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Review

Prospects for Chinese electric vehicle technologies in 2016–2020: Ambition and rationality

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ABSTRACT

As the world's largest market for vehicles, China is facing challenges related to energy security and urban air pollution. The development of electric vehicles has been determined to be the national strategy for solving these problems. By the end of 2015, China had become the world's largest electric vehicles market, but its core technologies are still less competitive in the global marketplace. A scientific national strategy for 2016 to 2020 is expected to play a critical role in China becoming the global leader in the electric vehicle industry. The research process for this strategy includes a review of the technologies for electric vehicles, market analyses, benchmarking of the top levels in the field, and expert interviews. By these approaches, the strengths and weaknesses of China's electric vehicle technologies and industry are assessed. Competitive and feasible quantitative goals for key components and powertrains are proposed by this paper, and a core issue has been determined to be the need to improve the safety of high-energy density traction batteries. Improving the power density of electric control units is expected to the core for electric vehicles' electronics and control systems. Key problems for the fuel cell stacks used in cars and buses have been identified by this paper to be, respectively, power density and durability. Long-range plug-in hybrid electric powertrains are the optimal candidate for Chinese plug-in hybrid electric vehicles. Lightweight material, intelligent driving technologies and special electric chassis are set to be the focus for improving the energy efficiency of battery electric vehicles. Comprehensive safety and recyclable electric vehicle technologies are set to become key issues in the future, and the Chinese government should research and develop these in advance.

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Abbreviations

AER	all electric range
NEV	new energy vehicle
BEV	battery electric vehicle
FCEV	fuel cell electric vehicle
PHEV	plug-in hybrid electric vehicle
REEV	range extended electric vehicle
NEDC	new European driving cycle
MEA	membrane electrode assembly
LFP	$LiFePO_4$
LMO	$LiMn_2O_4$
NCM	$Li(NiCoMn)O_2$
NCA	$Li(NiCoAl)O_2$
LTO	$Li_4Ti_5O1_2$
MCU	motor control unit
MOST	Ministry of Science and Technology of the People's Republic of China
MIIT	Ministry of Industry and Information Technology of the People's Republic China
MOF	Ministry of Finance of the People's Republic China
NDRC	National Development and Reform Commission of the People's Republic China
EOL	end of life
FE	fuel economy
CS	charging sustainable
UNDP	the United Nations Development Program
SW	Strength and weakness

1. Introduction

At present, the Chinese automotive industry is faced with great challenges. First, it is urgent for China to transform from being large to being strong. China is the largest automotive production and sales country in the world. Chinese vehicle sales and production exceeded 24 million in 2015, accounting for one-quarter of the total sales in the world, and vehicle ownership has reached 172 million [1]. The automotive industry has become a major contributor to the Chinese GDP in that the output of the Chinese automotive industry represents approximately 9% of China's GDP, playing an important role in government revenue and employment, but there are still many weaknesses in key technologies and R&D capabilities. The industry is in the process of transforming from one that is investment driven to one that is innovation driven.

President Xi notes that the development of NEVs is the only way for the Chinese automotive industry to transition from being large to being strong [2]. In addition, with the opening of automotive markets, competitive pressure will be greatly increased. All abovementioned will push local automotive enterprises to improve their independent innovation capabilities.

Second, the Chinese automotive industry is facing the severe challenge of automobile exhaust pollution control. Urban air pollution issues are becoming increasingly serious in China. Some research results show that tailpipe emissions are the main source of urban air pollution, especially PM2.5. It is very harmful to human health. Statistically, vehicle tailpipe emissions account for 31.1% of local PM2.5 emissions, ranking it first among all pollution sources [3]. Vehicle tailpipe emissions account for approximately 24% of pollution in first-tier cities, including Beijing, Tianjin, and Shanghai. The relevant research shows that the development of NEVs can reduce urban air pollution effectively [4]. In future, mass penetration of NEVs may lead to integrated development of sustainable transportation and grid [5]. The Air Pollution Control Action Plan issued by the state council declares that promoting the penetration of NEVs is an important route to reducing urban pollution [6].

Third, the challenges of energy security and climate change require the development of NEVs. With the rapid growth of vehicle ownership, China's crude oil consumption is increasing greatly [7]. The consumption of gasoline and diesel fuel exceeds 269.3 million tons in 2014 [8]. In 2015, foreign crude oil dependence is increased to 60.2% [9], and it is estimated that dependence on foreign oil will increase to more than 70% by 2030. That will pose a significant risk to Chinese energy security.

Carbon emissions from the transportation sector amounts to 630 million tons in 2011, accounting for 7.9% of the nationwide amount and representing the fastest growth rate among all sectors. Targeting a sustainable transport system, rigid oil consumption regulations have been issued by the Chinese government. They require the corporate-average fuel consumption (CAFC) of newly sold cars to be no more than 5 L/100 km by 2020 [10]. This target cannot be realized by improved engine technology and lightweight material application alone for internal combustion engine (ICE) cars. In the regulations, the NEVs are rewarded to develop. The fuel consumption of plug-in electric cars with an all-electric range (AER) of more than 50 km can be calculated with a multiplicity coefficient of up to 5 (see Equation (1)), and their fuel consumption can be calculated as 0 [11], so the development of NEVs is necessary for passenger car companies to meet CAFC regulations. This is especially true for automotive companies such as the Great Wall Automotive Company [12,13], because it mainly produce large-size passenger cars with high fuel consumption. CAFC is calculated as follows:

$$\mathrm{CAFC} = \frac{\sum_{i=1}^{N} \mathrm{FC}_i \times \mathrm{V}_i}{\sum_{i=1}^{N} \mathrm{V}_i \times \mathrm{W}_i} \quad (1)$$

where i is the vehicle model number, FC_i is the fuel consumption of model i, V_i is the volume of import or sales of the respective model, and W_i is the multiplication coefficient. The W_i of BEV, FCEV, or PHEV models with an AER of more than 50 km is 5 from 2016 to 2017, 3 from 2018 to 2019, and 2 from 2019 to 2020.

The above-mentioned analysis highlights how the penetration of NEVs can solve China's energy security and urban air pollution

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