Energy Policy ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Energy Policy

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

China's electric vehicle subsidy scheme: Rationale and impacts

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HIGHLIGHTS

- China's phase I and phase II electric vehicle subsidy schemes were reviewed.
- Major electric vehicle models in China's vehicle market were reviewed.
- The ownership costs of five defining electric passenger vehicle models were compared.
- Policies to promote electric vehicle deployment in China were discussed.

ARTICLE INFO

Article history:
Received 27 December 2013
Received in revised form
1 April 2014
Accepted 13 May 2014

Keywords:
Electric vehicle
Passenger vehicle
China
Subsidy
Ownership cost

ABSTRACT

To promote the market penetration of electric vehicles (EV), China launched the Electric Vehicle Subsidy Scheme (EVSS) in Jan 2009, followed by an update in Sep 2013, which we named phase I and phase II EVSS, respectively. In this paper, we presented the rationale of China's two-phase EVSS and estimated their impacts on EV market penetration, with a focus on the ownership cost analysis of battery electric passenger vehicles (BEPV). Based on the ownership cost comparison of five defining BEPV models and their counterpart conventional passenger vehicle (CPV) models, we concluded that in the short term, especially before 2015, China's EVSS is very necessary for BEPVs to be cost competitive compared with CPVs. The transition from phase I to phase II EVSS will generally reduce subsidy intensity, thus resulting in temporary rise of BEPV ownership cost. However, with the decrease of BEPV manufacturing cost, the ownership cost of BEPV is projected to decrease despite of the phase-out mechanism under phase II EVSS. In the mid term of around 2015–2020, BEPV could become less or not reliant on subsidy to maintain cost competitiveness. However, given the performance disadvantages of BEPV, especially the limited electric range, China's current EVSS is not sufficient for the BEPV market to take off. Technology improvement associated with battery cost reduction has to play an essential role in starting up China's BEPV market.

1. Introduction

China is facing severe environmental and climate challenges (Guan et al., 2008). Road transport emits around 8% of China's total energy related greenhouse gas (GHG) emissions (IEA, 2013) and the share is increasing very fast with the boom of vehicle stock (Hao et al., 2011d). As EVs offer the potentials to address oil security, air pollution and climate change, China took EV deployment as an essential strategy to tackle local pollution and GHG emissions issues. In the "Energy Saving and New Energy Vehicle Industry planning" issued in 2012, the accumulated sales of battery electric vehicle (BEV) and plug-in hybrid electric vehicles (PHEV) were projected to reach 0.5 million in 2015 and 5 million in 2020. To accomplish this target, China has launched comprehensive programs and policies to promote EV market penetration.

Abbreviations: AMT, automated mechanical transmission; AT, automatic transmission; BEPV, battery electric passenger vehicle; BEV, battery electric vehicle; CPV, conventional passenger vehicle; CVT, continuously variable transmission; EV, electric vehicle; EVSS, electric vehicle subsidy scheme; FCEV, fuel cell electric vehicle; FCR, fuel consumption rate; FEVSS, fuel-efficient vehicle subsidy scheme; GHG, greenhouse gas; HEV, hybrid electric vehicle; MSRP, manufacturer suggested retail price; NEDC, new European driving cycle; O&M, operation and maintenance; PHEV, plug-in hybrid electric vehicle; PHEPV, plug-in hybrid electric passenger vehicle; PV, passenger vehicle; SPM, subsidy phase-out mechanism; SPV, special purpose vehicle

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http://dx.doi.org/10.1016/j.enpol.2014.05.022
0301-4215/© 2014 Published by Elsevier Ltd.

Please cite this article as: Hao, H., et al., China's electric vehicle subsidy scheme: Rationale and impacts. Energy Policy (2014), http://dx.doi.org/10.1016/j.enpol.2014.05.022

Among all the policy instruments, vehicle purchase subsidy plays an essential part in starting up China's EV market.

Vehicle purchase incentives for EVs, notably subsidies and tax credits, have been adopted in many countries. In the U.S., activated by the Energy Policy Act of 2005, a maximum of $3400 tax credit was provided to hybrid electric vehicle (HEV) purchase between 2006 and 2010. The incentive for PHEV and BEV purchase started in 2010, which offers $2500–$7500 tax credit to PHEV and BEV purchase depending on vehicle's battery capacity (Internal Revenue Service, 2011). In Japan, the "Green Vehicle Purchasing Promotion Measures", which was passed by the Japanese Diet in 2009, provides purchase of environmentally friendly vehicles with up to 100,000 Yen subsidy and a combination of tax reduction and exemption incentives (JAMA, 2010). Under the "Clean Energy" subsidy program, EV purchase is eligible for a maximum of 850,000 Yen subsidy in 2013. As the world's most determined EV propellant, China launched the Electric Vehicle Subsidy Scheme (EVSS) in Jan 2009, followed by an update in Sep 2013, which we named phase I and phase II EVSS, respectively. The two-phase subsidy scheme specifies the subsidy duration, scope, standard, phase-out mechanism and pilot cities for both public and private EV purchase. It is one of the world's most comprehensive and incentive-strong subsidy schemes.

Vehicle purchase incentive can pose a wide range of impacts on vehicle market. Existing studies have evaluated the impacts of vehicle purchase incentive on many aspects, with a focus on consumer purchase behavior and vehicle market penetration. These studies typically employ an agent-based consumer choice model to simulate the effect of cost and other non-cost factors on vehicle choice. Mueller and de Haan (2009) established a two-stage model of individual decision process to estimate the effect of energy-efficiency feebates on consumer choice of new cars, concluding that consumers can have different reactions to feebates, either switching to a smaller car or a more efficient car with the same class. Eppstein et al. (2011) developed a spatially explicit agent-based vehicle consumer choice model to study the various influences, including policy incentives, on PHEV market penetration. Their study indicates that a ready-estimate of ownership cost to consumers can significantly enhance the market penetration of PHEVs. Al-Alawi and Bradley (2013) examined existing EV market modeling studies, calling for an improved interface with federal and state policy and its effect on automotive markets. Several studies discussed vehicle subsidy in a strategy framework. Yang (2010) argued that subsidy alone is not sufficient for the commercialization of electric vehicles, while limiting conventional vehicles could be more effective. Skerlos and Winebrake (2010) argued that a consumer income and location of purchase specific subsidy policy would yield higher social benefits. Ross Morrow et al. (2010) compared the policies of fuel tax, fuel economy standard and vehicle purchase tax credit, concluding that vehicle purchase tax credit is expensive and inefficient at reducing emissions.

As vehicle ownership cost is the essential factor affecting vehicle choice, many studies have focused on the evaluation of vehicle ownership cost. These studies typically include a set of computer simulation based or real-world demonstration based fuel economy and cost estimates for alternative vehicles. Plotkin and Singh (2009) compared the ownership costs of several alternative vehicle powertrains for light duty vehicles, concluding that advanced CV and HEV powertrains are likely to offer better cost effectiveness for fuel saving. Burke and Zhao (2012), based on similar approach, projected the ownership costs of alternative vehicle powertrains through 2030, with an evaluation of the impact of battery cost uncertainty. Peterson and Michalek (2013) estimated the cost effectiveness of PHEV battery capacity, finding that low-capacity PHEV and HEV are the more favorable solutions. Several studies further investigated the effect of alternative vehicle penetration on the energy consumption and emissions of the whole vehicle fleet at a macro level (Al-Ghandoor, 2013; Al-Ghandoor et al., 2012; Geng et al., 2013; Hang et al., 2013; Hao et al., 2014a, 2011b, 2010, 2012; Ou et al., 2012; Zhu, 2010). In general, existing studies have established a mature framework for vehicle ownership cost analysis. However, there is a lack of studies on vehicle purchase subsidy and ownership cost in China's context. Although China is providing intensity subsidy to EV purchase, their effect on consumer's purchase behavior is unclear. In this study, based on a comprehensive review of China's EVSS and market available EV models, we estimated the impact of EVSS on consumer's vehicle ownership cost, with the purpose of providing a thorough vision into the economic aspects of China's EVSS.

The following sections of this paper are organized as below. Section 2 investigates the rationale of China's phase I and phase II EVSS in terms of private purchase subsidy and public purchase subsidy, respectively. Section 3 examines the available EV models in China's vehicle market and their qualified subsidy under EVSS, with a brief discussion of the impacts of EVSS update on vehicle manufactures. Section 4 estimates the impacts of EVSS on vehicle ownership costs based on the comparison between China's five defining BEPV modals and their counterpart CPV models. Section 5 presents the policy implication derived from the ownership cost analysis. Section 6 draws conclusions from the whole study.

2. Rationale of China's EV subsidy schemes

Table 1 presents a comprehensive description of China's phase I and phase II EVSS. In this section, we described China's EVSS in the order of subsidy duration, scope, standard, phase-out mechanism and pilot cities.

2.1. Subsidy duration

The phase I EVSS started in 2009. In the beginning, subsidy was only available to public procurement, mostly transit buses and taxis. In 2010, subsidy was extended to include private purchase. The phase I EVSS ended at the end of 2012. After nine months of policy absence, the phase II EVSS was announced in Sep 2013 and will continue through 2015. It covers both public and private purchase.

2.2. Subsidy scope

Under phase I EVSS, the subsidy for public procurement covers all categories of EVs (HEV, PHEV, BEV and FCEV). The subsidy for private purchase covers only PHEV and BEV. HEV is considered as fuel-efficient vehicle and is subsidized under Fuel-Efficient Vehicle Subsidy Scheme (FEVSS). But the subsidy intensity of FEVSS (¥3000 per vehicle) is far lower than EVSS (Up to ¥60,000 per vehicle). Under phase II EVSS, subsidy covers PHEV, BEV and FCEV. Both public and private purchases of HEVs are excluded from the subsidy scheme. As nearly half of subsidized public vehicles during phase I EVSS are HEVs, the exclusion of HEV in Phase II EVSS will greatly curtail the subsidy benefits. There has been great controversy over whether HEV should be included in EVSS, as many people believe HEV should be given equal priority to PHEV and BEV. This subsidy scope partially reflects China's strategy on EV development, which place more priority on pure electric driving technologies.

2.3. Subsidy standard

2.3.1. Private purchase

Under phase I EVSS, subsidies for private purchase of PHEPV and BEPV are based on vehicle's battery capacity, with subsidy