Energy Strategy Reviews 4 (2014) 28–33

Contents lists available at ScienceDirect

Energy Strategy Reviews

journal homepage: www.ees.elsevier.com/esr

CASE STUDY

The controversial fuel methanol strategy in China and its evaluation

Hao Chen [a,b,*], Lu Yang [a], Peng-hui Zhang [a], Andrew Harrison [a]

[a] School of Automobile, Chang'an University, Xi'an, China
[b] Key Laboratory of Shaanxi Province for Development and Application of New Transportation Energy, China

ARTICLE INFO

Article history:
Received 20 October 2013
Received in revised form
28 June 2014
Accepted 3 July 2014
Available online

Keywords:
Fuel methanol
Energy strategy
Methanol automotive

ABSTRACT

Methanol has already been used widely throughout the whole nation. This paper firstly analyzes the strategic development of the use of methanol as a fuel in China, including standards, organization and the present situation. It points out the different standpoints at home and abroad on the highly controversial issue as to whether China should develop fuel methanol. Then it evaluates current strategies and introduces GHG emission as an evaluation method to be accepted both home and abroad. Recommendations for policies of fuel methanol are given to improve operation mode. It is suggested that only coal-abundant provinces should continue to use M5 as their alternative fuel for gasoline, while all other areas and provinces should gradually abandon the use of methanol. A small scale application of M85 and M100 should still be used for evaluating methanol's influence on the environment.

1. Introduction

Oil is non-renewable and its consumption soars with economic development. Since 2003, crude oil consumption in China has ranked second in the world [1]. Presently China's economy is growing at a breakneck pace, which contributes to the sharp increase in consumption. However, poor oil reserves can barely meet the oil demand and China's dependence on foreign oil has exceeded 50%, seriously threatening the Chinese national energy industry. Developing alternative fuels for vehicles is an effective approach for alleviating the pressures connected with the shortage of oil.

Common alternative fuels are still derived from fossil resources, such as natural gas (NG) and liquefied petroleum gas (LPG). There are three forms of NG used for vehicles: compressed natural gas (CNG), liquefied natural gas (LNG) and gas to liquid (GTL). CNG is in the predominant position and dual-fuel vehicles are designed or adapted for CNG fuel [2]. However, by 2012 in China NG reserve (3.1 trillion cubic meters) only accounted for 1.7% of the total and the global shares of production (107.2 billion cubic meters) and consumption (143.8 billion cubic meters) were 3.2% and 4.3% respectively [1]. Poor reserve resulted that NG share in primary energy consumption of China (4.73%) was far less than the shares of developed countries, such as 29.61% of the United States. Besides transportation fuels, NG is indispensable in domestic use, chemical industry, electricity generation and industrial fuels. Concerning about the poor reserve and the widespread use, in China NG can only be used on public transportation vehicles (buses and taxis) and commercial ones (trucks). As a result, most private cars are not allowed to be converted and application scale of NG on transportation is under limitation. The situation for LPG is the same.

Alternative bio-fuels derived from bio-resources are renewable and environment-friendly within the whole life cycle. The term 'bio-fuels' mainly refers to bio-diesel and fuel ethanol. Brazil and the United States lead the industrial production of ethanol fuel, together accounting for 87.8 percent of the world's production in 2010 and 87.1 percent in 2011. The two countries respectively use sugarcane and maize as feedstocks. Bio-diesel in the US is mainly derived from soybean and in Europe from rapeseed and some other sources [3]. In China, the fuel ethanol industry is widely used and actively promoted. It is mandatory to use E10 in nine provinces covering about one-sixth of vehicles [4]. Maize and wheat are the main raw materials. However, food price increases in 2008 affected social stability. So the government

* Corresponding author. School of Automobile, Chang'an University, the South Second-ring Road, 710064, Xi'an, China.
E-mail addresses: colen7680@126.com, huaze0550@aliyun.com (H. Chen), 544524157@qq.com (L. Yang), 962799259@qq.com (P.-h. Zhang), xiaandi@live.co.uk (A. Harrison).

http://dx.doi.org/10.1016/j.esr.2014.07.002
2211-467X/

realized that due to the large population, grain should only be used as food and not fuel, bringing production to an abrupt end. As a result, only non-grain feed-stocks, such as cassava, sweet sorghum, and cellulose materials, can be used for ethanol production and the development faces enormous challenges. Bio-diesel production and application in China is still in the initial phase and its prospect is uncertain.

Methanol fuel has been affirmed as a possible alternative energy source for use in vehicles [5]. Although methanol can be produced from a wide variety of renewable sources and alternative fossil fuel based feedstocks [6], in practice methanol is mainly produced from natural gas [7,8] and in China from coal. Because coal resources are relatively rich, methanol is considered to be the most important alternative fuel for gasoline and the best transitional fuel in the last twenty to thirty years [9,10]. This approach has caused intense domestic and international controversy.

2. Present status

2.1. Driving factor and development process

Before 2007 the fuel methanol industry developed spontaneously and this is called the first development stage. At that time, ethanol was compulsorily blended into gasoline in several regions to get an E10 mixture. As a result, horse meat was sold as beefsteak by substituting ethanol with methanol. Great economic benefit is a key driving factor, because methanol is much cheaper. Methanol has similar characteristics to ethanol and it is difficult to distinguish them. However, the oxygen content of methanol is higher than that of ethanol, and can achieve complete combustion and reduce HC and CO emissions. The influence of methanol on the engine's power performance can hardly be detected by the driver.

Confused management and poor operating standards in the fuel methanol industry has caused hazards and risks. In spite of this, six provinces with high methanol yields, Shanxi, Shaanxi, Inner Mongolia, Sichuan, Ningxia and Gansu, comprised an experimental region for the use of coal-based alcohol fuels, working according to their individual rules. Regional success promoted the development of the fuel methanol industry. The Chinese government promulgated the "Development report of China's alcohol and ether fuels and the clean automotives fueled with them" which set off a chain reaction for developing fuel methanol. The industry was extended to fifteen provinces and eleven of them formulated regional standards listed in Table 1.

Table 1
Application and regional standards for methanol gasoline.

Provinces	Application	Regional standards for methanol gasoline
Shanxi	M5, M15	DB14/T 92-2008 (M5, M15)
Xinjiang	M5, M15	DB65/T 2811-2007 (M5, M15)
Liaoning	M15	DB21/T 1478-2006
Sichuan	M10	DB51/T 448-2004
Zhejiang	M15, M30	DB33/T 756.1-2009 (M15), DB33/T 756.2-2009 (M30)
Shaanxi	M15, M25	DB61/T 352-2004 (M15), DB61/T 353-2004(M25)
Heilongjiang	M15	DB23/T 988-2005
Fujian	M15	DB35/T 919-2009
Jiangsu	–	–
Gansu	M15, M30	DB62/T 1874-2009 (M15, M30)
Guizhou	M15	DB52/T 618-2010
Hebei	M15	DB13/T 1303-2010

2.2. Present application

Methanol has a successful role as an alternative fuel, either by blending it with bio-products to produce bio-fuel or by blending it with gasoline [11]. Generally speaking, methanol-gasoline can be classified into low content methanol gasoline (M3-M5), middle content (M15-M30) and high content (M85-M100). "M" indicates the volume content of methanol except in the case of M100 where it indicates that it contains no gasoline but has other additives instead. In practice, M5, M10, and M15 are the usual forms of methanol gasoline in China. Ten provinces in particular have the regional standard for M15. For instance, in Shanxi province, so far more than one thousand gas stations sell M15.

2.3. Present consumption status

Although its application is on a large scale and wide ranging, the world fuel organization expressly prohibits the blending of methanol in vehicle fuels due to its corrosive nature, toxicity and potential harm to people's health. Accordingly, the Chinese government turns a blind eye to the fuel methanol industry and there is no official statistical data in regard to consumption. Only a general picture of the methanol industry can be statistically analyzed as listed in Table 2. Production capacity, yield and consumption soared recently. Capacity was much higher than the yield, mainly because enormous profits inspired the factories to over produce.

3. Development strategy

3.1. Developing high content methanol gasoline (M85 and M100)

Low content methanol gasoline has already accounted for a certain share in the vehicle fuel market. Gasoline vehicles can use it effectively without any structural change, which is convenient for the drivers. However, the low content means that the substitution effect is not obvious. Accordingly, the Chinese government has decided to develop high content methanol gasoline for certain purposes and expand the fuel methanol industry. When fueled with M85 or M100, engines must be specially designed [12]. Due to the low heating value of methanol, engines need to be adjusted by increasing the duration time of fuel injection to maintain power performance. Vehicles equipped with such engines are called methanol automotives.

Table 2
Data of methanol industry in China.

Year	Production capacity/10^4 tons	Yield/10^4 tons	Consumption/10^4 tons	Difference between capacity and yield
2002	386.00	231.80	411.70	154.20
2003	500.00	298.87	433.93	201.13
2004	600.00	440.64	573.21	159.36
2005	955.90	651.95	782.53	303.95
2006	1365.00	886.00	979.73	479.00
2007	1697.00	1218.00	1246.24	479.00
2008	2338.00	1285.00	1391.62	1053.00
2009	2628.00	1130.00	1657.42	1498.00
2010	3840.00	1752.00	2269.66	2088.00
2011	4654.00	2627.00	3195.80	2027.00
2012	5149.10	2640.46	3622.00	2508.64

Note: Data (2002–2011) from technology and market information for coal and coal chemistry in China for 2012.