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Policy Recommendations for Supporting the Development of Low Carbon Automotive Fuels in China

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This Report has been prepared with the assistance of the Energy Foundation China Sustainable Energy Program in Beijing by Ms Kang Liping, Mr. Robert Earley and Dr. Feng An at the Innovation Center for Energy and Transportation (*i*CET).

The purpose of the Report is to disseminate information on the policy needs of low carbon transportation fuels in China.

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Disclaimer

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Abstract

The Significance of Developing Low Carbon Automotive Fuels

In 2009, vehicle production and sales volume reached 13.79 million and 13.64 million, respectively, at an increase of more than 45%, making China the world's largest automobile market. Automotive fuel consumption has already surpassed 100 million tons, accounting for nearly a third of total fuel consumption. At the same time, automotive fuel lifecycle GHG emissions have reached an amount equivalent to 480 Mt CO2 eq. Over the next 30 years, car ownership, vehicle fuel consumption, and GHG emissions will sustain an upward trend; energy security and GHG emissions will also come under increasing pressure.

"Low carbon automotive fuel" refers to fuel which, through its full lifecycle (including the production and transportation of raw materials, fuel refining and storage, fuel consumption as well as other related emissions) of GHG emissions (grams of carbon dioxide equivalent) per unit of energy intensity (i.e., carbon intensity – g CO2e/MJfuel) below a baseline fuel emission level. Development of these fuels can improve national energy security, and help China to attain GHG emission intensity reduction targets; at the same time, innovation in the automotive industry and fuel technology industry, and enhancements in the competitiveness of the industry will become a driving force that ought to induce the government to place a great deal of importance on developing a strategic plan to encouraging and guiding the development of low carbon vehicle fuels.

What is a Low Carbon Automotive Fuel?

The future development of China's automotive fuels will be multi-faceted, so the method for determining low carbon evaluation criteria for low carbon automotive fuels must uphold the basic principles of comprehensiveness, authority, transparency, impartiality, and neutrality. Indeed, automotive fuel carbon intensity should be taken as the fundamental indicator. In light of the these principles, seven organizations, under the leadership of the Innovation Center for Energy and Transportation (*i*CET) and the guidance of the China National Institute of Standardization (CNIS) have drawn up two national standards: *Principles and Requirements for the Appraisal of the Lifecycle GHG Emission from Transportation-related Fuels* (national standard planning number: 20091267-T-469) and *Requirements for Reporting and Verifying the Lifecycle GHG Emissions from Transportation-related Fuels* (national standard planning number: 20091268-T-469), to establish a basic method for the determination of China's low carbon vehicle fuel.

Vehicle fuel carbon intensity is directly related to the type of feedstock used to make fuel, fuel production technology, technological standards, and automobile energy conversion technology. Given their normal carbon intensity values, coal-based methanol, direct

liquefied coal-to-liquid oil fuels (CTL), and other coal-based liquid fuels, are more than twice that of conventional gasoline and diesel, and are called “high carbon fuels.” Compressed natural gas (CNG), liquefied petroleum gas (LPG), and other “clean gas” fuels have carbon intensities 30-40% lower than standard petroleum fuels. Finally, many biofuels have even lower carbon intensities, with “second generation” cellulosic ethanol fuels offering GHG emission avoidance potentials of up to 60%, and used cooking oil biodiesel offering even greater proportions. Electricity and hydrogen “fuels” also have the potential to reduce the lifecycle GHG emissions of automobile transport. “Clean gas”, advanced biofuels, electricity and hydrogen fuels are all considered to be major potential sources of low carbon alternative automotive fuels.

Through the analysis of the technological maturity China’s automotive fuel technologies, strength of policy support, potential for reducing GHG emissions, industrial outlook, international competitiveness, it was found that the practical application of electric drive technology, hybrid technology, natural gas and LPG technology, and second generation biofuel technology all received a positive evaluation: the outlook for all four industries was optimistic, and international competitiveness strong. These results should guide China’s thinking on the development of low carbon automotive fuel, and through these fuels and industries, the large potential for reducing the GHG emissions from transportation should be vigorously promoted.

Conditions of and Challenges to Low Carbon Automotive Fuel Development in China

Natural gas and LPG, biofuels, electricity and hydrogen fuels, and other low carbon vehicle fuels have been given certain policy support by China, and have gradually developed a fixed share of the market. However, generally speaking, a clear plan and objective does not yet exist, policy support and implementation measures are not in place, key technological breakthroughs are needed, and the market system and standardization system need perfecting, among other issues. In particular, there is a lack of a real central “low carbon intensity” policy orientation. At the current stage, “low carbon automotive fuels” must obtain powerful government support, and only then will have space to develop and survive; this is the only way to realize the development of China’s future vehicle fuels.

International Experiences in Low Carbon Vehicle Fuels

It is worthwhile for China to draw lessons from international advances made in low carbon automotive fuel policy. The California “Low Carbon Fuel Standard (LCFS)”, the US “Renewable Fuels Standard II (RFS II),” the EU’s “Fuel Quality Directive (FQD),” and corresponding policies of member countries, take reducing the carbon intensity of fuel as their goal. Japan and Germany vigorously support transport electrification applications, promote the development of electricity and hydrogen fuels as automotive energy sources, and use all means to promote the continued development of low carbon electric vehicles. Brazil, in accordance with its own country's characteristics, wholeheartedly supports developing biofuels and reducing average carbon fuel intensity. The development of China's low carbon vehicle fuels, then, must progress according to the conditions of its own country while taking into account prior international experience, development in the direction of diversification, and major technological breakthroughs.

Alternative Vehicle Fuel and GHG Emission Scenario Analysis

This research undertook three major scenario analyses: a business as usual scenario, based on IEA projections, a biofuel support scenario, and a CTL support scenario to demonstrate the effect of fuel type on carbon intensity of the Chinese fuel system. In the biofuel scenario, it was found that by meeting its current biofuel consumption targets to replace fossil fuel by 2020, China could achieve 25 Mt CO_2eq in avoided emissions, or 3.5% of total gasoline and diesel emissions. Assuming that by 2030, China could achieve national E10 and BD5 mixing standards, avoided emissions could amount to 83 Mt CO_2e, 4.9% of total gasoline and diesel emissions.

However, the use of "high carbon" automotive fuels assumed in the CTL support scenario demonstrated that by 2020 and 2030, China could see increases of 100 Mt and 235 Mt CO_2e, respectively, in GHG emissions, an increase in the average automotive fuel carbon intensity of 7.7% and 10.5% respectively. Through the use of carbon capture and storage technology, this value could be brought in parity with the business as usual scenario, successfully demonstrating that liquefied coal automotive fuels will never be "low carbon."

Actively Promoting the Development of "Low Carbon" Electric Vehicles

Developing electric vehicles could have great significance for alleviating China's dependence on imported oil, but electricity "fuels" and electric vehicles must not be blindly expanded based on their potential for GHG reduction. The carbon intensity of electricity fuels, power sources, efficiency of electric vehicles, and other key technologies are all closely linked.

China should first give priority to its electric and electric coal infrastructure: from the perspective of China's current stage of technological development and electric infrastructure, the GHG emission reduction capability of electricity fuel is limited, but has rather large potential. Actively promoting the development of "low carbon" electric vehicles and improving GHG emission reduction potential, are important scientific management methods, and are keys to resolving the sustainable development of vehicle energy sources.

Policy makers should incorporate electricity fuel into the low carbon automotive fuel system, and continuously guide the development of electricity fuel in a low-carbon direction.

Objective of Developing Low Carbon Automotive Fuels

If China wants to develop a low carbon automotive fuel system, it must place great importance on supporting the development of the companies that can produce such fuel. One important condition is that the government must make mandatory rules regarding the use of alternative fuels as well as the use of alternatives that will reduce lifecycle GHG emissions. The government must also focus on improving the innovation system that can help produce fuels increasingly lower carbon intensity fuels.

Through initiatives such as the promotion of pilot projects, policy initiatives, and commercial applications, industry could be induced to produce fuels that will result in an average vehicle fuel GHG emission intensity 10% lower than 2005, by the year 2030. This industry, given the right incentives, could be a world-class innovator setting and meeting product and technical standards around the world.

Policy Recommendations for Developing Low Carbon Automotive Fuels

Seven policy recommendations have been put forward:

(1) Promote the diversification of various vehicle fuels, and furthering coordinating technological development with low lifecycle greenhouse gas emission kept in mind;

(2) Support the sustainable development of environmentally sustainable biofuels, and meeting or exceeding established consumption targets;

(3) Circumvent the rapid development of high carbon, coal-based liquid fuels; develop advanced, “lower carbon” coal-to-liquid fuels that can be developed commercially in times of national crisis, but do not promote them under normal conditions;

(4) Establish an organ in government responsible for low carbon sustainable development of automotive fuels within the nation’s functional departments, or clearly define a group that is regularly responsible for this task between the offices of related departments.

(5) Found a “Key State Laboratory for Automotive Fuel Lifecycle Research” ;

(6) Develop a “two-step” low carbon vehicle fuel policy mechanism;

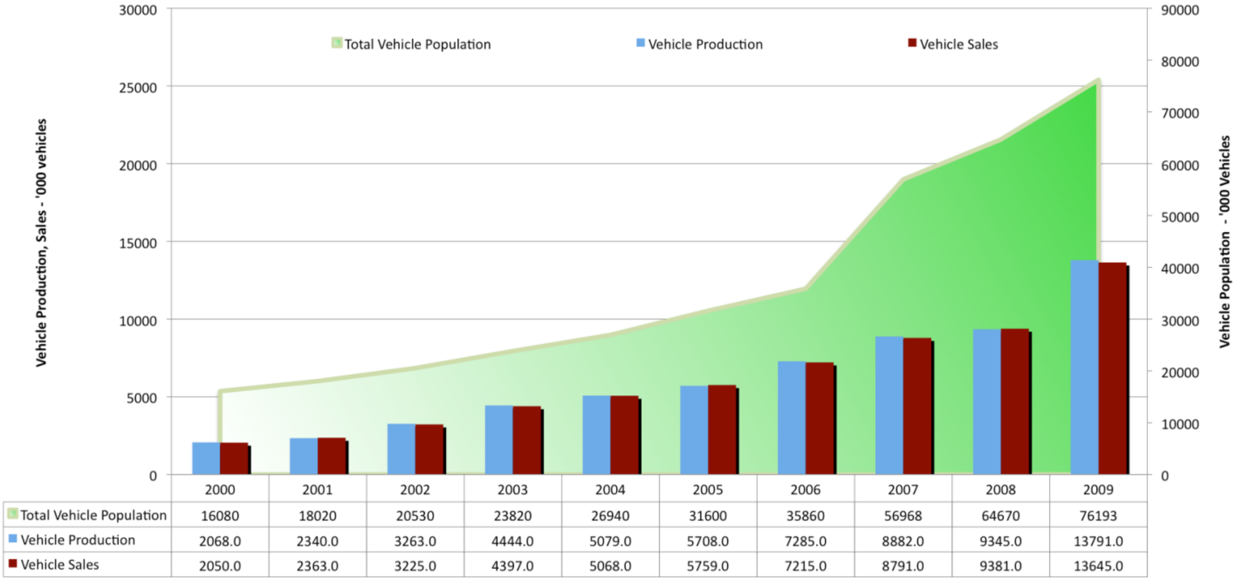
Step One: Establish an information system for reporting and verifying information about the carbon emissions and environmental sustainability China’s vehicle fuels;

Step Two: Based on the information collected from several years of information reporting, establish a default value for China’s GHG emissions.

(7) Establish a reasonable mandatory target for the use of low carbon automotive fuel in China that will achieve a lower target average fuel carbon intensity.

Foreword

China has witnessed momentous development in the automobile industry since the beginning of the 21st century. The average annual growth rates of automobile production and sales volume between 2000 and 2009 registered at 24.2% and 24.0% respectively. In 2009, automobile production and sales volume amounted to 13.79 million and 13.64 million respectively in 2009, both surpassing that of the US. This makes China the largest automobile producer and seller in the world, up 47.6% and 45.5% year-on-year. Growth and production of vehicles still maintained a 40% growth rate in the first half of 2010 compared with the same period last year, with a total average annual growth rate of about 20% since 2000. The vehicle population in 2009 reached 76.19 million, up nearly four-fold from that in 2000 (fig. 1).



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
🟩 Total Vehicle Population	16080	18020	20530	23820	26940	31600	35860	56968	64670	76193
🟦 Vehicle Production	2068.0	2340.0	3263.0	4444.0	5079.0	5708.0	7285.0	8882.0	9345.0	13791.0
🟥 Vehicle Sales	2050.0	2363.0	3225.0	4397.0	5068.0	5759.0	7215.0	8791.0	9381.0	13645.0

Figure 1 Vehicle production and cumulative population (China, 2000-2009)
Source: China Automotive Industry Development Annual Report (中国汽车工业发展年度报告)

At the same time, China's GDP maintain has maintained an 8-12% growth rate, resulting in obvious material improvement to peoples' livelihoods – and resulting in ever increasing demand for vehicles. The result is that the rate of car ownership for every 1,000 people in China was a mere 12.9 in 2000, but now the figure has increased to nearly 50. Having said that, compared with the advanced countries in the world, the vehicle ownership rate in China remains rather low, at only 6% of the US (800/1,000 people), 8% of the EU (600/1,000) and Japan (575/1,000). In this sense, the demand for vehicles in the future in China is expected to be huge with the vehicle population remaining on a fast growth trajectory. It is projected by the International Energy Agency (IEA) that the vehicle population in China will top 230 million in 2020 and 400 million in 2030[1]. The surging growth in automobile population means automotive energy consumption will also continue to grow quickly. The IEA has forecasted that by 2030, China's automotive energy consumption will surpass 400 Mt of fossil fuel, and continue growing at this extremely fast pace. Since the consumption of fossil fuel has a direct connection to GHG emissions, then automotive GHG emissions will also rise dramatically, resulting in negative impacts to the climate and environment in general.

"Low Carbon Automotive Fuel" refers to automotive fuel whose emission intensity is lower than that of currently-used fossil gasoline and diesel from a whole-lifecycle perspective (including feedstock production and transport, fuel manufacturing and transport, fuel combustion/consumption, and all other related emission-related processes such as emissions from land use change, emissions avoided from the use of co-products of fuel production, etc.). Typically, the intensity is calculated according to the equivalent CO_2 (carbon dioxide) emitted per megajoule energy (g CO_{2e}/MJ). As China's automotive industry develops, automotive fuel consumption also expanded dramatically, meaning that Greenhouse Gas (GHG) emission has increased greatly, as has risk to oil and energy security in general. The development of low carbon automotive fuels is an important method for encouraging the creation of new alternative fuels, improving national energy security and cutting back on transportation-related GHG emissions. These topics are all globally important issues, which should be considered seriously and integrated into strategic planning as a way to encourage and guide the "low carbon" oriented development of automotive fuels.

This policy recommendation report is the result of research on China's low carbon fuel development background and importance, low carbon automotive fuel identification methodology, international low carbon automotive fuel policy experience, development of alternative fuels in China with respect to GHG emission avoidance and reduction – including scenario analysis, and lastly offers a roadmap for achieving low carbon fuel system, and a target for China to aim for in reducing the carbon intensity of its fuel system. It is hoped that this report will offer Chinese industry and government new ideas that will help China to develop policy and economic development around lower carbon automotive fuels.

I. Significance of Low Carbon Automotive Fuel Development to China

(I) Improve National Energy Security and Reduce the Reliance of Vehicles on Petroleum

In 2009, the consumption of vehicle-use gasoline in China stood at 60 million tons while the consumption of vehicle-use diesel was approximately 53 million tons[2]. The consumption of automotive fuels accounted for 30% of the apparent consumption of crude oil, and the growth rate and proportion are likely to increase for the foreseeable future. At the moment, over 95% of China's automotive fuels are fossil-sourced gasoline and diesel. This means a strong reliance on oil (fig. 2).

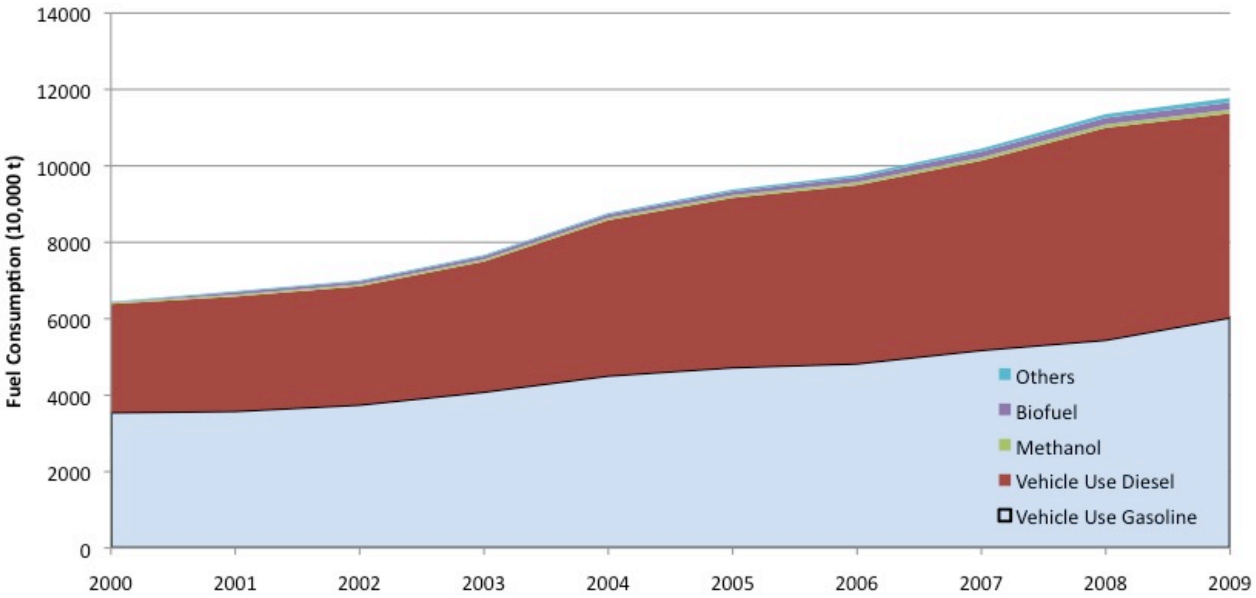


Figure 2 Annual automotive fuel consumption (China, 2000-2009)
Source: Automotive Industry Annual Report, China Petroleum and Chemical Industry Association, National Statistics Bureau of China – Compiled by *i*CET

In 2009, 52.6% of oil China spent was imported, surpassing the China's oil-dependence warning level of 50% for the first time[1]. The gap between oil supply and demand is ever widening, and it is estimated that China's dependence on foreign oil could reach 65-70% in 2020 and 80% in 2030. The consumption of automotive fuel has posed

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[1] http://english.peopledaily.com.cn/90001/90778/90860/6876626.html China's Foreign Oil Dependence Ratio Exceeds 50% of 1st Time. People's Daily Online

grave threats to oil security.

Encouraging the development of low carbon alternative fuels, and increasing the proportion of their use in the Chinese fuel system will reduce China's dependence on foreign fossil fuel, and increase national energy security.

(II) Reduce Transportation-Related Emissions and Meet National Emission Reduction Goals

China put forward its goal of GHG reducing the carbon intensity of its economy on a per GDP basis by 40-45% by 2020, compared to 2005 on the eve of the UN Climate Change Conference held in Copenhagen in December 2009. Automotive fuel consumption is the major GHG emission source from the transportation sector. In 2009, GHG emissions from the consumption of automotive fuels in China were nearly 480 million tons of equivalent CO_2 (lifecycle emissions), an increase of 80% from 2000.

As the consumption of automotive fuels increases, encouraging the development of fuels with low lifecycle carbon intensity (including feedstock production, fuel refining, transportation and final consumption) comes as one of the major means for fulfilling automobile energy demand and realizing the target of transportation-related GHG emission reduction and national emission reduction goals.

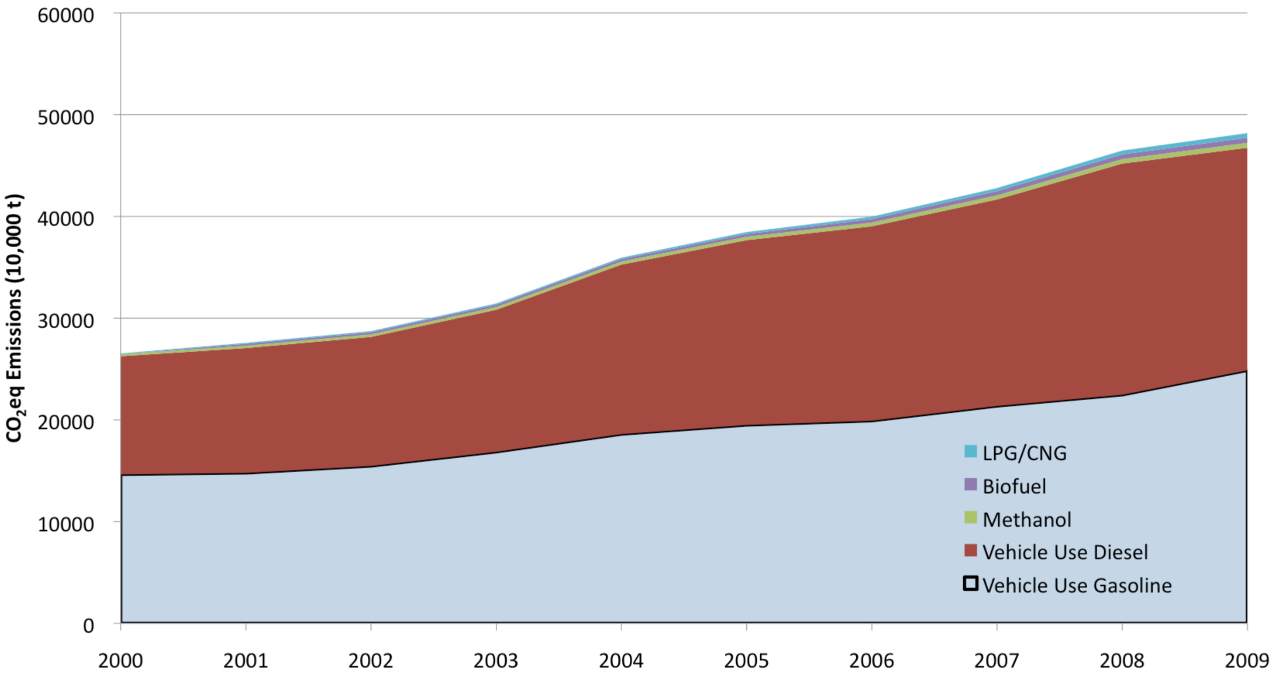

Figure 3 Annual Transportation Sector GHG emissions (China, 2000-2009)
Source: iCET, based on data from sources above

(III) Promote Technological Innovation and Elevate the Competitiveness of the Automobile and Fuel Industries

Against the backdrop of desired energy saving and emission reduction around the world, many of China's state-owned oil refining enterprises, automotive fuel producers, and innovation-oriented private enterprises，research institutes have increased capital and talent in the new energy technologies, fuel refining, and the low carbon-oriented development of fuels, especially on non-grain bio-fuel, natural gas-based automotive fuels and hydrogen fuel, and made major breakthroughs in these respects. Beyond that, automobile businesses have increased their efforts in the production of advanced engines, new energy vehicles, and electric vehicles, fuel cell vehicles (FCVs) and other "green" vehicles.

Based on the experience of jurisdictions around the world, such as California, Europe and Brazil, promoting the development of low carbon automotive fuels will facilitate China in strengthening technical R&D in this field, making breakthroughs in key technologies as a way to stimulate the development of relevant industries and seizing the commanding heights in this new round of development. This concept is explored in Chapter 3.

II. Identification and Selection of Low Carbon Automotive Fuels in China

(I) China Will Witness Automotive Fuel Diversity in the Future

China will likely face a more diversified development trend in automotive fuels as resources for production of alternative fuels are distributed differently in different regions and the demand for automobile energy increases. Apart from traditional gasoline and diesel fuels, wide-ranging fuels such as: the energy for electric vehicles and hydrogen production; natural gas-based fuels, such as compressed natural gas (CNG), liquefied natural gas (LNG); liquefied petroleum gas; coal-based liquid fuels such as methanol, dimethyl ether (DME), coal direct/indirect liquefied oil; and biomass-based fuels such as ethanol, and biodiesel will likely be introduced into the system of automotive fuels in the future. Under the encouragement of national policies that encourage the diversified development of automobile vehicles, the idea that one or two fuels play a central and predominant role in transportation in terms of economics, technology, and resource availability, simply is not very realistic.

While pressing ahead with automotive fuel diversification, the negative impact of each type of fuel on the environment and society must be understood, supervised and controlled; rather, work must be done to achieve sustainable and harmonious development between the diversification of automotive fuels on the one hand, and environment and social wellbeing on the other.

(II) Identification of Low Carbon Automotive Fuels

A scientific, authoritative, transparent, fair and neutral standard is the basis on which to determine whether an automotive fuel is “low carbon” and “sustainable” or not. These characteristics are defined below:

Scientific - A scientific appraisal system should fully consider the complete lifecycle

GHG emissions of a transportation fuel product within a widely accepted analytical boundary, rather than merely the combustion emissions of that fuel. Emissions from feedstock production, fuel production and refining, transportation, land use change, and terminal consumption, as well as emissions avoided in the use of waste products in fuel production as well as the use of fuel production byproducts to displace higher-carbon products (such as the use of DDGS from corn ethanol production to displace the use of corn feed in cattle)." Each fuel chain must have a complete analysis undertaken within its boundaries.

Authoritative - The appraisal method and standard should compulsory and implemented under the supervision of relevant, empowered authorities with emission evaluation standards, cover all relevant stakeholders.

Transparent - Evaluation methods and standards should be open and transparent, meaning that independent verifiers can accurately reproduce the results of any analysis submitted by fuel producers and providers. Databases of reference figures should be open and shared, with a dedicated, legally-empowered organization responsible for research, consultation, interpretation, training and communication with regards to the methodology, reference data and changes to policy.

Fair and Neutral - The appraisal method and standard should be fair, focusing on the concept of “low carbon,” and avoiding other bias against or towards particular technologies, companies or places; Any company or technology should be able to accurately evaluate its carbon intensity using the methodology, and a relevant and knowledgeable “third party” should be able to verify the results of the analysis;

Based on the above guiding ideology, Innovation Center for Energy and Transportation joined forces with seven organizations, including China National Institute of Standardization (CNIS) in drafting two national standards: *Principles and Requirement for the Appraisal of the Lifecycle GHG Emission from Transportation-related Fuels* (national standard planning number: 20091267-T-469) and *Requirements for Reporting and Checking Lifecycle GHG Emissions from Transportation-related Fuels* (national standard planning number: 20091268-T-469).[2] These standards are designed to review fuel lifecycle GHG emission

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[2] See appendix 1.

intensity (carbon intensity), service the development and delivery of government policies, assist in the appraisal and strategic decision making regarding GHG emissions of fuel and automobile enterprises, as well as in researches undertaken by academics. These standards aim to provide an integrated standard for the evaluation of GHG intensity of fuels.

(III) Identification of Low Carbon Automotive Fuels

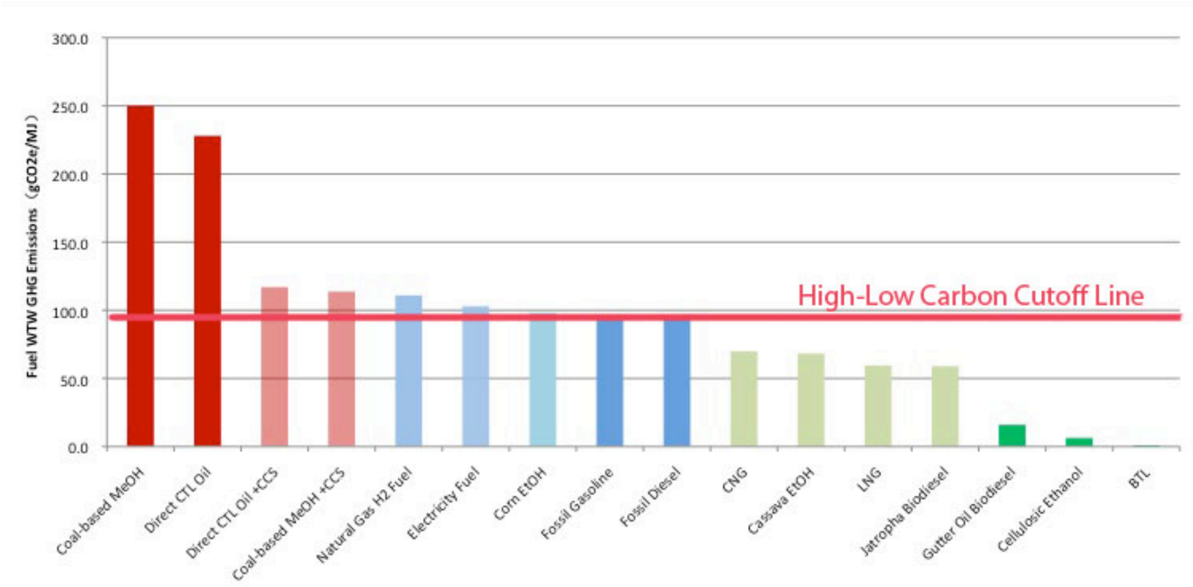

Figure 4 Automotive Fuel Lifecycle GHG Emissions – Average value comparison
Sources: Tsinghua University, CATARC, iCET, California Air Resources Board. See Appendix 1 for details.

According to observations by fuel lifecycle researchers[3], different feedstock sources, varieties, production technologies and technological levels will impact the “carbon intensity” of fuel with different results. The average levels of various fuels are specified in Fig. 4.

If traditional fossil diesel and gasoline are used as fuels for comparison, the GHG emission intensity of coal-based liquid fuels, such as coal-based methanol and fuels from direct coal liquefaction are around 100% higher than that of equivalent conventional fuel, and clearly belong to the “high carbon fuel” category when produced with currently available technology; but with the advanced productive technology in the future, such as “Carbon Capture and Storage (CCS)”, “Integrated Gasification Combined Cycle (IGCC)”, the GHG emission intensity of coal-based liquid fuels will be reduced dramatically, but compared with equivalent fuel, they would still be categorized as “high-carbon fuel”;

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[3] e.g. Farrell, Alexander E. and Daniel Sperling. 2007. A Low-Carbon Fuel Standard for California – Part 1: Technical Analysis and Part 2: Policy Analysis. Regents of the University of California.

however, the GHG emission intensity of LPG and CNG is 30-40% lower than that of equivalent fuel; the "carbon intensity" of the first generation of biofuel is closely linked to the source and varieties of feedstocks and production technologies, resulting in vastly different emission reduction potentials, but which are generally equivalent to or lower than that of diesel and gasoline. Based on data from laboratory and demonstrative projects[4], the second generation of biofuels can have very low carbon intensities with the potential to reduce lifecycle GHG emissions by more than 60% compared to conventional fossil fuel.

Electricity and hydrogen fuels are considered as important alternative fuels for vehicles in the future. However, the energy and drive systems of these vehicles are totally different from those associated with conventional fuels. Therefore, when determining whether electricity and hydrogen are low carbon "fuels", the energy efficiency of the automobile apart from upstream lifecycle GHG emission intensity of the production of electricity and hydrogen fuels must be taken into consideration so that these "fuels" can be compared based on energy expended per unit of distance and then compared with equivalent fuels in terms of GHG emissions.

Electric vehicles have been deemed a major technological channel for the realization of energy conservation and emission reduction in the automobile industry. However, at this time, China's power mix is mainly based on high-carbon, "coal-fired electricity" and as a result, the emission reduction potential of electric vehicles is uncertain[5].

According to research conducted by the Development Research Center of the State Council of China,[6] when comparing coal-fired electricity used in Battery Electric Vehicles (BEVs), and coal-based fuel used in internal combustion engine vehicles, the former demonstrates benefits in terms of both energy efficiency and GHG emission. Furthermore, when using electricity and hydrogen as automotive fuels to substitutes liquid fossil fuel, mobile emissions are transferred to a small number of fixed emission sources, a condition which is conducive to the implementation of advanced carbon capture technology and potentially realizing the goal of low carbon automotive fuels at some point in the future. The use of electricity also increases the potential for vehicles to make use of renewable energies such

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[4] e.g. Delucchi, Mark. (2006). Lifecycle Analyses of Biofuels. UC Davis: Institute of Transportation Studies. Retrieved from: http://escholarship.org/uc/item/1pq0f84z

[5] Hong Huo, Qiang Zhang, Michael Q. Wang, David G. Streets and Kebin He (2010) Environmental Implication of Electric Vehicles in China. Environ. Sci. Technol.,

[6] Development Research Center of the State Council of China, Conditions for Electric Vehicles in China to Become New Strategic Industry. 2009.

as wind and solar – energies that internal combustion engines simply cannot take advantage of.

In summary, natural gas and LPG, biofuel, electricity and hydrogen fuels have the greatest potential to become major sources for low-carbon alternative fuels for vehicles, and policies are needed in order to encourage their development, consumption and eventual replacement of conventional fossil fuels.

(4) China's Automotive Fuel Technology Application Pathway and Comparison

This section of the report will analyze China's automotive fuel application pathway technology maturity, government support, GHG reduction potential, manufacturing outlook, international competitiveness and overall evaluation according to a "four star" evaluation system (Table 1). The evaluation indicates that electric drive technology, hybrid vehicle technology, "clean gas" technology and second generation biofuel technologies are relatively beneficial in terms of manufacturing outlook and international competitiveness. These technologies are also in harmony with the development of low carbon automotive fuels in China.

At this time, electric drive technology has received a great deal of policy attention, with an entire set of related government policies, resulting in a series of key technology breakthroughs and ongoing improvement of the industrial system. Other low carbon automotive technologies and industries should also receive government support, particularly second-generation biofuels, and particularly those with high GHG emission avoidance and reduction potential, so as to make breakthroughs in technology and realize commercialization.

Generally, China should strongly support industrial improvement, and strengthen the international competitiveness of fuels and technologies that have high GHG emission reduction potential.

Table 1 China's Automotive Fuel Technology Application Roadmap and Overall Comparison

Fuel Category	Fuel Type	Application Technology	Technology Maturity	Level of Policy Support	Production Potential	International Competitiveness	GHG Emission Reduction	Overall Evaluation
Fossil Liquid Fuel	Gasoline and Diesel	Conventional gasoline vehicles	☆☆☆☆	☆☆	☆☆☆	☆☆	☆☆（baseline）	☆☆（baseline）
		Hybrid vehicles	☆☆☆	☆☆☆	☆☆☆☆	☆☆	☆☆☆	☆☆☆
Fossil Gas Fuels	CNG/LNG/LPG	Specific gas vehicle	☆☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆
Biofuels	First generation biofuel	Alternative fuel vehicle	☆☆☆☆	☆	☆	☆☆	☆☆☆	☆
	Second generation biofuel	Alternative fuel vehicle	☆☆	☆☆	☆☆☆☆	☆☆☆	☆☆☆☆	☆☆☆
Coal-based Fuels	Methanol	Alternative fuel vehicle	☆☆☆	☆☆	☆☆	☆☆	☆	☆
	CTL	Alternative fuel vehicle	☆☆	☆☆	☆☆	☆☆	☆	☆
Electricity Fuel	Grid electricity	Plug-in hybrid electric vehicle (PHEV)	☆☆	☆☆☆☆	☆☆☆☆	☆☆☆	☆☆	☆☆☆
		Pure battery electric vehicle (BEV)	☆☆	☆☆☆☆	☆☆☆☆	☆☆☆	☆☆	☆☆☆
Hydrogen Fuel	Hydrogen gas from natural gas	Hydrogen fuel cell vehicle (FCV)	☆	☆☆☆	☆☆☆	☆☆	☆☆	☆☆

III. Present Conditions and Challenges to the Development of Low Carbon Automotive Fuels in China

(I) Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG)

China has already promoted the use of natural gas and LPG vehicles in more than 80 cities in 25 provinces, mainly focusing on 19 cities. Among them are Sichuan, Chongqing, Xi'an, Urumqi and Beijing, which mainly promote the use of CNG, and Shanghai, Guangzhou, Changchun and Harbin, which largely promote the use of LPG; natural gas is still mainly used in buses and some taxis. In 2009, the population of natural gas and LPG vehicles stood at nearly 500,000, which consumed nearly 3.2 billion cubic meters of CNG, 300,000 tons of LPG, and substituted nearly 3.6 million tons of conventional fuel, accounting for 3% of the market share for automotive fuel.

Substituting "gas" for "oil" is in line with China's energy and environmental protection strategy. Measures taken to implement a policy system that promotes the use of natural gas and LPG vehicles have been comprehensive. In the past decade, different levels of government have put the development of natural gas and LPG vehicles high on the agenda, and have released a host of special plans and policies. A policy regulation system for natural gas and LPG vehicles has taken shape, marked by the guidance of a central policy that is supported by more specific local policies. On top of that, vehicles that use natural gas have been added to the list of preferential supply, which makes a great difference in promoting the development of natural gas.

China has faced many challenges while promoting the use of natural gas and LPG vehicles, especially while promoting the use of LPG vehicles. For instance, the policy system falls far short of a clear-cut objective and plan for the development of natural gas and LPG vehicles. The existing policies have failed to be fully implemented, while the supply system for natural gas and LPG vehicles, the quality control system for natural gas, and the technology for CNG and LPG automobiles all leave room for improvement. At the moment, 70% of CNG vehicles are recreational vehicles; beyond that, CNG and LPG vehicles have no advantages in cost effectiveness or convenience, which to some extent limits the promotion of vehicles using CNG and LPG.

In the future, the market share of natural gas and LPG vehicles could grow rapidly, spreading from regional areas to the entire country, and becoming a major alternative to diesel and gasoline in midwest China. The vehicles to be promoted may also be expanded from city buses and taxis to vehicles of driving schools, passenger cars travelling between urban and suburban areas, and some municipal vehicles, heavy trucks and private cars.

(II) Bioethanol and Biodiesel

Since 2004, China has initiated several pilot projects promoting the use of E10 fuel ethanol vehicles across 6 provinces (Heilongjiang, Jilin, Liaoning, Henan, Anhui and Guangxi) and 27 cities in some provinces, based on the national standard, *Ethanol Gasoline for Motor Vehicles*, and the established national and regional Leading Group for the Work of Promoting and Utilizing Vehicles Using Ethanol Gasoline. China’s fuel ethanol is promoted under the model of “appointed production and closed distribution” under five enterprises, including COFCO Zhaodong Ethanol, Henan Tianguan, Anhui Fengyuan Biochemistry, Jilin Fuel Ethanol, and COFCO (Guangxi) Biomass, as the designated producers of fuel ethanol sold by the fuel distribution systems in the demonstration regions, with PetroChina and Sinopec at the core as fuel distributors. In 2009, China’s production capacity of fuel ethanol reached 1.73 million tons, of which 200,000 tons were non-grain fuel ethanol. The sales volume of ethanol gasoline accounted for nearly 20% of total gasoline consumption.

China has stepped up support for the fuel ethanol industry since the pilot program for the promotion of ethanol gasoline was initiated, including subsidies, tax incentives and other financial policy supports. After six years of promoting ethanol gasoline, China has emerged as the third largest fuel ethanol producer in the world. At the moment, the first generation of fuel ethanol (grain ethanol) enjoys full-fledged policy support, technology, market integration and promotion. However, this type of fuel is in contrast with China’s principle for developing biofuels (i.e. does not compete with people for grain, does not compete with grain for land, and does not damage the ecological environment) so there will be no new projects that utilize the technology of producing ethanol from grain.

Going forward, the development of fuel ethanol will be marked by generation 1.5 ethanol (non-grain ethanol, such as cassava ethanol) and second generation, non-grain ethanol (cellulosic ethanol). Non-grain ethanol has already been used in the first industrialized project in Guangxi, but the material supply plan and production technology needs to be further improved. Meanwhile, other non-grain ethanol projects are still at the pilot program stage. Although non-grain ethanol doesn't compete with people for grain, it does potentially vie for high quality agricultural land where grain could be grown.

At the moment, national policy support for non-grain ethanol (as a final product) is similar to grain ethanol, and project approval has been slowed down. Cellulosic ethanol fully conforms to the principle for the development of biofuel, that is, its development isn't achieved at the expense of people and land; and it is conducive to the recycling of resources and to environmental stewardship. In this sense, it is taken as a major technical channel to substitute transportation-related energy and reduce emissions. Pilot programs with an annual production capacity of 500 to 3,000 tons of cellulosic ethanol have been put into operation, but there is still vast room for improvement in terms of key technologies and economic costs before this technology can achieve commercial operation. At the moment, China lacks the policy support and industrial policy to truly support cellulosic ethanol. An ambiguous policy attitude has become an important constraint along the way in the development of cellulosic ethanol in China, which has led to slow progress in areas such as industrial models, basic scientific research, and breakthroughs in production technologies.

In 2006, also China developed medium and long-term development targets for biodiesel, at 200,000 tons in 2010 and 2 million tons in 2020. In the past four years, Hainan, Fujian, Sichuan, Anhui and Shandong have developed a production capacity of 2 to 3 million tons, but the actual annual production capacity is less than 100,000 tons, representing severe over capacity. Contributing to over capacity are poor marketing channels as a result of inadequate feedstock supply, lack of product standards, and absence of an implementation plan for vehicles using biodiesel. Beyond that, lack of financial policy support acts as another major barrier. Biodiesel faces serious systematic problems.

Currently, China's biodiesel is largely produced by small and medium sized private companies using waste oil from the urban restaurant sector. Over the years, the top three energy giants including PetroChina, Sinopec, and CNOOC have made their presence known in the biodiesel industry, entering into agreements with local governments to plant energy crops, such as *Jatropha*, and identifying strategies for the development of biodiesel. The National Development and Reform Commission (NDRC) approved industrialized pilot programs producing biodiesel from *Jatropha* in 2008, which including a 60,000 tons per year project by PetroChina Nanchong, 50,000 tons per year by Sinopec Guizhou, and 60,000 tons per year by CNOOC Hainan. These projects have laid a solid foundation for feedstock plantation, production, storage, transportation and marketing of vehicle biodiesel and have guided the healthy development of the industry. The Hainan Provincial Government promulgated *"The Working Plan of Hainan Province for the Market-based Promotion of Biodiesel"* in 2009, and in September of 2010, released a local standard, entitled "*5% Biodiesel Mixed in Diesel Fuel (B5)"*, and became the first in China to promote the utilization of automotive blended diesel (B5) across the province. While these projects have established a trend in the industry, they have not yet successfully commercially produced biodiesel and have experienced various technical problems. Finally, in September 2010, the National Standard "*Biodiesel Fuel Blend B5*", which will come into force in February, 2011.

The fundamental reason behind the slow development of the biofuel industry over the years is weak policy support. Given the great significance of biofuels for automotive fuel substitution and GHG emission reduction, if biofuels could obtain policy support from the government, their potential for development will be huge.

(III) "Electricity" and "Hydrogen" Fuels

Battery Electric Vehicles (BEVs), Hybrid Electric Vehicles (HEVs), and Fuel Cell Vehicles (FCVs) have become the top three components of the new energy vehicle (NEV) plan for China. "Electric" and "hydrogen" fuels are widely seen as the major new types of alternative fuels for vehicles, with a strong potential for reducing emissions.

During the period of the 10th Five Year Plan, China started to implement a technical plan for NEVs, and has put into place an electric vehicle policy structure comprised of the "three verticals": BEVs, HEVs and FCVs, and the "three horizontals: powertrain control system technology, motor technology and its control system, and the power battery technology and its management system. In the past two years, China has released a host of industrial plans and supporting policies for the new energy vehicle industry, which include the Industrial Vehicle Restructuring and Rejuvenation Plan, which was rolled out in 2009. This would see China develop the production capacity of 500,000 new energy vehicles per year by 2011, including BEVs, plug-in hybrid vehicles (PHEVs) and HEVs; the sales volume of NEVs would account for about 5% of the total sales volume of passenger cars.

The "10 Cities, 1,000 New Energy Vehicles" plan, initiated by the Ministry of Science and Technology in 2008, was implemented in 13 cities, and the pilot cities increased to 25 in 2010. The Ministry of Finance rolled out financial subsidy measures for purchasing

NEVs by public institutions and individuals in January and May 2009 as a way to promote the expansion of NEVs to the field of passenger vehicles. Under the strong support of national policies, great breakthroughs and improvements have been achieved in battery performance and life span, construction of recharging infrastructure, and recharging standards. Many domestic vehicles producers, such as Shanghai Automotive Industry Corporation (SAIC), Chongqing Chang'an Automobile (CHANA), Beijing Automotive Works, BYD Auto, and Chery Automobile have increased input in "electrified" applications. As of August 1, 2010, 140 models of NEVs had been incorporated in the *List of Recommended Motor Types for the Demonstrative Promotion and Application of Energy Saving and New Energy Vehicles*. "Electric" and "hydrogen" fuels are bound to play an important role in addressing vehicle-use fuel alternatives, reducing GHG emissions, and contributing to a more promising future.

China's electric vehicles are still at the initial stages of development, and the promotion of "electric" and "hydrogen" fuels for electric vehicles are still facing many challenges that lack adequate solutions. To begin with, the production technology of electric vehicles, pilot technology of the industrialization of key parts and components, and the stability and durability of products leave room for improvement. Second, there is a lack of supporting infrastructure and after-sale service system for electric vehicles; third, the standardization system of electric vehicle needs to be improved and well managed. Generally speaking, the development of electric vehicles faces the picture of higher passions among enterprises and governments and lower passion among consumers. Higher price, uncertain access to repair services, and incompatible recharging facilities have severely curbed the development of electric vehicles. The impediments hampering the development of electric vehicles should be addressed in the promotion and application process of electric vehicle demonstration programs as a way to address the application of "electricity" and "hydrogen" fuels in electric vehicles.

IV. International Policy Experience in Low Carbon Automotive Fuels

Countries around the world have recently been paying more attention to the important role of low carbon automotive fuels in emission reduction, and have rolled out a host of policy supports and implementation measures for low carbon fuels. It is clear that the goal of developing low carbon fuels and the policy orientation has already gradually shifted away from biofuel sales targets towards an equal emphasis on both biofuel sales and lifecycle GHG emission reductions. This section will review the experiences of various countries and jurisdictions that have already established policies in this area.

(I) US Experience

America was the first country in the world to formulate policy using the goal of reducing the average fuel carbon intensity. Typical policies include the *California Low Carbon Fuel Standard* (LCFS), the *Renewable Fuel Standard* (RFS), and plan and policy support for electric automobiles.

The Low Carbon Fuel Standard – Arnold Schwarzenegger, Governor of California, signed the S-01-07 Executive Order in 2007 to promulgate the *Low Carbon Fuel Standard* for California with the goal of reducing the lifecycle of GHG emission intensity from transportation-related fuels 10% by 2020. This policy was approved by the California Air Resources Board (CARB) in April 2009, and came into force in January 2010. Ten states in the northeast and mid-Atlantic regions of the US have signed a Memorandum of Understanding to formulate mandatory low carbon fuel standards.

The Low Carbon Fuel Standard separately uses the carbon intensity per unit of energy (g CO_2eq/MJ) of conventional gasoline or diesel already provided to the market as its baseline. Alternative fuels to gasoline (in one system) and diesel (in another system) can be compared to this baseline. For those alternative fuels that are lower than the baseline carbon intensity, they will obtain GHG emission reduction credits (calculated by tons of equivalent CO_2). Relevant stakeholders who obtain the credits (such as refineries, deployment factories, producers and importers) are allowed to sell or purchase GHG emission shares based on market emission trading mechanisms.

The LCFS is technology-neutral, meaning that any low carbon fuels used for transportation are eligible for emission reduction shares, including low carbon fossil fuels (such as CNG, oil obtained from CCS), biofuel (such as ethanol and biodiesel) and other energy carriers (such as electric and hydrogen energy).[7]

The Renewable Fuel Standard *II* – The United States passed the *Energy Policy Act* in 2005 and established the Renewable Fuel Standard, which required an increase in the amount of renewable energy utilized year after year, eventually to reach 7.5 billion gallons of fuel in 2012; this target has been met ahead of schedule. Based on *the Energy Independence and Security Act*, the U.S. Environmental Protection Agency (USEPA) adopted the Renewable Fuel Standard II, which was expected to be implemented starting in July 2010. The policy is designed to promote the development of transportation-related renewable fuels, increase the share of biofuels in the U.S. fuel system, and roll out mandatory requirements for the usage and emission reduction capacity of renewable fuels; by 2022, the total amount of biofuels used would reach 36 billion gallons (or 110 million tons), and the minimum GHG emission reduction target would be 20% compared to the baseline fuels; the utilization of cellulosic ethanol would be 16 billion gallons, with an emission reduction target of 50%; the utilization of advanced biofuel would reach 21 billion gallons, compared to an emission reduction target of 60%. The United States hopes to elevate the amount of vehicle biofuels used, to realize an emission reduction target of automotive fuels through long-term implementation of the Renewable Fuel Standard II, and to achieve continuous reduction in fuel carbon intensity via technical innovation as facilitated by policy supports.

US Transport Electrification Policy The U.S. has taken the development of electric vehicles as one of its major national strategies, and the process of "electrification" is considered to be one of the key measures that will achieve vehicle energy alternatives and transportation-related GHG emission reduction. The use of 1 million plug-in electric vehicles by 2015 has been identified as a target. Policy support for industry such as tax incentives, purchasing incentives and increased science and technological input have been made available for plug-in electric vehicles (PHEVs) and fuel cell vehicles (FCVs). For example, 2,500 USD to 7,500 USD will be used for tax cuts for plug-in electric lightweight

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[7] Diesel, by nature of its greater energy content, as well as diesel engine technology, is more efficient than gasoline. However, since one of the objectives of the LCFS is to decrease dependence on fossil fuels, diesel was used as one baseline, while gasoline was used as another baseline for calculating credits. Fuels that replace gasoline will be compared to the gasoline emission baseline. Fuels that replace diesel will be compared to the diesel emission baseline.

vehicles, based on the vehicle weight and battery capacity, while lightweight FCVs could receive as much as 8,000 USD in tax incentives. Many states in the US have set up extra incentive plans for the purchasing of electric cars, with the highest amount of being 5,000 USD; US President Barack Obama announced the allocation of 2.4 billion USD to support the research and industrialized pilot operation of electric vehicles, 1.5 billion USD of which will go to the research and industrialization of advanced batteries and will be used to increase construction of infrastructure for electric cars; 400 million USD will be used in electric car pilot projects and surveys on electric infrastructure; 100 million USD will finance the infrastructure for electric cars in five states, and 54 million USD in tax incentives will be used to encourage the utilization of alternative fuels, including the construction of charging stations.

(II) EU Experience

As part of the efforts to achieve transportation-related energy alternatives, reduce the dependence of automotive fuels on fossil energy, control transportation-related GHG emissions and meet emission reduction targets, the European Commission made amendments to *the Renewable Energy Directive* (RED) and *the Fuel Quality Directive* (FQD) in 2009.

The Renewable Energy Directive requires that member states of the EU achieve 10% capacity in renewable energy as a fraction of total energy used in transportation, and deliver progress reports to the European Commission every two years. In order to encourage the application of renewable electricity to the transportation sector, renewable electricity consumed by electric vehicles could be reported according to 2.5 times the energy capacity, decreasing over time as electric vehicles become more common; on top of that, biofuels that use waste as raw materials could be reported according to 2 times the actual amount of energy consumption. The directive will be implemented before December 5, 2010, and member states will deliver their first implementation report before December 31, 2011.

The Fuel Quality Directive requires that by December 31, 2020, lifecycle GHG emission per unit of transportation-related fuel (liquid fuel and other types of vehicle-use energy) will be reduced by 10% compared with the base year (2011), and identifies ways to realize the target, including 6% being realized through advanced biofuel, 2% through improving existing production technology, and the remaining 2% realized through purchase of CERs on the CDM market.

The European Commission also pointed out that member states could implement a tax credit or exemption policy, a quota of renewable fuels, and other policies that would facilitate the realization of the target. Member states of the EU have defined development goals, and corresponding standards and policies for low carbon automotive fuels based on their national realities such as the *Renewable Transport Fuel Obligation* (RTFO) of the United Kingdom, the *Transport Biofuels Act* (TBA) of the Netherlands, and the *Biofuel Obligation* (BFO) of Germany, among others.

The UK's *Renewable Transport Fuel Obligation* (RTFO) – The UK has two years of practical experience through the design and implementation of the RTFO, which requires that all fossil fuels and biofuels sold on the market reach certain proportions, that a report on the lifecycle GHG emissions from those biofuels be made, and that the fuels be accredited according to certain approved sustainability standards. Qualified biofuels that have received accreditation by a third party, will be granted "carbon credits", which may then be traded by other fuel suppliers on a market developed within the policy. According to the first RTFO annual report released by the UK Renewable Fuel Agency in July 2009, the proportion of sales of biofuels reached 2.6% with supplied biofuels achieving an average fuel GHG emission intensity reduction of 47%, both achieving the expected targets. The target biofuel allocation for the 2009/10 period based on the successful implementation in 2008, was set at 3.25% (v/v); the target for 2013/2014 will increase to 5%.

***Policy for Promoting Transport Electrification*[8] –** European countries have taken the promotion of "electricity" fuel as an important part of the development of low carbon automotive fuels. Germany, France, the United Kingdom and other countries with advanced automobile industries have taken the lead in implementing this policy.

In November 2008, Germany put forward a goal to have 1 million BEVs and plug-in hybrid vehicles on the road within the coming decade. It is expected to invest 5 million EUR in the electric vehicle research and project demonstration, and 60 million EUR in the R&D of lithium battery technology. The buyers of electric vehicles could enjoy five years of tax breaks; other incentives for electric cars include free parking within certain city areas,

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[8] World Bank and Beijing Transportation Commission. Electric Vehicle Forum, June 28, 2010. Electric Vehicles: Global Status and China's New Energy Vehicle Project Applications.

congestion fee waivers, and driving access to low emission districts. The government will allocate funds to construct 500 charging stations in Berlin.

France’s goal is to have 2 million electric vehicles on the road by 2020, and it has already called for bids to carry out its plan for 50,000 electric vehicles. France will invest 400 million EUR in electric vehicle R&D and pilot projects, and 107 million EUR in the construction of charging infrastructure. Individuals who purchase electric vehicles with emissions of less than 60 gCO_2/km and other low emission vehicles would receive a 5,000 EUR subsidy on purchase of the vehicle.

The UK has been proactive in implementing and promoting an “electrification” industrial policy. It will invest 350 million GBP in R&D and pilot projects. Individuals who purchase electric vehicles would enjoy tax relief, while fleet buyers would enjoy vehicle use tax exemptions for the first five years. Transport congestion fees would be waived, exclusive parking lots for electric cars would be mapped out, and charging stations constructed. Starting in 2011, electric vehicle buyers would enjoy discounts of 25% off the marked price, up to 5,000 GBP off the marked price of vehicles.

(III) Japanese Experience

More than 99% of oil consumed in Japan is imported. Consequently, Japan has shown strong support for the use of low carbon automotive fuels and the development of “electrification”, and has been working to reduce the carbon intensity of automotive fuels through measures such as the development of electric vehicles and biofuels as a way to realize the goal of emission reduction and increased energy independence.

The “Action Plan for A Low Carbon Society,” unveiled in 2008, showed that by 2020, the number of “next generation’ HEVs will account for 50% of total new vehicles. Japan will invest 200 million USD into researching and improving battery power. Electric vehicle buyers could enjoy 2000 to 3000 USD in subsidies; at the same time, 90% of the car purchase tax would be reduced or waived in Kanagawa, and incentives would also be given in terms of parking fee rebates and road toll reductions. On top of that, Japan has put in place an “Action Plan for the Development and Popularization of Low-Pollution Vehicles,” and established a complete accreditation system of “Energy Efficiency and Low Emission Vehicles” to promote the development of low emission vehicles such as CNG vehicles, low carbon methanol vehicles, HEVs, BEVs, and FCVs, thereby promoting the use of low carbon automotive fuels.

Japan, a country with limited land resources, remains proactive in promoting biofuel as a kind of low carbon automotive fuel. In March 2006, Japan made an amendment to the *Biomass Nippon Strategy* (BNS) to emphasize that biofuel would be promoted as a transportation fuel. Japan has started to implement an incentive mechanism including bioethanol tax reliefs since 2008: 1.2 yen per liter off fuel tax for fossil fuel that which contains 3% bioethanol; ethanol producers are offered reduction or waiver of asset purchase tax in their first 3.5 years of operation, and Japan will provide interest-free loans for farmers who plant energy raw materials for the next ten years. According to the rules of light diesel standard identified in the *Quality Control Law*, the proportion of light diesel in biodiesel shall be no less than 5%, in an effort to meet automotive fuel safety and emission standards.

(IV) Brazilian Experience

Brazil works to reduce the carbon intensity of automotive fuel by developing biofuels as well as flex fuel vehicles.

Since 1975, Brazil has promoted a “National Ethanol Plan,” making it the first country in the world to promote fuel ethanol through mandatory legislation. In 2009, Brazil’s ethanol production stood at 19.8 million tons, and 40% of lightweight vehicles used ethanol as fuel, substituting 56% of the gasoline consumed in Brazil, and accounting for nearly 20% of the vehicle energy mix; the result was that 42.33 Mt of CO_2 emission was avoided. The biomass industry has become the largest key industry in Brazil. When the “National Ethanol Plan” was initiated, Brazil provided a huge amount of policy support in terms of tax breaks and subsidies; but at the moment, ethanol in Brazil can compete with fossil fuels without national subsidies.

The Brazilian government officially launched the “National Biodiesel Plan” in 2004 and adopted a decree in 2005, which demanded that all diesel sold on the market would contain at least 5% biodiesel, and this target is expected to be reached in eight years. The diesel output in Brazil was recorded at 1.4 million tons in 2009. For now, Brazil exempts all or part of the federal tax to those diesel producing companies that have passed “Social Fuel Seal” accreditation.

80% of Brazil’s oil is dependent on imports. The implementation of the “National Biofuel Plan” has made a great difference in mitigating national energy security, increasing citizen income, creating job opportunities, and reducing GHG emissions. Apart from the suitable weather, large area of cultivable farmland, and other favorable natural conditions, the successful implementation of “Brazil Biofuel Plan” could not have been realized without the legal guarantee of implementation provided by biofuel policy, strong tax and financial policy supports, and the high degree of value placed on the promotion of biofuel technologies and industry by the government.

V. Scenario Analysis on GHG Emissions from Automotive Fuel Alternatives in China

(I) Definition of the Business As Usual (BAU) Scenario

The base scenario of this report is primarily the 2010-2030 BAU scenario for China's transportation fuel consumption developed in "Transport, Energy and CO_2 (IEA, 2009)", and the 2010-2030 BAU scenario for transport energy identified in China's Low Carbon Economy Scenario released by the Energy Research Institute (ERI) of the NDRC, starting with automotive fuel consumption in 2005, and the projections of automotive fuel consumption in 2010, 2020 and 2030 as the basis for scenario analysis.

The report chiefly analyzes China's consumption of vehicle use fuels, and does not include the consumption of fuel in air, sea and railway transportation.

Vehicle Population

Overseas and domestic vehicle research institutes, such as the DRC (2003), the China Automotive Technology & Research Center (CATRC) (2003), the FAW Group (2003), the China Communications and Transportation Association (2006), and Argonne National Laboratory of the US Department of Energy (2006) have all made projections for China's future car population. The vehicle population in 2010 is estimated at 50-63 million, and this figure will reach 120-150 million in 2020, and 230-250 million in 2030. However, China's automobile industry witnessed momentous development between 2006 and 2009, which had far surpassed the projection figures of these institutes. The vehicle population in 2009 doubled the number of vehicles in 2006, reaching 76.19 million. According to the latest projection from the IEA (see Fig. 5), China will have 70 million vehicles by 2020, still a conservative estimate when compared with the actual figures. The IEA predicted that the vehicle population will surpass 230 million in 2020, and 425 million in 2030. This stable and strong growth trend should persist well into 2050, and into the even more distant future.

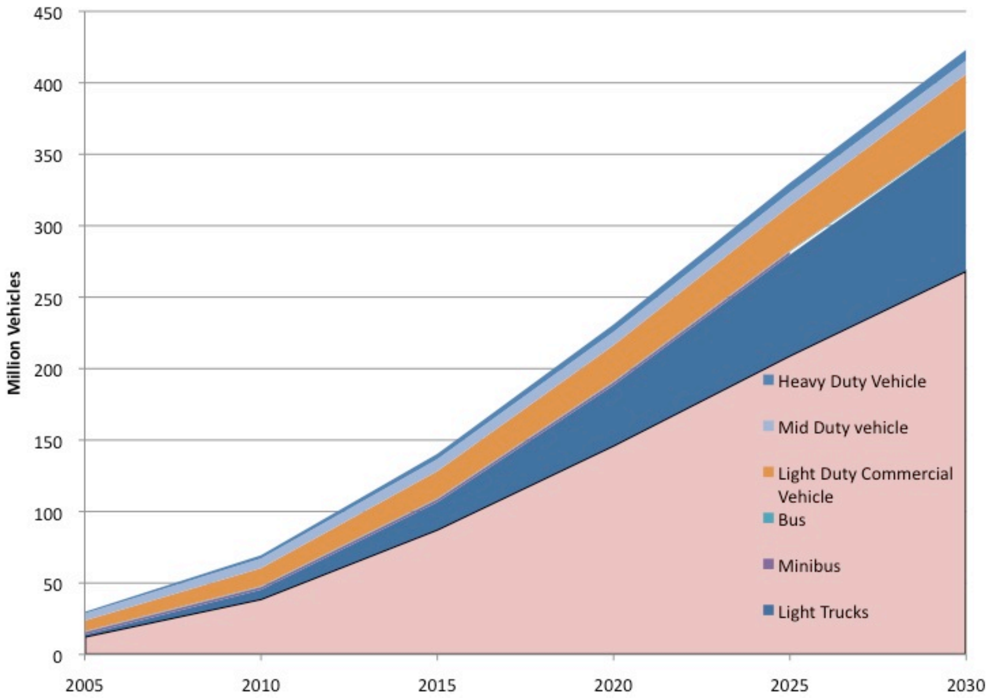


Figure 5: China Vehicle Population Forecast (IEA)
IEA (Transport, Energy and CO_2; 2009)

Automobile Fuel Consumption and GHG Emission

As the number of cars increases over time, the consumption of automotive fuels will demonstrate signs of marked increase. The IEA (2009) and ERI (2009) both made predictions for future transport fuel consumption (see Table 3), noting that the consumption energy by vehicles in China will increase sharply between 2010 and 2030, with consumption in 2030 nearly four-fold that of 2005, or 500 Mt of oil. This report takes the conservative BAU scenario from the IEA (2009) projections for analysis, meaning that automotive fuel consumption in China would reach 5.83 EJ, 12.57 EJ, and 19.11 EJ in 2010, 2020 and 2030 respectively, or 137, 292 and 444 million tons of traditional fossil fuels (fig. 6).

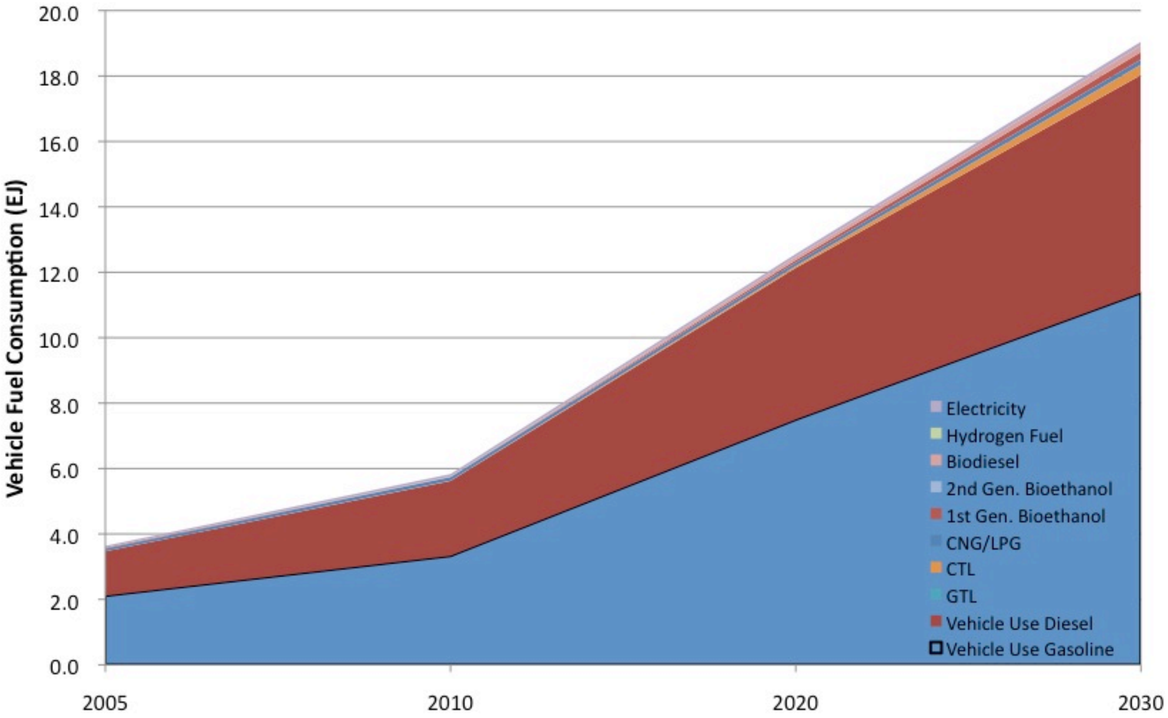
Fig. 7 shows that the GHG emissions resulting from automotive fuel consumption in China under BAU scenario should reach 550, 1,190 and 1,850 million tons in 2010, 2020 and 2030 respectively, taking into account the lifecycle GHG emission intensity of automotive fuel.

Table 3 Chinese Transport Energy Consumption Business as Usual Projection (2010-2030), EJ[9]

IEA	2005	2010	2020	2030
Transport Energy Consumption	4.56	6.92	13.94	20.82
Gasoline Consumption	2.11	3.33	7.50	11.38
Diesel Consumption	2.28	3.38	6.01	8.37

ERI	2005	2010	2020	2030
Transport Energy Consumption	4.68	7.38	15.55	23.35
Gasoline Consumption	1.91	3.24	7.06	10.12
Diesel Consumption	2.70	3.84	7.76	12.02

Note：1 EJ ＝ 10^{18}J. (1 billion GJ) Data sources：IEA, ERI



Note: 1 EJ = 10^{18}J

figure 6 Transport fuel consumption – BAU (China, 2005-2030)
Data Source: IEA *Transport Fuel and CO_2* (2009)

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[9] Diesel consumption includes automotive diesel consumption as well as off-road diesel consumption (e.g. Marine and rail use)

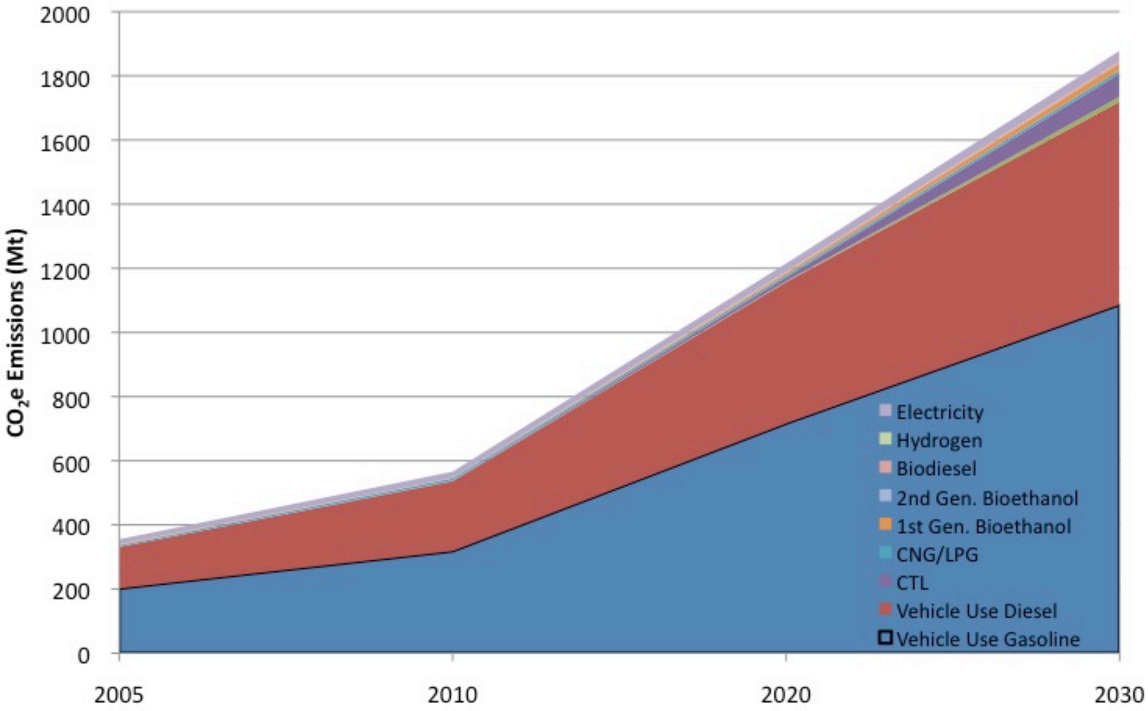

Figure 7 Transport Fuel Lifecycle GHG Emission, BAU (China, 2005-2030)
Data Source: calculations by *i*CET[10]

(II) Liquid Biofuel Alternate Scenario

Liquid biofuels, as automotive alternative fuels, have successfully gained a portion of the market share. The production of sugar-based ethanol in Brazil, and corn-based ethanol in the US, have both surpassed the volumes of tens of millions of tons. The feedstock sources for biofuels are wide ranging, offering huge emission reduction potential and increased domestic energy security. Many countries have taken the development of high-grade biofuel as a long-term strategy to achieve a low carbon, energy-independent transportation system.

China has set up a complete ethanol production and distribution system since it began to promote ethanol gasoline through pilot programs in 2004. In 2009, the output of fuel ethanol reached 1.73 Mt. Meanwhile, China has provided policy support to promote non-grain biofuels. Biofuels could potentially become one of the major channels by which China will develop low carbon automotive fuels.

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[10] Based on IEA Transport Fuel Consumption BAU calculations

Scenario Design for the Liquid Biofuel Alternate Scenario

Regarding the scenario design for alternative fuels for automotive use, this report has considered three types of biofuels, including conventional (first generation) bioethanol, advanced bioethanol, and biodiesel. The scenario targets are specified in Table 4.

Table 4 Scenario 1: Transport Fossil Fuel Replacement by Biofuel (Unit: 100kt)

Biofuel Type	2010	2020	2030
First Generation Bioethanol	15	15	15
Advanced (Second Generation) Bioethanol	20	85	265.8
Biodiesel	2	20	82.5
Total	37	120	360

The major basis for the design of this scenario's targets for biofuels is as follows:

Conventional bioethanol mainly refers to grain ethanol. China began to reject applications for "grain ethanol projects" since 2006, and has identified the purpose for the development of biofuels, i.e., "does not compete with people for grain, does not compete with grain for land, and does not damage the ecological environment." However, the major feedstock source for conventional bioethanol is still grain, and the imbalance of "competing with people for grain" still remains. Meanwhile, the other crops used for feedstock (for example, cassava) are often produced by occupying fertile farmland, "competing for land with grain". In this sense, the industrialized expansion and reproduction of conventional bioethanol still goes against national policy. In the scenario analysis the further development of conventional ethanol was not encouraged, so when determining the 2010, 2020 and 2030 values for conventional ethanol, the current annual consumption of 1.5 million tons per year was used.

"Advanced bioethanol" mainly refers to cellulosic ethanol. The targets for bioethanol, identified in the National Mid- to Long-term Development Plan for Renewable Energy adopted by the Executive Meeting of the State Council in August 2007, was used for the scenario analysis target, meaning two million tons more non-grain fuel ethanol will be used in 2010, and by 2020, the annual use of biofuel ethanol would reach 10 million tons (including the 1.5 Mt of conventional bioethanol). The promotion of E10 (content of ethanol: 10% v/v) across the country is used as the scenario analysis target for 2030. It is assumed that in the 2020 and 2030 targets, conventional ethanol consumption will remain fixed at 1.5 Mt, and advanced bioethanol will fill the remaining target space. Therefore, utilization of advanced biofuel would amount to 2 Mt, 8.5 Mt and 26.58 Mt in 2010, 2020 and 2030 respectively.

Biodiesel: the report uses the targets for biodiesel set in the National Mid- to Long-term Development Plan for Renewable Energy as the scenario analysis target; that is, by 2010, the annual utilization of biofuel will reach 200,000 tons, and the figure would reach 2 million tons by 2010. The goal is to realize BD5 (content of bio diesel 5% v/v) across the country by 2030.

The factors affecting lifecycle GHG emissions of biofuel are largely based on the results of relevant research both domestically and abroad, and focus on whole fuel chain lifecycle emissions. Detailed emission factors are shown in Table 5:

Table 5 Biofuel GHG Emission Factors (Calculated by iCET, based on Appendix 1) (g CO_2eq/MJ_{fuel})

Biofuel Type	2010	2020	2030
First Generation Bioethanol	92.9	92.9	92.9
Second Generation Bioethanol	6.3	6.3	6.3
Biodiesel	15.6	27.7	31.1

Regarding the emission factors of biofuel:

Conventional bioethanol: in 2009, the production of bioethanol was mainly based on corn, supported by wheat and cassava, in the ratio of roughly 6:1:1. It is assumed that the production structure of conventional bioethanol will remain unchanged in the future, and the emission factor of the first generation of bioethanol is determined by weighing the emission factors of corn, wheat and cassava, i.e., 92.9 g CO_2eq/MJ fuel (See Appendix 1)

Second generation bioethanol: cellulosic ethanol is largely used as the chief measuring gauge, i.e., 6.34 g CO_2eq/MJ fuel.

Biodiesel: China's biodiesel structure may experience some changes in the future. It is assumed that 100% of vehicle use biodiesel is waste vegetable oil-based diesel in 2010. The ratio would be 60% abandoned oil, 30% *Jatropha* and other oilseed-based diesel, and 10% liquefied biomass oil in 2020; the proportion would be 40%, 40% and 20% respectively, in 2030. Through weighing, the report concludes that the emission factors in 2010, 2020 and 2030 are 15.6, 27.7 and 31.1. g CO_2eq/MJ fuel.

Lifecycle GHG emission factors of other fuels are shown in Appendix 1.

Biofuel Scenario Analysis Results

Fig. 8 compares the lifecycle GHG emissions from the transport sector under both BAU scenario and the biofuel target scenario.

The comparison of GHG emissions under the BAU scenario and biofuel scenario is as shown in fig. 9, below. If China were to realize its biofuel development goals as identified in Mid- and Long-term Development Plan for Renewable Energy in 2010 and 2020, then the emission reduction would register at 0.96% (5.3 Mt CO_2e) and 2.23% (26 Mt CO_2e) respectively compared with levels under the BAU case. By 2010, 4.7 Mt CO_2e of emission reductions would come from the use of bioethanol, and 600,000 t CO_2e from biodiesel; By 2020, ethanol alternatives would avoid 20 Mt CO_2e equivalent, and 6 Mt CO_2e in reductions would come through the use of biodiesel. By 2030, if China saw the nation-wide use of E10 ethanol gasoline and BD5 blended diesel across the country, the GHG emission reduction by biofuels would amount to 5.04% compared to BAU, standing at 87 Mt CO_2e, of which nearly 63 Mt CO_2e would come from the use of bioethanol and 24 Mt CO_2e from biodiesel.

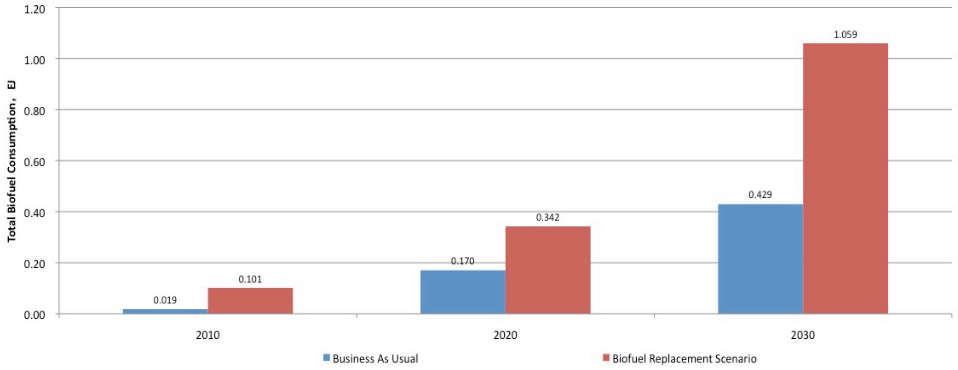


fig. 8 (a) Comparison of IEA BAU and biofuel target scenarios on energy basis.

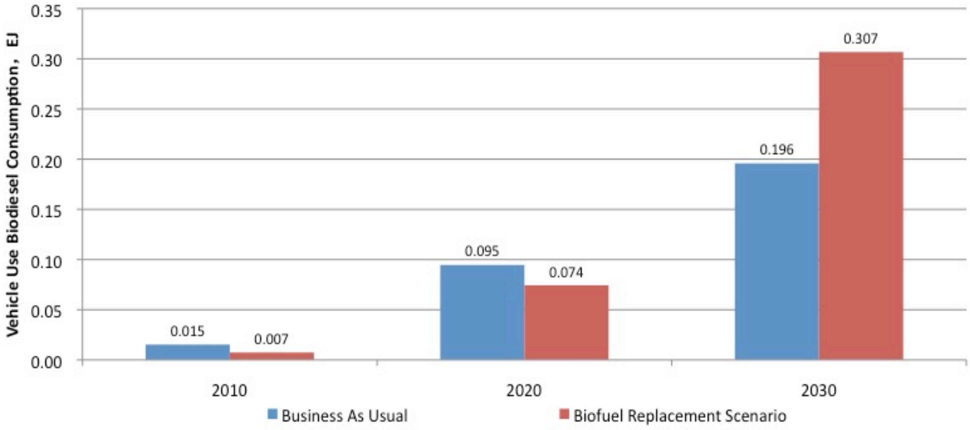


fig. 8 (b) Comparison of IEA BAU and biofuel target scenarios – biodiesel use (energy basis)

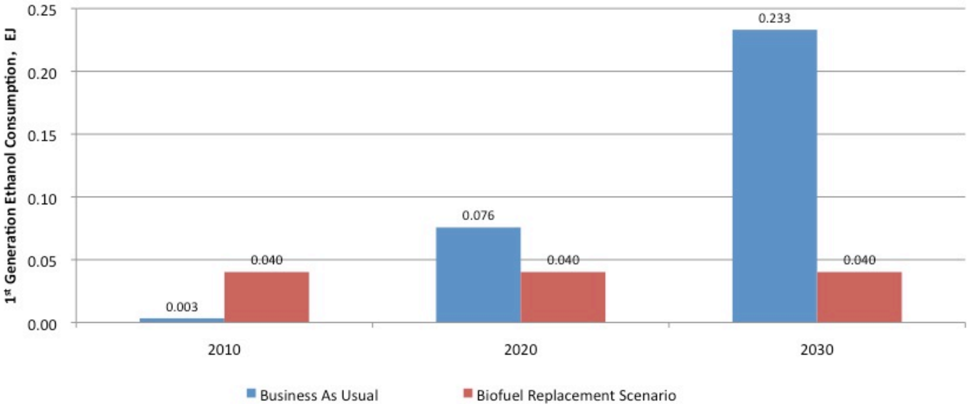


fig. 8 (c) Comparison of IEA BAU and biofuel target scenarios – 1st generation bioethanol (energy basis).

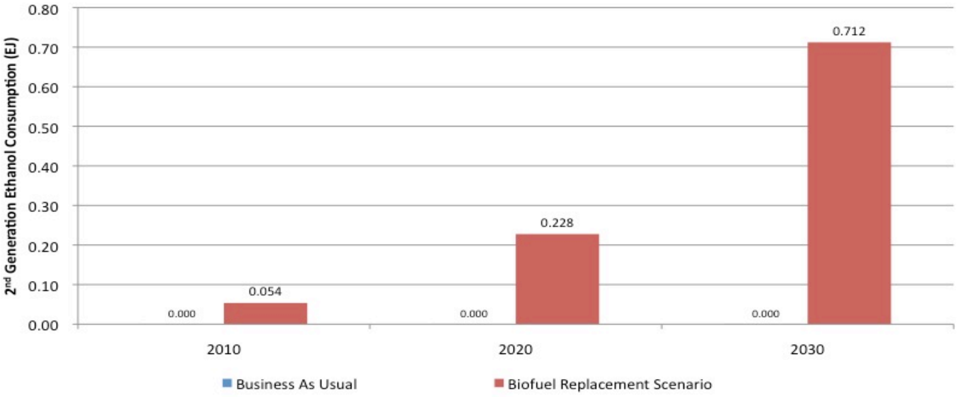


fig. 8 (d) Comparison of IEA BAU and biofuel target scenarios 2nd generation bioethanol (energy basis)

Figure 8 Scenario comparison – Biofuel Consumption

The comparison of GHG emissions between the BAU scenario and biofuel target scenario is as shown in fig. 9. Compared with the BAU scenario, emission avoidance in the biofuel scenario, if biofuels replace all transport energy on an energy basis, would stand at 0.8% in 2010, 1.6% in 2020 and 3.8% in 2030 respectively, with the emissions avoided reaching 4.5 Mt CO_2e, 18.8 Mt CO_2e and 70 Mt CO_2e.

If biofuels under the biofuel scenario in 2010, 2020 and 2030 replace only conventional gasoline and diesel, then the GHG emissions avoided would surpass 5.5 Mt CO_2e, 25 Mt CO_2eand 83 Mt CO_2e respectively, accounting for 1.0%, 3.5% and 4.9% of the total emissions from diesel and gasoline in the BAU scenario.

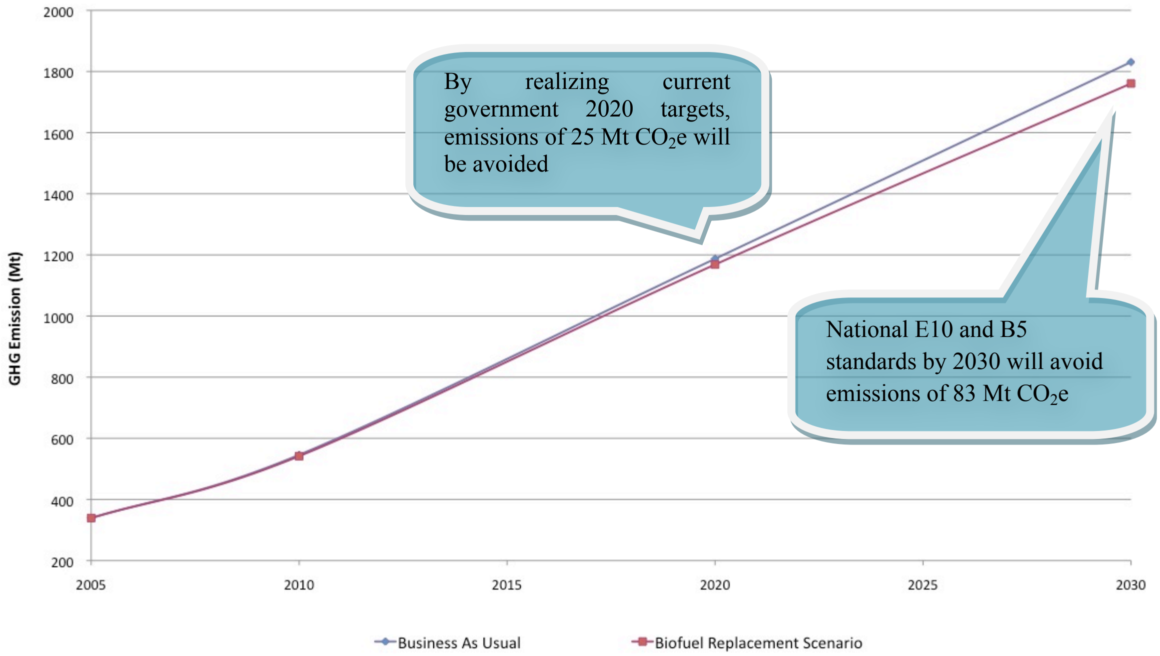


Figure 9 Transport energy in the BAU scenario replaced by biofuel targets: GHG emission comparison

(III) Coal-based Liquid Fuel Scenario

Coal-based methanol has been applied and promoted in the central, western and northern regions of China as an alternative automotive fuel. In recent years, Shaanxi, Shanxi, Guizhou, Xinjiang and Inner Mongolia have implemented local methanol fuel standards. In 2009, the amount of methanol for vehicle fuel is about 2 million tons. Two national standards, GB/T 23510-2009 *Vehicle Fuel Methanol* and GB/T 23799-2009 *Vehicle Use Methanol Gasoline* (M85) were officially implemented in November and December 2009 separately, signifying that methanol fuel could enter the market in a more regulated way and become a potential large-scale automotive fuel in the future.

Many leading coal chemical enterprises in China have been proactive in the construction and large-scale production planning of coal-to-liquids demonstration projects. In 2008, the NDRC issued a notice entitled *Notice Regarding the Question of Strengthening Coal-Based Oil Project Management*, thus strengthening project management, aiming for the healthy development of the coal-based oil technology. The direct liquefaction coal-to-liquids demonstration project established by Shenhua Group's Inner Mongolia Company held a trial run in early 2009 demonstrating great success. Coal-to-liquid fuel is also listed as one of the channels to realize automotive fuel independence in China.

Coal-based Liquid Automotive Fuel Scenario Design

Regarding the scenario design of alternative fuels for vehicle use, this Report has considered two major coal-based liquid fuels: coal-based methanol and coal-to-liquid oil. The target of alternative scenario is shown in Table 6.

Table 6 Automotive CTL fuel replacing fossil fuel scenario (100 kt)

Fuel type	2010	2020	2030
Coal-based methanol	200	1400	2100
CTL oil	150	1000	3000
Total	350	2400	5100

The basis for the coal-based liquid fuel scenario is as follows:

Coal-based automotive methanol: according to preliminary statistics on the utilization of automotive fuel methanol in China, the consumption amount in 2010 would be about 2 Mt. It is assumed for this scenario that 50% of gasoline delivered in China will be M15 in 2020 and 2030, with roughly 14 Mt and 21 Mt of methanol consumed respectively; another assumption is that all vehicle use methanol would come from coal and only substitute gasoline.

Coal-to-liquids oil: the targets for coal-to-liquids oil development outlined in the Draft National Mid- and Long-term Development Plan for the Coal Chemical Industry (2006 - unratified) have been used as the scenario analysis values, i.e. 1.5 Mt in 2010, 10 Mt in 2020 and 30 Mt in 2030 would be used respectively. Another assumption is that coal-to-liquids oil only substitute diesel.

Coal-based Liquid Fuel Scenario Analysis

Fig. 10 (below) compares the utilization of coal-based liquid fuels under both BAU scenario and alternative scenarios.

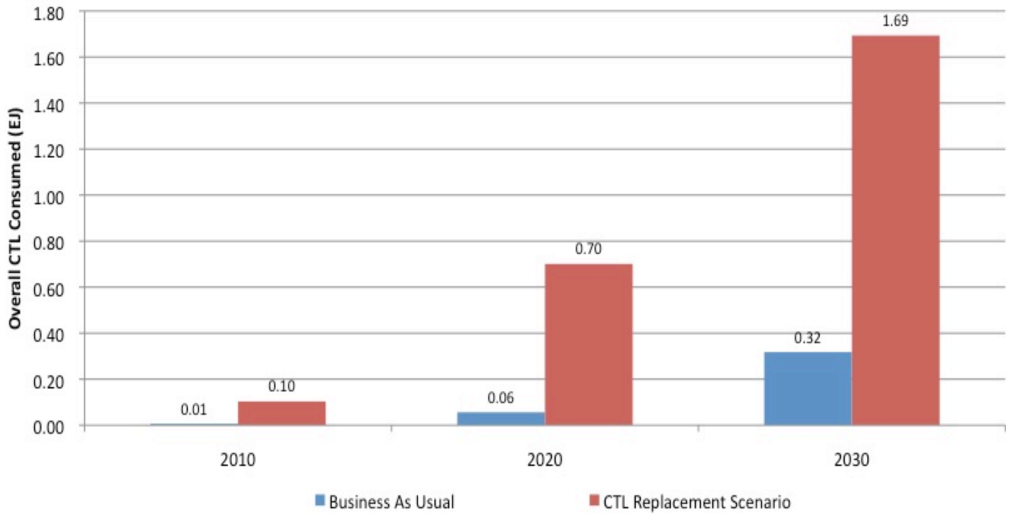


fig. 10 (a) Comparison of IEA BAU and overall CTL target scenario (energy basis)

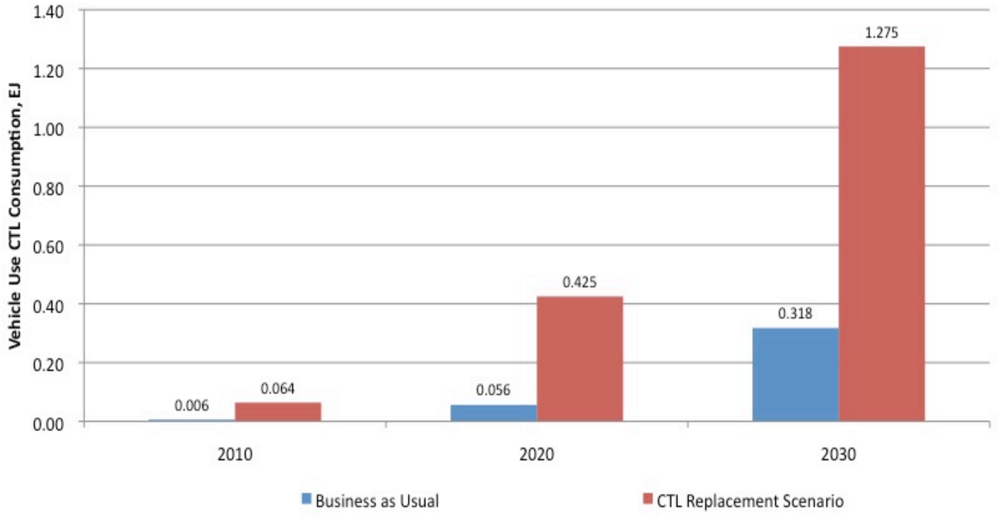


fig. 8 (b) Comparison of IEA BAU and direct liquefied coal to oil target scenario (energy basis)

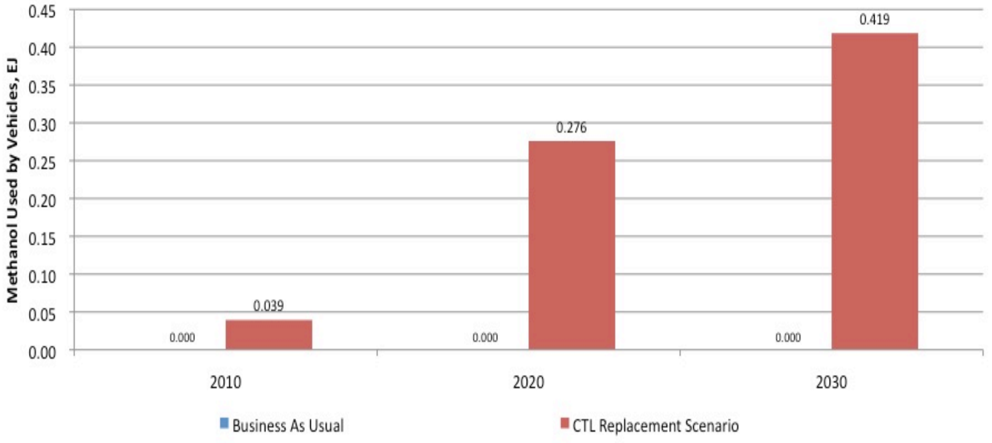
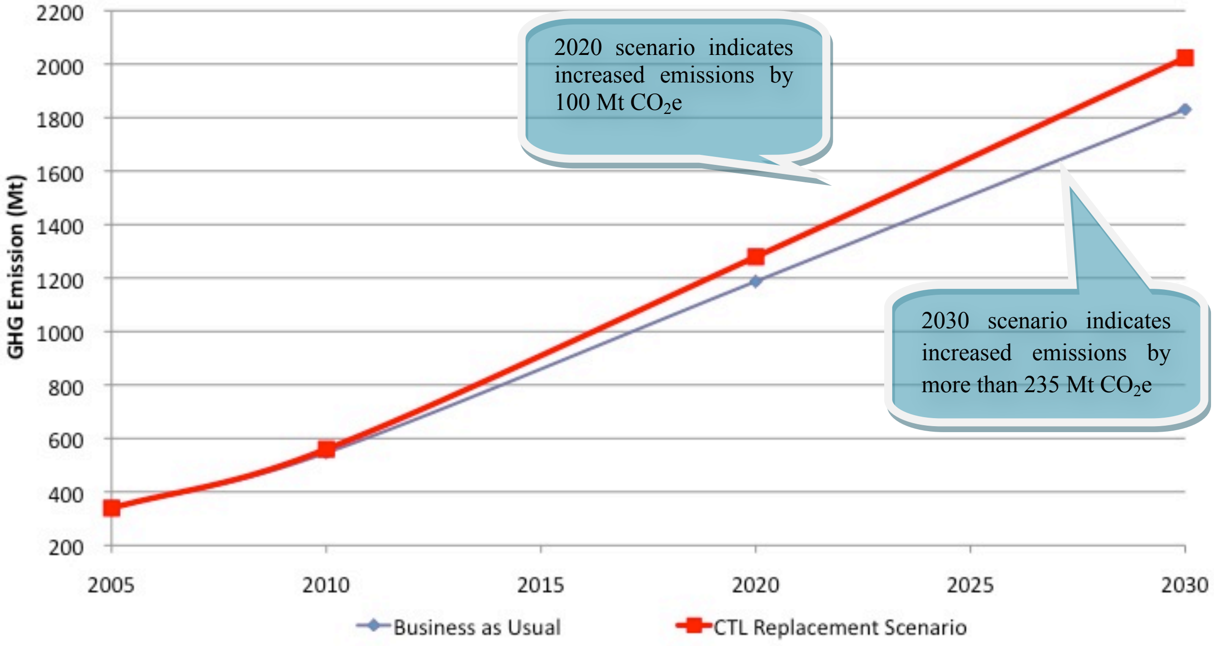


Fig. 10 (c) Comparison of IEA BAU and coal-based methanol consumption target scenario (energy basis)

Figure 10 CTL and BAU fuel consumption comparison

If the coal-based fuel scenario is achieved in 2010, 2020 and 2030, then 3.5%, 7.7% and 10.5% more GHG would be emitted compared with the BAU scenario, or 19 Mt CO_2e, 92 Mt $CO_2e$and 192 Mt CO_2e respectively. The absolute GHG emission increase as a result of substitution of conventional fossil fuel by coal-based liquid fuel would surpass 14 million tons, 100 million tons and 235 million tons of equivalent CO_2 (fig 11).



2020 scenario indicates increased emissions by 100 Mt CO_2e

2030 scenario indicates increased emissions by more than 235 Mt CO_2e

Figure 11 Conventional fossil fuel replaced by CTL vs. BAU scenario GHG emission comparison (2005-2030)

Advanced Coal-based Liquid Fuel Scenario Analysis

Assuming that all coal-based liquid fuel alternatives utilized in 2010 and 2030 be produced by using advanced technologies primarily including Carbon Capture and Storage (CCS), transportation GHG emission would see a slight increase compared with that of the BAU scenario (fig 12). This is a dramatically reduced GHG emission compared with the coal-based liquid fuel that is produced by using conventional technologies.

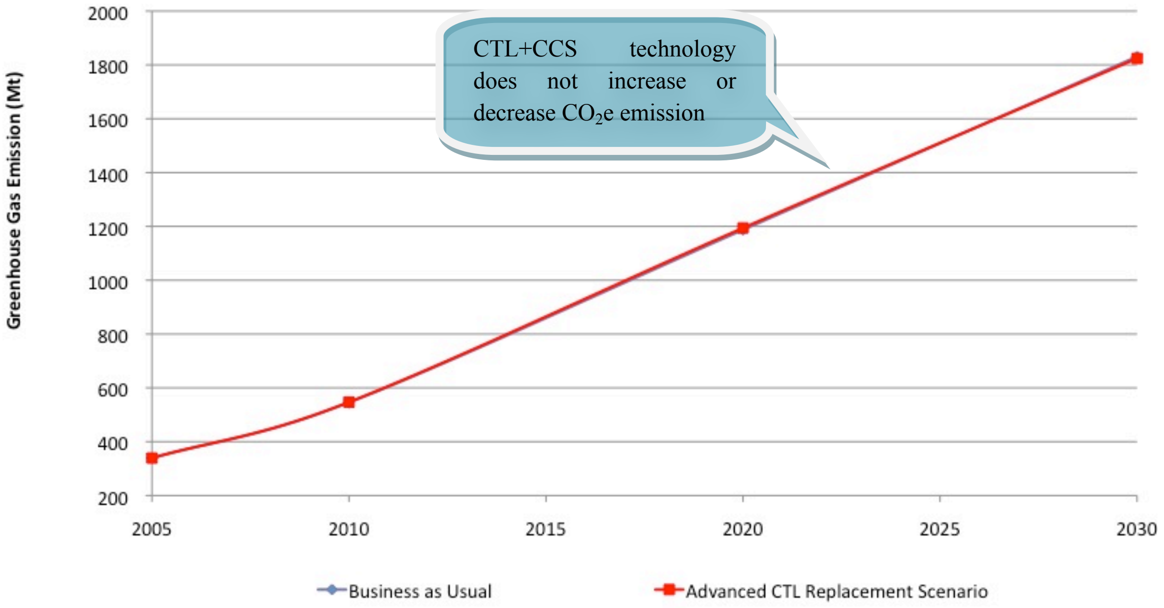


Figure 12 Conventional fossil fuel replaced by advanced CTL (with CCS) vs. BAU scenario GHG emission comparison (2005-2030)

(IV) Average GHG Emission Intensity of Automotive Fuels

Under the BAU scenario, the average fuel GHG emission intensity will continuously rise seeing a 2% increase between 2005 and 2030; if the biofuel scenario is realized, China could see a 4% reduction in the average automotive fuel GHG emission intensity by 2030 compared to the BAU scenario, to 93 g CO2eq/MJfuel (2% decrease compared to 2005 levels). However, if coal-based liquid fuel see an increase in consumption, average fuel carbon intensity would increase significantly. By 2030, if the methanol utilization reached 21 Mt and the utilization of coal-based liquid oil reached 30 Mt, the average automotive fuel carbon intensity in China would reach 107 g CO2eq/MJ fuel, an increase of 10.5% compared with the BAU scenario and a 12.8% increase from 2005. If CCS-enabled, advanced coal-based liquid fuel is utilized, the average carbon intensity is approximately equivalent to that of the base scenario (fig. 13).

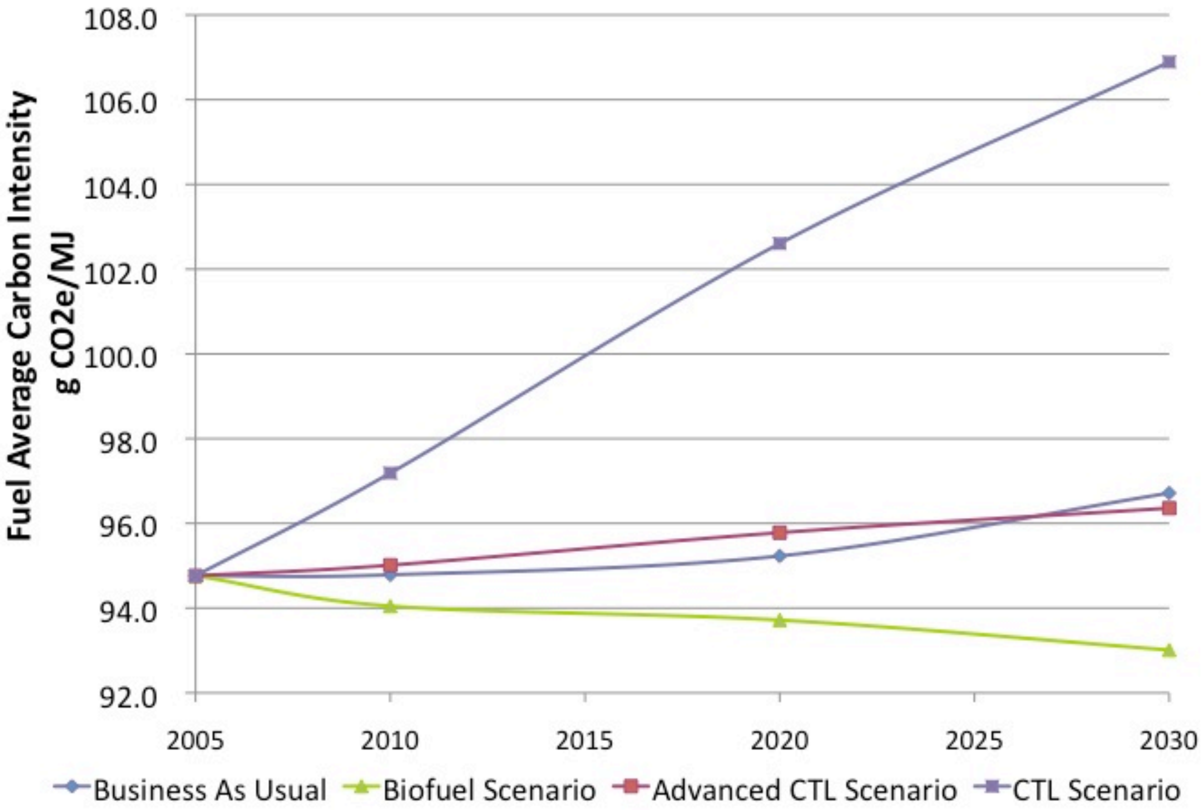


Figure 13 Fuel system carbon intensity comparison (all scenarios, 2005-2030)

(V) Discussions on the "Low Carbon" Development of Electric Vehicles

According to the IEA's BAU scenario, China's "new energy" light weight vehicles are mainly diesel, gasoline and hybrid vehicles with an expected population of 2.4 million by 2020 and 9 million by 2030 while BEVs and plug-in hybrid vehicles are rare seen in the BAU scenario. Hybrid vehicles still use traditional diesel and gasoline as their energy source while only BEVs and plug-in hybrid vehicles use exogenous power for their motive power.

Whether electric vehicles have absolute advantages in terms of energy consumption and lifecycle GHG emission when compared with vehicles that use traditional diesel and gasoline is an important question.

The Development Research Center of the State Council of China[11] (DRC 2009) conducted analysis on the relative advantages and disadvantages of BEVs and conventional diesel and gasoline vehicles with regard to energy consumption and GHG emission by using a lifecycle "well to wheels" analysis. BEVs were assumed to take the energy pathway

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[11] Development Research Center of the State Council of China, Conditions for Electric Vehicles in China to Become New Strategic Industry. 2009.

of “coal-electricity-electric motor” while conventional vehicles take the energy pathway of “petroleum-gasoline and diesel-combustion engine”. The results are displayed in fig. 14.

We can learn from this comparison that the primary energy consumed by BEVs and the CO_2 emitted per unit of distance are similar to those of gasoline and diesel vehicles, of which, energy consumption is better and lifecycle CO_2 emission is somewhat worse. But when compared with vehicles that use coal-to-liquid fuel rather than petroleum-based fuel, BEVs have evident advantages in both energy consumption and GHG emission.

It is significant that when electricity is used as vehicle energy, it could mitigate the foreign dependency ratio on oil and the ever-increasing pressure on transportation energy from the perspective of energy security. But at this time, the coal-fired power output accounts for more than 80% of gross electricity generation, and if the existing electricity production structure is not changed or advanced power generation technology is not utilized to reduce the carbon intensity of electricity, then electric vehicles have few advantages when compared with traditional diesel and gasoline vehicles with regards to total fossil energy consumption and lifecycle GHG emission.

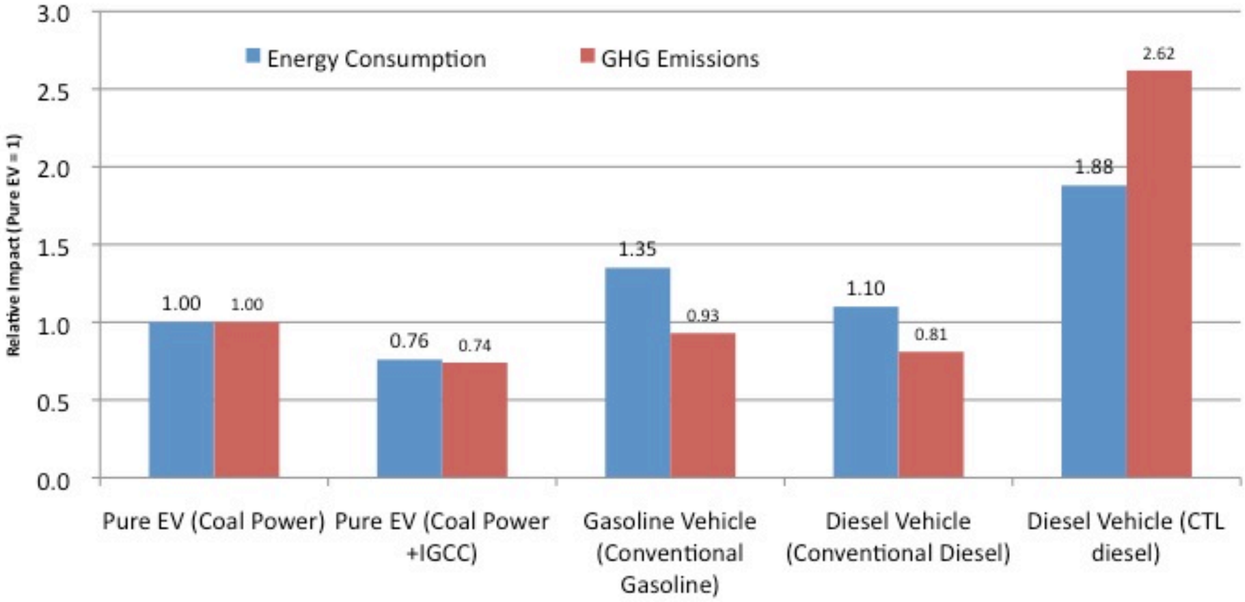

Figure 14 Relative Lifecycle GHG Emission Comparison of Five Technology Pathways (DRC, 2009)

Fig. 14 also indicates that if the electricity source of BEVs could use advanced, low carbon technologies (such as IGCC) to reduce the carbon intensity of electricity, the “coal-electricity to electric motor” energy pathway would demonstrate significant advantages in both energy consumption and GHG emission compared with conventional diesel and gasoline; at the same time, if the power supply structure could be further improved and the proportion of hydro power, nuclear power and power from renewable energy be increased, then fossil energy consumption and pollutant emission from electric vehicles could be further reduced.

At this time, it is important not to exaggerate the ability of electric “fuel” and electric vehicles to reduce GHG emissions from the transport sector, compared to conventional fossil fuels. At this stage of vehicle electrification in China, and the technology and structure of the grid, GHG emission reductions through the use of electricity as a main transport energy are limited. Actively developing a ***low carbon*** electric transportation is a systematic effort, and is a key in ensuring the sustainable development of transportation energy in China.

VI. Pathways and Objectives for China’s Low Carbon Automotive Fuels

(I) Major pathways for the development of Low Carbon Automotive Fuels

First, the government should pay close attention to and support the development of the low carbon automotive fuel industry. Only when government provides adequate priority, and defines laws, regulations and policy incentives, can the low carbon automotive fuel industry that is still in its initial stages achieve sound and healthy development. Rational targets for the development of low carbon fuels should be defined and adjusted in the short-term based on the condition of industrial development so that targets and actual implementation results could be matched. At the same time, coordination between different government departments should be strengthened, and the functions of various departments with respect to the carbon emission and sustainable development of fuels should be defined in order to build up governance capacity. Finally, governments should take responsibility for industrial development targets and implementation results, as well as publication of the implementation process on a regular basis.

Second, a balance must be struck between automotive energy alternatives and GHG emission reduction. China’s vehicle population will experience fast growth in the future, as will the consumption of automobile energy. At the same time, GHG emission reduction is becoming a national mission and responsibility in the mid- and- long-term. In this sense, equal emphasis should be laid on both automobile energy alternatives and GHG emission reduction while carefully identifying a national strategic roadmap for the mid- and- long-term future of automobile energy.

Third, China should work to achieve integration between innovation in core technologies as well as the scaling up of industry. Low carbon automotive fuel technologies are still, for the most part, at the demonstration stage, and are faced with some technical bottlenecks competitive edge shortfalls when compared with conventional fuels.

Governments should employ financial support, tax incentives and other policies to cultivate the development of the low carbon automotive fuel market; meanwhile, governments need to do more to encourage innovation and breakthroughs in low carbon automotive fuel and forge a mutually reinforcing relationship between market and technology. The final result would be improvement in R&D, design, manufacturing and operational capacities of the industry, breakthroughs in technologies and an emerging industry with technical innovation as the core capability, thus producing more opportunities for economic growth.

(II) Proposed Targets for China’s Low Carbon Automotive Fuel Development

China should strive to reduce the average carbon intensity of automotive fuel by 15% and make low carbon automotive fuel the leading orientation for China’s automobile energy strategy by 2030 through government facilitation, promotion of demonstration programs, policy support and commercial applications. As a result, a host of domestic enterprises with global core competitive edge will spring up across China, with motivation to produce world-class indigenous innovation and technology. Chinese low carbon fuel product standards and technical standards of low carbon fuels will be recognized and applied around the world, giving China a significant edge in the production of alternative automotive fuel technical research, demonstration application and industrial development.

VII. China's Low Carbon Automotive Fuel Development: Policy Suggestions

China has experienced extremely fast growth in automotive fuel consumption in the past two decades. If there is any failure to take effective measures or offer support, or if the development of high-carbon alternative fuel occurs, a consumption structure featured by high-carbon automotive fuel will emerge in the coming two decades, which will result in severe and negative climate change impacts in China and around the world, pose grave risks to national oil security, and work against the concept of sustainable development of the automobile energy industry in China.

China should proceed in its policy development while keepings its national realities in mind, and taking the advanced experience of other jurisdictions under advisement in order to achieve low carbon and low criteria emissions from the transport sector, as well as encourage the development of new, low carbon energies and technologies.

(I) Promote the Diversification of Automotive Fuels and the Complementary and Coordinated Development of Multiple Technologies to reduce GHG Emissions

China has recently released a series of policies to promote the development of electric vehicles, a type of vehicle which are deemed to be an important means to address energy security and lead to a low carbon transportation system in the future. However, it is an unavoidable truth that before electric vehicles become ubiquitous, liquid fuel will certainly remain the major source of transportation energy and GHG emission. Therefore, liquid automotive fuels must advance towards "lower carbon" in the next two decades if China hopes to see significant emission avoidance from the transport sector in the next two decades. In this way, it is essential to pay attention both to the energy replacement and emission reduction effects of electric vehicles, and on the other, to give full play to the energy replacement and emission reduction roles of other alternative fuels when defining policies and targets for automotive fuel.

(II) Support the Sustainable Development of Environment-Friendly Biofuels and Fulfill or Exceed the Already-established Targets

Domestic and overseas research indicates that many (but not all) biomass liquid fuels have lower carbon intensities than traditional fossil fuels, offering lifecycle GHG emission reductions of 30-120%. If biofuels are promoted as alternative automobile fuels on a large scale, their indirect impacts on society and the environment must be taken into consideration. A standard for the appraisal of both the direct and indirect impact of biofuels should be established in order to encourage the development of environment- and society-friendly biofuels and low carbon automotive fuel alternatives.

China should strive to at least meet already-set targets for biofuels by 2020. China rolled out its Mid- and Long-term Development Plan for Renewable Energy in 2007 and established goals for biofuels: by 2020, the annual utilization of bioethanol would reach 10 Mt and the annual utilization of biodiesel would reach 2 Mt. Should the country's industry achieve these targets, GHG emission could be reduced by 18.8 million tons compared with fossil diesel and gasoline.

In order to achieve these goals, however, new technologies such as second-generation biofuels will need to be developed, as these fuels can provide environmentally sustainable energy for transportation applications. At the same time, second-generation, cellulosic ethanol lifecycle GHG emission reductions could reach more than 60%, and result in beneficial environmental and social outcomes when being used together with conventional fuels. This type of also fuel conforms to China's policies for resource recycling, because they can be made from farm wastes. With such great potential, China should offer policy support in the forms of tax rebates or reductions, subsidies and industrial policy as a way to support the development of second-generation biofuels. A mechanism that brings together GHG emission reduction and financial subsidy such as a fuel-only carbon credit market should be established to create sound policy conditions for the industrial development of advanced low carbon fuels.

(III) Prevent the Unnecessary Development of High-Carbon, Coal-Based Liquid Fuels; Reserve Advanced Coal-Based Liquid Fuel Technologies as a Strategic Technology for Use in Times of Crisis

Every effort must be made to prevent the unnecessary and environmentally-unsustainable development of high-carbon, coal-based liquid fuel. Coal-based liquid fuel is highly carbon emission- and water consumption-intensive, achieving 80-200% increases over the GHG emission intensity of conventional gasoline and diesel. Every ton of coal-based liquid fuel requires more than 10 tons of water through its production process, imposing severe and negative impacts on local ecosystems. Not only is coal bad for the environment: coal chemistry needs huge high-risk capital investment, bringing greater pressure on society and the economy. Finally, China became a coal net importer in 2009, so there is no energy security benefit of using coal as opposed to using other materials as feedstock for transport fuel. For these reasons, China should strive to prevent the over-heated and large-scale development of high-carbon coal-based fuels.

Coal-based liquid fuel technologies should be developed only as a strategic technology in case of desperate shortage of alternative sources of energy. It is recognized that China's energy mix is mainly based on coal and R&D on Carbon Capture and Storage (CCS) is a technology that will be necessary for China to continue to develop and provide energy for its economy in the mid-term. From a lifecycle GHG emission perspective, CCS technology could collect and store over 60% of emissions over regular coal-based fuels. However, coal-based fuel is so carbon intense that even if we utilize CCS technology in the production of coal-based liquid fuel, the lifecycle GHG emission per unit energy is still somewhat higher than traditional fossil fuel. In this sense, substituting traditional fossil fuel with coal-based liquid fuel would inevitably lead to development towards a high-carbon transportation fuel system.

(IV) Establish an Institution Responsible for the Sustainable Development of Low Carbon Fuels

At the moment, China doesn't has a government institution up and running that is responsible for collecting information about lifecycle GHG emissions from fuels, formulating transportation fuel GHG emission reduction goals and other related policies, or collecting regulating social and environmental concerns caused by fuel at the systemic level. As automotive fuel consumption in China increases, it becomes increasingly important to establish an institution or assign authority for the sustainable development of low carbon fuels to an existing national functional department, such as the National Energy Administration.

Work to define and adjust the emission reduction goal for transportation fuel. At the moment, China has established pilot programs to develop many types and sources of alternative fuels, yet the government remains unfocused regarding the selection of likely alternative fuels and policy support they should receive. An institution responsible for the sustainable development of low carbon fuels would put China in a better position to obtain a comprehensive picture about the supply and demand conditions of various fuels across the country and to analyze the GHG emission data reported by fuel suppliers and producers in a concentrated manner on which GHG emission reductions and policies for low-carbon, sustainable transportation fuel could be developed.

Such an institution could use GHG emission performance standards to adjust the transport fuel mix based on GHG emission reduction objectives, and establish fiscal subsidies or and other carbon neutral mechanisms so that the market would lead decision making, thus encouraging the development of low carbon fuels, reducing the average carbon intensity of the fuel system, and avoiding the chance that the government would mistakenly choose to support high-carbon technologies.

Supervise the healthy development of low carbon fuels. It is crucial to supervise and manage the healthy development of low carbon fuels. Each type of alternative fuel has its drawbacks, particularly if not managed carefully from an economic perspective. Therefore benefits of any particular low carbon fuels should not be unreasonably emphasized without a full analysis of each individual fuel’s drawbacks taken into consideration. Unbridled optimism would lead to overinvestment, industrial accumulation and over capacity.

Meanwhile, the negative environmental and social impact of fuels should be taken into account. A standard for the appraisal of the environmental and social effects of fuels should be developed and the environmental and social effects of fuel-supplying enterprises should be publicized on a regular basis. Furthermore, supervision and oversight of the environmental and social impacts of imported fuel and feedstocks should be strengthened to ensure that the large amount of import fuel will not impose disastrous impact on the grain security, land use, environment and society of other countries. On January 1, 2010, China reduced the import tariff on fuel ethanol from 30% to 5%, demonstrating that China will import more fuel ethanol in the future. The institution responsible for the sustainable development of low carbon fuel should be responsible for tracing the environmental and social impact of fuel policy implementation.

Enhance international communication and cooperation on sustainability standards. The institution for the sustainable development of low-carbon fuel should maintain and strengthen cooperation with international institutions such as the Global Bioenergy Partnership, the Roundtable for Sustainable Biofuels under the United Nations, or the Roundtable on Sustainable Palm Oil as a way to leverage on the experience of others in setting standards for the sustainable development of low carbon fuels. At the same time, the institution should also share China's experiences as developing country in realizing low carbon fuel standards and policies with other countries. Through communication and cooperation, domestic production as well as international trade of sustainable low carbon fuels can be facilitated, bringing benefit to countries around the world.

(V) Establish "the National Center for Fuel Lifecycle Research"

In order to better understand the lifecycle impacts of automotive fuels on the environment, China should fund the establishment of a "Key State Laboratory for Automotive Fuel Lifecycle Research" under major academic institutions which will be responsible for:

1. ***Supporting the development and implementation of automotive fuel policies.*** The Center would mainly carry out research and analysis on the lifecycle of automobile fuels, support the government in developing relevant standards and policies for low carbon fuels and provide a scientific basis for standards and policies. Over the years, relevant institutions in China have conducted research on fuel lifecycles, such as Tsinghua University, Shanghai Jiaotong University, Tongji University, CATRC, and the Innovation Center for Energy and Transportation, but all were carried out in the form of academic research and were mostly funded by foreign foundations and enterprises. The research was carried out with no government policy as a background, and had strategic weaknesses such as short research periods and weak project consistency, which resulted in an incomplete and scattered database about China's automotive fuel lifecycles.

2. ***Establishing national databases and appraisal models for automobile fuel***. This Research Center should undertake research that results in the establishment of databases of basic information about various fuel feedstock sources and alternative automotive fuels of various types, and develop appraisal models in terms of fuel lifecycle energy efficiency, water resource consumption, GHG emission and other environmental and social impacts, which will be used by enterprises, academic institutions and governments as a means of substantiating their achievement of government targets in these area.

A “Key State Laboratory for Automotive Fuel Lifecycle Research” would give preference to evaluation of the lifecycle GHG emission intensity of conventional gasoline and diesel. It is very difficult to assess the emission cut effects of alternative fuels and to distinguish the emission differences of various alternative fuels without a real, authoritative and widely acceptable criterion about the lifecycle GHG emissions of fossil fuels.

(VI) Two-step Development of Policy Instruments for Low Carbon Automotive Fuel

Step 1: Establish a baseline GHG emission value for the current fuel system, as well as a fuel carbon intensity reporting system for fuel providers

International practice has demonstrated that after years of consistent and standardized effort to collect and process information and data about the GHG intensity of fuels and other products by governments and research institutes, governments can develop a set of policy tools to evaluate various fuel feedstock sources, different production technologies and lifecycle GHG emission of different fuels in a credible manner as a way to strengthen government confidence in the concept and development of emission reduction goals, strategic implementation of targets and timely achievement of targets.

At this time, China has no official system for collecting fuel lifecycle information, nor does it have a policy-oriented tool to evaluate the lifecycle GHG emissions of various fuels. It should be a top priority for China to establish a mandatory fuel information reporting system to collect data and require China’s fuel suppliers (including foreign-invested suppliers) to report information on the supplied fuel. The report should include fuel type, fuel source, producer and processes, GHG emission related to the production process, and environmental and social impacts according to standards set by government – and ideally in harmony with international fuel carbon reporting and sustainability standards. In so doing, China would better understand the basic information about fuels sold on the market. Fuel information should be reported to the Institution for the Sustainable Development of Low Carbon Fuels (as defined in recommendation IV) while authorized research institutions should process and analyze information and data as a way to provide basis for future policy formulation.

Step 2: Implement a set of fuel GHG emission default factors for fuels

Based on the information collected through the reporting system outlined in *Step 1*, build and constantly update a database of fuel GHG emission default values and evaluation model default values. Once lower carbon fuels are identified, and through government support of enterprises or fuel suppliers providing lower carbon fuels, the development of low carbon fuels can be effectively promoted, thus realizing the transportation sector's contribution to GHG emission reductions.

(VII) Define a Reasonable Goal for the Consumption of Low Carbon Automotive Fuels and an Average Carbon Intensity Goal

Reasonable consumption targets for low-carbon automotive fuels is conducive to the construction of a low carbon fuel system and the assurance of energy security; at the same time, the automotive fuel system also needs to identify an average fuel GHG emission intensity reduction target to realize the goal of transportation-related GHG emission reduction.

The government should be deliberate in its review of the implementation conditions of the two objectives, disclose relevant information to the public, and make proper adjustment to policies and implementation standards for every two or three years pursuant to the implementation conditions and the actual development of fuel technologies.

Targets could be achieved through the use of mandatory policies, tax incentives, fiscal subsidies and market regulation and control. For instance, mandatory policies could require that all fuels sold on the market shall meet the fuel carbon intensity target set in the given year and relevant parties who over perform (or fail to realize) the goals could meet the requirement by selling (or buying) carbon credits on a market; the government may encourage technical innovation by providing fiscal subsidies for innovation-driven enterprises; and low carbon fuel producers could enjoy tax incentives, among others.

Appendix 1 – On-road transportation fuel lifecycle GHG emission factors

In recent years, the EU and US have done a considerable amount of research on the lifecycle carbon emissions (i.e. carbon intensity) of on-road transportation fuels. Research resulting from policy motivations, including the JEC (2008)[12], CA-GREET (2009)[13] and RTFO (2009)[14] reports have received government funding and have publicly reported the emission factor data that they have produced. Some international agencies and organizations have summarized these reports, including the IEA (2008)[15] and Winrock (2008)[16]. Since 2007, Chinese research organizations including CATARC (2008)[17], Shanghai Jiaotong University (2009)[18], Tsinghua University (2008)[19] and *i*CET (2009)[20] have undertaken on-road transportation fuel lifecycle assessment research. This report makes use of emission factors from all major Chinese and international organization lifecycle emission research and calculates average emission factors, as listed in Table 7. This average has not taken into account possible changes in technology between 2010-2030 which might see reductions in carbon intensity. The authors strongly recommend that Chinese domestic researchers publicly produce reliable Chinese emission factor data for transport fuels in order to inform the policy making process, allow companies to make accurate reports on their own GHG emissions, and to provide a solid foundation for next-generation scientific research.

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Table 7 On-road Transportation Fuel Lifecycle GHG Emission Factors (China)

Fuel Type	GHG emission factor	
	g CO_2eq/MJ_{fuel}	t CO_2eq/t_{fuel}
Fossil Gasoline	95.55	4.12
Fossil Diesel	95.13	4.10
First Generation Bioethanol	92.88	2.49
Second Generation Ethanol	6.34	0.17
Biodiesel[21]	15.59	0.58
Coal-based methanol	250.25	4.93
Coal-based methanol+CCS	113.71	2.24
CTL Fuel	228.71	9.72
CTL+CCS	117.18	4.98
LPG	69.98	3.31
CNG	59.53	2.56
Electric Power[22]	124.00	1.004[23]

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[21] 2020/2030Biodiesel emission factors selected were 27.4 and 31.1 Mt CO2eq/EJfuel respectively.

[22] Emission factor for electricity is in units of kgCO2e/kWh.

Appendix 2 and 3 Draft National Standards (Chinese Language Only)

Appendix 2: The Principles and Requirements of Greenhouse Gas Emission Assessment for Transportation Fuel Life Cycle Before Usage Stage (Submission Draft)

Appendix 3: The Requirements of Greenhouse Gas Reports and Verification for Transportation Fuel Lifecycle Before Usage Stage

(Attached below)

ICS 13. 020.01
Z04

中华人民共和国国家标准

GB/T ×××××—××××

交通燃料使用前各生命周期阶段温室气体排放的评价原则和要求

The principles and requirements of greenhouse gas emission assessment for transportation fuel life cycle before usage stage

（报批稿）

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中华人民共和国国家质量监督检验检疫总局
中国国家标准化管理委员会　发布

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前言

本标准依据GB/T 1.1-2009给出的规则起草。

本标准由国家发展和改革委员会提出。

本标准由全国环境管理标准化技术委员会（SAC/TC 207）归口。

本标准起草单位：中国标准化研究院、能源与交通创新中心、清华大学、中国科学院生态环境研究中心、中国石油集团安全环保技术研究院、煤炭科学研究总院、中国粮油食品（集团）有限公司。

本标准主要起草人：陈亮、刘玫、康利平、张阿玲、张天柱、杨建新、于景琦、罗陨飞、林海龙。

交通燃料使用前各生命周期阶段温室气体排放的评价原则和要求

1. 范围

本标准规定了交通燃料使用前各生命周期阶段温室气体排放的评价原则和要求。

本标准适用于油气基燃料、生物质液体燃料以及煤基液体燃料等交通燃料从原料获取到交通燃料生产、输配、储存等各生命周期阶段中的温室气体排放评价，其它交通燃料生命周期的温室气体排放评价可参考本标准执行。

2. 规范性引用文件

下列文件对于本文件的应用是必不可少的。凡是注日期的引用文件，仅注日期的版本适用于本文件。凡是不注日期的引用文件，其最新版本（包括所有的修改单）适用于本文件。

GB/T 24040 环境管理 生命周期评价 原则与框架

GB/T 24044 环境管理 生命周期评价 要求与指南

ISO 14064-1 组织层次上对温室气体排放和清除的量化和报告的规范及指南（Specification with guidance at the organization level for quantification and reprorting of greenhouse gas emissions and removals）

3. 术语和定义

GB/T 24040、GB/T 24044和ISO 14064-1界定的以及下列术语和定义适用于本文件。为了便于使用，以下重复列出了GB/T 24040、GB/T 24044和ISO 14064-1中的某些术语和定义。

3.1

温室气体 greenhouse gas (GHG)

大气层中自然存在的以及由人类活动产生的能够吸收和散发由地球表面、大气层和云层所产生的波长在红外光谱内辐射的气态成份。

注：本标准中所涉及的温室气体主要包括二氧化碳（CO_2）、甲烷（CH_4）、氧化亚氮（N_2O）、氢氟碳化物（HFCs）、全氟碳化物（PFCs）和六氟化硫（SF_6）。

[ISO 14064-1—2006，定义2.1]

3.2

温室气体排放（简称GHG排放）greenhouse gas emission

在特定时段内释放到大气中的 GHG 总量（以质量单位计算）。

[ISO 14064-1—2006，定义2.5]

3.3

温室气体清除　greenhouse gas removal

在特定时段内从大气中清除的 GHG 总量（以质量单位计算）。

[ISO 14064-1—2006，定义2.6]

3.4

温室气体源　（简称为GHG源）　greenhouse gas source

向大气中排放 GHG 的物理单元或过程。

[ISO 14064-1—2006，定义2.2]

3.5

全球增温潜势　global warming potential (GWP)

将单位质量的某种GHG在给定时间段内辐射强迫的影响与等量二氧化碳辐射强迫影响相关联的系数。

注：**附录D** 给出了政府间气候变化专门委员会提供的全球增温潜势。

[ISO 14064-1—2006，定义2.18]

3.6

二氧化碳当量　carbon dioxide equivlent（CO2e）

在辐射强迫上与某种 GHG 质量相当的二氧化碳的量。

注：二氧化碳当量等于给定温室气体的质量乘以它的**全球增温潜势（3.5）**。

注：改写ISO 14064-1—2006，定义2.19

3.7

生命周期评价　life cycle assessment (LCA)

对一个产品系统的生命周期中输入、输出及其潜在环境影响的汇编和评价。

[GB/T 24040—2008，定义3.2]

3.8

共生产品　co- products

同一单元过程或产品系统中产出的任何两种或两种以上的产品。

[GB/T 24040—2008，定义3.10]

3.9

功能单位　functional unit

用来作为基准单位的量化的产品系统性能。

[GB/T 24040—2008，定义3.20]

3.10

温室气体活动水平数据　greenhouse gas activity data

GHG 排放或清除活动的定量数值。

注：GHG 活动水平数据例如能源、燃料或电力的消耗量，物质的产生量、提供服务的数量或受影响的土地面积。

[ISO 14064-1—2006，定义2.11]

3.11

初级活动水平数据 primary activity data

由直接测量获取的温室气体活动水平数据。

3.12

次级活动水平数据 secnondary activity data

由直接测量以外来源获取的温室气体活动水平数据。

3.13

排放因子 emission factor

单位活动水平的GHG排放量。

3.14

系统边界 system boundary

通过一组准则确定哪些单元过程属于交通燃料系统的一部分。

注：改写 GB/T 24040—2008，定义3.32。

3.15

温室气体报告（简称为GHG报告） greenhouse gas report

提供有关 GHG 信息的文件。

4. 评价原则

4.1 完整性

宜对系统边界内所有潜在的温室气体排放和清除活动进行评价。如果有温室气体排放或清除活动被排除，则应对它们进行单独陈述并进行合理解释。

4.2 透明性

评价过程应做出清晰的记录。并保证数据的真实性和可验证性，以确保能对结果做出合理解释。

4.3 一致性

宜使用统一的方法和措施以保证评价结果具有可比性。

5. 评价要求及方法学框架

5.1 总体要求

交通燃料使用前各生命周期阶段GHG排放评价应符合GB/T 24040和GB/T 24044的相关要求。评价完成后应给出结论，并宜编制GHG报告。

5.2 评价步骤

交通燃料使用前各生命周期阶段GHG排放评价步骤宜包括（见图1）：

a）制定评价目标；
b）确定系统边界；
c）确定功能单位；
d）收集数据；
e）分配；
f）温室气体排放评价；
g）不确定性分析；
h）GHG报告。

5.3 评价目标

制定评价目标时宜考虑：

a）评价理由；
b）应用范围；
c）评价结果的沟通对象；
d）结果是否将被用在对比论断中，并向公众发布。

5.4 系统边界

5.4.1 系统边界的确定

系统边界宜包括交通燃料生命周期中从原料获取到交通燃料生产、输配和储存等各个阶段中的GHG排放。在确定系统边界时，宜根据所制定的评价目标以及交通燃料的实际情况选择所包括的生命周期阶段（参见**附录A**），并宜根据重要程度确定所包含的生命周期阶段中各个GHG源（见**5.4.2**）。

5.4.2 GHG 源

在确定系统边界时，宜包括系统边界内所有的GHG源。但为了便于计算，可排除下列GHG源：

a）与在原料生产、原料转化为交通燃料或原料和产品运输过程中所使用装备的制造相关的GHG排放；
b）与在制备交通燃料过程中所必需的添加剂和催化剂的生产过程中所产生的GHG排放；
c）涉及人工劳动力所产生的GHG排放。

除上述GHG源外，如有任何GHG源被排除，应给出具体说明。

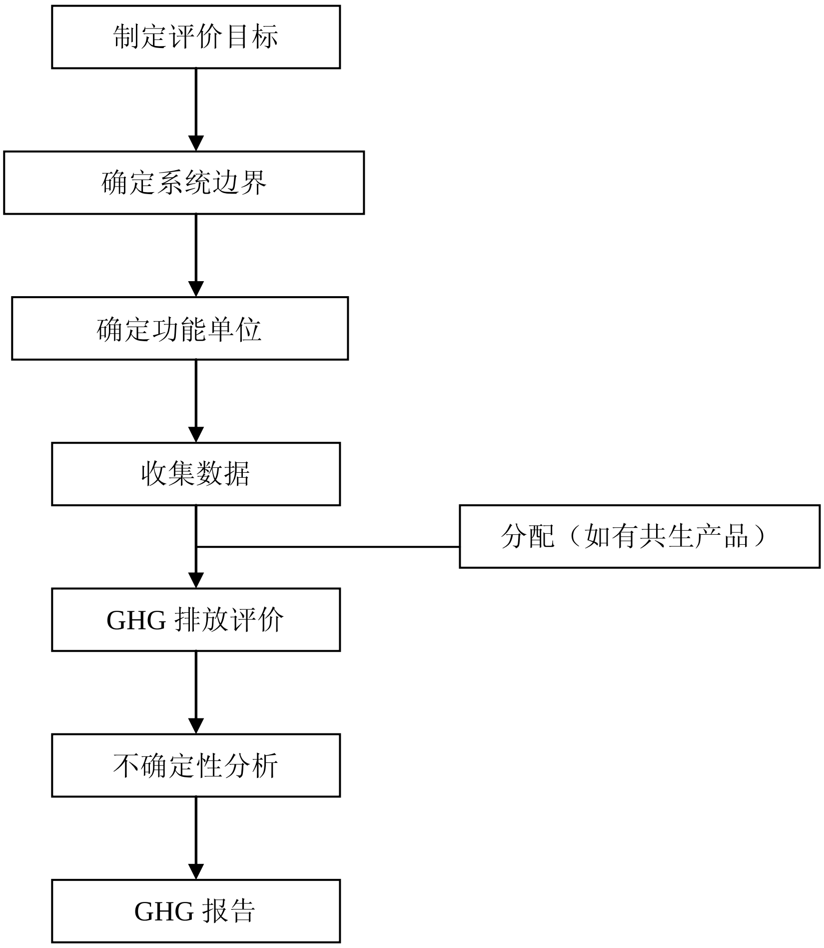

图1 交通燃料使用前各生命周期阶段GHG排放评价步骤

5.5 功能单位

应基于功能单位对交通燃料使用前各生命周期阶段GHG排放进行评价。在评价时，可选择单位交通燃料量作为功能单位。

5.6 数据收集

5.6.1 概述

在评价时，需要收集活动水平数据、排放因子数据以及其它与GHG排放相关的数据。对所有收集的数据应给出明确的数据来源。关于数据收集的示例参见资料性**附录B**。

5.6.2 活动水平数据收集

活动水平数据包括初级活动水平数据和次级活动水平数据。在数据准备过程中宜收集初级活动水平数据。当初级活动水平数据收集无法实现时，则可选择收集次级活动水平数据。

5.6.3 排放因子选取

排放因子的选取或计算应体现出交通燃料使用前各生命周期阶段GHG排放的实际情况。应对排放因子的选取依据或计算过程作出解释。

5.7 分配

在制备交通燃料过程中，如果存在共生产品，则需对系统边界内所有与该共生产品相关的GHG排放进行分配。分配的方法可包括（参见**附录C**）：替代法、质量法、能量法、价值法。在选取分配方法时应遵循如下原则：

a) 替代法可与其他任何一种方法同时使用；

b) 价值法、质量法以及能量法不能同时使用；

c) 如果使用价值法，那么所有共生产品都必须使用按价值法，包括能源共生产品在内。

5.8 评价方法框架

5.8.1 GHG 源评价

宜根据GHG源的特点采用不同的方法学对系统边界内GHG源进行基于功能单位的GHG排放评价。如果在制备交通燃料过程中存在共生产品，则应考虑GHG排放分配。

5.8.2 各生命周期各阶段的 GHG 排放评价

将交通燃料某一生命周期阶段内的所有GHG源基于功能单位的GHG排放量进行加和，得到该生命周期阶段内基于功能单位的GHG排放量。在加和过程中应确保各个源的GHG排放量结果的单位之间相适应，相关联数据活动水平一致。

5.8.3 系统边界内 GHG 总排放评价

将系统边界内的所有生命周期阶段中基于功能单位的GHG排放进行加和，得到系统边界内基于功能单位的GHG总排放量。在加和过程中应确保各生命周期阶段的GHG排放量结果的单位之间相适应。如果系统边界内存在GHG清除，则应将其从总排放量（基于功能单位）中予以扣除。

5.8.4 土地利用变化

在评价时，可不考虑土地利用变化所带来的GHG排放或清除的影响。

5.8.5 废弃物处置参照系统

使用废弃物作为交通燃料的原料时，宜做如下处理：

a）将废弃物进行处理所产生的GHG排放作为系统边界内的GHG清除量；同时，

b）将生产废弃物所代替的原料所产生的GHG也作为系统边界内的GHG清除量。

5.9 不确定性分析

不确定性分析宜考虑但不限于如下因素：

a）评价目标和范围中预先确定的问题；
b）数据来源及数据质量；
c）评价方法；
d）专家判断和经验。

5.10 评价结论及解释

对交通燃料使用前各生命周期阶段GHG排放评价后宜得出但不限于如下结论并对其做出解释：

a）系统边界；
b）功能单位；
c）数据收集情况；
d）基于功能单位的每个生命周期阶段的GHG源情况及排放量；
e）共生产品的种类、数量及基于功能单位的GHG排放分配；
f）基于功能单位的交通燃料使用前生命周期阶段GHG总排放量；
g）每个生命周期阶段的GHG排放量占总排放量的比例；
h）每个生命周期阶段内各个GHG源的贡献率；
i）不确定性分析过程及结果。

附录A

（资料性附录）

交通燃料使用前各生命周期阶段划分示例

A.1 生命周期阶段划分

A.1.1 油气基燃料

油气基燃料GHG排放生命周期评价可划分为如下4个阶段：

a) 原料准备阶段：即原料的开采阶段；
b) 原料运输阶段：原料运输至燃料生产厂；
c) 燃料生产阶段：在燃料生产厂进行燃料炼制与调配；
d) 燃料运输和储存阶段：燃料运输至销售点及储存。

A.1.2 生物质液体燃料

生物质液体燃料GHG排放生命周期评价可划分为如下5个阶段：

a) 原料准备阶段：主要包括原料作物的种植过程、收割过程等；
b) 原料预处理阶段：一般包括原料的干燥、贮藏及初加工；
c) 原料运输阶段：运输至生物质液体燃料工厂；
d) 燃料生产阶段：指在生物质液体燃料工厂所进行的生产作业；
e) 燃料运输和储存阶段：生物质液体燃料运输至燃料混配站或者销售点、储存。

A.1.3 煤基液体燃料

煤基液体燃料 GHG 排放生命周期评价可分为 5 个阶段：

a) 原料开采阶段；即煤炭的开采阶段；
b) 原料预处理阶段；一般包括煤炭的洗选、加工等过程；
c) 原料运输阶段；将选煤运输到燃料加工厂；
d) 燃料生产阶段；根据燃料加工厂的工艺和性质生产相对应的燃料；
e) 燃料运输和储存阶段；燃料运输至销售点和储存。

附录 B

（资料性附录）

交通燃料使用前各生命周期阶段 GHG 排放评价数据收集表示例

表B.1 生物乙醇生命周期GHG排放评价数据收集表示例

阶段划分	活动水平数据	活动水平数据单位	活动水平数据来源及确定性描述	注释及数据说明
第一阶段：原料种植阶段	描述：乙醇生产所对应的原料种植情况；			
基本数据				
产量（收购水分）				
收购水分含量				
农业土壤排放				
土壤 N_2O 排放水平				
农田 CH_4 排放水平				
农业化学试剂投入				
氮肥（N）施用量				
氮肥（N）温室气体排放因子				
磷肥 (P_2O_5)				
磷肥 (P_2O_5)温室气体排放因子				
钾肥(K_2O) 施用量				
钾肥(K_2O)温室气体排放因子				
其他肥料施用量				
其他肥料温室气体排放因子				
杀虫剂用量				
杀虫剂温室气体排放因子				
除草剂用量				
除草剂温室气体排放因子				
农业机械能耗投入				
农用柴油消耗量				
柴油温室气体排放因子				
农用汽油消耗量				
汽油温室气体排放因子				
农田副产物				
茎秆				描述副产品用途，并根据副产品分配方法收集对应数据；
其他				同上；
第二阶段：原料预处理阶段	描述：在进入乙醇生产工厂前所进行的系列预处理过程；			
预处理能耗投入				
柴油消耗量				

柴油温室气体排放因子	
电能消耗量	
电力温室气体排放因子	
第三阶段：原料运输阶段	描述：原料生产基地到乙醇生产工厂的运输过程；
运输方式一	
运输方式一所占比例	
运输距离	
运输单位质量燃料消耗量	
交通燃料温室气体排放因子	
运输方式二	
运输方式二所占比例	
运输距离	
运输单位质量燃料消耗量	
交通燃料温室气体排放因子	
第四阶段：乙醇生产阶段	描述：在乙醇生产工厂内发生的原料干燥、转化、废水处理等所有过程；
基础数据	
乙醇产率	
生产过程辅料投入	
辅料一 消耗量	
辅料一 温室气体排放因子	
辅料二 消耗量	
辅料二 温室气体排放因子	
生产过程能源投入	
动力原煤	
原煤温室气体排放因子	
电力消耗量	
电力温室气体排放因子	
副产品产出	
副产品一	描述副产品用途，并根据副产品分配方法收集对应数据；
副产品二	同上；
第五阶段：乙醇运输和储存阶段	描述：从乙醇生产工厂到乙醇汽油混配站的储运过程；
运输方式一	
运输方式一所占比例	
运输距离	
运输单位质量燃料消耗量	
交通燃料温室气体排放因子	
运输方式二	
运输方式二所占比例	
运输距离	
运输单位质量燃料消耗量	
交通燃料温室气体排放因子	

附录C

（资料性附录）

分配方法

C.1 替代法

共生产品的GHG排放可以用单独生产其所替代产品的生命周期GHG排放进行置换。

例如，共生产品为A，如果能够获得单独生产单位A产品过程中所排放的温室气体量，则可用共生产品A的产量乘以单位A产品GHG排放量，得到共生产品A的GHG排放量。

C.2 质量法

共生产品的GHG排放可以根据交通燃料制备过程中所产出的产品和共生产品的质量比例，对GHG排放量进行分配（示例见表C.1）。

C.3 能量法

共生产品的GHG排放可以根据共生产品中所含热值占制备过程中输出的总热值（包括燃料和共生产品）的比例作为GHG排放量的分配因子进行分配。

C.4 价值法

共生产品的GHG排放可以根据共生产品的市场价值占制备过程中输出的产品和共生产品的总市场价值的比例作为GHG排放量的分配因子进行分配。

C.5 价值分配法示例

表C.1是价值分配法的一个示例，其它分配方法可参考本示例。

表 C.1 价值分配法的示例表

第 1 步：确定每一个产品的市场价值，包括主产品和所有共生产品。（如下所示：在某条生物柴油生产线中，主产品是生物柴油，共生产品为粗甘油和硫酸钾）	
	元 / 吨
生物柴油	340.00
粗甘油	345.00
硫酸钾	75.00
第 2 步：确定单位主产品所产生的共生产品的产量（如单位生物柴油产生的粗甘油的产量）	
	共生产品（吨）/ 生物柴油（吨）
粗甘油	0.10
硫酸钾	0.04
第 3 步： 计算单位主产品所产生的副产品数量具有的市场价值	

	生物柴油
粗甘油	34.50
硫酸钾	3.00
生物柴油	340.00
所有产品的市场总价值	377.50
第 4 步： 计算各产品（包括主产品和共生产品）的温室气体排放分配系数	
生物柴油的分配系数（%）	90%
粗甘油的分配系数（%）	9.14%
硫酸钾的分配系数（%）	0.79%

附录 D

（资料性附录）

温室气体全球增温潜势

表 D.1 GHG 全球增温潜势

气体名称	化学分子式	全球增温潜势
二氧化碳	CO_2	1
甲烷	CH_4	25
氧化亚氮	N_2O	298
氢氟碳化物 (HFCs)		
HFC-23	CHF_3	14800
HFC-32	CH_2F_2	675
HFC-125	C_2HF_5	3500
HFC-134a	$C_2 H_2F_4$ (CH_2FCF_3)	1430
HFC-143a	$C_2 H_3 F_3$ ($C F_3C H_3$)	4470
HFC-43-10mee	$C_5H_2F_{10}$	1640
HFC-152a	$C_2 H_4 F_2$ ($C H_3CH F_2$)	124
HFC-227ea	C_3HF_7	3220
HFC-236fa	$C_3 H_2F_6$	9810
氢氟醚类化合物（HFEs)		
HFE-7100	$C_4F_9OCH_3$	500
HFE-7200	$C_4F_9OC_2H_5$	100
全氟碳化物（PFCs)		
全氟甲烷（四氟甲烷）	CF_4	6500
全氟乙烷（六氟乙烷）	C_2F_6	9200
全氟丙烷	C_3F_8	7000
全氟丁烷	C_4F_{10}	7000
全氟环丁烷	c-C_4F_8	8700
全氟戊烷	C_5F_{12}	7500
全氟己烷	C_6F_{14}	7400
六氟化硫	SF_6	23900

注：表 D.1 为政府间气候变化专门委员会（IPCC）于 2006 年为国家 GHG 清单的编制在其报告指南中发布的各种 GHG 在 100 年间的全球增温潜势。

参考文献

[1] IPCC 2006　国家温室气体清单指南。国家温室气体清单计划，政府间气候变化专门委员会

[2] ISO 14064-2　项目层次上对温室气体排放削减和清除增加的量化、监测和报告的规范及指南（Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reduction or removal enhancement）

[3] ISO 14064-3　温室气体审定与核查规范及指南（Specification with guidance for the validation and verification of greenhouse gas assertions）

[4] PAS 2050　商品和服务在生命周期内的温室气体排放评价规范（Specification for the assessment of the life cycle greenhouse gas emissions of goods and services）

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交通燃料使用前各生命周期阶段温室气体报告和核查要求

The requirements of greenhouse gas report and verification for transportation fuel life cycle before usage stage

（报批稿）

××××-××-××发布　　××××-××-××实施

中华人民共和国国家质量监督检验检疫总局
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前言

本标准依据GB/T 1.1-2009给出的规则起草。

本标准由国家发展与改革委员会提出。

本标准由全国环境管理标准化技术委员会（SAC/TC 207）归口。

本标准起草单位：中国标准化研究院、能源与交通创新中心、清华大学、中国科学院生态环境研究中心、中国石油集团安全环保技术研究院、煤炭科学研究总院、中国粮油食品（集团）有限公司。

本标准主要起草人：陈亮、刘玫、康利平、张阿玲、张天柱、杨建新、于景琦、罗陨飞、林海龙。

交通燃料使用前各生命周期阶段温室气体报告和核查要求

1. 范围

本标准规定了交通燃料使用前各生命周期阶段温室气体报告和核查的基本要求。

本标准适用于油气基燃料、生物质液体燃料以及煤基液体燃料等交通燃料从原料获取到交通燃料生产、输配、储存等各生命周期阶段中的温室气体报告的编制及核查，其它产品的生命周期温室气体报告和核查可参考本标准执行。

2. 规范性引用文件

下列文件对于本文件的应用是必不可少的。凡是注日期的引用文件，仅注日期的版本适用于本文件。凡是不注日期的引用文件，其最新版本（包括所有的修改单）适用于本文件。

GB/T 24040　环境管理 生命周期评价 原则与框架

GB/T 24044　环境管理 生命周期评价 要求与指南

ISO 14064-1　组织层次上对温室气体排放和清除的量化和报告的规范及指南（Specification with guidance at the organization level for quantification and reprorting of greenhouse gas emissions and removals）

3. 术语和定义

GB/T 24040、GB/T 24044和ISO 14064-1界定的以及下列术语和定义适用于本文件。为了便于使用，以下重复列出了GB/T 24040、GB/T 24044和ISO 14064-1中的某些术语和定义。

3.1

温室气体 greenhouse gas (GHG)

大气层中自然存在的以及由于人类活动产生的能够吸收和散发由地球表面、大气层和云层所产生的、波长在红外光谱内的辐射的气态成份。

注：本标准中所涉及的GHG主要包括二氧化碳（CO_2）、甲烷（CH_4）、氧化亚氮（N_2O）、氢氟碳化物（HFCs）、全氟碳化物（PFCs）和六氟化硫（SF_6）。

[ISO 14064-1—2006，定义2.1]

3.2

温室气体源 （简称为GHG源） greenhouse gas source

向大气中排放 GHG 的物理单元或过程。

[ISO 14064-1—2006，定义2.2]

3.3

共生产品 co- products

同一单元过程或产品系统中产出的任何两种或两种以上的产品。

[GB/T24040-2008，定义3.10]

3.4

温室气体活动水平数据 greenhouse gas activity data

GHG 排放或清除活动的定量数值。

注：GHG 活动水平数据例如能源、燃料或电力的消耗量，物质的产生量、提供服务的数量或受影响的土地面积。

[ISO 14064-1—2006，定义2.11]

3.5

排放因子 emission factor

单位活动水平的GHG排放量。

3.6

系统边界 system boundary

通过一组准则确定哪些单元过程属于交通燃料系统的一部分。

注：改写 GB/T 24040—2008，定义3.32。

3.7

功能单位 functional unit

用来作为基准单位的量化的产品系统性能。

[GB/T 24040—2008，定义3.20]

3.8

温室气体报告（简称为GHG报告） greenhouse gas report

提供有关 GHG 信息的文件。

3.9

核查 verification

对 **GHG 报告**进行系统的、独立的评价，并形成文件的过程。

注：改写 ISO 14064-1，定义2.35。

3.10

实质性 materiality

由于一个或若干个累积的错误、遗漏或错误解释，可能对 **GHG 报告（3.8）**或使用者的决策造成影响的情况。

注：改写 ISO 14064-1，定义2.28。

3.11

保证等级 level of assurance

核查委托方要求核查达到的保证程度。

注 1：保证等级是用来确定核查者设计核查计划的细节深度，从而确定是否存在实质性偏差、遗漏或误差解释。

注 2：改写 ISO 14064-1，定义 2.27。

4. 交通燃料生命周期GHG报告

4.1 概述

对交通燃料使用前各生命周期阶段 GHG 排放进行评价的组织或个人宜编制 GHG 报告。GHG 报告宜满足完整性、一致性、准确性的基本原则。

4.2 编制准备

在准备编制交通燃料使用前各生命周期阶段GHG报告时宜考虑下列事项并将其形成文件：

a) 编制依据；
b) 用途和用户；
c) 格式；
d) 包含的数据和信息；
e) 可获取性及传播方式。

4.3 编制内容

GHG 报告应包括但不限于下列内容：

a）报告责任人；
b）报告编制组织和人员；
c）报告目的；
d）活动水平数据覆盖时间；
e）系统边界；
f）功能单位；
g）数据收集情况；
h）评价方法学的说明；
i）每个生命周期阶段（4.4）的GHG源及基于功能单位的排放；
j）共生产品的种类、数量及基于功能单位的分配；
k）基于功能单位的交通燃料生命周期温室气体总排放量；
l）每个生命周期阶段的GHG排放量占总排放量的比例；
m）每个生命周期阶段内各个GHG源的贡献率；
n）不确定性分析过程及结果。

4.4 生命周期阶段

4.4.1 油气基燃料

油气基燃料GHG排放生命周期阶段可包括：

a) 原料准备：即原料的开采阶段；

b) 原料运输：原料运输至燃料生产厂；
c) 燃料生产：在燃料生产厂进行燃料炼制与调配；
d) 燃料运输和储存：燃料运输至销售点及储存。

4.4.2 生物质液体燃料

生物质液体燃料GHG排放生命周期阶段可包括：

a) 原料准备：主要包括原料作物的种植过程、收割过程等；
b) 原料预处理：一般包括原料的干燥、贮藏、及初加工；
c) 原料运输：运输至生物质液体燃料工厂；
d) 燃料生产：指在生物质液体燃料工厂所进行的生产作业；
e) 燃料运输和储存：生物质液体燃料运输至燃料混配站或者销售点、储存。

4.4.3 煤基液体燃料

煤基液体燃料 GHG 排放生命周期阶段可包括：

a) 原料开采；即煤炭的开采阶段；
b) 原料预处理；一般包括煤炭的洗选、加工等过程；
c) 原料运输；将选煤运输到燃料加工厂；
d) 燃料生产；根据燃料加工厂的工艺和性质生产相对应的燃料；
e) 燃料运输和储存；燃料运输至销售点和储存。

5. 交通燃料生命周期 GHG 报告核查

5.1 概述

如果 GHG 报告拟向公众发布，则应对 GHG 报告进行核查。

5.2 原则

5.2.1 独立性

保持独立于所核查的活动之外，无利害冲突或倾向性，在核查活动中保持客观，以确保其发现和结论都是建立在客观证据的基础上。

5.2.2 公正性

真实准确地反映核查活动、结论和报告结果。

5.3 要求

5.3.1 核查者

核查者应：

a) 具备承担其工作与责任的相应能力和职业素养；

b) 具有独立性；

c) 与核查委托方、GHG报告使用者之间不存在实际或潜在的利害关系；

d) 在核查过程中遵守执业操守。

5.3.2 保证等级

核查者应在核查过程开始之前与委托方共同商定核查的保证等级。保证等级规定了核查者对GHG报告做出结论的相对置信度。保证等级可分为两级，即：

a) 合理保证等级

核查者提供一个合理但不是绝对的保证等级，它表示委托方的GHG报告是实质性的正确。根据所实施的过程和程序，GHG报告，

——实质性的正确，并且公正地表达了GHG数据和信息；

——是根据有关GHG量化、监测和报告的国际标准，或有关国家标准或通行作法编制的。

b) 有限保证等级

不强调对支持GHG报告的GHG数据和信息进行具体的试验。根据所实施的过程和程序，没有证据表明GHG报告，

——不是实质性的正确，或未公正地表达GHG数据和信息；

——未根据有关GHG量化、监测和报告的国际标准，或有关国家标准或通行作法编制。

5.3.3 实施

5.3.3.1 概述

如果委托方所提供的信息不足以对交通燃料生命周期的GHG报告进行核查，核查者应停止核查。

5.3.3.2 核查计划

核查者应制定书面核查计划，宜包括：

a) 核查目的；

b) 保证等级；

c) 核查范围；

d) 核查活动安排。

在核查过程中，如有必要，应对核查计划进行修订。核查者应将此计划与委托方沟通。

5.3.3.3 对GHG报告数据和信息的评价

核查者应对交通燃料生命周期的GHG报告数据和信息做出评价，宜包括：

a) 功能单位的选取；

b) 系统边界的确定；

c) 活动水平数据的选择和管理；
d) 排放因子的选择和管理；
e) 收集、处理、合并和报告GHG数据和信息的过程；
f) 保证GHG数据和信息的准确性的体系和过程；
g) GHG排放评价方法的选择；
h) 共生产品的分配；
i) 错误、遗漏和错误解释的来源和大小。

5.3.3.4 核查结论

核查结论应包括：

a) GHG报告存在的偏差；
b) 核查是否达到了商定的保证等级。

如果委托方对GHG报告做出修改，核查者应对修改后的GHG报告进行评价，以确定所提供的证据能够支持这些修改。

5.3.3.5 核查记录

如有必要，核查者应保持记录，以证实遵守了本标准的要求。核查记录可根据核查计划和合同要求予以留存或销毁。

5.3.3.6 核查陈述

在完成GHG报告核查工作后，核查者应编制核查陈述，应包括但不限于：

a) 委托方名称；
b) 核查者名称；
c) 核查范围；
d) 保证等级；
e) GHG报告覆盖时间和核查时间；
f) 对GHG报告数据和信息的评价；
g) 核查结论。

5.3.3.7 核查后续活动

如果在做出核查陈述后发现了可能影响核查陈述的情况，核查者宜采取适当的行动。

参考文献

[1] ISO 14064-1　组织层次上对温室气体排放和清除的量化和报告的规范及指南（Specification with guidance at the organization level for quantification and reprorting of greenhouse gas emissions and removals）

[2] ISO 14064-3　温室气体审定与核查规范及指南（Specification with guidance for the validation and verification of greenhouse gas assertions）

[3] PAS 2050　商品和服务在生命周期内的温室气体排放评价规范（Specification for the assessment of the life cycle greenhouse gas emissions of goods and services）