ELECTRIC VEHICLE CONSIDERATIONS

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Contents

1.0 Preamble

- The Canadian government under Justin Trudeau has stated by 2040 all vehicles sold in Canada will be zero emission vehicles generally meaning rechargeable electric vehicles.
- While projecting the usage and mileage of such vehicles is difficult and subject to interpretation and speculation, the amount of energy being expended by that sector of the economy today is measured and reported.
- Using the actual measured amount of energy expended in this area today allows some determination of what conditions must exist for all vehicles in Canada to be electric in 2040.

1.0 Preamble (cont'd)

- The following analysis is based on generally reliable records maintained by Statistics Canada and is subject to only minor arithmetic manipulation to allow clear comparisons to present day situations.
- The key and only assumption is that people twenty years from now will continue to use their personal vehicles more-or-less as they use them today, and for the same reasons. This assumption is borne out by recent studies of Millennial driving habits and expectations.

2.1 Reported Gasoline Consumption

- The consumption reported on the slide 2.2 is from derived information stated as a daily average volume for 2017
- The derived information is compared to information from StatsCan and adjusted to match the official information which is on an annual basis on the slide 2.3 and re-tabulated on 2.4
- The adjusted values are summarized on slide 2.9 and discussed on slide 2.10.

2.2 Reported Daily Gasoline Volumes

PROVINCE OR AREA	CUBIC METERS PER DAY
(descending consumption)	
ONTARIO	45,163
QUEBEC	26,490
ALBERTA	18,605
BRITISH COLUMBIA	15,215
ATLANTIC CANADA	10,183
SASKATCHEWAN	7,755
MANITOBA	5,289
YK, NWT, NUV	116
TOTAL DAILY VOLUME	**128,816 M3**

2.3 DAILY VOLUME ADJUSTED

- STATSCAN estimates the national annual gasoline consumption for 2017 at 4.0 E+10 liters per year.
- Adjusting the daily average numbers on slide 2.2 to agree with the STATSCAN annual number yields the following table

2.4 Adjusted Daily Consumption

PROVINCE OR AREA	**CUBIC METERS PER DAY**
(descending consumption)	
ONTARIO	38,422
QUEBEC	22,536
ALBERTA	15,828
BRITISH COLUMBIA	12,944
ATLANTIC CANADA	8,663
SASKATCHEWAN	6,597
MANITOBA	4,500
YK, NWT, NUV	99
TOTAL DAILY VOLUME	**109,589**

2.5 Adjustment for Off-road Uses

- The reported adjusted daily volumes are then reduced by an estimated amount for off-road use, percentages ranging from 2% e.g. ON, PQ, to 4% in BC (fishing fleets) to 10% Atlantic Canada and 20% Northern Canada reflecting more rural lifestyles. This is shown on slide 2.6

2.6 Adjusted for Off-road Use

PROVINCE OR AREA	OFF-ROAD ADJUSTMENT	CUBIC METERS PER DAY
(descending consumption)		
ONTARIO	-2%	37,654
QUEBEC	-2%	22,085
ALBERTA	-2%	15,511
BRITISH COLUMBIA	-4%	12,426
ATLANTIC CANADA	-10%	7,797
SASKATCHEWAN	-2%	6,466
MANITOBA	-2%	4,410
YK, NWT, NUV	-20%	79
TOTAL DAILY VOLUME		**106,428**

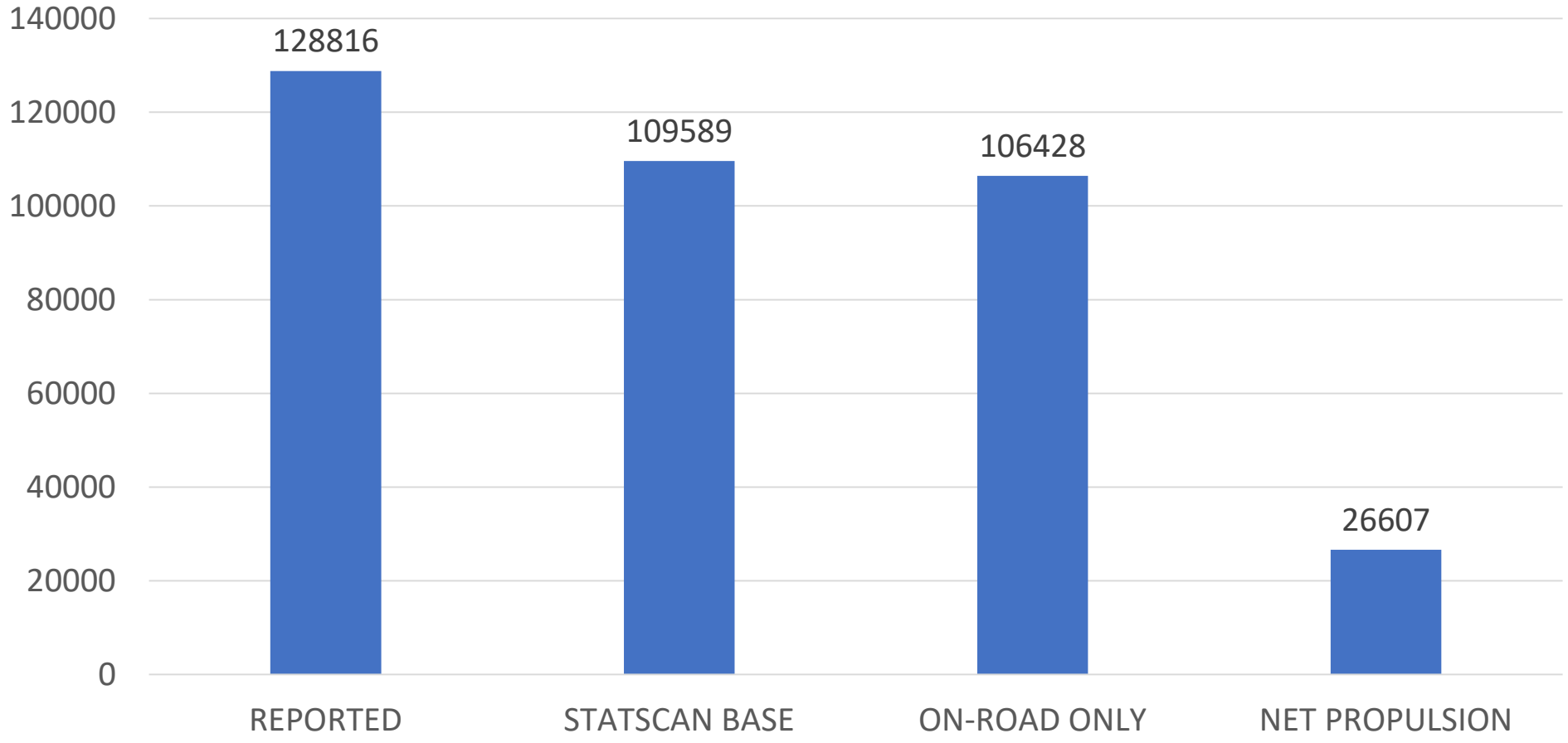
2.7 Adjustment for Engine Efficiency

- The next adjustment is applied on slide 2.8. Gasoline consumption in vehicles is thermodynamically inefficient with a range of from 20% of the input energy, (poorly maintained, older engines), to 30% for newer well-maintained vehicles actually being applied to moving the vehicle. So, an average engine efficiency of 25 % has been applied to reduce the amount of gasoline consumed to that estimated to be actually moving the vehicle.
- It should be noted that the wasted gasoline actually provides the heat for the passenger cabin and defrosting, not an inconsiderable amount, or value, in Canada.

2.8 Efficiency Adjusted Daily Consumption

PROVINCE OR AREA	**CUBIC METERS PER DAY**
(descending consumption)	(actual vehicle propulsion)
ONTARIO	9,420
QUEBEC	5,521
ALBERTA	3,878
BRITISH COLUMBIA	3,107
ATLANTIC CANADA	1,949
SASKATCHEWAN	1,616
MANITOBA	1,102
YK, NWT, NUV	20
TOTAL DAILY VOLUME	**26,607**

SLIDE 2.9
CUBIC METERS PER DAY (ANNUAL AVERAGE)



2.10 Volume Summary

- The actual volume of gasoline used for propulsion has been estimated from StatsCan numbers and reduced conservatively to minimize the projected amount of electrical capacity required to meet equivalent propulsion needs.
- The resulting volumes is particularly pertinent to passenger cars on a national basis.

3.0 Conversion from Volume by Day to Energy per Year

- To remove seasonal variations from later comparisons, the average gasoline consumption (as adjusted) per day will be converted into electrical equivalents in the following steps:
- 3.1 On this slide the adjusted daily consumption volume is converted to contained energy, by volume to mass 1M3=739 kg, and mass by specific energy to megajoules by 1 kg =45 MJ.
- On slide 3.2 the contained energy is converted to kilowatt hours by 1MJ=0.2777 KWH
- Slide 3.3 tabulates the information but converted to an annual basis and further converts the consumption to Megawatt.Hours

3.1 Daily Consumption Converted to Energy

PROVINCE OR AREA	**MEGAJOULES PER DAY**
(descending consumption)	NUMBER TIMES 10 TO Exponent
ONTARIO	3.13E+08
QUEBEC	1.84E+08
ALBERTA	1.29E+08
BRITISH COLUMBIA	1.03E+08
ATLANTIC CANADA	6.48E+07
SASKATCHEWAN	5.38E+07
MANITOBA	3.67E+07
YK, NWT, NUV	6.56E+05
TOTAL DAILY ENERGY	**8.85E+08**

3.2 Daily Consumption to Electrical Power

PROVINCE OR AREA	**KWH PER DAY**
(descending consumption)	Number times 10 to Exponent
ONTARIO	8.67E+07
QUEBEC	5.09E+07
ALBERTA	3.57E+07
BRITISH COLUMBIA	2.86E+07
ATLANTIC CANADA	1.80E+07
SASKATCHEWAN	1.49E+07
MANITOBA	1.02E+07
YK, NWT, NUV	1.82E+05
TOTAL DAILY KWH	**2.45E+08**

3.3 Daily Consumption to Annual MWH

PROVINCE OR AREA	**KWH PER YEAR**	**MWH PER YEAR**
(descending consumption)	Number times 10 to Exponent	Number times 10 to Exponent
ONTARIO	3.17E+10	3.17E+07
QUEBEC	1.86E+10	1.86E+07
ALBERTA	1.30E+10	1.30E+07
BRITISH COLUMBIA	1.04E+10	1.04E+07
ATLANTIC CANADA	6.55E+09	6.55E+06
SASKATCHEWAN	5.43E+09	5.43E+06
MANITOBA	3.71E+09	3.71E+06
YK, NWT, NUV	6.64E+07	6.64E+04
TOTAL ENERGY CONSUMED	**8.95E+10**	**8.95E+07**

4.0 Available Existing Electrical Supply

- Slide 4.1 presents information from STASCAN for the year 2017 as published in Table 25-10-0020-01.
- The quantities of electricity are as – produced, not installed capacity, over the full year.

4.1 Annual Production of Electricity

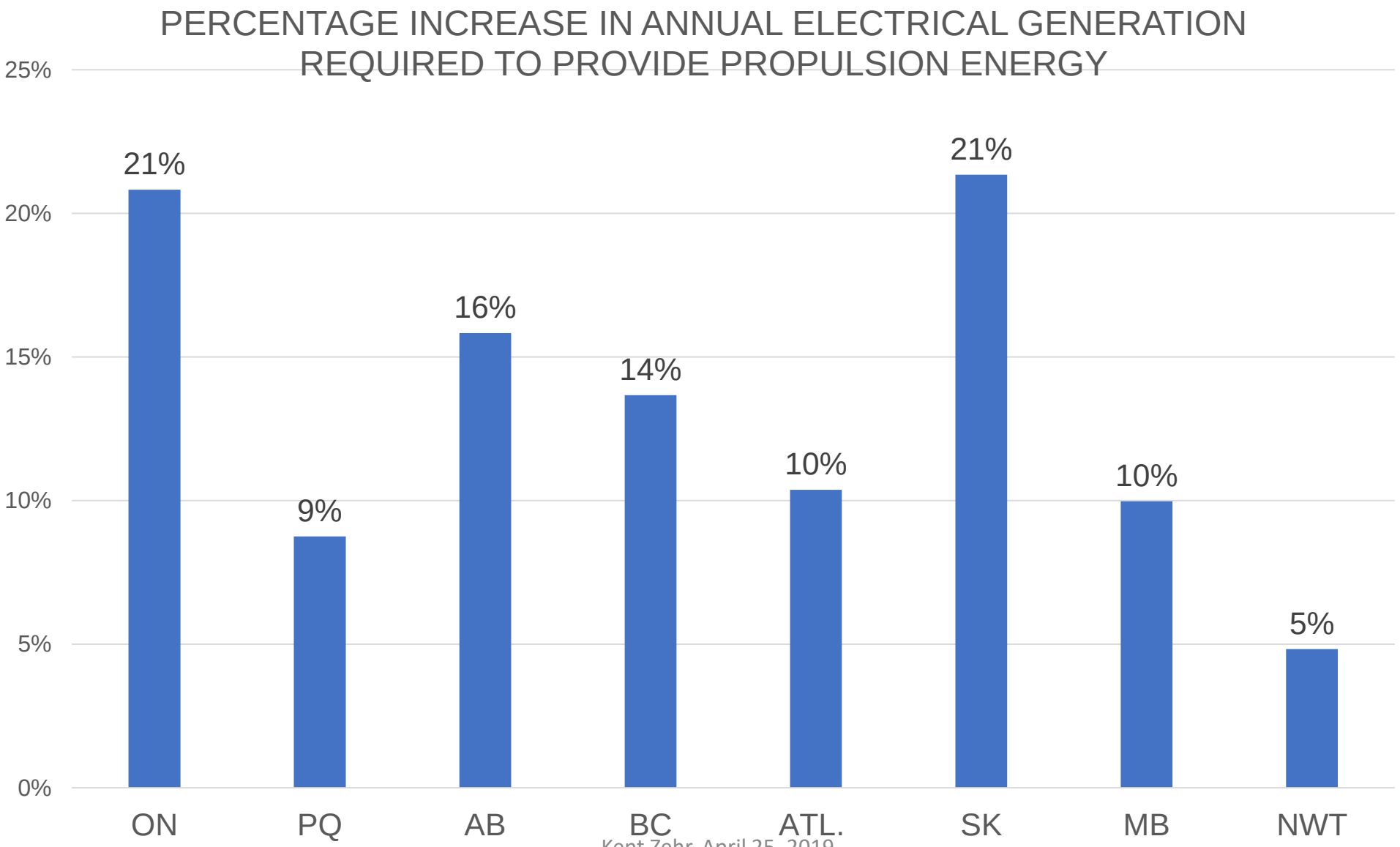
PROVINCE OR AREA	**ANNUAL MWH**
(descending consumption)	NUMBER TIMES 10 TO Exponent
ONTARIO	1.82E+08
QUEBEC	2.12E+08
ALBERTA	8.24E+07
BRITISH COLUMBIA	7.64E+07
ATLANTIC CANADA	6.32E+07
SASKATCHEWAN	2.55E+07
MANITOBA	3.72E+07
YK, NWT, NUV	1.38E+06
TOTAL ANNUAL PRODUCTION	**6.50E+08**

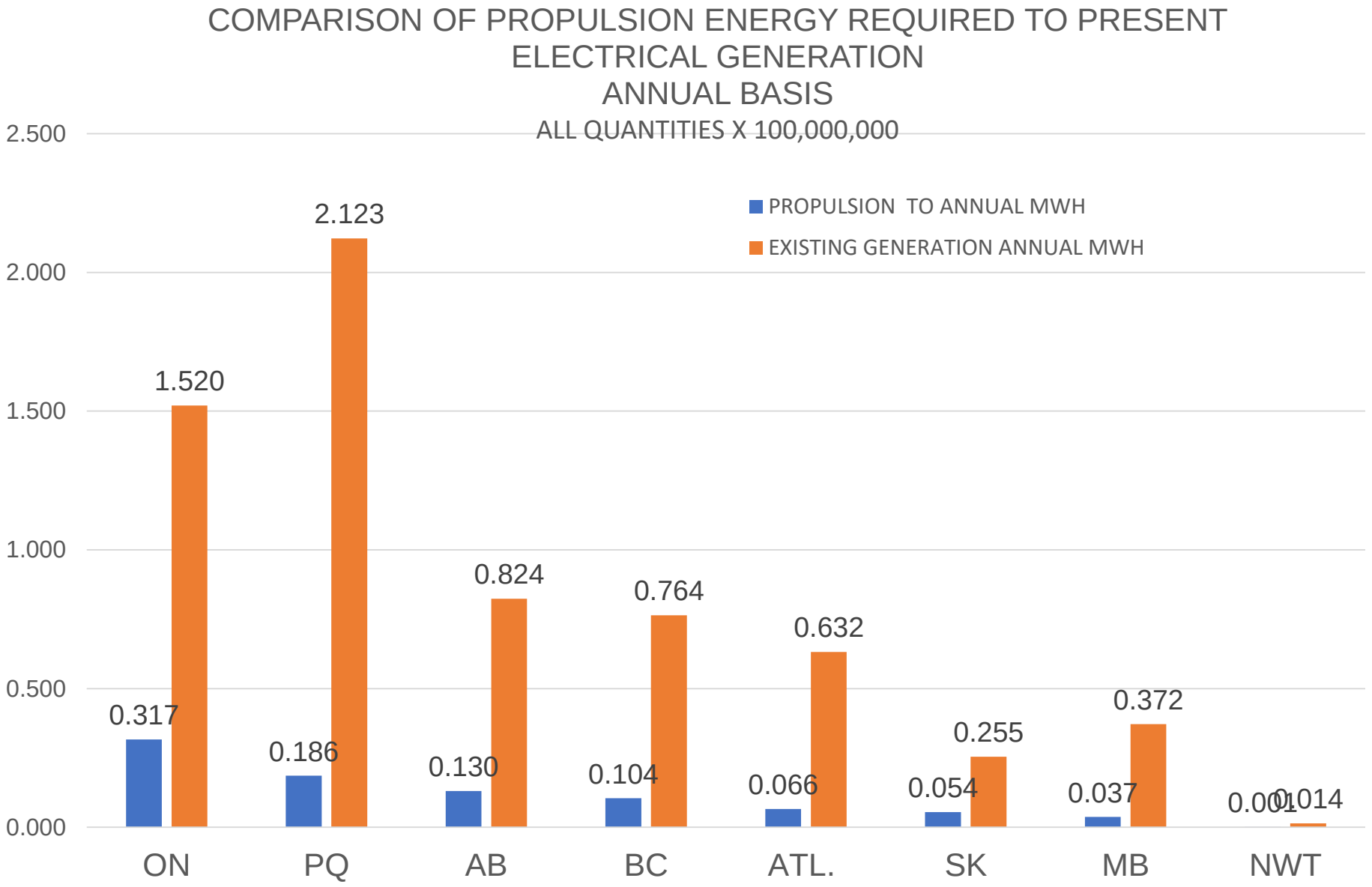
5.0 The Impact of Electrical Vehicles on Electrical Generation

- In the following slide the annual MWH of electricity equivalent necessary to replace the gasoline engine fleet from **Slide 3.3** is compared to the annual production capacity (as recorded by STATSCAN and shown on **Slide 4.1**) and the amount of expansion needed to meet this new demand is also calculated later.

5.1 Daily Consumption to Annual MWH

PROVINCE OR AREA	Replacement MWH Needed	MWH Produced Presently	Required Expansion %
ONTARIO	3.17E+07	1.82E+08	+21
QUEBEC	1.86E+07	2.12E+08	+9
ALBERTA	1.30E+07	8.24E+07	+16
BRITISH COLUMBIA	1.04E+07	7.64E+07	+14
ATLANTIC CANADA	6.55E+06	6.32E+07	+10
SASKATCHEWAN	5.43E+06	2.55E+07	+21
MANITOBA	3.71E+06	3.72E+07	+10
YK, NWT, NUV	6.64E+04	1.38E+06	+5
TOTAL ANNUAL ENERGY	**8.95E+07**	**6.50E+08**	**+14**


PERCENTAGE INCREASE IN ANNUAL ELECTRICAL GENERATION REQUIRED TO PROVIDE PROPULSION ENERGY
25%
20%
15%
10%
5%
0%
21%
9%
16%
14%
10%
21%
10%
5%
ON
PQ
AB
BC
ATL.
SK
MB
NWT


COMPARISON OF PROPULSION ENERGY REQUIRED TO PRESENT ELECTRICAL GENERATION
ANNUAL BASIS
ALL QUANTITIES X 100,000,000
PROPULSION TO ANNUAL MWH
EXISTING GENERATION ANNUAL MWH
2.500
2.000
1.500
1.000
0.500
0.000
0.317
1.520
0.186
2.123
0.130
0.824
0.104
0.764
0.066
0.632
0.054
0.255
0.037
0.372
0.001
0.014
ON
PQ
AB
BC
ATL.
SK
MB
NWT

5.2 Determination of Generation Capacity Needed

- The next slide shows what the percentage increase as calculated on slide 5.1 works out to as a generator requirement to more usefully gauge the size of the necessary changes.
- The expansion MWH necessary are simply converted by dividing by the number of hours in a year to determine a raw, as-produced, number. Actual machine and installation sizes will be substantially larger to meet the demand.

5.3 Megawatt Expansion to Meet Need

PROVINCE OR AREA	**MWH PER YEAR**	**MW OF EXPANDED GENERATION**
(descending consumption)	Number times 10 to Exponent	
ONTARIO	3.17E+07	3,613
QUEBEC	1.86E+07	2,119
ALBERTA	1.30E+07	1,488
BRITISH COLUMBIA	1.04E+07	1,192
ATLANTIC CANADA	6.55E+06	748
SASKATCHEWAN	5.43E+06	620
MANITOBA	3.71E+06	423
YK, NWT, NUV	6.64E+04	8
TOTAL ENERGY	**8.95E+07**	**10,212**

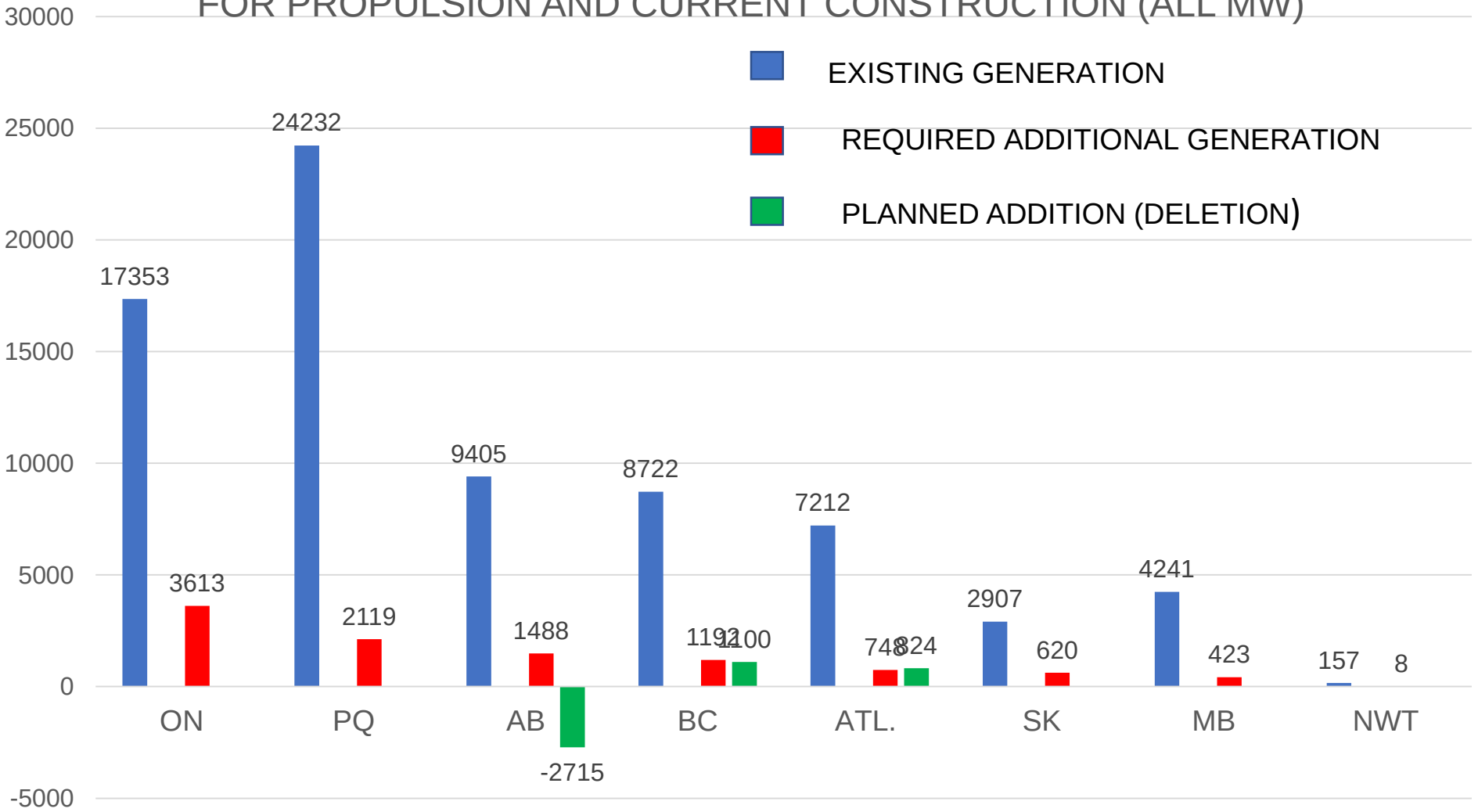
6.0 Comments and Conclusions

- At perfect efficiency, impossible, more than 10,000 megawatts of additional electrical generation capacity are required for Canada to be 100% electric passenger cars by 2040.
- At the present time, there are two large power projects being built in Canada, Site C in BC and Muskrat Falls in NL. Combined, they have a capacity of 1,924 megawatts, if they meet their design capacity.
- The existing projects have taken or will take more than five (5) years to reach production.

6.0 Comments cont’d

- There are no other large power generation projects even being contemplated in Canada currently. To meet the 2040 stated objective at least eight (8) more projects, of about the sizes being built, are required.
- In addition to the power generation, large amounts of additional electrical infrastructure will be needed to deliver the newly generated power to locations where it will be needed. None is planned now.

SLIDE 6.1 COMPARISON OF EXISTING GENERATION TO REQUIRED FOR PROPULSION AND CURRENT CONSTRUCTION (ALL MW)



6.0 Comments cont’d

- Given how electrical vehicles will be used, most for commuting and shopping, recharging will be a nighttime load on the power system. Weather may require day-time charging adding to base load demands. This eliminates solar and wind power from contention as new supply.
- Other technologies, fission and fusion, may be deployable in time to meet the projected demand. However, both of these technologies have long, long lead times and will be challenged to meet demand in even fifteen years.

6.1 Conclusions

- The subsidies for buyers of electric cars should cease immediately.
- A national consensus needs to be developed supporting increased power generation and distribution ahead of the demand coming on from electrical vehicles.