

## Why should the Canadian government promote the electric vehicle?

Fossil energy has played an important role in the history of mankind. Since the first car was invented, people can travel faster and farther, but at the same time, we are also faced with the side effects of the car, mainly air pollution. This is also the reason why many countries are vigorously promoting electric vehicles. People may not give up the habit and convenience of using petrol cars in a short time. That's why the government needs to motivate people to do this. And this article will explain it's worth doing to incentive people to buy electric vehicles.

Car emissions release greenhouse gases, which cause global warming. Many people know this, but maybe they don't care, because it's so far away from our lives that it is difficult for us to do something about it. However, many people don't know that the harm caused by automobile exhaust emissions is far more than that. When the car is working, many harmful elements will be produced, such as fine particles such as the well-known PM 2.5, carbon dioxide, sulfide, nitrogen oxides, chlorofluorocarbons, and so on. Some gases contribute to effective greenhouses, ozone depletion, and acid rain, while others are directly harmful to humans, animals, and plants. According to a report from the Canadian government called Human Health Risk Assessment for Gasoline Exhaust, more than 2 million people live in cities near major roads. Based on the 2015 Canadian exhaust emission statistics, the statistics of exhaust harmful substances, the respiratory diseases they cause, and the comprehensive analysis of the cases reported by hospitals, this report finally gives a social cost of 7.3 billion in 2015.

Most people still think that electric cars are inconvenient because they need time to wait for charging. From the perspective of the government, electric vehicles have positive externality, while gasoline vehicles have negative externality. Encouraging the use of electric vehicles can effectively solve the problem of pollution and social costs caused by automobile exhaust. So how can we achieve this goal effectively? A direct method is to encourage people to buy electric cars. A study called Electric Vehicle Incentive Policies in Canadian Provinces shows that the incentive policy affects people's decisions about buying electric vehicles.

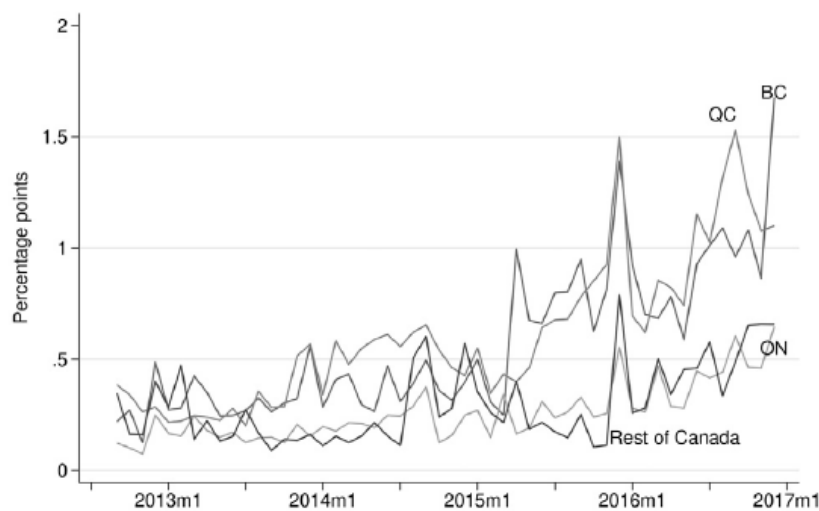


Fig1 from the study Electric vehicle incentive policies in Canadian provinces

This chart reflects the trend of the proportion of plug-in hybrid electric vehicle and battery electric vehicles in automobile sales in Ontario, Quebec and British Columbia during 2012 and 2016 under the incentive policy of purchasing specific PHEV/BEV. We can see a significant increasing trend, especially in BC and QC. In Ontario, Quebec and British Columbia, the average incentive money is about 5600 Canadian dollars. Furthermore, in the same study, the company estimated that if the average incentive of a specific electric vehicle model increased by \$ 1,000, the market share of that model will increase by about 5%. Also, 35% of the sales

due to reaction to the incentive policy. This strongly proves that the incentive policy will affect consumers' preference for purchasing electric vehicles.

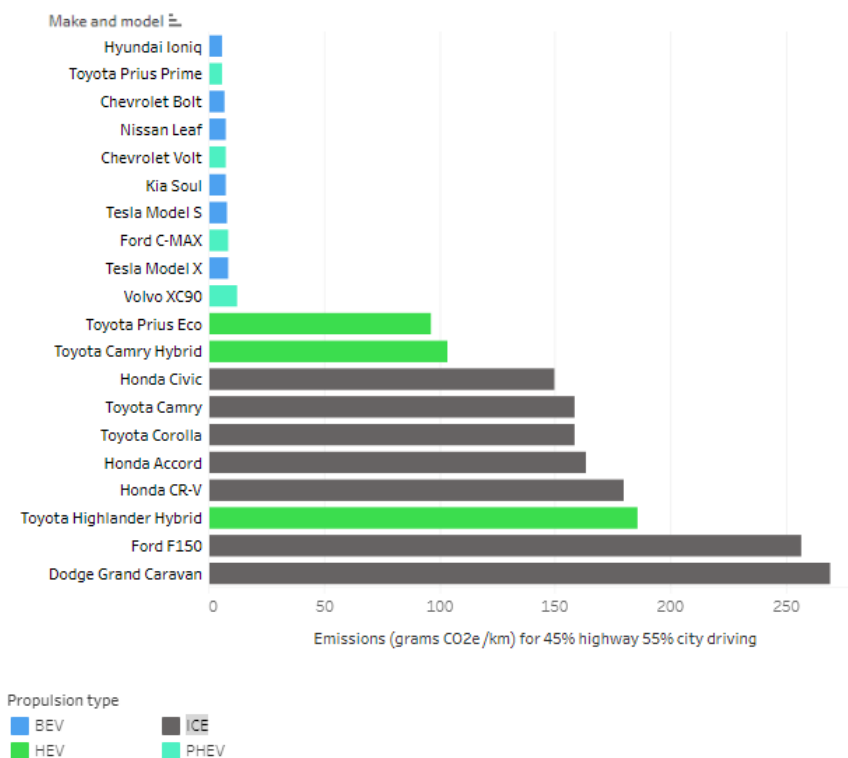
Someone may criticize that even increase the amount of EV, we will face the problem increasing amount of retired EV battery in the future which increase the environment pollution. The battery for EV to retire is when the capacity falls below some criterion, so even they are not enough for the EV, but they can be reused for other purpose. To deal with those cannot be reused, the government can set some regulation to make sure the battery is recycled properly. There is research called Retired Electric Vehicle (EV) Batteries shows that the battery manufacture decreasing the amount of toxic material to decrease the cost, therefore will reduce the danger of pollution. Therefore, compared with air pollution, we don't have to worry so much about the pollution caused by discarded batteries, because they are easier to manage and treat centrally. However, it is difficult to deal with air pollution with current technology.

People may also worry about whether Canada can produce enough electricity to charge so many electric vehicles, and whether the growing demand of electricity will lead to new pollution in power plant. To answer the first question, we can check the electricity consumption data on the website "World Data". It shows that Canada produces around 650 billion kilowatt-hours of electricity each year and consumes about 522 billion kilowatt-hours each year. Also, Canada even exports around 73 billion kWh of electricity. Using data from website Virta which shows average driving distance and average consumption of electricity in Finland. It gives the result

that the average driving distance is 16800 kilometers per year, and the average consumption of electric vehicles is 0.20 kWh per kilometer. Considering that Finland is a country with a similar winter to Canada, this data is convincing. The calculation shows that the average electric vehicle will consume 3360 kWh per year, and Canada's surplus electricity can meet the electricity consumption of about 21 million electric vehicles per year. Moreover, the total number of registered gasoline vehicles in Canada is around 23 million, so Canada has the ability to support the power of most of the vehicles. To answer the second question, we can first calculate how much CO<sub>2</sub> gasoline is produced by a car. Here are the data from the website of the Canadian government, which has selected several representative car in Ontario.

*How much do vehicles emit in different provinces?*

**Fuel associated GHG emissions from selected vehicles**



Data from Canada Energy Regulator(<https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2018/market-snapshot-how->

According to the data, the average emissions of internal combustion engines is around 180 g

CO<sub>2</sub> equivalent/km. Using the above data, we can calculate the carbon emission of about 69.5 million tons. The data from the Canadian government show that more than 80% of electricity production comes from clean energy sources, such as hydropower, nuclear energy, etc. This data also provides the data of 78 million tons of greenhouse gas emissions from the electricity sector in 2015. Now, we can say that increasing the share of electric vehicles will not increase the power burden, rather than increase the pollution, and it can reduce GHG emission by up to 69.5 million tons.

Now we want to talk about the cost and benefit of zero emission vehicles incentive policy. In the second paragraph, we mentioned that the social cost is about 7.3 billion. We also mention that in Ontario, Quebec and British Columbia, the average incentive policy amount of electric vehicles is about \$ 5600. If we want to reach the point of social efficiency, we should promote this policy. The problem is that one dollar in incentive policy will bring one dollar in social benefit, offsetting the social cost of GHG emission. Are there any other policies that are better? First of all, we can calculate how much carbon emissions can be reduced by the government's subsidy to none of the electric vehicles. Using the second chart and the previous data, we can compare how much carbon emissions a tram can reduce. With the same formal data of Finland, a car travels 16800km a year, while the average displacement of electric cars is 8 grams of CO<sub>2</sub>e per kilometer and that of internal combustion engines is 180 grams of CO<sub>2</sub>e per kilometer. Assuming that the average life of a car is 10 years, we can conclude that a tram can reduce carbon emissions by about 28.9 tons. Then, if we take the average incentive money of each electric vehicle in Ontario, Quebec and British Columbia which is 5600 \$ and divide it by this

data, we can conclude that the cost of reducing carbon emissions per ton is about 193 Canadian dollars. In the study called Electric Vehicle Incentive Policies in Canadian Provinces also provides data about cost of saving carbon emission per ton. It gives that their calculated cost of

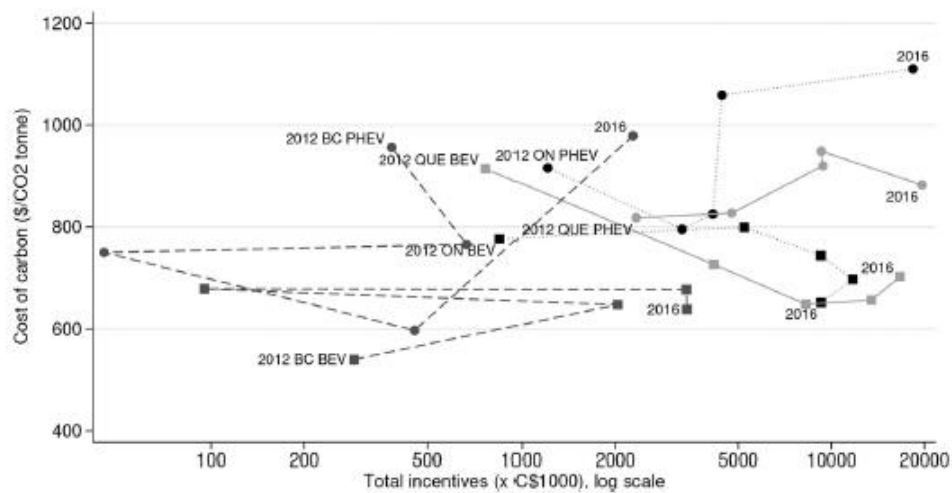


Fig 3 from the study Electric vehicle incentive policies in Canadian provinces

carbon emission reduction per ton is 700 to 880 Canadian dollars. This difference is very reasonable, because our estimation of carbon emission reduction is only based on a dozen models, and other costs of stimulating electric vehicles are not taken into account. According to the chart, we can see that the cost of carbon emission reduction did not change much in 2012 and 2016, but the incentives of some models even increased. Does this mean that this policy has failed? I don't think so, because the early stage of making changes itself requires a lot of costs. After all, people have been used to cars for more than 100 years. And is the cost of 600 to 800 Canadian dollars per ton to reduce carbon emissions too high? As mentioned in the second paragraph of our article, the social burden caused by air pollution in 2015 is 7.3 billion. If we calculate the cost of reducing carbon emissions by 700 Canadian dollars per ton, we can reduce carbon emissions by at least 10 million tons by spending 7.3 billion dollars. Even if the

reduction of 100 tons of carbon emissions won't directly offset the social burden of 7.3 billion, and the government doesn't spend so much incentive at once, because not so many people buy electric cars, this policy still has advantages and needs to be encouraged. The third paragraph explains that the government's incentives have really increased the sales of electric vehicles, and this kind of incentives not only directly subsidize consumers who choose electric vehicles, but also have no direct impact on the automobile market. This also gives consumers and the market a certain time to accept and respond. What's more, think about the positive externalities brought by carbon emission reduction, such as the growth of crops, people's health, the saving of medical resources, the quietness and odorless of electric vehicles, and so on. So is it still so expensive to reduce carbon emissions at a cost of 600 to 800 dollar per ton?

In summary, carbon emissions bring not only environmental pollution, but also social costs. The negative externality of automobile emissions will make society more inefficient and lower welfare. The positive externality of electric vehicles lies not only in the reduction of carbon emissions brought by clean energy, but also in the protection of people affected by automobile exhaust, which reduces the social burden. People also don't have to worry about the power burden and pollution caused by electric vehicles, because most of Canada uses clean energy to generate electricity and has enough electricity. The government's incentive policy for electric vehicles has an influence on the sales of electric vehicles, and this influence will not directly affect the efficiency of the automobile market. At present, the incentive policy seems to have a high cost for carbon emission reduction, but considering other positive and external effects, this cost is worthwhile and will gradually decrease, because with the increase of more charging

stations, it will be more and more convenient for electric vehicles to travel in cities. Although it takes more time to supplement energy for gasoline cars and electric cars, with the increasing number of charging stations, electric cars don't have to spend extra time to supplement energy, since gas stations are not so close to each other. Therefore, gradually, electric vehicles will become a trend, ultimately reducing the cost of government incentives.

(1830 words)



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