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## The development of new energy vehicles for a sustainable future: A review

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## ABSTRACT

With the rapid growing number of automobiles, new energy vehicle is becoming one of approaches to mitigate the dependence of the auto industry on petroleum so as to reduce pollutant emissions. The Chinese government has promulgated a number of policies from the perspectives of industrial development, development plans, demonstration projects, fiscal subsidies and tax incentives with an aim to promote the new energy vehicle industry. This paper presents a comprehensive and critical review of the policy framework for new energy vehicles. The analysis shows that electric vehicle has been assigned a top priority in the future development of the automobile industry in China. Policy guidance and planning has played a vital role to the growth of new energy vehicle industry. However, this industry faces significant challenges related to technologies, industrial chain and social factors. Some core technologies are still in its infancy. Similarly, the market share of new energy vehicles is very small in spite of the preferential policies. The construction of supporting facilities and infrastructures has to be accelerated in order to accommodate the growing demands. There is a long way to go for the industrialization and popularization of new energy vehicles in China.

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**1. Introduction**

The last decades witnessed the unprecedented expansion of energy consumption derived from the rapid economic growth in China. From 1980 to 2013, the total energy consumption in China surged from 17.67 billion GJ to 109.9 billion GJ. During the same period, the crude oil consumption increased more than 5.5 times from 3.66 billion GJ to 20.18 billion GJ [1]. This is compounded by the fact that over 57.8% of oil supply in China relies on importing. The Chinese auto industry developed rapidly during the same period, the automobile population increased by 75.8 times from 1.78 million to 137 million (see Fig. 1). In 2013, the output and sale volume of automobile in China reached 22.13 million and 21.98 million respectively, ranking first in the world [2]. With the fast growth of auto industry, the transport industry has become the largest oil consumer in China where 45.6% and 60.7% of the gasoline and diesel was consumed respectively in 2013 [1].

There are a number of factors that affect the energy consumption of the auto industry such as existing auto technologies; existing policies, e.g. fuel-economy policies and energy-savings policies [3–5]; socio-economic development [6]; energy efficiency standards [7]; road condition [8,9]; car-following models [10]; and total costs of ownership [11]. The significant amount of fossil energy consumed by automobiles is associated with an inevitable environmental pollution [12]. Auto exhaust emission has become one of the major sources of air pollution in China. In 2012, vehicles exhaust emitted 6.4 million tonnes of nitrogen oxides (NOx), 4.38 million tonnes of hydrocarbons (HC), 34.72 million tonnes of carbon oxide (CO), and 0.62 million tonnes of particulate matters (PM) [13]. Vehicles are responsible for about 90% of NOx and PM, and 70% of HC and CO in China [14]. Wang [15] projected that passenger car emissions in 2020 will reach CO 1.12 g/km, HC 0.12 g/km, NOx 0.09 g/km, PM10 0.018 g/km, CO2 214 g/km under a recent policy scenario. Developing new energy vehicle (NEV) is a promising way to mitigate the dependence of petroleum for the entire auto industry and to reduce emissions of pollutants [16–21]. In this paper, NEV is defined as the four-wheel vehicle using unconventional vehicle fuel as the power source, which includes hybrid vehicle (HV), battery electrical vehicle (BEV), fuel cell electric vehicle (FCEV), hydrogen engine vehicle (HEV), dimethyl ether vehicle (DEV) and other new energy (e.g. high efficiency energy storage devices) vehicles. NEV is also one of the most important future road transport technologies [22] which has attracted a growing attention from both the industry and academics [23,24].

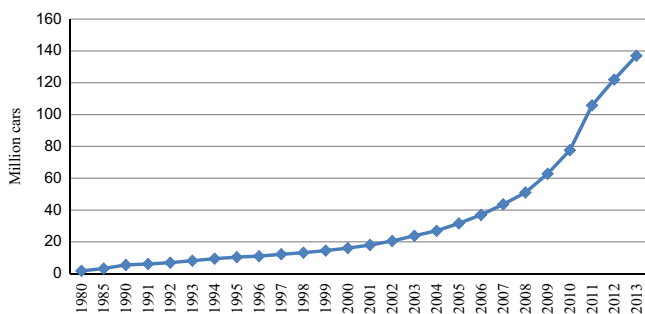


Fig. 1. Automobile population in China from 1980 to 2013.

In China, NEV plays a vital role in implementing the sustainable development strategy. It reduces not only fossil energy consumption but also air pollutants emission [25]. The Chinese government has devoted to reduce the carbon emission intensity per unit of GDP in 2020 by up to 45% compared to the level of year 2005. Currently, coal fired power plants occupy 78.1% of the total electricity output. New and renewable energies account for as low as 9.4% of the primary energy consumption [1]. It was projected that non-fossil energy will account for 11.4% of the primary energy consumption and generate 30% of electricity by 2015 [26]. The improved energy structure and electricity structure will bring more potential for the reduction of carbon emissions by developing NEV.

This study reports a critical analysis of the policies, the current status and future directions of Chinese auto industry and NEV industry. The findings provide both theoretical and practical references for the governments to formulate policies in order to further improve the auto industry in China.

**2. New energy vehicles in China**

The production of NEVs in China was not commenced until 2005. The National Development and Reform Commission (NDRC) released “Announcement for Vehicle Manufacturers and Products” in April 2005. Since then, the first Commercial Vehicle Permit for Dongfeng Hybrid-electric Bus in April 2005 [27], and the first Passenger Car Permit for Hybrid-electric PRIUS, produced by FAW-Toyota Company in the end of 2005 were approved [28]. By 16 June 2014, the Ministry of Industry and Information Technology (MIIT) has issued 58 batches of “Directory Application on Recommended Vehicle Types” for “Energy-Saving and NEV in Typical Application Project”. A total of 1111 vehicle types are listed officially [29].

Fig. 2 shows the sales volume and annual growth rate of NEV in China between 2006 and 2013. The NEV market was flat between 2006 and 2008, evidenced by the slightly increased sales volume, arguably due to the conservative attitude of consumers and comparatively higher price. With the stimulation of the related policies from governments as well as the tendency of diversification of NEV, the sales volume increased significantly since 2009. In 2013, 17.64 thousand NEVs were sold. It was projected that the sales volume will reach 35 thousand in 2014 which doubles the volume than the previous year [30]. However, this volume is still too small compared to the total automobile sales. In particular,

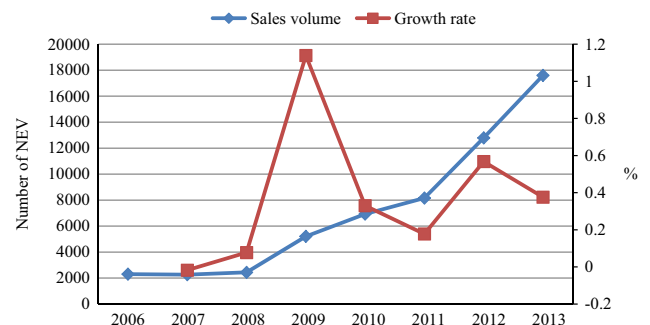


Fig. 2. Sales volume and annual growth rate of NEV in China between 2006 and 2013.

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