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Car dieselization: A solution to China's energy security?☆

Yanjun Ding [a], Wei Shen [b,*], Shuhong Yang [a], Weijian Han [c], Qinhu Chai [a]

[a] Department of Thermal Energy, Tsinghua University, Beijing 100084, China
[b] Ford AP Research, Ford Motor Company, Unit 4901, Tower C, Yintai Center. No. 2 Jianguomenwai Street, Beijing 100022, China
[c] Ford AP Research, Ford Motor Company, Research & Innovation Center, 2101 Village Road, Dearborn, MI 48121-1437, USA

HIGHLIGHTS

- Econometric approach is employed to forecast fuel and oil demand.
- Dieselization is a potential policy option to improve China's oil security.
- In favorable conditions, dieselization will cut more than 200 Mt oil import in 2020.
- In some cases; however, dieselization may have limited effect on oil saving.

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ABSTRACT

Recently, there is a renewed interest in car dieselization in China to address the challenge of oil security. We developed an econometric model to estimate the vehicle fuels and crude oil demands. The results indicate that if the average travel distance of cars is maintained at the level of 2010–16,000 km/yr, and if the distillation products mix of the refineries remains unchanged, China's crude oil demand in 2020 will reach 1060 million tonnes (Mt), which also results in an excess supply of 107 Mt of diesel. A new balance of diesel supply and demand can be reached and crude oil demand can be significantly reduced to 840 Mt by improving the production ratio between diesel and gasoline on the supply side and promoting passenger vehicle dieselization on the demand side. The crude oil demand will be reduced to 810 Mt in 2020, if the vehicle travel distance gradually drops to 12,000 km/yr. If so, dieselization will provide a rather limited added value—only 6% further oil saving by 2020. Dieselization is not a silver bullet but it depends on a series of key factors: growth rate of gross domestic products (GDP), vehicle sales, and vehicle annual travel distance.

1. Introduction

China's auto market has experienced a decade of growth spurt. The vehicle sales increased more than nine fold, from 2.1 million in 2000 to 19.3 million in 2012. Fast growing private ownership of passenger vehicles[1] resulted in a significant increase in the demand for gasoline, which led to a surge in crude oil demand. Based on the current mix of distillation products in China's oil industry, 1 tonne of gasoline output corresponds to about 5 tonnes of crude oil demand. The crude oil demand reached 455 million tonnes (Mt) in 2011, including 254 Mt of imported oil. We predict that China's crude oil demand will be more than 1 billion tonnes and that oil import may reach 850 Mt in 2020. The projected oil import is equivalent to the total demand of the United States or one third of the global oil trade in 2011, which will pose a large challenge to China's oil security.

Oil processing is a complex poly-generation system. In China's oil industry, the output of diesel versus that of gasoline (production D/G ratio) is generally in the range of 1.8–2.4. It is anticipated that there will be a potential diesel surplus under this ratio range if gasoline demand surges while the whole economy cannot digest the corresponding diesel output.

Compared to gasoline engines, diesel engines have an advantage in energy efficiency. The lower fuel taxes for diesel further increase the popularity of diesel cars in many European countries. The average market share of diesel cars in 27 countries of the European Union (EU-27) was 54.9% in 2012, and was as high as 70% in France, Portugal, Ireland and Luxembourg (EEA, 2013).

Dieselization of passenger vehicles has been one of the hot topics in China's auto industry. The "Automotive Industry Development Policy" released by the National Development and Reform

* Corresponding author. Tel.: +86 10 85070828; fax: +86 10 85070888.
E-mail addresses: wshen5@ford.com, wshen1205@gmail.com (W. Shen).

[1] The word "passenger vehicles" mentioned in this paper is same as that cited in China's national standard <GB 27999-2011 Fuel Consumption Evaluation Method and Targets for Passenger Cars> (SAC, 2011a), which refers to a vehicle used for passenger transportation with a maximum design gross vehicle weight (GVW) no more than 3500 kg and no more than 9 seats.

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Commission (NDRC) in 2004 clearly proposed to focus on R & D of the diesel engine technology. In 2008, the Society of Automotive Engineers of China (SAE China), the Development Research Center (DRC) of State Council and the China Automotive Technology and Research Center (CATARC) jointly submitted a proposal to the government to accelerate the development of advanced diesel cars. Some international vehicle manufacturers, like Volkswagen (VW), began to develop diesel passenger vehicles for China's market from the early 1990s and launched several diesel models after 2002. However, the sales and market shares of diesel passenger vehicles have been very low, as shown in Table 1.

The discussion of dieselization has become more important since the release of the "Energy Savings and New Energy Vehicle Industry Development Plan (2012–2020)" by the State Council in July 2012. New targets for sales-weighted average fuel consumption of new passenger vehicles are highlighted in this industry guiding document: 6.9 l/100 km (l/100 km) in 2015 and 5.0 l/100 km in 2020 (State Council, 2012). The latter target seems very difficult to achieve, especially as the technological progress and market penetration of new energy vehicles (NEVs), including plug-in hybrid vehicles (PHEVs), battery electric vehicles (BEVs) and fuel-cell electric vehicles (FCEVs), has been far less than the government expected—the costs of NEVs are still much higher than those of traditional cars and private consumers seem unenthusiastic. To achieve the passenger vehicles' fuel consumption target in 2020, some experts in the auto industry turn to diesel technology, which has much higher energy efficiency than its gasoline counterpart.

For a long time, the largest obstacles to the development of advanced diesel passenger vehicles have been poor diesel quality and shortage of diesel supply. However, significant changes are occurring in both areas.

Sulfur content is the most decisive factor in passenger vehicle dieselization among the many parameters of diesel quality. Many studies show that combustion products of sulfur, such as sulfur dioxide and sulfate particulate, can seriously reduce the operating efficiency of the tailpipe emission control systems of diesel passenger vehicles, including the NO_x storage-reduction catalyst (Matsumoto et al., 2000; Amberntsson et al., 2002), lean NO_x trap (LNT) (Choi et al., 2007), soot oxidation catalyst (SOC) (Peralta et al., 2006) and selective catalyst reduction (SCR) (IFQC, 2009). Reduction of sulfur content has been proven very helpful in lowering particulate matter (PM) emissions of diesel passenger vehicles (ACEA et al., 2006; Zhang et al., 2009; Blumberg et al.,2003).

Prior to 2003, only one mandatory standard for light diesel fuel was in effect in China and the sulfur content limit was no more than 2000 ppm (ppm, by weight) (SAC, 2000). This standard covered diesel usage for road transportation, agriculture machinery, and some industry and power generation boilers. The high sulfur content in China's diesel has been a major barrier for advanced diesel engine technology in the auto market (as shown in Fig. 1). To improve the diesel quality, the dedicated automobile diesel standard was released in 2003, in which the limit of sulfur content was set to no more than 500 ppm to separate automobile diesel from general diesel (SAC, 2003). However, it was initially

Table 1
The sales volume and market share of diesel passenger vehicle in China during 2007–2012.
Source:CATARC, 2008–2012, 2013.

	2007	2008	2009	2010	2011	2012
Sales volume	43,542	56,526	80,469	125,567	77,595	83,888
Market share (%)	0.69	0.84	0.78	0.91	0.54	0.54

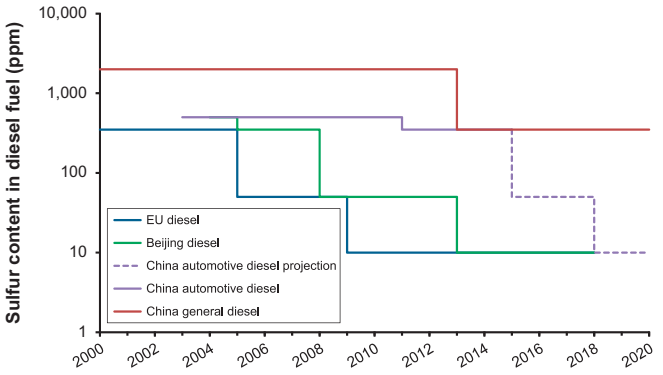

Fig. 1. The upper limit of sulfur content in China's diesel standards and projections for future.

only a recommended standard until 2009 when it was upgraded to a mandatory standard. The upper limit of the sulfur content in automobile diesel has been reduced to 350 ppm since July, 2011 (SAC, 2009). In the meantime, another new standard requires the ceiling of sulfur content in general diesel to also be reduced to 350 ppm after 2013 (SAC, 2011b). Beijing often releases tougher fuel standards than the national levels to deal with more and more serious air pollution challenges. The top limit of sulfur content for diesel fuel sold in Beijing was no more than 50 ppm in year 2008 (BBQTS, 2007). This standard has also been adopted by Shanghai and Guangzhou since 2009 and 2010, respectively. The most recent standard further reduces the sulfur content in diesel to 10 ppm, same as the Euro 5/6 fuel specification in EU (see Fig. 1). Using this kind of low-sulfur diesel, the tailpipe emission control systems can reach its maximum efficiency, making the emission levels of NO_x and PM of diesel passenger vehicles competitive with their gasoline counterparts. Information collected by our team shows that the Chinese state-owned oil giants have promised to reduce the sulfur content in automobile diesel to 50 ppm and further to 10 ppm nationwide during 2014–2017.

Diesel supply shortages have frequently appeared in China since the 1990s. However, China's supply and demand balance of road transportation fuels is changing rapidly, along with the surge in passenger vehicle sales in the last ten years. China became a diesel net exporter in 2009 and 2010, as shown in Fig. 2. However, this surplus was easily impacted by policy decisions (For example, when local governments decided to temporarily close coal-fired power plants to achieve the energy savings and GHGs reduction target set by the central government, the diesel demand for power generation skyrocketed at the end of 2010.).

Considering the progress in quality and supply of diesel, dieselization has recently become the renewed interest to meet the large challenge of China's oil security. The objective of this paper is to evaluate the potential of passenger vehicle dieselization and its impact on dependence of import oil and energy security. Using the bottom-to-up methodology, we developed a diesel & gasoline demand model and a crude oil demand optimization model. To achieve the oil security target, we analyzed the optimal diesel-gasoline balance structure and estimated the corresponding minimum crude oil demand till 2020 and provide some policy implications in the paper.

2. Methodology

A bottom-to-up module is established to evaluate the demand of diesel and gasoline in the future. The total crude oil demand will be calculated based on meeting the demands of both diesel and gasoline at the very least while taking into consideration the