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ARTICLE

The Status Quo and Development Trend of Low-carbon Vehicle Technologies in China

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Abstract

Three types of low-carbon vehicle technologies in China are reviewed. Potential effects are listed for those integrated energy-saving technologies for conventional vehicles. Low carbon transitions, including alternative vehicle power train systems and fuels, are discussed on their development status and trends, including life cycle primary fossil energy use and greenhouse gas emissions of each pathway. To further support the low-carbon vehicle technologies development, integrated policies should seek to: (1) employ those integrated energy-saving technologies, (2) apply hybrid electric technology, (3) commercialize electric vehicles through battery technology innovation, (4) support fuel cell vehicles and hydrogen technology R&D for future potential applications, (5) boost the R&D of second generation biofuel technology, and (6) conduct further research on applying low-carbon technologies including CO_2 capture and storage technology to coal-based transportation solutions.

Keywords: low carbon; vehicle technology; greenhouse gas

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1 Introduction

According to the *World Energy Outlook 2008* edited by the International Energy Agency (IEA), oil accounted for 96% of the total energy consumption in China's Transport Sector in 2005 and the oil consumption in the Transport Sector accounted for 35% of the total oil consumption in the whole country for that year, and the latter rate will rise to 55% in 2030. For CO_2 emissions, the Transport Sector accounted for about 8% of the total emission in China in 2005 and this proportion will rise to 11% in 2030. With the rapid growth of vehicle population, passenger and freight traffic in China's road transport, the pressure of both fuel shortages and greenhouse gas (GHG) emissions is increasing. A cluster of technology and policy tools are essential to control the vehicle population, reduce the average distance travelled, improve the level of fuel economy and decrease emissions [*Xu et al.*, 2009]. The in-depth study on the status quo and development trend of low-carbon vehicle technology will be helpful for policy-making regarding the en-

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ergy-saving of Transport Sector in China [*Yan and Crookes*, 2009].

2 Categories of low-carbon vehicle technology

As to the supplies of transport energy, there is a unanimous view that oil will play dominant roles in transport energy until 2030, while hydrogen or electric energy will replace oil ultimately in the future (later than 2030). There is an inevitable energy diversification trend in the transition period [*Wang and Ouyang*, 2007].

Like developed countries, China is taking three categories of measures including comprehensive energy-saving vehicle technologies application, vehicle power electrification and vehicle energy diversification to reduce car traffic energy consumption [*NEO and CATARC*, 2008]. Accordingly, the low-carbon vehicle technologies are sorted into three categories — integrated energy-saving technologies, vehicle power electrification technologies, and low-carbon vehicle alternative fuels (VAF) technologies [*AERT*, 2007].

3 Contents of integrated energy-saving technologies for conventional vehicles

There are four kinds of technologies for those integrated energy-saving vehicle [*NEO and CATARC*, 2008], energy-efficient technologies for conventional gasoline engine, advanced diesel engine technology, vehicle power train energy-saving technologies, and other comprehensive vehicle energy-saving technologies.

Firstly, conventional gasoline engine can get energy-saving merit if they have the following elements, low-friction, high compression ratio, multi-valve, variable air-fuel mixture ratio, fuel direct injection, and light-weight. The fuel economy can be improved by 3%–5%, 1%–3% and 10%–20% with the multi-valve technology, the variable valve timing technology, and the fuel direct injection technology employed respectively. Secondly, compared to the spark ignition gasoline vehicle, the same type diesel vehicle becomes 30% more fuel-efficient on average and this figure will be 30%–40% if it is an advanced diesel vehicle. Thirdly, fuel consumption can be cut with the multiple and continuously variable gear-shift ratios application. For example, the fuel economy can be improved by 2%–3% with one more gear-shift ratio added in the transmission system. Lastly, it represents an important energy-saving solution to cut down the overall vehicle weight — the fuel economy can be improved by 6%–8% if 10% of the overall vehicle weight is cut off.

4 Low-carbon development of vehicle power train systems

In the broad definition, electric vehicles include pure electric vehicles (EVs), hybrid electric vehicles (HEVs), and fuel cell electric vehicles (FCEVs) [*Edwards*, 2006]. They are low carbon electrification power train systems and do not only use the conventional compression-ignition and spark-ignition internal-combustion engine (ICE).

There remains the bottleneck for driving power and battery life of EVs though they have been put in use for decades and have a simple structure. However, EVs achieve actual zero-emission during their traveling, and have very low energy consumption per kilometer driven, and their fuel economy is considered to be 300% more than for gasoline vehicles in the same period [*Zhang et al.*, 2008]. According to the calculation of *Ou et al.* [2010], the EVs which are currently showcased in China consume 150 kW h per 100 km and the fuel economy is 300% of the baseline diesel vehicles which use 45 liter diesel when running the same distance. From the life cycle analysis (LCA) covering all the stages of energy resource extraction, transportation, fuel conversion, distribution and storage, EVs can save 27% of the total primary fossil energy and reduce 10% of GHG emissions. With