Energy xxx (2016) 1–9

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Some less-discussed externalities of contemporary electric vehicle mania in Canada

Alfred Wong

Arbokem Inc., Post Office Box 34173, Vancouver V6J 4N1, Canada

ARTICLE INFO

Article history:
Received 28 January 2016
Received in revised form
20 November 2016
Accepted 25 November 2016
Available online xxx

Keywords:
Economy
Electric vehicle
Electricity
Environmental
Greenhouse gas

ABSTRACT

Electric passenger vehicles are generally recognized to be the best-practicable alternative to gasoline-powered passenger vehicles, in the mitigation of greenhouse emission in the transportation sector of economically-developed countries. Energy stored in rechargeable batteries is the source of power for the operation of electric vehicles. The notable deterrents to the expanded implementation of the electric-vehicle strategy would include the adequacy of incremental and/or new power supply for recharging batteries, and fiscal implications for governments. In the 2012 reference year, the net outcome of re-deploying all power exported from British Columbia (Canada) to the USA for use by domestic electric vehicles would provide a conversion of ~47% of registered passenger motor vehicles. But this approach would increase the greenhouse gas emission by ~20 million tonnes of CO_2 equivalent annually, on the basis of increased CO_2 emission in the USA account. The export cessation would necessitate US electric utilities to increase their power generating capacity to make up for the shortfall in imports. The switchover to electric vehicles is projected to effect a revenue loss of ~C$600 million for the Government of British Columbia in the 2012 reference year.

1. Introduction

It is generally recognized that private use of internal-combustion motor vehicles is a very significant source of emission of greenhouse gases (GHG) in developed economies. In North America and western Europe, gasoline-powered vehicles are the most common means of private-use transportation. During the past decade, electric vehicles[1] (EV) have been promoted widely as the superior zero-pollution approach. Some of the notable technical problems encountered in the EV include the weight, capacity and durability of battery for energy storage. As reflected in the steady decline in the offered price of EV in the consumer market, considerable technical advances have been achieved to resolve these technical issues in recent years. However, the more fundamental problem of power availability for charging EV batteries has largely been ignored. It is generally assumed that “unlimited” supply of electric power would be available. Primary source of electric power is notably variable from region to region. For example, In France, most of the electricity is generated by nuclear fission reactors. In contrast, virtually all the electricity generated in Norway is from hydroelectric dams. In Canada, variation is substantial. In the province of Quebec, hydroelectric predominates, whereas in the province of Nova Scotia, thermal coal-fired generators are the principal source of electricity [32,34]. It is thus apparent that the widespread adoption of the EV strategy and its impact on the net GHG emission would be very different for example Quebec and Nova Scotia. Several power supply studies under prevailing situation in the European Union have suggested that there would be no significant shortage of power supply if an EV strategy was implemented to the level of 20–25% of present number of conventional motor vehicles (see, for example, [16,41].

The many Life Cycle Analysis studies conducted on the EV have generally concluded to be positive on a site-specific basis. In particular, one of the key LCA determinants is the ways and means of sourcing incremental and new supply of electricity for the charging of EV batteries (see, for example, [21,26,52]. Aquirre et al. [1] have concluded that battery EV are more energy efficient and less polluting than conventional gasoline vehicles, on the basis of assigned GHG emission factors for specific California gasoline formulation and mix of electricity. After all, an electric motor of an EV can operate at the efficiency of 80–90% [55–57]. In contrast, a typical internal-combustion gasoline engine would operate at

E-mail address: arbokem@arbokem.com.

[1] Except where noted, an electric vehicle means a battery-powered electric vehicle.

http://dx.doi.org/10.1016/j.energy.2016.11.126
0360-5442/

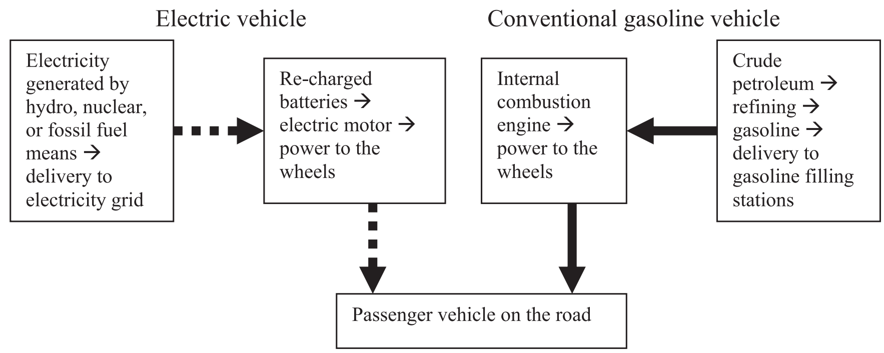

Fig. 1. Basic means of fuelling electric and conventional gasoline vehicles.

15–20% energy efficiency.[2] The arithmetic is thus very simple: using less gasoline means less emission of GHG, after accounting for any incremental increase in GHG emission arising from the implementation of the EV strategy.

This paper is aimed to examine the fundamentals of energy supply in the context of significant replacement of gasoline-powered with electric vehicles. British Columbia (a province of Canada) was selected to illustrate the problematical issues of power supply and fiscal demand.

The purpose of the present study was not to discuss the relative technical merits (or the lack of merits) of electric vehicles. Thus, any detailed comparison of technologies of gasoline-powered vehicles and EVs is not presently pertinent. The results of this study should be of interest to scientists, engineers, educators, students and politicians. It is well known that adequacy of revenue is the primary driving force directing government policies.

2. Methods

Public-domain data published by various government agencies were used in the present study. Analysis is greatly simplified because gasoline sold in Canada is used almost entirely by private automobiles. In contrast, diesel fuel is used sparingly by some private automobiles and virtually all buses and trucks. The 2012 reference year was chosen because the availability of essential public-domain data for analysis was complete.

The basic vehicle fuelling concept is illustrated in Fig. 1. Nissan Versa (gasoline powered) and Nissan Leaf (electricity powered) of 2012 model year were selected as the private 5-passenger vehicles for comparison purposes. It is assumed that recharging EV batteries is made through conventional household (110-volt, 15-A) plug-in outlets. The performance characteristics of both vehicles are based on data published by the US Environmental Protection Agency [55–57].

In order to demonstrate the impact of externalities of power supply on GHG emission, and the fiscal consequences for governments, a model EV strategy was constructed. The basis of the model is that power presently exported to the USA would be terminated summarily and the now-available power would be used for charging EV batteries. This approach circumvents the variable issues of comparative economics of owning and running an EV (versus a conventional gasoline powered vehicle) in view of variable environment of low benchmark pricing of petroleum, and uncertain continuing government subvention. Furthermore it is assumed that the implementation of the model EV strategy is unaffected by the steadily-converging parity in technical performance of EVs and gasoline-powered vehicles. In other words, the reduction of GHG emission in the passenger vehicle sector has priority over prevailing less-attractive comparative economics of owning and operating an EV, in the absence of any substantial new market intervention by governments.

It is recognized that as the conversion of (grid) electricity to energy stored in EV batteries become more efficient, the assigned allocation of electricity could “fuel” more EV, which might subsequently result in greater displacement of gasoline-powered vehicles, to a certain extent.

Life cycle analysis (LCA) is outside the scope of the present paper. LCA of electric vehicle technologies has been discussed extensive elsewhere for more than 2 decades (see for example [2,40,43,45,53,61].

3. Results and discussion

3.1. Gasoline consumption

In Canada, the consumption of gasoline is generally limited to motor vehicles with less than 4000 kg gross vehicle weight. Larger motor vehicles such as trucks and buses are nearly always powered by diesel fuel.

Table 1 shows the population trend as related to number of vehicles registered and consequent sale of gasoline. In comparison, the city of Vancouver, with about 13% of the British Columbia provincial population, has 24% of the registered vehicles in this class,[3] in 2012.

3.2. EV power demand

In the example case of Nissan Leaf all-electric vehicle, there has been a notable improvement in “fuel economy” as reflected with availability of improved batteries. In the 2012 model, the EPA rating was 34 per 100 miles (~21 KWh/100 km) and in the 2015 model year, the rating has decreased to 30 KWh/100 miles (~19 KWh/100 km). Table 2 shows that the improvement in fuel economy of comparative gasoline-powered Nissan Versa was interestingly similar between 2012 and 2015.

It is uncertain if substantial progress could be achieved in the application of energy to the wheel. Some the technical limitations include minimum friction required for traction and driving

[2] Energy efficiency denotes the conversion of energy in fuel into net power applied to the wheels of a motor vehicle.

[3] The numerical difference between “passenger vehicles registered” as described in the 2014 Transportation Panel Survey [65] and “motor vehicles <4000 kg gross vehicle weight) registered” is considered to be relatively minor for the purpose of the present analysis.

Please cite this article in press as: Wong A, Some less-discussed externalities of contemporary electric vehicle mania in Canada, Energy (2016), http://dx.doi.org/10.1016/j.energy.2016.11.126