire-risk with the storage of propane-fuelled vehicles in the underground storage areas of multi-residential buildings. This research note explores this issue from a quantitative perspective, examining data provided by the British Columbia (BC) Office of the Fire Commissioner (OFC) to retrospectively examine the frequency of propane-related fire incidents that occurred in multi-residential buildings. By way of providing a relevant comparison, the analysis also examines the fire incidents that occurred as a result of gasoline in the same contexts. Overall, from an analysis of almost 38,000 fires that occurred in BC over a five year period, there were no instances of structure fires in multi-residential buildings where the fuel for the fire and the material first ignited were propane, and the fire originated from the engine/fuel area of a vehicle. However, two other interesting findings that also emerged were:

- There was an issue associated with increased frequency of fires in multi-residential buildings involving propane that originated from recreational areas such as balconies and court yards.
- There was indication that propane-related vehicle fires occurred more frequently that was expected, potentially in-part as a consequence of transportation of propane within vehicles.

Overall, with respect to the current policy debate in this area, this analysis does not support the concerns about the potential fire risk posed by propane fuelled vehicles in the underground parking areas of multi-residential buildings, but is indicative of the potential risks associated with the recreational use of propane in multi-residential buildings and the other uses of propane in vehicles.

Background Information on Propane-Fuelled Vehicles

In some of the larger cities, multi-family dwelling units can make up to 35% of the total number of occupied residences [2]. Commonly, many of these multi-family properties have stratified rules, and/or municipal policies in place which stipulate what occupants are generally allowed to do, and not to do inside and outside of these residences. Often these pertain to such things as storage, parking, use of facilities, as well as noise. In many cases, the storage of propane has been restricted to contained designated storage areas, or has had strict rules which outline the use of propane for personal barbeque purposes. In some cases, polices have been in place which completely prohibit the storage or use of propane in these types of residential units [3]. The storage and use of propane cylinders (commonly in barbeques) is an important issue, and more research could certainly be conducted regarding those polices which completely prohibit it, the primary issue for the

purpose of this report is to specifically examine the potential increase in fire risk posed by parking/storing propane fuelled vehicles in the underground parking areas of multi-residential buildings.

Prior to outlining the findings of this research, it is important to briefly explain some background into this issue. Below, three topics are covered: (a) the overall safety of propane compared to other fuel sources, (b) the development of safety features intended to reduce the risks associated with the use of propane as a vehicle fuel source, and (c) the findings of some recent evaluations into the safety issues associated with propane fuelled vehicles.

First, with respect to the safety strengths of propane as a fuel source, the following three points can be made:

- Propane is non-toxic and it does not pose a risk of contamination to the environment. It is also lead-free, and contains very low levels of sulphur.
- Propane has an auto ignition temperature (850 – 900°F) that is higher than gasoline (495°F), which means it is more difficult to ignite
- Propane has the lowest flammability range of all alternative fuels (2.4 – 9.5%) – "so there must be the right combination of propane and oxygen, if there is too much or too little propane it will not burn" [4].

In addition to these properties of propane that make it a suitable fuel source, there is also a range of safety features that have been developed to reduce the risks associated with the use of propane in vehicles. These include:

- Propane fuelled vehicles are equipped with an onboard gas detector, and other safety valves which restrict fuel from flowing when the engine is turned off (parked).
- Propane tanks are twenty times more puncture-resistant than gasoline tanks – which means they are less likely to rupture in an accident, and if the vehicle were to catch fire, the propane tank is designed to control its pressure via a pressure relief valve, saving the tank from rupturing and causing further damage.
- Pressure release valves and overfill protection devices (OPD) as of 2007, are now a safety standard. The ODP is a stop-fill valve that stops the overfilling of these tanks when they reach 80% of their capacity. The remaining 20% allows for volume changes due to temperature fluctuations [4].

The OPD is important because of concerns that propane is a heavier fuel, and therefore could "settle" on the floor in an underground parking area if leaked, posing as a fire risk. However, a correctly operating OPD makes fuel leakage impossible, and therefore the potential risk of "settling" leaked fuel is minimal to none. In other words, these current devices do not allow for the overfilling of tanks, or the volume to change in the tanks as temperature increases – which is the underlying factor regarding the concern about fire risk. Even more importantly, in 2010 the United States Department of Energy, Alternative Fuels Data Center reviewed some concerns regarding the safe operating of propane, or liquid petroleum gas vehicle tanks (LPG) [5]. In this review, they found that 16% of the LPG fuelled fleets had OPD deficiencies. However, they concluded that even with a deficient OPD, an incident of overfilling meets only one of three conditions for a fire incident to occur. The conditions they noted were; (1) having an overfilled tank which would lead to the release of fuel, (2) rising temperatures, and (3) an ignition source. In their 2010 review, they were not aware of any incidents caused by the overfilling of a LPG vehicle tank [5, 6].

To summarize this section, both the safety properties of propane compared to gasoline, and the standard safety features in the construction of the tanks do not support the notion that there would be an increased fire

risk. In addition to this, a previous evaluation of this issue did not find instances where propane-fuelled vehicles posed an increased fire risk relative to other types of vehicles.

Research Objectives and Identifying Relevant Cases for Analysis

The objective of this research was to use existing fire incident data to examine the frequency of propane-related fires that occurred in the storage areas of multi-residential buildings. As a form of comparison, a parallel analysis was undertaken for fires that occurred as a result of gasoline.

As detailed above, the data for this evaluation was provided by the BC OFC and included a total of 37,492 fires that were reported between October 2006 and October 2011, with the data analysed using IBM SPSS 20. The data was de-coded using the BC Fire Reporting Manual, retaining residential structure fires[1] that occurred in multi-residential structures[2]. This process retained 2,542 fire incidents for subsequent analysis. The vehicle fire[3] analysis was based on examination of 8,933 reported incidents.

Results

Multi-Residential Structure Fires

Overall, the rate for fires in multi-residential structures where the fuel or energy was propane was 5.7 times greater than the rate for gasoline fires in these structures, providing the fuel for 3.4% of the fire incidents (see Table 1). Relative to gasoline, the combination of fuel and material first ignited occurred at a rate that was 1.8 times greater. Importantly, however, the bottom line in Table 1 demonstrates that there were no instances in the multi-residential structure fire dataset where the fuel/energy was propane, the material first ignited was propane, and the area of origin for the fire was the engine of fuel area of a vehicle. In comparison, there was one instance where this combination was observed with respect to gasoline.

TABLE 1. NUMBER, PERCENTAGE, AND RATE OF MULTI-RESIDENTIAL STRUCTURE FIRES AS A FUNCTION OF FUEL/ENERGY, MATERIAL FIRST IGNITED, AND ORIGIN AREA FOR PROPANE AND GASOLINE

	Propane			Gasoline		
Fire element for 2,542 multi-residential structure fires	# fires	% total fires	Rate per 1,000 fires	# fires	% total fires	Rate per 1,000 fires
Fuel or energy	86	3.4%	33.8	15	0.6%	5.9
Fuel/energy AND material first ignited	9	0.4%	3.5	5	0.2%	2.0
Fuel/energy AND material first ignited AND are of origin in engine or fuel area	0	0.0%	0.0	1	0.0%	0.4

Table 2 demonstrates that a large percentage of the fires where the fuel/energy was propane are likely the result of cooking and/or recreational use, as opposed to having anything to do with propane-fuelled vehicles.

[1] BC OFC Fire Reporting Manual property complex values: PC3100, PC3200, PC3300, PC3400, PC3500, PC3600, PC3700, PC3800, and PC3900.

[2] BC OFC Fire Reporting Manual property classification values: PR3210, PR3220, PR3230, PR3240, PR3250, and PR3290.

[3] BC OFC Fire Reporting Manual incident type = VC.

Overall, 30.2% of these fires involving propane as the fuel/energy originated on the court/patio/terrace of a building or an exterior balcony. In comparison, only 6.7% (1 incident) of the fires fuelled by gasoline originated from these locations. Overall, this meant that fires fuelled by propane were 4.5 times more likely to have originated from these external areas.[4] It is important to note here that additional analysis into the source of ignition for the two propane fires coded as having originated in a storage area, inside a building, revealed that one of these was caused by an unclassified vehicle-related heater, while the source of ignition for the other could not be determined.

TABLE 2. NUMBER AND PERCENTAGE OF MULTI-RESIDENTIAL STRUCTURE FIRES AS A FUNCTION OF ORIGIN AREA WHERE THE FUEL/ENERGEY WAS EITHER PROPANE OR GASOLINE

	Propane		Gasoline	
Origin Area	# Fires	% of Total	# Fires	% of Total
Assembly, family, sales area - laundry area (includes wash house)	1	1.2%	0	0.0%
Assembly, family, sales area - lounge, living room	0	0.0%	2	13.3%
Assembly, family, sales area - sleeping - 5 or more occupants	1	1.2%	0	0.0%
Assembly, family, sales area - sleeping - under 5 occupants	1	1.2%	3	20.0%
Assembly, family, sales area - washroom, locker area	8	9.3%	0	0.0%
Assembly, family, sales area - function area	2	2.3%	0	0.0%
Means of egress - hallway, corridor	1	1.2%	2	13.3%
Means of egress - stairway, exterior (includes fire escape, ramp)	0	0.0%	1	6.7%
Outside area - court, patio, terrace	15	17.4%	0	0.0%
Outside area - exposure fire	0	0.0%	1	6.7%
Outside area - parking area	0	0.0%	1	6.7%
Outside area - unclassified	3	3.5%	0	0.0%
Service facilities - factory built chimney (metal), flue pipe, gas vent	1	1.2%	0	0.0%
Service facilities - service shaft (includes pipe, conduit, vent)	1	1.2%	0	0.0%
Storage area - inside building - vehicle storage	2	2.3%	0	0.0%
Structural area - ceiling & floor assembly (includes concealed floor/ceiling space)	3	3.5%	0	0.0%
Structural area - ceiling & roof/ceiling space (attic)	7	8.1%	0	0.0%
Structural area - exterior balcony	11	12.8%	1	6.7%
Structural area - exterior roof	12	14.0%	0	0.0%
Structural area - exterior wall	9	10.5%	1	6.7%
Structural area - wall assembly (includes concealed wall space)	6	7.0%	0	0.0%
Utility and equipment area - heating equipment room	1	1.2%	1	6.7%
Vehicle area - engine area (includes running gear, wheels)	0	0.0%	1	6.7%
Vehicle area - passenger area	0	0.0%	1	6.7%
Cannot be determined	1	1.2%	0	0.0%
Total	**86**	**100.0%**	**15**	**100.0%**

[4] Significant difference, $|Z| > 1.96$.

Table 3 shows the relative numbers and percentages for the fire origin areas of the multi-residential structure fires for which either propane or gasoline was both the fuel/energy and the material first ignited. It is interesting to consider that, despite fewer absolute cases relating to gasoline, the 5 gasoline fires listed represent 33.3% of the overall sample of multi-residential structure fires for which gasoline was the fuel/energy. In comparison, the 9 fires listed in Table 3 only represent 10.5% of the sample of fires for which propane was the fuel/energy. With respect to the propane fires, 77.8% of these cases occurred on either a court/patio/terrace or an exterior balcony, and none of these incidents originated in a vehicle. In contrast, none of the gasoline fires originated in either of these exterior, recreational locations, and two of the five incidents involved a vehicle area.

TABLE 3. NUMBER AND PERCENTAGE OF MULTI-RESIDENTIAL STRUCTURE FIRES AS A FUNCTION OF ORIGIN AREA WHERE THE FUEL/ENERGEY AND MATERIAL FIRST IGNITED WAS EITHER PROPANE OR GASOLINE

	Propane		Gasoline	
Origin Area	# Fires	% of Total	# Fires	% of Total
Assembly, family, sales area - lounge, living room	0	0.0%	1	20.0%
Assembly, family, sales area - sleeping - under 5 occupants	0	0.0%	1	20.0%
Means of egress - hallway, corridor	0	0.0%	1	20.0%
Outside area - court, patio, terrace	4	44.4%	0	0.0%
Outside area - unclassified	1	11.1%	0	0.0%
Storage area - inside building - vehicle storage	1	11.1%	0	0.0%
Structural area - exterior balcony	3	33.3%	0	0.0%
Vehicle area - engine area (includes running gear, wheels)	0	0.0%	1	20.0%
Vehicle area - passenger area	0	0.0%	1	20.0%
Total	**9**	**100.0%**	**5**	**100.0%**

Vehicle Fires

In comparison to the multi-residential structure fires examined previously, the rate of vehicle fires where the fuel/energy was propane was 11.6 times lower than for gasoline fires (Table 4). When interpreting the results in this section, it is important to remember the estimates discussed previously indicate that only 0.3% of the vehicles on the road are fuelled either by electricity, natural gas, propane or an 85% ethanol/gasoline blend. Relative to gasoline, the combination of fuel and material first ignited being propane occurred at a rate that was 17.0 times less frequent. This rate difference is largest when the fuel/energy and material first ignited were gasoline, and the area of origin for the fire was the engine of fuel area of a vehicle, with the rate for these fires 34.8 times larger. This said, there were still 8 instances where this combination was observed with respect to propane.

As would be expected, given these are all vehicle fires, it is to be expected that the area of origin of all of these incidents are concentrated in the vehicle, outside area, or could not be determined (see Table 5). Some noteworthy trends did emerge with respect to the relative frequencies of fires in each of these areas of origin. First, fires where the fuel/energy was gasoline were 2.7 times more likely to occur in the engine area. In contrast, fires where the fuel/energy was propane were 2.1 times more likely to originate from the passenger

area, 5.0 times more likely to originate in the cargo area, and 3.5 times more likely to have occurred in an area that could not be determined.[5]

TABLE 4. NUMBER, PERCENTAGE, AND RATE OF VEHICLE FIRES AS A FUNCTION OF FUEL/ENERGY, MATERIAL FIRST IGNITED, AND ORIGIN AREA FOR PROPANE AND GASOLINE

	Propane			Gasoline		
Fire element for 8,933 vehicle fires	# fires	% total fires	Rate per 1,000 fires	# fires	% total fires	Rate per 1,000 fires
Fuel or energy	85	1.0%	9.5	988	11.1%	110.6
Fuel/energy AND material first ignited	22	0.2%	2.5	373	4.2%	41.8
Fuel/energy AND material first ignited AND are of origin in engine or fuel area	8	0.1%	0.9	278	3.1%	31.1

TABLE 5. NUMBER AND PERCENTAGE OF VEHICLE FIRES AS A FUNCTION OF ORIGIN AREA WHERE THE FUEL/ENERGEY WAS EITHER PROPANE OR GASOLINE

	Propane		Gasoline	
Origin Area	# Fires	% of Total	# Fires	% of Total
Vehicle area – engine area (includes running gear, wheels)	19	22.4%	605	61.2%
Vehicle area – fuel area	8	9.4%	101	10.2%
Vehicle area – control area	1	1.2%	25	2.5%
Vehicle area – passenger area	19	22.4%	107	10.8%
Vehicle area – cargo area	13	15.3%	30	3.0%
Vehicle area – undetermined area	13	15.3%	83	8.4%
Outside area – exposure	3	3.5%	7	0.7%
Cannot be determined	9	10.6%	30	3.0%
Total	**85**	**100.0%**	**988**	**100.0%**

As with the multi-residential structure fires, previously, Table 6 shows the origin areas (relative numbers and percentages) of vehicle fires for which either propane or gasoline was both the fuel/energy and the material first ignited. The same pattern was observed here as with the structure fires, in as much as the 22 propane fires represented 25.9% of the overall sample of vehicle fires for which propane was the fuel/energy, which was less than the 37.8% (n = 373 fires) of the total sample of gasoline fires. As before, fires where the fuel/energy and the material first ignited were both gasoline were 2.5 times more likely to occur in the engine area, while propane fires that met both criteria were 7.7 times more likely to have originated from the cargo area.[6]

[5] All differences discussed in this paragraph were significant, |Z| > 1.96.

[6] All differences discussed in this paragraph were significant, |*Z*| > 1.96.

TABLE 6. NUMBER AND PERCENTAGE OF VEHICLE FIRES AS A FUNCTION OF ORIGIN AREA WHERE THE FUEL/ENERGEY AND MATERIAL FIRST IGNITED WAS EITHER PROPANE OR GASOLINE

	Propane		Gasoline	
Origin Area	# Fires	% of Total	# Fires	% of Total
Vehicle area – engine area (includes running gear, wheels)	5	22.7%	211	56.6%
Vehicle area – fuel area	3	13.6%	67	18.0%
Vehicle area – control area	0	0.0%	8	2.1%
Vehicle area – passenger area	4	18.2%	41	11.0%
Vehicle area – cargo area	5	22.7%	11	2.9%
Vehicle area – undetermined area	4	18.2%	22	5.9%
Outside area – exposure	0	0.0%	2	0.5%
Cannot be determined	1	4.5%	11	2.9%
Total	**22**	**100.0%**	**373**	**100.0%**

Discussion and Conclusions

Overall, assuming fairly that BC does not differ significantly from the rest of Canada, and after reviewing five years of BC fire incidents, there does not appear to be support for the notion that propane fuelled vehicles pose an increased fire risk in underground parking areas of multi-residential buildings when compared with gasoline fuelled vehicles. This said, this analysis has revealed two other interesting findings that need to be emphasized by way of a conclusion:

- There does appear to be an issue associated with propane-fires on the outside areas and balconies of multi-residential buildings. This pattern is consistent with research that has identified weakness associated with fires that commence on the exterior of multi-residential buildings [7].
- There is some suggestion that vehicle fires related to propane occur more frequently than would be expected as a base-rate of vehicles on the road, with this statistic potentially elevated as a function of the storage and transportation of propane within vehicles rather than simply related to the use of propane to fuel vehicles themselves.

Moving forward, in attempting to address these issues, potential solutions could include developing strategies for safer storage and/or use of propane on balconies (in the form of barbeques, etc.). As it stands, it is possible that this issue is exacerbated by aging, expired propane tanks and inadequately serviced cooking facilities, along with the common use of alcohol in conjunction with these recreational tools. However, in addition to this, research findings indicate that these external areas pose a significant vulnerability to multi-residential buildings that needs to be addressed in a manner that acknowledges the legitimate use of these areas whilst simultaneously reducing the likelihood of fire. With respect to addressing propane-related fires in vehicles (not related to fuel) and in the common areas of multi-residential buildings, additional research would be warranted, with a view to developing effective prevention strategies where appropriate.

References

[1] Natural Resources Canada Office of Energy Efficiency, *Canadian Vehicle Survey, 2009, Summary Report*, 2009.

[2] City of Surrey, *Annual (2012) Review of the Surrey Official Community Plan*, in *Corporate Report* 2012.

[3] J. Moher. *Barbeques on balconies: reducing the risk*. The Condo Voice 2009 [cited 2012 September 5]; Available from: www.himprolaw.com/barbecues-and-balconies-reducing-the-risk.pdf.

[4] Canadian Propane Association. *Propane: your energy solution for today and tomorrow*. [cited 2012 September 10]; Available from: http://www.propane.ca/.

[5] U.S. Department of Energy Energy Efficiency and Renewable Energy. *Alternative Fuels Data Center: Propane vehicles*. 2012 [cited 2012 October 1]; Available from: http://www.afdc.energy.gov/vehicles/propane.html.

[6] T. Mouw, *Proceedings of the Standing Senate Committee on Transport, Infrastructure and Communities, Issue 042, Evidence*, 2012, Vice-President, Alternative Fuels, Roush Enterprises.

Author Biographical Information

Jennifer Armstrong, M.A., is the Research Coordinator in the Centre for Public Safety and Criminal Justice Research, School of Criminology and Criminal Justice, University of the Fraser Valley. Contact her at Jennifer.Armstrong@ufv.ca.

Joseph Clare, Ph.D., is the strategic planning analyst for the Surrey Fire Service, an Associate Professor in the Crime Research Centre, University of Western Australia, and a member of the Institute of Canadian Urban Research Studies, Simon Fraser University. Contact him at joe.clare@uwa.edu.au.

Len Garis is the Fire Chief for the City of Surrey, B.C. and is an Adjunct Professor in the School of Criminology and Criminal Justice at the University of the Fraser Valley and a member of the Institute of Canadian Urban Research Studies, Simon Fraser University. Contact him at Len.Garis@ufv.ca.

Acknowledgements

Special thanks to Rebecca Denlinger, BC Fire Commissioner and Shelley Ballantyne, Fire Reporting Systems Officer, Emergency Management BC, for the provision of the BC data discussed in this report. This work would not have been possible without the contributions of these individuals.