

# ENHANCING ENVIRONMENTAL LOAD MITIGATION BENEFITS FROM CLEAN ENERGY VEHICLE INCENTIVES: IN CONTEXT OF METRO VANCOUVER

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## ABSTRACT

The invention of vehicles and driving have forever changed the way the world lives, both the developed and the developing, providing people with access to private means of transport, yet the unintended economic, environmental, and social costs of driving have become apparent the past few decades. While it is essential to fundamentally reduce automobile dependency with strategic land use planning and paradigm shift in the long run, motor and fuel efficiency should play a key role mitigating environmental load in the short run, with electric vehicles being one of the alternatives.

Much of the existing literature has conducted benefit cost analyses of clean energy vehicle adoptions and investigated their incentive policies both from consumers' and social perspectives, but none has investigated how a particular policy's social benefits can be enhanced by taking consumer preferences into consideration in a more aggregate manner. Incentive policies that incorporate consumer preferences have potential to increase social and individual benefits in addition to initially intended environmental benefits.

The objective of this thesis is to investigate methods that could potentially enhance the social benefits resulting from environmental load mitigation such as climate change and air pollution from the provision of incentives for electric vehicles in British Columbia, particularly its Metro Vancouver region. By monetizing the private benefits of incorporating under-utilized facilities such as HOV lanes and parking into the policy using existing data and simulations and investigating consumer preferences of different incentives, the study attempts to quantitatively demonstrate the government is able to reach more potential electric

vehicle drivers with smaller subsidies installment by implementing non-monetary incentives, resulting in larger social benefits.

Based on the IPCC report's marginal damage cost of greenhouse gas emissions and APEEP model's marginal damage cost of dominant air pollutants emissions, it was estimated each adoption of an electric vehicle from a conventional gasoline vehicle in Metro Vancouver results in \$ 679.06 of environmental load mitigation benefits in monetary terms over the course of eight years. Given its relatively clean power sources that do not depend on coal, British Columbia expects much environmental benefits and achievement of its stringent greenhouse gas emissions reduction target from adoption of electric vehicles.

Providing consumers with monetary benefits, however, is not the only method to incentivize them to switch to electric vehicles. In addition to the monetary incentives, HOV (high occupancy vehicle) lane permits allow electric vehicle drivers to use reserved, fast lanes, significantly reducing travel time during peak hours, and complimentary street parking provides them with access to parking spots operated by governments free of charge. When the government implements those non-monetary incentives in addition to the existing monetary incentives, now they are able to subsidize a greater number of electric vehicles within the same budget constraint and without reducing each consumer's utility.

Based on the available government data about household expenditures and traffic patterns, investigations estimated that free street parking and provision of an HOV lane permit result in annual private benefits of \$109.52 and \$64 respectively. In case of HOV lane permits, however, only 7.1% of electric vehicle drivers would live and commute where direct time savings benefits from HOV lanes are expected, and thus it is not ideal to reduce the same amount of monetary incentives in return for provision of non-monetary incentives.

In order to further understand consumers' preferences for different non-monetary incentives in addition to the currently implemented monetary incentives, a consumer survey

was conducted targeting Metro Vancouver residents. Despite only 3.85% of the respondents living and commuting routes with HOV lanes, 34.6% answered they are willing to accept reduction in monetary incentives in return for HOV lane permits for five years. Unexpectedly 53.8% of the respondents answered better availability of public charging infrastructure would positively affect their electric vehicle purchase in addition to monetary incentives; this compares to 42.3% for free street parking and 28.8% for HOV lane permits.

Given the diverse set of preferences for different types of incentives and strong preference for charging infrastructure revealed in the survey, the study presents two policy recommendations to enhance the total social benefits out of the policy.

First, the government shall allow consumers to select combinations of monetary and non-monetary incentives, as opposed to the conventional one-size-fits-all approach of incentive provision. Such scheme is expected to result in the enhancement of consumer utility, with incentives being allocated to those who highly value them, and avoid congestion resulting from overprovision of HOV lane permits and complimentary parking. Assuming 30% of new electric vehicle buyers would choose one or more of the non-monetary incentives for five years and accept \$500 reduction of monetary incentives, the total environmental load mitigation benefits from the policy would increase by 6%.

Secondly, the government requires further investigation on consumers' preference strength among monetary incentives, non-monetary incentives, and charging infrastructure development and allocate financial resources accordingly to maximize drivers' utility. Currently 95% of electric vehicle drivers in British Columbia live in single detached houses, while much of the population lives in multi-unit residential buildings where they need to share parking with other tenants. For many, it is necessary the infrastructure is organized before they are able to start considering purchasing electric vehicles in the first place.

Further adoption of electric vehicles is an important first step to attaining environmental objectives without sacrificing convenience of driving in the short run. Governments are expected to utilize various traffic resources and strategically implement policy instruments with a better understanding of consumer preference in order to maximize the benefits for all.

*Key words: electric vehicles, incentive policy, environmental benefits, non-monetary incentives, consumer preferences*