A Brief Review of China's Methanol Vehicle Pilot and Policy

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Abstract

China has the world largest vehicle population and energy consumption, based on its own natural energy resources and methanol industry achievement, China has recently decided to use methanol nationwide as a transportation fuel to face the challenges of energy security and air pollution.

After 20 years of research and demonstration of methanol vehicles, in 2012 the Chinese government initiated a methanol vehicle pilot program led by the Ministry of Industry and Information Technology (MIIT). The 10-city, 5-province pilot program included over 1,000 vehicles running on neat methanol or M100. The pilot fleet accumulated nearly 200 million kilometers of operation using 24,000 tons of methanol. This pilot program verified methanol vehicle adaptability, reliability, fuel economy savings, safety, and environmental performance. During the pilot, industry standards for construction and safe management of methanol fuel fueling stations were developed and is now used as the guidance for the industry. Cities like Guiyang and Xi'an have now adopted aggressive plans to further expand M100 fleet and the methanol fuel refueling network.

Based on the positive results of the pilot, the significance of the development is the recent promotional policies for methanol vehicles and methanol as a transportation fuel which was released by eight government ministries and agencies on 19 March 2019[1]. This is the first time such a policy was aligned and endorsed by all the key government agencies concerning the development of methanol as a clean transportation fuel and it will enable consumer's free choice to purchase methanol fueled vehicles and mass application of methanol vehicles under further preferential policies from central and local governments. Chinese OEMs have produced a number of new light- and heavy-duty vehicle models, with 32 models certified by MIIT for commercial sales. Leading the mass production of methanol vehicles, Geely Auto has established production facilities capable of producing of 300,000-500,000 units of methanol engines and cars at manufacturing bases in China. Within five years, the fleet of M100 vehicles in China could reach 50,000 cars, trucks and buses, consuming more than 500,000 metric tons of methanol (166 million gallons/628 million liters).

[1] Guidance of Developing Methanol Vehicles Applications in Some Parts of China, MIIT, http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757016/c6684042/content.html

Background

Followed 40 years of global efforts on using methanol as an automobile fuel, based on China's own energy resources position -- "Rich in coal and rare in oil and gas" -- China began its own research work on methanol vehicles. Fueled by high concentration methanol blends from the late 1980s, international OEMs like Volkswagen and Ford were involved in the early stages of China's efforts, and then Chinese OEM like First Automobile Works (FAW) and Geely Auto tested their own prototypes under national research programs.

Energy security and clean air concerns are driving forces for the Chinese government to develop methanol vehicles in this century. As China has become the world's largest automobile market and crude oil consumer, tailpipe emission from a total of 310 million vehicles in China has become a major contributor to the air pollution[2]. The growing population of vehicles also exacerbates the energy security risk, as China consumes 126 million metric tons (MMTs) of gasoline and 156 MMTs of diesel in 2018, with 903 MMTs of crude oil consumption, with an overseas import dependency of over 70%[3].

To address the technical and other concerns for the development of methanol vehicles, MIIT initialized its Methanol Vehicle Pilot in 2012. The pilot began with 150 Geely M100 taxies in Jinzhong City, Shanxi Province. The Pilot then expanded to other cities in Shanxi, Shannxi, Shanghai, Guizhou and Gansu, with over 1000 vehicles in total. The MIIT Pilot program closed in 2018 with positive results in durability, emission including formaldehyde, environment impact, and human health effect.

As Chinese methanol vehicle R&D was expanding, the Chinese domestic methanol industry has grown to the world's largest producer and consumer, with annual demand reaching 45 million metric tons in 2018 (15 billion gallons/57 billion liters. Energy and fuel applications have also become key components of methanol consumption in China, such as methanol gasoline blending, direct methanol fuel in automobiles (M100), cook stoves and boilers, MTBE & DME production, total of which takes 40% of China's methanol consumption in 2018.

1. The Pilot and its implementation

1.1 Government Requirements

The Pilot was announced by the **Notice on Launching Methanol Vehicle Pilot Project (MIIT's Energy Conservation No.42, 2012)** by MIIT in January 2012. The notice includes the overall thinking, major objectives, basic principles, plan compilation, organizing work and operation, and other contents.

As a vehicle performance verification program, MIIT regulated the pilot projects to be carried out strictly in

[2] Ministry of Ecology and Environment of PRC, China Vehicle Environmental Management Report 2018, http://www.vecc-mep.org.cn/huanbao/content/944.html

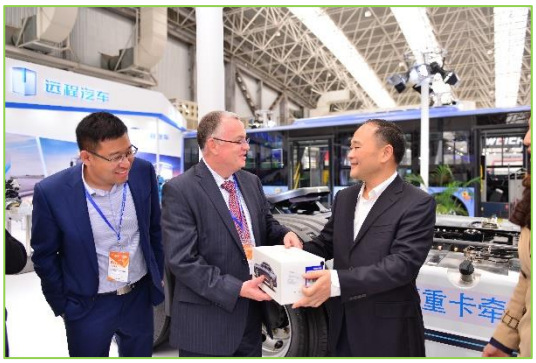
[3] China Petroleum and Chemical Industry Federation (CPCIF), Annual Report of Chinese Petroleum and Chemical Industry Economy Operation, 29th of Jan, 2019

compliance with government permit regarding issues related to the piloting areas, methanol fuels and methanol vehicles: only M85 and M100 methanol fuels were permitted in the piloting areas which were Shanxi, Shannxi and Shanghai in 2012; and two more areas, Gansu and Guizhou joined in 2014. The M100 methanol fuel is regulated to comply with "***GB/T23510-2009 Fuel Methanol for Motor Vehicles***" standard. Methanol fuel production, supply and refueling had to be government-authorized. Methanol vehicles in pilot areas were those included in the Announcement Vehicle Producers and Products by MIIT and meeting methanol vehicle products technical requirements by MIIT. The operator of methanol vehicles also had to be government-authorized. The number of methanol vehicles were verified and approved by MIIT. Methanol vehicles were driven in designated areas or routes.

1.2 Leadership and Working Bodies

In order to ensure the smooth operation of the pilot project, a leading group was established in MIIT in 2010. Headed by the vice-minister, the leading group is comprised of the heads of several departments and bureaus, including Department of Energy Conservation and Resources Utilization, Department of Raw Material Industry, Department of Planning, Department of Industrial Policies, Department of Equipment Industry, Department of Science & Technology, and Department of Finance. The leading group office was set up under Department of Energy Conservation and Resources Utilization, and is in charge of formulating working plans and facilitating priority issues.

Further, to ensure the smooth operation of the pilot project, an expert panel was set up by MIIT in 2012. The panel is made of experts from multiple fields, including the fields of energy, internal combustion engine, vehicles, oil products, chemical industry, public health, and environmental protection. Experts played an important role in launching field visits to the pilot areas, putting on record and reviewing implementation plans, proving important technical issues, and reviewing and approving important documents.



Some provincial and municipal-level industry and information technology (economy and information technology) authorities and pilot cities set up such working bodies as Pilot Technical Data Collection and Processing Center.

China Internal Combustion Engine Industry Association (CICEIA), China Association of Alcohol and Ether Fuels and Automobiles (CAAEFA), China Association of Automobile Manufacturers (CAAM), National Institute of Occupational Health and Poison Control under Chinese Center for Disease Control and Prevention, Tianjin University, Beijing Institute of Technology, the Methanol Institute, and other organizations as supportive institutions completed the work entrusted by MIIT, and thus facilitated the smooth implementation of the pilot project.

1.3 Related Administrative Measures and Technical Specification

To guide local government on the pilot implementation, apart from Methanol Vehicle Products Technical Requirements issued in the **Notice on Launching Methanol Vehicle Pilot Project (MIIT's Energy Conservation No.42, 2012)**, Methanol Vehicle Pilot Project Implementary Plan Compilation Guideline was

released by MIIT in 2012. In 2013, MIIT issued **Administrative Measures for Methanol Vehicle Pilot Project Technical Data Collection**, which defined the data to be collected and the collection method. In 2015, MIIT issued ***Guidelines for Construction of Methanol Fuel Fueling Stations*** and the ***Guidelines for Safety Operation of Methanol Fuel***, which not only helped the government departments with the approval and acceptance work related to the methanol fueling station projects by providing technical data, but also guided and standardized safety management work in the pilot project.

1.4 Other supportive policy by the local governments

In order to ensure the smooth implementation of the pilot project, related provincial and municipal-level industry and information technology (economy and information technology) authorities actively coordinated the efforts of functional departments within the province to solve policy-related issues, arrange dedicated funds and do other important work involved in the project implementation. Also, in order to ensure the smooth implementation, the municipal governments of those pilot cities coordinated the efforts of municipal-level functional departments in addressing the following major issues: taxi license quota, the construction of fueling stations, methanol fuel safety issues, purchase tax exemption, and motorway tolls exemption for methanol vehicles.

2. Results and Achievements of the Pilot

After roughly six years' operation, MIIT began to organize acceptance reviews for each pilot city together with National Development and Reform Commission (NDRC), Ministry of Science and Technology (MOST), experts from other related ministries were also invited.

2.1 General Review

Under the pilot program, 1,024 methanol fueled vehicles were placed into operation in Jinzhong, Changzhi, Xi'an, Baoji, Yulin, Hanzhong, Lanzhou, Pingliang, and Guiyang, including 904 Geely M100 methanol taxis, 100 M100 methanol buses of Zhengzhou Yutong Bus, 5 methanol/diesel duel fuel tracks from Shaanxi Heavy Auto Enterprise, and 15 M100 multi-function automobiles from Shaanxi Tongjia Automobile Co., Ltd. Average vehicle running time is over two years in average with the longest running time of three years. The total pilot mileage is over 184 million kilometers, with methanol fuel consumption over 24,000 metric tons. 32 models of methanol vehicle were certified in the pilot. Some cities expanded their methanol vehicles operation fleets, and the total number of methanol vehicle being operated in China reached over 7,000 units in 2019. The latest methanol vehicles operation in China is shown in Table 1 below.

Table1 Methanol Vehicle Operation in China（by February 2019）

Province	City	Vehicle Type	Vehicle No.
Shanxi	Jinzhong	Taxi	260
	Changzhi	HD Bus	96
Shanghai	Minhang	Taxi	18
Shannxi	Xi'An	Taxi	3,897
	Baoji	Taxi	200
		Mini MPV	15

	Yulin	Self-Dumping Truck	5
	Hanzhong	Taxi	20
Guizhou	Guiyang	Taxi	5,380
Gansu	Lanzhou	Taxi	150
	Pingliang	Taxi	50
		Total	10,091

In the pilot review, only a few vehicle malfunctions were observed in the initial operation stage, owning to the methanol fuel quality caused by the re-construction of fueling facilities. Apart from these initial teething issues, no concentrated technological failures occured, no human health impact was undermined due to methanol, nor did serious safety accidents concerning methanol poisoning and death occur. All pilot vehicles operated smoothly, and all performance indicators and daily maintenance correspond to that of traditional fuel (ie. gasoline and diesel) vehicles.

In the pilot, health checks were conducted on 1,199 people from a variety of occupations with potential methanol exposure like vehicle drivers & maintenance works, fueling station staff, operators in methanol fuel blending: no human health issues were observed. Methanol vapor levels were also measured under the commission of MIIT by the National Institute of Occupational Health and Poison Control under Chinese Center for Disease Control and Prevention. Samples were taken from vehicles, fueling stations, maintenance garage, etc., and all the results are below the national standard of PC-TWA 25mg/m^3 and PC-STEL 50 mg/m^3.

Fuel Economy

The fuel used in the pilots was mainly M100 fuel with technical agreement between auto producers and fuel blenders so there were no major quality issues discovered in the pilots. Fuel additives were used in the M100 fuel, with cost of 80RMB per ton of M100 fuel, roughly no more than 5% of the total cost of the methanol fuel.

From the pilot work in Jinzhong of Shanxi Province, calculated by the total operation mileage and fuel sales volume, the M100 methanol fuel consumption for Geely taxi is 15.3 liters/100km, the energy consumption is 237.8MJ; a comparison of taxi fuel cost among M100, gasoline and Compressed Natural Gas (CNG) for the local taxi is calculated in the pilot as:

Table 2 Taxi Fuel Cost Comparison of Taxi in Jin Zhong City

	Gasoline	CNG	M100
Fuel Price RMB/L	5.51	3.5 RMB/m^3	1.8
Fuel Economy L/100km	8	8.8 m^3/100km	13.5
Fuel Cost Saving %	37.5	10.6	--

Note: the fuel price is based on the operation in November of 2015;

From the pilot work in Yulin City of Shannxi Province, based on the test of the coal transportation company, the M100 methanol fuel consumption for a dual fuel truck with Diesel-Methanol Compound Combustion (DMCC) technology, without load is 20.9 liters/100km, and diesel consumption is 16.8 liter, the total energy consumption is 925MJ. The M100 methanol fuel consumption for full-loaded is 24.75 liters/100km, the diesel consumption is 25 liters/100km, and the total energy consumption is 1277MJ.

From the pilot work of Changzhi City of Shanxi Province, according to the city bus operation company, the methanol fuel consumption for M100 methanol bus is 51liters/100km, the energy consumption is 750MJ/100km; According to the customer, the M100 methanol fuel consumption for M100 methanol fuel multi-function automobile is 16.5 liters/100km, and the energy consumption is 257MJ.

2.2 Human Health and Environment Impact

In the pilot program, health checks were conducted on 1,199 people from a variety of occupations with potential methanol exposure like vehicle drivers & maintenance works, fueling station staff, operators in methanol fuel blending; no human health issues were observed. Methanol vapor level were also measured under the commission of MIIT by the National Institute of Occupational Health and Poison Control under Chinese Center for Disease Control and Prevention. Samples were taken from vehicles, fueling stations, maintenance garage, etc., and all the results are below the national standard of PC-TWA 25mg/m^3 and PC-STEL 50 mg/m^3.

Methanol improves the tailpipe emission for the methanol vehicles, which were certified complying with China National 4 Emission standard in the pilot. During the pilot, three passenger cars with mileage over 60,000 km of each were randomly picked and tested in China Automobile Technology and Research Center (CATARC), the results and required emission level are shown in Table 3:

Table 3 Tailpipe Emission Result of Passenger Cars in the Pilot

Vehicle No.	Mileage (km)	Test Items (g/km)							
		HC (g/km)		CO (g/km)		NOx (g/km)		HCHO (mg/km)	
		Limit	Result	Limit	Result	Limit	Result	Limit	Result
1	65030	0.10	0.04	1.00	0.39	0.06	0.05	10	0.737
2	79210	0.10	0.07	1.00	0.69	0.06	0.05	10	0.605
3	64552	0.10	0.05	1.00	0.60	0.06	0.04	10	0.733

For the formaldehyde emission, the tests followed the technical requirements in the pilot and the results shown are all below the required limit of 10mg/km. The 10mg/km formaldehyde emission limit was decided according to past requirements from the State of California in the United States, when there were methanol vehicles certified.

2.3 Fueling Infrastructures and Venting

In the pilot period, 20 fueling stations for methanol fuel were put into use, with 13 fixed stations and 7 skid mounted stations.

Compared to the gasoline/diesel fueling stations, the cost of building a methanol fuel fueling station with the same standard and scale is roughly equivalent. From the experience from Shanxi Province, excluding the land lease, project approval and inspection cost, a methanol fuel fueling station of 4*40m^3 storage tanks and 4 pumps with 16 guns, costs 3.2 million RMB (USD$475,000). To retrofit gasoline/diesel station of one storage tank and one pump with 4 guns with additional work on gasoline/diesel pipeline sealing and censoring, the total cost is no more than 30,000 RMB (USD$4,500).

The price of the methanol fuel sold in the stations were determined by the operators based on the market. Usually, the methanol fuel price changes according to the local retail price change of gasoline and natural gas, which are directly impacted by the global oil price.

Cities of Guiyang and Xi An have issued local promotional policies to encourage wide deployment of methanol fueling stations, with planned numbers targeting at 35 by 2020 and 45 by 2019 respectively.

3 Future Trend

3.1 Policy

It is expected that the methanol vehicles in China will follow a “pilot-expansion-promotion” strategy to gain more market share first from pilot areas then to other regions of the country. In the 2019 policy, the registration limitation is released, so that consumers can buy a methanol fueled vehicle from the market and have the vehicle registered.

Unlike electric vehicles (EVs), the Chinese central government does not offer subsidies to methanol vehicles, but leaves the right to adopt subsidies to the local governments. Governments of Shanxi Province, Gui Zhou Province and Xi An City provide subsidies for methanol vehicles, roughly about 5,000 RMB (USD$750)/passenger cars and 10,000 RMB (USD$1,500)/commercial vehicles. China is reducing the subsidies for EVs, and the cash subsidy will be down to zero after 2020; “Passenger car producer average fuel consumption and new energy vehicle credits, also called “Double Credit Scheme” will be introduced to encourage automakers to produce more vehicles with higher efficiency and cleaner fuel by providing positive credits, whereas gasoline/diesel vehicles are given negative credits. Automakers with net-negative credits shall buy enough credits or will received penalties. MIIT is studying how to involve methanol fueled vehicles into this credit scheme: by giving proper credits, automakers can improve their credit balance sheet by introducing methanol vehicles without the huge investment associated with other types vehicles.

More national and even international standards are expected to be made or upgraded, in the area of vehicles, key components, M100 fuel, construction and maintenance of fueling stations. During the period of the Pilot, China's vehicle emission standard is evolving fast from National IV in 2012 to National VI by 2019. Based on the pilot testing, it is certain that future methanol vehicles shall comply with the latest emission standard, i.e. National VI. Formaldehyde and unburnt methanol emissions reductions are also required with even lower limits for different types methanol vehicles when certified.

3.2 Methanol Vehicle Production

Encouraged by MIIT's pilot, OEM's in China are developing more methanol fueled vehicle and engine models as solution to achieve future requirement from customers and government regulation.

Geely Auto

Geely Auto and its affiliated companies started R&D work of methanol cars from 2005. At present, Geely Auto has released methanol versions of passenger cars based on its current product platform, with the mass production of methanol vehicles now underway. Geely has invested and complete the manufacturing facilities of 300,000-500,000 units of methanol engine plants and methanol vehicle manufacturing bases in the cities of Jinzhong, Guiyang and Nanchong.

Not only cars, Geely is also producing trucks and buses. Geely Commercial Vehicle Division has demonstrated a methanol heavy-duty truck and a bus for the future market.

Geely is also at the forefront of methanol vehicles in racing. In the 2019 Dakar Rally, the GEELY AUTO SHELL LUBRICANT COOPER TIRE team uses M100 fuel in their racing cars.

Tianjin University

Research team led Prof. Yao Chunde in Tianjin University has developed a new technology for using methanol in heavy-duty compression ignition engines -- DMCC (Diesel/Methanol Compound Combustion) -- which starts the engine with only diesel fuel, and switches to diesel methanol dual fuel after the engine fully warms up. This technology avoids the shortcomings of methanol difficultly with cold start and gives full play to the advantages of the two fuels. With this technology, the engine has two separate fuel systems. This is not only a conversion technology for existing heavy-duty (HD) vehicles, but also works for new commercial vehicles.

Tianjin University has worked with Chinese OEMs including Shannxi HD Trucks Group, Sinotruck, Weichai Power and Yu Chai for different models of engines and trucks, with field demonstrations carried out in many provinces of China.

FAW

Extensive R&D work has also been conducted by FAW, its car division has developed M85 demonstration car

and their commercial vehicle division has produced some models of M100 trucks which were trialed in coal mines. Its joint venture FWA JY also provided HD engines to Yu Tong Bus, which produced 100 M100 buses for the MIIT pilot in Changzhi City of Shanxi Province.

Other OEMs, which are developing methanol vehicles, includes Brilliance Auto, BAIC, Shanxi Tongjia Auto, Shanxi Chenggong Auto. The two biggest HD engine producers, Wei Chai and Yu Chai are also developing their own methanol fueled engine models. Other key technology providers includes Fuel Injection Technologies (FiT) for engine injection and calibration technology, and Liu Zhou Original Co. for dedicated methanol fuel injectors.

Other Innovations

As a clean and affordable transportation fuel, methanol can also bridge the gap for the China's booming vehicle electrification. New technologies to utilize methanol in such vehicles are also being developed in China. Olah Motors uses methanol to produce electricity via a small internal combustion engine for EV range extension; Olah Motors has established a fleet of 30 methanol range extended lorry trucks in current trails. Palcan and Hydrogen Co., are using methanol as hydrogen carrier for PEM Fuel Cells. Palcan's first Reformed Methanol Fuel Cells (RMFC) vehicle has been certified and five vehicles are now in trial operation.

Summary

Built on the success of the MIIT-led M100 Pilot Program, China has made significant progress in promoting methanol as a clean fuel from addressing challenges from both energy security and air pollution.

The recent policy jointly endorsed by the eight government ministries and agencies will further promote fuel applications in a more coherent and systematic way. We expect implementing policies will be issued by provincial government. To date, Guiyang and Xi'an have set excellent examples.

The M100 engine technology development that has been led by Geely and other domestic OEMs will be widely used in cars, trucks, and buses across China.

We continue to see the importance of promoting best safe handling practices critical to help ensure a sustainable development of methanol fuel applications in the country. China has also made it clear that it will help promote this application outside China. This will provide opportunities for the Methanol Institute and its members to participate in the methanol fuel application growth in the country and help share the best practices of China to other countries.

About the Author:

Mr. Kai Zhao serves as the Methanol Institute's China Chief Representative, based in Beijing. In this role, Mr. Zhao is responsible for supporting and advancing the association's public policy activities in China. He provides strategic development and tactical leadership in MI's government relations activities in China, including liaising with MI members, affiliated Chinese trade associations, government officials, and media on areas affecting the methanol industry. Mr. Zhao is also responsible for helping to drive initiatives aimed as

fostering the save use and handling of methanol and derivative products in China.

About the Methanol Institute (MI):

MI serves as the global trade association for one of the world's most vibrant and innovative industries. Founded in 1989, MI represents methanol producers, distributors, and technology providers in every corner of the globe – from our headquarters in Singapore and regional offices in Washington, D.C., Brussels, and Beijing. MI and its members dedicate significant resources to developing best practices for the safe handling, transportation, and use of methanol. www.methanol.org

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