Future transportation systems in China

ALTERNATIVE FUELS AND ADVANCED VEHICLE TECHNOLOGIES OUTLOOK

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With China's on-road transportation sector growing rapidly with projected carbon dioxide emissions in the billions of tonnes by 2050, China is looking at clean fuel alternatives in order to drive the sector and maintain growth.

INCREASING TRANSPORTATION DEMAND IN CHINA

Over the past three decades, China has experienced rapid growth in the population of motor vehicles with the annual growth rate over 10 per cent, a trend that is likely to continue. As a result, oil consumption and carbon dioxide (CO_2) emissions associated with on-road transportation are increasing fast. The Chinese government has been paying close attention to oil demand since the contribution of imported oil to Chinese total oil consumption keeps increasing; currently it is over 40 per cent. To relieve imported oil dependence, the Chinese government has been expanding considerable efforts to save oil use. In 2004, for example, China issued its first national fuel consumption standard for passenger cars (GB19578-2004) to improve vehicle fuel efficiency.

However, no matter how conservative the projection of future vehicle population is, current policy efforts still do not offset the increase in oil consumption. Carbon dioxide emissions from the on-road transportation sector will continue to increase. A recent study by Argonne National Laboratory and the Energy Foundation projected China's on-road vehicles consuming approximately 614-1,016 million tonnes of oil per year (12.4-20.6 million barrels per day) with associated emissions of 1.9-3.2 billion tonnes of CO_2 per year in 2050. This will put tremendous pressure on the balance of the Chinese and world oil supply and demand and could have significant implications on climate change.

FUTURE VEHICLE/FUEL SYSTEM OPTIONS

Recently, alternative transportation fuels and advanced vehicle technologies are being promoted to help solve urban air pollution problems, reducing greenhouse gas (GHG) emissions and relieving dependence on imported oil in the developed countries as well as the developing countries, such as China. These vehicle/fuel systems could be classified in two categories in terms of technology availability. The first includes those technologies which are readily available, such as compressed natural gas vehicle (CNGV), liquefied petroleum gas vehicle (LPGV), ethanol and biodiesel flexible fuel vehicle (E85 FFV) and grid-independent hybrid electric vehicle (GI HEV). The second category includes those technologies still under R&D and estimated to be ready in the next 10 to 20 years, such as hydrogen fuel cell vehicle, grid connected HEV (also called plug-in HEV), and pure electric vehicle (EV).

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CNG and LPG vehicles

Compared with conventional gasoline, CNG and LPG have around 20 per cent and 10 per cent lower carbon intensity, respectively, on the energy basis, eg per MJ of each fuel. As the upstream steps to produce a unit of LPG require less energy than gasoline, LPG can achieve more carbon reductions. If we consider from the fuel cycle point of view (also called well-to-wheels, including vehicle operation as well as upstream fuel production processes), both LPG and CNG vehicles could achieve 15 per cent -20 per cent CO_2 reduction versus conventional gasoline vehicle based on per km driven.

CNG and LPG vehicles in China have been increasing steadily over the past decade. For example, it was estimated that there were at least 200,000 CNG cars and buses in China by the end of 2006. In early 2007, more than 650 natural gas stations were built in China. In the near term, in those provinces with abundant natural gas resources, such as Sichuan Province, the penetration of CNG vehicles will continue to increase.

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Diesel vehicle

Diesel engines are inherently more energy efficient compared with their gasoline counterpart. As a result, diesel vehicles emit around 15 per cent lower CO_2 than their gasoline counterparts based on per km driven. The penetration of diesel cars to China's vehicle stock is pretty slow, primarily due to the concern of relatively high particle/NO_x emissions. Because the leading criteria air pollutant in most Chinese cities is PM10, the promotion of diesel cars will be limited without stringent controls on tailpipe particle emissions.


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However, dieselisation has been largely observed over the past decade in the category of commercial vehicles all over China.

Ethanol and biodiesel flexible fuel vehicles

China is the third largest ethanol producer worldwide, producing around one million tonnes of ethanol per year. Most of this ethanol is produced from corn. Current production of biodiesel is pretty small in China at around 100,000 tonnes a year. The biodiesel feedstock is primarily from used cooking oil or other animal oils. Bioethanol and biodiesel are considered as renewable fuels and carbon free because the carbon in the fuel originally came from the atmosphere via photosynthesis. However, corn or other agricultural food based ethanol production will be limited due to the concern of food safety issue in China. Furthermore, as coal is the primary process fuel for ethanol production in Chinese mills, upstream CO_2 emissions may offset the carbon benefit from such biofuel production. In the long term, the Chinese government is pursuing cellulosic biomass based fuels with biomass as the process fuel, which could make such biofuels close to a real carbon free. This effort, however, is still in an early R&D stage.

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Grid-independent hybrid electric vehicle (GI HEV)

Compared with a conventional engine counterpart, GI HEV is usually 30-50 per cent more energy efficient. The significant improvement of fuel economy makes hybrid vehicles probably one of the most promising vehicle technologies in the near future. Domestic car manufacturers in China are also putting a major effort in developing hybrid technologies. The Chery Company, for example, is planning to sell at least 50 per cent of its new cars with a hybrid system after 2010. There are no major technical barriers in the gird-independent hybrid technology. The hot sale of hybrid vehicles, led by Toyota, in North America,

Japan and other developed countries proves the success of GI HEV. This will only help to cut the cost of HEV to compete with its conventional engine counterpart.

Hydrogen fuel cell vehicle

The hydrogen fuel cell vehicle is considered to be one of the most promising vehicle technologies in the long run because of its high energy efficiency, zero carbon emissions and tailpipe pollutant emissions at the vehicle operation stage. Furthermore, hydrogen is an energy carrier instead of energy source. It could potentially be produced by various feedstocks, which means every region in China has some indigenous fossil or renewable resource that can be used to make hydrogen. For example, in Sichuan Province, hydrogen could be produced from natural gas; and in Zhejiang Province, hydrogen could be produced from nuclear or cellulosic biomass.

The hydrogen fuel cell vehicle is still in the early R&D stage and there are several major concerns to be addressed before its mass penetration. For example:

- The investment to develop a hydrogen infrastructure is huge.
- Coal is the majority fossil energy source in China. Producing hydrogen from coal without carbon capture and storage (CCS) may result in significant CO_2 emissions.

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Plug-in hybrid electric vehicle and electric vehicle

Similar to hydrogen fuel cell vehicles, plug-in hybrid electric vehicles (HEV) and electric vehicles (EV) are promising vehicle technologies in the long term. These vehicle technologies use another energy carrier, electricity. The advantage of plug-in HEV/EV compared with hydrogen fuel cell vehicles is that the electricity infrastructure is currently available. The disadvantage is the fact that majority feedstock of power generation in China is coal. Without CCS, these technologies will have tremendous CO_2 emissions at the upstream electricity generation stage. The plug-in HEV and EV are still in the early R&D stage in China.

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