BRI International Green Development Coalition
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Research on Carbon Emission Standards of Automobile Industry in BRI Participating Countries

In April 2019, Chinese and international partners officially launched the BRI International Green Development Coalition (BRIGC) at the Second Belt and Road Forums for International Cooperation. BRIGC aims to establish a policy dialogue and communication platform, an environmental knowledge and information platform, and a green technology exchange and transfer platform, so as to advance global consensus, understanding, cooperation, and action of a green Belt and Road Initiative (BRI).

Climate change is the most severe challenge facing human society. As a typical energy and resource intensive industry, the automobile industry is one of the key industries to tackle climate change. The BRI participating countries have a large potential demand for automobile consumption in the future, and there is ample room for the development of the automobile industry. At the same time, most BRI countries have not yet established a comprehensive carbon emission standard system for the automotive industry, and with the increase in vehicle production and sales, carbon emissions from the automotive industry are expected to increase rapidly.

Against this background, this report selects China, the United States, Singapore, Indonesia, Poland, South Africa and Pakistan to assess the development potential of the automotive industry and the construction of carbon emission standards, from the perspective of standard type and name, relevant authorities, legal basis, vehicle type, management object, etc. According to the above analysis of current status of carbon emission standard construction and the future development trend of automobile industry, policy suggestions are put forward from the national level, Industrial level and enterprise level to strengthen the carbon emission standard construction of automobile industry in BRI countries.

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Climate change and other environmental impacts have caused damage to natural systems, leading to frequent natural disasters. In order to deal with climate change, the Paris Agreement calls for limiting global temperature rise to 1.5℃ or 2 ℃ and puts forward that all parties should achieve the balance between anthropogenic greenhouse gas emissions and carbon removal or sinks, namely carbon neutrality, on an equal basis in the second half of this century. At present, nearly 133 countries, including China, have put forward carbon neutrality targets in different forms, accounting for about 72% of global carbon emissions and 85% of the total global economy.

At present, the number of vehicles per thousand people in BRI countries is far below the world average level. In the future, automobile consumption and potential demand for replacement are bigger, and the room for automobile industry development is wide. However, as a typical energy and resource-intensive industry, the automobile industry highly depends on energy and resources with high carbon emission intensity. In addition, most BRI countries have not yet established a sound carbon emission standard system, so it lacks a basis for carbon emission management, and implementation is insufficient with ineffective results. With the increase of automobile production and sales, it is expected that carbon emission will increase rapidly. In the context of carbon neutrality, the lack of carbon emission standards, high carbon emissions and low competitiveness of the industry will be the obstacle to the healthy and sustainable development of the automobile industry for BRI countries.

In order to assess the development of carbon emission standards of the automobile industry in BRI countries and provide feasible policy recommendations, this report selects five typical countries, including Singapore, Indonesia, Poland, South Africa, Pakistan as the research object in terms of carbon emissions, vehicle sales, standard construction, regional distribution and availability of data. China, the United States and the European Union are selected as the control group to compare the carbon emission standards with that of the five countries. Based on the analysis, it is shown that the automobile industry of the BRI countries is still facing problems in terms of inadequate technological innovation, incomplete carbon emission standards, and lack of targeted policy framework. Policy recommendations from national, industrial and corporate levels have been proposed to give scientific and reasonable advice for the construction of carbon emission standards for the automobile industry. At the national level, it is advised to promote mutual trust and mutual recognition among countries in the relevant carbon emission standards, formulate a policy framework for vehicle carbon emission standards, and establish a supporting policy system to promote the smooth implementation of emission reduction targets. It is also advised to support the development of new energy and other low-carbon automobile industries and improve the development mechanism of new energy vehicles. At the industrial level, it is advised to improve the accounting methods of automobile carbon emission in the whole life cycle, including a low-carbon quantitative method system covering carbon emission detection methods, evaluation methods and accounting indicators. At the corporate level, it is suggested automobile enterprises strengthen their capacity to design effective carbon emission reduction pathways.

1. Introduction

1.1 Research Background

The concept of carbon neutrality has been gaining popularity. Climate change and other environmental degradation problems have caused damage to the natural system, resulting in frequent natural disasters. There are countless fires in Australia, the eruption of the Al volcano in the Philippines, the rise of Antarctic glacier temperature, the accelerated melting of glaciers, locust disasters in East Africa, grassland fires in Mongolia and so on. More and more studies and facts show that the negative impact of climate change will be more extensive and intense than originally expected, and its impact speed will be faster. However, there is still a big gap between the nationally determined contribution (NDC) target and action plan proposed by countries under the Paris Agreement and the emission path under the 2°C temperature control target. By 2030, there will be an annual emission reduction gap of 12~15 billion tons of carbon dioxide equivalent (CO2e)[1] According to this calculation, by the end of the 21st century, the median global temperature rise will reach 2.7°C, the probability of lower than 2°C is less than 5%, and the probability of higher than 3°C is more than 25%[2]. In addition, according to the sixth assessment report issued by the Intergovernmental Panel on climate change (IPCC) in August 2021, the current global average temperature rise level has reached 1.09°C, which is not far from the target of 1.5°C. Therefore, it is urgent for countries to implement and put forward emission reduction targets and further strengthen climate action. At present, nearly 130 countries, including China, have proposed carbon neutralization targets in different forms, accounting for about 65% of global carbon emissions and about 70% of the total global economy[3]. In this context, low-carbon is becoming the main theme of national development and all countries are in pursuit of low carbon development. All sectors and industries need to take concrete actions to transform to low-carbon development.

The carbon emission from the car industry has been growing fast. The transportation industry is an important area of global energy consumption and greenhouse gas emissions. As shown in Figure 1, the carbon emission of the transportation industry gradually increased from 1990 to 2018. In 2018, the contribution of the transportation industry to the total global greenhouse gas emission was 25%, ranking the second largest emission industry [4]. In the transportation industry, road traffic carbon emission is one of the important components of global carbon emission. In 2016, the energy consumption of passenger cars alone accounted for 58% of the global transportation industry, accounting for about 20% of the world's total terminal energy consumption and carbon dioxide emissions [4]. Governments, domestic and foreign automobile enterprises and industry institutions need to take actions to promote carbon emission reduction in the automobile industry.

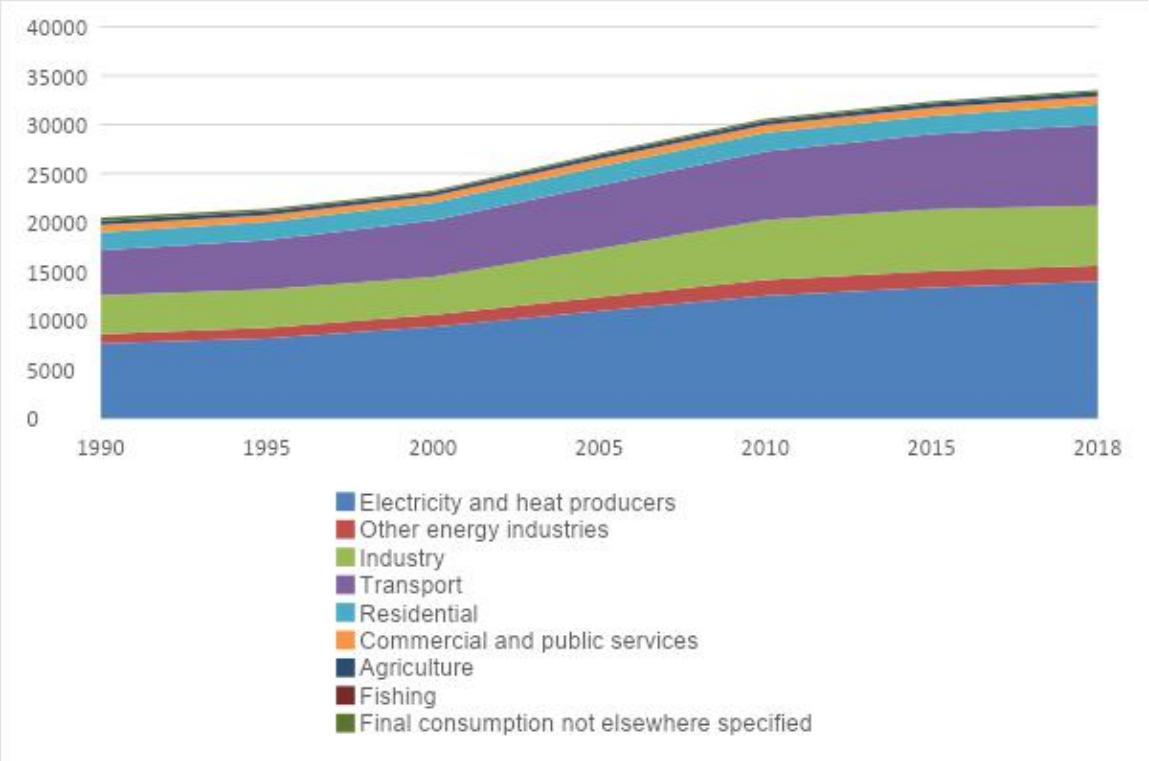


Fig 1 Carbon emission by sectors from 1990 to 2018

The carbon trading system of the automobile industry has been gradually established. At present, the EU has set up a carbon border regulation mechanism, that is, the collection of a carbon tax. EU proposed that all commodities under the EU carbon emission trading system (EU-ETS) should be included in the collection scope of carbon tariff, which may involve intermediate products and end products in the future. The United States, Britain, Canada and other countries are also promoting their own carbon border regulation tax. Secondly, the EU is formulating carbon footprint limit regulations for auto parts and complete vehicles exported to the EU. In the 2019 CO2 emission standard for passenger cars and light commercial vehicles, it is necessary to evaluate the life cycle carbon emissions of passenger cars and light commercial vehicles at the EU level. The feasibility of establishing a general LCA methodology for life cycle carbon emission evaluation and data submission shall be evaluated no later than 2023. At the same time, it was pointed out that follow-up measures should be taken and legislative recommendations should be made as appropriate. The European Battery and Waste Battery Law proposed that the maximum carbon footprint limit of batteries will be issued before July 1, 2027. In order to reduce compliance costs, European automobile enterprises such as BMW, Daimler, Volkswagen and Volvo have put forward their own "carbon neutralization" goals, which will be realized by 2040 or 2050 respectively, and have put forward carbon emission management requirements for the whole industrial chain. The carbon trading system of the automobile industry has been gradually established, and the "going global" of automobile products will face greater pressure and challenges of carbon emission.

BRI participating countries have great room for automobile development. At present, most BRI countries have far less car ownership than the world average level. For example, in 2015, Pakistan had only 16.1 vehicles with a thousand people, which was equivalent to 62 people owning a car. The future demand for automobile replacement was huge. The BRI countries, however, are mostly developing countries and emerging markets. Currently, they are mainly based on the second industry, which has higher dependence on energy and resources with lower production efficiency. In the past 5 years, the

growth rate of the total carbon dioxide emissions of the countries along the BRI is much faster than the world average, and the average unit GDP emissions are 50% higher than the global average[5]. As energy and resource-intensive industry, the carbon emission of single vehicle is also relatively high. As the total number of cars sales and ownership increase, the carbon emissions of the automobile industry will increase. Therefore, although BRI countries have huge development potential, yet the pressure of environmental protection will hinder the development of the domestic automobiles. The automobile products that do not meet the carbon emission requirements will lose the market.

The BRI countries lack carbon emission standards for the automobile industry. Most of the BRI countries have not yet issued the carbon emission standard system for the automotive industry. The quality certification standard of automobile enterprises is difficult to meet international standards, thus affecting the pace of exporting new energy vehicles in the BRI countries. Based on the carbon emission standards of the European Union and other foreign automobile industries, China is stepping up the formulation of carbon emission standards of the domestic automobile industry in order to build its low-carbon competitiveness. We need to join hands with BRI countries to blaze a path of green and low-carbon development to effectively address the challenges posed by climate change and boost high-quality development.

Under this background, it is imperative to study the status quo of the carbon emissions and the carbon emission standards of the automobile industries for the typical BRI countries and regions (Singapore, Indonesia, Poland, South Africa, Pakistan, etc.), and provide support for China to enhance the capacity of BRI countries in the fight against climate change.

1.2 Research Purpose

The purpose of the research is to sort out the carbon emission standards of the automobile industry in representative countries of the BRI initiative through literature research and expert interview, analyze the progress, shortcomings and challenges of carbon emission standards, learn the experience of the automotive industry carbon emission standards from China, the United States, the European Union and other developed countries, and provide scientific and reasonable policy advice and decision support for government departments, financial institutions and enterprises and other stakeholders. It also aims to improve carbon emission management in the automotive industry of countries participating in the BRI countries and to help and guide the development of the automobile industry in the BRI countries, enhance the international low-carbon competitiveness of automotive products, including new energy vehicles, as well as to promote green development cooperation in the BRI automobile industry.

1.3 Research Roadmap

The general report consists of five chapters. The second chapter reviews the construction of carbon emission standards for the automotive industry in China and developed countries. The third chapter analyzes the status of automobile development and carbon emission standards of the BRI participating countries and regions. The fourth chapter compares the carbon emission standards of the BRI countries with China, Europe and the United States and other countries or regions, and identifies the advantages and disadvantages of carbon emission standards for the BRI countries. Based on the key issues identified by Chapter four, the fifth chapter provides scientific and reasonable policy recommendations for the construction of carbon emission standards for the automobile industry in BRI countries, so as to provide references for the government, industry organizations and automobile enterprises. The specific research roadmap is shown in Figure 2.

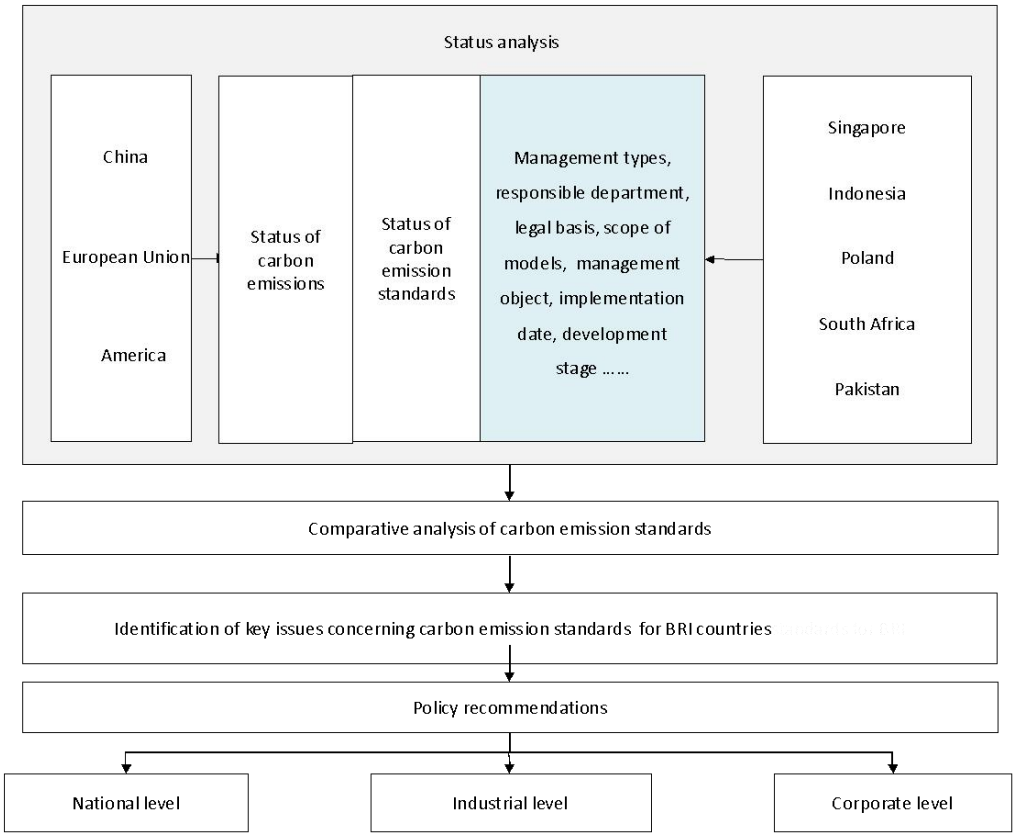


Fig 2 Research Roadmap

1.4 Research Object

Model range: As an important part of the automobile industry, passenger vehicle and light commercial vehicles account for a large proportion of ownership and carbon emissions, and the standard construction is relatively perfect and representative. Due to space constraints, this report mainly studies the carbon emission standards of passenger vehicles and light commercial vehicles.

Country scope: select 3 groups of objects. The first is China which is an advocate for BRI, and the second group is developed countries, represented by the European Union and the United States, which are powerful automobile countries with improved carbon emission standards. The third group is typical BRI countries. From the perspective of carbon emissions, vehicle sales, standard construction, regional distribution and availability of data, 5 representative countries including Singapore, Indonesia, Poland, South Africa and Pakistan are selected as research objects.

Standard range: the development of carbon emission standards of BRI countries will be studied based on carbon emission standards and fuel economy. The fuel economy standard takes the fuel consumption during vehicle driving as the supervision object and puts forward requirements for the fuel consumption within a certain driving mileage or the driving mileage of certain fuel consumption. In view of the internal relationship between fuel consumption and carbon emission, fuel economy standard will play a role in reducing carbon emission and is an indirect means of carbon emission supervision.

Carbon emission range: This report covers standard policy research of all greenhouse gases. In this report, carbon emission refers to specific carbon dioxide emission or greenhouse gas emission.

Overall carbon emission standard research is shown in Fig 3.

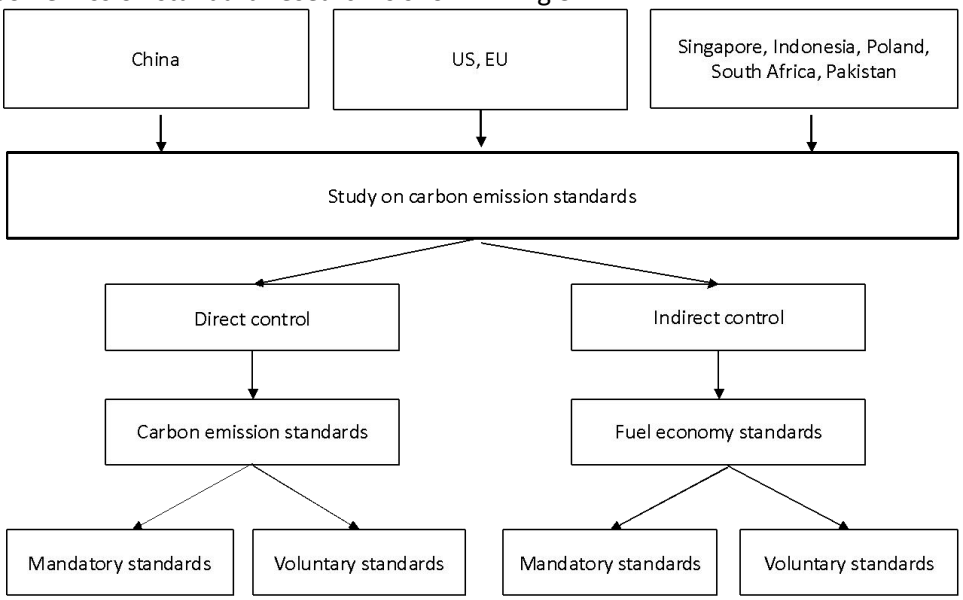


Fig 3. Carbon emission standard research framework

2. Development status of automobile industry carbon emission standards in China and the world

A sound carbon emission standard system is the basis for national carbon emission management. This chapter focuses on the standard name, responsible department, legal basis, model range, management object, implementation time, development stage, boundary range, current standard, current target value, target value accounting method, current limit value, limit value accounting method, actual value accounting method, actual value test condition, management mode, flexible mechanism, punishment mechanism and other supporting measures, and based on which analyzes the construction of carbon emission standards in China, the European Union and the United States.

2.1 Development status of carbon emission standards in China's automobile industry

At present, China has established a standard system with fuel consumption as the regulatory object for the automobile industry, which has entered Phase V since 2021. At this stage, China has not issued formal policies and regulations on carbon emission standards, and the Ministry of Ecology and Environment is stepping up the formulation of the Technical Specifications for Life Cycle Carbon Emission Accounting of Passenger Vehicles and corresponding management policies, in order to improve the standard policy system of the automobile industry.

2.1.1 Development status of fuel consumption standards in China’s automobile industry

2.1.1.1 Fuel management policy evolution for China’s automobile industry

China has implemented the management of passenger vehicle fuel consumption since 2005. By 2020, China's passenger vehicle fuel consumption management has experienced four stages of development, and is currently in the fifth stage, as shown in Figure 4.

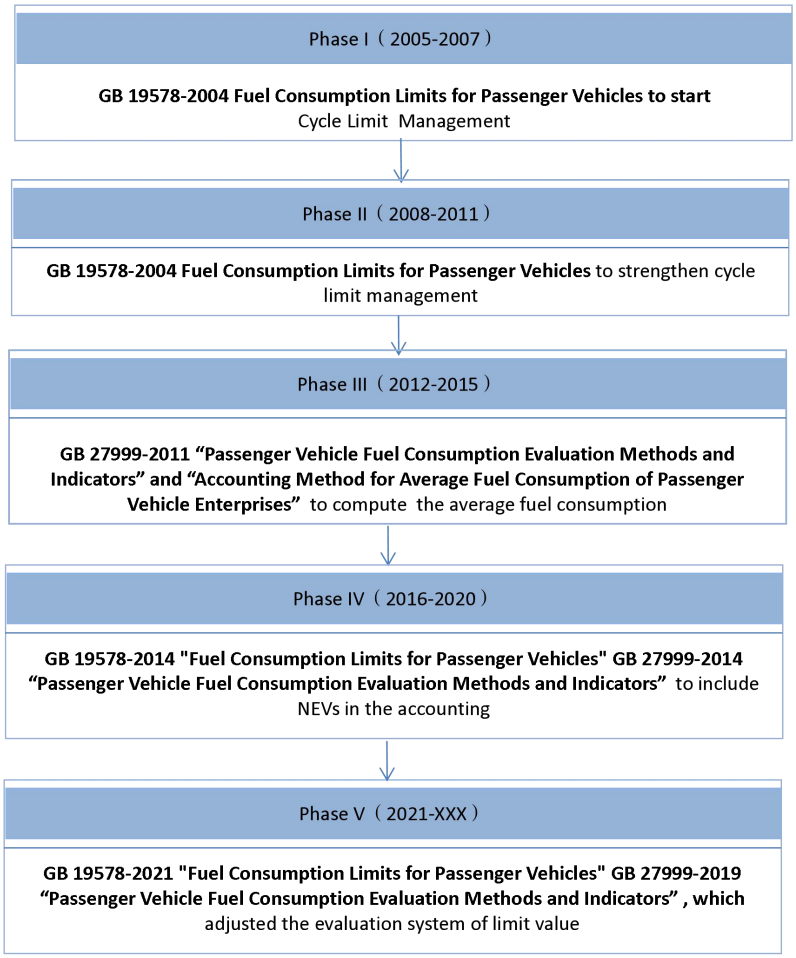


Fig 4 Development history of fuel consumption standards

1) Phase I and phase II (2005-2007 and 2008-2011)

GB 19578-2004 "Fuel Consumption Limits for Passenger Vehicles" is a mandatory national standard established for the first time in China to control vehicle fuel consumption. The standard stipulates that light passenger cars are divided according to weight, and defines the fuel consumption limits of each quality interval. The standard is implemented in two stages from July 1, 2005, and July 1, 2008, respectively. The first stage is based on the average fuel consumption of passenger cars in China at that time, and the second stage is 10% lower than the first stage. The implementation of the standard has played a positive role in reducing the fuel consumption of passenger cars. Statistics show that from the formulation of standards in 2002 to 2006, the fuel economy of vehicles has increased by about 10%, reaching the expected goal.

2) Phase III (2012-2016)

In view of the implementation effect and defects of phase I and phase II standards, China issued GB 27999-2011 27999-2014 "Passenger Vehicle Fuel Consumption Evaluation Methods and Indicators" (phase III) in 2011. The standard draws lessons from the American CAFE method and introduces the accounting method of "enterprise average fuel consumption" for the first time, which is no longer limited to a single model. Instead, the overall assessment evaluates all the models and production capacity produced by the enterprise, that is, on the premise of meeting the enterprise's average fuel consumption limit, the enterprise is allowed to produce some models with excessive fuel consumption.

Considering the enterprise product technology cycle, the standard was introduced in 2012, carried out in stages, and fully implemented in 2015, reaching the goal of 6.9l/100km. In March 2013, the Ministry of Industry and Information Technology issued the accounting method for average fuel consumption of passenger car enterprises for the first time, further defined the accounting scope, accounting subject and accounting method of average fuel consumption of passenger car enterprises, and began to implement the disclosure system.

3) Phase IV (2016-2020)

On December 22, 2014, China officially issued the phase IV standard schemes 19578-2014 "Fuel Consumption Limits for Passenger Vehicles (GB 19578-2014)" and "Passenger Vehicle Fuel Consumption Evaluation Methods and Indicators (GB 27999-2014)", which were officially introduced and implemented from January 1, 2016, and set target values year by year to reduce the average fuel consumption of new passenger cars in China to 5L/100km by 2020. The standard continues to use the evaluation system that combines the fuel consumption of vehicle models and the average fuel consumption of enterprises according to the quality of equipment. This standard revision is mainly based on GB19578-2004 and gb27999-2011, further tightening the fuel consumption limit and target value of vehicle models, narrowing the scope of vehicles with special structures, including new energy and alternative fuel vehicles in the calculation of enterprise average fuel consumption, and encouraging the development and application of "external recycling technology" and other advanced energy-saving technologies. It also specified that the average fuel consumption of the enterprise shall be calculated according to the production or import volume.

4) Phase V (2021-)

In recent years, with the sustained and rapid development of the national economy and the acceleration of urbanization, China's automobile industry has developed rapidly, resulting in more and more prominent problems of energy shortage and environmental pollution. Phase V will accelerate the cultivation and development of energy-saving vehicles and new energy vehicles control and reduce the fuel consumption of vehicle models to effectively alleviate the pressure of energy and environment and promote the sustainable development of automobile industry.

On December 31, 2019, the Ministry of Industry and Information Technology issued the mandatory national standard GB 27999-2019 27999-2014 "Passenger Vehicle Fuel Consumption Evaluation Methods and Indicators" [6]. The new standard expands the scope of application, tightens the target value of fuel consumption, and adjusts the preferential multiple related to new energy vehicles. GB 19578-2021 "Fuel Consumption Limits for Passenger Vehicles" [7] was officially implemented on July 1, 2021. On the basis of the 2014 version, the evaluation system of fuel consumption limits for vehicle models was changed from a stepped type grouped by the quality of equipment to a linear type based quality of equipment, the fuel consumption limits for vehicle models were adjusted, and the reference value of CO2 emissions corresponding to the fuel consumption limits was added.

2.1.1.2 Evolution of supporting systems for the fuel consumption management

With the continuous improvement and updating of fuel consumption standards, relevant supporting management systems have also been improved. A number of measures have been issued from different aspects such as test certification, management disclosure and incentive measures, and a relatively perfect fuel consumption management system has been established.

1) Test certification

Test Method for Fuel Consumption of Light Vehicles is the basic standard in the energy-saving standard system of light vehicles in China. It is very important to accurately test and evaluate the fuel consumption of passenger vehicles. The current GB/T19233-2020 Test Method for Fuel Consumption of Light Vehicles was issued in June 2020, which revised the scope of application of the standard, and the test cycle was changed from NEDC cycle to WLTP cycle and driving conditions of Chinese vehicles. In the Test Method for Fuel Consumption of Light Vehicles standard, CO2 emission is tested and recorded, and CO2 emission is taken as the factor for calculating fuel consumption. Therefore, the management of fuel consumption has achieved a certain effect on carbon emission.

2) Disclosure system

The disclosure system of automobile fuel consumption is an important measure to implement the automobile industry development policies. In July 2009, the Ministry of Industry and Information Technology formulated and issued the regulations on the Management of Fuel Consumption Labeling of Light Vehicles, which clearly stipulates the detection, reporting, filing, labeling, disclosure, supervision and punishment in terms of the fuel consumption of vehicles. According to the Accounting Method for Average Fuel Consumption of Passenger Vehicle Enterprises issued in 2013, all enterprises selling passenger vehicles within the customs territory of China shall timely report the fuel consumption data for the produced or imported vehicles to the Ministry of Industry and Information Technology as required, which shall publish the fuel consumption and relevant information of passenger vehicles through the vehicle fuel consumption notification system. The implementation of the average fuel consumption of each accounting entity enterprise shall be publicized before March 20 every year, and the report on the average fuel consumption of passenger vehicle enterprises of the previous year shall be issued before June 1 every year.

3) Incentive measures

In terms of tax rate preference, since 2009, the central government has begun to vigorously support the promotion and application of new energy vehicles, and promote the long-term development of new energy vehicle industry through fiscal subsidies, tax incentives and other fiscal policies and double credit management mechanism.

2.1.2 Carbon emission management policy studies for China’s automobile industry

China is stepping up the “Technical Specification for Life Cycle Carbon Emission Accounting of Passenger Vehicles” standard, in order to provide a legal basis for policymakers, industry institutions and automobile enterprises to carry out carbon emission management. Different from the existing carbon emission standard, this standard is based on the concept of life cycle. The accounting includes the carbon emission generated in the raw material acquisition stage, vehicle production stage, fuel production stage and fuel use stage (i.e. road driving stage), taking into account the trend that the carbon emission will transfer to the whole industrial chain with the electrification of vehicles. At the same time, based on “Technical Specification for Life Cycle Carbon Emission Accounting of Passenger Vehicles”, this report puts forward policy suggestions on automobile life cycle carbon emission management of "two dimensions and four measures". Firstly, establish HJ/GB-T standard for life cycle carbon emission for carbon emission accounting of passenger cars. Secondly, based on the accounting standards, it is expected to promote the construction of a carbon emission disclosure system and

improve the public low-carbon awareness from 2021 to 2022. Finally, it is expected to launch a series of incentive and restraint measures from 2023 to 2025, including low-carbon technology inventory, quota management and carbon tax, to guide automobile enterprises towards green and energy-saving models with low energy consumption, low pollution and low carbon emission.

Tab 1 Carbon emission standards for China's automobile industry

Standard Type	Fuel Consumption	Carbon Emission
Name	GB 19578-2021 "Fuel Consumption Limits for Passenger Vehicles" GB 27999-2019 "Passenger Vehicle Fuel Consumption Evaluation Methods and Indicators" GB 20997 "Light Commercial Vehicle Fuel Consumption Limits"	Technical Specification for Life Cycle Carbon Emission Accounting of Passenger Vehicles (to be developed)
Management department	Ministry of Industry and Information Technology	Ministry of Ecology and Environment
Legal basis	Energy conservation and the New Energy Automobile Industry Development Plan (2012-2020)	
Model range	Passenger vehicle and light commercial vehicle	Passenger vehicle
Management object	enterprises	enterprises
Implementation date	Passenger vehicle: 2021 Light commercial vehicle: 2015	TBC
Development stage	Since the issuance of the Passenger Vehicle Fuel Consumption Limits standard in 2004, the fuel consumption limits studies have undergone 5 phases.	Get started
Boundary	Fuel use period	Life cycle

Current standards	GB 19578-2021 "Fuel Consumption Limits for Passenger Vehicles" GB 27999-2019 “Passenger Vehicle Fuel Consumption Evaluation Methods and Indicators” GB 20997-2015 “Light Commercial Vehicle Fuel Consumption Limits”	None
Target value	The average fuel consumption of passenger cars dropped to 5L/100km in 2020, and the carbon dioxide emission was about 120g/km. In 2025, it will drop to 4L/100km, and the carbon dioxide emission will be about 95g/km	None
Target value accounting method	Vehicle model: calculate according to the quality of equipment Enterprises: target value is a weighted average based on production and output	None
Current limit value	based on the quality of equipment	based on the quality of equipment
Limit value accounting method	Determine single vehicle limit value based on the quality of equipment, fuel type and seats	Determine single vehicle limit value based on the quality of equipment, fuel type and seats
Actual value accounting method	Accounting fuel consumption with carbon balance method based on the emission of CO2, CO and HC	None
Actual value test condition	WLTC	None
Management types	(1) notification management (2) double credit management, fuel consumption credit transfer, clean energy vehicle credit and transaction	TBC

Flexible mechanism	(1) Set aside a transition period for existing products and fully consider the payback period of enterprise investment products. (2) The requirements of CAFC will be tightened year by year and fully meet the standards in 2020. (3) For the energy-saving technology or device that cannot be reflected or incomplete in the existing test methods but has obvious effect in practical use, it is allowed to reduce the fuel consumption of the vehicle model accordingly. (4) Quota reservation: the quota better than the enterprise target value can be reserved for the next year and valid for three years.	TBC
Punishment mechanism	Enterprises whose negative points are offset shall suspend the application for announcement, be included in the list of dishonest enterprises and publicized	TBC
Other supporting mechanisms	Parallel management of enterprise average fuel consumption and new energy vehicle credits	TBC

2.2 Development status of carbon emission standards in international automobile industry

2.2.1 European Union

2.2.1.1 Current state of carbon emission

As can be seen from Figure 5, compared with 1990, the carbon emission of EU transport industry increased by 33% in 2018 [8]. Road traffic carbon emission is one of the important components of the total emission of the EU, among which the carbon emission of light vehicles (passenger vehicles and light commercial vehicles) is the top priority. As can be seen from Figure 6, in 2018, the carbon emission of the transportation industry accounted for 29% of the total carbon emission of the whole industry, of which the carbon emission of passenger cars and light trucks accounted for 15% [9]. Therefore, passenger cars and light commercial vehicles are particularly important for the EU to achieve the target of 55% emission reduction in 2030 and carbon neutrality in 2050.

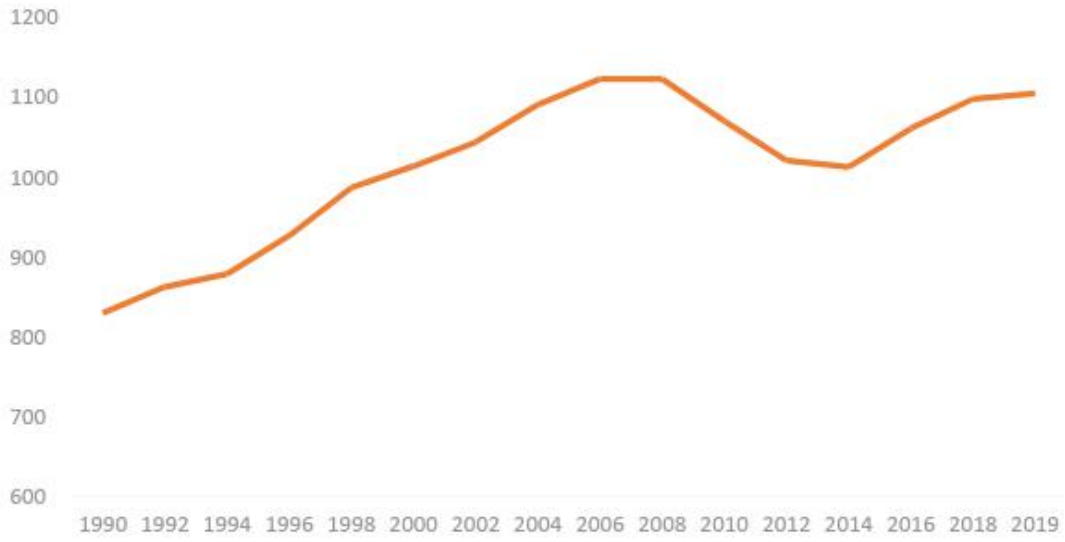


Fig 5. GHG emission of EU transport sector from 1990-2019 (MtCO2e)

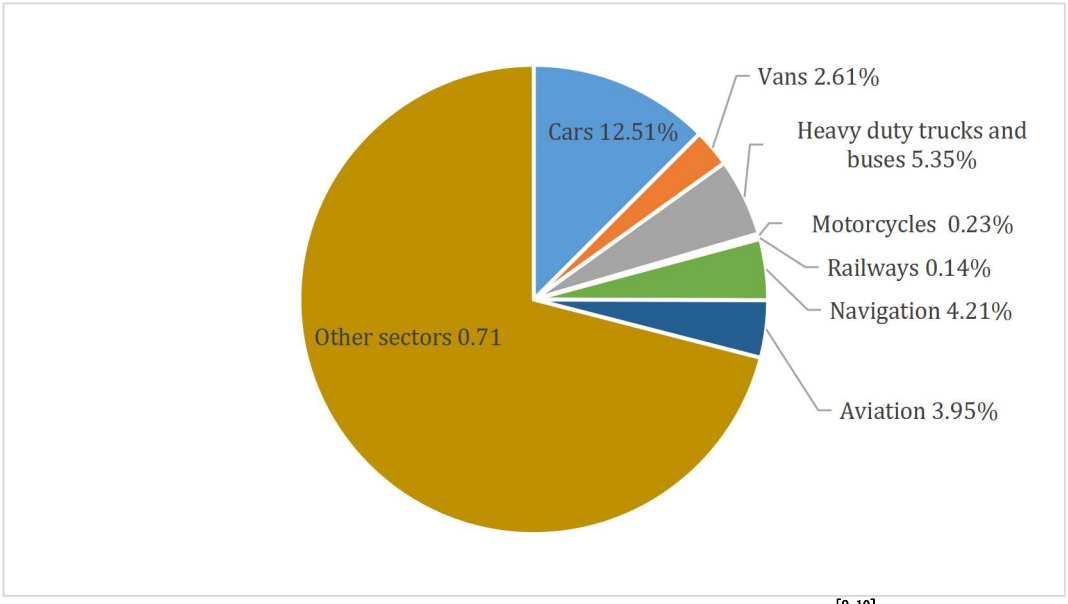


Fig 6 GHG emission ratio of EU transport sector in 2018 [9-10]

2.2.1.2 Carbon emission standards

The EU has always attached importance to climate issues and has taken a series of green and low-carbon development measures. Especially after the politicization of environmental issues, the EU's measures have been strengthened. The EU's policy on climate issues is divided by the Kyoto protocol. Before signing the protocol, the EU mainly carried out macro analysis around the elements and objectives of climate policy. After signing the protocol, the EU took the lead in launching the EU trade emission system, transferred from macro research to micro research, and began to manage specific industries. In order to strengthen the carbon emission management of road traffic, the EU formally proposed in 2007 that it would implement a mandatory regulatory policy based on carbon emission indicators to guide the supply side low-carbon transformation of the automotive industry and seize the commanding heights of future industry development. Based on this, the EU has put forward a series of policies and measures for passenger cars. In December 2008, the EU accepted the proposal on the average carbon emission target of passenger car fleet. Taking all automobile manufacturing enterprises as the responsibility subject, the EU has taken newly registered passenger vehicles as the object, and the carbon dioxide emission per kilometer as the core index for the comprehensive evaluation of automobile manufacturing enterprises. Led by the European Commission and with the full participation of Member States, regulation (EC) 443/2009 CO2 emission standards for passenger cars and light commercial vehicles were issued in 2009 and officially launched in 2012.

1) CO2 emission target

The regulation stipulates that the average CO2 emission of newly registered passenger vehicles within the EU in 2015 must reach the target of 130g/km, which can be achieved through the improvement of vehicle technology, the implementation of measures and innovative technology. At the same time, the regulation stipulates that the average CO2 emission of new passenger vehicles shall be less than 95g/km by 2020. After the amendment of the regulations in 2014, the target for 2021 is 95g/km, which is equivalent to a 40% reduction over 2007 (Regulation (EU) No 333/2014). On April 17, 2019, the EU officially adopted regulation (EU) 2019/631 [11], specifying the goal of reducing CO2 emissions by 15% for passenger cars and light commercial vehicles in 2025; The target of reducing CO2 emissions by 37.5% for passenger vehicles and 31% for light commercial vehicles by 2030; At the same time, the regulation decides to continue to adopt the previous carbon emission target value. From 2021, 100% will reach 95g/km, exceeding 1g, and a fine of 95 euros will be imposed. In the opinions on the revision of carbon emission standards for passenger vehicles adopted on July 14, 2021, the European Commission proposed to set stricter carbon dioxide emission standards for new passenger vehicles and light commercial vehicles, support the development of zero-emission and low emission vehicle markets, and support the construction of corresponding charging infrastructure [12].

2) Test conditions

Because there are many factors affecting the actual road emission of vehicles and it is difficult to obtain the data, the vehicle carbon emission data at this stage adopts the method of laboratory testing. All test data shall be provided by a third-party testing organization. Each model produced by an automobile manufacturing enterprise shall enter the sales link after being tested and certified by a third-party testing organization. The previously used test condition is the New European Driving Cycle (NEDC). Due to the large deviation between this condition and the actual road emission, the EU recently used the World Light-Vehicle Test Procedure (WLTP) to replace NEDC and implemented it on September 1, 2018.

3) Supporting mechanisms

- Flexible convention implementation mechanism

In order to help enterprises gradually adapt to regulatory requirements, it provides a gradual introduction and joint performance system. The gradual introduction mechanism allows automobile manufacturing enterprises to select a certain proportion of new vehicles for performance every year, and the introduction proportion is required to increase year by year until it rises to 100%. Under this mechanism, automobile manufacturers can choose to temporarily exclude some models with high carbon emission intensity, so as to reserve a certain buffer time and reduce the performance cost of enterprises as a whole. In addition, enterprises can form a consortium to realize joint performance.

Tab 2. New vehicle ration under the gradual introduction mechanism

Year	2012（130g/km）	2013（130g/km）	2014（130g/km）
New vehicle ratio	65%	75%	80%
Year	2015-2019 (130g/km)	2020（95g/km）	2021（95g/km）
New vehicle ratio	100%	95%	100%

- Consumer side guidance

All EU member states have introduced different preferential policies for low-carbon vehicle purchases to guide consumers to buy low-carbon vehicles and assist automobile manufacturers to realize low-carbon transformation.

4) Implementation effects

As shown in Figure 7, driven by EU incentives, the proportion of EU electric vehicle sales in 2020 jumped from 3% in 2019 to 10%. The increasing sales of electric vehicles throughout Europe have led to a sharp decline in carbon dioxide emissions from new vehicles. This reduction means that some carmakers have achieved their CO2 target for 2020, while others are close to the target. The carbon emission of new cars in the EU decreased from 122g/km in 2019 to 111g/km in the first half of 2020, the largest decline since 2008[10].

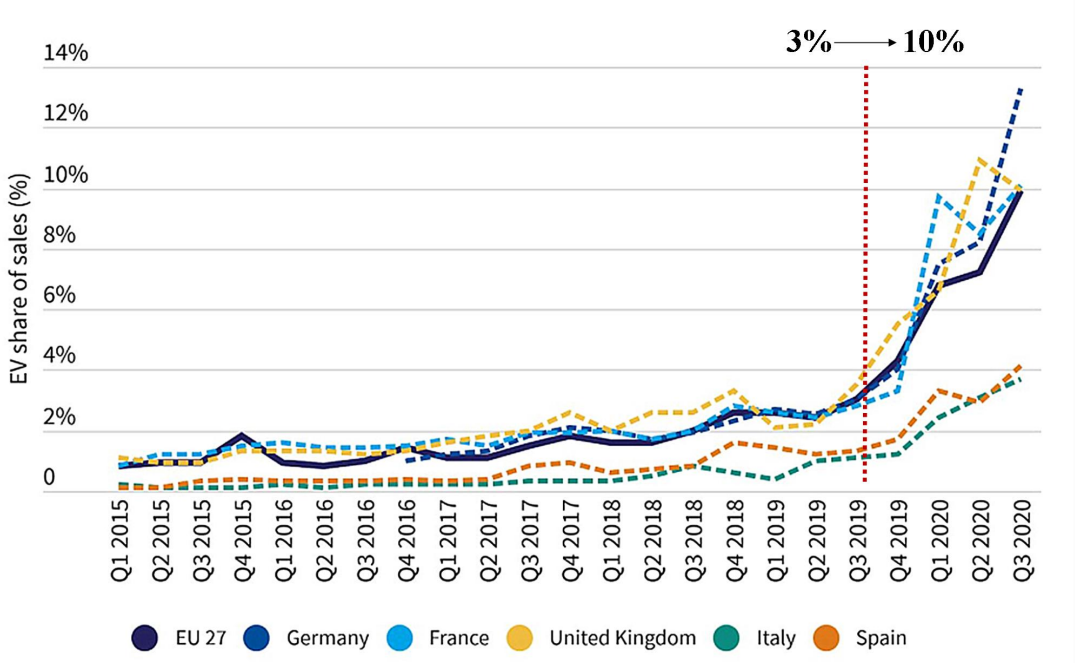


Fig 7. Quarterly electric vehicle sales share from 2015-2020

2.2.2 United States

2.2.2.1 Current status of carbon emission

Transportation industry is the key area of greenhouse gas emission in the United States. As can be seen from figure 8, after a brief decline, the carbon emissions of the U.S. transportation industry have gradually increased since 2013. Therefore, the United States has issued a series of regulations for light vehicle enterprises to control greenhouse gas emissions.

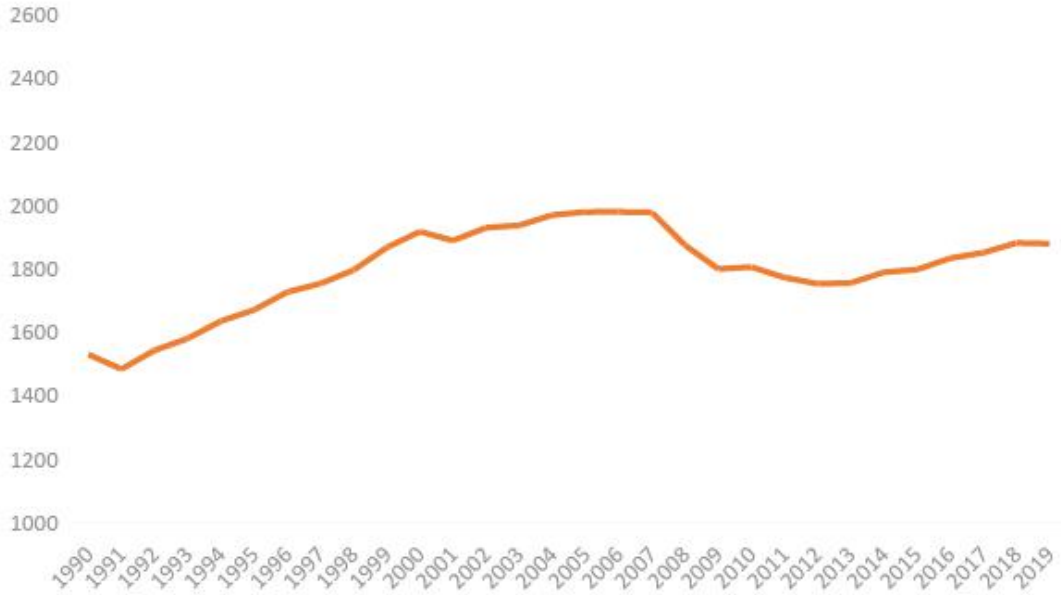


Fig 8. GHG emission for the transport sector in the US from 1990-2019

2.2.2.2 Current status of carbon emission standards

1) Introduction of footprint

Quality of equipment is more relevant to greenhouse gas (GHG) emissions, but dividing by quality of the equipment will produce a wrong direction and is not conducive to the development of light vehicles. Therefore, the United States proposed in the rule making announcement in 2007 that the calculation of the parameters of each vehicle type shall be adopted when calculating the single car standard of passenger car cafe from the model year 2011. The introduction of footprint effectively improves the accuracy and rationality of the standard. Footprints refer to the product of wheelbase and wheelbase of a vehicle (footprints = axle track × wheelbase), generally speaking, it is the size of the car. When formulating the target, the larger the footprint, the smaller the target standard. That is, the larger the size of the vehicle, the lower the standard of fuel consumption. Taking the footprint as the weighting coefficient can increase the accuracy of carbon emission accounting to a certain extent. This rule skillfully solves the long-standing protest of manufacturers in the past: in order to achieve the CAFE goal, manufacturers must reduce the sales of large vehicles.

2) CO2 emission targets

In 2012, the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) issued the Greenhouse Gas Emission and Company Average Fuel Economy Standard for New Models of 2017 and beyond (hereinafter referred to as GHG and CAFE standards) [13]. EPA is responsible for managing GHG emissions during vehicle use, and NHTSA is responsible for managing fuel economy (CAFE). The model objects managed by GHG and CAFÉ standards include passenger cars and light trucks, which are applicable to every automobile manufacturer selling in the U.S. market.

Calculation method of single vehicle GHG target value: firstly, based on statistical data, the linear relationship between footprint area and carbon emission is fitted, and the carbon emission value of corresponding footprint area is obtained; Then, the linear relationship is modified by the maximum and minimum functions, that is, the CO2 target value of a specific vehicle type = MAX [maximum limit, c × footprint area + d] (c, d are correlation coefficients).

Calculation method of the CO2 target value of enterprise fleet: the enterprise calculates the CO2 target value of the whole fleet according to the GHG target value of each vehicle model and the weighted average of sales volume.

Generally speaking, the total sales of passenger cars or light trucks in the U.S. market (after the fuel economy and greenhouse gas emissions of each model are based on the weighted average of sales) of each automobile manufacturer must meet this standard. If you fail to meet CAFE, you will be fined; if the carbon emission requirements are not met, EPA has the right to cancel the license of the automobile manufacturer to sell in the United States.

3) Supporting measures

The United States has established the concept of credit amount (points) in the GHG and CAFE standards. The credit amount refers to the surplus after the automobile enterprise reaches the CO2 and CAFE limits in a certain year, which can be used for trading and transfer. Transaction means that the credit amount can be bought and sold directly in the enterprise. On the one hand, transfer means that the credit amount can be transferred between a passenger car and light truck fleets within the enterprise; On the other hand, in terms of time, the credit amount of a year can be transferred to the index evaluation in the next few years.

Enterprises that meet the standards can be rewarded with credit lines. Enterprises that fail to meet the standards can use credit lines to make up for it. If there are no (or insufficient) credit lines, enterprises can choose to submit a "recycling plan" to NHTSA to describe what enterprises need to do in the next three years to earn enough credit lines to make up for it. If the enterprise does not comply with the regulation, EPA will further evaluate the fine.

Tab 3. Carbon emission standards in the international automobile industry

Countries	United States	European Union
Name of Standards	GHG and CAFE standards	CO2 emission standards for passenger vehicles and light commercial vehicles
Responsible Department	EPA, NHTSA	EU
Legal Basis	CAFÉ: Energy Policies and Conservation Act (EPCA) GHG: Clean Air Act (CAA)	Treaty establishing the European Community, 175(1)
Model Range	Passenger vehicles Light trucks	Passenger vehicles Light commercial vehicles
Management Object	Enterprises	Enterprises
Implementation Date	2017	2020
Management Types	Simultaneous control on fuel consumption and GHG	CO2
Boundaries	Fuel use period	Fuel use period, considering transition to the whole life cycle
Current Standards	The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule	EU 2019/631 CO2 Emission Standard for Passenger Vehicles and Light Commercial Vehicles
Current Target Value	Carbon emission target value of US new fleet: 114gCO_2/km in 2011 Fuel economy target value: 44.2mpg in 2011	Passenger vehicles in 2011: 95 gCO_2/km; Light commercial vehicles: 147 gCO_2/km

Accounting method for the target value	Single vehicle: footprint area-carbon emission model Enterprises: the target value of single vehicle carbon emission is weighted average by sales volume	Based on the annual output of the enterprise: < 1000 vehicles, no target; 1000 ~ 10000 vehicles, apply to the EU for setting exclusive emission reduction targets; 10000 ~ 300000 vehicles, and the emission reduction target in 2020 is to reduce the carbon emission by 45% compared to 2007; > 300000 vehicles and the target value is calculated according to the average quality of equipment.
Accounting method for the actual value	Single vehicle: carbon emission measured experimentally; Enterprise: the carbon emission measured by single vehicle test is weighted average by sales volume	Single vehicle: carbon emission measured experimentally; Enterprise: carbon emissions detected by single vehicle test are weighted average according to output
Test conditions for the actual value	The CO2 emission of gasoline vehicles is tested according to FTP-75, and the CO2 emission of electric vehicles is 0	Test conditions: the CO2 emission of gasoline vehicle is tested according to WLTP, and the CO2 emission of electric vehicle is 0
Management types	Total volume management	Target decomposition and classified management: formulate the EU wide carbon emission target per kilometer of new vehicles, and decompose the target to various automobile manufacturing enterprises. According to the annual output, enterprises are divided into four categories and set different goal.

Flexible mechanism	Enterprises that meet the standards can be rewarded with a credit line, and enterprises that do not meet the standards can use a credit line to make up for it. Recovery plan: if there is not enough credit line, the enterprise can submit a "recycling plan" to NHTSA, describing the enterprise's work plan for the next three years, so as to earn enough credit line to make up for it; If the enterprise does not comply with the regulation, EPA will further evaluate the fine. First three and last five years: if there are no remaining points in the first three years, you can overdraw the points in the next five years.	In order to help enterprises gradually adapt to regulatory requirements, it provides a gradual introduction and joint performance system. The gradual introduction mechanism allows automobile manufacturing enterprises to select a certain proportion of new vehicles for performance every year, and the introduction proportion is required to increase year by year until it rises to 100%.
Punishment mechanism	CAFE: if it is lower than the standard by 0.1mpg, a fine of $5.5 will be imposed and owned by Ministry of Finance. GHG: the sales of unqualified products shall be stopped, and EPA shall determine the fine of the unqualified products.	Since 2019, enterprises will be fined 95 euros for exceeding 1g/km.
Other supporting measures	For the new CAFE standard, NHTSA and EPA have issued a list of countermeasures for automobile enterprises. It mainly uses the existing technology to meet the requirements of the new CAFE standard, including the use of advanced engine, transmission, automobile air conditioning technology, etc	(1) Encourage the R & D and application of new technologies: including environmental protection innovation mechanism and low emission vehicle preferential mechanism. (2) Provide performance flexibility: the gradual introduction mechanism allows automobile manufacturers to select a certain proportion of new vehicles for performance every year, and the introduction proportion is required to increase year by year until it rises to 100%. (3) Consumer side guidance.

3. Status of carbon emission standards in typical BRI participating countries

3.1 Singapore

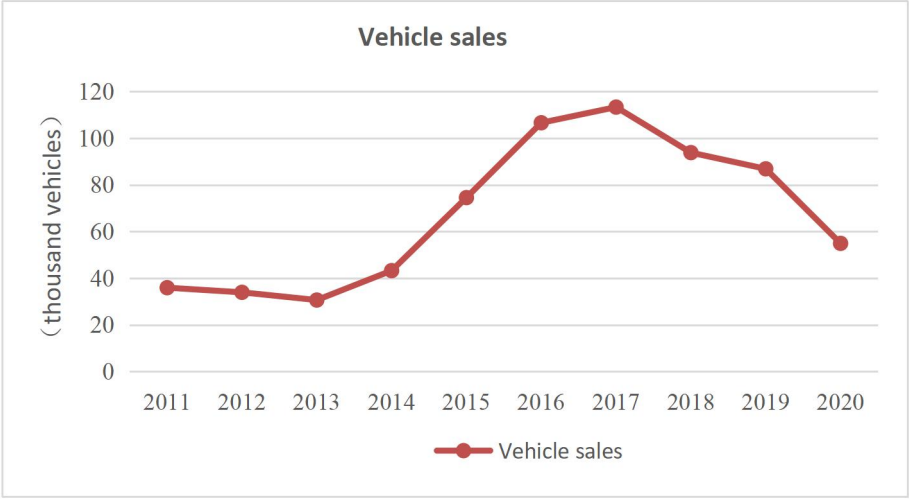
3.1.1 Status of carbon emission

The population and land area of Singapore is relatively small, and the car sales is also smaller than other BRI countries. As shown in Figure 9, vehicle sales[1] increased from 36 thousand in 2011 to 55 thousand in 2020. Sales figures changed little from 2011 to 2014. Sales figures showed a clear growth trend after 2014. In 2020, the sales volume of Singapore also declined significantly due to COVID-19 influence.

The car ownership[2] in Singapore increased from about 610000 in 2005 to 810000 in 2015. The overall trend was growing first, and peak in 2013, and showed a slight downward trend afterwards, indicating that the car ownership in Singapore has been at a high level that the country can carry. The population per thousand shows an obvious trend of increasing first and then decreasing, which is in line with the relatively gentle inverted U-shape as a whole. In 2005, the number of cars per thousand people was 144, and in 2015, it was 147 cars per thousand people. The peak appeared in 2010, which was 157 cars per thousand people.

[1] Vehicle sales in various countries quote the Markline, https://www.marklines.com/portal_top_cn.htm

[2] Vehicle production and car ownership in various countries quote the Organisation Internationale des Constructeurs d'Automobiles (OICA), https://www.oica.net/



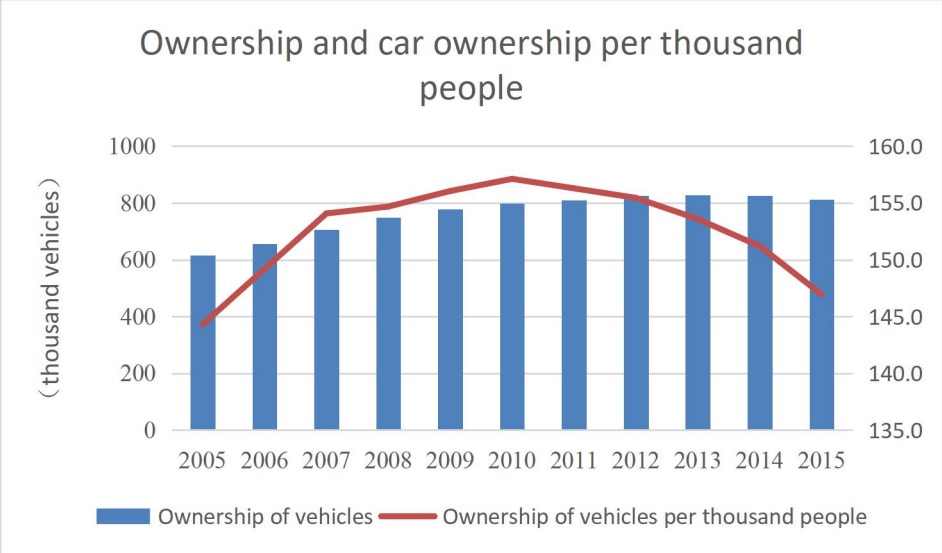
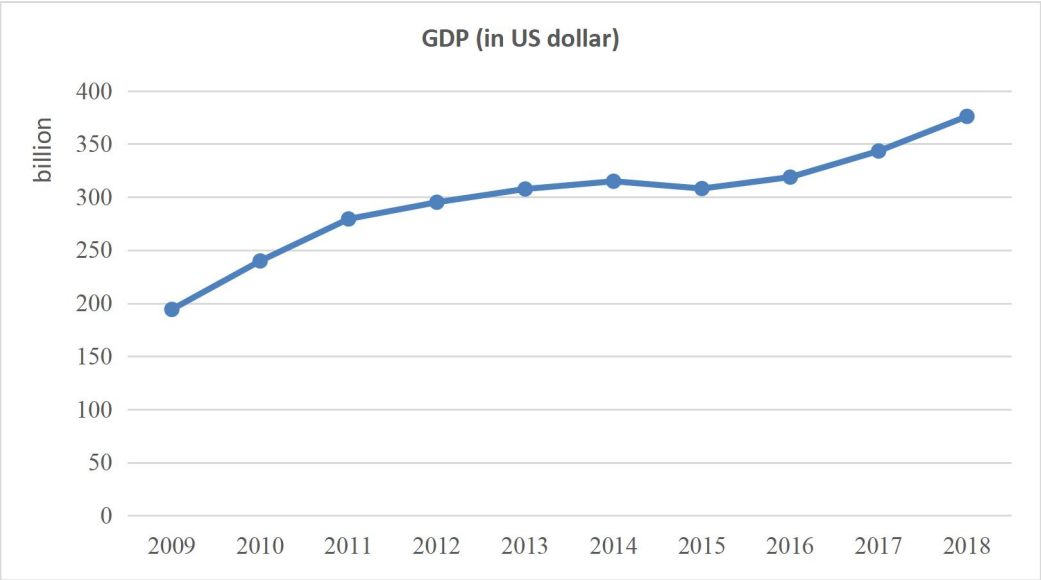


Fig 9 Vehicle sales, car ownership and car ownership per thousand people

Singapore's economic development is relatively stable. Its GDP[3] has grown from about the US $200 billion in 2009 to about US $376 billion in 2018. From 2009 to 2012, the overall GDP growth was relatively fast, the GDP growth was relatively flat from 2012 to 2016, and showed a good growth trend after 2016.

In terms of the national carbon emissions, Singapore's carbon emissions showed a trend of gradual growth in fluctuation between 39 million tons to 47 million tons from 2009 to 2018, and the growth of carbon emissions was relatively stable after 2012. At the same time, the carbon emissions per unit of GDP show a downward trend, and the carbon emissions per unit of GDP are at a small value. By 2018, the carbon emissions per unit of GDP will only be 0.0835 kg per unit of GDP (purchasing power parity). It is expected that there will be some room for decline in the future.

[3] GDP, population, and carbon emissions quote World Bank data, https://data.worldbank.org/indicator



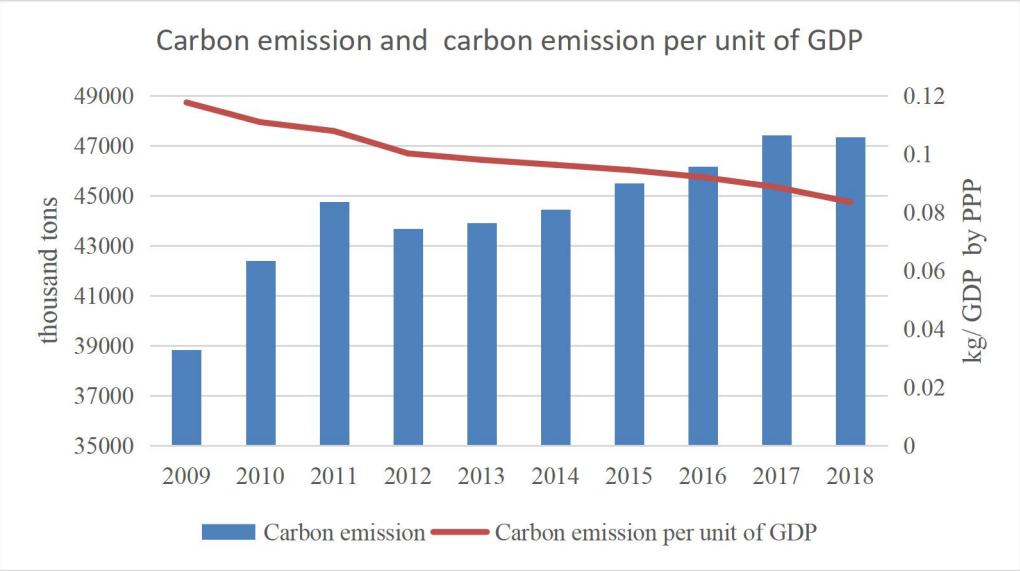


Fig 10. Carbon emissions, GDP and carbon emission per unit of GDP

Due to the small overall carbon emissions and low data accuracy, the carbon emissions[4] of Singapore's transportation industry did not change significantly from 2009 to 2018 and basically remained at the level of 7 megatons of carbon dioxide, indicating that Singapore's domestic transportation industry is relatively stable without obvious fluctuations. There is a weak growth in the number of thousands of existing cars, and the carbon emission of the automobile industry is not expected to increase significantly in the future.

[4] The carbon emissions of the transportation industry in various countries quote the IEA, https://www.iea.org/

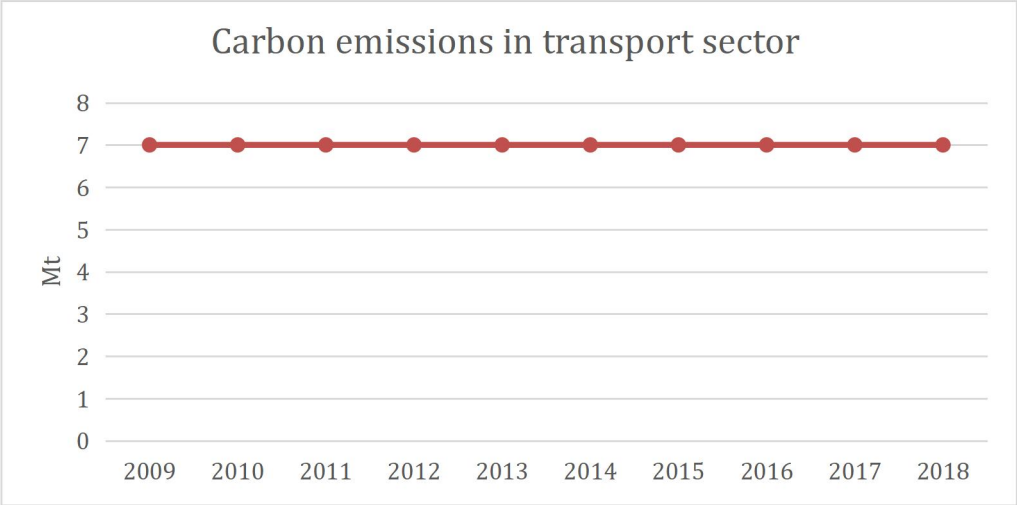


Fig 11. Carbon emission of Singapore's transport/automobile industry

3.1.2 Carbon emission standards

In 2013, the Land Transport Authority (LTA) of Singapore introduced and implemented the Carbon Emissions-Based Vehicle Scheme (CEVS), giving rebates or levying surcharges according to the cleanliness of vehicles to encourage consumers to buy cleaner vehicles. CEVS divides vehicles into nine levels according to carbon emissions, A1~A4, B and C1~ C4. The registered vehicles or taxis belong to class A, and consumers will receive emission subsidies, which can be used to offset the Additional Registration Fee (ARF) of vehicles; if the emission of the registered car or taxi exceeds the standard, i.e. class B car, the emission penalty shall be paid. The revised vehicle carbon emission plan was issued in 2015, which is applicable to vehicles registered from July 1, 2015 to December 31, 2017. Compared with the previous version, the revised vehicle carbon emission plan strengthens the carbon emission requirements and reduces the carbon emission limit of each level. In 2018, pollutant emission will be included in the regulatory scope, and CEVS will be changed to Vehicle Emission Scheme (VES), which is applicable from January 1, 2018 to December 30, 2020. Vehicles will be rated according to the indicators with the worst carbon emission and pollutant performance. As shown in Table 4, before July 1, 2018, VES was based on carbon dioxide (CO2), hydrocarbons (HC), carbon monoxide (CO) and nitrogen oxides (NOx), and particulate matter (PM) was added on July 1. In 2021, Singapore further strengthened its carbon emission requirements by revising VES. In the enhanced VES, the discount for clean vehicles and the punishment for vehicles with excessive pollution is further strengthened. It is worth mentioning that when managing carbon emissions, Singapore not only calculates the carbon emissions of traditional fuel vehicles, but also considers the carbon emissions of upstream power production of electric vehicles. The power consumption of new energy vehicles will be converted into carbon emissions through the power carbon emission factor of 0.4g CO2 / Wh.

Tab 4. Vehicle Emission Scheme of different stage

Registration time	2013.1.1-2015.6.30	2015.7.1-2017.12.31	2018.1.1-2018.6.30	2018.7.1-2020.12.31	2021.1.1-2022.12.31
Name of Standards	CEVS	Revised CEVS	VES		Enhanced VES
Accounting Range	CO_2	CO_2	CO_2, HC, CO, NO_X	CO_2, HC, CO NO_X, PM	CO_2、HC、CO、NO_X、PM

Tab 5. Details of enhanced VES

Grades	CO_2(g/km)	HC (g/km)	CO (g/km)	NOx (g/km)	PM (mg/km)	discounts	Additional fee
A1	A1≤90	A1≤0.020	A1≤0.150	A1≤0.007	A1= 0.0	$25,000	N.A.
A2	90<A2≤125	0.020<A2≤0.036	0.150<A2≤0.190	0.007<A2≤0.013	0.0<A2≤0.3	$15,000	N.A.
B	125<B≤160	0.036<B≤0.052	0.190<B≤0.270	0.013<B≤0.024	0.3<B≤0.5	N.A.	N.A.
C1	160<C1≤185	0.052<C1≤0.075	0.270<C1≤0.350	0.024<C1≤0.030	0.5<C1≤2.0	N.A.	$15,000
C2	C2>185	C2>0.075	C2>0.350	C2>0.030	C2>2.0	N.A.	$25,000

Tab 6. Carbon emission standards of automobile industry in Singapore

Standard types	**Carbon emission**
Name of Standards	VES
Responsible department	LTA
Legal basis	National Climate Change Strategy (NCCS)
Model range	Cars, taxis

Management object	Consumers
Implementation date	Jan 1, 2021
Development stage	According to the registration date, the following four emission plans apply to cars or taxis. CEVS is applicable from January 1, 2013 to June 30, 2015; Revised CEVS is applicable from July 1, 2015 to December 31, 2017; VES is applicable from January 1, 2018 to December 31, 2020; Enhanced VES is applicable from Jan 1, 2021 to Dec 31 2022.
Boundaries	Fuel production and use period
Current standards	Enhanced VES
Current target value	CO_2 targets: Single vehicle CO_2 emission limit: subsidy given to vehicles with emissions lower than125gCO_2/km; fines imposed on vehicles with emissions exceeding 160gCO_2/km
Accounting method of target value	From Jan 1, 2021 to Dec 31, 2022, enhanced VES is based on CO_2, HC, CO, NO_X and PM of cars and taxis
Accounting method of actual value	Single vehicle: carbon emission tested by experiment
Test condition of actual value	CO2 emission of gasoline vehicles shall be tested according to WLTP; Electric vehicles are converted according to the electric carbon emission factor of 0.4gco2/Wh

Management types	Consumer-oriented single vehicle management
Flexible mechanism	From January 1, 2018 to June 30, 2018, VES determines the vehicle grade based on the carbon dioxide (CO2) emissions of vehicles or taxis and the emissions of HC, CO and NOx; From July 1, 2018, particulate PM is added as another indicator to determine the grade of vehicles, including five gases: CO2, HC, CO, NOx and particulate matter.
Punishment mechanism	The pollutants with the worst performance determine the grade of the vehicle and the corresponding VES reward amount or surcharge. The penalty for CO2 emission is 160g/km
Other supporting measures	If the vehicle's emissions are clean, consumers will receive an emissions discount that can be used to offset the vehicle's Additional Registration Fee (ARF).

3.2 Indonesia

3.2.1 Status of carbon emission

The car ownership and the number of cars per thousand people in Indonesia showed the same growth trend. The number of cars increased from 9.06 million in 2005 to 22.51 million in 2015, and the number of cars per thousand people increased from 40 in 2005 to 87.1 in 2015, showing a continuous growth trend.

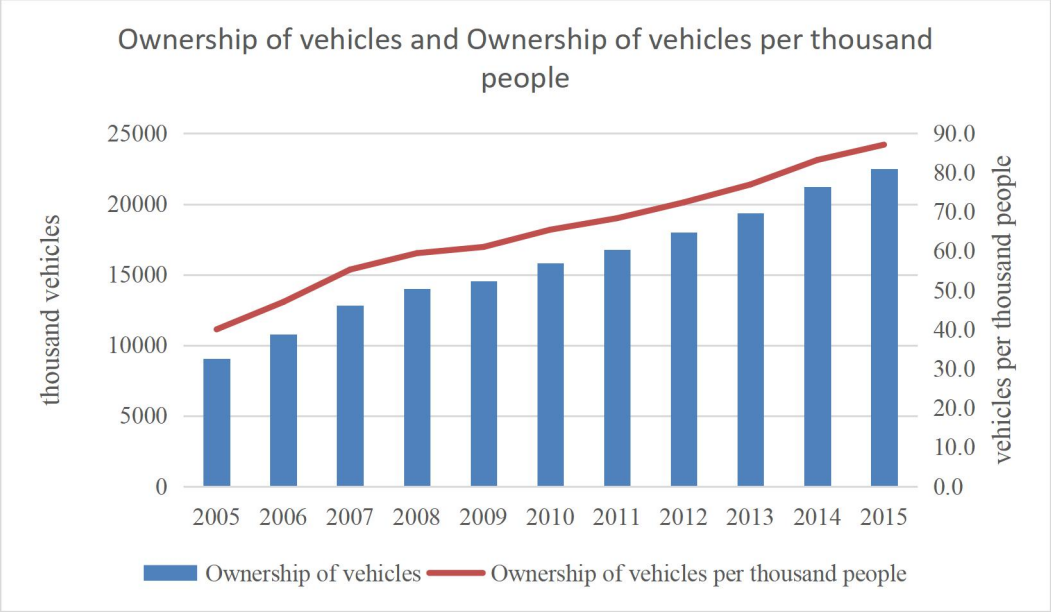


Fig 12. The car ownership and number of cars per thousand people in Indonesia

Indonesia's GDP grew rapidly from 2009 to 2011, from US $539.6 billion in 2009 to US $893 billion in 2011. From 2011 to 2016, GDP basically changed little. After 2016, GDP increased to a certain extent, reaching US $1.04 trillion in 2018. Carbon emissions showed a fluctuating upward trend, increasing from 394 million tons in 2009 to 583 million tons in 2018. Carbon emissions per unit of GDP showed a fluctuating slight decline, from 0.206 kg of GDP per purchasing power parity US dollar in 2009 to 0.187 kg of GDP per purchasing power parity US dollar in 2018. Indonesia is an emerging and rapidly growing automobile market. In 2019, it is the 11th largest automobile market in the world and the largest automobile market in ASEAN. However, the country's automobile industry has high carbon emissions and the average fuel efficiency is lower than that of most large markets, including China, Japan, Europe and India. The car ownership and the number of cars per thousand people in Indonesia has increased rapidly in recent years, but there is still a certain gap compared with the world average level. It is expected that there will be great development potential in the future. With the increase of automobile ownership per thousand people in the future, Indonesia's automobile industry will contribute more carbon emissions to the domestic transportation industry and promote the increase of carbon emissions in the transportation industry.

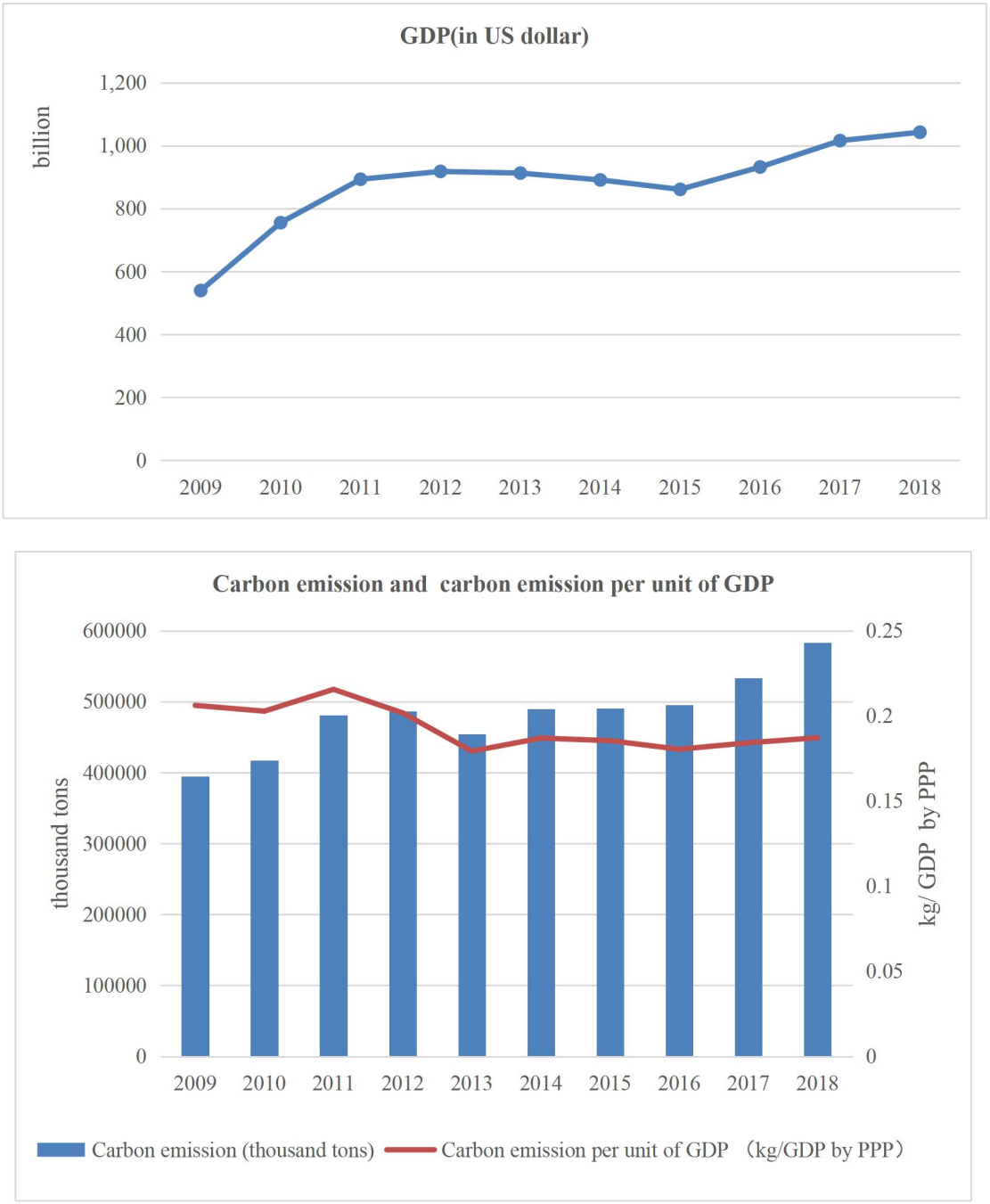


Fig 13. Carbon emission, GDP and carbon emission per unit of GDP in Indonesia

3.2.2 Carbon emission standard

Indonesia regards the automobile industry as the driving force of its industrial development, especially electric vehicles. The national energy plan (RUEN) released in 2017 sets the goal of achieving a fleet of 2200 electric vehicles and 2.1 million two-wheeled electric vehicles by 2025 [14]. Meanwhile, presidential Regulation No. 55/2019 has opened a new chapter in the development of pure electric vehicles in Indonesia. The regulation provides clear guidance for the development of pure electric vehicles in the automobile industry and sets four objectives: (i) determine the ministries/agencies responsible for and leading the implementation, (ii) formulate the definition and technical specifications of pure electric vehicles, (iii) improve the manufacturing capacity of pure electric vehicles,

and (iv) promote the market transformation from traditional fuel vehicles to pure electric vehicles [15]. The Indonesian government said that it was ready to produce lithium batteries and that it had the lithium, nickel and cobalt needed to produce lithium batteries. In addition, two battery manufacturers that can produce second-generation lithium batteries (with the higher output power density and improved safety) are being established.

However, compared with other markets, Indonesia currently lags behind in vehicle electrification. The Indonesian Automobile Industry Association reported that only 20 Plug-in hybrid electric vehicles (PHEV) were sold in 2019, and there were no purely electric vehicles. Although the situation improved in 2020, a total of 250 pure electric vehicles were sold from January to October 2020, but the category or brand was not specified in detail. The sales volume of electric vehicles in Indonesia is very low, far behind other markets. For example, the sales of electric vehicles in the main markets in 2019 are: China (1.1 million), the United States (330000), Europe (590000) and Japan (40000).

Indonesia has not yet introduced a strong policy directly aimed at vehicle fuel efficiency. Although improving automobile fuel economy has been incorporated into the ASEAN Regional Plan and consolidated through the ASEAN Fuel Economy Roadmap 2018-2025. The Indian government has no specific action plan in this regard, and the goal of setting fuel economy standards for vehicles in 2017-2019 set in the National Energy Plan released in 2017 has not been achieved. However, policies related to vehicle fuel efficiency have been introduced, including vehicle identification programs and low-cost green vehicle programs.

Vehicle labelling plan

The vehicle labelling plan was proposed in 2003 through MoEF Regulation No.141/2003. Based on the Euro II emission standard, manufacturers are required to publish the emission information of CO, HC, NOx, HC, NOx and particulate matter through public display, including vehicle labels. However, it does not require manufacturers to provide specific information on fuel economy or carbon dioxide emissions [15]. Its subsequent MoEF Regulation No.20/MENLHK/ SETJEN/KUM(1/3/2017)[16] laid the foundation for the emission standard equivalent to EU IV, and it is required to disclose the emission level[17], as shown in Figure 14. Only a few manufacturers voluntarily display information on fuel consumption or CO2 emissions.

Fig 14. Example of vehicle emission labels

Low-cost green vehicle plan

In 2013, through government regulation No. 41/2013, the Indonesian government launched the Low-Cost Green Cars (LCGC) to provide tax incentives for small vehicles that meet fuel efficiency requirements.

Luxury tax, value-added tax, annual turnover tax, transfer tax and other taxes shall be paid for cars sales in Indonesia. The luxury tax is set at between 10% and 125% of the value of the product. Under the LCGC plan, the luxury tax does not apply to small, fuel-efficient and low-cost vehicles. For example, the standard is not applicable to vehicles with less than 10 seats, engine capacity less than 1200cc (gasoline) or 1500cc (diesel) and fuel economy more than 20km/L specified in the New European Driving Cycle (NEDC). In addition, luxury goods tax will be exempted if the maximum selling price does not exceed idr95 million (about USD 6500 at the exchange rate in December 2020, excluding transfer tax, circulation tax and local tax). This plan has led to a significant increase in the demand for qualified vehicles for the LCGC project, as shown in Figure 15.

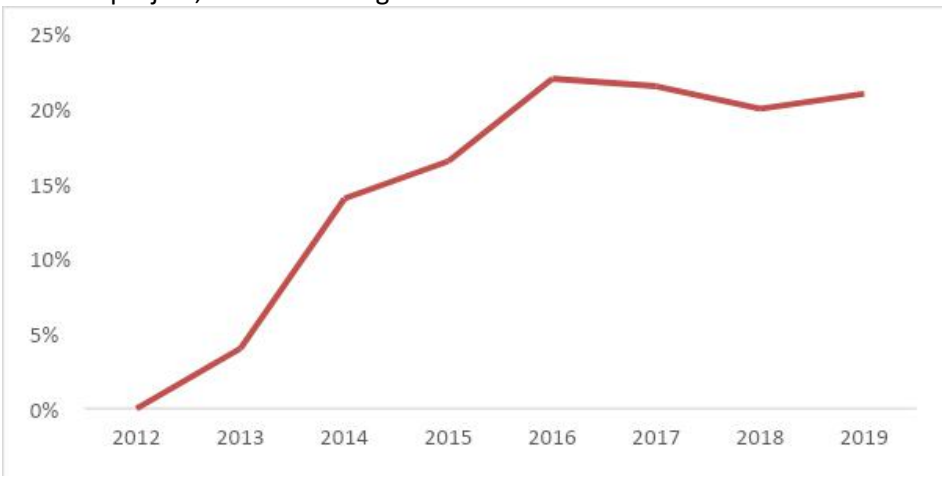


Fig 15. Market share oflow-cost green cars

LCGC plans to amend government regulation No. 73/2019, which will enter into force in October 2021 [18]. The most significant differences in the new regulations are: (a) luxury tax rates are no longer calculated only based on engine capacity, but consider engine efficiency and emissions; (b) The LCGC project was expanded into the Low Carbon Emission Vehicle (LCEV) project.

Under the new regulations, LCEV project includes not only LCGC, but also hybrid vehicles, flexible engine [14] vehicles and electric vehicles. The new regulations set a carbon emission limit of 120g/km for passenger cars with engine capacity not exceeding 1200cc (gasoline) and 1500cc (diesel). The fuel economy limit for gasoline vehicles is still 20km/L (gasoline), while the fuel economy limit for diesel vehicles is 21.8km/l (diesel). The luxury tax rate for low-cost green vehicles meeting LCEV standards is 3%. For domestically produced vehicles, the tax rate is zero for PHEVs, BEVS and FCEVs with fuel consumption higher than 28km/L or CO2 emission not higher than 100g/km. If fully imported, the luxury tax rate for PHEV, Bev and FCEV is 15%. The revised luxury tax system is an improvement because it includes CO2 emissions and fuel efficiency as criteria for determining tax rates. However, the range of CO2 used to determine the tax rate is too wide to provide continuous incentives to improve the efficiency of passenger cars. As a best practice, the use of continuous tax rates is more effective than the use of stepped schedules.

3.3 Poland

3.3.1 Status of carbon emission

The automobile sales in Poland first decreased significantly from 2011 to 2020, and then fluctuated from 600 thousand to 700 thousand from 2014 to 2019. In 2020, due to the influence of COVID-19, the output of automobiles decreased to 450 thousand. In 2011, there was a large gap between automobile sales in Poland and automobile production. The automobile sales in 2011 were only about 300000. After slow growth, automobile sales increased to about 550000 by 2019, and the gap with automobile production was further narrowed. In 2020, Poland's automobile production and sales are basically the same.

In terms of car ownership, it increased steadily from 14.8 million in 2005 to 24.2 million in 2015. The growth trend remained stable without major fluctuations. In terms of car ownership per thousand people, the growth trend keeps pace with car ownership. From 2008 to 2015, the growth rate is slightly faster than car ownership. By 2015, the car ownership per thousand people in Poland was 638 vehicles per thousand people.

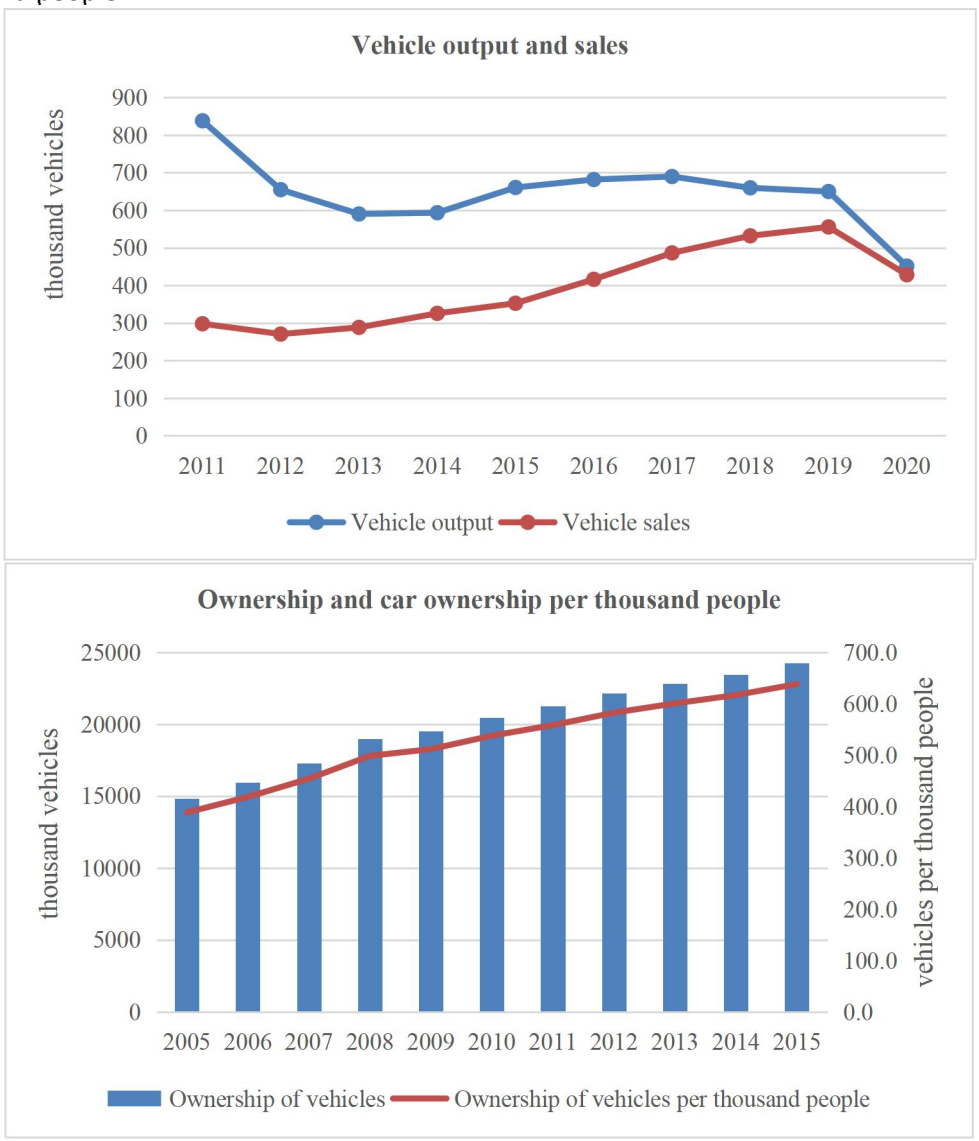


Fig 16. Vehicle production and sales, ownership, population and ownership per thousand people in Poland

In terms of Poland's national GDP, Poland's GDP increased from 440 billion US dollars in 2009 to 580 billion US dollars in 2018. The overall growth rate was small and decreased to a certain extent in 2011-2012 and 2014-2016. In terms of national carbon emissions, Poland's carbon emissions experienced a decline and growth after growth. 2009-2010 was the growth stage, 2010 was the highest point of carbon emissions, with an emission of 313 million tons of carbon dioxide. 2010-2014 was the decline stage, with a minimum of 286 million tons in 2014, and then gradually increased to 313 million tons in 2018. Carbon emissions per unit of GDP show a downward trend, from 0.40 kg of GDP per purchasing power parity US dollar in 2009 to 0.26 kg of GDP per purchasing power parity US dollar in 2018, limiting the effect of emission reduction.

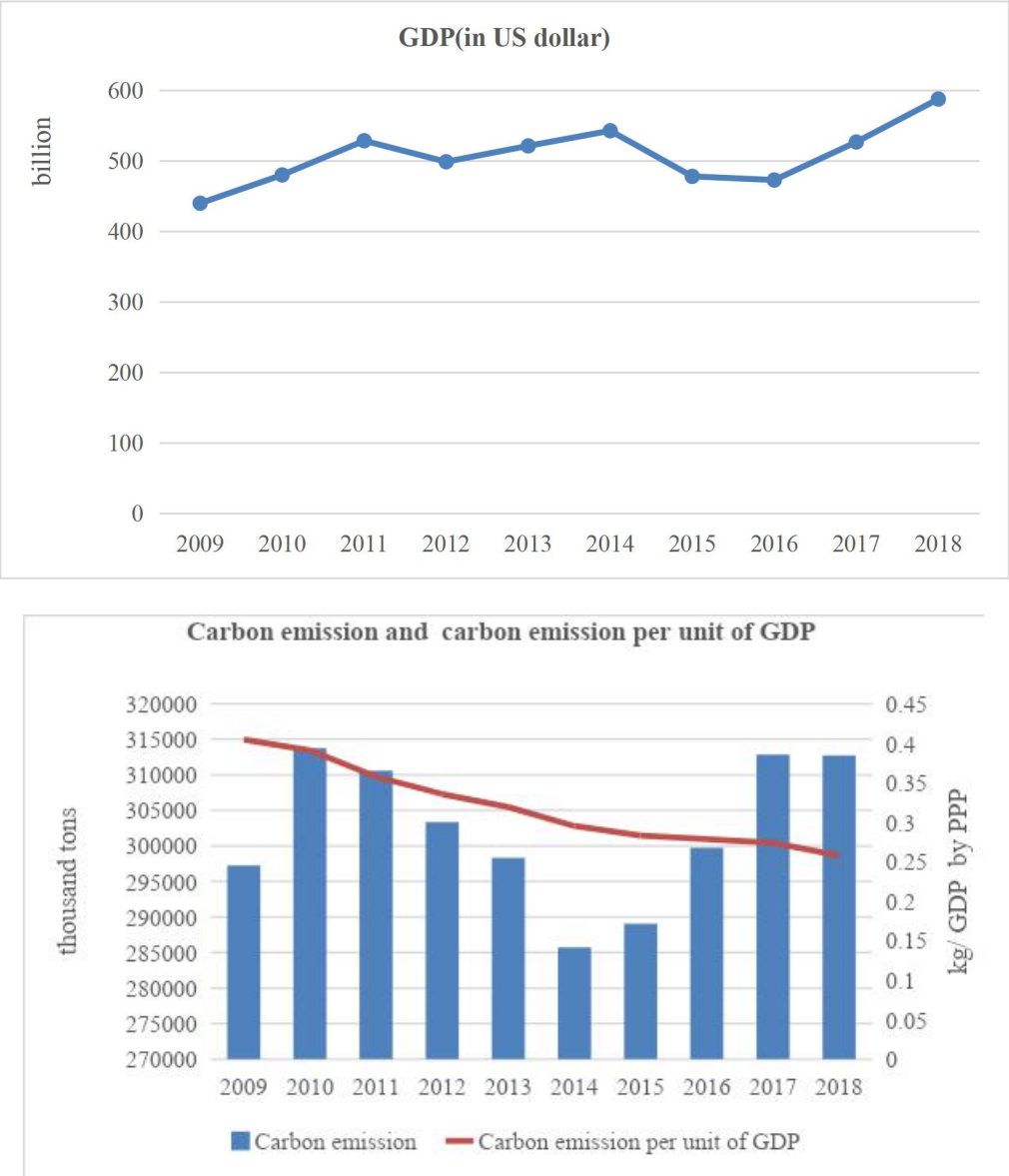


Fig 17. Carbon emission, GDP, carbon emission per unit of GDP

For the transport industry, the carbon emission in Poland showed a relatively stable and slight decline from 2009 to 2013. 2013 witnessed the lowest carbon emission, with a total emission of 43 megatons of carbon dioxide. It showed a gradual growth trend from 2013 to 63 megatons of carbon dioxide in 2018. In 2015, the number of cars per thousand people in Poland reached nearly 700, far higher than the world average. It is expected that there will be no significant increase in the future. Accordingly, the

carbon emission of the automobile industry will remain relatively stable and even decline under the condition of mandatory measures.

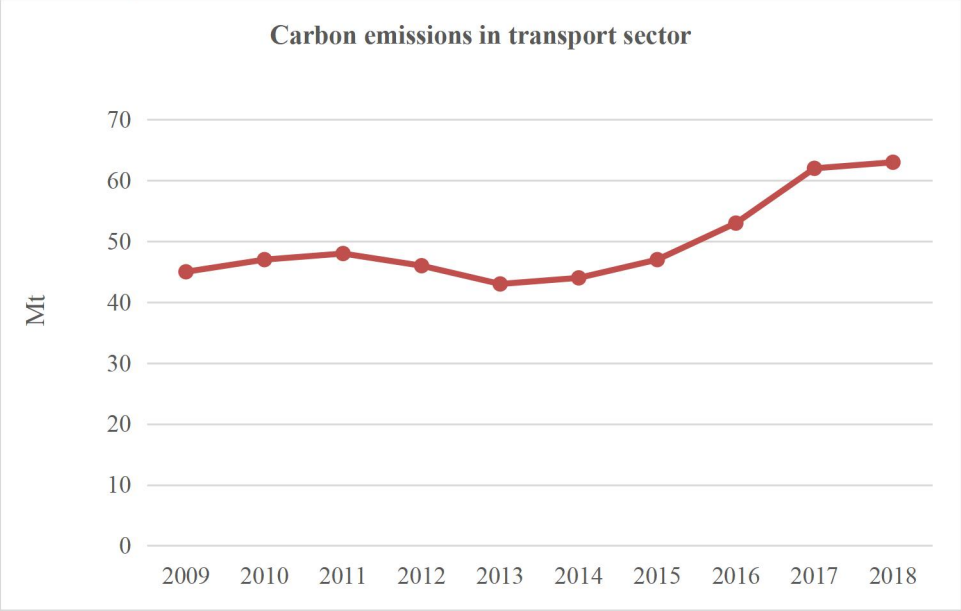


Fig 18. Carbon emission of the transport sector in Poland

Poland is one of the member states of the European Union. The carbon emission policies of the automobile industry are consistent with those of the European Union, with a perfect carbon emission standard system.

3.4 South Africa

3.4.1 Status of carbon emission

South Africa's automobile production and sales volume fluctuated mainly from 500 thousand to 600 thousand from 2011 to 2019, showing a trend of growth in the early stage. After 2015, it gradually stabilized. In 2020, due to the influence of COVID-19, the output and sales volume of automobiles decreased to a certain extent.

In terms of car ownership and one thousand people ownership, the car ownership in South Africa increased from 6.8 million in 2005 to 9.6 million in 2015. The overall growth trend was obvious and only decreased in 2010. The number of cars per thousand people increased from 143 in 2005 to 173 in 2015. The overall trend is consistent with the trend of car ownership.

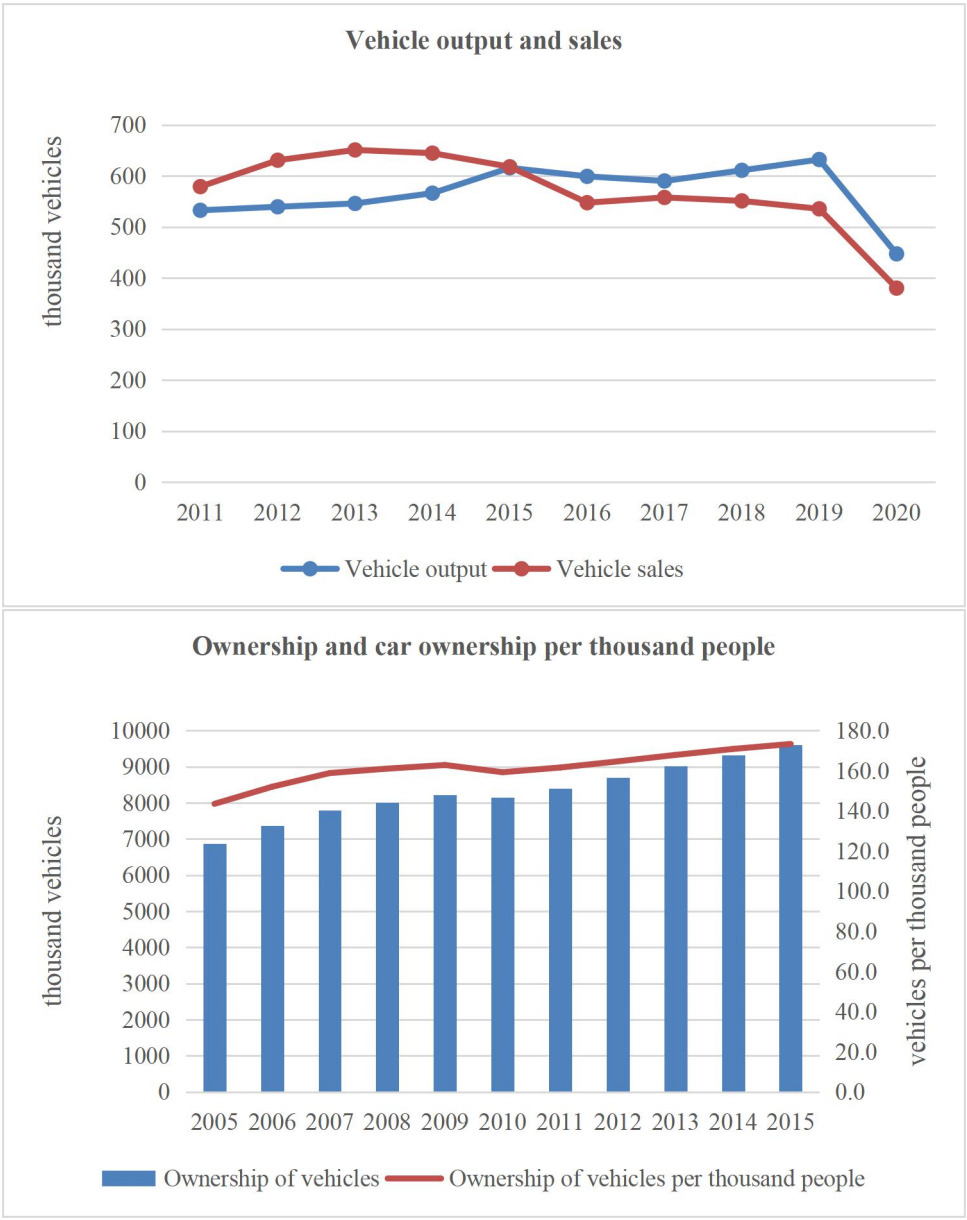


Fig 19. Vehicle production and sales, ownership, population and one thousand people ownership

In terms of national GDP development, South Africa's GDP increased from nearly 300 billion US dollars in 2009 to about 360 billion US dollars in 2018, with a small range of growth. GDP grew rapidly from 2009 to 2011, and increased to about 400 billion US dollars at the current price in 2011, showing a downward trend from 2011 to 2016, and then gradually increased after 2016.

In terms of national carbon emissions, from 2009 to 2018, the national carbon emissions fluctuated between 400 million tons and 450 million tons. In 2014, the national carbon emissions reached the extreme value and showed an increasing trend after falling in 2015. Carbon emissions per unit of GDP decreased from 0.7 kg of GDP per purchasing power parity dollar in 2009 to 0.58 kg of GDP per purchasing power parity dollar in 2018. The overall decline was small. There was a certain degree of stability and rebound in the middle process. After 2014, carbon emissions per unit of GDP had a significant decline process.

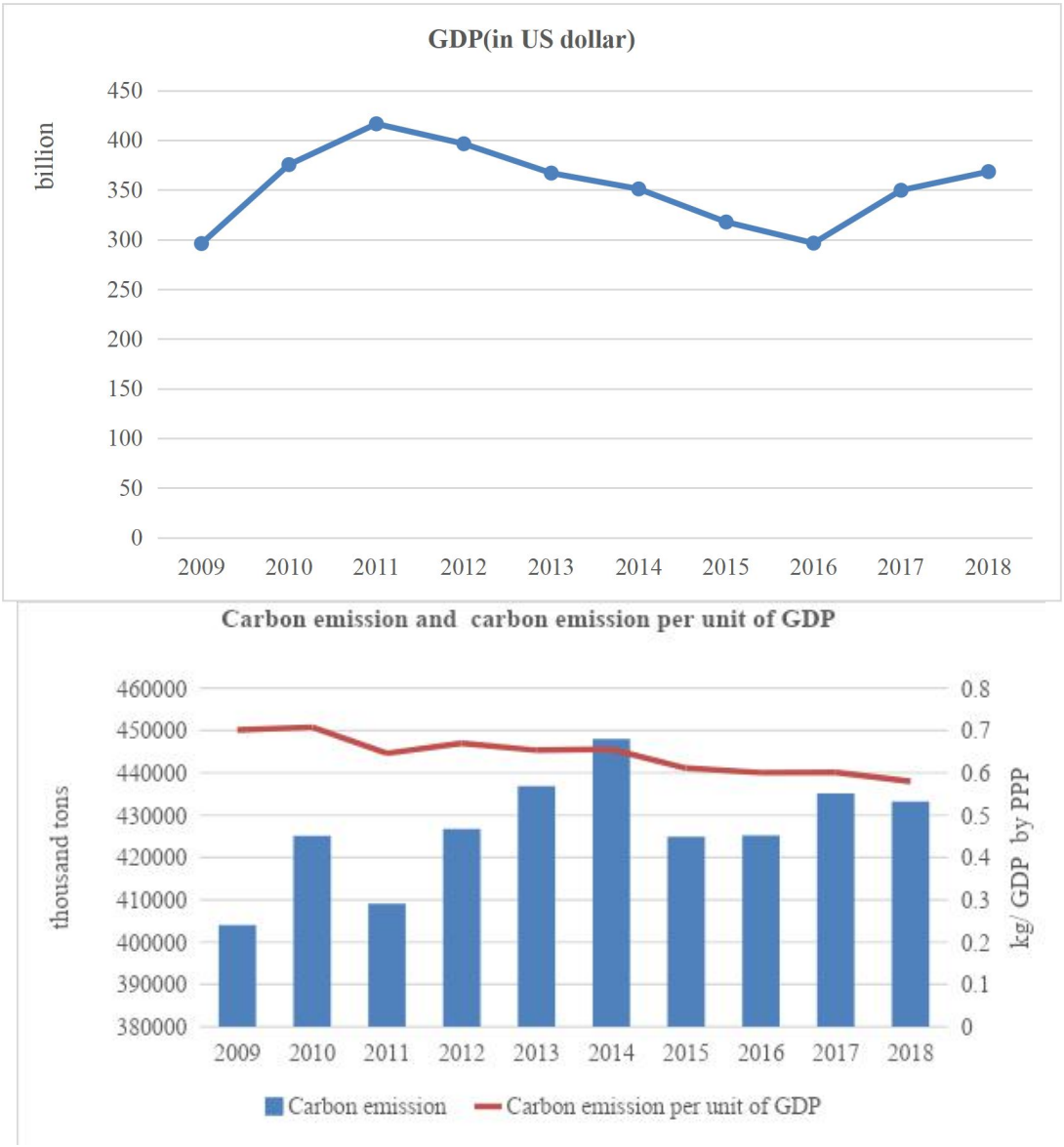


Fig 20. Carbon emission, GDP, carbon emission per unit of GDP

The carbon emission of South Africa's transport industry increased from 45 megatons of carbon dioxide in 2009 to 57 megatons of carbon dioxide in 2018. The overall growth is relatively slow, and the growth will stagnate in some years. As far as automobiles are concerned, South Africa not only leads the automobile industry on the African continent in terms of car ownership and new car sales, but also is the main automobile manufacturing center in the region and one of the largest automobile manufacturing centers in the world. According to the data of OICA, the number of passenger cars in South Africa in 2015 was 6.4 million. This is by far the largest fleet in Africa, accounting for 22.6% of African vehicles. In 2015, the sales volume of new passenger cars exceeded 412000, accounting for about 37% of the African market, 60% higher than Egypt, the second-largest new car market in Africa. The transport sector is the second largest contributor to greenhouse gas emissions in the country, second only to the energy production sector, mainly due to South Africa's heavy dependence on fossil fuels. Given South Africa's relatively young population and the country's sustained GDP growth, carbon emissions from the transport sector are expected to expand unless such growth is limited by relevant management tools.

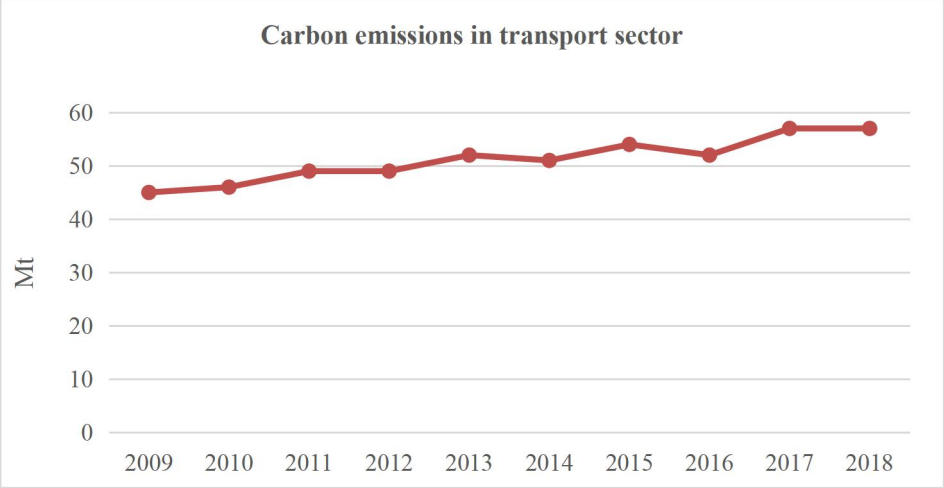


Fig 21. Carbon emission of transport/automobile industry in South Africa

3.4.2 Carbon emission standards

In 2018, South Africa issued the South Africa Green Transport Strategy (2018-2050), which proposes to strive to provide a world-class transportation system to reduce transportation costs and the amount of greenhouse gases and other pollutants emitted by the industry. The transport sector accounts for 10.8 per cent of the country's total greenhouse gas emissions. In addition to the direct emissions from the combustion of these fuels, there are also indirect emissions from fuel production, refining and transportation. South Africa issued the regulations on fuel economy and carbon dioxide labelling in 2016, which stipulates the mandatory labels for new passenger cars, indicating the fuel economy (1/100km) and carbon dioxide emission (g/km) of the model according to a certain predetermined format. Meanwhile, the government also issued the biofuel regulatory framework and the government electric vehicle procurement policy in 2016 to promote the development and sales of biofuels and electric vehicles in China.

The South African government imposes fuel tax and carbon tax on the transportation industry. The carbon tax aims to balance the competitive environment between carbon-intensive (fossil fuel-based companies) and low-carbon emission sectors (renewable energy and energy-saving technologies). It also encourages consumers and businesses to adjust their behavior to reduce emissions. At the same time, the carbon tax aims to promote the meaningful and permanent reduction of greenhouse gas emissions and minimize any potential adverse impact on the competitiveness of low-income families and industries.

In order to promote the sales of electric vehicles in South Africa and make contributions to the achievement of greenhouse gas emission reduction targets, the South African government has formulated relevant policies, including providing incentives for electric vehicle manufacturers to produce and sell electric vehicles at reasonable prices for local and export markets in South Africa; cooperate with local research institutions to study electric vehicle batteries; converting old technology vehicles with high emission factors into electric vehicle technology; assist in the establishment and development of Local Electric Vehicle OEMs.

3.5 Pakistan

3.5.1 Status of carbon emission

Pakistan's car ownership increased from 1.76 million in 2005 to 3.22 million in 2015, showing a steady growth trend, including a rapid growth from 2010 to 2013. Pakistan's car ownership per thousand people is small, but it has a growing trend. It increased rapidly from 2005 to 2011 and slowed down after 2011, which may be mainly due to the rapid growth of the population.

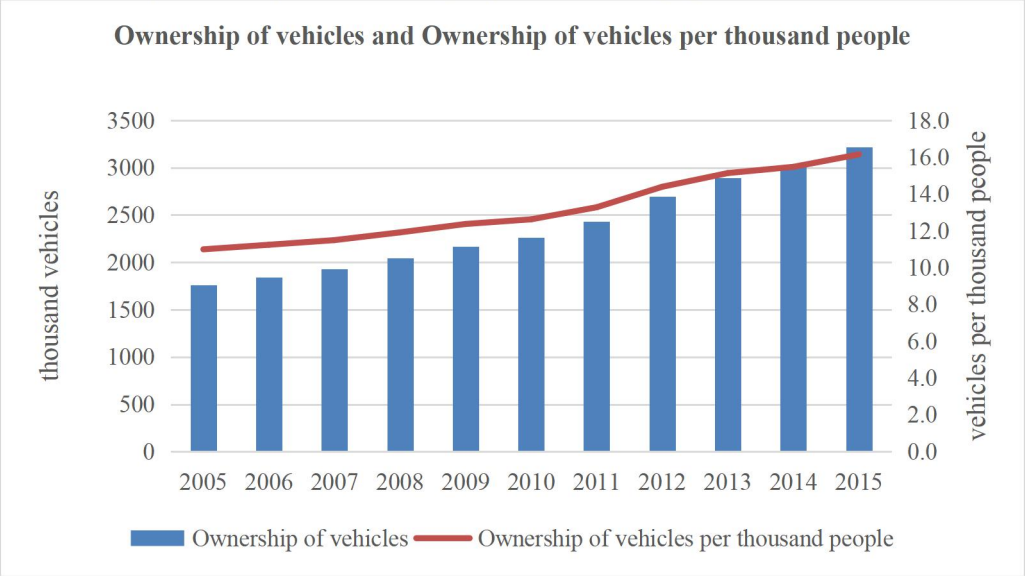


Fig 22. Vehicle production and sales, ownership, population and ownership per thousand people in Pakistan

Pakistan's national GDP increased from US $168.1 billion in 2009 to US $314.6 billion in 2018, showing an upward trend as a whole. However, the growth was slow in some years, relatively slow from 2011 to 2014, and achieved relatively rapid growth in 2010 and 2016.

Pakistan's total national carbon emissions remained basically unchanged from 2009 to 2013, showing a gradual growth trend from 2014 to 2018, from 154 million tons in 2014 to 208 million tons in 2018. From 2009 to 2018, carbon emissions per unit of GDP experienced a trend of first decline and then rise, and began to show a downward trend in 2018. The highest point of carbon emission per unit of GDP appeared in 2009, which was 0.214 kg GDP per purchasing power parity dollar. After declining year by year, it reached the lowest point of 0.185 kg GDP per purchasing power parity dollar in 2013 and then began to grow gradually. By 2017, it reached the stage high point of 0.208 kg GDP per purchasing power parity dollar.

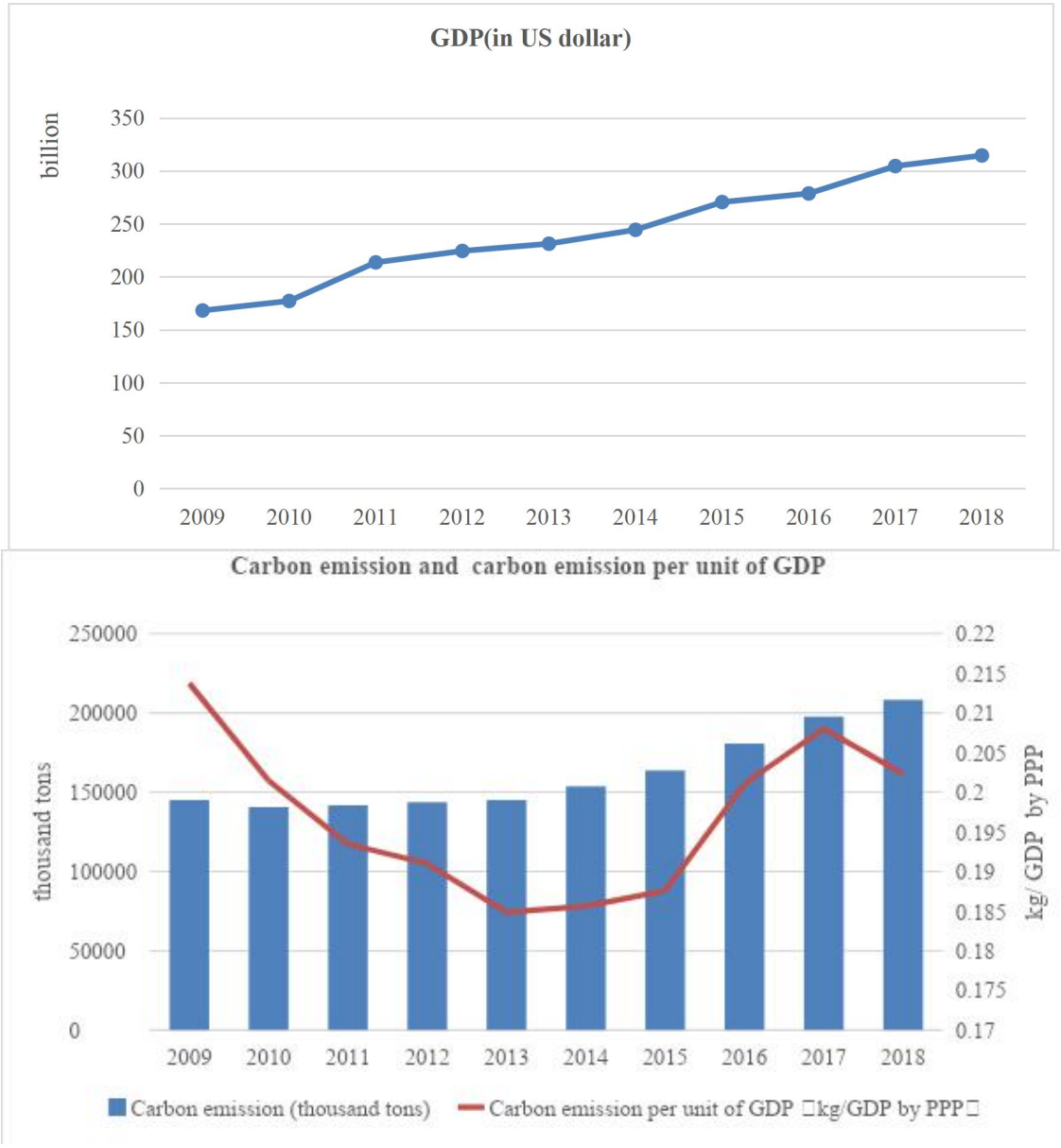


Fig 23. Carbon emission, GDP and carbon emission per unit of GDP

From 2009 to 2018, the carbon emission of the transport industry in Pakistan showed a trend of first stable and then slow growth, from 33 megatons of carbon dioxide emission in 2009 to 57 megatons of carbon dioxide emission in 2018, and increased rapidly from 2014 to 2018. The vehicle ownership per thousand people in Pakistan is far lower than the world average level and other BRI countries, while its GDP will grow steadily. It is expected the car ownership per thousand people will greatly increase and so will the total number of vehicles. At that time, the automobile industry will contribute more carbon emissions to the transport industry and exert greater pressure on carbon emission reduction.

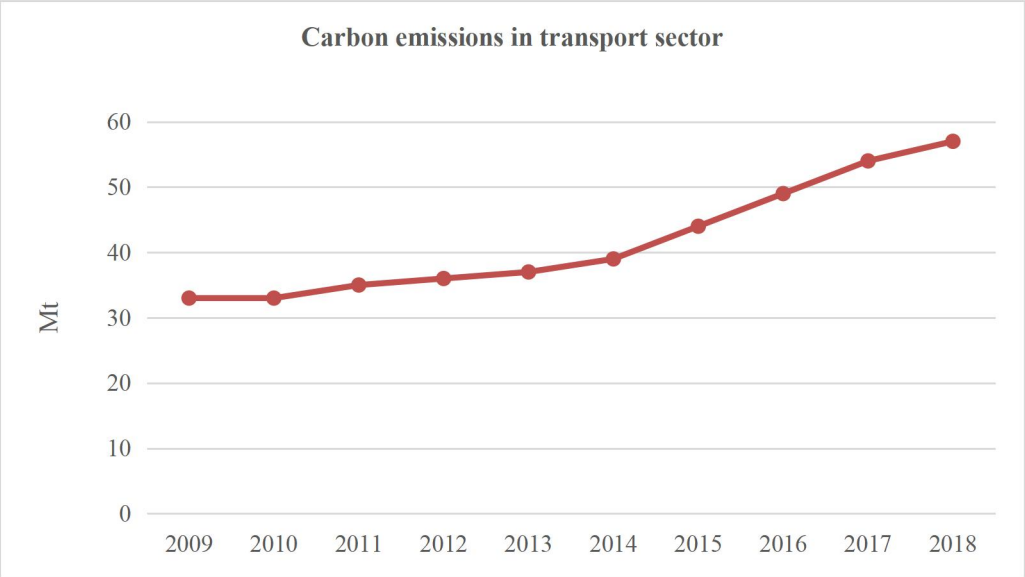


Fig 24. Carbon emission of transport/automobile industry in Pakistan

3.5.2 Carbon emission standards

The climate change department of the Pakistani government is responsible for managing greenhouse gas emissions. Pakistan has now signed various multilateral environmental agreements / Conventions/protocols commonly used in the world.

In terms of Pakistan's own domestic legislation, the environmental protection law of Pakistan was promulgated in 1997, and based on this, the national environmental quality standards were promulgated and relevant requirements were made on environmental testing, hazardous substance management, medical waste management, industrial wastewater management, sustainable development fund, motor vehicle exhaust and noise, drinking water quality and ambient air quality.

Pakistan issued the national environmental policy in 2005, which provides an overall framework for solving the environmental problems faced by Pakistan, mainly to solve the problems of freshwater and coastal water pollution, air pollution, and lack of appropriate waste management, forest deforestation, biodiversity loss, desertification, natural disasters and climate change. In terms of energy efficiency and renewable energy policy of policy, Pakistan proposes to promote energy efficiency and renewable energy to achieve self-sufficiency and sustainable development of energy supply. To this end, the government will give preferential status and tax preference to domestic energy-saving products and imported products, and formulate and implement a plan to convert public transport fueled by compressed natural gas.

In 2010, Pakistan suffered a climate change disaster, and the catastrophic floods displaced 20 million people. In 2012, the Pakistani government approved and issued the national climate change policy and established the national climate change ministry. In the national climate change policy, Pakistan proposed to properly address the challenges of climate change and pursue sustained economic growth. In the field of road transportation, Pakistan proposed to formulate and strictly implement motor vehicle emission standards, inspect and promote the use of biofuels in local transportation, promote the transportation sector to use more compressed natural gas in line with the compressed natural gas supply on the market, and plan and develop the public transportation system of metropolis.

4. Comparative analysis of carbon emission standards and problem identification in the automobile industry

4.1 Comparative analysis of carbon emission standards in the automobile industry

From the perspective of the management category, the European Union and the United States focused on managing vehicle fuel consumption in the early stage. With the gradual increase of carbon emissions in the automobile industry, the EU and the United States gradually realized the importance of carbon emission management and began to strengthen the control of carbon emissions in the automobile industry. At present, the EU automobile industry takes carbon emission as the control object and continues to improve carbon emission standards. U.S. fuel economy and carbon emission standards are in parallel, and different institutions are responsible for setting different energy conservation and emission reduction targets. At this stage, China mainly carries out quota management for automobile fuel consumption and has not formally implemented carbon emission standards, but the corresponding technical specifications for passenger vehicle life cycle carbon emission accounting and passenger vehicle life cycle carbon emission quota standards are being formulated to strengthen the carbon emission management of the automobile industry. Among BRI countries, Singapore has launched a long history of carbon emission management. Currently, carbon emissions and other pollutants are integrated into vehicle emission plans. The worst performance indicators determine vehicle grades and apply to different reward and punishment mechanisms. Other BRI countries in this study not only failed to implement carbon emission standards, nor set up fuel economy standards.

From the perspective of target value or limit value requirements, the EU and the United States have set clear target values and continuously tightened them. At present, China is also formulating limit requirements, which are related to vehicle quality of equipment. Vehicles with different quality of equipment are applicable to different limit values. Among BRI countries, Singapore divided vehicles into five grades according to vehicle emissions and pollutants. Vehicles that do not meet the requirements of the index will be punished. Other BRI countries in this study have not yet issued clear quota requirements. Carbon emission targets are proposed in the low-cost green vehicle plan implemented in Indonesia, and vehicles meeting the target requirements will enjoy tax-free preferential policies.

In terms of whether it is mandatory, the carbon emission standards in Europe and the United States are mandatory standards. If the European Union exceeds 1g, it will be fined 95 euros. The United States requires that unqualified products will be fined. At present, China is working on the Life Cycle Carbon Emission Limit for Passenger Vehicles, which sets carbon emission limits for different models according to the quality of equipment. Among BRI countries, Singapore and Poland, which already have carbon emission standards, are also mandatory standards. Singapore will include CO2, HC, Co, NOx and PM into the vehicle emission plan at the same time. The vehicle grade will be determined according to the indicators with the worst performance, and the vehicles with the worst performance will be punished. Other BRI countries in this study have not yet implemented mandatory carbon emission requirements. Indonesia has encouraged consumers to purchase green low-carbon vehicles through vehicle labelling schemes and low-cost green vehicle schemes, which is not mandatory.

In terms of the management stage, Europe and the United States mainly focus on carbon emission in the road driving stage. In the future, the EU has plans to shift to full life cycle carbon emission management. In the 2019/631 CO2 emission standard for passenger cars and light commercial vehicles, it is proposed that it is necessary to evaluate the full life cycle carbon emission of passenger cars and light commercial vehicles at the EU level, assess and establish a common LCA methodology no later than 2023, and take follow-up measures to put forward legislative suggestions as to appropriate.

China's carbon emission control of the automobile industry based on the whole life cycle not only considers the carbon emission in the road driving stage but also includes the carbon emission in the upstream raw material acquisition stage, vehicle production stage and fuel production stage. With the popularity of electric vehicles and fuel cell vehicles, carbon emissions will gradually shift from the road driving stage to the whole industry chain. The whole life cycle carbon emission management will play an important role in decarbonizing the whole industry of automobile industry. Singapore is one of the BRI countries to consider the incorporation of electric power production into carbon management. Although other BRI countries have not published specific carbon emission standards, but the relevant policies showed they are focused on the management of carbon emissions during the road driving period.

From the perspective of management policies and measures, the smooth promotion of European and American standards has reduced the difficulty of enterprise performance, and implemented many measures, such as publicity system, low-carbon logo, flexible performance mechanism, etc. At present, based on the technical specifications for carbon emission accounting of passenger cars, China is also working out measures such as low-carbon technology catalogue, low-carbon labelling, carbon tax and quota management. At present, Singapore mainly focuses on reward and punishment mechanisms. Other BRI countries are also formulating relevant policy objectives, such as fuel economy and carbon dioxide labelling, government electric vehicle procurement policy, electric vehicle incentive mechanism, battery research and development, etc. However, because there are no mandatory emission reduction targets in the automobile industry, the implementation effect of the existing policies needs to be further evaluated.

Tab 7. Comparison of carbon emission standards of different countries

Country	Standard types	Standard name	Model range	Target value or value limit	Boundaries	Mandatory or not	Relevant policies
China	Carbon emission	Technical specification for life cycle carbon emission accounting of passenger vehicles, Life cycle carbon emission allowances for passenger vehicles	Passenger vehicles	Based on the quality of the equipment	Life cycle	TBC	TBC
	Fuel economy	Fuel consumption limits for passenger vehicles, GB 20997 Fuel consumption limits for light commercial vehicles	Passenger vehicles and light commercial vehicles	Based on the quality of the equipment	Road driving period	Yes	Disclosure system, renewable car subsidy and double credits
US	Carbon emission	The Safer Affordable Fuel Efficient (SAFE) Vehicles Rule	Passenger vehicles and light trucks	114g/km in 2021	Road driving period	Yes	Disclosure system and fuel labelling
	Fuel economy	The Safer Affordable Fuel Efficient (SAFE) Vehicles Rule	Passenger vehicles and light trucks	44.2mpg in 2021	Road driving period	Yes	Credits transaction and transfer, flexible implementation mechanism
EU	Carbon emission	EU 2019/631 CO_2 emission Standards for passenger vehicles and Light Commercial Vehicles	Passenger vehicles and light commercial vehicles	Passenger vehicles: 95gCO_2/km; light commercial vehicles: 147gCO_2/km	Road driving period	Yes	More than 1 g will be fined 95 euros; Flexible implementation mechanisms and preferential policies for the purchase of low-carbon vehicles
Singapore	Carbon	VES	cars and taxis	CO_2 indicators:	Power generation	Yes	Discounts and

	emission			Single vehicle CO_2 emission limit: subsidy <125gCO_2/km; fine>160gCO_2/km	and road driving period		surcharge
Indonesia	None	None	None	None	-	-	Set electric vehicle targets, vehicle identification schemes, low carbon emission vehicle schemes
Poland	Carbon emission	EU 2019/631 CO_2 emission standards for passenger vehicles and light commercial vehicles	Passenger vehicles and light commercial vehicles	Passenger vehicles: 95 gCO_2/km; Light commercial vehicles: 147gCO_2/km	Road driving period	Yes	More than 1 g will be fined 95 euros; Flexible implementation mechanisms and preferential policies for the purchase of low-carbon vehicles
South Africa	Carbon emission and fuel economy	None	None	None	-	-	Fuel economy and CARBON dioxide labelling, government EV procurement policies, EV incentives
Pakistan	Fuel economy	None	None	None	-	-	Tax preference for energy saving products

4.2 Problem identification of carbon emission standards for the automobile industry

4.2.1 Lack of low-carbon technology in the automobile industry

At present, the economic development of the BRI country relies mainly on energy resources and energy efficiency. In most countries, low-carbon technology innovation in the automobile industry is insufficient, and energy-saving and low carbon haven't received enough attention in work and life, and the carbon emission policy is still lacking. If we do not accelerate the research and development of low-carbon technologies and formulate carbon emission management policies, under the background of carbon neutralization, the export market of the automobile industry may be impacted by the non-compliance of carbon emissions.

4.2.2 Unestablished technical standard system of carbon emission

At present, most BRI countries have insufficient capacity to calculate carbon emissions. The basic carbon emission technical standard system, including detection methods, evaluation methods and indicators, terms and definitions is lacking, lagging behind the developed countries or regions such as Europe and America in terms of carbon emission management. Therefore, BRI countries need to establish their own technical standards, which provide a basis for quantifying carbon emissions and carbon emission management by government, industry organizations and enterprises.

4.2.3 Undetermined clear standard system of carbon emissions

The BRI countries in this study, except for the fact that Singapore has a clear carbon emission standard, the rest of the countries have not issued relevant regulations. Indonesia once proposed to introduce fuel economy standards during 2017-2019 in the national energy technology, but it ended nowhere. On the basis of improving the carbon emission management capacity of the industry, gradually formulating carbon emission targets suitable for the current stage of the country is of great significance to promote automobile enterprises to improve the quality of vehicle models, reduce carbon emissions through low-carbon technology research and development, recycled material use and other low-carbon measures, and meet the requirements of foreign laws and regulations.

4.2.4 Lacking of targeted carbon reduction policy framework

At present, the BRI country's policies on emission reduction in the automobile industry are mostly distributed in the national strategic document or guidance document, industrial strategy document and energy industry strategy document. There is no comprehensive and specific management for the automobile industry. Therefore, it is necessary to formulate operational carbon emission reduction targets and policy frameworks to promote the decarbonization of the automobile industry.

5. Conclusions and Suggestions

In the context of carbon neutrality, low carbon has become the main theme of global development. As one of the industries with the fastest growth rate of carbon emission, the automobile industry has become the key control object of carbon emission management. Developed countries or regions such as the European Union continue to improve their carbon emission management policies for the automobile industry and tighten management objectives. At present, the BRI countries are lagging behind in developing carbon emission standards and the basic technical standards and policy management systems are missing. Therefore, the BRI countries should learn from advanced experience and formulate policies on carbon emission management in the automobile industry, which is of great significance for dealing with foreign regulatory requirements, enhancing product competitiveness and promoting the development of low-carbon and high-quality automobile industry.

In summary, this report proposes recommendations for carbon emission standards development for BRI countries from national, industrial and enterprise level.

5.1 National Level

To deepen international cooperation in the BRI countries. At present, China has accumulated some experience in low-carbon technology research and development, carbon emission accounting methods, accounting capacity-building and other related carbon emission management of the automobile industry on the basis of drawing lessons from carbon emission standards in foreign developed countries. China should actively share its successful experiences with BRI countries, promote the R&D of low carbon technologies, improve carbon emission management capacity, to join hands with BRI countries to move toward low carbon and high-quality development for the automobile industry. Besides, we should promote mutual understanding and recognition of carbon emission related standards, promote international cooperation and facilitation of economic and trade exchanges, and promote the import and export of automobile products.

To develop the standard policy system of the auto industry. On the premise of improving the carbon emission accounting capacity, comprehensively evaluate the domestic economic development and emission reduction cost, put forward a scientific and reasonable automobile industry-standard system, set specific and feasible carbon emission reduction indicators for the automobile industry, and establish a supporting policy system to promote the smooth implementation of emission reduction indicators. At present, China is formulating the life cycle carbon emission limit for passenger cars and simultaneously studying and formulating flexible policies and measures such as publicity system, low-carbon logo, low-carbon technology catalogue, carbon tax and so on. China can work together with BRI countries to jointly carry out the research on standard policy systems, share China's successful experiences in the formulation of a carbon emission standard policy system, and pool strength of all countries to jointly promote the smooth development of the automobile standard policy systems.

To support the development of the new energy automobile industry. As a strategic emerging field, new energy vehicles will play a major role in automobile carbon neutralization and are becoming the focus of competition in the automobile industry of various countries. Therefore, the BRI countries should build new energy automobile industry according to the new development requirements under the low-carbon era, formulate new energy vehicle industry development plan, and improve the development mechanism of new energy vehicles, so as to overcome the existing obstacles of new energy vehicles and create a favourable policy environment for the development of new energy vehicles, so as to seize the opportunities to accelerate the development of their automobile industry.

5.2 Industrial Level

To improve the construction of the basic method system of the automobile industry. The low-carbon quantification method system is the basis for the implementation of automobile carbon emission management. It is suggested to establish a low-carbon quantification method system with automobile carbon emission accounting method as the core and covering carbon emission detection methods, evaluation methods and indicators on the basis of fully learning from the method systems of China and developed countries and in combination with the actual situation of our country. It not only provides methodological support for the national implementation of carbon emission management policies but also provides a basis for automobile enterprises to strengthen the capacity-building of carbon emission management.

To strengthen the construction of the personnel team of the automobile industry. Accelerate the construction of disciplines and talents related to carbon emission management in the automobile industry, establish a perfect talent reserve system for carbon emission standards, and invite industry authorities and enterprise representatives to participate in the formulation of standards.

To establish an effective feedback mechanism. At present, the BRI countries have a weak foundation for carbon emission management. In implementing the carbon emission management policy of the automobile industry, an effective feedback mechanism should be established in the automobile industry and the differences between theoretical level and actual level in the implementation of the policy will be collected and analyzed. It is suggested that policymakers should change relevant policies in time according to the actual situations, to maximize the effectiveness of policy implementation.

5.3 Enterprise Level

To strengthen the carbon emission capacity of automobile enterprises. Because the BRI countries have not yet had the relevant policies of carbon emission management, and the experience of automobile enterprises in carbon emission management is insufficient, and the carbon emission management capability and foundation are relatively weak. Therefore, under the guidance of the standard policy system and carbon emission accounting method system, enterprises should build enterprise standards including use stage accounting standards and waste recycling standards, establish enterprise internal data system, and develop corresponding accounting toolkit to strengthen their own carbon emission capacity-building.

To design an effective path for reducing emissions. After having the basic carbon emission capacity, find out the internal carbon emission of the enterprise, compare the differences with the national goals, allocate the target differences to each link by analyzing the carbon emission characteristics and emission reduction potential of each link, formulate effective emission reduction schemes for each link, and finally achieve energy conservation and carbon reduction, so as to realize the national goal, and improve the low-carbon competitiveness of the automobile industry.

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