

## A Review of the Research on the Measurement Methods of Greenhouse Gas Emission Reduction for LNG Automotive Applications

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**Abstract**—With the rapid development of economy in China, the demand of the society to the transportation industry is also increasing [1]. This has produced a large number of car greenhouse gas, causing serious damage to the environment. As a new development of clean energy industry, liquefied natural gas (LNG) vehicles has a good environmental, economic and social benefits. The development of LNG vehicle is an effective way to mitigate greenhouse gas emissions. From the perspective of LNG vehicle greenhouse gas emission reduction calculation, the research analyzes the factors of effect on LNG automobile energy-saving and emission reduction. Then research carries out systematic quantitative analysis on greenhouse gas emission reduction. According to the new LNG automobile greenhouse gas reduction quantification method, a calculation model of energy-saving emission reduction potential is established and the important role of LNG in traffic energy saving and emission reduction is expounded.

**Keywords**—LNG vehicle; greenhouse gas; index decomposition; life cycle; calculation method

### I. INTRODUCTION

The transportation industry consumes one-third of the total fuel consumption, which is the second only to the manufacturing industry[1]. Transportation process will produce a huge number of greenhouse gases. The destruction of the environment is extremely serious. In order to reduce greenhouse gas pollution and protect the ecological environment, we must reduce greenhouse gas emissions from the transportation industry to promote the process of energy saving and emission reduction in the transportation industry.

Liquefied natural gas, as a kind of clean energy which can effectively replace the petroleum, has received extensive attention from all sectors of the industry. In the transport

industry, the implementation of the liquefied natural gas vehicles is a highly efficient use of liquefied natural gas in the way, and it plays an important role in energy conservation and emission reduction. The 13th Five-year national planning encourages the development of LNG vehicle and efficient utilization of natural gas project, and LNG vehicle was also listed in "natural gas use policy" as "giving priority to the development of the project". Under such a background, it is necessary to determine a new accounting method to research LNG vehicle development and LNG vehicle greenhouse gas emissions.

### II. DOMESTIC AND FOREIGN RESEARCH ON GREENHOUSE GAS CARBON EMISSION MEASUREMENT

There are many international carbon emission accounting methods, but the main measurement system is divided into two types. The first accounting system mainly refers to the accounting based on the country or region. This accounting method is mainly to take the IPCC inventory method, using the list of activity data listed in the index decomposition of emissions. Another accounting system mainly refers to the accounting of products, enterprises and projects. This accounting method is mainly from the perspective of the whole life cycle of products and the calculation use carbon footprint method.

IPCC inventory method is based on the release of a country or region accounting. IPCC release of the < national greenhouse gas inventory Guide > in the collection of activity data and emission factors of these two kinds of data. The carbon emission of an activity is calculated by multiplying the activity data with the corresponding emission coefficient. And the default values for various emission factors are listed in the < Guide >. This carbon emission calculation method is widely accepted. So this method is

recognized as the most authoritative accounting method of carbon emission.

D.Diakoulaki used the exponential method to decompose the CO<sub>2</sub> emissions associated with energy[2]. K.Liaskas used the IPCC inventory method to decompose the European CO<sub>2</sub> emissions [3].Tae-H yeong Kwon used the index method to decompose the British Automobile carbon emission[4].

In recent years, the exponential decomposition method is used more and more in CO<sub>2</sub> emission estimation of various industries in China.

Ming Zhang applied logarithmic mean Divisia index decomposition method (LMDI) and complete decomposition method (Laspeyres) to investigate the transportation sector energy consumption related data.Then he decomposed the energy consumption of CO<sub>2</sub> produced in the process.And the relevant factors affecting the energy consumption of the transportation sector were analyzed in a quantitative way[5].

Chunlan Liu used the logarithmic index decomposition method to decompose the CO<sub>2</sub> emissions in Beijing City.She found that the CO<sub>2</sub> emissions was related to energy consumption structure, energy consumption intensity and industrial structure and other factors[6].

Based on the statistics of the carbon emission in the boundary of Jiuzhaigou nature reserve, Ruihong Sun combined with life cycle method to create a list of carbon emissions.The carbon footprint of the protected area is studied.Then the new management mode of carbon emission reduction is explored to determine the key factors and potential factors of carbon emission reduction[7].

According to the changes of influencing factors, Yalong Lian improved the existing exponential decomposition model and established a more detailed decomposition model.Based on the investigation of energy consumption in transportation industry,he measured the effect of transportation structure, energy consumption intensity and turnover on the transportation energy loss to promote the structural adjustment of the transportation industry[8].

Cheng Xu used LMDI method and Kaya identity to research urban traffic and calculated the energy consumption. He analyzed the effects of various factors on the variation of total energy consumption and studied on energy consumption index decomposition model in different scenarios.A new energy consumption analysis method was provided in the multi factor interaction system[9].

Ao Zhao applicated LMDI method and Kaya equation to analyze the various sectors of greenhouse gas emissions trends[10].

Chengshan Chu investigated the urban transportation energy for the reduction of greenhouse gas emissions. He studied the fuel emissions, greenhouse gas accounting methods. Then he accounted for the greenhouse gas emissions of buses and taxis[11].

Accounting based on the product, enterprise and project , also known as the carbon footprint method.It calculate the carbon emission in the whole life cycle.PAS2050 standard which is widely used at present is the most complete public available specification.The calculation of carbon emissions

through the whole life cycle of the product (including distribution, use and recycling) of carbon emissions[12].

Chunjing Shang studied the carbon emissions of the construction industry according to the theory of life cycle (LCA). The paper defines the greenhouse gas accounting scope.And according to the amount of greenhouse gas emissions, she calculated the construction industry life cycle greenhouse gas emissions[13].

Huajun Cao studied the machine life cycle stages and constructed the quantitative description method for the evaluation of machine tool life cycle greenhouse gas emissions.According to the evaluation method,he analyzed the impact properties of carbon emission of machine tools, and calculated quantitatively the various stages of the machine tool emissions of carbon[14].

Chenglong Chu studied the greenhouse gas emissions from the life cycle of the construction industry.Then he compared the greenhouse gas emissions from 3 kinds of structure of reinforced concrete, light steel and wood.In the end,the concrete ways of reducing greenhouse gas emission were studied[15].

Zhihui Zhang studied the life cycle of a building.On the basis of determining the boundary of carbon emission calculation, he analyzed the construction and maintenance of greenhouse gas emissions.Then he constructed the evaluation system of greenhouse gas emissions in the construction industry[16].

Xujie Feng evaluated the high speed railway energy consumption and greenhouse gas emissions of carbon footprint.Then he evaluated the energy saving and reduction of greenhouse gas emissions of concrete results. In the end,he established the calculation model of greenhouse gas emission [17].

### III. DOMESTIC AND FOREIGN LNG AUTOMOBILE GREENHOUSE GAS EMISSION REDUCTION MEASURE RESEARCH PRESENT SITUATION

Xiaodan Lin used life cycle assessment (LCA) methodology and investigated passenger traffic volume of Beijing city. By comparing the new energy vehicles, such as natural gas vehicles with ordinary gasoline, diesel vehicles,it is found that the development of new energy buses can effectively save energy and reduce greenhouse gas emissions, and has a significant role in the development of low carbon city[18].

School of chemical engineering; Tianjin University Xiao Wu analyzed the emission results of nitrogen oxides and other pollutants after natural gas combustion.She carried out numerical simulation by mathematical model and calculation software.It proved the huge environmental protection of natural gas vehicles[19].

Chongqing University Rui Wu studied natural gas automobile alternate fuel system and investigated the production of natural gas liquefied natural gas, methanol fuel consumption by using life cycle assessment of the indicators of the alternative fuel system.He evaluated the indexes of the alternative fuel system by Using the life cycle method .And economic benefits are evaluated from the three aspects of energy consumption, environmental development[20].

Xiaoqing Shi used the fuel life cycle theory of impact factors of electric vehicle greenhouse gas emissions. She established the new greenhouse gas emissions calculation method to calculate the six different situations of electric vehicle greenhouse gas emission reductions[21].

Fei Zhou Studied the process of natural gas production. He monitored the greenhouse gas emissions in the production process and established the model of greenhouse gas emissions accounting[22].

Zhongfu Tan compared the electric vehicles and fuel vehicles. He compared energy consumption and greenhouse gas emissions of two different energy vehicles, then he analyzed the energy saving potential of electric vehicles in 3 modes[23].

Chaowen Dong used whole life cycle method to calculate the domestic energy consumption and pollution emissions on the model of GREET2011. The life cycle process of natural gas, biomass and petroleum three kinds of energy is analyzed[24].

Dalian Maritime University Yang Li used influence factor analysis to analyze the existing problems in the highway transportation industry. And he established energy saving and emission reduction evaluation system from the aspects of technology, management and energy structure[25].

Lingli Wang applied system dynamics method to analyze the problem of greenhouse gas emission reduction in China's transportation industry. She analyzed the relationship between the variables and the system construction of the greenhouse gas emission reduction model[26].

Xiaoyue Tu applied life cycle method to compare the energy consumption of liquefied natural gas (LNG) vehicles and diesel vehicles in the production, driving stage. By comparing the energy loss situation, it is proved that the total energy consumption of LNG vehicle is lower[27].

The research status quo at home and abroad can be found that most researchers are more inclined to establish the evaluation index system of greenhouse gas emission reduction. They tried to resolve the relevant industry in the greenhouse gas emission reduction achievements from different levels and constructed evaluation index system in theory. However, there are less research on the quantitative calculation of greenhouse gas emission reduction and greenhouse gas emission reduction measurement system is not perfect[28]. Among them, the research of LNG automobile greenhouse gas emission reduction is few and few. So we need to start from the actual application of LNG car, combined with the current situation of the development of technology to study a set of suitable for LNG car greenhouse gas emission standards. It can help us accurately measure the economic and environmental protection of the LNG automobile and promote the application of the liquefied natural gas in the traffic industry.

#### IV. LNG VEHICLE GREENHOUSE GAS EMISSION REDUCTION COUNTERMEASURES

In the face of China's increasingly serious traffic pollution and greenhouse gas emissions too much of the status quo, the development of liquefied natural gas vehicles

is an effective scheme to protect the environment and save energy. With the rapid development of the technology of LNG vehicle, LNG technology practical application of the technical difficulty is getting less and less. LNG car has reached the level of practical technology. The situation that LNG cars become more and more popular is the inevitable trend. LNG car can not only reduce energy consumption and produce huge economic benefits, but also has a good effect of greenhouse gas emission reduction with good environmental benefits. But in the current application, there are still some deficiencies and can be improved.

##### A. Deficiencies In Current Research

Through the analysis of domestic and foreign scholars' research content, there are some problems in the research on the measurement of greenhouse gas emission reduction by LNG.

The establishment of the model is very one-sided and not established from the whole argument. What's more, it is not used system method to analyze the transportation industry energy saving and emission reduction system. It is a failure that scholars don't put forward the corresponding technical scheme and model.

The analysis method of LNG automobile greenhouse gas measurement is not systematic. The analysis of the application and effect evaluation of LNG automotive technology is too one-sided and there is no systematic analysis and discussion.

In the energy saving, the specific calculation of the emission reduction is less. It's failed to establish a complete assessment method of greenhouse gas emission reduction effect. It needs to compare with other fuel vehicle exhaust components to illustrate the advantages of environmental protection.

##### B. Lng Automobile Greenhouse Gas Emission Reduction Proposal

Facing the problems existing in the LNG vehicle greenhouse gas emission reduction, on the one hand we must continue to strengthen the development of technology, research and development more practical energy saving LNG car. And it's necessary to improve the combustion efficiency of the gas. On the other hand, we must build up a complete carbon emissions index calculation model and calculate accurately greenhouse gas emission of LNG vehicle.

To establish the LNG automobile greenhouse gas emission reduction effect measurement model, we must first determine the LNG car greenhouse gas emission project boundary and the applicable conditions. And it's necessary to know the scope of the clear study. Then, we should test the most representative carbon dioxide in greenhouse gases and analyze the whole process including the production of liquefied natural gas. In addition, we should determine the emission factors and the influence factors of the greenhouse gas emission. Based on the decomposition model of pollutant factors, we can calculate quantitatively the whole process of energy saving index and emission reduction index. Moreover, we can use energy saving and emission reduction index to

evaluate the effect of energy saving and emission reduction. In the end, it is necessary to construct the greenhouse gas emission measurement model for LNG vehicles compared with other fuel vehicles.

## V. CONCLUSION

In order to cope with the problems of energy shortage and environmental pollution in the process of social development, it is necessary to promote energy conservation and emission reduction in the transportation industry. The effect of greenhouse gas emission reduction is the key link in the evaluation of energy saving and emission reduction. It's helpful to the government and related industries to develop reasonable environmental protection measures. Therefore, it is necessary to establish a suitable evaluation index and calculation model. We must analyze the specific effects of LNG in the greenhouse gas emission reduction and establish the calculation model of LNG greenhouse gas emission reduction. It is conducive to the promotion of LNG vehicles, reduce greenhouse gas emissions and promote the construction of ecological civilization.

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