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Economic Cooperation

The Impact of Government Policy on Promoting New Energy Vehicles (NEVs)

– The Evidence in APEC Economies

Automotive Dialogue

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Produced by
Beijing Capital Energy Technology Co. Ltd
No.11 Anxiang Beili, Chaoyang Dist. Beijing 100101, People's Republic of China

Li Xia (Contract Manager)
Tel: (86 10) 6485 3179
Mobile: (86 13) 71768 6620
Email: vince1986@263.net

For
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 6891 9600
Fax: (65) 6891 9690
Email: info@apec.org
Website: www.apec.org

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Abstract

The upward trend in fuel prices and the desire to reduce pollution levels mean that the electric vehicle has become an increasingly attractive alternative in recent years. This project addresses the need for an empirical study to examining the impact of government policies introduced to promote NEVs in main members of APEC economies. The aim of this project is to assess the effect of policy on development of NEVs and explore the factors that would potential influence customers' acceptance of NEVs. With a literature review of NEV policies of APEC economies, public policies have been directed at four basic features of the electric vehicle: the charging network; increasing demand for these vehicles; industrialization and research and development programs; and the introduction of electric vehicles in programs of sustainable mobility. In order to analyze the relation between NEVs development and government policy instruments, a fuzzy logic based model is proposed to evaluate the effectiveness of NEV policy. The project is hoped to enhance the efficiency of policy instruments for NEVs, particularly demand-side incentives which can be a helpful means of stimulating NEV adoption by potential customers. The results describe the public policies that have been implemented around the APEC economies to overcome the barriers to the adoption of electric vehicle so that it might become the vehicle of the future.

Special Instruction

All contents are derived from public information such as the internet and document database. Limited by the degree of openness of resources, it's hard to get comprehensive data of NEV policy. The viewpoint does not represent the APEC's viewpoint.

Contents

1 INTRODUCTION

1.1 Background

Transport, as an important source of CO2 emissions, has attracted world-wide concern in terms of environmental protection. According to the evidence from the IEA (2009), transportation sector was responsible for 23% of total CO2 emissions worldwide.

New Energy Vehicles (NEVs) are vehicles using non-traditional fuels (ethanol, biogas, and biodiesel); and also refers to any technology of powering an engine that does not involve solely petroleum (e.g. electric vehicles, fuel cell vehicles, solar powered vehicles, and various hybrids of these. These new emerging vehicles are also known as alternative energy vehicles. NEVs are of particular strategic importance for APEC economies for several reasons. Reducing the dependence on fossil fuels is considered important, as well as environmental arguments related to CO2 emission and other air pollutants (vehicle emission is one of the major sources of air pollution). Realizing such challenges caused by transportation sector, several new propulsion systems for NEVs have emerged and entered the market, or are ready to enter the market in near future. It has been acknowledged that the adoption of NEVs is an effective way to reduce harmful emissions of greenhouse gases. However, the cost disadvantages of the NEVs as well as their limited driving range have to be overcome in order to achieve a shift toward NEVs in the transportation sector. Therefore, government policy instruments are important to improve the technical level of NEVs, especially in product maturity, and encourage the purchase of NEVs. Among the APEC economies, the different policy approaches have been adopted to promote the industry of NEVs.

The APEC economy is the largest new vehicle market in the world and the largest emerging market in NEVs. Many economies, such as the United States and China, have set up goals to develop NEVs. It has been acknowledged that

government policy instruments are important to improve the technical level of NEVs, especially in product maturity, and encourage the purchase of NEVs. However, the efficiency of the NEV policies are not encouraging according to the sales of NEVs. At the same time, how to evaluate and improve the efficiency of NEV policy, is crucial for NEV industry.

In May 2014 at the APEC Senior Officials in Qingdao, The 'Impact of Government Policy on Promoting New Energy Vehicles - The Evidence in APEC Economies (IGPPNEVs)' project was put forward. In September 2014, the 21st Automotive Dialogue was held in Shanghai, discussed about and reached broad consensus on the proposal of IGPPNEVs between sponsors and co-sponsors. On July 2016, the project was lunched.

1.2 Research Objective

This project addresses the need for an empirical study to examining the impact of government policies introduced to promote NEVs in main members of APEC economies. The objective of this project is to assess the effect of policy on development of NEVs and explore the factors that would potential influence customers' acceptance of NEVs. The results are hoped to enhance the efficiency of policy instruments for NEVs, particularly demand-side incentives which can be a helpful means of stimulating NEV adoption by potential customers. The findings of this project will give a better understanding of government policy on NEVs, and share experiences of promoting low carbon technology. This project will develop recommendations on how to increase the market share of NEVs and

promote the trade and economic cooperation among the member of APEC economies. On the other hand, the project is also to make a good platform to exchange the information and experience about NEVs development.

From the perspective of regional development, it is expected to promote connectivity, including enhancing physical infrastructure, institutional and people-to-people connectivity by the way of hardware capacity for NEVs (e.g. charging facilities) and institutional cooperation (e.g. Beijing Institute of Technology in China, Malaysia Automotive Center, Automotive Research & Testing Center in Chinese Taipei and Taiwan Institute of Economic Research). It can be considered as the projects that specifically and significantly contribute to promoting regional economic integration via free and open trade and investment (Rank 1, Funding Criteria for All APEC-Funded Projects in 2014). Especially, the outputs of this project are expected to promote the development of NEVs which can provide a kind of sustainable travel service and promote the automotive trade. This promotion will contribute to the connectivity of people, as well as APEC economies. This project will also contribute to sustainable development through promoting NEVs markets by understanding the dynamics of the policy and market behavior (Rank 2, Funding Criteria for All APEC-Funded Projects in 2014).

1.3 Research Methods

1.3.1 Document Analysis

Document analysis is a social research method and is an important research tool in its own right and is an invaluable part of most schemes of triangulation. Documentary work involves reading lots of written material (it helps to scan the documents onto a computer and use a qualitative analysis package). A document is something that we can read and which relates to some aspect of the social world. Official documents are intended to be read as objective statements of fact. There are three primary types of documents:

- Public Records: The official, ongoing records of an organization's activities. Examples include annual reports, policy manuals, statistical handbooks et al.
- Personal Documents: First-person accounts of an individual's actions, experiences, and beliefs. Examples include e-mails, reflections/journals, and newspapers.
- Physical Evidence: Physical objects found within the study setting (often called artifacts). Examples include posters, agendas, handbooks, and training materials

Steps in Document Analysis include:

Step 1. Define the environment: the requirements, external requirements, the document universe, the set of document types.

Step 2. Define the textual features you care about.

Step 3. Identify the relationships among the features.

Step 4. Enrich the collection of text features.

1.3.2 Consistent Fuzzy Preference Relations (CFPR)

Advantage: Firstly, it can be easily to compute the relative weights of each main criteria and sub-criteria by using CFPR method. The CFPR method needs not to consider any complex integration, differentiation and simultaneous equations. Secondly, the CFPR process can effectively reduce the pairwise comparison frequency. Thirdly, the CFPR method can ensure consistency.

Procedure: Fuzzy preference relations: a fuzzy preference relation P on a set of alternatives X is a fuzzy set that denoted by the product set $X \times X$ with a membership function $\mu_p : X \times X \to [0,1]$. The preference relation is represented by the $n \times n$ matrix $P = (p_{ij})$, where $p_{ij} = \mu_p(x_i, x_j) \ \forall i, j \in \{1,\ldots,n\}$. Herein, p_{ij} indicates the fuzzy preference ratio of alternative x_i to x_j, if $p_{ij} = 1/2$ indicates that no difference exists between x_i and x_j, if $p_{ij} = 1$ means that x_i is absolutely preferred to x_j, and if $p_{ij} > 1/2$ implies that x_i is preferred to x_j. The entire procedure for calculating weight of criterion is shown below:

Step 1. Suppose a set of alternatives, $X = \{x_1, \ldots, x_n\}$, associated with a reciprocal multiplicative fuzzy preference relation $A = (a_{ij})$ with $a_{ij} \in [1/9, 9]$. Then, the corresponding reciprocal fuzzy preference relation, $P = (p_{ij})$ with $p_{ij} \in [0,1]$ associated with A is defined as $P = g(A)$, i.e., $p_{ij} = g(a_{ij}) = \frac{1}{2}(1 + \log_9 a_{ij})$, where g is a transformation function which can transform a reciprocal multiplicative preference relation matrix into kinds of preference relation. $\log_9 a_{ij}$ is considered because a_{ij} is between *1/9* and *9*. When a_{ij} is between *1/5* and *5,* then $\log_5 a_{ij}$ is used.

Step 2. For a reciprocal fuzzy preference relation $P = g(A)$, where $P = (p_{ij})$, the following statements are equivalent; $p_{ij} + p_{jk} + p_{ki} = \frac{3}{2}, \quad \forall i, j, k$,

$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2}, \quad \forall i < j < k$

Step 3. For a reciprocal fuzzy preference relation, $P = (p_{ij})$, the following statements are equivalent.

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2}, \quad \forall i < j < k, \quad p_{i(i+1)} + p_{(i+1)(i+2)} + \cdots + p_{(j-1)j} + p_{ji} = \frac{j - i + 1}{2}, \quad \forall i < j$$

According to step **3**, we can structure a consistent fuzzy preference relation *P* on $X = \{x_1, x_2, \ldots, x_n, n \geq 2\}$ from *n*-1 preference values $\{p_{12}, p_{23}, \ldots, p_{(n-1)n}\}$.

The weight of criterion can be severally acquired. The larger weight can get the higher rank which means the criterion is more important.

1.3.3 Database System for the NEV Policy

The Database is focus on the NEV policy, the aims are:

- Gathering the policy of NEV in APEC economies;
- Evaluating the efficiency of NEV policy;
- Finding the best policy for developing the NEV industry.
- The system function can be defined as:
- Gathering all the original text of the policy;
- Explain the original text into the data and test the result;
- Evaluating the policy;
- Recommend mode of best policy.

2 FACTORS IN NEV DEVELOPMENT

Electric vehicles have a number of advantages over internal combustion engine (ICE), vehicles, yet present a number of drawbacks. One of the main reasons for promoting electric vehicles is that they exploit more energy efficient technology than that use by ICE vehicles. As the WWF (2008) and the International Energy Agency (2008) report, electric vehicles are four times more energy efficient than ICE vehicles. In fact, Ahman (2001) shows how vehicles powered by alternative energy (basically, electric vehicles, plug-in hybrid electric vehicles and fuel-cell electric vehicles) are twice as energy efficient as current ICE vehicles.

This increased energy efficiency can also result in a reduction in greenhouse gas emissions, although the magnitude of these reductions depends critically on the technology used to produce the electricity. If most of the electricity can be produced using sources of renewable energy (solar, wind, etc.), reductions in greenhouse gases will be high, but if the dominant technologies are coal and oil, the reduction will be minimal (Transport and Environment, 2010).5 As Hadley and Tsvetkova (2009) point out, the impact of the introduction of hybrid or electric vehicles will depend on the technological mix used for electricity generation, as well as the time of day (demand peaks or valleys) when recharging takes place, among others.

A further advantage of the electric vehicle is that it should lead to an improvement in city air quality (as electricity generating plants are typically located some distance away) and noise levels. As Greenpeace et al (2010) report, if the increase in electricity demand coincides with a valley in consumption, this could improve the efficiency of electricity generating plants.

Despite the potential benefits of electric cars, it should be borne in mind that they do not represent an unequivocal panacea. As the Transport & Environment report (2009b) stresses, it is likely that technological advances in electric vehicle development will not be fast enough to ensure compliance with the greenhouse gas limits fixed for the coming decades. Kageson (2005) expresses his doubts about the possibilities of hybrid vehicles being introduced quickly enough, since in 2004 only 8,500 new hybrid vehicles

were registered, representing just 0.06 percent of new vehicles in EU-15.

One explanation for the slow introduction of electric vehicles is the obstacles this technology faces when compared to internal combustion. According to the Citi report (2009), the main obstacles are:

1. Costs. - Although the long-term costs of electric vehicles are not as great as those of ICE vehicles (based on lower maintenance and fuel costs), the cost of acquisition remains higher because of the price of the cell battery pack. Ensuring a competitive purchase price will, therefore, largely depend on the evolution of battery costs (the main cost involved in these vehicles). Predictions of battery costs vary from company to company, but seem to provide for a significant reduction, which should facilitate their competitiveness.

However, for the time being, and for some time to come, the cost of the battery will remain one of the main obstacles to the adoption of the electric vehicle, so much so that some companies are beginning to spread the cost of the battery, which is being granted under lease. The cost of acquisition seems to be a barrier to the spread of electric vehicles, and has led to public sector intervention through subsidies for the purchase of such vehicles, and to R&D support to reduce battery costs.

2. Infrastructure for recharging. - Although in some cities, such as London, Rome and Berlin, small networks exist for recharging vehicles, the spread of such networks is slow. Charging points installed in homes are slow but relatively inexpensive (around $250), while more rapid charging requires an investment of several thousand euros.

The failure to develop recharging networks can induce "range anxiety" in vehicle owners, that is, the fear of not reaching a charging point before the battery dies. This fear can be a significant barrier to the introduction of the electric vehicle, and here the public sector can play an active role in disseminating information about the location of these charging points to help reduce this "anxiety".

A further point to note regarding recharging points is their compatibility. The homogeneity of systems between economies, in order to avoid any incompatibility, is essential for the diffusion of electric vehicles. Here, there is an obvious role for public

regulation.

3. Consumer acceptance. - Various reports conclude that consumers would be willing to make the switch if the electric vehicle reduced energy costs. Pike Research (2009) reports that two-thirds of consumers would even be willing to pay a higher price for the vehicle, under this condition. Thus, a regulatory framework and a set of clear, stable electricity rates are important in ensuring consumers are fully informed of the savings in their energy costs. Measures to facilitate public information concerning energy supply to the potential consumers of electric vehicles would therefore help in the introduction of electric vehicles.

4. The evolution of other technologies. - The existence of vehicles using other technologies (fuel cell, biofuels, ethanol, hydrogen, etc.) and the conversion of ICE vehicles in more environmentally friendly cars (with higher levels of fuel efficiency) represent obvious competitors for electric vehicles. Identifying the best technology for the future and focusing public efforts in developing this technology will not be a straightforward matter.

In attempts to overcome these barriers, various factors will come into play. These can be classified as being either endogenous (government support, industry initiatives) or exogenous (increases in fuel prices, economic crisis, reduction of fossil fuel reserves) in nature. In this study, we focus above all on the former, but we must not forget the existence of the latter, which may have a significant influence on the adoption or otherwise of electric vehicles. In the case of the endogenous factors, it is not only public authorities that can promote the introduction of electric vehicles but industry too has a role to play in overcoming the barriers that hinder development (especially of batteries and charging networks).

The role of the Public Administration is clearly critical as far as environmental regulations that indirectly promote the use of electric vehicles are concerned. In the case of Europe these include: 1) Directive 2009/28/EC which states that 10% of the energy used in transport must be provided by renewable sources by 2020. 2) The EC regulation 443/2009 which imposes reductions in average emission levels for vehicle manufacturers,

setting objectives of 130 gCO2/km for 2015 and 95 gCO2/km for 2020.

3) The European strategy to promote the use of environmentally friendly vehicles (COM, 2010; 186 final) which establishes as priorities the development of electric vehicles that are at least as safe as conventional ones, a European standard for charging points, a public charging network, a smart grid and research programs for the safe recycling of batteries.

If we examine a number of pilot projects implemented in various cities around the world, we can see how the nature and extent of public intervention have changed considerably. Wiederer and Philip (2010) present case studies in four cities that have run pilot schemes for the introduction of electric vehicles and which provide examples of the roles that the public sector might adopt.

- Singapore, in June 2010, initiated a project to invest 20 million dollars in setting up a comprehensive network of recharging points, and to provide subsidies for the purchase of electric vehicles. The primary goal of local government is to attract the electric car industry to Singapore.

- The Indian city of Bangalore has no specific plan to promote electric vehicles, yet there are over a thousand electric vehicles of the REVA brand (a domestic producer) on the streets. This seems to indicate that, at least in this particular case, there is no need for active intervention on the part of the public authorities to promote demand for electric vehicles.

It is interesting to note how the pilot projects run in these cities have given different emphases to the deployment of electric vehicles: industrialization, in the case of Singapore; full network development, in the case of London; and the recharging network, in the case of Berlin. Likewise, the degree of public sector involvement varies significantly from one project to another: from simple guidelines for private companies (the case of Bangalore and Berlin) to an active role in the market though heavy investment (the case of Singapore and London).

The sections that follow break down the measures applied by the public authorities as they seek to address the main barriers and to promote the development of electric vehicles.

3 LITERATURE REVIEW OF NEV POLICY

A lot of policies have been issued by the central and local governments to promote the adoption of NEVs, but these have different effects. The dilemma between policy support and consumers' purchase on NEVs is common in many economies of APEC. According to the experience of NEV application, economic viability and a successful introduction of alternative propulsion systems will mainly depend on economic aspects such as relative average costs in comparison to internal combustion engines. As a kind of newly emerged vehicles, NEV industry need strong support from the perspective of government policies, such as R&D support, consumer subsidy, tax preference et al. In recent decades, more and more policy instruments have been introduced to promote NEV industry in APEC economies.

This section starts with a review of the main policy instrument which are applied in NEV industry and NEV consumption; and then moves on to a brief summary of policy frameworks influencing customer preference for NEVs and NEV industry development.

3.1 Policy Summary

3.1.1 Australia

Australia does not currently have an economy-wide electric vehicle policy framework and there is limited overall support and incentives in comparison to our global peers. There has been policy activity at a state and local government level, however overall policy has been limited to modest registration discounts and partial support for public charging. The table below outlines current electric vehicle policy support measures in Australian states and local governments.

For example, the South Australia government is aiming to see an increase in the number of 'stand-alone' hybrid electric vehicles and plug-in electric vehicles registered in South Australia.

In partnership with Adelaide City Council, installing Adelaide's first 'smart' electric vehicle recharging bollards in the Adelaide Central Market carpark. What's more, the

South Australia government is establishing Australia's first grant program for electric vehicle recharging stations, and purchasing two of the first volume production electric vehicles to be released in Australia – the Mitsubishi i MiEV – to use in the Government fleet.

Table 3-1 Current EV policy support measures in Australian state and local governments

Policy Type	QLD	NSW	SA	VIC	ACT	WA	Score
Direct Vehicle Incentive	✗	✗	✗	✗	✗	✗	0
Charging Infrastructure Support	✓	✓	✓	✗	✗	✗	3
Registration Incentives	✓	✓	✗	✓	✓	✗	4
Stamp Duty Discounts	✓	✗	✗	✗	✓	✗	2
Government Fleet Incentives	✗	✗	✗	✗	✗	✗	0
Vehicle Lane Privileges	✗	✗	✗	✗	✗	✗	0
Toll Lane Exemption	✗	✗	✗	✗	✗	✗	0
Discounted Parking	✓	✗	✓	✓	✗	✓	2
Free Charging	✓	✓	✓	✓	✗	✓	5
Score	5	3	3	3	2	2	-

Source: Energeia (2016)

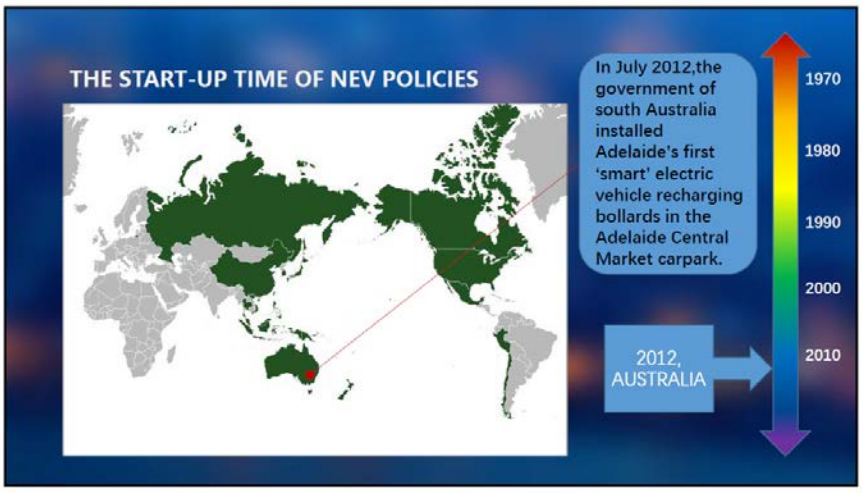

Figure 3-1 the NEV policy briefing for Australia

3.1.2 Canada

Canada has made good effort to promote NEV development. For example, the 2010 Natural Resources Canada Roadmap sets vision of 500,000 EVs by 2018. The Automotive Innovation Fund was renewed for a second round of $250 million over 5years. In the first round, $70.8 million went to Toyota in part to develop EVs for the

Canadian marketplace. Sustainable Development Technology Canada funding EV related projects such as the LaCima Corp. ultracapacitor technology and the TM4 Inc. electric propulsion system.

In the provinces of Canada, there are some different policies to improve electric vehicles such as purchase price offs, building new charging stations, equipping parking lots with charging infrastructures, green license plate for electric cars, funds for R&D, improving electric capacity for electric vehicles, and so on.

For example, The Government of Ontario has set out a vision for 5% EVs by 2020. They set a Vehicle purchase incentive program (up to $8,500), gave green license plate to electric cars to grant single occupant Evs can access to the high occupancy lanes on Ontario's 400 series highways, announced that 20% of new Ontario Public Service passenger vehicle purchases will be electric by 2020, and targeted R&D funding through the Next Generation Jobs Fund.

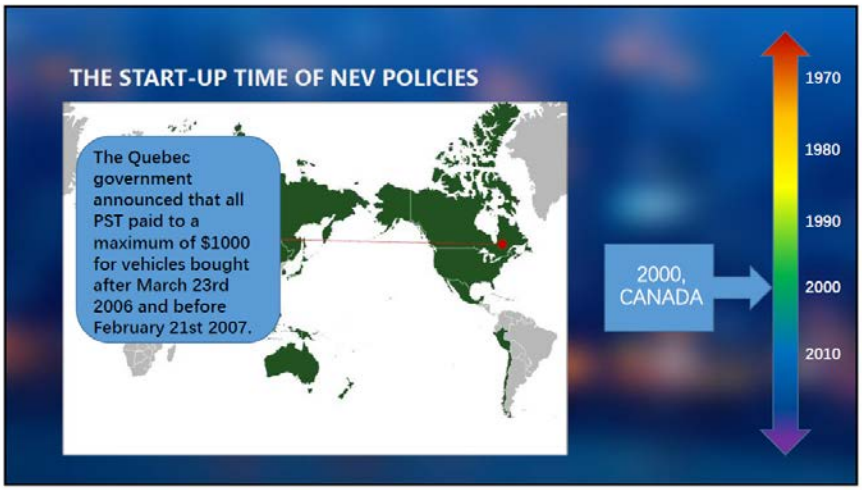

Figure 3-2 the NEV policy briefing for Canada

3.1.3 People's Republic of China

Since NEVs are not only eco-friendly means of transportation, but also crucial to the energy security of China, the Chinese government has been making great efforts to introduce and promote NEVs. China has set the target of having more than 500,000 battery-electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs) on the road by

2015 and 5 million by 2020. Various efforts have been initiated to encourage their production and adoption, which include providing financial supports for NEV production companies, issuing marketing promotion policies, conducting market demonstrations of NEVs, and enhancing the construction of infrastructural facilities. For the basic research, the 863 Program, the Ministry of Science and Technology's key program for the promotion of strategic R&D, identified NEVs among its priority areas and began to finance projects in this area. During the following 10 years, the 863 Program provided a total of 2 billion yuan to support the research efforts of Chinese car manufacturers, universities, and research institutes. For the NEV manufacture, the central government aims to establish one or two auto-manufacturers with the production capability of more than 1 million NEVs per year, and three to five auto-manufacturers of more than 50,000 per year.

Also many pilot projects have been lunched to promote NEVs. On January 24th, 2009, the Chinese central government initiated the "Ten Cities, Thousand Vehicles Program" (hereafter referred to as 'the program') to stimulate the adoption of NEVs. Beijing, Shanghai, Chongqing, Changchun, Dalian, Hangzhou, Ji'nan, Wuhan, Shenzhen, Hefei, Changsha, Kunming and Nanchang were selected as the cities for the demonstration and promotion of NEVs. Each city was challenged to roll out pilots of at least 1000 NEVs. In July 2010, the pilot cities of NEV demonstration were increased to 30; and the program was further expanded from focusing on government fleet applications to including private consumers in Shanghai, Changchun, Shenzhen, Hangzhou, and Hefei.

Additionally, the economic means is very common in the policies of Chinese central government and local governments. The policies state that the Chinese central government will pay a subsidy of up to 50,000 yuan to any consumer who purchases a plug-in hybrid vehicle (PHEV) and 60,000 yuan for an all-electric, or battery-electric vehicle (BEV). The subsidies for consumers are enhanced by additional subsidies from local government. For example, in Beijing and Shenzhen, NEV buyers can claim additional subsidies of RMB 60,000 for BEVs; and in Shanghai RMB 40,000–50,000 for

NEVs are being offered.

According to the "China New Energy Vehicle Development Project" issued in July 2011 (hereafter referred to as the project), the Ministry of Finance will grant a total of RMB 100 billion to support the development of the NEV industry from 2011 to 2020. Specifically, 50 billion yuan will be invested to assist in the research and industrialization of key technologies of NEVs; 30 billion will be given to stimulate the demonstration and consumption of NEVs.

The incentive policies for NEVs in China are generous and could substantially reduce the incremental cost of purchasing a NEV. According to the statistics from the Ministry of Finance, the planned subsidy budget for NEV purchase was 5 billion yuan.

Figure 3-3 the NEV policy briefing for P. R. China

3.1.4 Japan

The whole chain of Japanese government support, including the context in which these different policies have been implemented since the early 1970s, is studied. The Japanese Government has adopted a comprehensive strategy including R&D, demonstration programs and market support guided by long-term strategic plans. The role of the Government has been that of a conductor in the development process supplying both R&D support and artificially created niche markets, and easing the way for targeted technologies by means of legislation and standards.

The government set a target, in 2020, the next generation vehicles (NEVs) should make up for 50%. In 2030 the proportion will be 70%.

(1) R&D support

The MITI has promoted electric vehicles (BPEVs) since 1971, launching a 5-year government-industry R&D programme. The MITI also funded company R&D between 1978 and 1996 supporting leasing projects.

In 1995 BPEV field tests were launched by the MITI but these were replaced by several BPEV-ITS programmes starting in 1998, demonstrating the feasibility of BPEVs in combination with Intelligent Transportation Systems (ITS).

Under the New Sunshine Programme, 7 R&D on polymer electrolyte fuel cells (PEMFC) has been undertaken since 1992. Research is also conducted under the same programme on lithium batteries (through the organization LIBES) since 1992. The aim was to develop both stationary and vehicle applications of the next generation of batteries based on lithium. In 1997 the MITI initiated the Advanced Clean Energy (ACE) vehicle programme. This is an R&D programme extending from 1997 to 2003 with the objective of developing different high-energy efficient hybrid vehicles.

The MITI funded programmes are usually long (4-10years) and divided into three phases starting with (i) R&D on basic technologies, then (ii) demonstration and prototype, and the last phase (iii) production and early deployment. All three phases receive government funding. However, companies and other interested parties are expected to increase their share of responsibility as the technology comes closer to commercialization. Generally, the MITI funds company research on technologies that are in the public interest with 100% funding at the early stage of development and between 50 and 67% as the technology comes closer to commercialization. Standardization projects receive 100% funding from the MITI.

(2) Support for infrastructure

The ECO-Station Project, was initiated in 1993 with the aim of establishing 2000 fuelling stations for clean-energy vehicles by the year 2000. Approximately 50% of these

were intended as BPEV charging stations. Quick-charging facilities for BPEVs with nighttime energy storage systems for load levelling were targeted.

(3) Market support

From 1978 to 1996 the JEVA conducted various leasing and purchasing incentive programmes. These programmes included relief from commodity and acquisition tax in 1975 and 1976, leasing services directed towards private enterprises, the collection of field data for further research, feasibility studies and subsidies to local governments to buy BPEVs.

In 1996, an BPEV Purchasing Incentive Programme was introduced which replaced existing leasing and purchasing incentive programmes that had been in operation since 1976. Fifty percent of the extra incremental vehicle price was subsidized.

When it comes to direct market support, the MITI takes half of the financial risk of a new technology, e.g. subsidizes half of the extra cost compared to a comparable ICEV. Local governments and other agencies can supply further funding within their area jurisdiction. A government program has allowed for a one-time bonus for EVs and other qualified fuel-efficient vehicles since 2009. The program was extended to 2013 with adjustment, and provides a bonus based on the price difference between the EV and a comparable gasoline car. The bonus is capped at 850,000 JPY (about 6,300 EUR).

Within the framework of the Millennium Project the JARI and the NEDO are conducting a standardization project especially targeting future fuel cell vehicles The programe is planned to end in 2005 when a viable fuel cell vehicle market has hopefully been established.

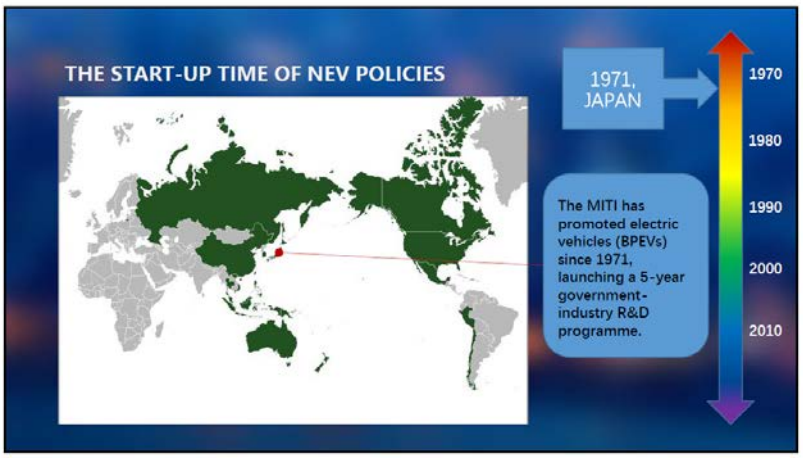

Figure 3-4 the NEV policy briefing for Japan

3.1.5 Republic of Korea

The project for the development of electric vehicles prototypes has been supported by the government and core parts such as motors, inverters and batteries have been developed by parts manufacturers since December 1992 in Republic of Korea.

The policy "Entering the four Great Green Car Powers by 2013" was established in October 2009 to encourage the development of electric vehicles and opened the door to greater commercialization.

In December 2010, government announced a plan for improving the competitive power of electric vehicles by 2015 through the "Green Car Roadmap". The roadmap leads a project to develop a semi-medium sized electric vehicle to be commercialized in 2015. A total of 44 institutes including Hyundai Motor are participating in this project, and government is contributing over 70 billion KRW.

The "Development of a new hybrid powertrain system and control technology" became the driving force of the technology development program, the "Development of a high power lithium secondary battery for hybrid vehicle" pushed development of the next generation battery program from September 2009, and the "Development of the technology for plug-in hybrid electric vehicles" prompted the strategy technology development program from 2007.

Korea Electric Power Co. (KEPCO) set up an electric vehicle charging tariff in June 2010 that can provide almost the same price as the prime cost of electricity to the charging provider and the charging provider gives the service to customers with a tariff subsidize the initial charger installation cost and operation fee.

The Automotive Management Act certified low-speed electric vehicles from March 30, 2010, and the laws and regulations necessary to drive such as assigning driving zones, the design of road signs, and the safety standards of this type of vehicle were also completed.

On April 16th, 2012, government announced a plan to commercialize 2,500 electric vehicles by 2012 through the "Ceremony of Electric Vehicle Commercialization 2012" and confirmed the sales price, subsidy and funding for the infrastructure to support the operation of electric vehicles. In terms of the sales price of the high speed and the light weight electric vehicles, Ray EV (Kia Motor Co.) was supported by a subsidy of $1,364 (1$=1,100KRW) and support for the charging infrastructure of $800. The sales price of the low speed electric vehicle was supported by a subsidy of $1,909 and support for a charging infrastructure of $525. In addition, a tax cut of up to $3,818 for costs such as individual consumption, acquisition, and education was provided.

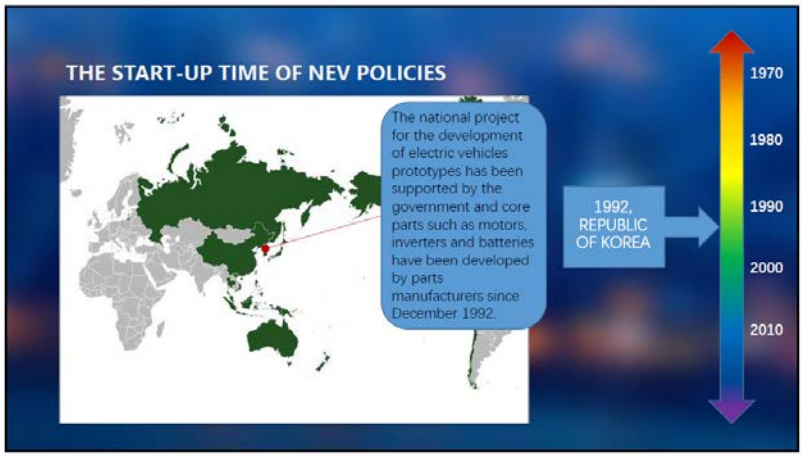

Figure 3-5 the NEV policy briefing for Republic of Korea

3.1.6 New Zealand

The New Zealand Government, together with industry and local government, has set a target of doubling the number of electric vehicles in New Zealand every year, to reach approximately 64,000 by 2021. This is about two percent of New Zealand's current light vehicle fleet.

The Government's Electric Vehicles Programme has several key elements:

- Extending the Road User Charges exemption for light electric vehicles: providing an exemption from Road User Charges (RUC) is a way to encourage the switch to electric vehicles. The value of the exemption to the typical vehicle owner is about $600 per year. Operators of light electric vehicles are estimated to receive road user charges exemptions valued at approximately $36 million by 2021.
- Introducing a new Road User Charges exemption for heavy electric vehicles: The value of this exemption varies depending on the weight of the vehicle, and distance travelled per year, but will be higher than for light electric vehicles.
- Work across Government and the private sector to investigate bulk purchasing : The Government has directed the Ministry of Business, Innovation and employment to investigate coordinated bulk purchase of electric vehicles across public and private sector fleets.
- Support the development and roll-out of public charging infrastructure.
- A economy-wide electric vehicle information and promotion campaign: The Energy Efficiency and Conservation Authority will lead an information and promotion campaign over the next five years. $1 million per year will be spent on the campaign.
- A contestable fund of up to $6 million per year to support innovation.
- Enabling electric vehicles to access bus and high occupancy vehicle lanes.
- Review of tax depreciation rates and the method for calculating fringe benefit tax for electric vehicles.
- Review ACC levies for plug-in hybrid electric vehicles.

- Establishment of an Electric Vehicles Leadership Group.

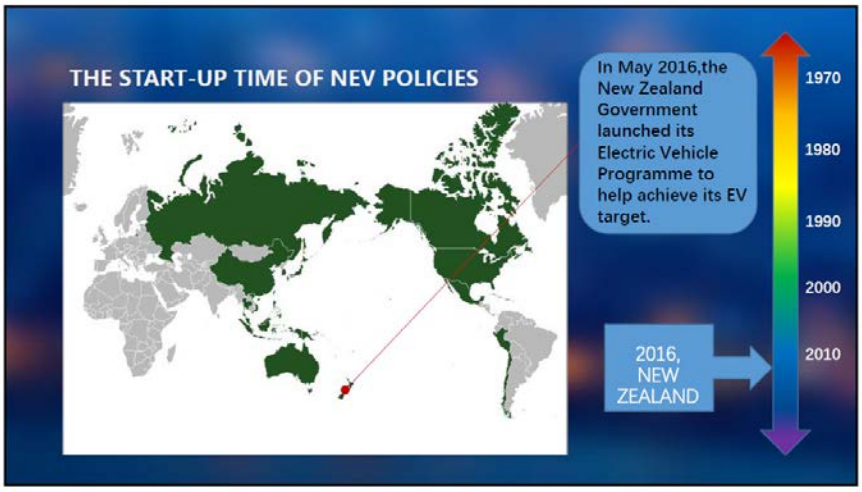

Figure 3-6 the NEV policy briefing for New Zealand

3.1.7 Singapore

To encourage green vehicles, Singapore has introduced a green vehicle rebate (GVR) scheme in 2001 which offers an offset on the registration fees for green vehicles. Recent upgrade of the GVR scheme allows a rebate equivalent to 40% of vehicle's open market value (OMV) for electric, petrol–electric hybrid, CNG, bi-fuel (CNG/petrol) passenger cars, 5% of OMV for buses and commercial vehicles with the same fuel type, and 10% of OMV for electric motorcycles. The number of green vehicles increased from a mere 713 in 2006 to 4582 in 2009, of which 30 are buses and 1859 were taxis.

Singapore, in June 2010, initiated a project to invest 20 million dollars in setting up a comprehensive network of recharging points, and to provide subsidies for the purchase of electric vehicles. The primary goal of local government is to attract the electric car industry to Singapore.

In June 2011, the government announced the launch of the electric vehicle test-bed in Singapore.

In December 2014, the government announced plans to trial an electric vehicle (EV) car-sharing programme which will see the introduction of up to 1,000 EVs and the charging infrastructure to support their use. Some 2,000 charging points will be set up

here for an islandwide electric vehicle car-sharing programme started in May 2016.

Singapore will launch an electric vehicle (EV) car-sharing programme in collaboration with Bolloré Group by mid-2017. EVs will be deployed in every single Housing & Development Board (HDB) town by 2020, to allow as many residents as possible to enjoy car-sharing facilities.

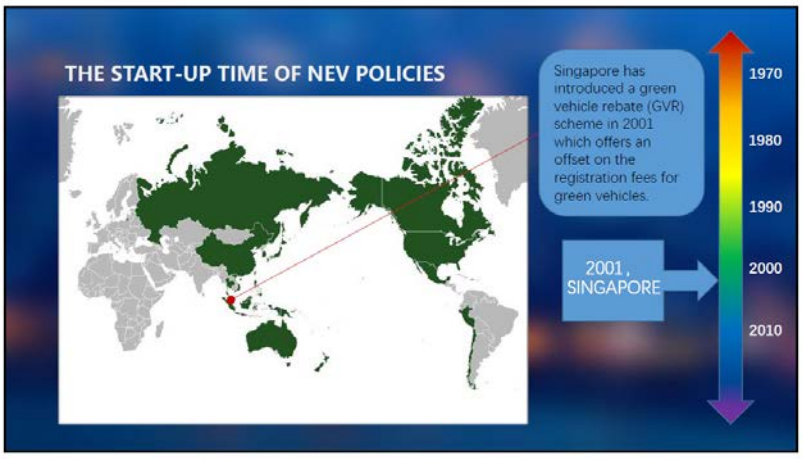

Figure 3-7 the NEV policy briefing for Singapore

3.1.8 United States

In the United States, the federal government has set some federal incentive policies towards electric vehicles such as federal purchase incentive and federal charging infrastructure tax credit. To incent purchasing, the government set that BEV and PHEV cars purchased in or after 2010 are eligible for a federal income tax credit of up to $7,500. The credit varies based on the battery used to power the vehicle (kWh), and will begin to phase out to 50% of the full credit amount once a manufacturer has reached 200,000 PHEVs and BEVs sold. The federal charging infrastructure tax credit which was announced in the Fixing America's Surface Transportation (FAST) Act reauthorized the tax credit for EV charging supply equipment until 12/31/16. If the charging station is considered personal property, the tax credit is the smaller of 30% of the station's cost or $1k; if the charging station is considered business property, the credit is worth the smaller of 30% of the station's cost or $30k.

In 2010, President Obama announced the plan of the "next generation electric vehicle", which aimed to fund $1.5 billion to manufacturers to produce high efficiency batteries and their components. The plan was also to provide $500 million to produce other components needed for EVs, such as electric motors and other key components. Indeed, the United States has set itself the goal of having 1000,000 hybrid electric vehicles in 2015.

There are additional state level policies, such as access to the HOV lane, sales tax exemptions, registration incentives, insurance discounts and parking incentives. Most of the states has announced their own policies of state level.

The Zero-Emission Mandate: Special provisions in the Clean Air Act (Section 177) allow states to either follow the federal requirements for vehicle emission regulations, or to adopt those of California. Nine states have adopted the California regulation: Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont – also known as the "ZEV Mandate States". In 2012, California adopted its most recent regulations, requiring that 15 percent of new vehicle sales in 2025 be zero-emission vehicles (ZEVs). These regulations apply to the 9 states that have also adopted the CA regulations.

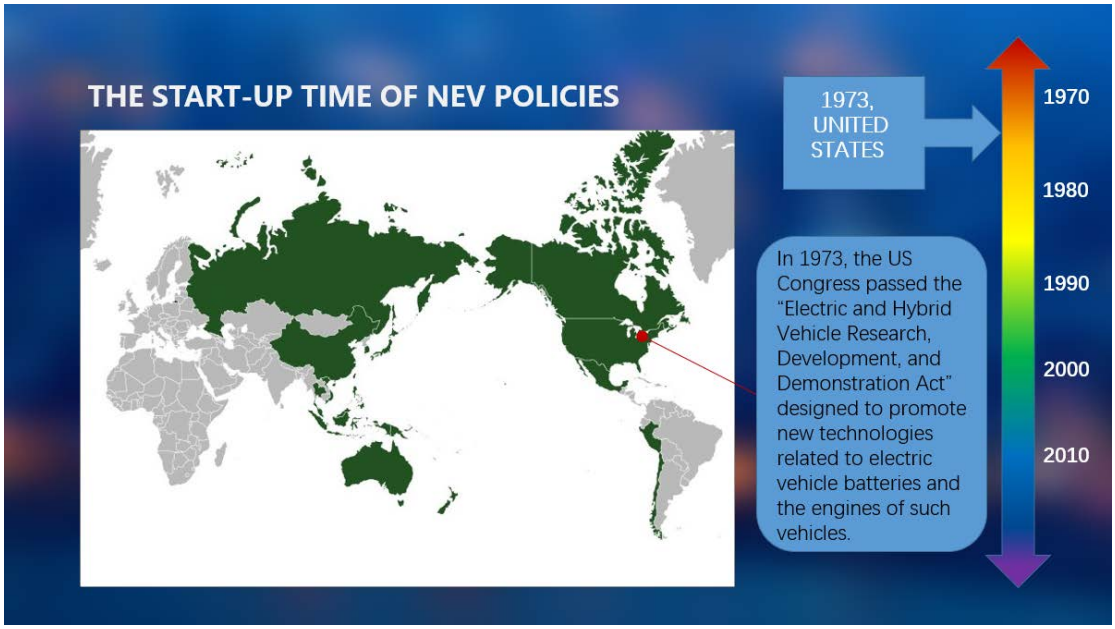

Figure 3-8 the NEV policy briefing for the United States

3.2 Policy Analysis

3.2.1 People's Republic of China

Since 2009, Chinese government has published 39 policies in total, which is less than American policy number. What's more, the publish density of the policies in each year is pretty high.

Among these policies, above half of them were promoting policies, which means the government is highly concentrated on the environment of EV development.

The proportion of laws and regulations achieves 21%, which is the highest among all the economies. It shows that the government is paying high attention to the regulations of EV market.

R&D supporting policies account for 15%, and all of them were released between 2015 and 2016. It means the government was trying to change the strategy in EV development in recent years, and it was gradually turning its focus from the market to R&D.

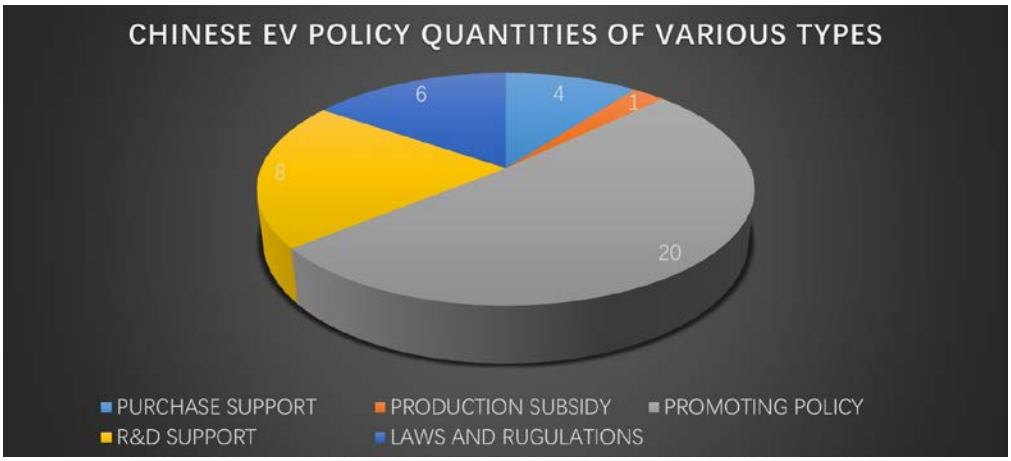

Figure 3-9 the NEV policy variety of People's Republic of China

3.2.2 Japan

Japanese government was highly concentrated on the promotion of NEV, on this purpose, 57% of the policies it issues belong to the promoting type.

Japan has paid a lot of attention to the R&D of NEV technology. This phenomenon was related to the maturity of Japanese NEV technology. Thanks to this advantage, NEV is one of the main export productions of Japan now.

At the same time of paying efforts to prompt NEV, the Japanese government didn't pay as much attention to the domestic purchase and sales.

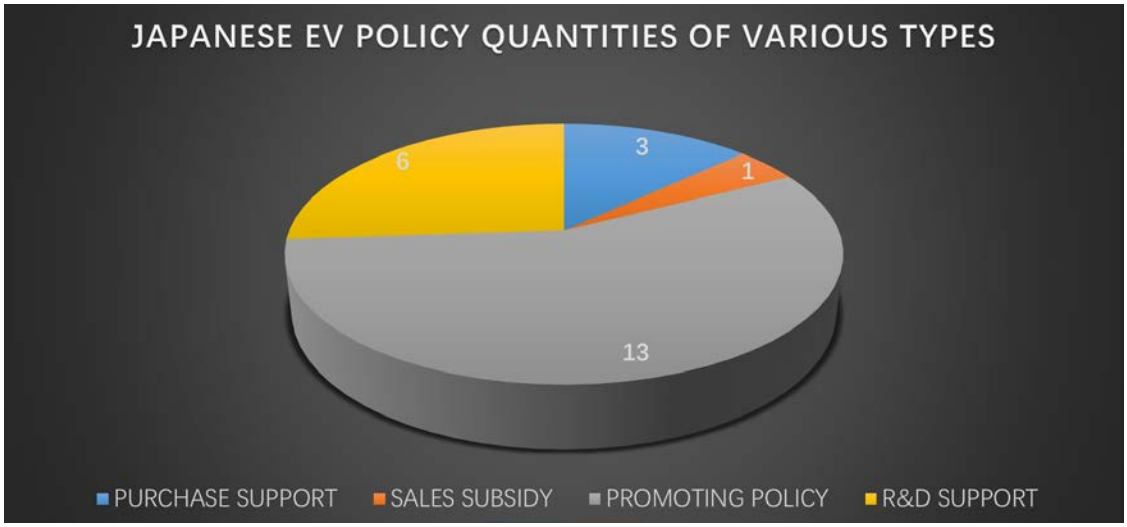

Figure 3-10 the NEV policy variety of Japan

3.2.3 Republic of Korea

The government of Korea was mainly concentrated on the R&D of the core parts in EV, and it supported research project for the development of the NEV prototypes. About a half of the policies were concerning R&D. However, all the policies were released before 2010, the efforts of NEV development were gradually decreasing in recent years.

Besides the R&D policies, the government was also concentrated on the EV promotion, purchase and regulations.

In recent years, Republic of Korea issued only a small scale of policies, the upgrading speed has witnessed an obviously shrink.

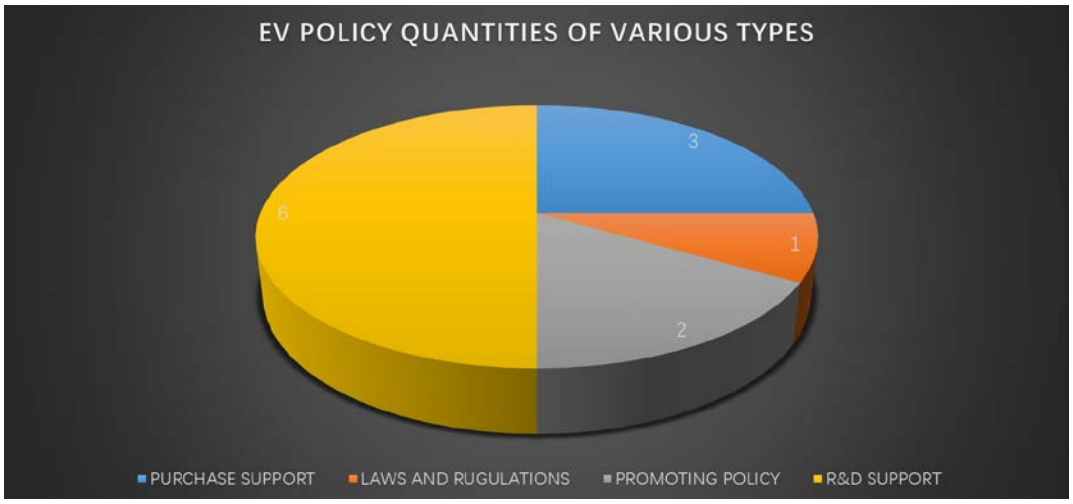

Figure 3-11 the NEV policy variety of Republic of Korea

3.2.4 United States

From 2000, the United States government, along with the state governments, has issued a large number of policies to promote the NEV development, which were updated rapidly and covered a large geographical range.

Most of the policies were issued to provide support for NEV purchase and using convenience, which account for almost 80%. There are only 5 policies that could be divided into R&D support, which seems to be a small quantity. What's more, 4 of the 5 policies were issued after 2007, which shows the United States government was paying more attention to R&D nowadays.

To exert an efficient management on NEV, there are 12 states which have begun to charge a small account of NEV registration fee. This also shows, in another way, that the NEV quantity in the United States has achieved a considerable scale, which needs special management.

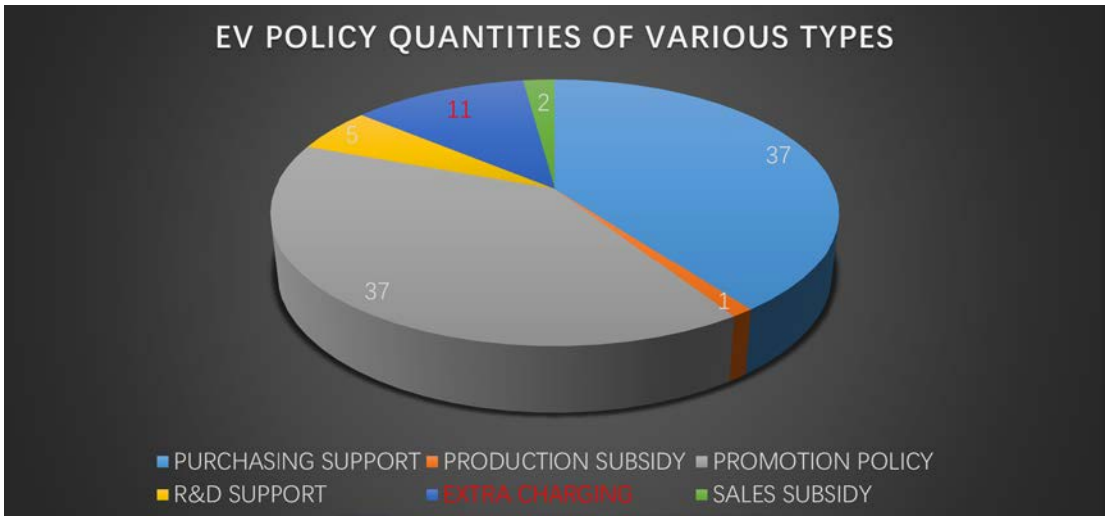

Figure 3-12 the NEV policy variety of the United States

3.2.5 Policy quantity and EV stock

If we compared the NEV quantity to the NEV policy quantity of each economy, we can get a chart, which shows some relations between the policy quantity and the vehicle quantity.

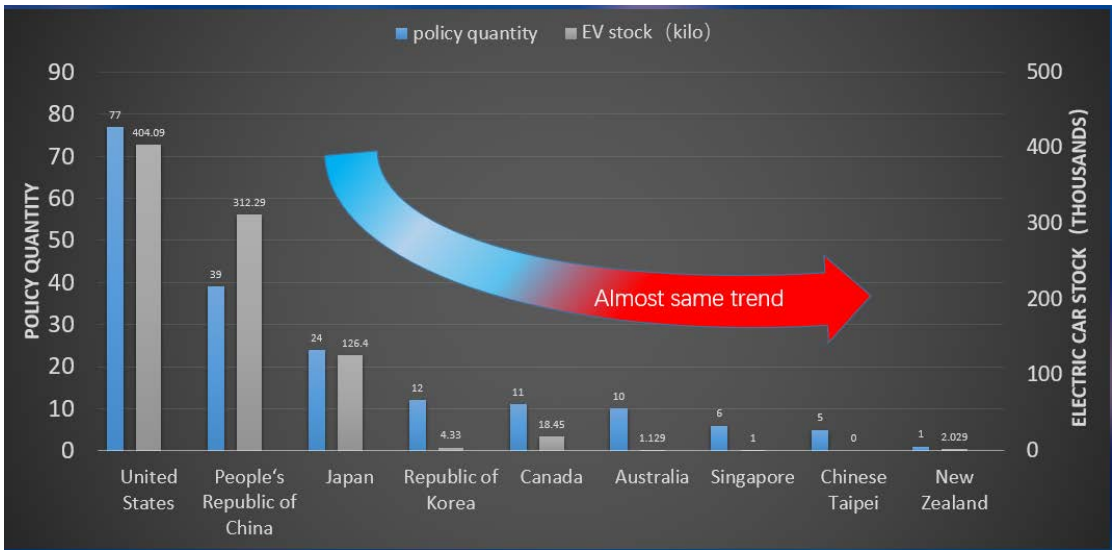

Figure 3-13 the relation between the NEV policy and NEV stock

We could draw a conclusion that the more promoting policies a economy has published, which means more emphasis on the development of the electric vehicle industry, the easier it is to expand the number of electric vehicles. The reasons are as follows:

(1) The economies developed electric vehicle in advance (such as the United States and Japan), which have long periods of accumulation, could achieve considerable scale of EV quantity.

(2) The EV policies with a wide geographical coverage, makes the EV development more completed. For example, the United States has released more than 60 state-level EV policies, almost covered all the states.

(3) High density of EV policies. For example, China has released 39 policies since 2009. These efforts are inextricably linked to the significant increase in the number of electric vehicles in China.

4 EVALUATING THE EFFECTIVENESS OF NEV POLICY

According to the literature review of NEV policy, many economies from APEC, such as China; Japan; and the United States, have set up goals and made good effort to develop NEVs. Nowadays, many researches have carried out to promoting the technology of NEVs. Nevertheless, as a new breeding industry, the development of NEVs depends on the support of government greatly. For example, in China, the production and sales of NEVs are influenced significantly by government policy. However, there is still a huge gap between China's NEV industry and that of other economies on technology development, talent reserves and industrial cooperation.

Besides the NEV technology, previous research also focused on the policy instruments of NEV industry. According to the literature review, policy guidance and planning played a vital role to the growth of NEV industry (Yuan et al., 2015). Stimulated by the policy shift, electric vehicle production has increased considerably, thereby contributing respectively 23% and 44% of the total NEV production in 2010 and 2011 (Gong et al., 2013). Nevertheless, the NEV industry faces significant challenges related to industrial chain, social factors and technologies. The Japanese Government has adopted a comprehensive strategy including R&D, demonstration program and market support guided by long-term strategic plans. The results show that flexibility, adaptability and cooperation in terms of technical choice is necessary in policy. Three alternative policy support measures, namely an up-front price support, a CO2-tax, and an increase in the fuel consumption tax for ICE (internal combustion engines) could promote NEVs, and NEVs will be cost-competitive with ICE if projected production volumes and thus economies of scale are reached (Gass et al., 2014). Except these alternative policy support measures, market support, even in the early phases of development, is an important complement to R&D for gaining experience and building markets (Ahman, 2006). Policy intending to give NEVs a foothold in the market should not only focus on mainstream consumers but also should focus on niche markets—specially car-sharing and postal fleets—and early adopters including green consumers (Green et al., 2014). In China, marketing strategy of enterprise and consumer

behavior is influenced profoundly by government policy (Zhang et al., 2013). Meanwhile, government policy has a positive adjustment function in NEVs economic benefits, consumer's purchase intentions and acceptable price. It further enhances consumer environmental protection spirit and meets their psychology needs. Government incentive policy, especially monetary incentives, imposes marked influence on the sales of NEVs. New technology developed by enterprises and research institutions under the encouragement of government could effectively reduce the cost of NEVs and make it more attractive (Liu and Kokko, 2013). The consumers' willingness to buy NEVs and the purchase time is deeply affected by government policy (Zhang et al., 2011).

The mentioned research mainly examined the effect of government policy through NEV industry and consumer's perspective. However, it is important to analyze the effect of policy on NEV industry in the perspective of macro analysis of policy itself. With the aim of studying the effectiveness of policy instruments on NEV industry, and analyzing the improvements for the policy efficiency of NEV development, this research proposes an evaluation framework for NEV policy based on consistent fuzzy preference relations (CFPR). A case study of Chinese NEV policy evaluation is performed to verify the proposed method. The results are hoped to give a better understanding of NEV policy efficiency and policy measures for NEV development. The remaining part of the research is organized as follows. Section 2 will introduce the consistent fuzzy preference relation as the evaluating method. Section 3 will propose the evaluating criteria for NEV policy efficiency. Then a case study in China is conducted to verify and validate the evaluating index and method. Some conclusions and future works will be discussed in the last section.

4.1 Consistent fuzzy preference relations

Saaty (1980) proposed the analytic hierarchy process (AHP) for solving multi-criteria decision problems, which included many comparisons of criteria. In AHP, a questionnaire needs to contain questions for every grouped n-criterion pairwise comparison. However, if the n increases or such n-criterion group increases, the number of pairwise comparison increases. It may cause experts mental fatigue or inconsistent

situations due to so many questions and comparisons. In the case of inconsistencies, questionnaires have to be refilled again, which results in inefficiency and the waste of time.

Consistent fuzzy preference relations (CFPR) can avoid the aforementioned problem effectively. CFPR is used to establish the pairwise comparison matrices and construct the decision matrices of pairwise comparisons using additive transitivity. Experts only need to answer n-1 comparisons. The remaining $(n\text{-}1)(n/2\text{-}1)$ values of pairwise comparisons of each n-criterion can be derived by using CFPR method, which only involves simple calculations and the procedure guarantees a consistent result in comparisons.

4.1.1 Preference relations

Preference relations (PR) enable experts to give values for a set of criteria and a set of alternatives. The value expresses the preference degree of the first alternative over the second alternative. Fundamentally, two kinds of preference relations are applied in the decision-making problems: multiplicative preference relations and fuzzy preference relations.

Multiplicative preference relations (Chiclana et al., 1998): A multiplicative preference relation A on a set of alternatives X is represented by a matrix A. A can be obtained by

$$A \subseteq X \times X, A = (a_{ij}), \quad \forall i, j \in \{1, \ldots, n\} \tag{1}$$

where a_{ij} is the preference ratio of alternative x_i over x_j. Saaty suggests measuring a_{ij} using a ratio scale from 1 to 9 scales (Saaty, 1980). When $a_{ij} = 1$ means the indifference between x_i and x_j; $a_{ij} = 9$ represents that x_i is absolutely preferred to x_j; $a_{ij} > 1$ denotes that x_i is preferred to x_j. The preference relation A is typically assumed to be a multiplicative reciprocal, given by

$$a_{ij} \cdot a_{ji} = 1, \quad \forall i, j \in \{1, \ldots, n\} \tag{2}$$

Fuzzy preference relations (Chiclana et al., 1998): a fuzzy preference relation P on a

set of alternatives X is a fuzzy set that denoted by the product set $X \times X$ with a membership function

$$\mu_p : X \times X \to [0,1] \tag{3}$$

The preference relation is represented by the $n \times n$ matrix, where $p_{ij} = \mu_p(x_i, x_j)\ \forall i, j \in \{1,\ldots,n\}$. Herein, p_{ij} indicates the fuzzy preference ratio of alternative x_i to x_j when $p_{ij} = 1/2$ indicates that no difference exists between x_i and x_j , $p_{ij} = 1$ means that x_i is absolutely preferred to x_j , and $p_{ij} > 1/2$ implies that x_i is preferred to x_j . In this case, the fuzzy preference matrix P is usually assumed to be an additive reciprocal, that is,

$$p_{ij} + p_{ji} = 1, \qquad \forall i, j \in \{1,\ldots,n\} \tag{4}$$

However, inconsistency may exist in traditional decision matrices. To solve this problem, Herrera-Viedma proposed the consistent fuzzy preference relations (CFPR) used to construct the decision matrices of pairwise comparisons based on additive transitivity (Herrera-Viedma et al., 2004). Three important propositions in CFPR are described as follows.

4.1.2 Consistent fuzzy preference relations

Proposition 1. Suppose a set of alternatives, $X = \{x_1,\ldots,x_n\}$, associated with a reciprocal multiplicative fuzzy preference relation $A = (a_{ij})$ with $a_{ij} \in [1/9, 9]$. Then, the corresponding reciprocal fuzzy preference relation, $P = (p_{ij})$ with $p_{ij} \in [0,1]$ associated with A is defined as $P = g(A)$, i.e.,

$$p_{ij} = g(a_{ij}) = \frac{1}{2}(1 + \log_9 a_{ij}) \tag{5}$$

where *g(*)* is a transformation function which transforms a reciprocal multiplicative preference relation matrix into preference relation. $\log_9 a_{ij}$ is considered because a_{ij} is between $1/9$ and 9. When a_{ij} is between $1/5$ and 5, $\log_5 a_{ij}$ is used.

Proposition 2. For a reciprocal fuzzy preference relation $P = g(A)$, where $P = (p_{ij})$, the following statements are equivalent;

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2}, \qquad \forall i, j, k \tag{6}$$

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2}, \qquad \forall i < j < k \tag{7}$$

Proposition 3. For a reciprocal fuzzy preference relation, $P = (p_{ij})$, the following statements are equivalent.

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2}, \qquad \forall i < j < k \tag{8}$$

$$p_{i(i+1)} + p_{(i+1)(i+2)} + \cdots + p_{(j-1)j} + p_{ji} = \frac{j-i+1}{2}, \qquad \forall i < j \tag{9}$$

By **Proposition 3,** we can structure a consistent fuzzy preference relation P on $X = \{x_1, x_2, \ldots, x_n, n \geq 2\}$ from n-1 preference values $\{p_{12}, p_{23}, \ldots, p_{(n-1)n}\}$.

A decision matrix with values not in the interval [0, 1], but in an interval [-k, 1+k], k>0, can convert the obtained values with a transformation function that preserves reciprocity and additive consistency. The transformation function f(x) is given by the following steps (Herrera-Viedma et al., 2004):

Step 1 compute the set of preference values B as

$$B = \{p_{ij}, i < j \wedge p_{ij} \notin \{p_{12}, p_{23}, \ldots, p_{(n-1)n}\}\}$$

$$p_{ij} = \frac{j-i+1}{2} - p_{i(i+1)} - p_{(i+1)(i+2)} - \cdots - p_{(j-1)j}$$

Step 2 compute value k

$$k = \left|\min\{B \cup \{p_{12}, p_{23}, \ldots, p_{(n-1)n}\}\}\right|$$

Step 3

$$p = \{p_{12}, \ldots, p_{(n-1)n}\} \cup B \cup \{1 - p_{12}, \ldots, 1 - p_{(n-1)n}\} \cup \neg \mathrm{B}$$

Step 4 the transformation function f(x) is

$$f : [-k, 1+k] \to [0,1],\ f(x) = \frac{x+k}{1+2k}, k > 0$$

4.1.3 Evaluation of the weights of criteria

After the fuzzy preference relation matrices, $P=(p_{ij})$, of pairwise comparisons is constructed, the weight of each factor is ready for calculation. The average preference, f_i, of each criterion in main criteria can be computed by the following

$$f_i = \frac{1}{n}\sum_{j=1}^{n} p_{ij} \tag{10}$$

where p_{ij} is the value in the preference relation matrix *P* and *n* is the number of criteria. The weight w of each criterion can be defined as follows

$$w_i = \frac{f_i}{\sum_{i=1}^{n} f_i} \tag{11}$$

4.1.4 Method discussions

The CFPR method in AHP hierarchy is more convenient than the traditional AHP method. Firstly, it is easier to compute the relative weights of each main criteria and sub-criteria using CFPR method. The CFPR method does not need to consider any complex integration, differentiation or simultaneous equations. Secondly, the CFPR process enables researchers to effectively reduce the pairwise comparison frequency. For instance, the CFPR method only needs to perform 2+7+5+4=18 pairwise comparisons, whereas the AHP method must perform $C_2^3 + C_2^8 + C_2^6 + C_2^5 = 56$ pairwise comparisons. And obviously the CFPR method spends less time in comparison than the AHP method. Thirdly, the CFPR method ensures consistency. Inconsistency always occurs in comparison with traditional AHP if each group has a number of criteria to compare. Nevertheless, the consistency of decision matrices can be guaranteed by CFPR.

4.2 Criteria for Evaluating NEV Policy

New energy vehicle policy, as the public policy, is a crucial process to design the evaluation system of NEVs policy. The NEVs policy is a complex system; and a large

number of factors need to be considered before the evaluation. Whether the evaluation system is reasonable or not will determine the result of the evaluation directly. In the premise of following the principle of comprehensiveness, comparability, independence, guidance and quantification, great attention is paid to guarantee the clarity of the criteria selection and the gradation of the criteria structure, and establish perfect, scientific and reasonable evaluation system. According to the general procedure of public policy making such as policy formulation and implementation, NEVs policy evaluation criteria system is established. It contains the following three aspects: NEV industry development criterion, NEVs technology research and development criterion, as well as NEVs application and popularization criterion.

The Criterion A (NEV industry development criterion) mainly focuses on industry development policy, which is the base of NEV industry development. The scientific, feasibility and comprehensiveness of industry development policy provides a good condition for the healthy development of NEV industry. The Criterion A contains eight sub-criteria as follows. The standard system includes battery specification, charging station (pile), standards of charging facilities, standard of key components, etc. The access system supports social capital and companies with technology innovation capability to develop and manufacture NEVs (Brown et al., 2010). Industry development roadmap provides a development orientation for NEV industry. Industrial R&D subsidy is necessary to supply the effective capital support for companies and is significantly and positively correlated to an economy's NEVs market share (Sierzchula et al., 2014). NEV infrastructures contain charging station, charging pile, parking lot, etc. Infrastructures are very important for the development of NEV industry because NEVs industrialization needs the support of infrastructure.

The Criterion B (NEVs technology research and development criterion) is pertaining to the core technology of NEVs. The core technology of NEVs, including the technology of key parts and the technology of related infrastructure, is a vital factor that constrains the development of the NEVs market. Only technical breakthroughs can drive ordinary consumers to purchase NEVs. The Criterion B has six sub-criteria

demonstrated as follows. Charging station (pile) is the charging place for NEVs when the battery power is low. The charging time in express charge mode and slow charge mode are two of the most important factors influencing consumers' decision to buy NEVs. Battery technology determines battery energy storage ability and service life which affects NEVs mileage. About the NEV power system, there are several factors should be taken in consideration, e.g. the type of NEVs, charging time, charging characteristic and charging mode. With the development of NEV technology, it is necessary to establish a convenient integration power system to efficiently manage power supply process in generation, transmission, distribution. Therefore, other new technology, such as intelligent transportation technology, connected vehicle, also plays an important role in the development of NEV industry.

The Criterion C (NEVs application and popularization criterion) mostly concerns the widespread use of NEVs. For now, most consumers adopt a wait-and-see attitude to NEVs. The application and popularization of NEVs is an effective strategy to eliminate the wait-and-see attitude of consumers on buying NEVs. The Criterion C includes five sub-criteria illustrated as follows. Demonstration effect means that drawing the attention of the consumer by regarding NEVs as taxi, bus, postal vehicle and so on (Zheng et al., 2012). Consumer subsidy is a general way to encourage consumers to purchase NEVs. The subsidy standards always differ depending on driving mileage. Consumer cognitive and acceptable level reflects consumers' preferences for NEVs, which is most likely to affect consumers' choice for NEVs (Zhang et al., 2011). Government procurement is an effective manner to promote NEVs when NEVs are not widely accepted by consumers.

The main criteria and the sub-criteria for evaluating NEV policy are listed in Table 1.

Table 1 The AHP model of New Energy Vehicle Industry Policy

Notation	Main criteria (Level 1)	Notation	Sub-criteria (Level 2)
A	NEV industry development	A1	industry standard system and access system
		A2	technological achievements industrialization and marketization

	criterion	A3	industry development roadmap
		A4	energy consumption structure
		A5	industrial tax preference
		A6	industrial R&D subsidy
		A7	infrastructure
		A8	business model
B	NEVs technology research	B1	charging station (pile) technology
		B2	technical level of total vehicle
	and development criterion	B3	battery technology
		B4	power system technology
		B5	intelligent technology
		B6	connected vehicle technology
C	NEVs application and	C1	demonstration effect
		C2	consumer tax preference
	popularization criterion	C3	subsidy for NEV purchase
		C4	consumer cognitive and acceptable level
		C5	government procurement

4.3 Case study

This research summarized some influential factors according to the AHP hierarchy mentioned in aforementioned literature. The sample data were obtained from six NEVs policy experts. In this example, the entire procedure for constructing decision matrix is shown as follows:

Step 1, according to Proposition 1, the results of the experts' scores, expressed by linguistic variables, are transferred into Saaty's scale as listed in Table 2 for all the 22 criteria. Tables 3–6 show the experts' scores.

Step 2, using Eq. (5) to transfer each expert's scores into the raw scores and get the initial decision matrices. The rest of the decision matrices values can be obtained by using Propositions 1 and 3.

Step 3, taking into account of each expert's views, computing the average of fuzzy preference relation of each expert and regarding it as the basis of calculating each criterion weight. The complete decision matrices of main criteria and sub-criteria are summarized in Tables 7–10.

Step 4, by using Eq. (10) and Eq. (11), the average preference and the weight of every criterion and sub-criteria can be acquired. The results are shown in the columns

'average' and 'weight' in Tables 7–10 respectively. The column 'rank' in Tables 7-10 represents the degree of preference. The larger weight can get the higher rank.

Table 2 Degree of relative importance between two criteria

Definition	Degree of relative importance
Equally important	1
Moderately Important	3
Strongly Important	5
Very strongly important	7
Absolutely important	9

Table 3 Preference relation matrix for pairwise comparison of main criteria

	E1	E2	E3	E4	E5	E6
A	1/3	1/3	1	1/5	1/3	1
B	3	5	3	3	5	3
C						

Table *4 Preference relation matrix for pairwise comparison of criterion A*

	E1	E2	E3	E4	E5	E6
A1	1/3	1/3	1/5	1/5	1	1/3
A2	3	5	5	7	3	5
A3	1/3	1/7	1/3	1/5	1/5	1/3
A4	3	3	3	3	5	3
A5	1	3	3	3	1	3
A6	1/5	1/3	1/5	1/3	1/3	1/5
A7	7	7	5	5	7	5
A8						

Table 5 Preference relation matrix for pairwise comparison of criterion B

	E1	E2	E3	E4	E5	E6
B1	3	5	5	7	5	3
B2	1/5	1/3	1/3	1/3	1/7	1/5
B3	3	5	5	3	3	5
B4	3	3	3	7	5	3
B5	1	3	3	5	3	1

Table 6 Preference relation matrix for pairwise comparison of criterion C

	E1	E2	E3	E4	E5	E6
C1	3	5	5	3	5	3
C2	1	1/3	1	1/3	1/3	1
C3	1/3	1/5	1/7	1/5	1/3	1/3

C4	5	7	3	5	5	3
C5						

Table 7 Complete comparison matrix and rank of main criteria

	A	B	C	Average	Weight	Rank
A	0.500	0.357	0.653	0.503	0.335	2
B	0.643	0.500	0.796	0.646	0.431	1
C	0.347	0.204	0.500	0.351	0.234	3

Table 8 Complete comparison matrix and rank of criterion A

	A1	A2	A3	A4	A5	A6	A7	A8	Average	Weight	Rank
A1	0.500	0.331	0.615	0.364	0.587	0.744	0.499	0.831	0.559	0.140	3
A2	0.669	0.500	0.785	0.534	0.756	0.913	0.669	0.999	0.728	0.182	1
A3	0.385	0.215	0.500	0.249	0.471	0.628	0.384	0.715	0.443	0.111	6
A4	0.636	0.466	0.751	0.500	0.723	0.879	0.635	0.966	0.695	0.174	2
A5	0.413	0.244	0.529	0.277	0.500	0.657	0.412	0.744	0.472	0.118	5
A6	0.256	0.087	0.372	0.121	0.343	0.500	0.256	0.587	0.315	0.079	7
A7	0.501	0.331	0.616	0.365	0.588	0.744	0.500	0.831	0.560	0.140	3
A8	0.169	0.001	0.285	0.034	0.256	0.413	0.169	0.500	0.228	0.057	8

Table 9 Complete comparison matrix and rank of criterion B

	B1	B2	B3	B4	B5	B6	Average	Weight	Rank
B1	0.500	0.696	0.523	0.699	0.875	0.999	0.716	0.239	1
B2	0.304	0.500	0.327	0.504	0.680	0.804	0.520	0.173	3
B3	0.477	0.673	0.500	0.676	0.852	0.977	0.692	0.231	2
B4	0.301	0.496	0.324	0.500	0.676	0.801	0.516	0.172	4
B5	0.125	0.320	0.148	0.324	0.500	0.625	0.340	0.113	5
B6	0.001	0.196	0.023	0.199	0.375	0.500	0.216	0.072	6

Table 10 Complete comparison matrix and rank of criterion C

	C1	C2	C3	C4	C5	Average	Weight	Rank
C1	0.500	0.815	0.723	0.414	0.765	0.643	0.257	2
C2	0.185	0.500	0.408	0.099	0.449	0.328	0.131	5
C3	0.277	0.592	0.500	0.191	0.541	0.420	0.168	3
C4	0.586	0.901	0.809	0.500	0.851	0.729	0.292	1
C5	0.235	0.551	0.459	0.149	0.500	0.379	0.152	4

Table 7 shows that the rank of main criteria is B (NEVs technology research and development criterion) > A (NEV industry development criterion) > C (NEVs application and popularization criterion), which reveals the opinions of experts on NEVs policy. The result indicates that NEVs technology research and development criterion is the most important factor in NEVs policy. NEVs technology includes battery technology,

power system technology, charging technology, etc. Technology research and development is the core issue of NEV industry and the foundation for the development of NEV industry. Hence, NEVs policy should pay more attention to technology research and development of NEVs. NEV industry development criterion is another key criterion. Many economies in APEC take NEV industry development as a part of a economy strategy, establishing and implementing incentive policy to support NEVs R&D. The difference in NEVs R&D policy in various economies is the priority research area. For instance, Japan makes industrial competitiveness as the first target. Therefore, Japan focuses on developing three kinds of electric vehicle: Plug-in Hybrid, Pure Electric and Fuel Cell. The United States pays more attention to energy conservation and emissions reduction. As a result, Extended Range Electric Vehicle and Pure Electric Vehicle are given priority in the process of industry development.

In the sub-criteria of NEV industry development criterion (criterion A), A2 > A4 > A1 = A7 > A5 > A3 > A6 > A8 (it corresponds respectively to technological achievements industrialization and marketization, improving energy consumption structure, industry standard system and access system, infrastructure, industrial tax preference, industry development roadmap, industrial R&D subsidy, and business model) as shown in Table 8. Industrialization and marketization of technological achievements has the biggest impact. Research results of NEVs are conducted in universities and scientific research institutions. Most results of previous research remain in the stage of laboratory, which lack of industrialization, particularly in power system, battery and other key parts. The result demonstrates that policy has to encourage companies and research institutes to use new technology to improve the performance of NEVs, which is an important factor to expand NEVs market. Improving energy consumption structure requires reducing dependence on petroleum resources and increasing the use of solar energy, wind energy, hydropower and other renewable energy sources. Moreover, improving the consciousness of the people to use green energy is also a vital step. Policy makers should focus on providing infrastructures for a large-scale production of NEVs. In addition, since infrastructure is strongly related to NEVs ownership, different kinds of

infrastructure should be provided according to different usage modes. Make sure that the speed of infrastructure construction and NEVs popularization are consistent. (Sierzchula et al., 2014). Other criteria such as industry standard system and access system, industry development roadmap and industrial tax preference are also situated in relatively upper ranks. These cannot be ignored when formulate policies.

According to Table 9, the rank of the sub-criteria of NEVs technology research and development criterion (criterion B) is B1 > B3 > B2 > B4 > B5 > B6 (it corresponds respectively to charging station (pile) technology, battery technology, technical level of total vehicle, power system technology, intelligent technology, connected vehicle technology). According to the result, charging station (pile) technology ranks the top. The charging station (pile) technology is closely related to charge time, construction cost, etc. The consumers always want to shorten the charge time as much as possible, as well as charge their vehicles anytime and anywhere. Battery technology of NEVs is another important criterion because it determines the driving mileage of NEVs. The battery technology is the most crucial criterion that consumers always take it as the evaluating standard when buying a NEV. Improving whole vehicle technology could shorten product development period, reduce cost and enhance competitiveness. It is beneficial to improve NEV industry competitiveness. The other three criterions, power system technology, intelligent technology and vehicular networking technology, are also critical for NEVs technology research and development.

4.4 Conclusions

In this research, the consistent fuzzy preference relations (CFPR) are introduced to evaluate the efficiency in NEVs policy which includes three main criteria. According to CFPR in AHP structures, it is easily to construct the multi-criteria decision matrices and evaluate the significance of each criterion of NEVs policy. The policy efficiency can be directly evaluated with the weights calculated using expert scores. The process of calculation is easy and simple. Important information can be acquired from the evaluation results for the use of policy makers in the future practice. According to the weights in the proposed model, the most important main criterion is NEVs technology

research & development criterion. Nowadays, NEVs are limited by disadvantages such as battery capacity, driving range and. Many key technologies of NEVs, especially power battery technology, fuel cell technology and hybrid energy management system, are technical difficulties all over the world. It is difficult to achieve a breakthrough in a short time. Hence, policy makers need to introduce policies focusing on technology R&D to encourage universities, research institutions and enterprises to overcome technical obstacles. Certainly, the other two main criterions should also receive enough attention.

In the sub-criteria, charging station (pile) technology, battery technology of NEVs, technological achievements industrialization and marketization, improving energy consumption structure, infrastructure, consumer cognitive and acceptable level, demonstration effect and consumer subsidy exert important influence on NEVs. These criteria constitute aspects such as technology, market, consumer, infrastructure and subsidy. However, whether consumer accepts NEVs still depends on the economy of NEVs, the convenience of infrastructure and service, encouragement policies as well as the cognition of consumer. Policy makers should consider these aspects when formulate policies. The development and popularization of NEVs need powerful support of the government. In this research, as an example, only several professionals' opinions were collected to estimate and verify the model. Actually, the NEV users are important to improve the NEV technology effectiveness, and their preferences are useful to estimate the model. Therefore, the data sample will be enlarged in the future work to obtain more instructive results.

5 DISCUSSION ON NEV DEVELOPMENT IN APEC

Increasing fuel prices and growing environmental concerns are two key factors enhancing the potential of the electric vehicle as a valid alternative to the internal combustion engine. However, electric vehicles must still overcome a host of barriers (both technical and economic) if they are to compete with traditional vehicles. Many APEC economies have lunched promoting policies to develop the NEV industry and increase NEV purchases. Especially for the last decade, more and more attentions have been paid on NEV development. As a result, the NEV industry develops fast and the sales of NEV increases continuously. It can be concluded that the policy instruments can promote the development the NEV industry.

The government does not only influence R&D by providing funding for selected research projects, but also by defining technical standards and influencing market demand. The most important measures when it comes to influencing market demand are the subsidies to public and private purchases of NEVs. The subsidies are not only intended to stimulate the development of a market for NEVs, but they also have an impact on how this market will look: the specific structure of the subsidy programs promotes certain technologies while it discourages others. Taking China as an example, the subsidy program for the public sector states that buyers of hybrid vehicles can receive subsidies of up to 50,000 yuan (7500 dollar) depending on the fuel efficiency rate, but that electric vehicles qualify for higher subsidies. According to the experience in APEC economies, economic support can stimulate the NEV purchases and NEV R&D.

However, economic support is not proper for a long-term development strategy. Therefore, a systematic policy framework should be research comprehensively to make NEV industry develop sustainably. On the other hand, policy makers should introduce more policies focusing on technology R&D to overcome the disadvantages of NEVs. The technology R&D is another important factors in influencing NEV development. As a new emerged industry, NEV industry need a long-term support. For example, the development of an extensive charging network capable of overcoming the problems of "range anxiety"; the ability to guarantee sufficient demand for electric vehicles so as to

maintain such charging networks; and the development of batteries (the principal component of an electric vehicle) that can provide greater autonomy while ensuring lower production and replacement costs are the goals that must be achieved if electric vehicles are to be successfully incorporated in the automobile market. Therefore, economic support and technology support, both of them are indispensable for NEV development.

Today, more and more economies are implementing these, or similar, measures to facilitate the introduction and consolidation of NEVs so that it might become the mode of transport in the future. However, the barriers remain considerable and greater involvement is required from the public administration to tackle "the chicken or the egg" dilemma faced by the sector and the negative effects that a poor tariff regulation would have on the vehicle market even electric market.

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6 APPENDIX

Review of NEV policy in main APEC economies.

No.	Economy	TIME	Policy Type	Introduction
1	CANADA	2009	Promotion policy	Electric Vehicle Technology Roadmap for Canada
2	CANADA	2013.1	Promotion policy	the Automotive Innovation Fund was renewed for a second round of $250 million over 5years. In the first round, $70.8 million went to Toyota in part to develop Evs for the Canadian marketplace.
3	CHINA	2009.1	Promotion policy	The Chinese central government initiated the "Ten Cities, Thousand Vehicles Program" (hereafter referred to as 'the program') to stimulate the adoption of NEVs. Selected the cities for the demonstration and promotion of NEVs. Each city was challenged to roll out pilots of at least 1000 NEVs.
4	CHINA	2010.6	Purchasing support	The policies state that the Chinese central government will pay a subsidy of up to 50,000 yuan to any consumer who purchases a plug-in hybrid vehicle (PHEV) and 60,000 yuan for an all-electric, or battery-electric vehicle (BEV). These subsidies for consumers are enhanced by additional subsidies from local government.
5	CHINA	2011.1	Promotion policy	the Ministry of Finance will grant a total of RMB 100 billion to support the development of the NEV industry from 2011 to 2020. Specifically, 50 billion yuan will be invested to assist in the research and industrialization of key technologies of NEVs; 30 billion will be given to stimulate the demonstration and consumption of NEVs.

6	CHINA	2012.7	Promotion policy	Set the target of having more than 500,000 battery-electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs) on the road by 2015 and 5 million by 2020
7	CHINA	2013.9	Promotion policy	To promote the market penetration of electric vehicles (EV), CHINA launched the Electric Vehicle Subsidy Scheme phase II.
8	CHINA	2013.9	Promotion policy	Reduce vehicle use by encouraging green transport, increasing the cost of use and other measures.
9	CHINA	2014.2	Promotion policy	The promotion notice to promote the application of new energy vehicles.
10	CHINA	2014.7	Promotion policy	The guidance from General Office of the State Council on accelerating the application of new energy vehicles
11	CHINA	2014.7	Promotion policy	Notice of the Development and Reform Commission on the Relevant Issues Concerning the Price Policy for the Electricity Consumption of Electric Vehicles
12	CHINA	2014.9	Purchasing support	notice for new energy vehicles vehicle about purchase tax exemption.
13	CHINA	2015.1	Production subsidy	the Ministry of Finance and the State Administration of Taxation will levy a consumption tax on batteries and paints on February 1, 2015, with the approval of the State Council. For the mercury-free primary batteries, "Nickel-metal hydride batteries"), lithium primary batteries, lithium-ion batteries, solar cells, fuel cells and all vanadium flow batteries are exempt from consumption tax.

14	CHINA	2015.2	R&D support	Key R&D program: special programs focus on the implementation of New energy vehicles (draft)
15	CHINA	2015.3	Promotion policy	implementation advise on accelerating the promotion of the application of the new energy vehicles in the transportation industry
16	CHINA	2015.3	Laws & regulations	Standard Conditions of Automotive Power Storage Battery Industry
17	CHINA	2015.4	Purchasing support	China's 2016-2020 plan on providing fiscal support for the development and utilization of new-energy vehicles.Aims at further accelerating the development of the new-energy vehicle industry. According to the plan, the amount of fiscal subsidies for various new-energy vehicles will mainly depend on the effect of energy saving and emission reduction of such vehicles, it adds.
18	CHINA	2015.5	Purchasing support	In order to promote energy saving and encourage the use of new energy, in accordance with relevant provisions of the "Vehicle and Vessel Tax Law of the People's Republic of China" and its implementing regulations, upon approval by the State Council, the preferential vehicle and vessel tax policies on energy-saving vehicles & vessels using new energy
19	CHINA	2015.5	Promotion policy	reduced fuel-price subsidy for inner-combustion engine (ICE) buses and increased operation subsidies to NEV buses, which aimed to incentivize more bus companies to adopt NEVs
20	CHINA	2015.5	R&D support	"made in CHINA 2025"

21	CHINA	2015.6	Laws & regulations	Access Management Rules for New Energy Automobile Manufacturers and Products
22	CHINA	2015.10	Promotion policy	Guidelines to Expedite Building of Charging Infrastructure
23	CHINA	2015.10	Promotion policy	Guiding Opinions of the General Office of the State Council on Accelerating the Construction of Electric Vehicle Charging Infrastructure
24	CHINA	2015.11	R&D support	New energy car ten years development roadmap
25	CHINA	2015.11	Promotion policy	In November 2015 the Chinese Ministry of Transport, the Ministry of Finance and the Ministry of Industry and Information Technology jointly released a new regulation, which obligates local governments and relevant stakeholders to promote the integration of electric buses in public transport fleets.
26	CHINA	2015.12	Promotion policy	Notice of the Ministry of Housing and Urban-Rural Development on Enhancing the Planning and Construction of Urban Electric Vehicle Charging Facilities
27	CHINA	2016.1	R&D support	Administrative Measures for Lithium Ion Battery Industry Standard Announcement
28	CHINA	2016.1	Promotion policy	Notice on the Reward Policy of New Energy Vehicle Charging Infrastructure and Strengthening the Popularization and Application of New Energy Vehicles during the 13th Five Year Plan Period

29	CHINA	2016.1	Promotion policy	Recommended Vehicle Model Directory for the Popularization and Application of NEVs.To date 3 directories including 1022 NEV models have been issued.
30	CHINA	2016.1	R&D support	Battery specifications from a total of 25 producers have been judged to conform to the "Standard Conditions of Automotive Power Storage Battery Industry", and their details have been published in 3 directories.
31	CHINA	2016.1	Promotion policy	Notice on the Implementation of Verification of New Energy Automobile Popularization and Application
32	CHINA	2016.2	Laws & regulations	Interim Measures for the Management of Industry Standard Announcement of the Comprehensive Utilization of New Energy Vehicle Used Power Battery
33	CHINA	2016.2	Promotion policy	Regulations on the Management of Urban Bus and Electric Bus Passenger Transportation
34	CHINA	2016.4	R&D support	Supplementary notice on the Application of Enterprises for Auto Power Battery Industry Standard Conditions
35	CHINA	2016.4	Laws & regulations	Low-speed Electric Car Standard Project Approval Soliciting Public Opinions
36	CHINA	2016.4	R&D support	Hydrogen Energy and Fuel Cell Technology Strategic Direction Planning Objectives
37	CHINA	2016.5	R&D support	Notice on the Implementation of Major Projects Package of Manufacturing Industry Upgrading and Reconstruction

38	CHINA	2016.5	Promotion policy	Technical Specification for Electric Automobile Remote Service and Management System
39	CHINA	2016.6	Laws & regulations	Electric Bus Safety Specifications
40	CHINA	2016.8	Laws & regulations	Access Management Rules for New Energy Automobile Manufacturers and Products
41	JAPAN	1971	R&D support	The MITI has promoted electric vehicles (BPEVs) since 1971, launching a 5-year government-industry R&D programme.
42	JAPAN	1976	Promotion policy	The MITI established a basic market expansion plan for BPEVs in 1976. This plan (and the following revised versions) was a comprehensive commercialisation plan coordinating government agencies,companies and municipalities in their efforts to expand BPEV development. Barriers were identified and the relevant actors were called upon to make efforts to remove these barriers through technical development, amending laws and taxes, creating new standards and building a fuel infrastructure.
43	JAPAN	1978	R&D support	The MITI also funded companyR&D between 1978 and 1996 supporting leasing projects (MITI, 1990).
44	JAPAN	1991	Promotion policy	As a consequence, a third and more aggressive market expansion plan for BPEVs was issued by the MITI in 1991. The goal was then to have 200,000 BPEVs on the road by the year 2000 (MITI, 1990).

45	JAPAN	1992	R&D support	Under the New Sunshine Programme, R&D on polymer electrolyte fuel cells (PEMFC) has been undertaken since 1992. Research is also conducted under the same programme on lithium batteries(through the organisation LIBES) since 1992. The aimwas to develop both stationary and vehicle applications of the next generation of batteries based on lithium.
46	JAPAN	1993	Promotion policy	ECO-Station In 1993 Japan initiated a project (ECO-Station Project) aimed at introducing 2,000 recharging stations for clean energy vehicles by 2000. Of that number, around half were for electric vehicles (Hayashi et al, 1994). The infrastructure ECO-Station Programme failed to meet the targets of approximately 1000 installed BPEV quick-charging facilities by 2000. To date, only 36 stations have been established for BPEVs.
47	JAPAN	1993	Promotion policy	Also the larger prefecture governments (Tokyo,Chiba, Kanagawa, Osaka and Hyogo) laid out aggres-sive market plans in 1993 for introducing BPEVs in order to reduce NO x emissions in accordance with the Auto-NO x Law. The plans included a total number of almost 100,000 BPEVs and 170,000 LPGVs in the year 2010.The larger prefecture governments did not meet (or even come close to) the aggressive targets for BPEVs set in 1993 in which the total number of BPEVs in Japan in 2000 was set to 2600.
48	JAPAN	1995	R&D support	In 1995 BPEV field tests were launched by the MITI but these were replaced by several BPEV-ITS pro-grammes starting in 1998, demonstrating the feasibility of BPEVs in combination with Intelligent Transportation Systems (ITS).
49	JAPAN	1995	Promotion policy	Ahman (2006)describes how, under the Environment Conservation Programme in 1995, the Japanese government announced the replacement of 10% of its public vehicles by 2000 with vehicles producing lower emissions.

50	JAPAN	1996	Purchasing support	In 1996, an BPEV Purchasing Incentive Programme was introduced which replaced existing leasing and purchasing incentive programmes that had been in operation since 1976. Fifty percent of the extra incremental vehicle price was subsidized.
51	JAPAN	1997（upgraded in 2001）	Promotion policy	Produce 110000 BPEVs，2110000 HEVs and FCEVs before 2010
52	JAPAN	1997	R&D support	In 1997 the MITI initiated the Advanced Clean Energy (ACE) vehicle programme. This is an R&D programme extending from 1997 to 2003 with the objective of developing different high-energy efficient hybrid vehicles.
53	JAPAN	1998	Sales subsidy	During the first 2 years of the Clean Energy Vehicles Introduction Programme (1998–2000) 276 BPEVs and 12,242 HEVs were subsidized by the programme. The total number of HEVs sold was 22,400, thus only 55% of sales was subsidized, whereas most of the BPEVs sold received a subsidy.
54	JAPAN	2000	Promotion policy	The study group expects the introduction phase to be between 2005 and 2010, when 50,000 fuel cell vehicles will be introduced in public utilities and FC-related companies. The target for the year 2020 is 5,000,000 sold FCEVs.
55	JAPAN	2001	Promotion policy	In 2001, the government also established a goal to replace all used vehicles with cleaner alternatives, of which 60% were expected to be hydrogen-electric mix (EVAAP, 2002).
56	JAPAN	2009	Promotion policy	Build 200 charging stations in Tokyo.
57	JAPAN	2009	Purchasing support	Provides a bonus based on the price difference between the EV and a comparable gasoline car. The bonus is capped at 850,000 JPY (about 6,300 EUR).

58	JAPAN	2010	Promotion policy	Electric vehicle stock in the whole vehicle market achieves 50% in 2020.
59	JAPAN	2010	Promotion policy	Private-sector efforts： 2020：conventional vehicles make up more than 80%；Hybrid vehicles make up 10-15%；Electric vehicles,Plug-in hybrid vehicles make up 5-10%. 2030：conventional vehicles make up 60-70%；Hybrid vehicles make up 20-30%；Electric vehicles,Plug-in hybrid vehicles make up 10-20%；FCEVs make up 1%；Clean diesel vehicles make up under 5%. Government targets： 2020：conventional vehicles make up 50-80%；Hybrid vehicles make up 20-30%；Electric vehicles,Plug-in hybrid vehicles make up 15-20%；FCEVs and clean diesel vehicles all make up 1%. 2030：conventional vehicles make up 30-50%；Hybrid vehicles make up 30-40%；Electric vehicles,Plug-in hybrid vehicles make up 20-30%；FCEVs make up under 3%；Clean diesel vehicles make up 5-10%.

60	JAPAN	2011	R&D support	research directions of electric vehicles by Japan Automobile Research Institute（JARI）： Research into emissions and fuel economy test methods； Investigation into AC standard charger feasibility； FCVs standardization activity； HEVs standardization activity； Batteries and chargers standardization activity； Battery performance assessment；Fuel cell performance assessment.
61	JAPAN	2013	Promotion policy	As of October 2013, 1,858 quick chargers have been set up in Japan. Suppliers will increase the supply to meet the government's diffusion target of 5,000 quick chargers by 2020. The establishment of about 100 hydrogen supply stations is targeted in preparation for the market introduction of FCVs.
62	JAPAN	2014	Purchasing support	EVs/FCVs/PHVs/Clean Diesel Vehicles/Natural Gas Vehicles：免 Acquisition Tax (on vehicle acquisition) ,免 Tonnage Tax (during vehicle ownership) ,第一年 Automobile Tax (during vehicle ownership)减 75%。

63	JAPAN	2014	Promotion policy	When the consumption tax rate reaches 10% (scheduled in October 2015, will be finally decided in December 2014), taxation methods in accordance with eco-friendly performance will be introduced in the Automobile Tax as a taxation at the time of acquisition. This will lead to a concrete decision in the FY2015 Tax reforms.
64	REPUBLIC OF KOREA	1992.12	R&D support	Project for the development of electric vehicles prototypes and core parts.
65	REPUBLIC OF KOREA	1998	R&D support	(Next-Generation Vehicle Development
66	REPUBLIC OF KOREA	2007-2009	R&D support	Development of a new hybrid powertrain system and control technology. Development of a high power lithium secondary battery for hybrid vehicle. Development of the technology for plug-in hybrid electric vehicles.
67	REPUBLIC OF KOREA	2009.10	R&D support promotion policy	The policy "Entering the four Great Green Car Powers by 2013" was established in October 2009 to encourage the development of electric vehicles and opened the door to greater commercialization.
68	REPUBLIC OF KOREA	2009.12	R&D support	Demonstration business for the charging infrastructure continues with the participation of a total of 48 companies
69	REPUBLIC OF KOREA	2010.3	Laws & regulations	Certified low-speed electric vehicles，and the laws and regulations necessary
70	REPUBLIC OF KOREA	2010.6	Promotion policy	Set up an electric vehicle charging tariff
71	REPUBLIC OF KOREA	2010.12	R&D support	Government announced a plan for improving the competitive power of electric vehicles，contributing over 70 billion KRW.
72	REPUBLIC OF	2012	Purchasing support	Tax exemptions of FCEV

	KOREA			
73	REPUBLIC OF KOREA	2012.4	Purchasing support	Government announced a plan to commercialize 2,500 electric vehicles and confirmed the sales price, subsidy and funding for the infrastructure to support the operation of electric vehicles.
74	REPUBLIC OF KOREA	2015	Promotion policy	Government has targeted 200,000 EVs and 1,4000 charging stations by 2020
75	REPUBLIC OF KOREA	until 2015	Purchasing support	The policy of tax exemption for hybrid vehicle penetration
76	NEW ZEALAND	2016.5	Promotion policy purchasing support R&D support	Extending the Road User Charges exemption for light electric vehicles Introducing a new Road User Charges exemption for heavy electric vehicles Work across Government and the private sector to investigate bulk purchasing Support the development and roll-out of public charging infrastructure A economy-wide electric vehicle information and promotion campaign A contestable fund of up to $6 million per year to support innovation Enabling electric vehicles to access bus and high occupancy vehicle lanes Review of tax depreciation rates and the method for calculating fringe benefit tax for electric vehicles Review ACC levies for plug-in hybrid electric vehicles Establishment of an Electric Vehicles Leadership Group
77	SINGAPORE	2001	Promotion policy purchasing support	Green vehicle rebate (GVR) scheme which offers an offset on the registration fees for green vehicles. In 2013 upgrade of the GVR scheme allows a rebate.

78	SINGAPORE	2010.6	Promotion policy purchasing support	Singapore, in June 2010, initiated a project to invest 20 million dollars in setting up a comprehensive network of recharging points, and to provide subsidies for the purchase of electric vehicles. The primary goal of local government is to attract the electric car industry to Singapore.
79	SINGAPORE	2011.6	R&D support	Announced the launch of the electric vehicle test-bed in Singapore today.
80	SINGAPORE	2014.12	Promotion policy	Announced plans to trial an electric vehicle (EV) car-sharing programme which will see the introduction of up to 1,000 EVs and the charging infrastructure to support their use.
81	SINGAPORE	2016.5	Promotion policy	Some 2,000 charging points will be set up here for an islandwide electric vehicle car-sharing programme
82	SINGAPORE	mid of 2017	Promotion policy	BlueSG Pte Ltd, a subsidiary of Bolloré Group, signed an agreement today with the Land Transport Authority (LTA) and Economic Development Board (EDB) to operate BlueSG, a economy-wide car-sharing programme.
83	CHINESE TAIPEI	1993.7	R&D support	The e-Scooter LEV project sponsored by the Ministry of Economic Affairs (MOEA) and EPA of CHINESE TAIPEI Government
84	CHINESE TAIPEI	2008	R&D support	An EV key module technology development project； a parallel R&D project executed by TARC to conduct the fundamental research
85	CHINESE TAIPEI	2009.5	Promotion policy	regulating sales of gasoline motorcycle to replace the less competitive 50cc engine motorcycles by light electric vehicles (LEV)； formulated standards for e-Scooter's performance and safety； 8,000 units of 2W e-Scooter in 2009, and 100,000 by the end of 2012.

86	CHINESE TAIPEI	2009.5	Purchasing support	Earmarks NT$1.6 billion (US$49.7 million) to subsidize buyers of 2-wheelers electric scooters
87	CHINESE TAIPEI	2009.5	Laws & regulations	Standards formulating for improving the e-Scooter's performance, safety, and efficiency
88	UNITED STATES	1973	R&D support	United States Congress passed the "Electric and Hybrid Vehicle Research, Development, and Demonstration Act"
89	UNITED STATES	2005	Purchasing support	Congress proposed the EPAct 2005 [32]
90	UNITED STATES	2005	Production subsidy	start a "phase-out" after a manufacturer exceeds a vehicle sales limit, which is a stepwise tax credit
91	UNITED STATES	2007	R&D support	"Energy Independence and Security Act of 2007" (EISA-2007)
92	UNITED STATES	2008	Purchasing support	"Energy Improvement and Extension Act of 2008"
93	UNITED STATES	2009	Purchasing support	United States Clean Energy and Security Act of 2009 (ACES-2009) , as well as the American Recovery and Reinvestment Act of 2009 (ARRA-2009) had authorized federal tax credits for qualified PEVs, and the credits ranged from $2500 to $5000, depending on battery capacity.
94	UNITED STATES	2009	Purchasing support	Through this system, people would get $3500 or $4500 if they exchanged their less fuel-efficient vehicle for a higher fuel-efficiency vehicle, which includes some HEVs.

95	UNITED STATES	2010	R&D support	President Obama announced the plan of the “next generation electric vehicle” , which aimed to fund $1.5 billion to manufacturers to produce high efficiency batteries and their components. The plan was also to provide $500 million to produce other components needed for EVs, such as electric motors and other key components.
96	UNITED STATES	2011	R&D support	As part of the more recent US strategic plan (US Department of Energy, 2011), the "American Recovery and Reinvestment Act” (ARRA) greatly expands the resources available for industrial investment, a significant portion of which are assigned to the energy industry. These resources include “tax credits” to build vehicles powered by batteries. Indeed, the United States has set itself the goal of being able to produce 500,000 hybrid electric vehicles in 2015.
97	UNITED STATES	2012	Promotion policy	In the EV Everywhere Grand Challenge Blueprint, the United States government made a plan to produce 1000000 Evs.
98	UNITED STATES	2012	R&D support	For instance, the government is going to provide $120 billion over the next five years to fund the new Joint Center for Energy Storage Research (JCESR), which is led by the Argonne National Laboratory in Chicago with five labs, five universities and four private-sector enterprises.
99	UNITED STATES	2015	Purchasing support	At least 20 states have considered legislation in 2015 to encourage the purchase and increased use of hybrid and PEVs. A federal tax credit of up to $7,500 is available in addition to state incentives for electric vehicles. The tax credit will expire once 200,000 qualified PEVs have been sold by each automotive manufacturer.