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**CHINA AUTOMOBILE LOW CARBON ACTION PLAN**

中汽中心 | 数据

# CHINA AUTOMOBILE LOW CARBON ACTION PLAN (CALCP) RESEARCH REPORT 2021

- MARCHING TOWARDS NET ZERO OVER WHOLE LIFE CYCLE

# Cover Story

“Lucid waters and lush mountains are invaluable assets.” As the nexus between the human kind and nature, the automotive industry can contribute positively to the natural world.

The China Automobile Low Carbon Action Plan (CALCP) Research Report 2021 has its front cover themed on the whole life cycle of automobiles, along with clear waters, green mountains and the harmonious coexistence between the human kind and nature. It shows that vehicles can not only provide people with comfort, convenience and safety, but also contain green, low-carbon and clean properties.

For the low-carbon development, the connotation of vehicle has been indefinitely extended, impacting on each and every facet of human production and life and enabling the transformation towards carbon neutrality over the entire value chain of the automotive industry. The CALCP program will guide the industry through the growth towards net zero emission during the whole life cycle.

## Technical Support Organizations (in no particular order)

United Nations Environment Programme (UNEP); World Economic Forum (WEF); World Resource Institute (WRI); World Steel Association (worldsteel); Aramco Asia; University of Cambridge; University of Nottingham; University of California, Davis; University of Southern Denmark; National Center for Climate Change Strategy and International Cooperation (NCSC); Energy Research Institute of NDRC; National Technical Committee of Auto Standardization, CATARC; China Electricity Council; National Big Data Alliance of New Energy Vehicles; Public Data Acquisition and Monitoring Research Center for New Energy Vehicles, Shanghai Municipality; Tsinghua University; Institute of Energy, Peking University; Institute of Urban Environment, Chinese Academy of Sciences; China University of Petroleum; Beijing Institute of Technology; Beijing Normal University; and Beijing University of Technology

# Preface

Much scientific evidence shows that one of the major causes for today's climate change globally is the greenhouse gases (GHG) from human activities, especially the huge amount of them produced since the Industrial Revolution. To deal with the climate change, the Paris Agreement aims to limit global temperature increase to below 2 degrees Celsius above pre-industrial level, and ideally, to keep the increase within 1.5 degrees Celsius, by the end of this century. To reach the aim, the signatories should, on an equal basis, try to balance the man-made emissions and carbon sinks at the source of greenhouse gases, in order to achieve carbon neutrality during the latter half of this century. On September 22, 2020, President Xi Jinping solemnly announced that China aims to have $CO_2$ emissions peak by 2030 and achieve carbon neutrality by 2060.

As one of the economic pillars of China, the automotive industry has seen its overall GHG emissions increasing rapidly and remaining strong over the entire value chain and intensive on a single-vehicle basis. Also, there exist a number of issues, such as the lack of a policy on vehicular GHG emission standards, the ambiguity in carbon neutrality for an independent brand, and the weakness of Chinese companies in the low-carbon competition. The targets of the Chinese government to have its carbon peak by 2030 and the carbon neutrality by 2060 will act as a major opportunity for the automotive industry to transform and upgrade itself and realize green, low-carbon and high-quality growth, and for China to actively participate in the global climate governance and honor its commitment as a responsible power. When all the industries are marching towards net zero emission, the automotive industry should develop its leading and driving role sufficiently, by choosing the right path and pushing and pulling its upstream and downstream counterparts on the value chain in a decarbonization effort. Only in this way can the independent automotive brands grow stronger.

In 2018, Automotive Data of China Co., Ltd. (ADC) established the World Automotive Life Cycle Association (WALCA) and launched the China Automotive Low Carbon Program (CALCP). Now it has accounted for and published results on whole life cycle GHG emissions of vehicles for four years consecutively.

In 2021, ADC initiated the research for the CALCP Research Report 2021 ("Report") by working with 24 other organizations and institutions in China and other countries. First, the Report develops whole life cycle GHG emission calculations on the basis of single vehicles and fleets, to analyze the life cycle GHG emission levels per single vehicle and per fleet. It adopts the China Automotive Life Cycle Model (CALCM) to study the passenger vehicles sold in the territory of China in 2020. Second, it establishes three scenarios, i.e. the current policy scenario, the intermediate emission reduction scenario and the intensive emission reduction scenario, by choosing eight reduction paths, i.e. power grid cleaning, vehicle electrification, material efficiency, vehicle production energy efficiency, GHG emissions of power batteries, vehicle use energy efficiency, alternative fuels and consumption modes, and by conducting predictions and analyses over the life cycle GHG emissions on the basis of single vehicles and fleets by 2025, 2030, 2050 and 2060 in these three scenarios. Last but not least, it offers recommendations for achievement of carbon neutrality of the automotive industry in each phase. Hopefully it will become a useful reference for government agencies, industrial organizations, vehicle manufacturers and individuals in their carbon neutrality-related activities.

# Editorial Committee

**Chief Editor** Yi Feng

**Associate Editors in Chief** Yijing Hui; Peng Zhang;
Dongchang Zhao; Shujie Xu

**Main Authors** Xin Sun; Mingnan Zhao; Jianxin Li;
JiaangLi; Hongjie Zhang; Tongzhu Zhang;
Zhipeng Sun; Bing Qian; Huanran Liu
Xingyu Xue; Chunhui Liu;Yang Li;
Yifei Kang;Yan Zhang; Ting Zhang
(in no particular order)

# EXPERT TEAM INTRODUCTION

| Name | Organization |
|---|---|
| Amir F. N. Abdul-Manan | Aramco Asia |
| Aimin Ma | National Center for Climate Change Strategy and International Cooperation (NCSC) |
| Can Wang | Tsinghua University |
| Cuimei Ma | National Center for Climate Change Strategy and International Cooperation (NCSC) |
| Fanran Meng | University of Cambridge |
| Fuqiang Yang | Natural Resources Defense Council (NRDC) |
| Gang Liu | University of Southern Denmark |
| Huiming Gong | The Energy Foundation |
| Jixin Liu | United Nations Environment Programme (UNEP) |
| Jon McKechnie | University of Nottingham |
| Junfeng Li | National Center for Climate Change Strategy and International Cooperation (NCSC) |
| Junjun Deng | Beijing Institute of Technology |
| Kejun Jiang | Energy Research Institute of NDRC |
| Libo Zhou | China Electricity Council |
| Lixiao Zhang | Beijing Normal University |
| Lulu Xue | World Resource Institute |
| Peng He | World Economic Forum |
| Qimin Chai | National Center for Climate Change Strategy and International Cooperation (NCSC) |
| Russell T. Balzer | World Auto Steel |
| Shaoliang Zhong | World Steel Association (worldsteel) |
| Weidong Zhang | China Electricity Council |
| Weiqiang Chen | Institute of Urban Environment, Chinese Academy of Sciences |
| Xiang Zhang | Beijing Institute of Technology |
| Xianzheng Gong | Beijing University of Technology |
| Xiaohua Ding | Public Data Acquisition and Monitoring Research Center for New Energy Vehicles,Shanghai Municipality |
| Xingyu Xue | Aramco Asia |
| Xinzhu Zheng | China University of Petroleum (Beijing) |
| Yan Lan | BRI International Green Development Alliance |
| Yunshi Wang | University of California, Davis |

# MESSAGES FROM EXPERTS

* In alphabetical order

**Amir F. N. Abdul-Manan**

Science specialist, Saudi Aramco

"China has pledged to peak its national GHG emissions by 2030, and to ultimately achieve carbon neutrality by 2060. Decarbonizing passenger road transport in one of the largest automobile markets in the world will be key to successfully mitigating GHG emissions in China and globally. The "China Automobile Low Carbon Action Plan (CALCP) Research Report (2021)" is a timely and relevant publication that outlines technological opportunities for the automotive sector in the country. By adopting a Life Cycle Assessment (LCA) approach, the Automotive Data of China (ADC) has demonstrated the role that a broad mix of technologies can play, and that their climate change mitigation potentials depend critically on the source of energy that is used to power the vehicle. Thus, this report highlights the importance of availing cleaner electricity for the charging of electrified vehicles, and equally, the need for low-carbon fuels for use in advanced, highly-efficient combustion engines. The report further assesses several fleet decarbonization scenarios and draws important insights, key of which is the opportunity for accelerating and reducing peak emissions by expediting the deployment of low-carbon electrofuels in China."

**Aimin Ma**

Deputy Director, National Center for Strategic Research and
International Cooperation on Climate Change

""China plays a vital role in tackling climate change, and the announcement of the" double carbon "goal sets higher requirements for carbon emission reduction. The automobile industry is an important carrier of road traffic. With the growth of China's economy, people's demand for travel is increasing day by day, and the number of cars will continue to increase. As the number of passenger cars in China is still dominated by gasoline cars, it is necessary to effectively control carbon emissions in this field. In this study, the current situation of carbon emissions in China's passenger car industry was fully studied through the life cycle research method, and the future development trend was predicted. The countermeasures and suggestions put forward by this study can provide support for the formulation of carbon emission reduction policies and measures in China's passenger car industry. "

**Can Wang**

Tsinghua University, professor

“China Automobile Low-carbon Action Plan (2021)" makes full and detailed analysis of China's passenger car carbon emissions inventory, fleet carbon emissions and future emission reduction trend from the perspective of the whole life cycle by using the latest data of the automobile industry. The report is of great significance for China to accelerate the promotion of new energy vehicles, promote carbon emission reduction in the transportation industry and promote the energy structure adjustment strategy. "

**Cuimei Ma**

National Center for Strategic Research and International Cooperation on Climate Change, Deputy Director/Associate Research Fellow of Department

" China Automobile Low-carbon Action Plan (2021) provides a theoretical method for quantifying the greenhouse gas emissions of passenger cars from the perspective of life cycle, and is of positive significance in promoting the technological transformation and upgrading of the automobile industry, coping with the possible green trade barriers in the automobile trade field and further improving the competitiveness of China's automobile industry in the international market."

**Fuqiang Yang**

Peking University Energy Research Institute Distinguished Researcher

"This study provides a specific life cycle accounting method for greenhouse gas emissions of fuel vehicles and electric vehicles, which is helpful for enterprises to understand the carbon emission sources of their products at different stages of life cycle, and can formulate targeted emission reduction measures, thus laying a solid foundation for the low-carbon development of China's automobile industry. In order to cope with climate change and achieve the goal of carbon neutrality, we need to strengthen cooperation in different fields, hoping that more enterprises and institutions will respond to the call of the state and actively invest in low-carbon development. "

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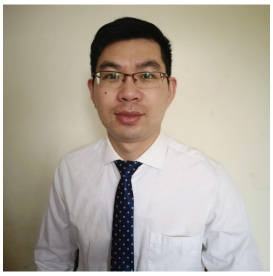
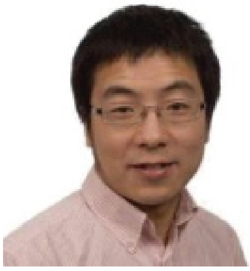
* In alphabetical order



**Fanran Meng**

University of Cambridge, Research Associate

The "China Automotive Low-Carbon Action Plan (CALCP) Research Report (2021)", based on detailed inventory data, has established a vehicle- and fleet- scale carbon emission accounting method, quantified the life cycle carbon emissions of passenger vehicles in the vehicle and fuel cycle. Considering international carbon neutral policies and regulations, the report has analysed the path of carbon peaking and carbon neutrality in China's auto industry under different scenarios. This provides a solid data basis and decision-making basis for the relevant carbon emission policies in the future. It thus has significant implications to support the Chinese auto industry achieve the goal of carbon neutrality ahead of the 2060 schedule."



**Gang Liu**

Professor, University of Southern Denmark

"The automotive industry is one of the sectors that are the most difficult to realize an overall GHG emission reduction in light of the modern industrial system. Its whole life cycle GHG emission consists of the direct emissions in the use phase of vehicles and the indirect emissions from the energy and industry sectors that support the automotive sector. Building on the China Automobile Low Carbon Action Plan Research Report 2020, the China Automobile Low Carbon Action Plan Research Report 2021 further refines the accounting framework. Under the carbon peaking and carbon neutrality visions of China, it takes into account the dynamics of fleets, electric systems and consumption patterns that are suitable under the condition of China. It studies the GHG emission paths in various dynamic scenarios and provides policy recommendations. It will play a significant role in the realization of net zero for passenger vehicles of China."

**Huiming Gong**

The Energy Foundation, Senior Project Director of China Transportation Project

"The 14th Five-Year Plan period is a crucial period for building the carbon emission model and data base of the industry, which will lay a solid foundation for vigorously promoting the carbon emission management and emission reduction of the industry during the 10th Five-Year Plan period. Automobile industry, as a major energy consumer in the transportation industry, is an industry with sustained and rapid growth in various industries. Promoting low-carbon action in the automobile industry will not only strongly support the national goal of peaking carbon emissions around 2030, but also help the rapid decline of total carbon emissions after 2030. Different from the previous calculation of total carbon emissions from top to bottom according to the consumption of different energy varieties, the bottom-up correlation analysis is more conducive to closely combining the research of management measures and the analysis of related emission reduction potential, and the perspective of life cycle analysis will be more conducive to comprehensive and systematic understanding and solution of problems and challenges. It is hoped that the research of China Automotive Data Co., Ltd. will continue to break through and provide better management support for the low-carbon development and technological progress of China's automobile industry. "

**Junfeng Li**

Former Director, National Center for Strategic Research and International Cooperation on Climate Change

" China Automobile Low-carbon Action Plan (2021)" uses the evaluation method of the whole life cycle to comprehensively and systematically calculate the carbon emission intensity and total carbon emission of passenger cars in China. The model adopts the latest industry data, quantifies the carbon emissions of passenger cars in China from different levels of bicycles, enterprises and fleets, and predicts the change trend until 2060. This research not only has important research value for the low-carbon development of passenger cars and bicycles in China, but also has huge significance for the green low-carbon sustainable development of passenger car enterprises and industries in China. "

# MESSAGES FROM EXPERTS

* In alphabetical order

**Jixin Liu**

Associate Expert, United Nations Environment Programme (UNEP)

“Cars contribute about one fourth of the total greenhouse gas emissions that are connected with energies globally. Their share is expected to rise further to one third of the global total by 2050. China is the largest automobile market, and its car stock reached 372 million in 2020, ranking in the first place globally. Last year, the Chinese government announced its aim to have its CO2 peak by 2030 and the carbon neutrality by 2060. The automotive industry, as one of the three arenas that see the fastest growth of GHG emissions, is essential to the successful peaking and neutrality of GHG emissions in China.To promote cleaner and more efficient automobiles is the only way to achieve low-carbon and net zero emission. Building on previous studies on GHG emissions on the single vehicle level, the China Automobile Low Carbon Action Plan Research Report 2021 provides a study of the fleet stock structure of China for the first time. It introduces the fleet model to assess changes in the total GHG emission and the ratios of the emissions in the fuel cycle and the vehicle cycle, in different policy scenarios, on the level of the automotive industry. The result will help improve and perfect the emission standards and management systems for the automotive industry. It will accelerate the transformation and electrification process. It will also be a good reference for other countries in developing similar studies.”

**Jon McKechnie**

University of Nottingham, Associate Professor

Understanding the full environmental impact of passenger cars requires a comprehensive evaluation of material production, vehicle manufacture, use, and end-of-life. The China Automotive Low Carbon Action Plan Research Report provides data and methods required to undertake this assessment for the China context, and will underpin efforts of industry and government to address life cycle emissions in this sector towards China’s ambitious targets for 2060.”

**Junjun Deng**

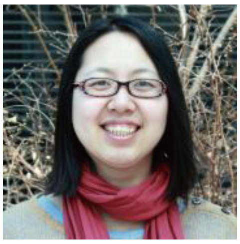
Special Associate Researcher, School of Mechanics and Vehicles
Beijing Institute of Technology

"The Research Report on China Automotive Low Carbon Action Plan (2021) takes the low carbon competitiveness of China's automotive products as the entry point and analyzes the urgency of the automotive industry's shift to green and low carbon development. Based on detailed basic data, it establishes a life cycle GHG emission accounting method for individual vehicles, fleets and companies, and proposes a key path for carbon neutrality in the automotive industry by building on the model measurement results and its policy recommendations. It is of great significance in promoting the automotive industry to achieve the double carbon target."

**Lixiao Zhang**

Vice Dean & Professor, School of Environment
Beijing Normal University

"As one of a series of reports, the China Automobile Low Carbon Action Plan (CALCP) Research Report 2021 further refines the accounting framework and parametric system, takes into full consideration the carbon neutrality vision, and develops dynamic analyses of multiple scenarios. It raises different path options for the automotive industry in different time periods. It is very important as it helps the automotive industry of China to further enhance its technology and achieve carbon neutrality."



**Lulu Xue**

Fellow, World Resource Institute

"The China Automobile Low Carbon Action Plan (CALCP) Research Report 2021 is one of the first research studies in China that adopts the LCA methodology to evaluate the life cycle GHG emissions on the level of single vehicles, companies and fleets. From the industrial perspective, it reveals how the automotive greenhouse gas emissions are closely connected with the in-depth GHG emissions of the electricity and industrial sectors, especially the steel sector. On the level of whole vehicle manufacturers, it shows that to achieve the business-level carbon neutrality, the emissions over the entire supply chain need be controlled, and the green supply chain and the purchase of green electricity be promoted."

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* In alphabetical order

## Peng He

China Lead, World Economic Forum

"Electricity, manufacturing and transport are the main contributors of CO2 emissions in China. The automotive sector is one of the pillars of the manufacturing sector, as well as one of the main consumers of the energy sector and one of the main emitters of the transport sector. It will play an essential role in the comprehensive achievement of carbon peaking and carbon neutrality. The automotive industry has benefited from globalization, but is faced with intensive global competition as well. The low-carbon development over the entire value chain will be the next new trend for the automotive industry in the world. The participants should have their deployments and plans ready in advance. On the basis of collected data, the China Automobile Low Carbon Action Plan Research Report establishes a carbon footprint accounting system over the whole life cycle. It provides a reference for the low-carbon and sustainable development of the automotive industry. It also offers thoughts and ideas for the full decarbonization of the industrial sector and the perfection of the circulation economy pattern. The World Economic Forum recognizes that the transition to a circular economy in the automotive industry cannot be realized without the cooperation and efforts of regulators and industry. It has launched the "Circular Cars Initiative" at Davos 2020 with partners like Systemiq, etc. China is the world's largest automotive market and will lead the industry's innovative development in the field of decarbonization and circular economy. I hope that the Report will inspire many other sectors with innovative thoughts, explorations and practices on low-carbon development, to promote the collaborative development between automobile, energy and transport sectors. The World Economic Forum's Circular Cars Initiative would like to join forces with Automotive Data of China Co., Ltd. to contribute to the realization of carbon peaking and carbon neutrality objectives."

**Qimin Chai**

Departmental Head & Fellow, National Center for Climate Change Strategy and International Cooperation (NCSC)

"The China Automobile Low Carbon Action Plan Research Report follows closely the carbon peaking and carbon neutrality strategies of China and the international developments of related industries. It has been the first of its kind in the study and argumentation of the whole life cycle emissions of vehicles. It raises very good comprehensive solutions, impact analyses and policy recommendations for the high quality and carbon-neutral development of the automotive industry in the medium-to-long run in China. It is very significant strategically and academically."

**Russell T. Balzer**

World Steel Association, Technical Direct Automotive Steel

"With the release of the 2021 China Automotive Low Carbon Action Plan Research Report, CATARC continues to be a leader in the global movement to adopt LCA as the critical metric for measuring the environmental performance of vehicles. The 2021 report further enhances our understanding of vehicle impact across the entire life cycle by highlighting impacts that are not captured by tailpipe-only methods.。"

**Shaoliang Zhong**

Chief Representative, World Steel Association Beijing Representative Office

"The Research Report on China Automotive Low Carbon Action Plan (2021), compiled and published by Automotive Data of China Co., Ltd., brings together the industry wisdom of many authoritative institutions and universities in the automotive industry chain, with detailed data and strict logic. It provides highly informative research material for automotive and related companies, research institutions, government decision-making departments creatively from a total life cycle perspective and geared towards the 2060 carbon neutrality target."

# MESSAGES FROM EXPERTS

* In alphabetical order

## Weidong Zhang

Division Head, Department of Industrial Development and Environment,China Electricity Council

“The China Automobile Low Carbon Action Plan Research Report 2021 adopts the LCA methodology and develops the life cycle GHG emission accounting model on the level of single vehicles, companies and fleets, in a scientific and reasonable manner. It provides a theoretical method to quantify the whole life cycle GHG emissions of passenger vehicles. It calculates the whole life cycle GHG emissions of passenger vehicles that use six types of fuels. It also predicts the GHG emission trends in the next 40 years. It studies the carbon neutrality paths under different scenarios and provides carbon neutrality recommendations in different time periods, for the automotive industry. It will play a significant role in helping the automotive industry of China achieve net zero.”

## Weiqiang Chen

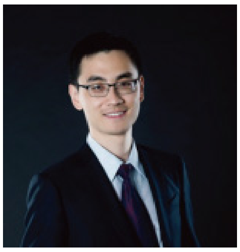
Fellow, Institute of Urban Environment
Chinese Academy of Sciences

“The China Automobile Low Carbon Action Plan (CALCP) 2021, which is launched and completed by Automotive Data of China Co., Ltd., is a very important project. It is based on a large numbers of data studies and analyses. It traces and predicts the GHG emission features and reduction potentials of passenger vehicles that vary in the year of production, age and fuel, in a comprehensive and systemic manner. It provides a solid data basis and decision-making support for the making of GHG emission strategies for the automotive industry in light of the carbon peaking and carbon neutrality objectives. It forms an important scientific foundation to enable the low-carbon transformation and sustainable development for the mobility sector of China.”

**Xianzheng Gong**

Professor, Beijing University of Technology

" China Automobile Low-carbon Action Plan (2021), adhering to the concept of life cycle, has carried out a large number of meticulous pioneering studies on carbon emission accounting methods, models and basic data of passenger cars in China, and has been systematically applied to carbon emission accounting and forecasting of passenger cars, enterprises and industries in China, which has important guiding significance for comprehensively interpreting the life cycle carbon asset management of China's passenger car industry, and provides important reference and technical path direction for the automobile industry to achieve the goals of peak carbon dioxide emissions and carbon neutrality."



**Xingyu Xue**

Aramco Asia, Head of Strategic Transport Analysis Team (China)

" China Automobile Low-carbon Action Plan (2021)" provides reliable data support and theoretical basis for promoting China's passenger car industry to achieve the goal of "double carbon"(carbon neutrality and peak carbon emission) The report emphasizes the importance of life-cycle carbon emission management policies and reveals that a series of technical solutions are needed to achieve the carbon emission reduction targets of the passenger car industry, including the use of low-carbon fuels, electric vehicles and efficient hybrid technologies. It provides important theoretical support for car companies, relevant government departments and scientific research institutions to formulate technical routes and policy plans. "

**Xiang Zhang**

Vice Dean & Professor, School of Management and
Economics, Beijing Institute of Technology

“The carbon neutrality of the automotive industry will be essential for China to realize its carbon peaking and carbon neutrality objectives. By centering around the carbon neutrality objective, the China Automobile Low Carbon Action Plan Research Report 2021 adopts the life cycle GHG emission accounting models, and studies the GHG emissions and carbon neutrality paths of passenger vehicles by 2060. It provides an accounting basis for the decision-making process in the future. it is an important reference for the automotive industry to realize the carbon neutrality objective.”

# MESSAGES FROM EXPERTS

* In alphabetical order

## Xiaohua Ding

Deputy Director, Shanghai New Energy Vehicle Public Data Collection and Monitoring Research Center

“The China Automobile Low Carbon Action Plan Research Report 2021 is a professional research report that is focused on the whole life cycle GHG emissions of passenger vehicles in China. It will help other countries to understand the current GHG emissions of Chinese passenger vehicles. In addition, through international bench-marking, China will know how the GHG emissions of passenger vehicles change in other countries. The Report is necessary in order to achieve the low-carbon objective of the automotive industry.”

## Xinzhu Zheng

Assistant Professor, China University of Petroleum (Beijing)

“The China Automobile Low Carbon Action Plan Research Report 2021 is based on accurate and detailed data and scientific accounting models. It quantifies the whole life cycle GHG emissions of passenger vehicles and studies the carbon neutrality paths for the automotive industry under the carbon neutrality objective. The result will create a scientific methodological support for the life cycle GHG emission accounting and assessment of passenger vehicles and lay a decision-making basis for the emission reduction of the automotive sector. It is significant in the low-carbon and sustainable development of the automotive industry.”

**Yunshi Wang**

University of California, Davis, Director of China Energy and Transportation Center, Co-Director of China-US-Netherlands ZeroEmission Vehicle Policy Laboratory

" China Automobile Low-carbon Action Plan (2021)" has made significant improvements on the basis of 2020. In 2021, the life cycle carbon emissions of passenger cars were analyzed in more detail, and the role of pure electric vehicles in carbon reduction was further confirmed. As I said when I gave congrats for the 2020 report, this report provides a good foundation for China's future carbon emission regulations for automobiles. "

**Yan Lan**

Deputy Director of the Secretariat of Belt and Road International Alliance for Green Developmen

"Based on models and data, the Research Report on China Automotive Low Carbon Action Plan (2021) scientifically and objectively assesses the whole life cycle GHG emissions of the automotive industry and proposes specific paths for the industry to achieve carbon neutrality, thereby providing important technical support for the government and automotive industry companies to make relevant decisions."

# HISTORY REVIEW

汽车行业节能与绿色发展成果发布会在天津召开

发布时间：2019-01-03 14:36　来源：节能与综合利用司

2018年12月27日，中国汽车技术研究中心（以下简称中汽中心）在天津召开汽车行业节能与绿色发展成果发布会，发布了2018年度第二批中国生态汽车评价（C-ECAP）结果以及汽车行业低碳行动计划研究成果。100多名来自行业协会、企业、媒体等方面的代表参加了发布会。

为落实国家绿色发展政策，引导汽车绿色消费，推动汽车企业落实社会责任，自2015年起，中汽中心依据车内空气质量、综合油耗、尾气排放等方面标准执行情况、消费者关注程度和社会责任承担情况，开展了多批次的汽车生态设计评价。本次会议上，中汽中心领导发布了2018年度第二批评价结果，并向获评企业颁发了证书。同时，通报了2019年新版《生态汽车评价规程》。

中汽中心是汽车行业唯一入选工业和信息化部工业节能与绿色发展评价中心的机构。为推动汽车行业绿色发展，评价中心在节能减排政策研究、绿色工厂创建、节能与绿色标准制定等方面开展了大量工作。2018年重点实施了“中国汽车低碳行动计划”，对中国境内销售的纯电动乘用车，开展全生命周期碳排放核算，此次发布会发布了长安奔奔EV 2018款等5款车型的核算结果。这些工作的开展有力地促进汽车行业开展生态设计，推广应用先进节能低碳技术，有利于汽车行业实现低碳绿色发展。

## CONFERENCE OF ENERGY SAVING AND GREEN DEVELOPMENT ACHIEVEMENTS OF AUTOMOBILE INDUSTRY HELD IN TIANJIN

Released Time: PM2:36 3rd January 2019 Source: Department of Energy Conservation and Resources Utilization,Ministry of Industry and Information Technology of the People's Republic of China

On December 27th, 2018, China Automotive Technology and Research Center (hereinafter referred to as China Automotive Center) held a conference with the theme of energy-saving and green development achievements of the automobile industry in Tianjin, and released the results of the second batch of China Eco-car Assessment Programme (C-ECAP) in 2018 and the "China Automobile Low Carbon Action Plan" Research Report of the automobile industry. More than 100 representatives from industry associations, enterprises and media attended the conference.

In order to implement the national green development policy, guide the green consumption of automobiles, and promote the automobile enterprises to fulfill their social responsibilities, since 2015, China Automobile Center has carried out a number of batches of automobile ecological design evaluations based on the implementation of standards in the aspects of air quality, comprehensive fuel consumption, exhaust emission, consumer concerns and social responsibility. During the conference, the leaders of China Automotive Center released the second batch of evaluation results in 2018 and issued certificates to the evaluated enterprises. At the same time, the 2019 new edition of "Eco-car Evaluation Regulations" was released.

China Automobile Center is the only institution in the automobile industry that has been selected as the evaluation center of industrial energy conservation and green development of the Ministry of Industry and Information Technology. In order to promote the green development of the automobile industry, the evaluation center has conducted a great deal of work in the policy research of energy conservation and emission reduction, the establishment of green factories, the formulation of energy conservation and green standards, etc. In 2018, the "China Automotive Low-carbon Action Plan" was implemented, and the carbon emission accounting of electric passenger cars sold in China was carried out in the full life cycle. This conference released the accounting results of five models including Changan Benben EV 2018. These efforts effectively promote the ecological design of the automobile industry, popularize and apply advanced energy-saving and low-carbon technologies, and help the automobile industry to realize the development of low-carbon life.

## 2019 CHINA INTERNATIONAL FORUM ON AUTOMOTIVE ECOLOGICAL DESIGN HELD IN HANGZHOU

Released Time: AM11:38 26th June 2019  Source: Department of Energy Conservation and Resources Utilization, Ministry of Industry and Information Technology of the People's Republic of China

2019中国汽车生态设计国际论坛在杭州召开

发布时间：2019-06-26 11:38　来源：节能与综合利用司

2019年6月20—21日，第六届中国汽车生态设计国际论坛在浙江省杭州市召开。论坛由中国汽车技术研究中心有限公司（下称“中汽中心”）及杭州市人民政府联合主办，来自相关机构的领导、国内外专家学者、车企代表、主流媒体等嘉宾共计300余人参加论坛。工业和信息化部节能与综合利用司派员参加。

论坛围绕“生态设计推动汽车行业绿色健康发展”主题，共同探讨汽车行业绿色发展的政策动向，分享绿色实践经验，推动汽车行业可持续发展，加快汽车行业绿色变革。论坛期间，中汽中心发布了中国汽车有害物质管理行业白皮书、中国生态汽车评价（C-ECAP）2019年第一批评价车型结果以及中国汽车低碳行动计划最新研究进展等研究成果。

On June 20-21, 2019, the 6th China International Forum on Automotive Ecological Design was held in Hangzhou, Zhejiang Province. The forum was co-host by China Automotive Technology and Research Center Co., Ltd. (hereinafter referred to as "China Automotive Center") and Hangzhou Municipal People's Government. There are almost 300 guests from relevant institutions, foreign and domestic experts and scholars, representatives of automobile enterprises and mainstream media attended the forum. Specialists from Department of Energy Conservation and Resources Utilization of the Ministry of Industry and Information Technology also attended the conference.

Focusing on the theme of "Ecological design promotes the green and healthy development of the automobile industry", it discussed the policy trend of green development of the automobile industry, shared green practical experience, promoted the sustainable development of the automobile industry and accelerated the green reform of the automobile industry. During the forum, China Automotive Center released the white paper of China's automobile hazardous substances management industry, the results of the first batch of evaluation models of China Eco-car Assessment Programme (C-ECAP) in 2019 and the latest research progress of China Automobile Low-carbon Action Plan.

## RELEASE OF "CHINA AUTOMOBILE LOW CARBON ACTION PLAN" RESEARCH REPORT (2020)

Released Time: AM9:48 23rd September 2020  Source: Department of Energy Conservation and Resources Utilization,, Ministry of Industry and Information Technology of the People's Republic of China

中国汽车低碳行动计划2020年研究成果发布

发布时间：2020-09-23 09:48　来源：节能与综合利用司

近期，中汽数据有限公司发布了“中国汽车低碳行动计划2020年研究成果”。今年以来，中汽数据有限公司联合联合国环境规划署、国家应对气候变化战略研究和国际合作中心、世界资源研究所和北京工业大学等16家国内外机构开展了《中国汽车低碳行动计划2020》研究，初步提出了乘用车单车、企业和汽车行业碳排放核算方法，并针对2019年中国境内所生产的乘用车，核算不同燃料类型乘用车的全生命周期碳排放。研究成果展现了中国乘用车生命周期碳排放的历史演进过程和发展趋势，致力于引导汽车企业实施绿色化低碳化设计、选用低碳环保新材料，利用先进低碳技术装备、加快新能源汽车推广应用、推动中国乘用车全生命周期的碳减排。

（相关成果可至http://www.auto-eaca.com下载）

Recently, Automotive Data of China Co., Ltd. released "China Automobile Low Carbon Action Plan" Research Report (2020). Earlier this year, Automotive Data of China Co., Ltd has carried out the research of "China Automobile Low-carbon Action Plan" with 16 foreign and domestic institutions such as the United Nations Environment Programme (UNEP), the National Center for Climate Change Strategy and International Cooperation (NCSC), the World Resources Institute (WRI) and Beijing University of Technology. It preliminarily developed the carbon emission accounting methods of a single passenger vehicle, enterprises and automobile industries, and calculated the carbon emissions of passenger vehicles with different fuel types in the full life cycle produced in China in 2019. The research results show the historical evolution process and development trend of the life cycle carbon emissions of China's passenger vehicles . It is committed to guiding automobile enterprises to implement green and low-carbon design, select new low-carbon environmental protection materials, and utilize equipment with advanced low-carbon technology so as to accelerate the promotion and utilization of new energy vehicles and promote the carbon emission reduction of China's passenger vehicles in the full life cycle.

（Related achievements are available to download at http://www.auto.eaca.com ）

# HISTORY REVIEW

中国汽车低碳行动计划2021年研究成果发布

发布时间：2021-07-21 09:05 来源：节能与综合利用司

近期，中汽数据有限公司发布了“中国汽车低碳行动计划2021年研究成果”。

研究报告在汽车生命周期评价模型（CALCM）和车队生命周期评价模型（CAFLAM）基础上，针对2020年中国境内销售的乘用车，开展了单车和车队全生命周期的碳排放核算。按照现有政策供给总体不变、政策加力促进行业减排和政策强力推动减排三种情景，围绕电网清洁化、车辆电动化、材料效率、车辆生产能效、动力蓄电池碳排放、车辆使用能效、替代燃料和消费模式等八种减排路径，进行了2025年、2030年、2050年和2060年的单车和车队的生命周期碳排放情况预测和分析。

（相关成果可至http://www.auto-eaca.com下载）

## RELEASE OF “CHINA AUTOMOBILE LOW CARBON ACTION PLAN” RESEARCH REPORT (2021)

Released Time: AM9:05 21st July 2021  Source: Department of Energy Conservation and Resources Utilization, Ministry of Industry and Information Technology of the People’s Republic of China

Recently, Automotive Data of China Co., Ltd. released "China Automobile Low Carbon Action Plan" Research Report (2021). Based on the China Automotive life cycle assessment Model (CALCM) and China Automotive Fleet Life Cycle Assessment Model (CAFLAM), the report implemented the carbon emission accounting of the single passenger vehicles and fleets in the full life cycle for passenger vehicles sold in China in 2020. Three scenarios are designed in the research, which are Stated Policy Scenario by maintaining the overall policy supply unchanged, Median Decarbonization Scenario by strengthening the policy to promote the carbon emission reduction of industries, and Deep Decarbonization Scenario by intensively strengthening the policy to promote the emission reduction respectively. The life cycle carbon emissions of single passenger vehicles and fleets in 2025, 2030, 2050 and 2060 were analyzed based on the three designed scenarios with the combination of eight decarbonizing methods including clean power grid, electrification of vehicles, material efficiency, energy efficiency of vehicle production, carbon emissions of traction batteries, energy efficiency of vehicle use, alternative fuels and consumption patterns.

（Related achievements are available to download at http://www.auto.eaca.com ）

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# 01

# "CARBON NEUTRALITY" IN AUTOMOTIVE INDUSTRY

## 1.1 Carbon Neutrality Defined

"Carbon Neutrality" means a balance between man-made emission sources and the man-made carbon sinks through vegetation and carbon capture and storage. The carbon neutrality objective can be set on the level of the planet, a country, a city or a company. It can refer to the emission of carbon dioxide ($CO_2$) only in a narrow sense, or the emission of all greenhouse gases (carbon) broadly[1]. On September 22, 2020, President Xi Jinping solemnly announced at the United Nations General Assembly that China aims to have $CO_2$ emissions peak by 2030 and achieve carbon neutrality by 2060. These objectives have become a national strategy and been introduced in a portfolio of ecological civilization constructions. For the development of the green and low-carbon circulation economy, the Chinese Communist Party (CPC) committees and governments at all levels should create their own timetables, road maps and construction maps to realize carbon peaking and carbon neutrality. The raising of these objectives will be significant for China in its working with the climate crisis, increasing its voice in the international climate governance, and strengthening its industrial transformation process.

Be a party in the international consensus and perform the Paris Agreement. The report of the Intergovernmental Panel on Climate Change (IPCC) shows that the average temperature is now about 1 degree Celsius above the pre-industrial level globally. The continuously increasing temperature will cause climate change and the sea level rise and other consequences. The Paris Agreement Under the United Nations Framework Convention on Climate Change, which was entered into in 2016, aims to limit the global temperature increase to below 2 degrees Celsius above pre-industrial level and ideally, to keep the increase within 1.5 degrees Celsius, by the end of this century. To reach the aim, the signatories should, on an equal basis, try to achieve carbon neutrality during the latter half of this century. Now, nearly 130 countries, including China, have had their carbon neutrality objectives in different forms, taking up around 65% of the total GHG emission globally or about 70% of the economic aggregate in the world. In the face of the new global pattern to deal with climate change, China will have to actively participate in the global governance and in building up the community of common destiny for all mankind.

Be a responsible power. Currently, the United States of America (USA) and the European Union (EU) still have the dominating say in the global climate governance system, while the voice of developing countries has been weak. Due to the long-standing difference between developed and developing countries, the climate governance has grown at a very slow pace. As China has declared its carbon neutrality objective, it raises its voice as a responsible power in the process. It will lead the system towards an all-inclusive, all-benefiting and efficient and effective direction.

Strengthen industrial transformation process and promote high quality development. With the dramatic growth of its economy, China will see its energy demand increasing continuously. However, due to the serious mismatch between the domestic energy production and demand structures, the gap of the energy demand will have to be filled up by import on a large scale. The Report on Oil and Gas Industry Development in China and Other Countries 2019 shows that China's reliance on foreign oils and gases exceeded 70% in both of these two aspects in 2019, which was far above the 50% safety line[2] and is still on the increase. The foreign reliance and the competition for resources will endanger the sustainability of the Chinese industries. Secondly, despite its decreasing recently, the carbon intensity of China remains higher than that of the USA or the EU. In 2019, the carbon intensity of the USA and the EU was 2.3 tons per USD and 1.9 tons per USD, while that of China was 7.1 tons per USD, or 3.1 times higher than the USA or 3.7 times than the EU. The carbon neutrality objective will effectively push the low-carbon transformation of the industries of China, reduce the energy and resource investment, and lower its reliance on foreign energies. Moreover, it will increase the effectiveness of the Chinese industries in working with the emission policies of China and other countries and improve their dynamics in the outer circulation cycle so that they can grow healthy in both the inner and outer circulation cycles.

Revitalize the green and beautiful country. Carbon neutrality is a part of the Beautiful China program, an important grip to build ecological civilization, and an internal requirement for green growth. According to the ecological civilization timetable depicted in the 19thCPC National Congress and the National Ecological Environment Protection Conference, the Beautiful China will be built up basically by 2035 and fully by the middle of this century. Moreover, China will try to have its carbon peak by 2030, with the GHG emission per GDP to be 25~35% lower by 2035, and to achieve carbon neutrality by 2060. It shows that carbon peaking and carbon neutrality are essential milestones for our Beautiful China dream come true. They are necessary to create a force to reversely drive the green and low-carbon circulation. In addition, we need work with other countries to take good care of our planet and develop a basis for ecological civilization. All of us will have to step on the road of green growth and march towards carbon neutrality.

## 1.2 Importance of carbon neutrality in the automotive industry

The automotive industry has become one of the key industries in China's GHG emission management because of its long industry chain with wide radiation, fast growth of total GHG emission and high carbon intensity of single vehicle, which is of great significance to promote the green and low-carbon transformation of its upstream and downstream industry chains and achieve carbon neutrality in China.

First, the rapid growth of GHG emissions in the automotive industry makes it one of the fastest-growing areas of GHG emissions in China at present. China, as the world's largest automobile manufacturer, has ranked first in the world in terms of automobile production and sales for 12 consecutive years. As shown in the Figure below, the overall vehicle sales from 2001 to 2020 were on the rise, with an average annual growth rate of 12.57%. In 2020, China's automobile stock reached 281 million[3], with production and sales reaching 25.225 million and 25.311 million respectively[4]. Meanwhile, China is also becoming a large exporter of automobiles, with 995,000 automobiles exported in 2020[4]. With the increase of automobile production and sales and exports, as a typical resource- and energy-intensive industry, the automotive industry has not yet decoupled carbon emissions from economic growth and become one of the fastest-growing areas of GHG emissions in China at present. Direct GHG emissions from vehicles travelling on roads reached nearly 800 million tons in 2019, accounting for about 8% of China's total GHG emissions (Automotive Data of China Co., Ltd. (ADC)).

Second, with long industrial chain and extensive radiating surface, the automotive industry serves as an important means to promote the carbon neutrality of the upstream and downstream industry chains. To peak GHG emission and achieve carbon neutrality is a broad and profound economic and social systemic reform. All industries need to accelerate the transition to carbon neutrality and promote the realization of the goal of carbon neutrality. As an important pillar industry of China's national economy, the automotive industry is characterized by long industry chain, wide radiation and strong driving force. According to the data of National Bureau of Statistics, the overall revenue of China's automobile manufacturing industry in 2019 was 8.08 trillion yuan, which will indirectly drive upstream and downstream industries with massive scale of about 40 trillion output value according to the driving multiplier of 1:5 for upstream and downstream industries[5]. The realization of carbon neutrality in the automotive industry will become an important grip to promote carbon neutrality in the upstream and downstream industry chains.

Third, China has high GHG emission intensity for single vehicle and weak low-carbon competitiveness compared with developed countries. Currently, the life cycle GHG emissions of battery electric vehicle in China are about 12% higher than those of the EU. With the implementation of the European Green Deal and a series of low-carbon strategies, including the European Battery Directive, the Circular Economy Action Plan, the Sustainable and Smart Mobility Strategy, the EU Hydrogen Strategy and the EU Energy Systems Integration Strategy, the gap between China and Europe in terms of single-vehicle carbon intensity is expected to further widen in the future[6, 7]. Meanwhile, developed countries are establishing a new international trade dimension based on life cycle GHG emissions. First, the EU established a carbon border adjustment mechanism, i.e., carbon tax collection, and proposed that all goods under the EU-ETS should be included in the scope of carbon tariff collection and involved both intermediate and end products (including automotive products). The US, UK, Canada and other countries are also promoting their own carbon border adjustment taxes. Second, the EU is developing carbon footprint limit regulations

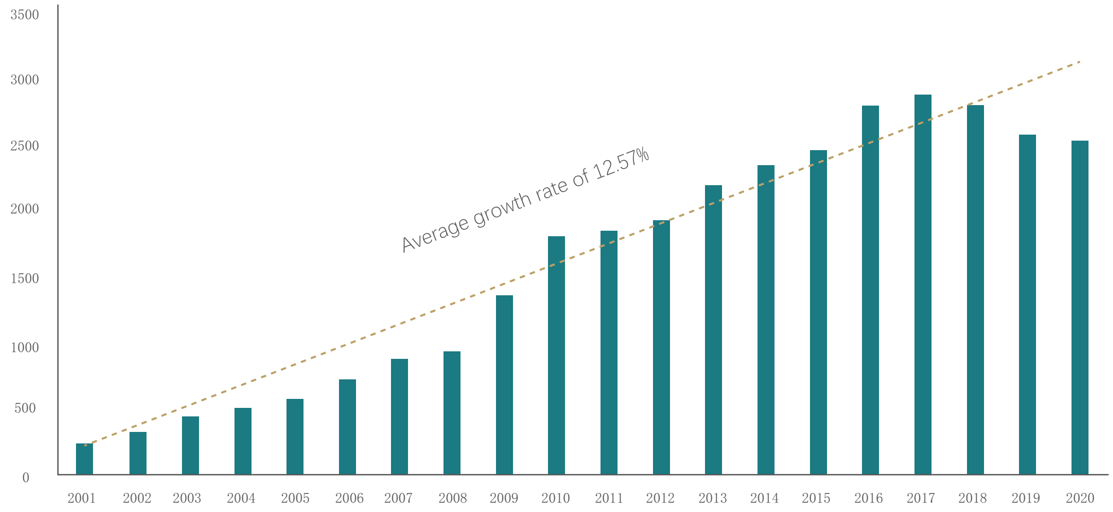


Figure 1 Vehicle sales in China from 2001 to 2020

for automotive components and complete vehicles exported to the EU. According to the 2019 $CO_2$ Emission Standards for Passenger Vehicles and Light-duty Commercial Vehicles, it's necessary to assess the whole life cycle GHG emissions of passenger vehicles and light-duty commercial vehicles at the EU level. The feasibility of establishing a common LCA methodology for the evaluation and data reporting of life cycle GHG emissions should be assessed no later than 2023. It also points out that follow-up measures should be taken and legislative proposals should be made as appropriate. The proposal of the EU's Regulation Concerning Batteries and Waste Batteries proposes that maximum carbon footprint limits for batteries will be introduced by July 1, 2027. In this context, compared with developed countries, China is subject to weak low-carbon competitiveness in terms of automotive products, and China will face greater pressure and challenges of GHG emissions to make its automotive products available worldwide.

In summary, carbon neutrality in the automotive industry plays an important role in both reducing the growth rate and intensity of GHG emissions in the automotive industry itself, and driving GHG emission reduction in the upstream and downstream industry chains. Accelerating the green and low-carbon transformation of the automotive industry and further moving towards net zero emissions over whole life cycle is of great significance for China to achieve the goal of carbon neutrality, marks the key milestone for China to realize the dream of building a strong automotive industry and is an important guarantee for promoting the harmonious coexistence between human beings and nature.

## 1.3 The meaning of carbon neutrality in the automotive industry

In this report, "carbon neutrality" refers to the net zero GHG emissions over whole life cycle of a vehicle. At the product level, carbon neutrality refers to net zero emissions over whole life cycle of a vehicle, including the vehicle cycle and fuel cycle. At the fleet level, fleet carbon neutrality refers to the net zero emissions of all vehicles in the fleet stock at different life cycle stages in a given year.

At present, international car companies have proposed their own carbon neutrality targets, mainly involving three levels: factory, product and enterprise, and the time point for achieving carbon neutrality is by 2050. For example, Daimler proposed to "eventually build a new fleet of carbon neutrality cars in the next 20 years"; Volvo proposed to "develop the company into a global zero-load climate benchmark enterprise by 2040"; Toyota proposed a zero life cycle $CO_2$ emissions challenge to "achieve zero $CO_2$ emissions throughout the life cycle of vehicles" and the factory zero $CO_2$ emission challenge "to achieve zero $CO_2$ emissions in global factories by 2050"; Nissan proposed "to achieve vehicles life cycle carbon neutrality by 2050". The carbon neutrality at the factory and enterprise levels proposed by car companies mainly refers to GHG emissions at the production and operation stages without involving the whole life cycle concept. Among these car companies, some of them explicitly proposed the whole life cycle carbon neutrality of a single vehicle, but more of them didn't specify or only included the road driving stage.

In the future, with the development of electrification and intelligence of automobiles, changes will also take place in their GHG emissions to gradually shift from the use of automobiles to the whole industry chain, and the GHG emissions related to the production and manufacturing of vehicles themselves and the production of upstream component suppliers will become increasingly important. Therefore, the whole life cycle carbon neutrality of the automotive industry is of particular significance in promoting GHG emission reduction in the automotive supply chain and improving the market competitiveness of supply chain enterprises. Therefore, the carbon neutrality referred to in this report covers the whole life cycle of automobiles, including the carbon neutrality of single vehicle and fleets, with a view to provide reference for the work related to automotive carbon neutrality.

# 02

# STANDARDS AND REGULATIONS ON AUTOMOTIVE LIFE CYCLE GHG EMISSIONS

## 2.1 Overview of low carbon standards and regulations for each stage of the vehicle life cycle

At present, a global system of standards and regulations has been established for each stage of the whole life cycle of automobiles, or even the whole stage. According to the different types of standards, they can be divided into low-carbon constraint indicator-based standards and regulations, low-carbon quantitative accounting-based standards and regulations, low-carbon technical path-based standards and low-carbon basic general-related standards, as shown in Figure 2 below.

As mentioned earlier, the scope of whole life cycle GHG emission accounting for automotive products includes vehicle cycle and fuel cycle. In the automotive life cycle low-carbon standard system in Figure 2, the vehicle cycle includes the vehicle manufacturing stage (including raw material acquisition, material processing and manufacturing, complete vehicle production, and repair and maintenance component production) and the vehicle recycling stage (including recycling and dismantling, re-manufacturing, cascade utilization and recycling). The fuel cycle includes the vehicle fuel production stage (oil well - fuel tank), the vehicle product energy efficiency management stage (fuel consumption management), and the fuel (vehicle) use stage (fuel tank - wheels).

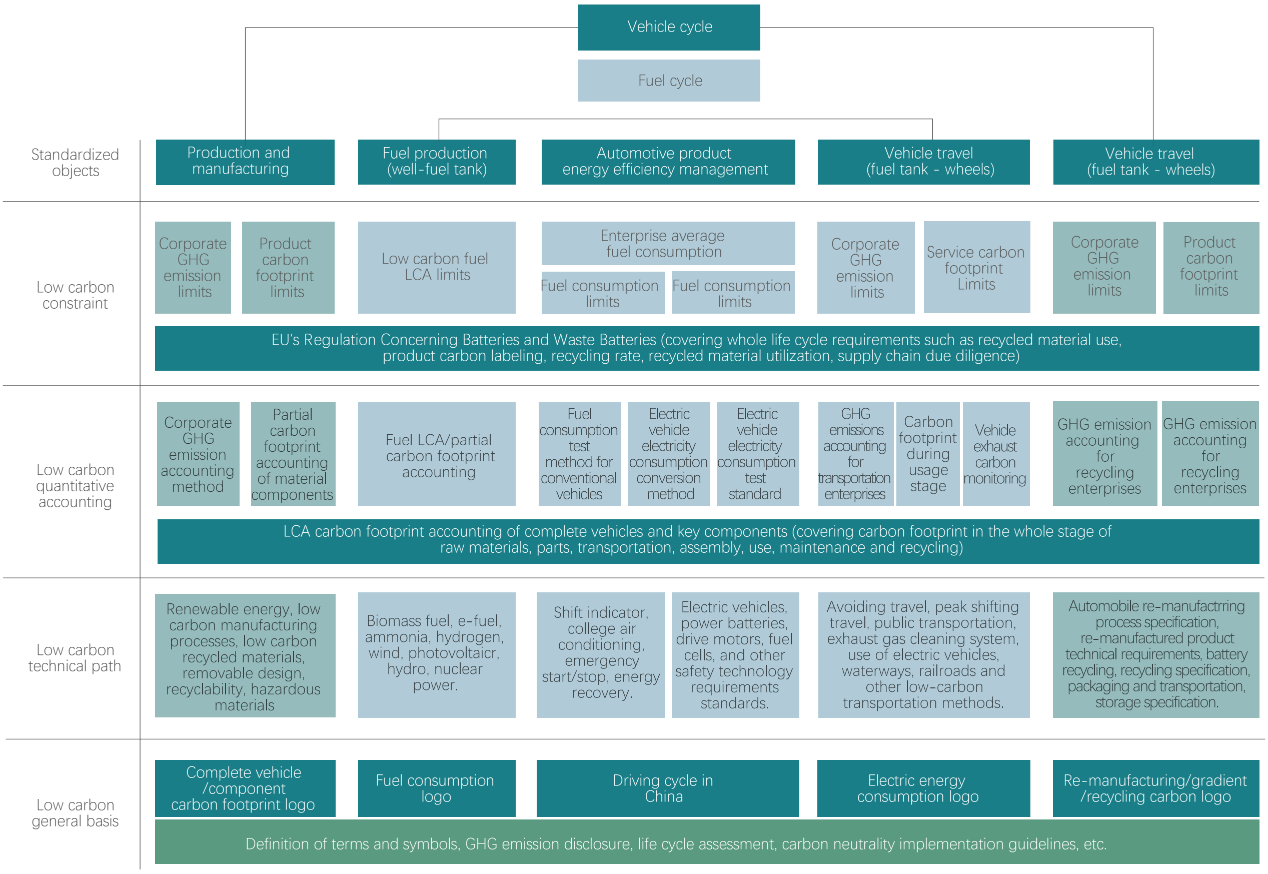


Figure 2 Automotive life cycle standards and regulations system

## 2.2 Whole life cycle standards and regulations for automotive products

At present, the standards and regulations for GHG emissions accounting and management around the whole life cycle of automotive products mainly include general methods and specific standards and regulations for automotive products. General low carbon quantitative accounting standards mainly include ISO 14067, GHG protocol product accounting standards, PAS2050, etc. The automotive industry can carry out the whole life cycle GHG emission accounting and quantification of automotive vehicles and key components based on these general standards. At present, the whole life cycle GHG emission-related standards for automotive products mainly include PEFCR - Product Environmental Footprint Category Rules: High-voltage Rechargeable Batteries for Mobile Applications of EU.

Meanwhile, there are also some standards and regulations involving the constrained type of life cycle carbon footprint of automotive products, such as the EU's Regulation Concerning Batteries and Waste Batteries, which puts forward relevant constrained index requirements from the whole life cycle of power batteries, such as the ratio of recycled materials used, waste battery collection rate, waste battery material recycling level, carbon label, and hazardous substances, electrochemistry and durability, etc. The main index requirements are shown in Figure 3.

**Recycling**
Resource attributes

New battery recycled material use rate requirement

| Timeline | Content of recycled materials in battery active materials | | | |
|---|---|---|---|---|
| | Cobalt | Lead | Lithium | Nickel |
| 2030. 01. 01 | ⩾12% | ⩾85% | ⩾4% | ⩾4% |
| 2035. 01. 01 | ⩾20% | ⩾85% | ⩾10% | ⩾12% |

Waste battery collection rate requirements

| Timeline | Battery type | | |
|---|---|---|---|
| | Lead-acid | Lithium-based | Other |
| 2025. 01. 01 | 75% | 65% | 50% |
| 2030. 01. 01 | 80% | 70% | |

Waste battery material recycling level

| Timeline | Recycled material | | | | |
|---|---|---|---|---|---|
| | Cobalt | Copper | Lead | Lithium | Nickel |
| 2025. 01. 01 | 90% | 90% | 90% | 35% | 90% |
| 2030. 01. 01 | 95% | 95% | 95% | 70% | 95% |

**Low carbon**
Energy attributes

| | Timeline | Regulatory requirements |
|---|---|---|
| Battery carbon footprint requirements | 2024. 07. 01 | The accompanying technical file shall contain a carbon footprint statement drafted in accordance with the enabling legislation |
| | 2026. 01. 01 | Labeling indicating the carbon footprint performance level of the battery and stating in the technical file that the carbon footprint and carbon footprint performance level are calculated in accordance with the enabling legislation established by the European Commission |
| | 2027. 07. 01 | Demonstrate in the accompanying technical file that the declared cycle carbon footprint value is below the maximum limit set by the enabling act |

**Green**
Environmental

| | Substance name | Limit conditions |
|---|---|---|
| Hazardous Substance Requirements | Mercury and its compounds | Batteries (whether or not contained in appliances) should not contain more than 0.0005% mercury by weight; not more than 0.1% mercury by weight in homogeneous materials of batteries in vehicles regulated by 2000/53/EC. |
| | Picks and their compounds | Not more than 0.01% of picks in battery homogeneous materials in vehicles controlled by 2000/53/EC, not applicable to vehicles exempted under 2000/53/EC Annex II. |

**Durability**
Product attributes

| | Battery type | Timeline | Electrochemical performance and durability parameters |
|---|---|---|---|
| Electrochemical and durability performance | General purpose and portable | 2027. 01. 01 | Battery capacity, minimum mean discharge time, shelf life, cycle life, leakage resistance |
| | Rechargeable industrial and electric vehicle batteries with internal storage greater than 2kwh | 2026. 01. 01 | Rated capacity and capacity decay; power and power decay; internal resistance and internal resistance increase; capacity cycle efficiency and its decay; set condition life expectancy |

Figure 3 Requirements of EU's Regulation Concerning Batteries and Waste Batteries on the life cycle of power battery

Meanwhile, in the future, China will carry out research on quantitative standards for whole life cycle GHG emission accounting around road vehicle products and component products. After data accumulation, it will carry out research on basic general standards such as whole life cycle carbon footprint limit standards, terms and definitions, and carbon labels for road vehicle products and component products, gradually improve the standard system of low-carbon development of automobile life cycle. In summary, the current standards and regulations involving automotive product life cycle low-carbon constraints, low-carbon quantitative accounting, etc. are shown in Table 1.

Table 1 Standards and regulations on life cycle low-carbon management for automotive products

| No. | Type | Standard number | Standard name |
|---|---|---|---|
| 1 | Low carbon constraints | COM(2020) 798 final | EU's Regulation Concerning Batteries and Waste Batteries (draft) |
| 2 | | Under development | GB/T Whole life cycle carbon footprint limits for road vehicle products<br>GB/T Whole life cycle carbon footprint limits for road vehicle components |
| 3 | Low carbon quantitative accounting | The GHG Protocol | Product life cycle accounting standards |
| 4 | | ISO 14067:2018 | Carbon footprint of products Requirements and guidelines for quantification |
| 5 | | PAS 2050-2011 | Specification for life cycle greenhouse gas assessment of goods and services |
| 6 | | PEFCR | Rules for product environmental footprint categories: high-voltage rechargeable batteries for mobile applications |
| 7 | | Under development | GB/T Carbon footprint of road vehicle products Type rules Passenger vehicles<br>GB/T Carbon footprint of road vehicle products Type rules Commercial vehicles<br>GB/T Carbon footprint of road vehicle products Type rules Trailers<br>GB/T Carbon footprint of road vehicle products Type rules Motorcycles<br>GB/T Carbon footprint of road vehicle products Type rules Power battery<br>GB/T Carbon footprint of road vehicle products Type rules Others |
| 8 | Low carbon general basis | Under development | GB/T Road vehicles General requirements for carbon management Terms and definitions<br>GB/T Road vehicles General requirements for carbon management Product carbon footprint labeling |

# 03

# LIFE CYCLE GHG EMISSIONS ACCOUNTING METHODOLOGY FOR AUTOMOBILE

This study applies the Life Cycle Assessment (LCA) method to account for the life cycle carbon (GHG) emissions of passenger vehicles. LCA is the compilation and evaluation of inputs, outputs and their potential environmental impacts during the life cycle of a product system.

Based on the requirements of national standards GB/T 24040-2008, GB/T 24044-2008 and ISO 14067-2018, with China Automotive Life Cycle Database (CALCD), Automotive Data of China Co., Ltd. developed China Automotive Life Cycle Assessment Model (CALCM) based on the characteristics of the Chinese automotive industry. At present, the new version of CALCM-2021 has been officially launched. Based on the previous version, the new version is not only clearer and more concise, but also adds data and calculation functions for power battery, manufacturing process and material recycling, which provides more powerful support for the automotive life cycle assessment research work. In order to facilitate the operation of enterprises, it has developed OBS, a life cycle assessment tool, to account for GHG emissions in different product dimensions, such as materials, parts and vehicles, and to provide enterprises with analysis of emission reduction paths. The CACIS was developed to assist OEMs and suppliers to collect, manage and account for GHG emission data in the whole life cycle from raw materials, parts, production, use and recycling. When accounting for GHG emissions, the data information in CACIS can be directly imported into the automotive life cycle assessment tool - OBS for utilization, which reduces the difficulty and process of GHG emissions accounting for enterprises and improves their own GHG emissions accounting and management capabilities.

In this study, the CALCM-2021 model was applied to account for the life cycle GHG emissions of passenger vehicles in China in 2020. The data of model name, model size, vehicle mass, fuel type, fuel consumption, production volume, etc. required in the accounting process were obtained from Automotive Data of China Co., Ltd. The data such as the weight of materials for single passenger vehicle, GHG emission factors of materials, production energy consumption of complete vehicle and GHG emission factors of fuel are derived from CALCD.

Among them, the accounting methods for life cycle GHG emissions of single vehicle, enterprise and fleet of passenger vehicles are detailed in chapters 3.1~3.4.

## 3.1 Vehicle life cycle GHG emissions accounting model

### 3.1.1 Determination of purpose and scope

#### 3.1.1.1 Functional units

Changes relative to 2020: with reference to GB/T 32694 and GB/T 19596-2017, the study object was redefined, with gasoline M1 vehicles (gasoline ICEVs) and diesel M1 vehicles (diesel ICEVs) changed to passenger vehicles that use single gasoline or diesel; conventional hybrid passenger vehicles changed to non-externally rechargeable hybrid passenger vehicles; and plug-in hybrid passenger vehicles changed to plug-in hybrid electric passenger vehicles.

The purpose of this study is to account for the life cycle GHG emissions of passenger cars produced in China. The target of the study is M1 vehicles with a maximum design mass not exceeding 3500 kg, including passenger vehicles that only use gasoline or diesel, non-externally rechargeable hybrid passenger vehicles, plug-in hybrid electric passenger vehicles, and battery electric passenger vehicles (hereinafter referred to as "gasoline vehicles", "diesel vehicles", and "conventional hybrid vehicles", "plug-in hybrid vehicles", "battery electric vehicles"). The functional unit of this study is the transportation service provided by a passenger vehicle driving 1 km during its life cycle, and the life cycle driving mileage is calculated as $(1.5\times10^5)$ km. In this study, according to the IPCC Guidelines for National Greenhouse Gas Inventories, GHG emissions accounted for include greenhouse gas emissions including carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride.

### 3.1.1.2 System boundary

The life cycle system boundary of passenger vehicles evaluated in this study includes the whole life cycle stages including vehicle cycle and fuel cycle of passenger vehicles. Among them, the vehicle cycle of passenger vehicles includes raw material acquisition, material processing and manufacturing, complete vehicle production, and maintenance (tire, lead battery, and fluid replacement); the fuel cycle of passenger cars, i.e., "Well to Wheels (WTW)", includes the production of fuel (Well to Pump) and the use of fuel (Pump to Wheels). For fuel vehicles, WTP includes stages such as crude oil extraction and refining and processing; for electric vehicles, WTP includes stages such as production and transmission of electricity (thermal power, hydropower, wind power, photovoltaic power generation, nuclear power, etc.).

The transportation process of raw materials and parts, etc., the manufacturing of equipment for passenger vehicle production, plant construction and other infrastructure are not included in the boundary. The system boundary diagram of life cycle GHG emission accounting for passenger vehicles is shown in Figure 4.

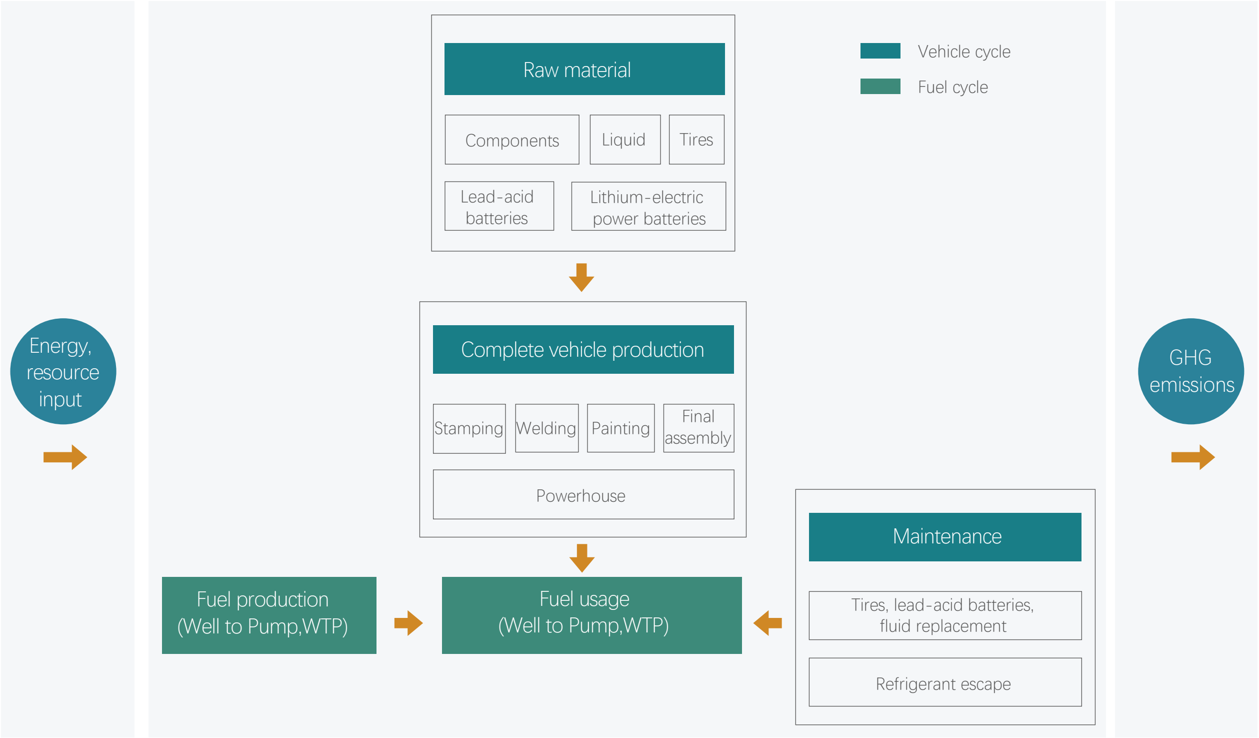


Figure 4 System boundary diagram of life cycle GHG emission accounting for passenger vehicles

## 3.1.2 Inventory data

### 3.1.2.1 Vehicle cycle inventory data

The vehicle cycle in this study no longer accounts for specific parts, but directly accounts for the GHG emissions of materials. The whole vehicle is divided into five parts: components, tires, lead-acid batteries, lithium-ion power batteries and liquids, and a total of 23 materials are verified, considering the ratio of material GHG emissions and weight to each part and the verifiability of the data, as shown in Table 2.

Table 2 Summary of materials within the scope of accounting

| NO. | Material category |
|---|---|
| 1 | Steel |
| 2 | Cast iron |
| 3 | Aluminum and aluminum alloys |
| 4 | Magnesium and magnesium alloys |
| 5 | Copper and copper alloys |
| 6 | thermoplastics |
| 7 | thermosets |
| 8 | Rubber |
| 9 | Fabric |
| 10 | Ceramics / Glass |
| 11 | Lead |
| 12 | Sulfuric acid |
| 13 | Glass fiber |
| 14 | Lithium iron phosphate |
| 15 | Lithium nickel cobalt manganate |
| 16 | Lithium manganate |
| 17 | Graphite |
| 18 | Electrolyte: lithium hexafluorophosphate |
| 19 | Lubricant |
| 20 | Brake fluid |
| 21 | Coolant |
| 22 | Refrigerant |
| 23 | Washing fluid |

The data on the weight ratio of vehicle cycle parts, tires, lead-acid batteries, lithium-ion power batteries and fluids and the respective material composition ratio, material GHG emission factor and GHG emission factor of the whole vehicle production are from CALCM-2021. The data on the weight ratio of parts, tires, lead-acid batteries, lithium-ion power batteries and fluids and the respective material composition ratio are from the dismantled production-weighted average of more than 90 mainstream models of Automotive Data of China Co., Ltd.

In addition, this study accounts for GHG emissions from tire replacement, lead battery replacement, fluid replacement and refrigerant escape during vehicle driving for vehicle cycle, as well as GHG emissions from manufacturing processes such as complete vehicle stamping, welding, painting, final assembly and powerhouse. The number of tire, lead battery, fluid replacement and refrigerant escape is shown in Annex 2.

As shown in Annex 3, the GHG emission data of vehicle materials, energy, fuel and vehicle production in this study are obtained from the China Automotive Life Cycle Database (CALCD), which represents the average data in China. CALCD is the first localized automotive life cycle database in China, covering more than 20,000 items of life cycle inventory process data related to automotive products, including basic materials, energy, transportation and processing, as well as product process data such as key automotive components and complete vehicles with inventory data categories including resource consumption, energy consumption, environmental pollutant emissions, greenhouse gas emissions, and economic costs.

#### 3.1.2.2 Fuel cycle inventory data

The fuel consumption data for passenger vehicles in this study are based on test data from the NEDC.

The GHG emission factor data for fuel production were obtained from the CALCD and represent the average level in China, as shown in Annex 4. Among them, the GHG emission factors for electricity are measured based on the energy structure in China in 2017 (64.7% for coal power, 18.6% for hydropower, 6.5% for renewable power, 3.9% for nuclear power, 3.2% for natural gas power, and 3.1% for oil power) according to the national average level.

GHG emissions from fuel use were calculated using the $CO_2$ conversion coefficient in GB 27999-2019. For gasoline use, they are calculated using 2.37 kg$CO_2$e/L and for diesel use, they are calculated using 2.60 kg$CO_2$e/L; GHG emissions from the use of electricity were calculated using 0.

## 3.2 Single-vehicle life cycle GHG emission accounting method

### 3.2.1 Vehicle cycle GHG emission accounting method

Vehicle cycle GHG emissions are calculated according to equation (1).

$$C_{Vehicle} = C_{Material} + C_{Production} + C_{Relcement} \quad \ldots\ldots (1)$$

Where: $C_{Vehicle}$ ——— vehicle cycle GHG emissions，kg$CO_2$e

$C_{Material}$ ——— GHG emissions from raw material acquisition，kg$CO_2$e

$C_{Production}$ ——— GHG emissions from the production of the whole vehicle，kg$CO_2$e

$C_{Relcement}$ ——— GHG emissions from maintenance (tire, lead battery, refrigerant replacement),kg$CO_2$e

### 3.2.1.1 Raw material acquisition stage

Changes relative to 2020;

(a) This year, the GHG emissions of the raw material acquisition stage is no longer calculated in accordance with the complete vehicle, but divided into five separate parts, including component materials, lead-acid batteries, lithium-ion power batteries, tires and liquids.

(b) The scope of raw materials was expanded and the materials with ratio of weight or GHG emissions accounting for more than 1% of each part of the material were incorporated into the accounting scope. Fabric and glass fiber and four new liquid materials were added, respectively, namely lubricants, brake fluid, coolant and washing fluid, etc.

(c) Plastics were classified as thermoplastics and thermosets without being distinguished separately.

(d) The GHG emission factors of some materials were updated.

The GHG emissions of raw materials acquisition stage should be calculated according to equation (2) with the calculation results rounded (rounded off) to two decimal places.

$$C_{Materials} = C_{Parts} + C_{Lead\ acid\ battery} + C_{Li\text{-}Ion\ battery} + C_{Tyres} + C_{Fluids} \cdots\cdots(2)$$

Where $C_{Material}$ ——— GHG emissions from the raw material acquisition stage, $kgCO_2e$

$C_{Parts}$ ——— GHG emissions from components, $kgCO_2e$

$C_{Lead\ acid\ battery}$ ——— GHG emissions from lead-acid batteries, $kgCO_2e$

$C_{Li\text{-}Ion\ battery}$ ——— GHG emissions from lithium-ion power battery, $kgCO_2e$

$C_{Tyres}$ ——— GHG emissions from tires, $kgCO_2e$

$C_{Fluids}$ ——— GHG emissions from liquid, $kgCO_2e$

Automobile parts (the whole vehicle excluding tires, batteries and liquid parts) GHG emissions should be calculated according to equation (3) with the calculation results rounded (rounded off) to two decimal places.

$$C_{Parts} = \sum ( M_{Part\ material\ i} \times CEF_{Part\ material\ i} ) \cdots\cdots(3)$$

Where $C_{Parts}$ ——— GHG emissions of the component, $kgCO_2e$

$M_{Part\ material\ i}$ ——— weight of part material i, kg.

$CEF_{Part\ material\ i}$ ——— GHG emission factor of component material i, $kgCO_2e/kg$.

The equation for calculating GHG emissions from lead-acid batteries is shown in equation (4) with the calculation results rounded (rounded off) to two decimal places:

$$C_{\text{Lead acid battery}} = \sum\left(M_{\text{Lead acid battery material } i} \times CEF_{\text{Lead-acid battery material } i}\right) \cdots\cdots(4)$$

Where $C_{\text{Lead acid battery}}$ ——— GHG emission of lead-acid battery, kg$CO_2$e

$M_{\text{Lead acid battery material } i}$ ——— weight of lead-acid battery material i, kg

$CEF_{\text{Lead-acid battery material } i}$ ——— GHG emission factor of lead-acid battery material i, kg$CO_2$e/kg

The lithium-ion power battery GHG emissions of battery electric passenger vehicles, plug-in hybrid electric passenger vehicles and non-external rechargeable hybrid passenger vehicles can be calculated separately and the weight of the power battery of passenger vehicles that only use gasoline or diesel is calculated as 0. Calculation equation is shown in equation (5) or (6) with the calculation results rounded (rounded off) to two decimal places.

$$C_{\text{Li-Ion battery}} = \sum\left(M_{\text{Li-Ion battery } i} \times CEF_{\text{Li-Ion battery } i}\right) \cdots\cdots(5)$$

$$C_{\text{Li-Ion battery}} = R_{\text{Li-Ion battery}} \times CEF_{\text{Li-Ion battery}} \cdots\cdots(6)$$

Where $C_{\text{Li-Ion battery}}$ ——— GHG emission of lithium-ion power battery, kg$CO_2$e

$M_{\text{Li-Ion battery } i}$ ——— weight of lithium-ion power battery material i, kg

$CEF_{\text{Li-Ion battery } i}$ ——— GHG emission factor of lithium-ion power battery material i, kg$CO_2$e/kg

$R_{\text{Li-Ion battery}}$ ——— capacity of lithium-ion power battery, kWh

$CEF_{\text{Li-Ion battery}}$ ——— GHG emission factor of lithium-ion power battery pack, kg$CO_2$e/kWh

Tire GHG emissions can be calculated separately, and the calculation equation is shown in equation (7) with the calculation results rounded (rounded off) to two decimal places.

$$C_{\text{Types}} = \sum\left(M_{\text{Types material } i} \times CEF_{\text{Types material } i}\right) \cdots\cdots(7)$$

Where $C_{\text{Types}}$ ——— GHG emissions of tires, kg$CO_2$e

$M_{\text{Types material } i}$ ——— weight of tire (5 including 1 spare tire) material i, kg

$CEF_{\text{Types material } i}$ ——— GHG emission factor of tire material i, kg$CO_2$e/kg

The equation for calculating liquid GHG emissions is shown in equation (8) with the calculation results rounded (rounded off) to two decimal places.

$$C_{Fluids} = \sum(M_{Fluid\ material\ i} \times CEF_{Fluid\ material\ i}) \cdots\cdots(8)$$

Where $C_{Fluids}$ ——— GHG emissions of liquids, kg$CO_2$e

$M_{Fluid\ material\ i}$ ——— weight of liquid material i, kg

$CEF_{Fluid\ material\ i}$ ——— GHG emission factor of liquid material i, kg$CO_2$e/kg

### 3.2.1.2 Complete vehicle production stage

Change relative to 2020: The low-level calorific value and carbon content per unit calorific value of common fossil fuels were updated.

The GHG emission of the complete vehicle production stage should be calculated according to equation (9) with the calcula-

$$C_{Production} = \sum(E_r \times CEF_r + E_r \times NCV_r \times CEF'_r) + M_{CO_2} \cdots\cdots(9)$$

Where $C_{Production}$ ——— GHG emissions from the production stage of the complete vehicle, kg$CO_2$e

$E_r$ ——— the amount of energy or fuel r purchased externally, kWh, m3or kg, etc

$CEF_r$ ——— GHG emission factor of energy or fuel r production, kg$CO_2$e/kWh, kg$CO_2$e/m3 or kg$CO_2$e/kg

$CEF'_r$ ——— GHG emission factor for energy or fuel r use, t$CO_2$e/GJ

$NCV_r$ ——— the average low-level heat of energy or fuel r, GJ/t, GJ/$10^4$ $Nm^3$; adjustment has been made according to the China Energy Statistics Yearbook 2019

$M^{CO^2}$ ——— the amount of $CO_2$ escape from the welding process, kg$CO_2$e

### 3.2.1.3 Repair and maintenance stage

Changes relative to 2020: the replacement of liquid materials such as new lubricants, brake fluid, coolant and washing fluid was taken into consideration and the number of replacements is shown in Annex 2.

GHG emissions from maintenance (tires, lead batteries, fluid replacement and refrigerant escape) are calculated according to equation (10).

$$C_{Re\ placement} = C_{Tyre\ r} + C_{Lead\ acid\ battery\ r} + C_{Fluids\ r} \quad \cdots\cdots(10)$$

Where $C_{Replacement}$ ——— Carbon emission at the stage of repair and maintenance, $kgCO_2e$

$C_{Tyre\ r}$ ——— Carbon emission due to the replacement of tyres (4 tyres) at the stage of use, kgCO2e

$C_{Lead\ acid\ battery\ r}$ ——— Carbon emission due to the replacement of lead acid battery, kgCO2e

$C_{Fluids\ r}$ ——— Carbon emission due to the replacement of fluids and the loss of refrigerants (once), kgCO2e

GHG emissions due to tire replacement (2 times, 4 tires each) should be calculated according to equation (11) with calculation results rounded (rounded off) to two decimal places.

$$C_{Tyres\ r} = \sum(M_{Tyre\ material\ ri} \times CEF_{Tyre\ material\ i}) \times 2 \quad \cdots\cdots(11)$$

Where $C_{Tyres\ r}$ ——— GHG emissions due to tires (4 pcs) replacement during the use stage, $kgCO_2e$

$M_{Tyre\ material\ ri}$ ——— weight of material i of the replacement tires (4 pcs), kg

$CEF_{Tyre\ material\ i}$ ——— GHG emission factor of tire material i, $kgCO_2e/kg$

GHG emissions due to lead-acid battery replacement (2 times) should be calculated according to equation (12) with calculation results rounded (rounded off) to two decimal places.

$$C_{lead\ acid\ battery\ r} = \sum(M_{lead\ acid\ battery\ material\ i} \times CEF_{Fluid\ material\ i}) \times 2 \quad \cdots\cdots(12)$$

Where $C_{lead\ acid\ battery\ r}$ ——— GHG emissions due to lead-acid battery replacement, $kgCO_2e$

$M_{lead\ acid\ battery\ material\ i}$ ——— weight of lead-acid battery material i, kg

$CEF_{Fluid\ material\ i}$ ——— GHG emission factor of lead-acid battery material i, $kgCO_2e/kg$

GHG emissions due to liquid replacement and refrigerant escape (1 time) should be calculated according to equation (13) with calculation results rounded (rounded off) to two decimal places.

$$C_{Fluids\ r} = \sum(M_{Fluid\ material\ i} \times CEF_{Fluid\ material\ i} \times R_{Fluid\ material\ i}) + M_{Refrigerant} \times GWP_{Refrigeranti} \quad \cdots\cdots(13)$$

Where $C_{Fluids\ r}$ ——— GHG emission due to liquid change and refrigerant escape (1 time) during the use stage, $kgCO_2e$

$M_{Fluid\ material\ i}$ ——— weight of liquid material i, kg $M_{Refrigerant}$ ——— weight of refrigerant, kg

$CEF_{Fluid\ material\ i}$ ——— GHG emission factor of liquid material i, $kgCO_2e/kg$

$R_{Fluid\ material\ i}$ ——— number of replacements of liquid material i

$GWP_{Re\ frigeranti}$ ——— the global warming potential of the refrigerant

## 3. 2. 2 Fuel cycle GHG emission accounting method

### 3.2.2.1 Fuel production stage

Changes relative to 2020: The production boundaries for gasoline and diesel were expanded and the GHG emission factors for gasoline and diesel production were adjusted accordingly.

GHG emission from fuel production of M1 vehicles that only use gasoline or diesel, non-externally rechargeable hybrid passenger vehicles, and battery electric passenger vehicles should be calculated according to equation (14), with the calculation results rounded (rounded off) to two decimal places.

$$C_{Fuel\ production} = FC \times CEF_{Fuel} \times L/100 \quad \cdots\cdots(14)$$

Where $C_{Fuel\ production}$ ——— emissions from fuel production, $kgCO_2e$

$FC$ ——— Fuel consumption, L/100km or kWh/100km, the fuel consumption of gasoline M1 vehicles and diesel M1 vehicles is measured according to GB/T 19233, the fuel consumption of non-externally rechargeable hybrid passenger vehicles is measured according to GB/T 19753, and the power consumption of battery electric passenger vehicles is measured according to GB/T 18386.

$CEF_{Fuel}$ ——— GHG emission factor of fuel production, $kgCO_2e/L$ or $kgCO_2e/kWh$

$L$ ——— life cycle driving range of passenger vehicle, calculated as $(1.5\times10^5)$ km

The GHG emissions from fuel production of plug-in hybrid electric passenger vehicles should be calculated according to equation (15), with the calculation results rounded (rounded off) to two decimal places.

$$C_{Fuel\ production} = FC_{State\ B} \times L/100 \times \left(1-\sum_{i=1}^{c} UF_e\right) \times CEF_{Gasoline} + EC_{State\ A} \times L/100 \times \sum_{i=1}^{c} UF_e \times CEF_{Electricity} \quad \cdots\cdots(15)$$

Where $C_{Fuel\ production}$ ——— emissions from fuel production, $kgCO_2e$

$FC_{State\ B}$ ——— B-state fuel consumption of externally rechargeable hybrid passenger vehicles, L/100km, using the value measured according to GB/T 19753.

$L$ ——— life cycle driving range of passenger vehicle, calculated as $(1.5\times10^5)$ km

$\sum_{i=1}^{c} UF_e$ ——— cumulative value of battery electricity utilization factor as of c test cycles, calculated according to GB/T 19753

$CEF_{Gasoline}$ ——— the GHG emission factor for gasoline production, $kgCO_2e/L$

$EC_{State\ A}$ ——— A-state electric power consumption of externally rechargeable hybrid passenger vehicles, in kilowatt hours per 100 kilometers (kWh/100km), using the values measured according to GB/T 19753

$CEF_{Electricity}$ ——— GHG emission factor of electricity production, $kgCO_2e/kWh$

### 3.2.2.2 Fuel use stage

The GHG emission during the fuel use of M1 vehicles that only use gasoline or diesel, non-external rechargeable hybrid passenger vehicles, battery electric passenger vehicles should be calculated in accordance with equation (16) with the calculation results rounded (rounded off) to two decimal places.

$$C_{Fuel\ use} = FC \times K_{CO_2} \times L/100 \quad \cdots\cdots(16)$$

Where $C_{Fuel\ use}$ ———— GHG emissions from fuel use process, $kgCO_2e$

$FC$ ———— fuel consumption, L/100km or kWh/100km, the fuel consumption of gasoline M1 vehicles and diesel M1 vehicles is measured according to GB/T 19233, the fuel consumption of non-externally rechargeable hybrid passenger vehicles is measured according to GB/T 19753, and the power consumption of battery electric passenger vehicles is measured according to GB/T 18386.

$K_{CO_2}$ ———— conversion coefficient refers to GB/T 19753, which is 2.37 kg/L for gasoline models, 2.60 kg/L for diesel models, and 0 for battery electric passenger vehicles.

$L$ ———— life cycle driving range of passenger vehicles, calculated as $(1.5 \times 10^5)$ km

The GHG emission of plug-in hybrid electric passenger vehicle during fuel use process should be calculated according to equation (17) with the calculation results rounded (rounded off) to two decimal places.

$$C_{Fuel\ use} = FC_{State\ B} \times L/100 \times \left(1-\sum_{i=1}^{c} UF_c\right) \times K_{CO_2} \quad \cdots\cdots(17)$$

Where $C_{Fuel\ use}$ ———— GHG emissions from fuel use process, $kgCO_2e$

$FC_{State\ B}$ ———— B-state fuel consumption of externally rechargeable hybrid passenger vehicle, L/100km, using the value measured according to GB/T 19753.

$L$ ———— life cycle driving range of passenger vehicles, calculated as $(1.5 \times 10^5)$ km

$\sum_{i=1}^{c} UF_c$ ———— cumulative value of battery electricity utilization factor as of c test cycles, calculated according to GB/T 19753

$K_{CO_2}$ ———— conversion coefficient, 2.37 kg/L for gasoline models

## 3.3 Enterprise average life cycle GHG emission accounting method

The enterprise GHG emission accounting adopts the output-weighted average method. The annual average GHG emissions of an enterprise are calculated by dividing the sum of the product of the GHG emissions of each model of the enterprise

$$C_{Enterprise} = \frac{\sum_{1}^{N} C_i \times V_i}{\sum_{1}^{N} V_i} \quad \cdots\cdots(18)$$

Where $C_{Enterprise}$ ———— average GHG emissions of the enterprise, $gCO_2e/km$

$C_i$ ———— GHG emission of the ith model, $gCO_2e/km$

$i$ ———— serial number of passenger vehicle models

$V_i$ ———— the annual production of the ith model

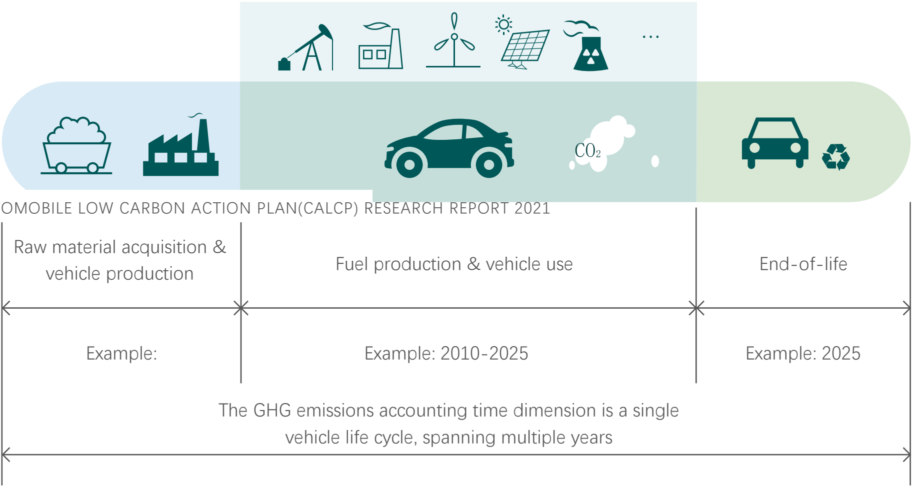
## 3.4 Fleet life cycle GHG emission accounting method

The China Automotive Fleet-based Life Cycle Assessment Model (CAFLAM) accounts for GHG emissions at the fleet level of passenger vehicles from a life cycle perspective. Compared with the single vehicle model, which focuses on the carbon intensity of vehicle products, the fleet model focuses on the total GHG emissions of the vehicle industry. The fleet model can be used for the following purposes:

(1) Calculate the future fleet stock structure through the input of parameters such as historical retention structure, vehicle survival rate, and future stock or sales volume;

(2) Calculate the total GHG emissions generated by vehicles in the fleet at different life cycle stages based on the fleet stock structure;

(3) Calculate the year-by-year trend of total fleet GHG emissions under different scenarios through a series of parameter settings; based on the calculation results, provide relevant policy recommendations for GHG emission reduction in the automotive industry.



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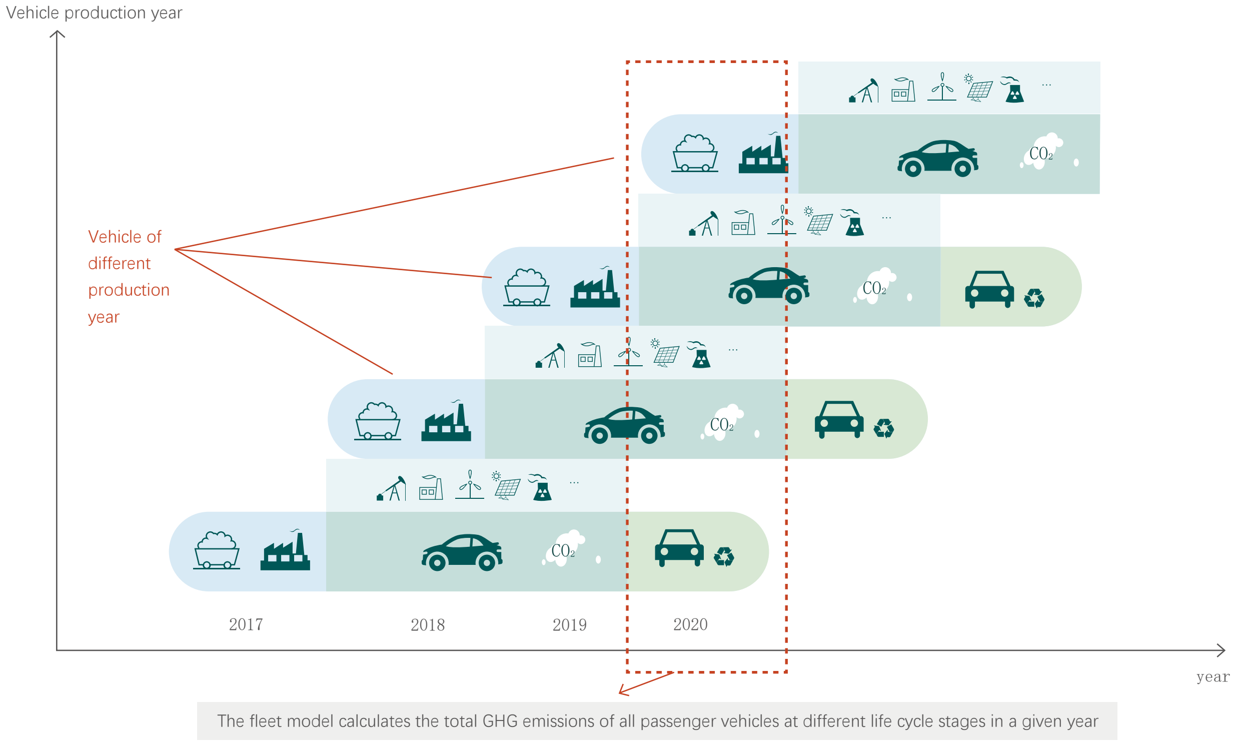


The fleet model calculates the total GHG emissions of all passenger vehicles at different life cycle stages in a given year

Figure 5: Differences between the life cycle GHG emissions accounting methods for single passenger vehicle and fleets

Figure 5 shows the main differences between the life cycle GHG emissions accounting method for passenger vehicles and the GHG emissions accounting method for fleets. For a passenger vehicle, the time dimension of GHG emissions accounting is the life cycle of the vehicle, i.e. the GHG emissions generated from the raw material extraction to the end of the vehicle's life; for a passenger vehicle fleet, the time dimension of GHG emissions accounting is a time section, i.e. a specific year, and the life cycle GHG emissions of the fleet is the sum of GHG emissions of all vehicles at different life cycle stages in the fleet stock in that year.

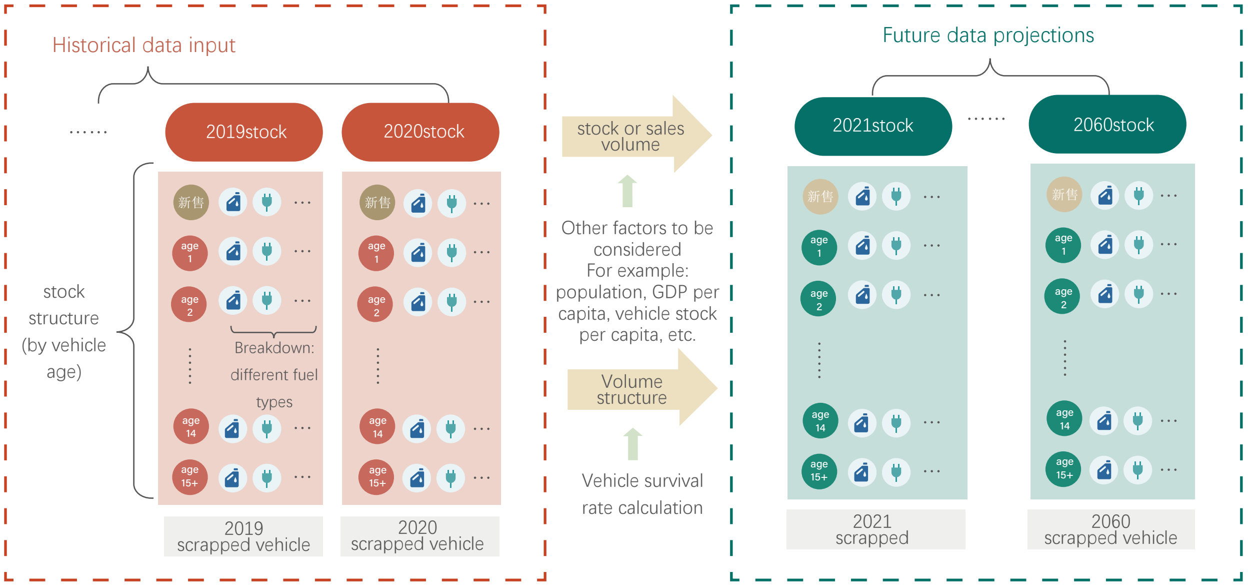


Figure 6 Calculation method of the stock structure of passenger vehicle fleets

To account for GHG emissions at the fleet level, the most important point is to clarify the fleet stock structure, i.e., the ratio of vehicles in the fleet in a given year under different age and fuel type and other labels. Firstly, as mentioned earlier, at different life stages of vehicles, GHG emissions to be considered are different. For example, for new vehicles sold in the year, the GHG emissions generated from the acquisition of raw materials and vehicle production need to be calculated; while for vehicles in service, the GHG emissions generated from fuel production and fuel use need to be calculated; secondly, for vehicles by fuel type, the emissions generated from their use stages need to be calculated separately, because the emission factors for the production and use stages of different fuels are different; in addition, for vehicles of different ages, the fuel consumption and annual driving range may be different. Therefore, their GHG emissions from the fuel cycle will be different.

The fleet stock structure is calculated as shown in Figure 6 in the following way.

$$Stock_{y,t} = Stock_{y-1,t} + Sale_{y,t} - Scrap_{y,t} \quad \cdots\cdots(19)$$

Where *Stock* ———— fleet stock, units

*Sale* ———— new vehicles sold, units

*Scrap* ———— scrapped vehicle, units

where *y* ———— year

*a* ———— age of the vehicle

*t* ———— fuel type

For the end-of-life vehicle Scrap, there are:

$$Scrap_{y,t,a} = Stock_{y-1,t,a} \times (1 - SR_a) \quad \cdots\cdots(20)$$

$$Scrap_{y,t} = \sum_{a=age} Scrap_{y,t,a} \quad \cdots\cdots(21)$$

Where *SR* ———— vehicle survival rate, %

Survival rate is defined as follows:

$$SR_a = \frac{P_{(op,a)}}{P_{(op,a-1)}} \quad \cdots\cdots(22)$$

That is, it is the probability that the vehicle will still operate normally at the age of a under the condition that the vehicle at the age of a-1 operates normally. The vehicle survival rate in this study is referenced from the literature[8].

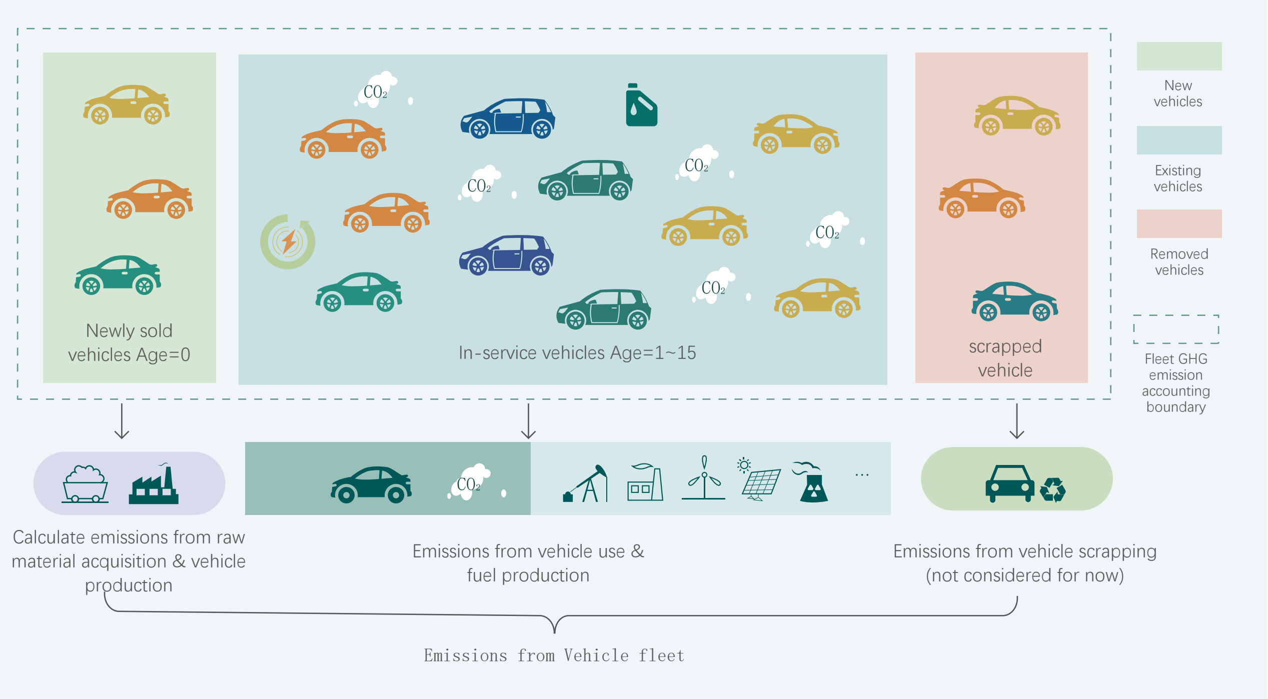


Figure 7 Life cycle GHG emission accounting boundary for passenger vehicle fleets

After obtaining the structure of passenger vehicle fleet stocks for each year, GHG emissions can be calculated for vehicles of different ages and fuel types to obtain the GHG emissions of the fleet as a whole. The accounting boundary for the life cycle carbon emissions of the passenger vehicle fleet is shown in Figure 7. For vehicles aged 0, i.e., newly sold vehicles, the GHG emissions from raw material acquisition and vehicle production are calculated; for vehicles aged 1 to 15, the GHG emissions from fuel production and fuel use are calculated; for scrapped vehicle, the GHG emissions from the scrap stage are calculated. Due to the lack of data on the scrap stage, carbon emissions from this stage are not considered in this study at this time.

The specific accounting methods for the life cycle GHG

$$C_{fleet,y,t} = Sale_{y,t} \times C_{vehicle,y,t} + \sum_{a=1}^{a=15} Stock_{a,y,t} \times FC_{a,y,t} \times VKT_{a,y,t} \times (CEF_{y,t} + K_{CO_2}) \quad \cdots\cdots(23)$$

Where $C_{fleet,y,t}$ ——— fleet life cycle GHG emissions, kg$CO_2$e

$C_{vehicle,y,t}$ ——— single vehicle cycle GHG emissions, kg$CO_2$e

$FC$ ——— fuel consumption, L/100 km, kWh/100 km or kg/100 km

$VKT$ ——— driving range of vehicle per year, km

$CEF$ ——— GHG emission factor for fuel production, kg$CO_2$e/L, kg$CO_2$e/kWh or kg$CO_2$e/kg

$K_{CO_2}$ ——— conversion coefficient refers to GB/T 19753, 2.37 kg/L for gasoline models, 2.60 kg/L for diesel models, and 0 for battery electric passenger vehicles

# 04

# STATUS ANALYSIS: 2020 VEHICLE LIFE CYCLER GHG EMISSIONS STUDY RESULTS

## 4.1 Single vehicle life cycle GHG emission research results

### 4.1.1 Research results of single vehicle life cycle GHG emissions of passenger vehicles

#### 4.1.1.1 4.1.1.1Total life cycle GHG emissions of passenger vehicles

In this study, based on the aforementioned GHG emission accounting method and 2020 passenger vehicle sales data (excluding imported models), the total life cycle GHG emissions of passenger vehicles in 2020 were measured and the results show that the total life cycle GHG emissions of passenger vehicles in 2020 were huge, at 670 million t $CO_2$ e and effective control of passenger vehicle GHG emissions is crucial for China to achieve GHG emission reduction targets and peak GHG emissions. Next, analysis will be given on GHG emissions by fuel type, class and different life cycle stages.

（1） GHG emission analysis of models by fuel type

Figure 8 shows the whole life cycle GHG emissions of passenger vehicles by fuel type in 2020, including gasoline vehicles, diesel vehicles, conventional hybrid vehicles, plug-in hybrid vehicles and battery electric vehicles.

As can be seen in Figure 8, there are significant differences in the GHG emissions of passenger vehicles by fuel type. Relative to other vehicle types, gasoline vehicles contribute the vast majority of the total life cycle GHG emissions of passenger vehicles sold in 2020, emitting 630 million t $CO_2$e, accounting for 94.2%; followed by battery electric vehicles, accounting for 3.0% of the total life cycle GHG emissions (20 million t $CO_2$e); the remaining three fuel types of passenger vehicles emit a total of 20 million t $CO_2$e, accounting for only 3%, contributing little to the total life cycle GHG emissions of passenger vehicles sold in 2020.

Similar to 2019, gasoline vehicles will account for a much higher ratio of GHG emissions than other fuel types in 2020, partly because of their higher GHG emissions per vehicle, and partly because gasoline vehicles will have the highest ratio of sales among the models sold in 2020. The higher total GHG emissions of battery electric vehicles and conventional hybrid vehicles are also related to their sales volume. As shown in Figure 9, 17.486 million gasoline vehicles were sold in 2020, accounting for 91.9% of total sales in 2020; 412,000 conventional hybrid vehicles were sold in 2020, accounting for 2.2% of total sales in 2020; 209,000 plug-in hybrid vehicles were sold in 2020, accounting for 1.1% of total sales in 2020; and 910,000 battery electric vehicles were sold in 2020, accounting for 4.8% of total sales in 2020.

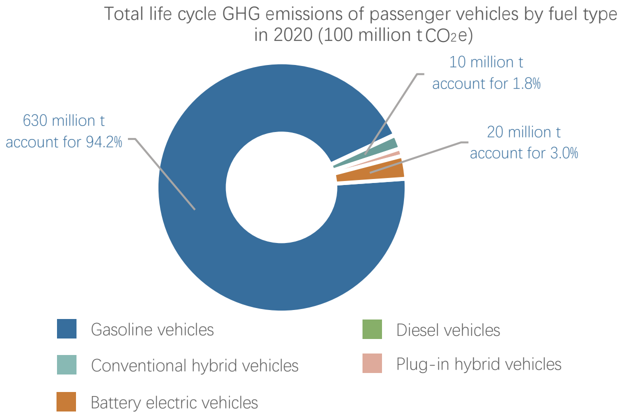


Figure 8 Life cycle GHG emissions of passenger vehicles by fuel type

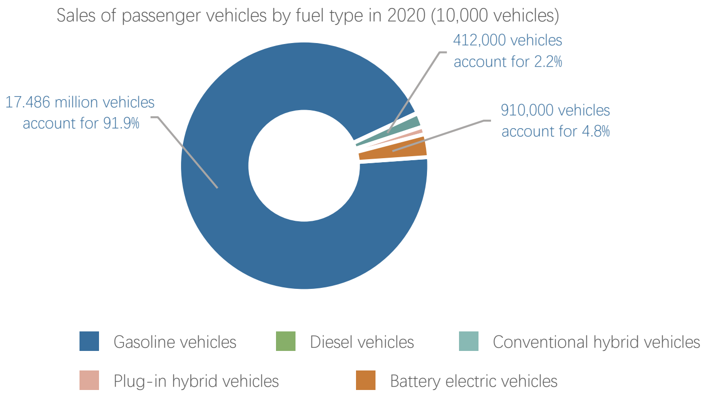


Figure 9 Sales of passenger vehicles by fuel type in 2020

### (2) GHG emission analysis of vehicles by class

Figure 10 shows the whole life cycle GHG emissions of passenger vehicles by class sold in 2020. Figure 11 shows the sales volume of passenger vehicles by class. The vehicle classes in this report are classified into seven categories: A00, A0, A, B, C, D and "Other". As can be seen in Figure 10, there are significant differences in the GHG emissions of passenger vehicles by class. Compared with other classes of vehicles, Class A vehicles account for a larger share of the total life cycle GHG emissions of passenger vehicles sold in 2020, emitting a total of 400 million t $CO_2$e, accounting for 59.1%, followed by Class B vehicles, emitting 160 million t $CO_2$e, accounting for 24.3%. The rest of the vehicle classes emit 110 million t $CO_2$e, accounting for only 16.6%. After analysis, it can be seen that the reason why GHG emissions of Class A passenger vehicles are much higher than those of other classes is mainly due to their higher sales volume than other models. As shown in Figure 11, 11.464 million Class A passenger vehicles were sold in 2020, accounting for 60.2% of the total sales in 2020.

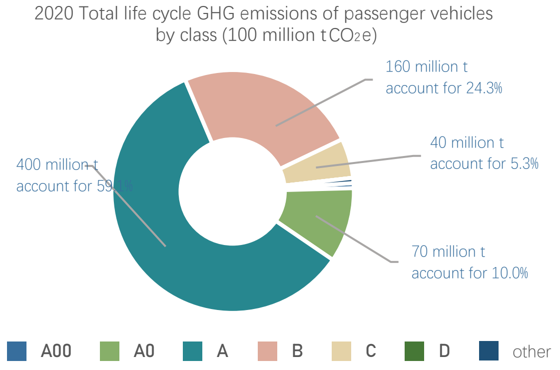


Figure 10 Life cycle GHG emissions of passenger vehicles by class

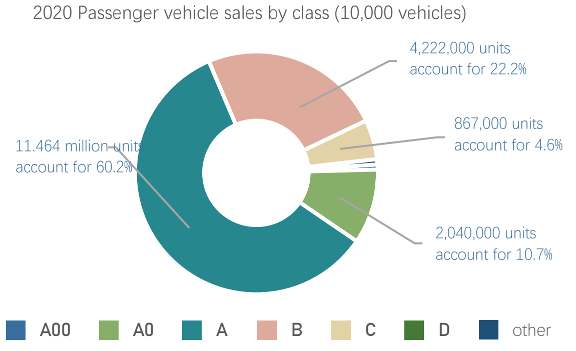


Figure 11 Sales volume of passenger vehicles by class in 2020

### 4.1.1.2 Life cycle GHG emissions of passenger vehicles by fuel type

According to the accounting method of single-vehicle GHG emissions, the sales volume of passenger vehicles by fuel type is weighted and averaged to calculate the average GHG emissions per kilometer driven of passenger vehicles by fuel type in 2020, as shown in Figure 12. Among the five passenger vehicles with five different fuel types, diesel vehicles have the highest average GHG emission, which is significantly higher than other fuel types, at 331.3g $CO_2$e/km; gasoline vehicles have the next highest average GHG emission, at 241.9g $CO_2$e/km; plug-in hybrid vehicles have 211.1g $CO_2$e/km; conventional hybrid vehicles have 196.6g $CO_2$e/km, and battery electric vehicles have the lowest GHG emissions, at 146.5g $CO_2$e/km.

Compared with 2019, the average GHG emissions of gasoline, diesel, conventional hybrid, and plug-in hybrid vehicles are higher and the average GHG emissions of battery electric vehicles are lower due to the updated accounting methodology. Among them, the emission of conventional hybrid vehicles, diesel vehicles, plug-in hybrid vehicles, gasoline vehicles increased by 17.6%, 17.5%, 16.7% and 15.7% respectively and the emission of battery electric vehicles decreased by 4.8%, as the A00 battery electric vehicles with lower GHG emissions per kilometer driven accounted for 32.7%, which contributed more to the reduction of average GHG emissions among battery electric vehicles sold in 2020.

Compared with traditional gasoline and diesel vehicles, conventional hybrid vehicles, plug-in hybrid vehicles and battery electric vehicles have GHG emission reduction potential, of which, battery electric vehicles have the greatest GHG emission reduction potential, 39.5% and 55.8% lower than that of gasoline and diesel vehicles, respectively; conventional hybrid vehicles have the second highest GHG emission reduction, 18.7% and 40.6% lower than that of gasoline and diesel vehicles, respectively.

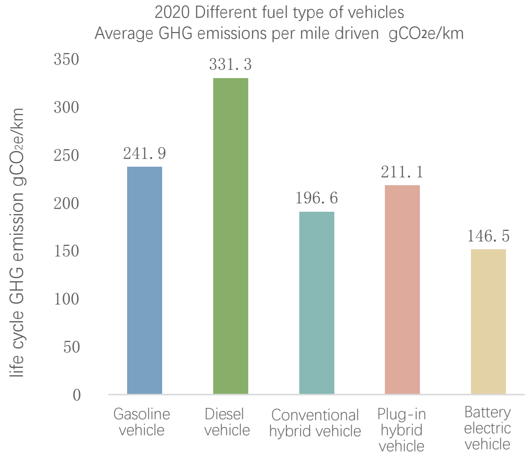


Figure 12 Average GHG emissions per kilometer driven for passenger vehicles by fuel type in 2020

### (1)Analysis of GHG emission ratio of passenger vehicles by fuel type at each life cycle stage

Figure 13 shows the ratio calculated based on GHG emissions of passenger vehicle by fuel type at different stage of life cycle (vehicle cycle and fuel cycle). It can be seen that the life cycle GHG emission shares of passenger vehicles by fuel type differ significantly and the GHG emission contributions of passenger vehicles of all five fuel types are greater in the fuel cycle stage than in the vehicle cycle stage. The GHG emissions of gasoline and diesel vehicles mainly come from the fuel cycle, accounting for 76.0% and 75.3%, respectively. With the increase of electrification of vehicle models, the ratio of vehicle cycle gradually increases, while the fuel cycle gradually decreases. The ratios of vehicle cycle GHG emissions and fuel cycle GHG emissions of battery electric vehicles are close to each other, but the ratio of fuel cycle is still slightly higher.

Ratio of GHG emissions of passenger vehicles by fuel type at different stages of life cycle

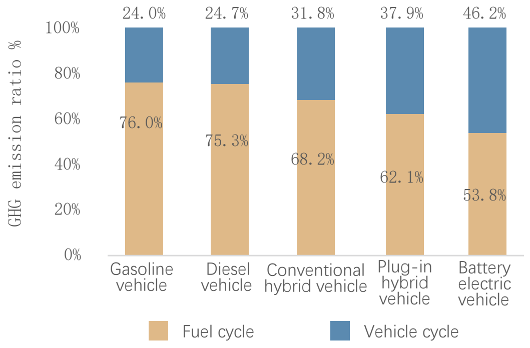


Figure 13 Ratio of GHG emissions of passenger vehicles by fuel type at different stages of life cycle

Compared with the data in the Research Report on China Automotive Low Carbon Action Plan 2020, the vehicle cycle GHG emission ratios of all five fuel types show an increasing trend as the accounting method in this report expands the scope of vehicle cycle accounting.

The large gap between the ratios of vehicle cycle and fuel cycle of conventional fuel vehicles and battery electric vehicles is mainly due to two aspects. On one hand, as electric vehicles need to be driven by power batteries, the raw material acquisition of power batteries and the manufacturing stage of batteries will emit a large amount of greenhouse gases. Therefore, the GHG emissions of battery electric vehicles in the vehicle cycle stage will increase compared with fuel vehicles. On the other hand, as battery electric vehicles are driven by electricity, the energy conversion efficiency of battery electric vehicles is higher than that of fuel vehicles, and the direct emissions during the use of battery electric vehicles are zero. Therefore, the GHG emissions of the fuel cycle of battery electric vehicles will be lower compared with fuel vehicles.

### (2) Analysis of GHG emission ratio of passenger vehicles by class at each stage of life cycle

As shown in Figure 14, the ratios of GHG emissions of passenger vehicles by fuel type are further analyzed (Class D and "other" passenger vehicles are not included in the comparison). For vehicle of different fuel types, according to the order of A00, A0, A, B, C, as the model level increases (the model becomes larger), the ratio of fuel cycle roughly shows a gradually decreasing trend. For plug-in hybrid vehicles, the fuel cycle ratio of Class B vehicles is slightly higher than that of Class A vehicles, probably because, compared with Class A vehicles, the average fuel consumption, electricity consumption and battery capacity of Class B vehicles increase, which has a greater impact on GHG emissions, leading to an increase in the fuel cycle ratio of Class B vehicles.

Breakdown of the ratio of GHG emissions of passenger vehicles by fuel type at different stages of life cycle

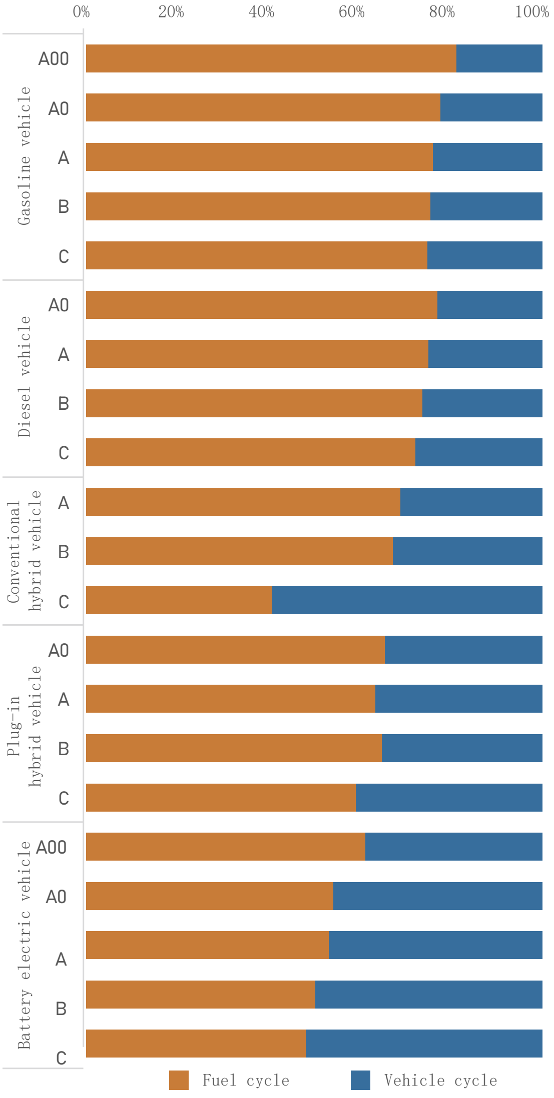


Figure 14 Breakdown of the ratio of GHG emissions of passenger vehicles by fuel type at different stages of life cycle

The fuel cycle GHG emissions of passenger vehicles by fuel type are shown in Figure 15, and the ratio of each part is shown in Figure 16. The vehicle cycle GHG emissions by fuel type vary widely and are distributed between 78.7-231.2g $CO_2e$/km, with diesel vehicles emitting the largest amount of carbon, followed by gasoline vehicles, and battery electric vehicles the least. Secondly, the GHG emissions of each part of the fuel cycle of passenger vehicles by fuel type also differ significantly (Figure 20), with the fuel use GHG emissions of gasoline, diesel and conventional hybrid vehicles accounting for about four times the fuel production; the fuel use GHG emissions of plug-in hybrid vehicles accounting for about 1/3 of the fuel production, which should be related to their fuel characteristics; and the fuel use GHG emissions of battery electric vehicles being 0.

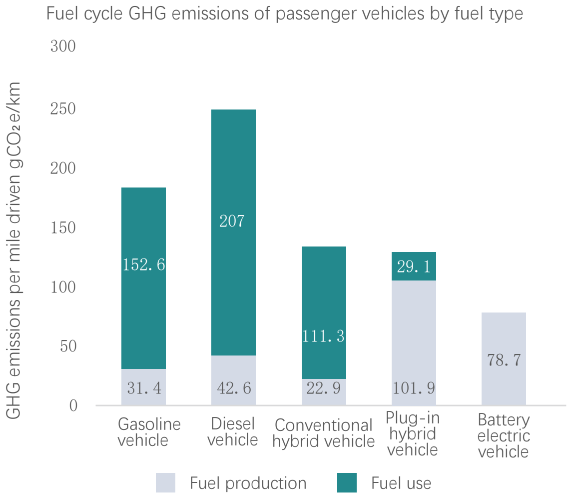


Figure 15 Fuel cycle GHG emissions of passenger vehicles by fuel type

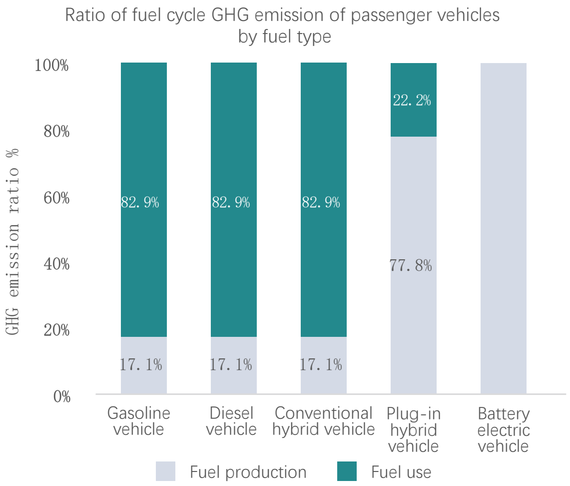


Figure 16 Ratio of fuel cycle GHG emission of passenger vehicles by fuel type

The vehicle cycle GHG emissions of passenger vehicles by fuel type are shown in Figure 17, and the ratio of each component is shown in Figure 18. The vehicle cycle GHG emissions of vehicles by fuel type range from 58.0 to 80.1g $CO_2e$/km, with diesel vehicles emitting the most, followed by plug-in hybrid vehicles, and gasoline vehicles the least. Secondly, the GHG emissions of each part of the vehicle cycle of passenger vehicles by fuel type also differ significantly (see Figure 18), with the highest ratio of GHG emissions in the raw material acquisition stage, followed by refrigerant escape and the least GHG emissions from lead-acid battery replacement.

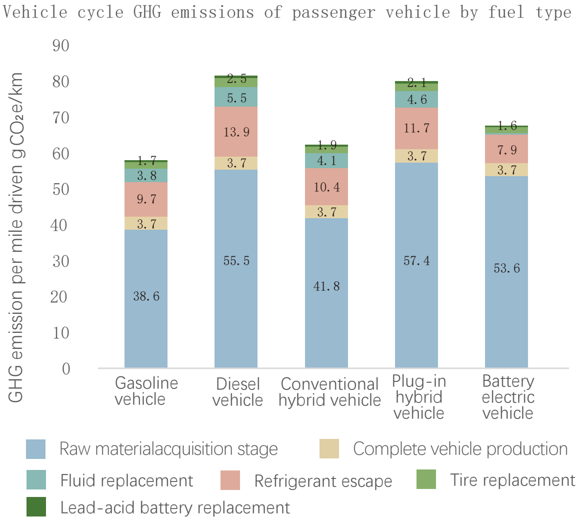


Figure 17 Vehicle cycle GHG emissions of passenger vehicles by fuel type

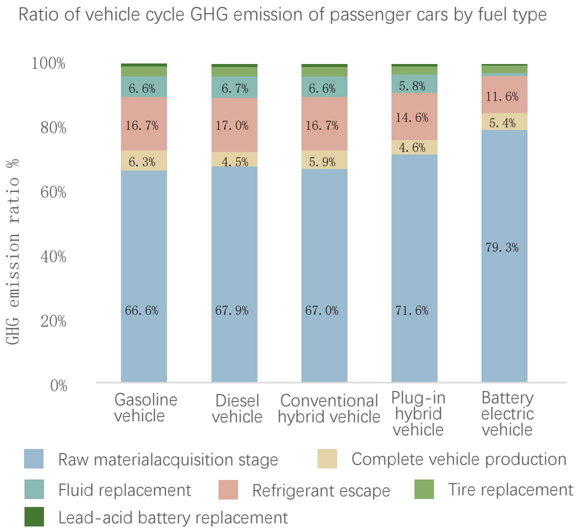


Figure 18 Ratio of vehicle cycle GHG emissions of passenger vehicles by fuel type

The GHG emissions in the raw material acquisition stage of passenger vehicles by fuel type are shown in Figure 19, and the ratio of each part is shown in Figure 20. The GHG emissions in the raw material acquisition stage range from 38.6-57.4g$CO_2$e/km, with plug-in hybrid vehicles having the largest GHG emissions, followed by diesel vehicles, and gasoline vehicles the least. Secondly, the GHG emissions of each part in the raw material acquisition stage of passenger vehicles by fuel type also differ significantly (see Figure 20). With the increase of electrification, the ratio of GHG emissions of component materials gradually decreases, and the ratio of GHG emissions of power battery gradually increases. The ratio of GHG emissions of component materials of gasoline, diesel and conventional hybrid vehicles all exceed 90% and the ratio of component materials of plug-in hybrid vehicles is 77.9%. The ratio of GHG emission from the component materials of battery electric vehicles is 48.1%; the ratio of GHG emission from the power battery of conventional hybrid vehicles is 0.8%, the ratio of GHG emission from the power battery of plug-in hybrid vehicles is 18.3%, and the ratio of GHG emission from the power battery of battery electric vehicles is 49.3%, accounting for nearly half of the raw material acquisition stage, exceeding the ratio of GHG emission from the component materials.

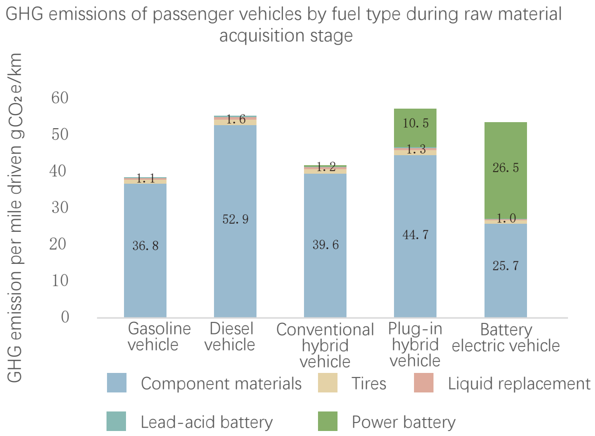


Figure 19 GHG emissions of passenger vehicles by fuel type during raw material

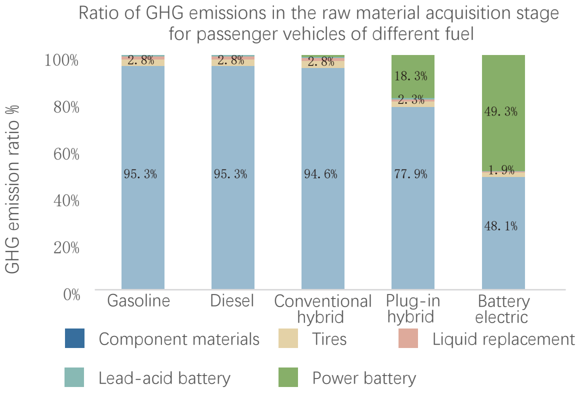


Figure 20 Ratio of GHG emissions of passenger vehicles by fuel type during raw material acquisition stage

### 4.1.1.3 Accounting results of life cycle GHG emissions for passenger vehicles by class

According to the calculation method of the weighted average life cycle GHG emissions of passenger vehicles sales by class (see Appendix 6 for the model classification method), the average value of GHG emissions per kilometer driven for passenger vehicles by class is shown in Figure 21 and Figure 22. It can be seen that in the order of A00, A0, A, B and C, the GHG emission per kilometer driven increases gradually with the increase of the model class, and the average value of class A00 vehicles is 101.9g$CO_2$e/km, and the average value of class C vehicles is 273.4g$CO_2$e/km. The reason for the huge gap between the GHG emission per kilometer driven of class A00 vehicles and other classes of vehicles is that, among class A00 vehicles, the sales of battery electric vehicles with lower GHG emission are large (99.0% of sales), thus lowering the GHG emission per kilometer driven of class A00 vehicles.

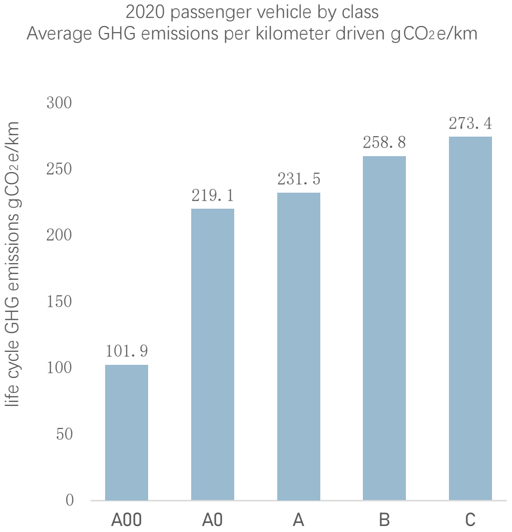


Figure 21 GHG emissions per kilometer driven for passenger vehicles by class

Note: This study does not consider Class A0 diesel vehicles (1 model), Class A0 plug-in hybrid vehicles (3 models), Class C diesel vehicles (1 model), Class C conventional hybrid vehicles (2 models), and Class D vehicles (only 2 models of gasoline vehicles), because their models are small in quantity and their GHG emissions per kilometer driven are not representative; "other" models are not considered because their classification criteria are not clear.

Among the passenger vehicles by fuel type at all levels, GHG emissions per kilometer driven show a decreasing trend in the order of diesel, gasoline, plug-in hybrid, conventional hybrid, and battery electric vehicles, and compared with other fuel types, battery electric passenger vehicles possess the GHG emissions reduction potential throughout their whole life cycle.

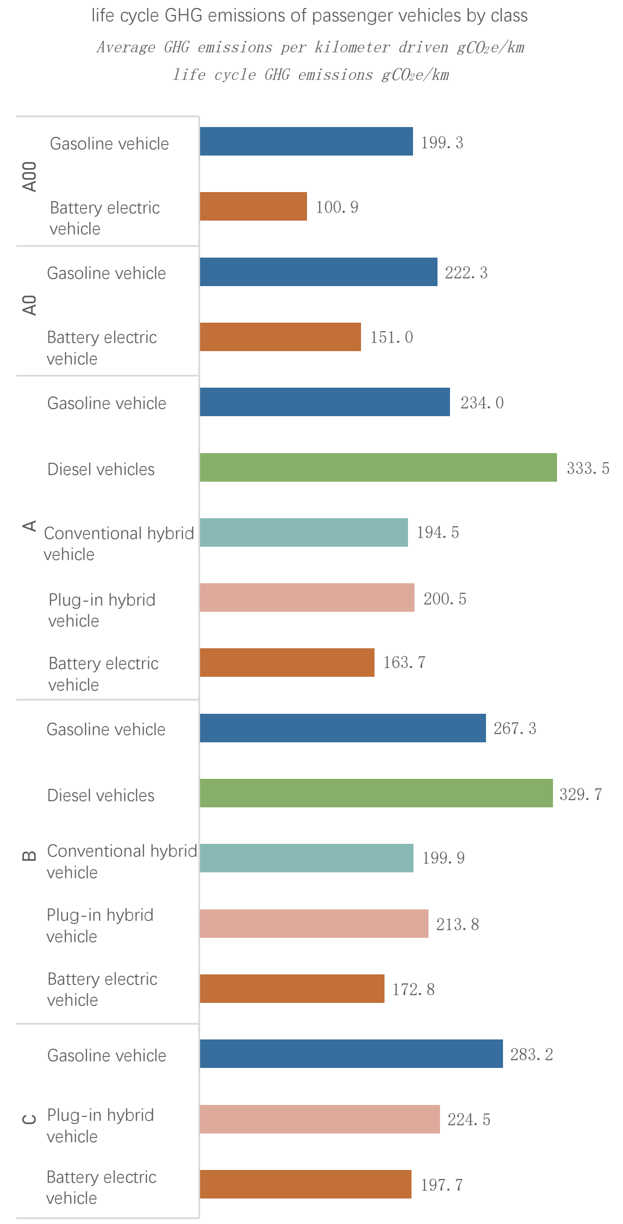


Figure 22 Breakdown of GHG emissions per kilometer driven for passenger vehicles by class

In the following, the GHG emissions per kilometer driven for passenger vehicles by class are shown in detail. In order to reflect the representativeness, the models are filtered according to the sales volume; meanwhile, the models with the same sales name under the same fuel type are filtered to analyze the models with the highest GHG emissions per kilometer driven. After filtering, the data of models of each fuel type are as follows: 392 gasoline vehicles, 8 diesel vehicles, 19 conventional hybrid vehicles, 49 plug-in hybrid vehicles, and 112 battery electric vehicles. The GHG emission ranking per kilometer driven for passenger vehicles by fuel type and class is shown below, broken down into sedans and SUVs (including MPVs). As the number of models under some filtering conditions is small, they are not shown.

### (1) Class A00 passenger vehicles

This section checks the GHG emission data per kilometer driven of class A00 passenger vehicles and there are 16 models of battery electric vehicles, all of which are sedans.

### ▶ Class A00 battery electric vehicles

#### Top 10 sedans

Figure 23 shows the top 10 vehicles with the lowest GHG emission in the Class A00. From the lowest to highest GHG emissions per kilometer driven, they are Hongguang mini (89.4g $CO_2e$/km), Baojun E100 (106.0g $CO_2e$/km), Baojun E200 (106.7g $CO_2e$/km), SAIC Clever (108.7g $CO_2e$/km), Scenery E1 (112.3g $CO_2e$/km), BYD E1 (114.9g $CO_2e$/km), Euler Black Cat (107.7g $CO_2e$/km), Euler White Cat (108.4g $CO_2e$/km), Baojun E300 (122.7g $CO_2e$/km), BAIC EC (125.5g $CO_2e$/km).

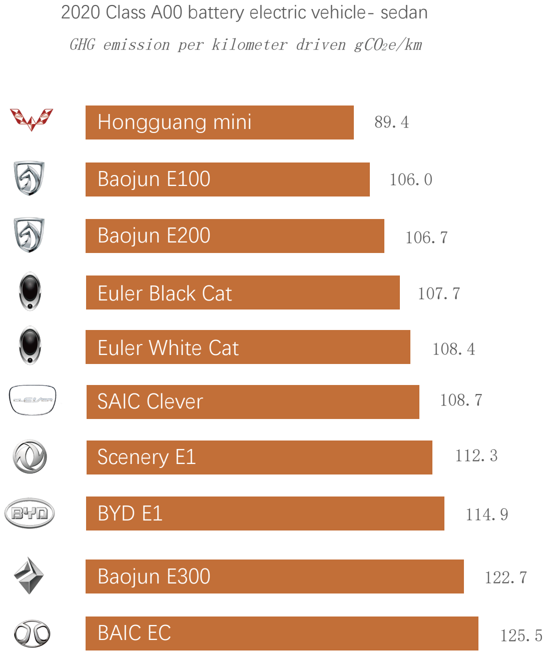


Figure 23 Top 10 models for Class A00 battery electric sedans

## (2) Class A0 passenger vehicles

This section checks the GHG emission data per kilometer driven of Class A0 passenger vehicles. There are 55 models of Class A0 gasoline vehicles; 26 models of battery electric vehicles.

### Class A0 gasoline cars

#### Top 10 sedans

Figure 24 shows the top 10 models of Class A0 gasoline vehicles with the lowest GHG emissions. From the lowest to the highest GHG emissions per kilometer driven, they are Yaris L (192.0g $CO_2e$/km), Yaris L (194.9g $CO_2e$/km), ViosFS (198.3g $CO_2e$/km), Vios (202.0g $CO_2e$/km), Fit (202.6g $CO_2e$/km), Pegas (205.4g $CO_2e$/km), Kia K2 (209.7g $CO_2e$/km), Baojun310 (211.7g $CO_2e$/km), Riona (217.8g $CO_2e$/km), VW POLO (218.7g $CO_2e$/km).The difference in GHG emissions per kilometer driven between the Top 10 and Class A0 gasoline cars is not significant, mainly due to the small difference in overall mass and fuel consumption between their different models.

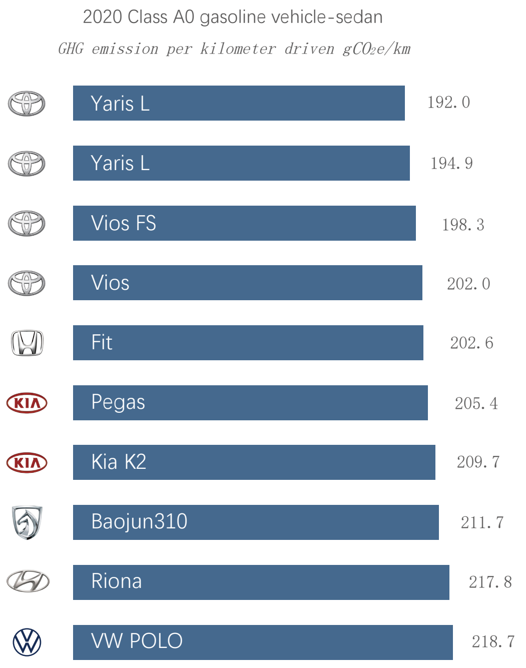


Figure 24 Top 10 models for Class A0 gasoline sedans

#### Top 10 SUVs

Figure 25 shows the top 10 models with the lowest GHG emission for Class A0gasoline SUVs (including MPVs). From lowest to highest GHG emission per kilometer driven, they are Kicks (213.7g$CO_2e$/km), KX1 (218.3g$CO_2e$/km), Vision X3 (222.5g$CO_2e$/km), Hyundai ENCINO (228.0g$CO_2e$/km), Audi Q2L (229.5g$CO_2e$/km), Trumpchi GS3 (231.6g$CO_2e$/km), Binyue (233.8g$CO_2e$/km), Changan CS15 (237.5g$CO_2e$/km), Baojun 510 (239.6g $CO_2e$/km), MG ZS (240.6g$CO_2e$/km). The GHG emission per kilometer driven of Class A0 gasoline SUVs are generally higher than that of sedans, which is related to the higher fuel consumption and overall mass of SUVs.

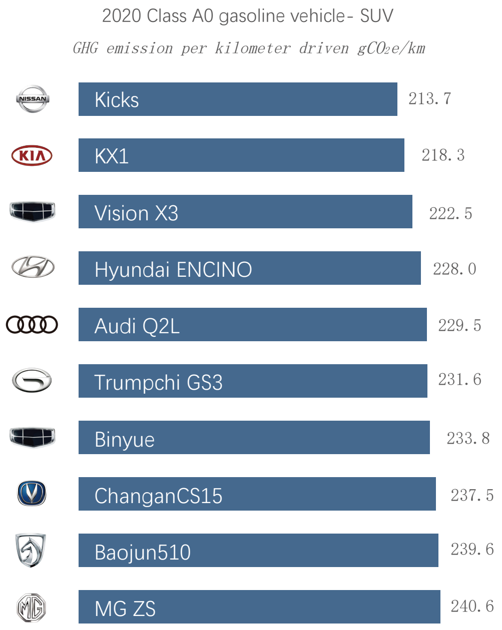


Figure 25 Top 10 models for Class A0 gasoline SUVs

### Class A0 battery electric sedan

#### Top 4 sedans

Figure 26 shows the GHG emissions of four Class A0 battery electric sedans. From lowest to highest GHG emission per kilometer driven, they are Neta V (129.6g $CO_2e$/km), BYD E2 (147.6g $CO_2e$/km), Chery eQ2 (147.7g $CO_2e$/km), and JAC iEV7 (148.4g $CO_2e$/km).

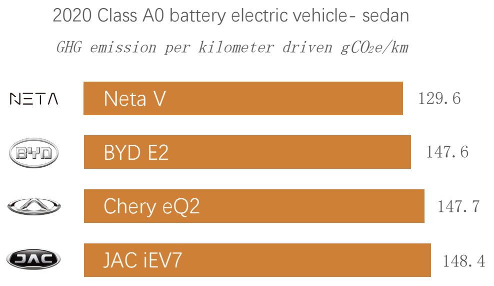


Figure 26 Top 4 models for Class A0 battery electric sedans

### SUV Top10

Figure 27 shows the top 10 models with the lowest GHG emissions for Class A0 battery electric SUVs (including MPVs). From lowest to highest GHG emissions per kilometer driven, they are Neta N01 (144.8g $CO_2$e/km), BYD S2 (148.3g $CO_2$e/km), BYD D1 (154.5g $CO_2$e/km), MG ZS (157.4g $CO_2$e/km), Audi Q2L (157.7g $CO_2$e/km), COS 1°A500 (157.8g $CO_2$e/km), Changxing (157.8g $CO_2$e/km), Changan CS15 (160.6g $CO_2$e/km), BYD Yuan (162.7g $CO_2$e/km), BAIC EC5 (166.9g $CO_2$e/km).

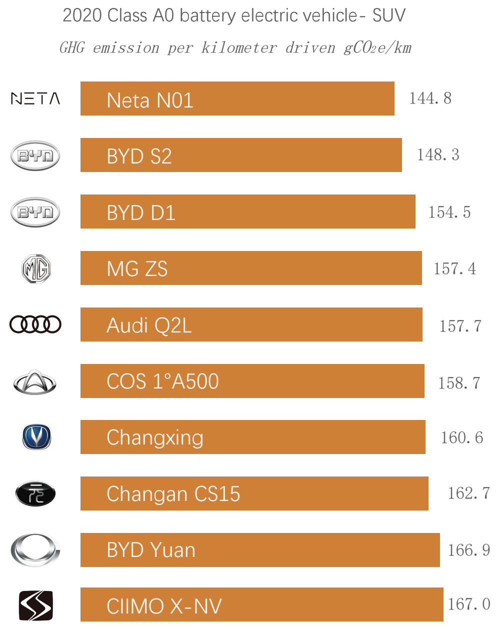


Figure 27 Top 10 models for Class A0 battery electric SUVs

## Class A passenger vehicles

This section checks the GHG emission data per kilometer driven of Class A passenger vehicles. There are 202 models of Class A gasoline vehicles, 11 models of conventional hybrid vehicles, 30 models of plug-in hybrid vehicles, and 47 models of battery electric vehicles.

### Class A gasoline vehicles

#### Top 10 sedans

Figure 28 shows the top 10 Class A gasoline sedans with the lowest GHG emissions. From the lowest to highest GHG emissions per kilometer driven, they are Bluebird (201.2g $CO_2$e/km), Tiida (201.3g $CO_2$e/km),Elantra(203.4g $CO_2$e/km),Envix (207.3g $CO_2$e/km), Jetta VA3 (207.8g $CO_2$e/km), Venucia D60 (212.7g $CO_2$e/km),Roewei5(213.5g $CO_2$e/km),Cavalier (214.3g $CO_2$e/km),Escort(217.8g $CO_2$e/km),Focus (218.3g $CO_2$e/km).

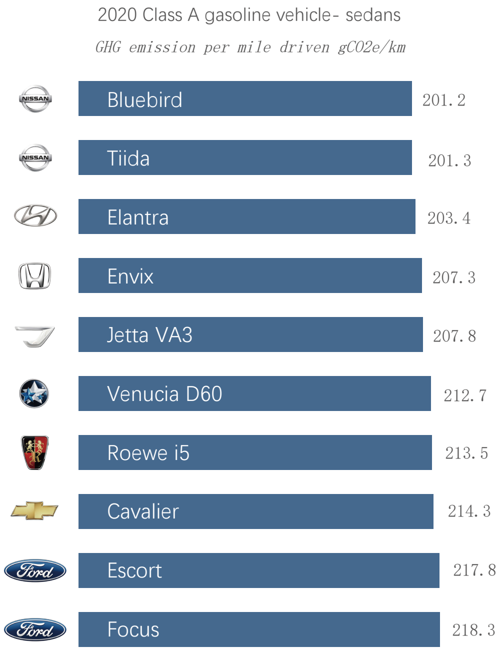


Figure 28 Top 10 models for Class A gasoline sedans

### Top 10 SUVs

Figure 29 shows the top 10 models of Class A gasoline SUVs (including MPVs) with the lowest GHG emissions. From the lowest to the highest GHG emissions per kilometer driven, they are T-cross (218.6g$CO_2$e/km), Tacqua (220.0g$CO_2$e/km), Izoa (229.1g$CO_2$e/km), Toyota C-HR (221.9g$CO_2$e/km), Kamiq GT (224.1g$CO_2$e/km), Karoq (225.7g$CO_2$e/km), Kamiq (229.9g$CO_2$e/km), Mazda CX-30 (230.9g$CO_2$e/km), COS 1° (231.0g$CO_2$e/km), Emgrand GS (231.1g$CO_2$e/km).

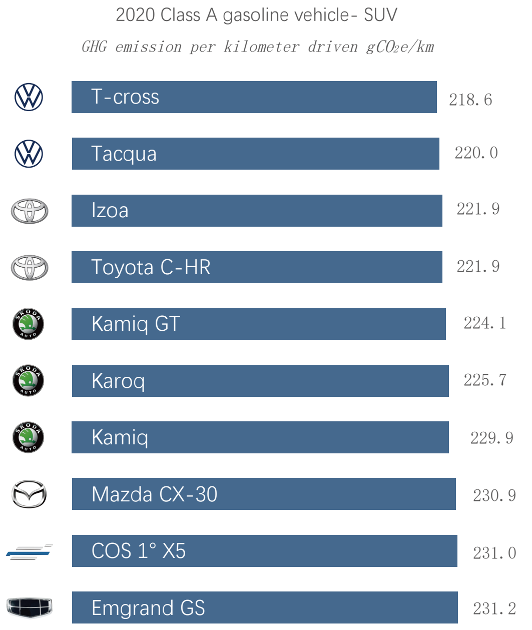


Figure 29 Top 10 models for Class A gasoline SUVs

## Class A conventional hybrid vehicle

### Top 4 sedans

Figure 30 shows the top 4 Class A conventional hybrid sedans with the lowest GHG emissions per kilometer driven. From lowest to highest GHG emissions per kilometer driven, they are Crider (170.8g $CO_2$e/km),Envix(172.1g $CO_2$e/km),Corolla (173.9g $CO_2$/km), and Levin (174.6g$CO_2$e/km). Except for the Roewe ei6, which emits 100g$CO_2$e/km per kilometer driven, all other models are higher than 170g$CO_2$e/km.

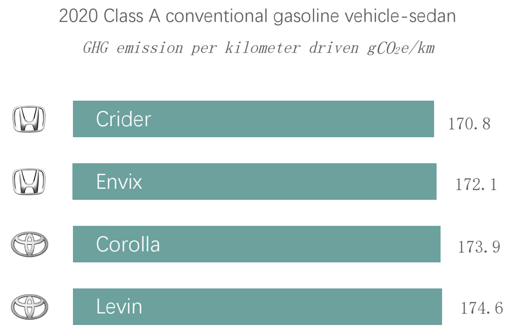


Figure 30 Top 5 models for Class A conventional hybrid sedans

### Top 7 sedans

Figure 31 shows the top 7 Class A conventional hybrid SUVs (including MPVs) with the lowest GHG emissions per kilometer driven. From the lowest to highest GHG emissions per kilometer driven, they are Roewe eRX5 (118.1g$CO_2$e/km), LYNK&CO01 (203.7g$CO_2$e/km), Acura CDX (206.2g$CO_2$e/km), Wildlander (208.0g$CO_2$e/km), Toyota RAV4 (209.3g$CO_2$e/km), Breeze (213.1g$CO_2$e/km), and Honda CR-V (225.9g$CO_2$e/km). Class A conventional hybrid SUVs differ significantly in GHG emissions per kilometer driven. Except for the Roewe eRX5, which is lower, the rest of the models are distributed from 203.7 to 235.7g$CO_2$e/km.

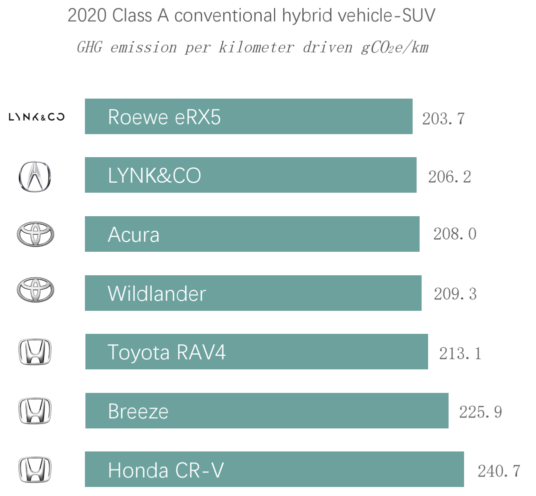


Figure 31 Top 8 models for Class A conventional hybrid vehicles

## Class A plug-in hybrid vehicle

### Top 10 sedans

Figure 32 shows the Top 10 Class A plug-in hybrid sedans with the lowest GHG emissions per kilometer driven. From the lowest to highest GHG emissions per kilometer driven, they are Roewe ei6 (160.5g CO$_2$e/km), Elantra (160.7g CO$_2$e/km), Corolla (162.2g CO$_2$e/km), Levin (162.2g CO$_2$e/km), Roewe ei6 MAX (167.7g CO$_2$e/km), MG6 (168.2 g CO$_2$e/km), Kia K3 (169.6g CO$_2$e/km), Emgrand (172.7g CO$_2$e/km), Buick Velite 6 (182.6g CO$_2$e/km), and Emgrand GL (197.0g CO$_2$e/km). The GHG emissions per kilometer driven of these 10 models vary widely, ranging from 160.5 to 197.0g CO$_2$e/km.

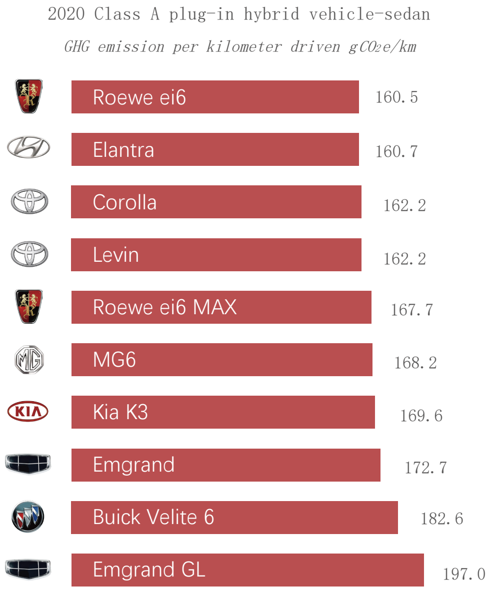


Figure 32 Top 10 models for Class A plug-in hybrid sedans

### Top 10 SUVs

Figure 33 shows the top 10 Class A plug-in hybrid SUVs (including MPVs) with the lowest GHG emissions per kilometer driven. From the lowest to the highest GHG emissions per kilometer driven, they are Trumpchi GS4 (182.7g CO$_2$e/km), Shirui (185.7g CO$_2$e/km), Xingyue (197.4g CO$_2$e/km), BYD Song MAX (202.2g CO$_2$e/km), Jiaji (202.5g CO$_2$e/km), Roewe eRX5 (204.7g CO$_2$e/km), SAIC Maxus EUNIQ5 (207.7g CO$_2$e/km), MG HS (213.1g CO$_2$e/km), Aircross (215.1g CO$_2$e/km), BYD Song (217.5g CO$_2$e/km).

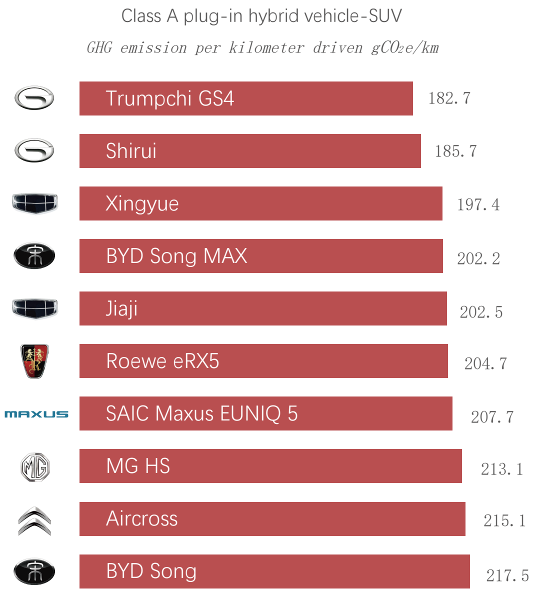


Figure 33 Top 10 models for Class A plug-in hybrid SUVs

## Class A battery electric vehicles

### Top 10 sedans

Figure 34 shows the Top 10 models of Class A battery electric sedans with the lowest GHC emissions per kilometers driven. From the lowest to the highest GHC emissions per kilometers driven, they are eElyee (143.4gCO$_2$e/km), BYD E3 (147.7gCO$_2$e/km), ORA iQ (148.9gCO$_2$e/km), Golf (149.1gCO$_2$e/km), ORA Good Cat ( 149.5gCO$_2$e/km), NISSAN (151.4gCO$_2$e/km), BORA (152.4gCO$_2$e/km), VENUCIA D60 (156.8gCO$_2$e/km), Lavida (157.0gCO$_2$e/km) and LAFESTA (159.7gCO$_2$e/km).

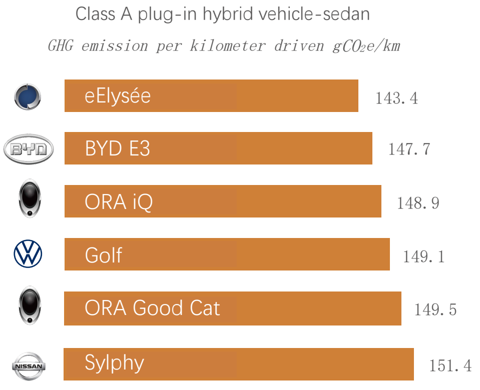


Figure 34 Top 10 models for Class A battery electric sedans

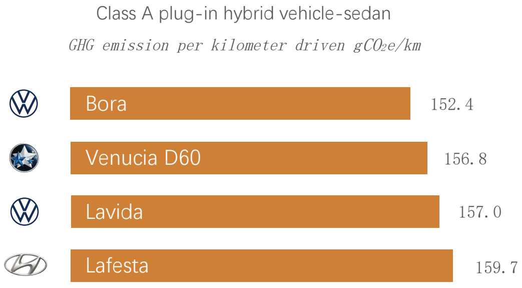


Figure 34 Top 10 models for Class A battery electric sedans

### Top 10 SUVs

Figure 35 shows the top 10 Class A electric SUVs (including MPVs) with the lowest GHG emissions per kilometer driven. From the lowest to the highest GHG emissions per kilometer driven, they are Izoa (164.3g $CO_2e$/km), Cosmos (165.1g $CO_2e$/km), Toyota C-HR (165.7g $CO_2e$/km), Roewe ERX5 EV (166.0g $CO_2e$/km), Emgrand GSe (166.9g $CO_2e$/km), Jetour X70S (168.5g $CO_2e$/km), Tiggo E (168.7g $CO_2e$/km), Buick Velite 7 (169.6g $CO_2e$/km), Red Flag E-HS3 (171.5g $CO_2e$/km), and Geometry C (172.4g $CO_2e$/km). There is no significant difference in GHG emissions per kilometer driven for these 10 models, ranging from 164.3 to 172.4g $CO_2e$/km.

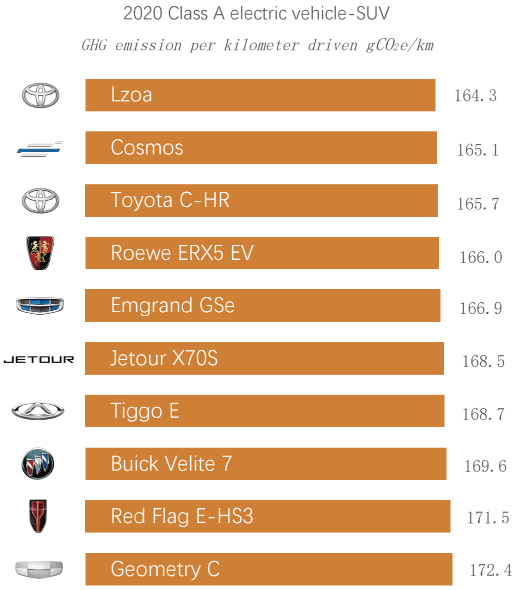


Figure 35 Top 10 models for Class A battery electric SUVs

## (4) Class B passenger vehicles

This section checks the GHG emission data per kilometer driven of Class B passenger vehicles, with 108 models of Class A gasoline cars, 6 models of conventional hybrid vehicles, 11 models of plug-in hybrid vehicles, and 18 models of battery electric vehicles.

### ▶ Class B gasoline vehicles

### Top 10 sedans

Figure 36 shows the top 10 Class B gasoline sedans with the lowest GHG emissions. From the lowest to highest GHG emissions per kilometer driven, they are Honda INSPIRE (230.9g $CO_2e$/km), Camry (234.2g $CO_2e$/km), Peugeot 508L (237.9g $CO_2e$/km), Trumpchi GA6 (240.1g $CO_2e$/km), Avalon (240.6g $CO_2e$/km), Teana (249.9g $CO_2e$/km), Orlando (249.9g $CO_2e$/km), MalibuXL (251.0g $CO_2e$/km), Preface (251.7g $CO_2e$/km) and Beijing U7 (253.0g $CO_2e$/km). There is no significant difference in GHG emissions per kilometer driven for these 10 models, ranging from 230.9 to 254.5g $CO_2e$/km.

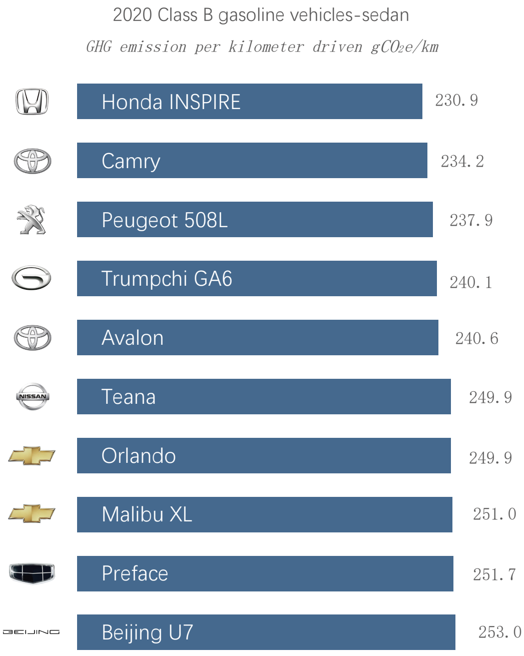


Figure 36 Top 10 Class B Gasoline Sedans

### Top 10 SUVs

Figure 37 shows the Top 10 models of Class B gasoline SUVs with the lowest GHG emissions. From the lowest to highest GHG emissions per kilometer driven, they are Venucia T90 (244.2g$CO_2$e/km), Peugeot 5008 (256.5g$CO_2$e/km), BYD Song PLUS (258.0g$CO_2$e/km), Mercedes-Benz GLB-Class (267.0g$CO_2$e/km), Beijing X7 (270.5g$CO_2$e/km), COS 1°X7 (273.4g$CO_2$e/km), SAIC Maxus D60 (2274.6g$CO_2$e/km), Scenery 580 (278.5g$CO_2$e/km), Wuling Hongguang S3 (279.4g$CO_2$e/km), Exeed TXL (284.0g$CO_2$e/km). There is no significant difference in GHG emissions per kilometer driven for these 10 models, ranging from 256.5 to 285.6g$CO_2$e/km.

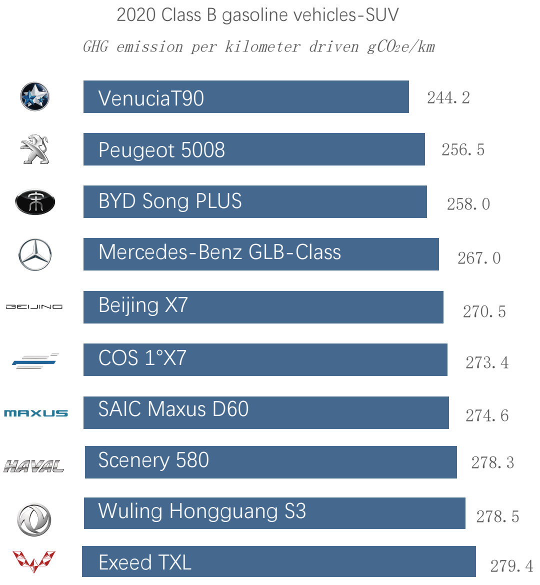


Figure 37 Top 10 models for Class B gasoline SUVs

## Class B conventional hybrid vehicle

### Top 4 sedans

Figure 38 shows the Top 4 Class B conventional hybrid vehicles with the lowest GHG emissions. From the lowest to highest GHG emissions per kilometer driven, they are Camry (181.2g$CO_2$e/km), Avalon (188.0g$CO_2$e/km), Avalon (240.6g$CO_2$e/km), Honda INSPIRE (188.2g$CO_2$e/km), and Accord (189.8g$CO_2$e/km). There is no significant difference in GHG emissions per kilometer driven between these 4 models, ranging from 181.2 to 189.8g$CO_2$e/km.

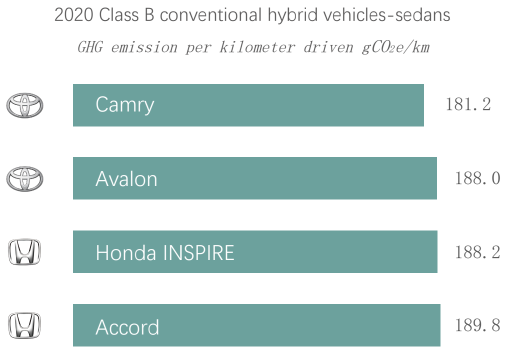


Figure 38 Top 4 models for Class B conventional hybrid sedans

## Class B plug-in hybrid vehicles

### Top 7 sedans

Figure 39 shows the Top 7 Class B plug-in hybrid sedans with the lowest GHG emissions. From lowest to highest GHG emissions per kilometer driven, they are Kia K5 (184.4g$CO_2$e /km), Bo Rui GE (202.0g$CO_2$e/km), Roewe e950 (204.0g$CO_2$e/km), Sonata IX (204.1g$CO_2$e/km), Passat (206.9g$CO_2$e/km), Magotan (221.0g$CO_2$e/km), and Volvo S60L (233.3g$CO_2$e/km). The GHG emissions per kilometer driven of these 8 models are significantly different, ranging from 184.4 to 233.3 g$CO_2$e/km.

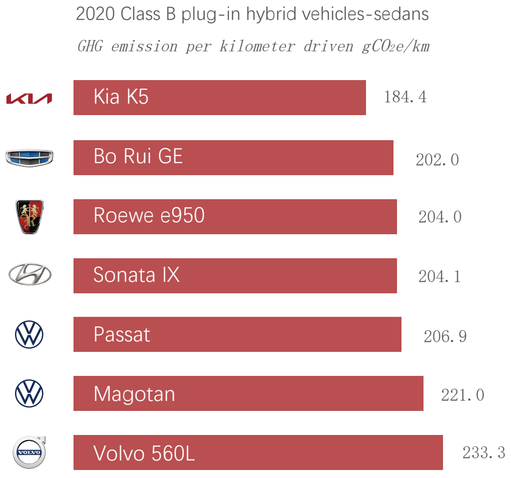


Figure 39 Top 7 models for Class B plug-in hybrid sedans

### SUV Top4

Figure 40 shows the Top 8 Class B plug-in hybrid SUVs with the lowest GHG emissions. From the lowest to highest GHG emissions per kilometer driven, they are Scenery 580 (210.2g$CO_2$e/km), Commander (245.2g$CO_2$e/km), WEY VV7 (202.0g$CO_2$e/km), and Volvo XC60 (256.7g$CO_2$e/km). The GHG emissions per kilometer driven of these 4 models are significantly different, ranging from 210.2 to 256.7g$CO_2$e/km.

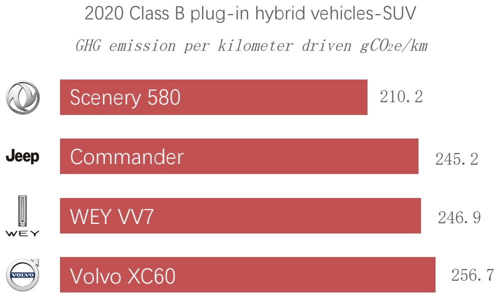


Figure 40 Top 4 models for Class B plug-in hybrid SUV

## ▶ Class B battery electric vehicles

### Top 5 sedans

Figure 41 shows the Top 5 models with the lowest GHG emission for Class B battery electric sedans. From the lowest to highest GHG emissions per kilometer driven, they are Trumpchi AION.S (165.1g$CO_2$e/km), GAC i5 (165.1g$CO_2$e/km), JAC iC5 (173.9g$CO_2$e/km), BAIC EU7 (178.4g$CO_2$e/km), and Tesla Model 3 (182.2g$CO_2$e/km). The GHG emission per kilometer driven of these five models are not significantly different, ranging from 165.1 to 182.2g$CO_2$e/km.

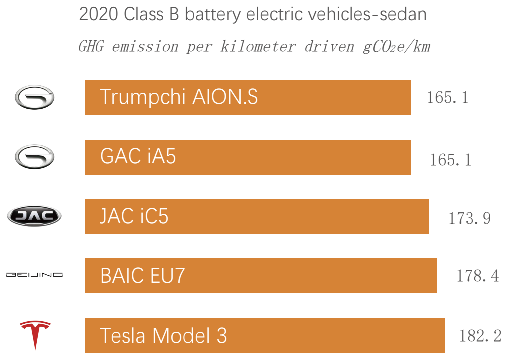


Figure 41 Top 5 models for Class B battery electric sedans

### Top 10 SUVs

Figure 42 shows the top 10 Class B battery electric SUVs with the lowest GHG emissions. From lowest to highest GHG emissions per kilometer driven, they are MARVEL R (177.7g$CO_2$e/km), COS 1°X7 (180.4g$CO_2$e/km), Roewe Marvel X (185.4g$CO_2$e/km), Ant (187.7g$CO_2$e/km), Trumpchi AION V (196.7g$CO_2$e/km), Lingzhi (198.7g$CO_2$e/km), BMW iX3 (212.2g$CO_2$e/km), Hycan 007 (217.8g$CO_2$e/km), Trumpchi AION LX (224.3g$CO_2$e/km), and BAIC ARCFOX αT (228.2g$CO_2$e/km). The GHG emissions per kilometer driven of these 10 models vary widely, ranging from 177.7 to 228.2g$CO_2$e/km.

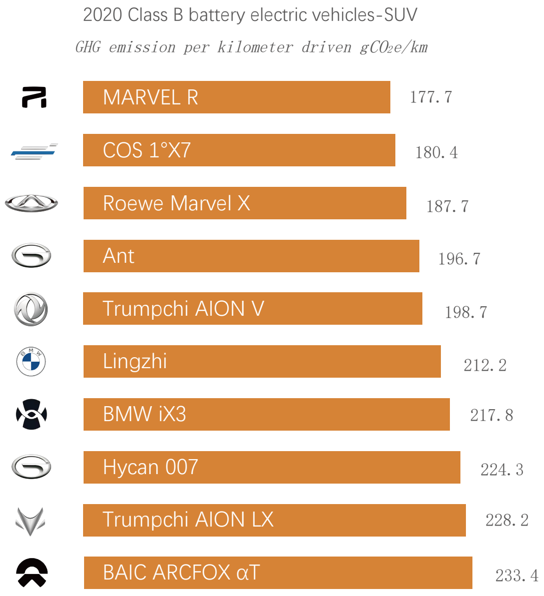


Figure 42 Top 10 models for Class B battery electric SUVs

## (4) Class C passenger vehicles

This section checks GHG emissions per kilometer driven for Class C passenger vehicles, of which there are 17 models of Class C gasoline vehicles.

## ▶ Class C gasoline vehicles

### Top 10 sedans

Figure 43 shows the top 10 models of Class C gasoline cars with the lowest GHG emissions. From the lowest to highest GHG emissions per kilometer driven, they are Citroen C6 (253.0g $CO_2$e/km), Cadillac CT5 (271.2g $CO_2$e/km), Volvo S90 (272.0 $CO_2$e/km), Taurus (284.1g $CO_2$e/km), BMW 5 Series (295.3 g $CO_2$e/km), Cadillac XTS (319.7g $CO_2$e/km), Jaguar XFL (322.5g $CO_2$e/km), Mercedes-Benz E-Class (323.8g $CO_2$e/km), and Red Flag H7 (330.6g $CO_2$e/km), Crown (334.0 $CO_2$e/km).

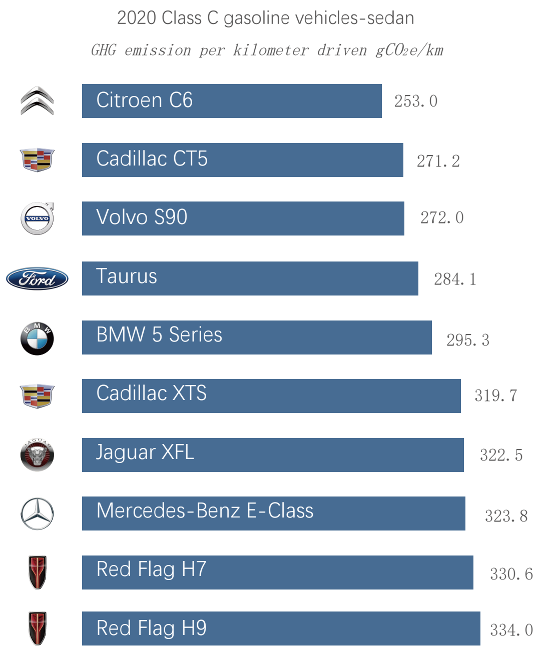


Figure 43 Top 10 models for Class C gasoline sedans

## 4.2 Results of life cycle GHG emission study

### 4.2.1 Results of life cycle GHG emission study of passenger vehicle enterprises

#### 4.2.1.1 Overview

This section checks the average GHG emission data of enterprises based on the passenger vehicle sales weighted by GHG emissions per kilometer driven in enterprises, and the passenger vehicles sold in 2020 are from 122 enterprises respectively. The average GHG emissions of passenger vehicles produced by enterprises range from 92.3 to 523.0g $CO_2$e/km, with an arithmetic average of 232.8g $CO_2$e/km and there is a significant difference between enterprises in terms of average GHG emissions. Some enterprises mainly produce electric vehicles have lower average GHG emissions, for example, Linktour Motors Co., Ltd. has the lowest average GHG emissions of 92.3g $CO_2$e/km. The average GHG emission of the companies that mainly produce fuel vehicles is higher, for example, the corporate average GHG emission of Beiqi Tap Off-road Vehicle Technology Co., Ltd. is 414.1g $CO_2$e/km, which is about 4.6 times of the aforementioned company as the overall mass and fuel consumption of its main production models are relatively large; and Zhonghengtian Off-road Vehicle, as the company with the largest average GHG emission of 523.9g $CO_2$e/km, due to its main production of Class C SUV models, the overall mass and fuel consumption is large and the average GHG emissions of the company is far more than other companies.

#### 4.2.1.2 Average GHG emissions of enterprises of different series

Figure 44 shows the average GHG emission of companies of different series. From the Figure, it can be seen that there are eight major series of automotive enterprises in China. In addition, the average GHG emissions of enterprises of each series range from 214.7 to 280.5g $CO_2$e/km, among which the average GHG emissions of American, South Korean, French series and independent manufacturers are lower, with their average GHG emissions of 214.7g $CO_2$e/km, 220.0g $CO_2$e/km, 227.6g $CO_2$e/km and 229.7g $CO_2$e/km respectively. The reason for the lower average GHG emissions of American, South Korean and French companies is that most of the models sold are Class A0 and A models with lower GHG emissions; the reason for the lower average GHG emissions of independent companies is the higher sales of Class A00 battery electric vehicles with low GHG emissions, which in turn lowers the average GHG emissions of the companies.

## 4.3 Fleet life cycle GHG emission research results

According to the statistics of CCA, the passenger vehicle stock in China from 2012 to 2020 is shown in Figure 45. It can be seen that passenger vehicle stock in China still maintains a relatively stable growth trend, and gasoline vehicles are still the most dominant fuel type, accounting for more than 96% of passenger vehicle stock in 2020.

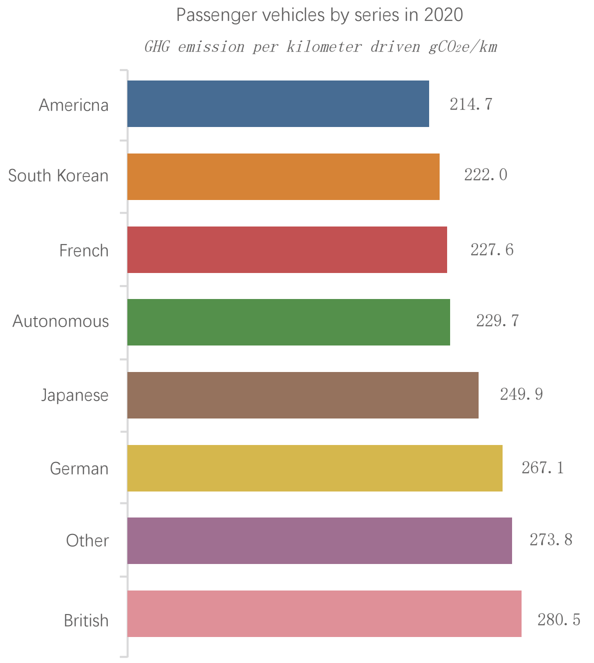


Figure 44 Average corporate GHG emissions

According to the statistics of CCA, the passenger vehicle

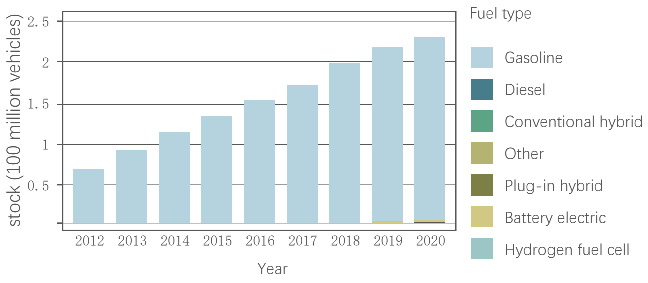
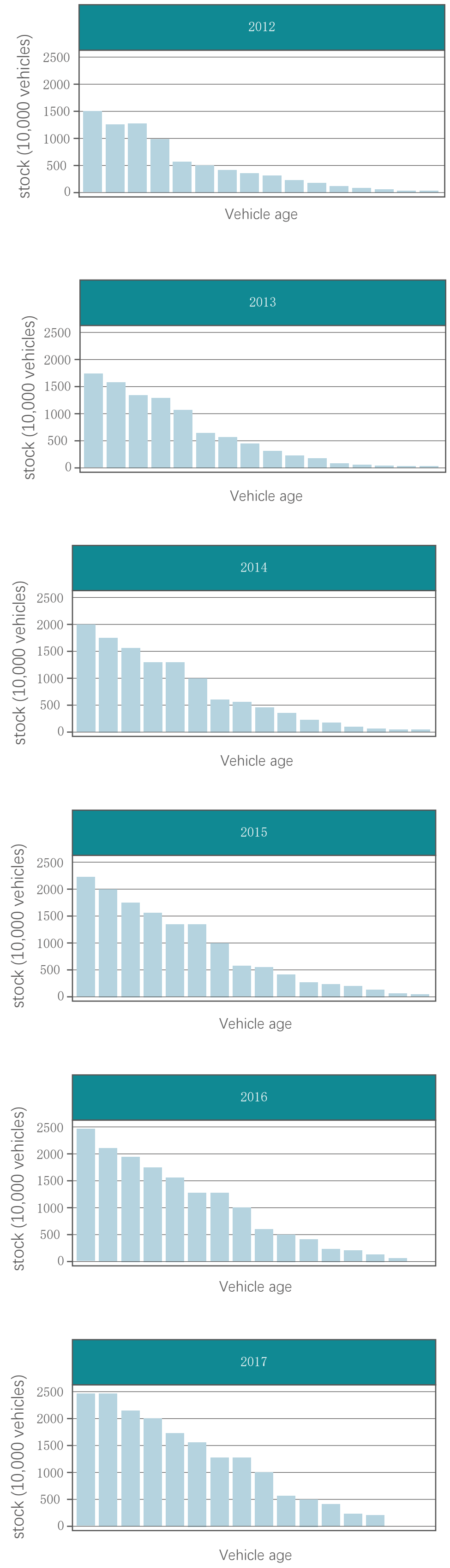


Figure 45 Passenger vehicle fleet stock in China from 2012 to 2020

As shown in Figure 46, the stock structure of China's passenger vehicle fleet from 2012 to 2020 is obtained by age and fuel type, in which vehicles aged 0 are the new vehicles sold in that year. For the new vehicles sold in 2019 and 2020, there is a more obvious decrease in the number of vehicles compared with the previous years, and the main reason for this decrease may be the impact of COVID-19. In addition, vehicles aged 15, include vehicles aged 15 and above.



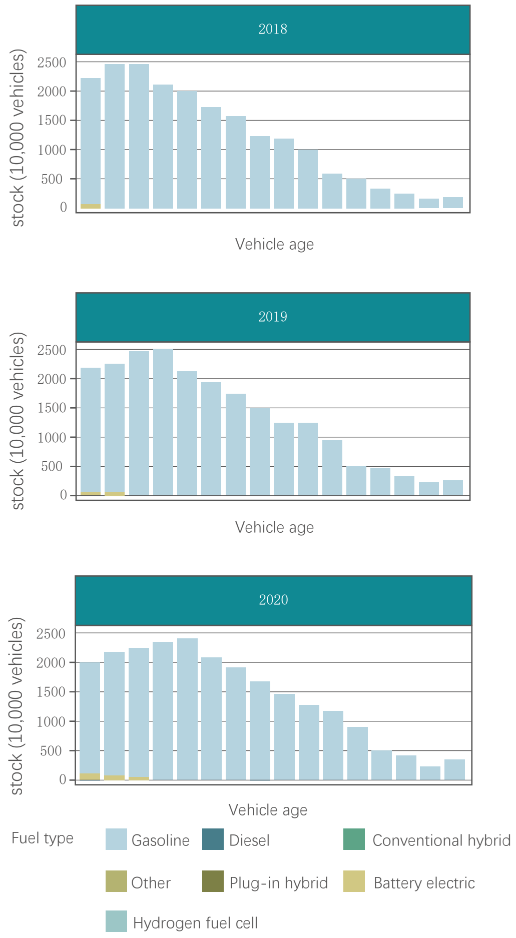
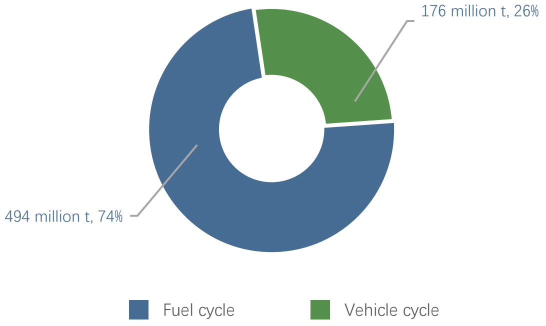


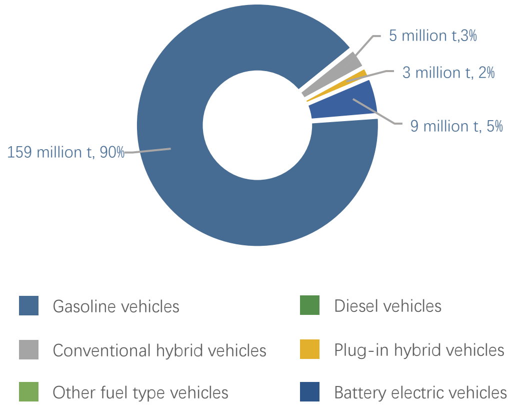
Figure 46 Passenger vehicle fleet stock structure from 2012 to 2020

According to the calculation method of GHG emissions in the fleet model, the total GHG emissions of passenger vehicle fleet in 2020 can be calculated.

(a) Life cycle GHG emissions of passenger vehicle fleet in 2020 (100 million t$CO_2$e)



(b) Vehicle cycle GHG emissions of passenger vehicle fleet in 2020 (100 million t$CO_2$e)



(c) Fuel cycle GHG emissions of passenger vehicle fleet in 2020 (100 million t$CO_2$e)

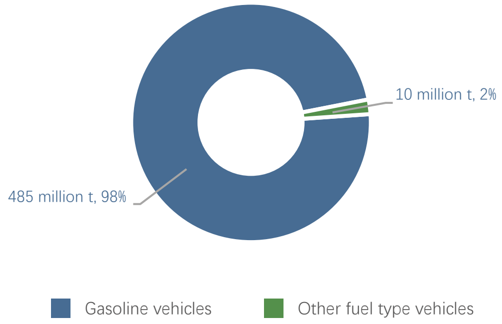


Figure 47 Life cycle GHG emissions of passenger vehicle fleet in 2020

The life cycle GHG emission level of China's passenger vehicle fleet can be obtained through the calculation of the passenger vehicle single vehicle model CALCM and the fleet model CALFAM. As shown in Figure 47 (a), the total life cycle GHG emissions of China's passenger vehicle fleet in 2020 are about 670 million t$CO_2$e, of which about 74% of GHG emissions come from the fuel cycle of the fleet and 26% from the vehicle cycle of the fleet; as shown in Figure 47(b), for the vehicle cycle of the fleet, gasoline vehicles generate about 90% of the GHG emissions, followed by battery electric vehicles, conventional hybrid vehicles and plug-in hybrid vehicles, accounting for 5%, 3% and 2%, respectively. With the gradual promotion of new energy vehicles, the ratio of GHG emissions of battery electric vehicles and plug-in hybrid vehicles in the fleet vehicle cycle will gradually increase; as shown in Figure 47 (c), the vast majority of GHG emissions generated in the fuel cycle come from gasoline vehicles, accounting for about 98% or more.

# 05

# PATH ANALYSIS OF CARBON NEUTRALITY IN THE AUTOMOTIVE INDUSTRY

## 5.1 Overall technical route

The automotive industry involves many fields such as energy, industry and transportation, etc. To achieve the goal of carbon neutrality in the automotive industry, it is necessary to consider all aspects and explore practical and feasible emission reduction paths. This study adopts a bottom-up approach and calculates GHG emission parameters of different types of passenger vehicles at different life cycle stages through CALCM model, and applies CAFLAM model to calculate life cycle GHG emissions at the fleet level by combining the predicted data of stock and sales volume, based on which scenario analysis is conducted to study the impact of different emission reduction measures on the carbon neutrality of the automotive industry and analyze practical emission reduction paths. The overall technology road map is shown in Figure 48.

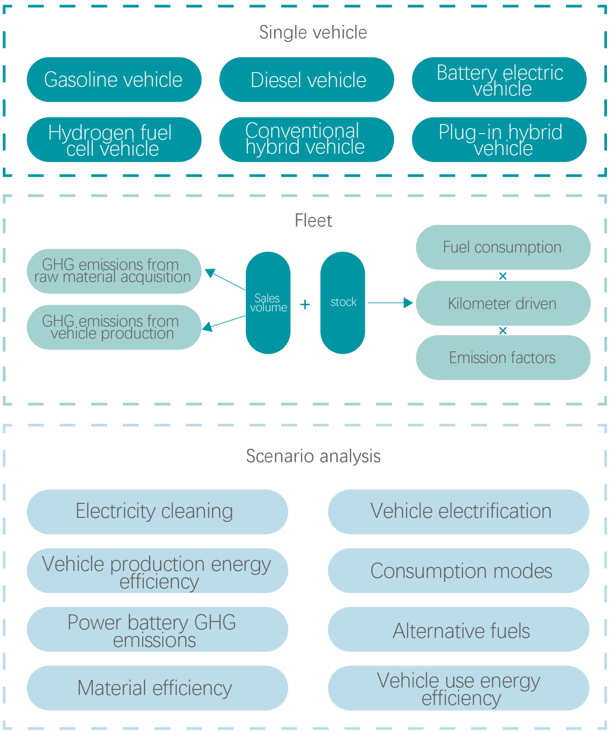


Figure 48 Carbon neutrality analysis technical road map for automotive industry

As shown in Figure 49, according to the forecast of ADC, China's passenger vehicle stock will show a growth trend for a long time in the future, and is expected to reach about 410 million units in 2050; new car sales will also show a growth trend in the time from 2020 to 2050 and the new car sales are expected to peak at about 36 million units in about 2050.

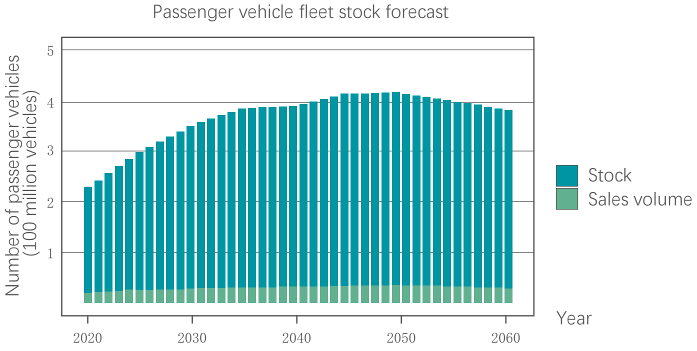


Figure 49 China's passenger vehicle fleet stock and sales forecas

This shows that the growth potential of China's passenger vehicle stock is still huge. Without effective emission reduction measures, GHG emissions from the passenger vehicle fleet will continue to increase with the growth of stock and new vehicle sales, and the ratio of GHG emissions from the automotive sector in China's total GHG emissions will continue to rise. Therefore, it is required to analyze the emission reduction effects of different emission reduction paths for passenger vehicle fleets and adopt the most effective emission reduction measures at different time stages. Only in this way can we peak GHG emissions and achieve carbon neutrality in the automotive industry as early as possible.

## 5.2 Carbon neutrality path analysis

After determining the basic situation that China's passenger vehicle stock will demonstrate a growth trend for a long time in the future, the way to reduce the total fleet

GHG emissions while the stock grows is the key issue to achieve carbon neutrality in the automotive industry. To this end, it is necessary to explore different ways of reducing emissions throughout the life cycle of automobiles, and determine an effective path to achieve the life cycle carbon neutrality goal of China's automotive industry by comprehensively evaluating the impact of different emission reduction measures on the life cycle GHG emissions of the passenger vehicle fleet.

### 5.2.1 Scenario setting

In order to evaluate the emission reduction effect of different emission reduction paths on passenger vehicle fleets, this study set up three low-carbon emission reduction scenarios based on a series of authoritative reports, industry information, academic studies and internal analysis, i.e., the current policy scenario, the intermediate-level emission reduction scenario and the intensive-level emission reduction scenario, with different emission reduction parameters set in each scenario, followed by calculations and analysis through the passenger vehicle fleet life cycle GHG emission model to evaluate variation of total life cycle GHG emissions, ratios of fuel cycle and vehicle cycle GHG emissions of passenger vehicles and fleets in different scenarios. For different scenarios, eight emission reduction measures, including electric power cleaning, vehicle electrification, alternative fuels, material efficiency, vehicle production energy efficiency, power battery GHG emissions, vehicle use energy efficiency, and consumption modes, are considered as influencing factors in this study.

#### 5.2.1.1 Current policy scenario

The current policy scenario is set based on the current situation in China with the variation trend of relevant parameters similar to the historical variation trend. The annual variation rate of parameters is relatively moderate. In this scenario, the ratio of non-fossil energy generation gradually increases, and the ratio of non-fossil energy generation is expected to be about 45% in 2030 and 94% in 2060; the ratio of vehicle electrification is steadily on the rise, and the sale of traditional fuel type vehicles is expected to be banned in 2060; the sales volume of hydrogen fuel cell vehicles gradually increases and then maintains a certain ratio in the newly sold vehicles; the energy structure of key materials is gradually optimized and the energy efficiency of vehicle production is gradually improved; the vehicle use energy efficiency is gradually improved; the ratio of recycled material use is improved year by year; the annual vehicle driving range remains unchanged.

#### 5.2.1.2 Intermediate-level emission reduction scenario (neutrality by 2060)

The intermediate-level emission reduction scenario is based on the current policy scenario and the annual rate of variation of each emission reduction parameter is increased to a certain extent. In this scenario, the ratio of non-fossil energy generation is gradually on the rise, and the ratio of non-fossil energy generation is expected to be about 51% in 2030 and 96% in 2060; the ratio of vehicle electrification is steadily on the rise, and the sale of traditional fuel type vehicles is expected to be banned in 2050; the sales volume of hydrogen fuel cell vehicles gradually increases, and then maintains a certain ratio in the newly sold vehicles; the energy structure of key materials is gradually optimized and the energy efficiency of vehicle production is gradually improved; the vehicle use energy efficiency is gradually improved; the ratio of recycled material use is improved year by year; the annual vehicle driving range drops slightly.

#### 5.2.1.3 Intensive-level emission reduction scenario (neutrality by 2050)

The intensive-level emission reduction scenario is the most aggressive, and the relevant emission reduction parameters are set at the maximum value of emission reduction. The annual rate of variation of each parameter increases significantly. The ratio of non-fossil energy generation in this scenario increases the fastest year by year, and is expected to account for about 53% of non-fossil energy generation in 2030 and 97% in 2060; the ratio of vehicle electrification increases significantly, and the sale of traditional fuel type vehicles is expected to be banned in 2035; the sales volume of hydrogen fuel cell vehicles gradually increases, and then maintains a certain ratio in the newly sold vehicles; the energy structure of key materials is quickly optimized and the change rate of energy efficiency of vehicle production is improved greatly; the variation rate of vehicle use energy efficiency is improved greatly; the ratio of recycled material use is improved by large margin year by year; the annual vehicle driving range drops greatly.

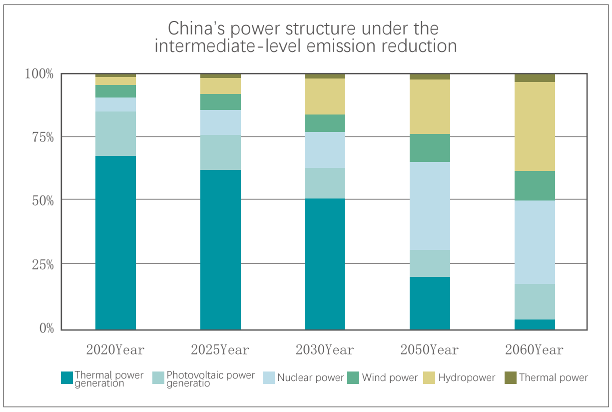
### 5.2.2 Parameter settings

This summary will detail the relevant abatement parameter settings in the three scenarios.

#### 5.2.2.1 Power grid cleaning

The adjustment of China's power structure and the increase of the ratio of renewable energy generation play a crucial role in the low-carbon development of the automotive industry. On one hand, with the promotion of passenger vehicle fleet electrification and the gradual elimination of traditional fuel vehicles, the GHG emissions of, passenger vehicle fleet driving stage will gradually shift to the energy supply side, and the electricity emission factor will directly determine the GHG emissions of fleet fuel cycle; on the other hand, considering from the vehicle cycle of the fleet, the emissions generated from various stages of vehicle raw material acquisition and vehicle production are closely related to the electricity emission factor. At present, the average GHG emission factor of China's power grid is still relatively high compared with developed countries such as Europe and the United States, mainly because China's coal power accounts for a relatively high percentage. This is also determined by the characteristics of China's coal, poor oil and gas resources reserves. From the perspective of energy security, coal power is indeed the security of China's electricity, but for GHG emission reduction needs, in the process of reducing emissions, it's required to set some limits on coal power and enhance the ratio of renewable energy generation, while strengthening the construction of power grids, enhance the power dispatching capacity, the development of energy storage technology, to prevent the potential problems such as the blackout in Texas, the U. S. due to the increase of ratio of wind power, photovoltaic and other renewable power.

The power factor in this study is set based on the calculation of the power generation ratio of various energy sources under different scenarios, and the relevant data are mainly referred to the IPCC Fifth Assessment Report[9], the Report on China's Energy and Electricity Development Planning Study for 2030 and Outlook for 2060[10], and the relevant research results of the National Center for Strategic Research and International Cooperation to Address Climate Change, the Energy Research Institute of the National Development and Reform Commission, and the China Electricity Council and other institutions.



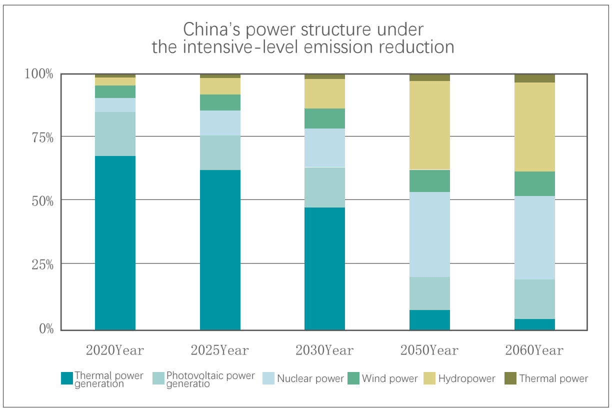


Figure 50: Forecast of China's electricity structure under three scenarios

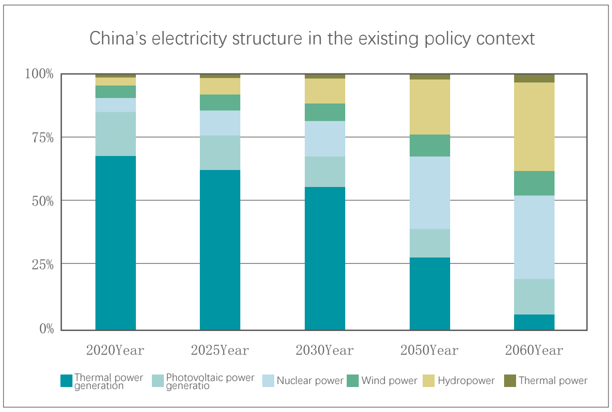


Figure 50 shows the ratios of electricity generated by each type of energy source in China from 2020 to 2060 under the current policy scenario, the intermediate-level emission reduction scenario, and the intensive-level emission reduction scenario, respectively. The main difference between the three scenarios is the variation of the ratio of renewable energy generation over time. In the current policy scenario, the ratio of renewable energy generation grows the slowest, and in the intensive-level emission reduction scenario, the ratio of renewable energy development grows the fastest. Based on the energy structure in the three scenarios, the average electricity GHG emission factors of the national grid in different years can be calculated, as shown in Figure 51.

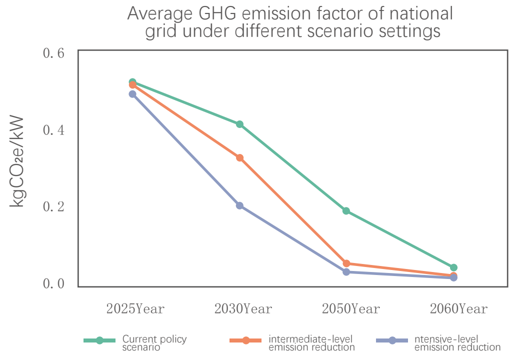
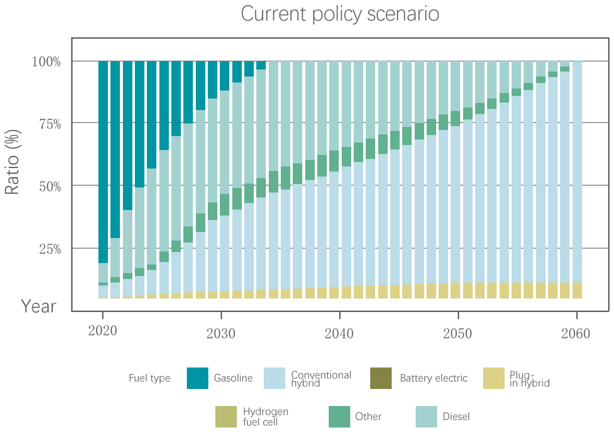
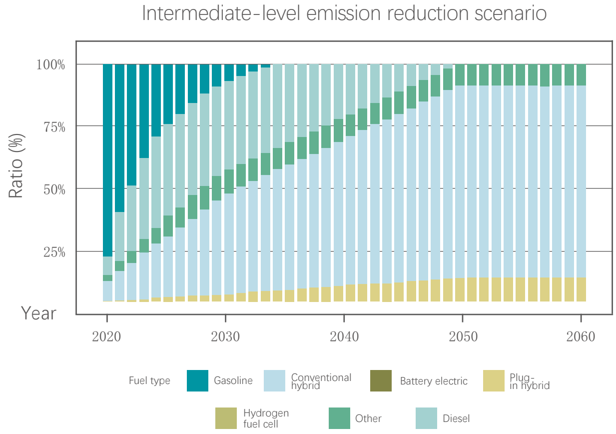

Average GHG emission factor of national grid under different scenario settings

Figure 51 Average GHG emission factors forelectricity in China under three scenarios

## 5.2.2.2 Vehicle electrification

The electrification of the passenger vehicle fleet is mainly realized by increasing the ratio of new energy vehicles in new vehicles sold and limiting the sale of traditional fuel vehicles gradually. With the retirement of in-service traditional fuel vehicles and the increase of new energy vehicles in new vehicles, the increase of the ratio of new energy vehicles in the stock is gradually realized.


Current policy scenario


Intermediate-level emission reduction scenario

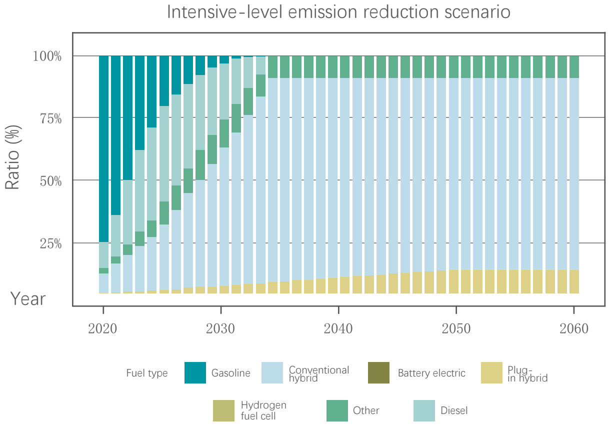
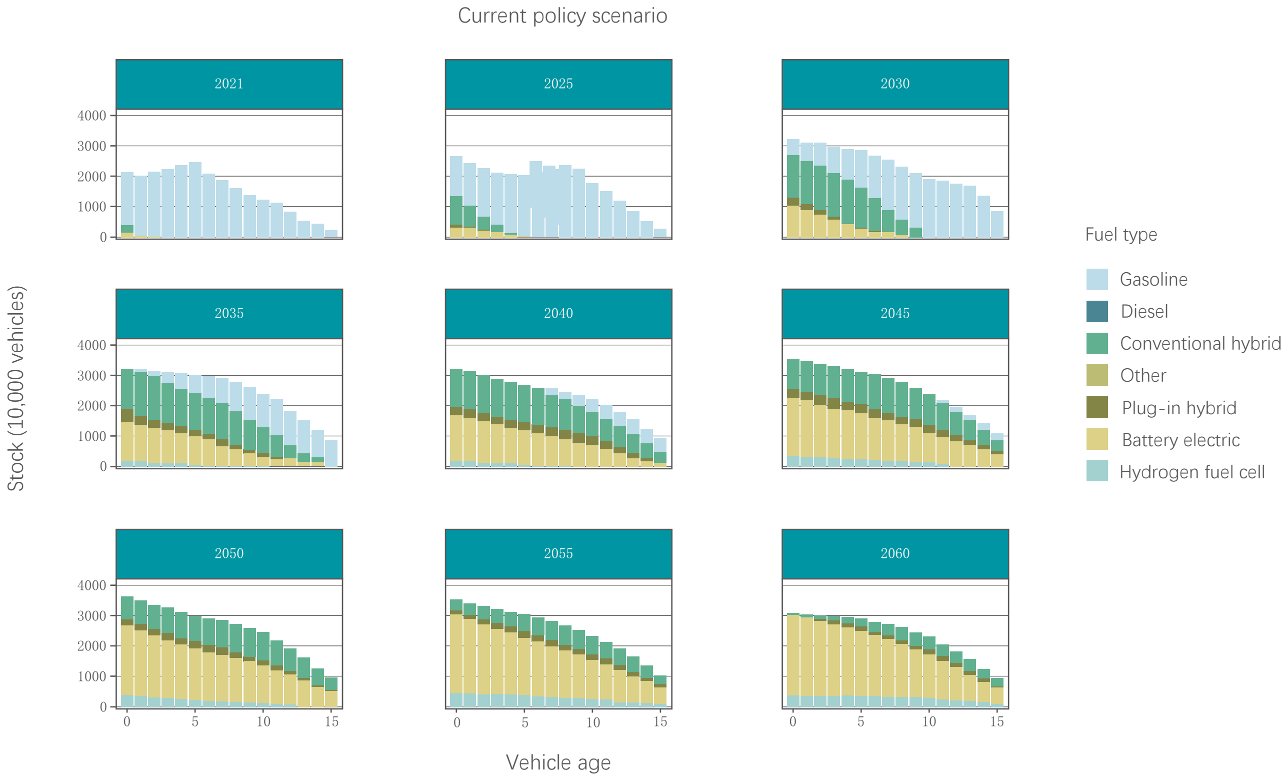
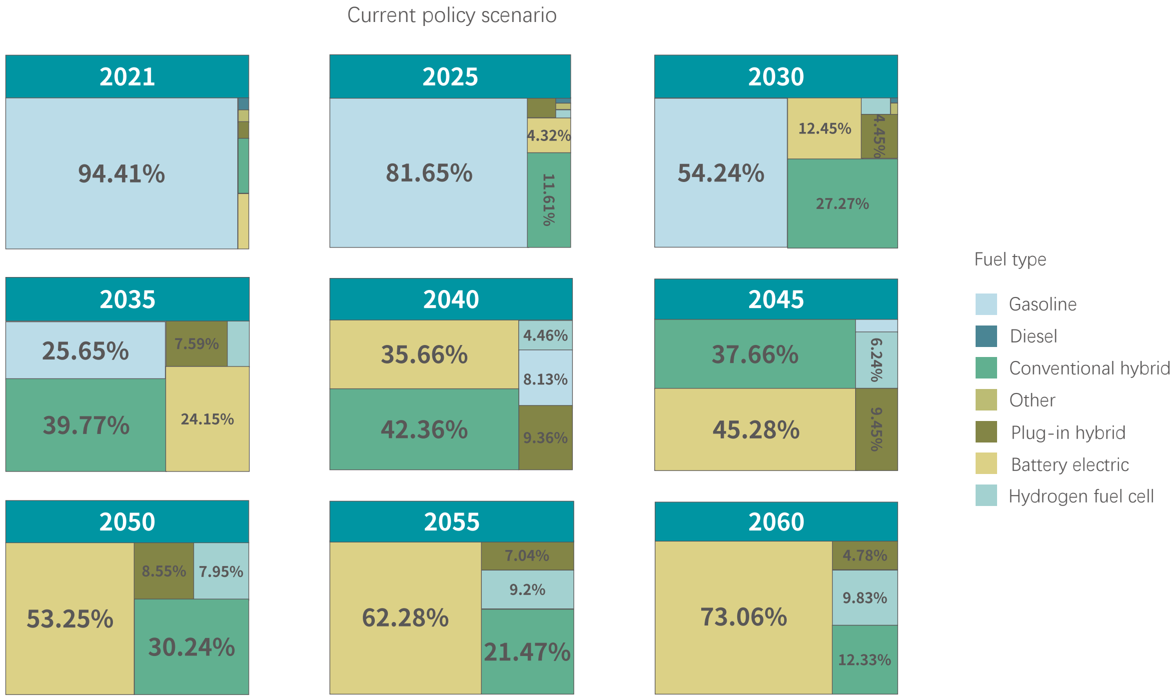

Intensive-level emission reduction scenario

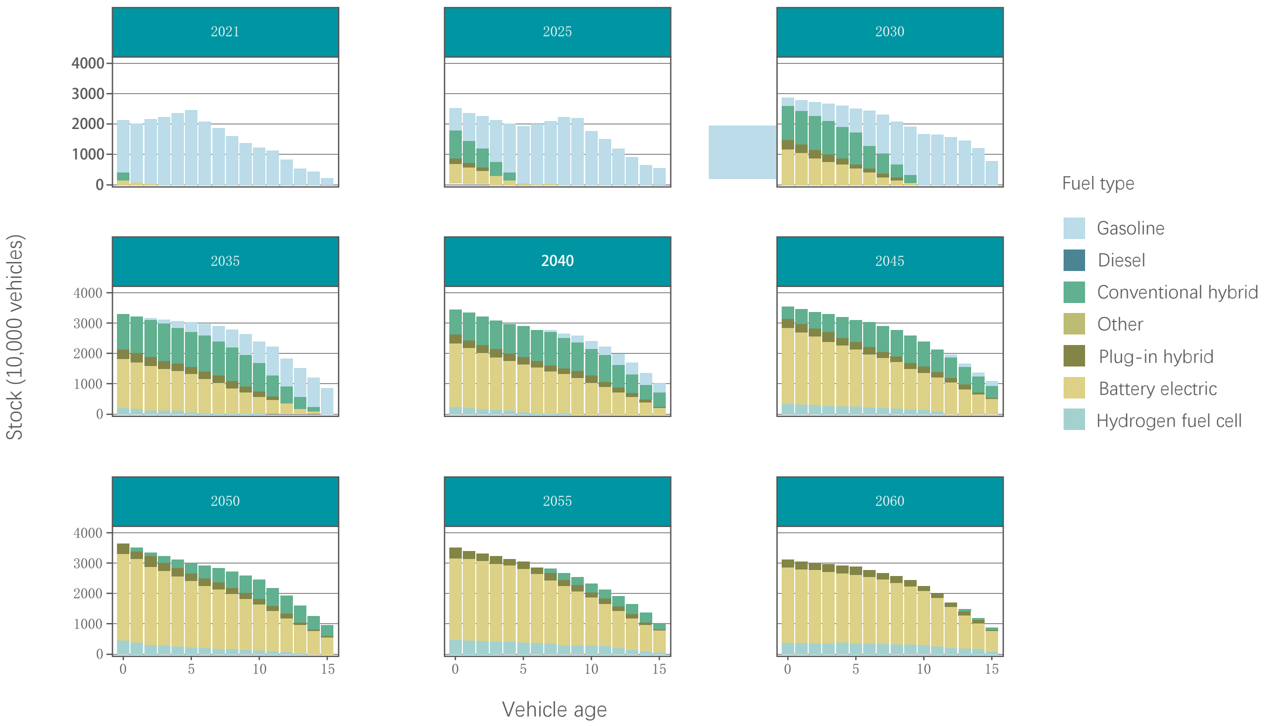
Figure 52 Ratio of various fuel types in new vehicle sales under three scenarios

Based on the forecast of future new vehicle sales in this study, parameters such as the ratio of new energy vehicles in new vehicles and the ratio of battery electric vehicles in new energy vehicles at different time points were under different scenarios. As shown in Figure 52, under the current policy, the ratio of new energy vehicles is gradually on the rise in new vehicle sales. 90% of new vehicle sold in 2060 are new energy vehicles. Hydrogen fuel cell vehicles account for 10% of passenger vehicle sales and the ratio of traditional fuel vehicles gradually decrease with the increase in the ratio of new energy vehicles. Among them, conventional hybrid vehicles account for 100% of conventional fuel vehicle sales around 2035; under the intermediate-level emission reduction scenario, it is expected that around 90% of new vehicle sold in 2050 will be new energy vehicles with hydrogen fuel cell vehicles accounting for 10% of passenger vehicle sales. The ratio of traditional fuel vehicles will gradually decrease as the proportion of new energy vehicles increases. Conventional hybrid vehicles will account for 100% of traditional fuel vehicle sales by around 2035. Under the intensive-level emission reduction scenario, conventional fuel vehicles will account for 0% of sales around 2035, with only new energy vehicles and hydrogen fuel cell vehicles in new vehicle sales after 2035, and 10% of hydrogen fuel cell vehicles around 2050.

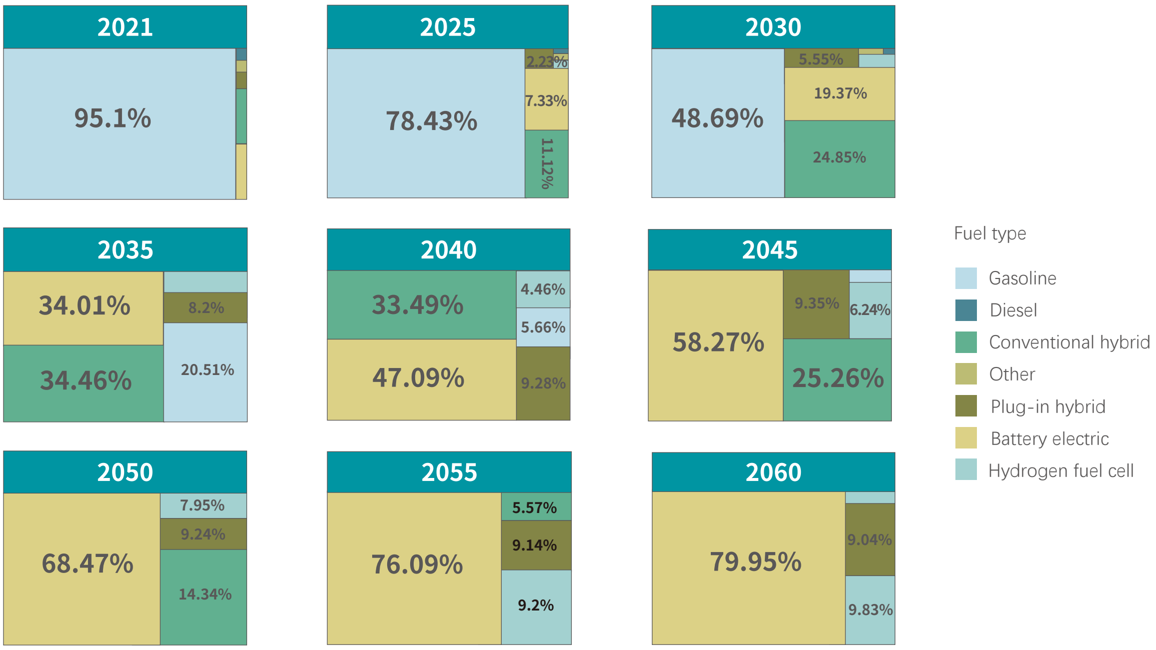

Current policy scenario
2021
2025
2030
2035
2040
2045
2050
2055
2060
Stock (10,000 vehicles)
4000
3000
2000
1000
0
0
5
10
15
Vehicle age
Fuel type
Gasoline
Diesel
Conventional hybrid
Other
Plug-in hybrid
Battery electric
Hydrogen fuel cell

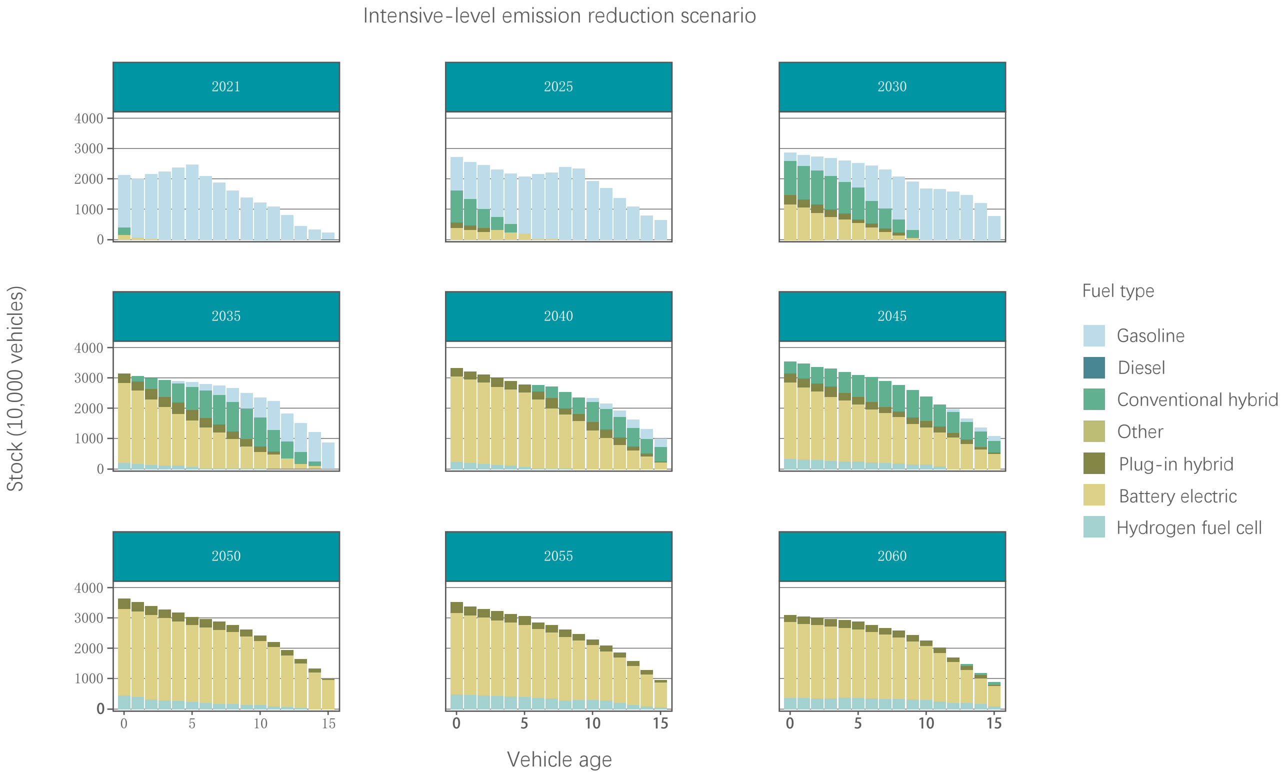

Current policy scenario
2021
94.41%
2025
81.65%
4.32%
11.61%
2030
54.24%
12.45%
4.45%
27.27%
2035
25.65%
7.59%
39.77%
24.15%
2040
35.66%
4.46%
8.13%
42.36%
9.36%
2045
37.66%
6.24%
45.28%
9.45%
2050
53.25%
8.55%
7.95%
30.24%
2055
62.28%
7.04%
9.2%
21.47%
2060
73.06%
4.78%
9.83%
12.33%
Fuel type
Gasoline
Diesel
Conventional hybrid
Other
Plug-in hybrid
Battery electric
Hydrogen fuel cell

Intermediate-level emission reduction scenario



Intermediate-level emission reduction scenario





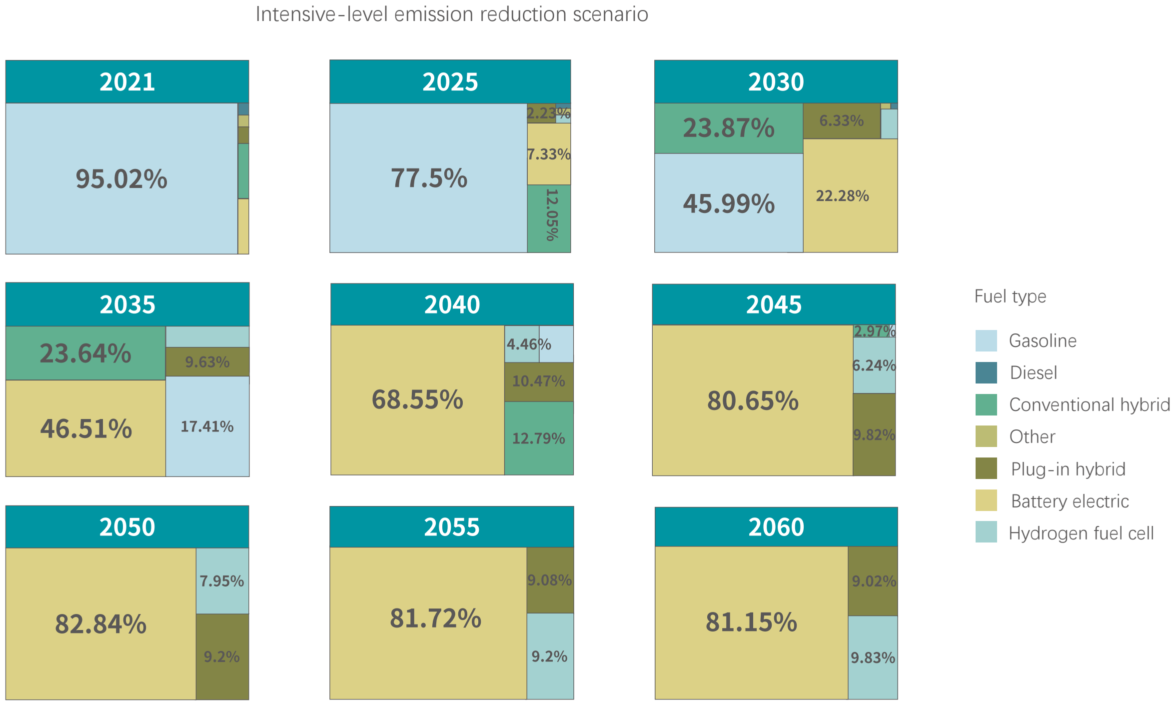
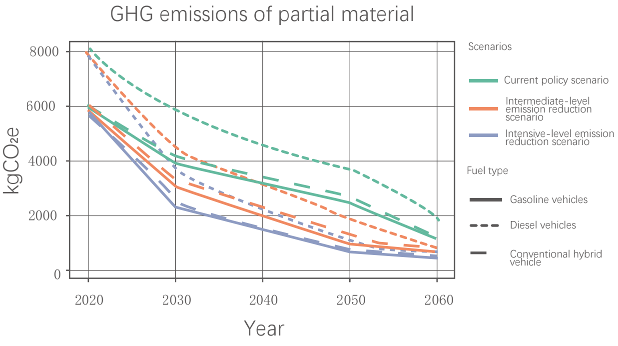


Figure 53 Variation of fleet stock structure for each future year under three scenarios

After determining the ratio of sales of each fuel type in different scenarios, the passenger vehicle fleet stock structure for the coming years can be obtained through fleet model under three scenarios. Figure 53 shows the passenger vehicle fleet stock structure for each of the three scenarios in 2021, 2025, 2030, 2035, 2040, 2045, 2050, 2055, and 2060. Under the current policy scenario, diesel vehicles will be completely phased out around 2050, but there will still be a portion of conventional hybrids in the fleet stock until 2060. In addition, battery electric vehicles account for about 73% of the fleet stock in 2060; in the intermediate-level emission reduction scenario, gasoline and diesel vehicles in the conventional energy vehicles will be basically phased out around 2045, conventional hybrid vehicles will be completely phased out around 2060. The battery electric vehicles will account for 80% in the stock in 2060; In the intensive-level emission reduction scenario, the conventional hybrid vehicles in the passenger vehicle fleet, including conventional hybrid vehicles, will be completely phased out around 2050, and battery electric vehicles will account for 81% of the fleet in 2060. The ratio of hydrogen fuel cell vehicles in 2060 under all three scenarios is about 9.8%.

## 5.2.2.3 Material efficiency

Future vehicle material efficiency improvement is mainly reflected in the reduction of energy consumption of material production and the increase of recycled material content. In addition, the impact of grid cleaning is also simultaneously included in the assessment. The above three factors affect the material emission factor. In this study, this parameter focuses on four materials, namely steel, aluminum, copper and plastic, which account for a high ratio of vehicle production. The change in the material energy use structure and the ratio of recycled material use over time were mainly provided by the World Steel Association and Beijing University of Technology.



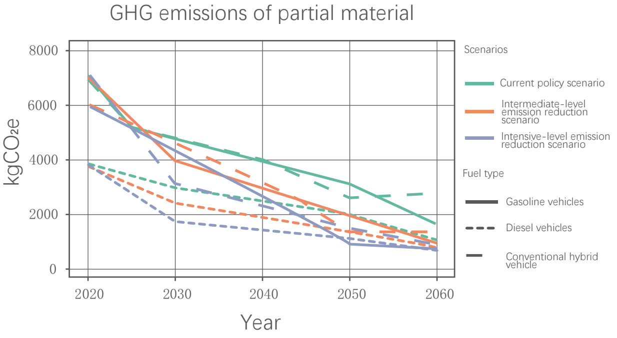


Figure 54 Variation of GHG emission of vehicle cycle component materials affected by material efficiency improvement over time under three scenarios

After considering the material efficiency improvement of key materials, the GHG emission of vehicle cycle component materials by fuel type in different years under different scenarios are calculated according to the single vehicle model, as shown in Figure 54.

## 5.2.2.4 Vehicle production energy efficiency

Vehicle production energy efficiency mainly considers the reduction of GHG emission in the whole vehicle manufacturing stage due to the energy efficiency improvement. Taking the GHG emission of the whole vehicle production in 2020 as the existing policy value and considering the influence of grid cleaning, the percentage of GHG emission reduction in the whole vehicle production stage is set under three scenarios. The specific parameters are shown in Figure 55.。

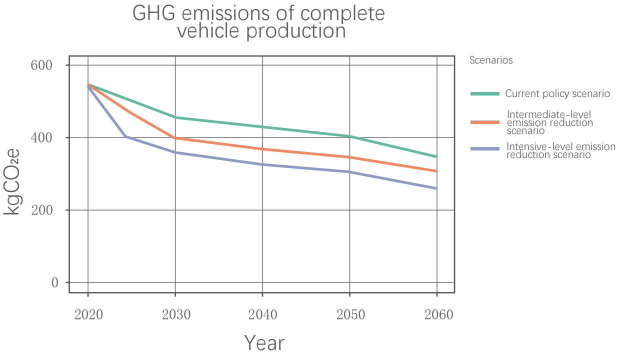


Figure 55 Variation of GHG emission of whole vehicle production over time under three scenarios

### 5.2.2.5 Power battery GHG emissions

Power battery GHG emissions mainly consider the emission reduction effect due to the reduction of energy consumption of battery production. It mainly applies to conventional hybrid vehicles, battery electric vehicles, plug-in hybrid vehicles and hydrogen fuel cell vehicles. The GHG emissions generated from the production of power battery in the three scenarios over time are shown in Figure 56.

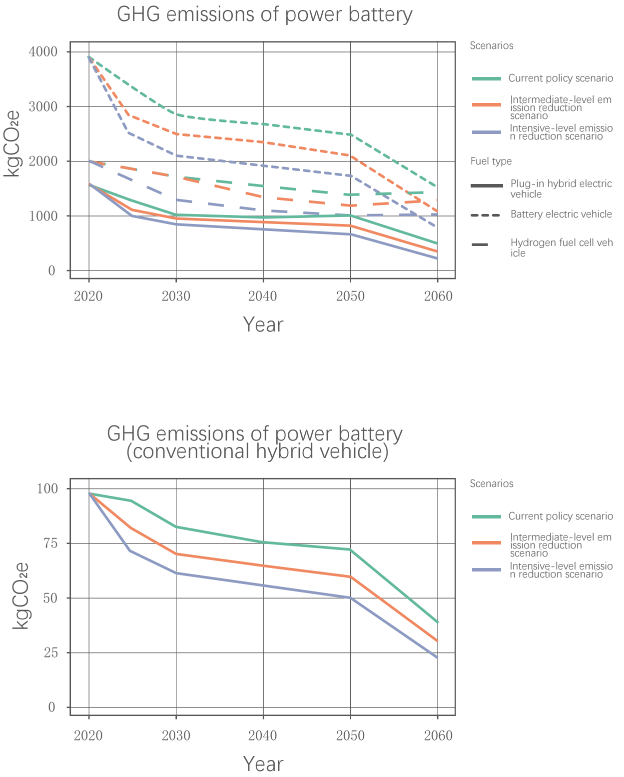
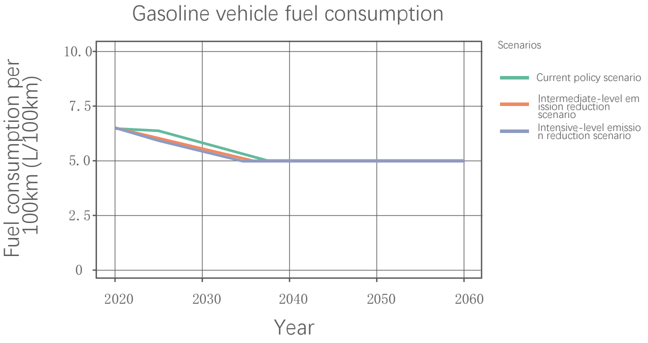
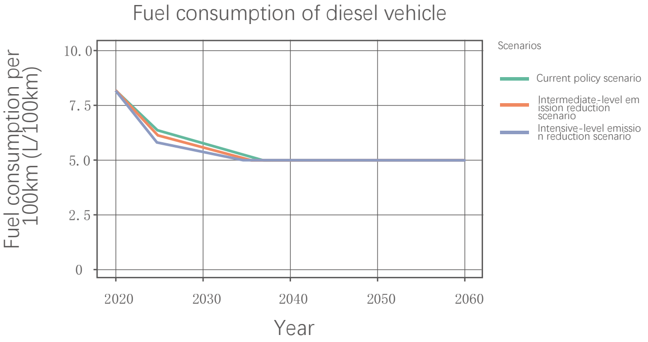


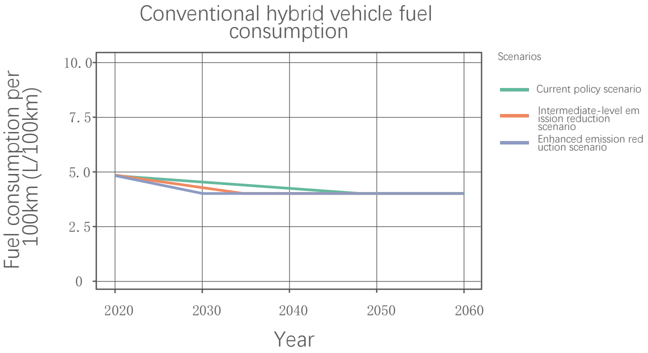
Figure 56 Variation of power battery GHG emissions over time under three scenarios

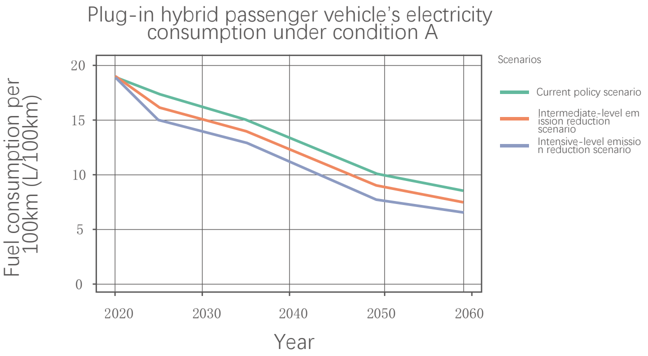
### 5.2.2.6 Vehicle use energy efficiency

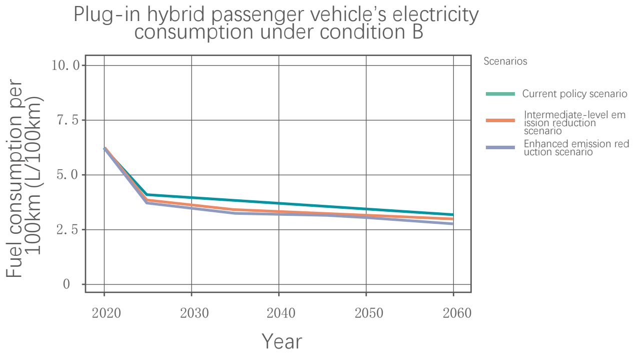
Vehicle use energy efficiency mainly considers the reduction of GHG emissions due to the reduction of vehicle fuel consumption. The fuel consumption of vehicles with different fuel types is calculated as the industry average with the weighted average of sales volume in 2020, and the changes of fuel consumption of vehicles with different fuel types are set for different scenarios. The specific parameters are shown in Figure 57.

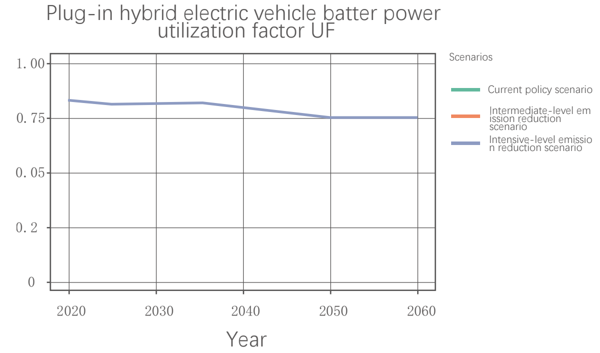


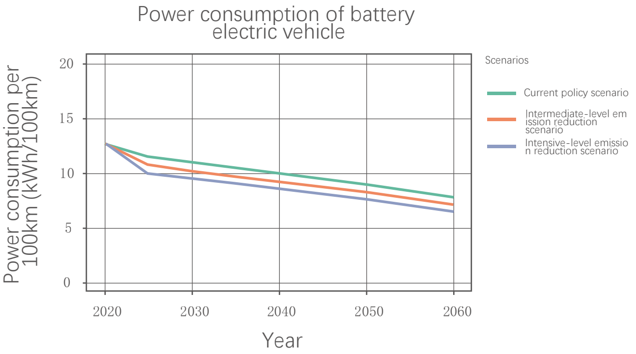












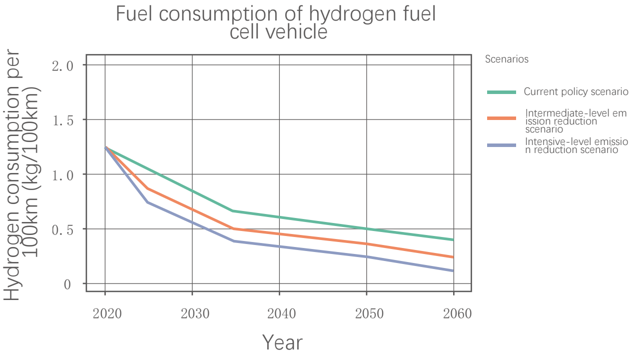
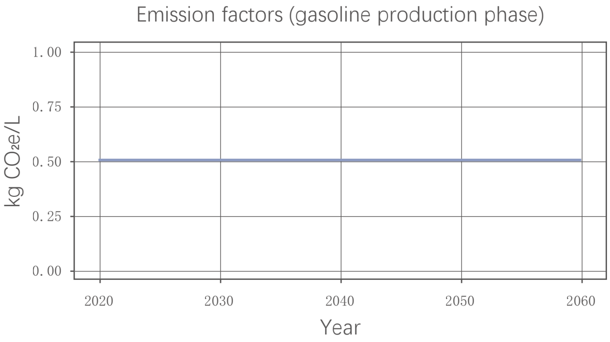
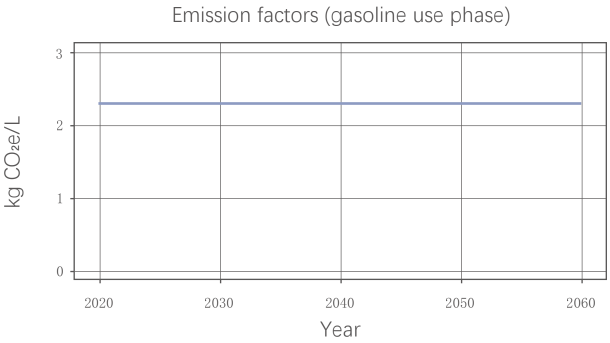


Figure 57 Variation of vehicle fuel consumption over time for different fuel types under three scenarios

### 5.2.2.7 Alternative fuel

The two main alternative fuels considered in this study are electricity and hydrogen fuel. The emission factors concerning electricity are consistent with the parameters set in the grid cleaning. The emission factors for the hydrogen fuel production stage are mainly calculated based on the weighted average of the hydrogen production quantities of different hydrogen production processes. There are six main hydrogen production methods considered in this study, namely steam methane recombination hydrogen production, coal gasification hydrogen production, chlor-alkali hydrogen production, coke oven gas hydrogen production, biomass hydrogen production, and renewable power generation - electrolytic water hydrogen production, with the influence of electricity taken into account. The relevant GHG emission factors were provided by Aramco Asia. The specific parameters are shown in Figure 58. For gasoline and diesel, the production and use stage emission factors are assumed to remain constant in the future in all three scenarios, and the electricity emission factors are shown in Figure 52.





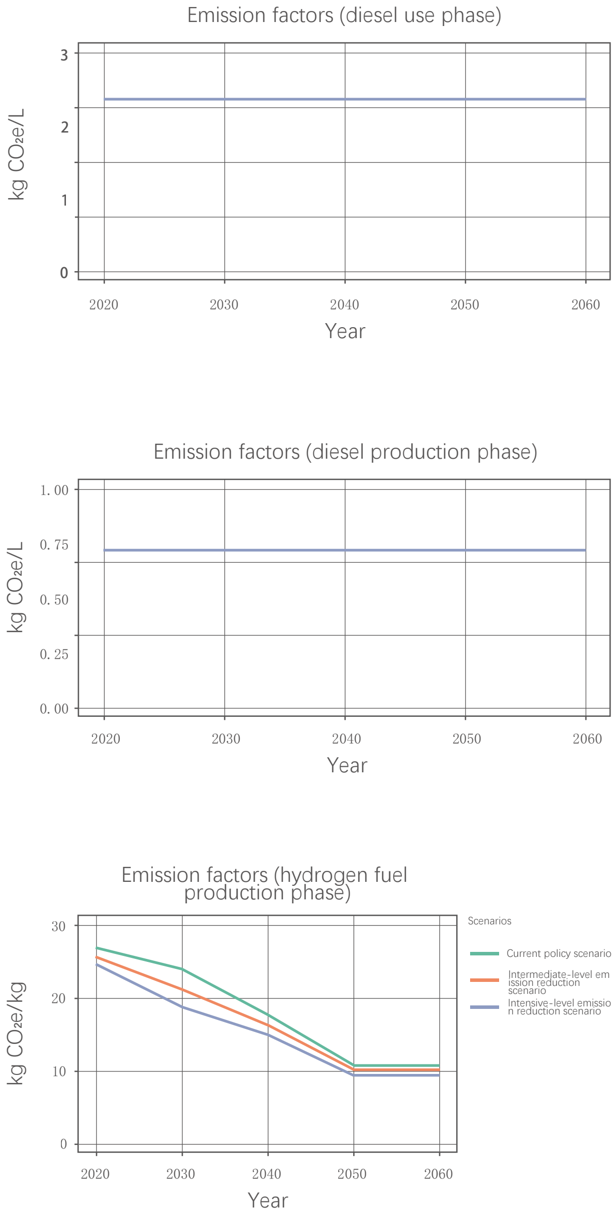


Figure 58 Variation of different fuel emission factors over time under three scenarios

### 5.2.2.8 Consumption mode

The consumption modes in this study mainly consider the variation of the intensity of vehicle use, i.e., the variation of annual vehicle driving range. In this chapter, the variability of annual driving range of conventional fuel vehicles and new energy vehicles is distinguished, where the annual driving range data of conventional fuel vehicles in 2020 are from WRI and the annual driving range data of new energy vehicles are from the New Energy Vehicle National Big Data Consortium. In the current policy scenario, the annual driving range of conventional fuel vehicles and new energy vehicles are assumed to remain the same. In the intensive-level emission reduction scenario and the deepened-level emission reduction scenario, the annual driving range tends to decrease over time, and the annual driving range of traditional fuel vehicles and new energy vehicles gradually converge. The specific parameter settings are shown in Figure 59, where the annual driving range of new energy vehicles in the existing policy and the medium scenario remain the same.

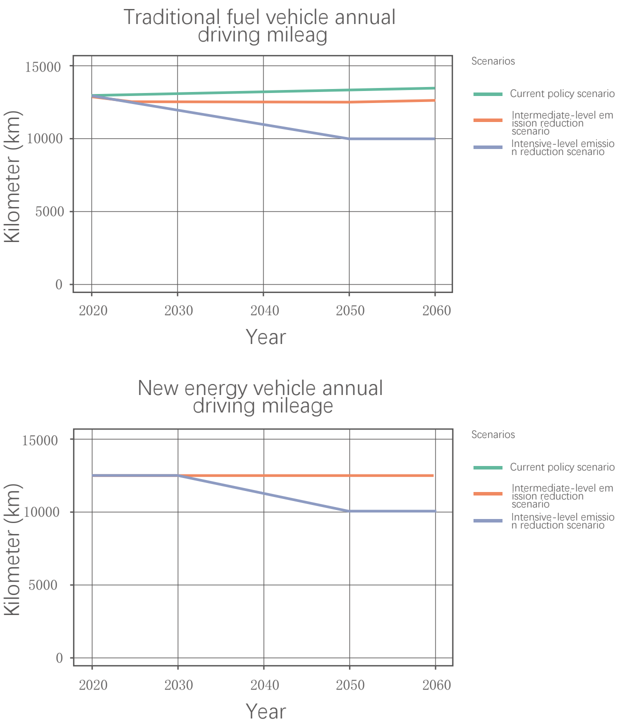


Figure 59 Variation of annual driving range of single passenger vehicle over time under three scenarios

## 5.3 Life cycle GHG emission intensity of passenger vehicles under different scenarios

Under the three emission reduction scenarios, namely the current policy scenario, the intermediate-level emission reduction scenario and the intensive-level emission reduction scenario, the projected GHG emission values per kilometer driven in 2025, 2030, 2050 and 2060 for the five fuel types: gasoline, diesel, conventional hybrid, plug-in hybrid and battery electric vehicles are shown in Figure 60. Under the three emission reduction scenarios, all five fuel types of passenger vehicles, show significant emission reductions, with gasoline, diesel and conventional hybrid vehicles showing a small reduction after 2050 due to the nature of the internal combustion engine.

In 2020 and 2060, for example, the GHG emissions per kilometer driven will be reduced in the order of battery electric vehicles, plug-in hybrid vehicles, gasoline vehicles, diesel vehicles, and conventional hybrid vehicles. Among them, the emission reduction effect of battery electric vehicles is the most obvious, with 82.5%, 87.6% and 90.0% reduction in GHG emissions per kilometer driven under the current policy scenario, intermediate-level emission reduction scenario and intensive-level emission reduction scenario, respectively; the emission reduction effect of conventional hybrid vehicles is the least, with 31.5%, 33.6% and 34.2% reduction in GHG emissions per kilometer driven under the current policy scenario, intermediate-level emission reduction scenario and intensive-level emission reduction scenario, respectively. In the same scenario, the emission reduction effect of gasoline vehicles is 34.3%, 35.9% and 36.3% lower, respectively.

The vehicle cycle emission reduction effects of the five fuel passenger vehicles under three scenarios are shown in Figure 61. Taking the vehicle cycle GHG emissions in 2020 and 2060 as an example, the emission reduction effect under the current policy scenario is reducedin the order of diesel, conventional hybrid, battery electric, gasoline,and plug-in hybrid vehicles, and the reduction percentagesare 68.0%, 67.5%, 67.4%, 67.4%, and 67.2%, respectively. Under the intermediate-level emission reduction scenario, the emission reduction effect is reduced in the order of battery electric vehicles, diesel vehiclesdiesel vehicles, conventional hybrid vehicles, plug-in hybrid vehicles and gasoline, vehicles, and the emission reduction ratio is 75.6%, 74.4%, 74.2%, 74.2%, and 74.1%, respectively. Under the intensive-level emission reduction scenario, the emission reduction effect is reduced in the order of battery electric vehicles, plug-in hybrid vehicles, diesel vehicles, conventional hybrid vehicles, and gasoline vehicles, and the reduction ratios are 80.3%, 76.7%, 76.2%, 75.9%, and 75.8%, respectively

The vehicle cycle emission reduction effects of the five fuel passenger vehicles under three scenarios are shown in Figure 61. Taking the vehicle cycle GHG emissions in 2020 and 2060 as an example, the emission reduction effect under the current policy scenario is reduced in the order of diesel, conventional hybrid, battery electric, gasoline, and plug-in hybrid vehicles, and the reduction percentages are 68.0%, 67.5%, 67.4%, 67.4%, and 67.2%, respectively. Under the intermediate-level emission reduction scenario, the emission reduction effect is reduced in the order of battery electric vehicles, diesel vehicles, conventional hybrid vehicles, plug-in hybrid vehicles, and gasoline vehicles, The fuel cycle reduction effects of the five fuel passenger vehicles under three scenarios are shown in Figure 62. Taking the fuel-cycle GHG emissions in 2020 and 2060 as an example, the emission reduction effect is reduced in the order of battery electric vehicles, plug-in hybrids, diesel vehicles, gasoline vehicles, and conventional hybrids, and the reduction percentages under the current policy scenario are 95.5%, 82.0%, 38.5%, 23.9%, and 14.8%, respectively. Under the intermediate-level emission reduction scenario, the reduction percentages are 97.8%, 84.3%, 38.5%, 23.9%, and 14.8%, respectively. Under the enhanced abatement scenario, the abatement percentages were 98.3%, 86.2%, 38.5%, 23.9%, and 14.8%, respectively.

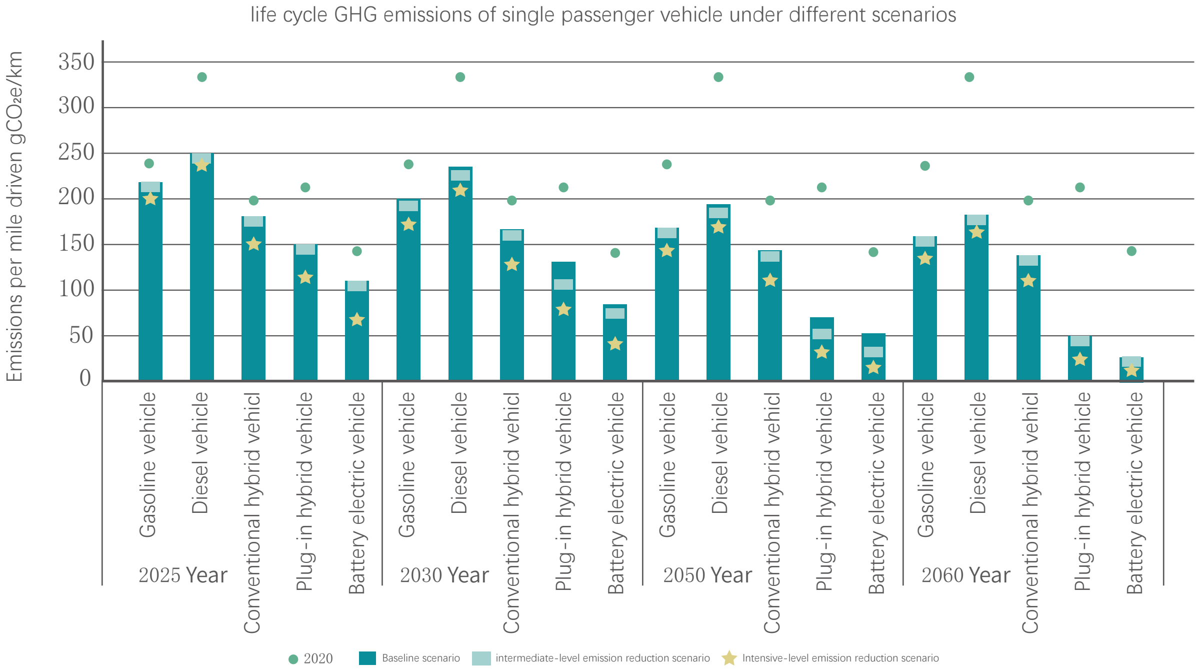


Figure 60 Life cycle GHG emission per kilometer driven for single passenger vehicle under three scenarios

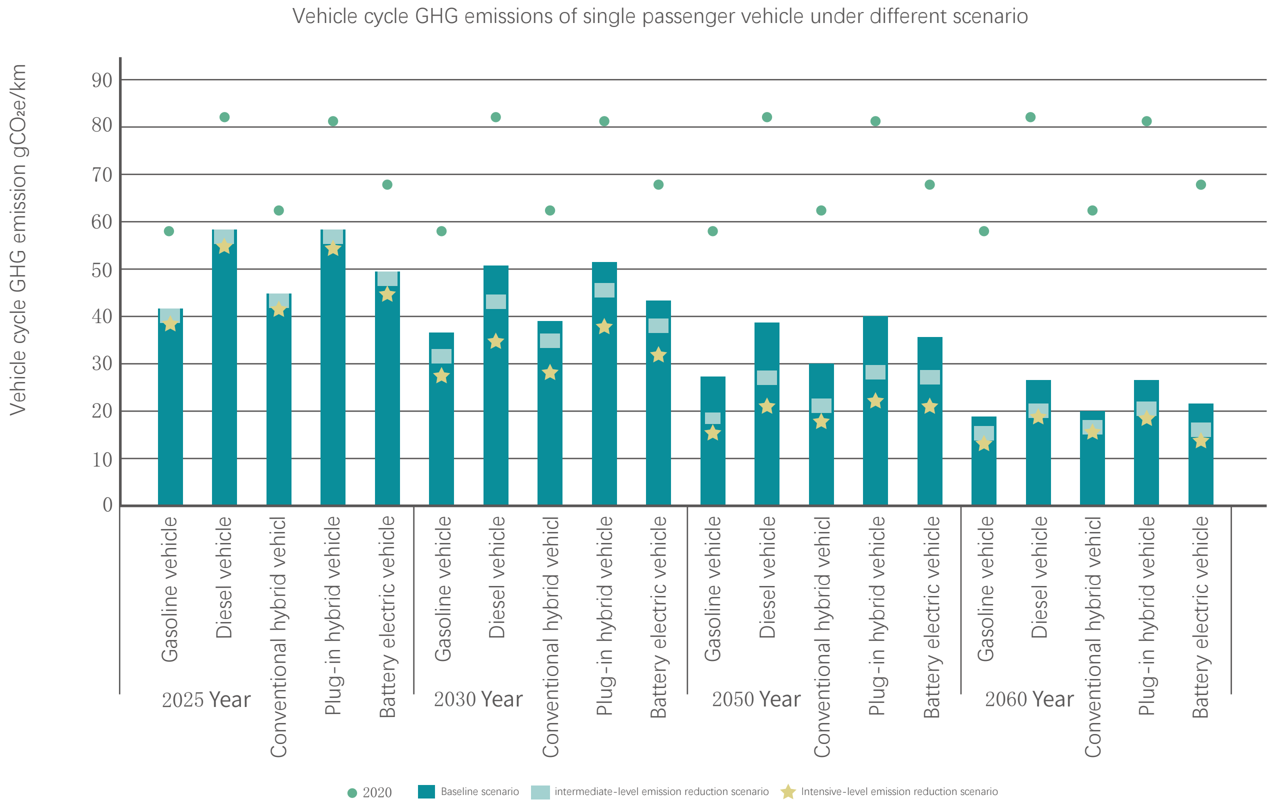


Figure 61 Vehicle cycle GHG emissions of single passenger vehicle under three scenarios

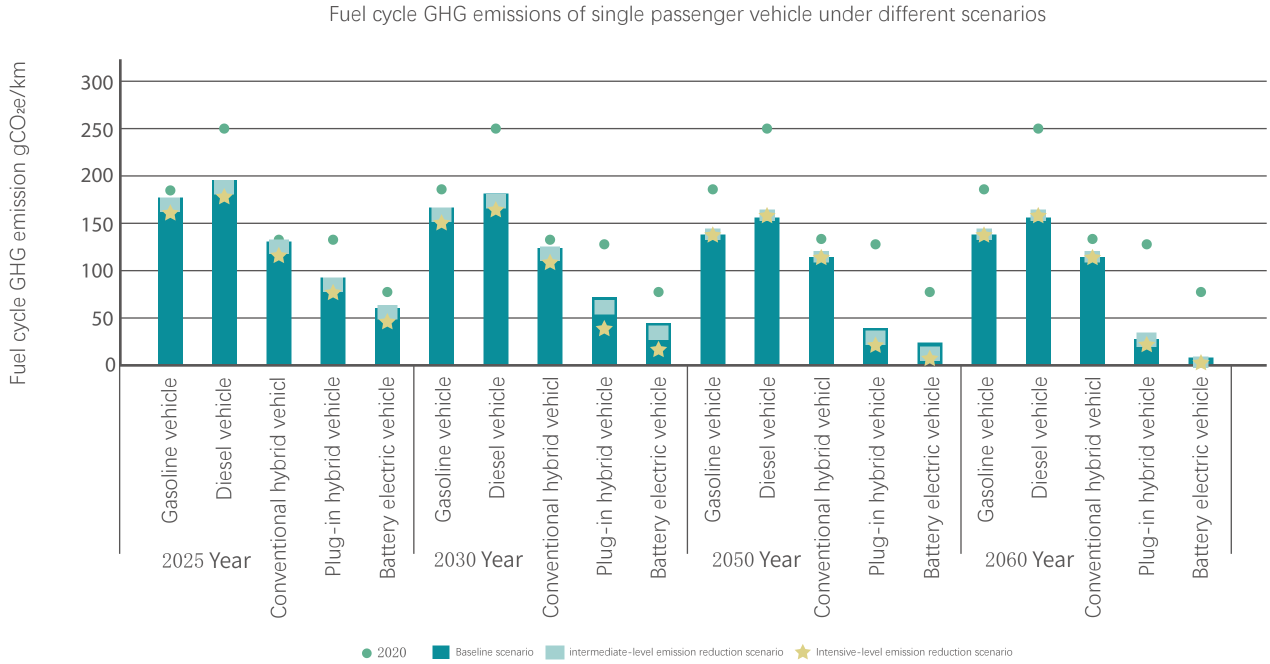


Figure 62 Fuel cycle GHG emissions of single passenger vehicle under three scenarios

The analysis of the life cycle emission reduction potential of battery electric vehicles under current policy scenario is shown in Figure s 63-66. The largest contributor to the emission reduction of battery electric vehicles is grid cleaning, which contributes between 10% and 50% in different scenarios; material efficiency is also important to the GHG emission reduction of battery electric vehicles, which can reduce the GHG emission of battery electric vehicles by 4%-13%; with the development of time, the role of power battery GHG emission on the GHG emission reduction of battery electric vehicles becomes more and more obvious, increasing from 4% to 7%; the use energy efficiency and grid cleaning both act on the GHG emission reduction of battery electric vehicle fuel cycle. The emission reduction effect of using energy efficiency tends to decrease as the grid becomes cleaner. Among the different emission reduction measures, the role of energy efficiency in production is the least obvious, mainly due to its low ratio in the life cycle GHG emissions of battery electric vehicles.

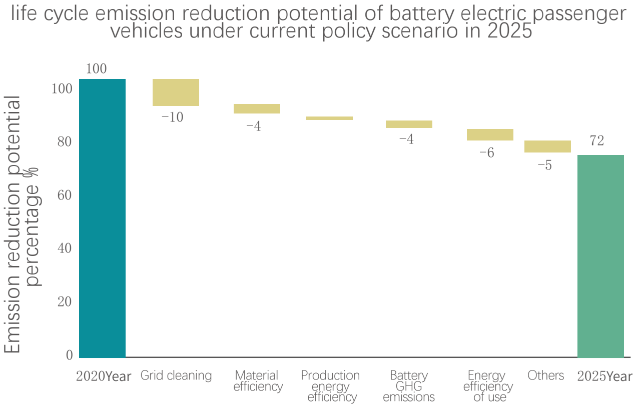


Figure 63 Life cycle emission reduction potential of battery electric passenger vehicles under current policy scenario in 2025

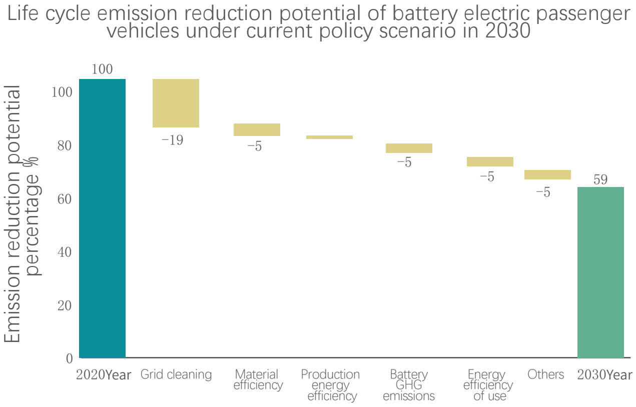


Figure 64 life cycle emission reduction potential of battery electric passenger vehicles under current policy scenario in 2030

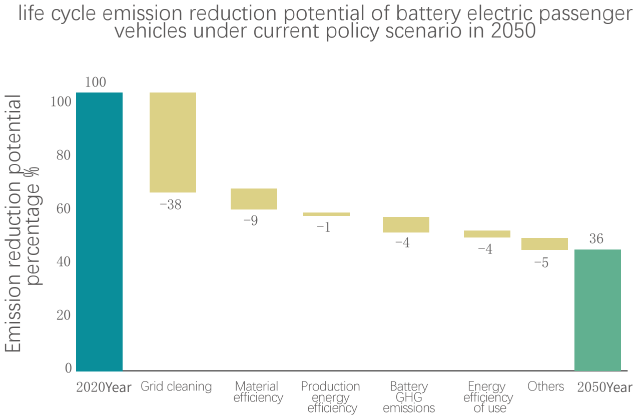


Figure 65 Life cycle emission reduction potential of battery electric passenger vehicles under current policy scenario in 2050

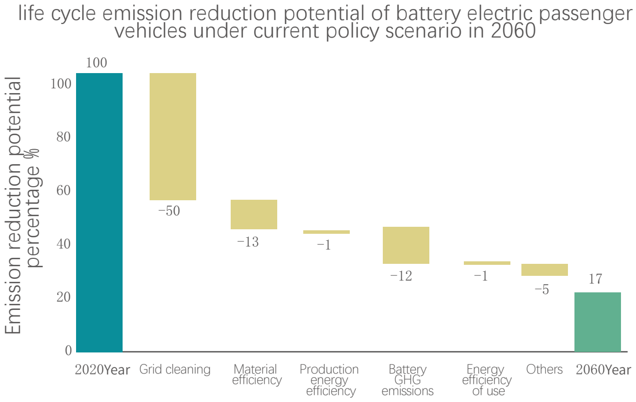


Figure 65 Life cycle emission reduction potential of battery electric passenger vehicles under current policy scenario in 2060

## 5.4 Total life cycle GHG emissions of passenger vehicle fleet under different scenarios

After determining the different parameters under three scenarios, the fleet model can be used to calculate the life cycle GHG emissions of the fleet under the corresponding scenarios.

### 5.4.1 Total fuel cycle GHG emissions of passenger vehicle fleet under different scenarios

Based on the fleet stock structure and the annual driving range of a single vehicle, the annual driving range of the fleet can be calculated.

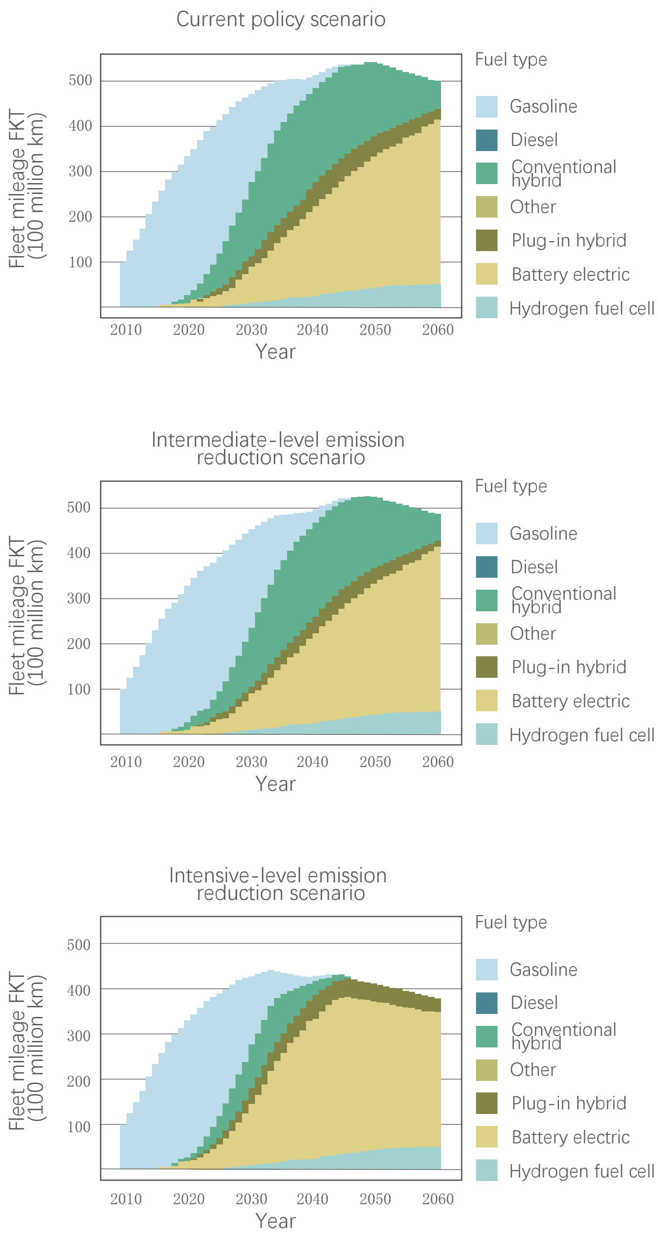
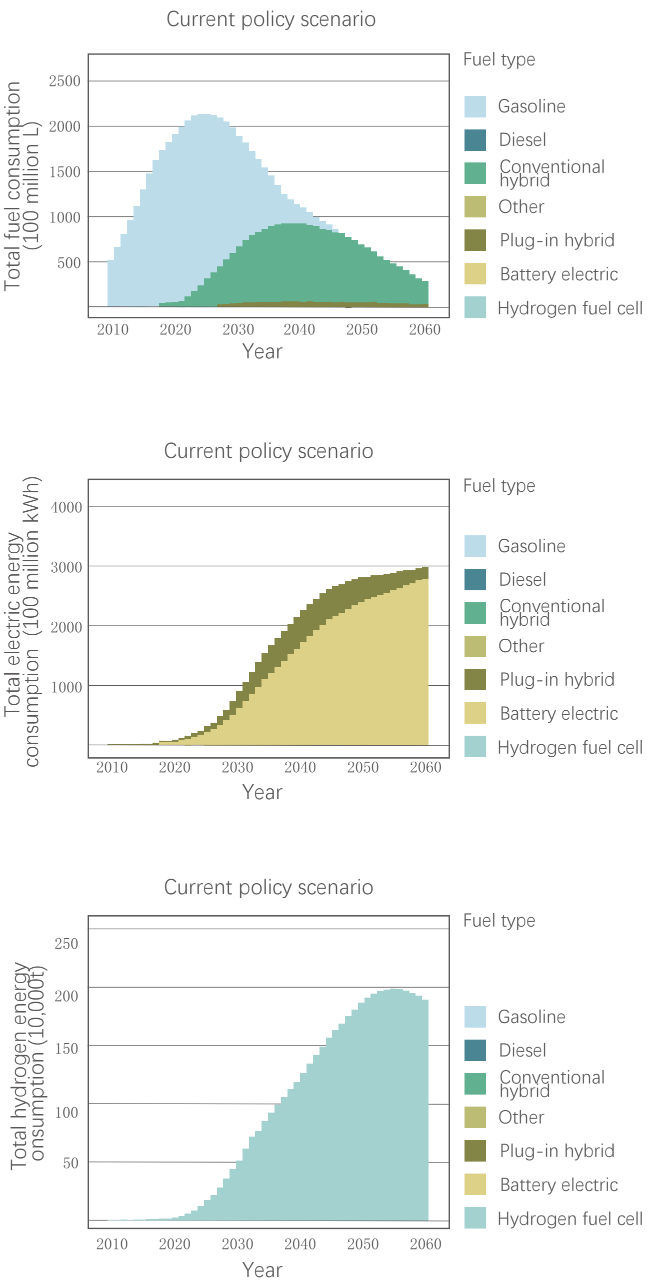


Figure 67 Forecast of annual passenger vehicle fleet mileage under three scenario

As shown in Figure 67, the variation of annual driving range of passenger vehicle fleet under the current policy scenario, the intermediate-level emission reduction scenario, and the intensive-level emission reduction scenario are shown respectively. As shown in the Figure, for the current policy scenario and the intermediate-level emission reduction scenario, the trend of annual fleet driving range is basically consistent with the trend of fleet stock growth, and for the intensive-level emission reduction scenario, the annual fleet driving range reaches the maximum around 2035 due to the large annual decrease in vehicle driving range.



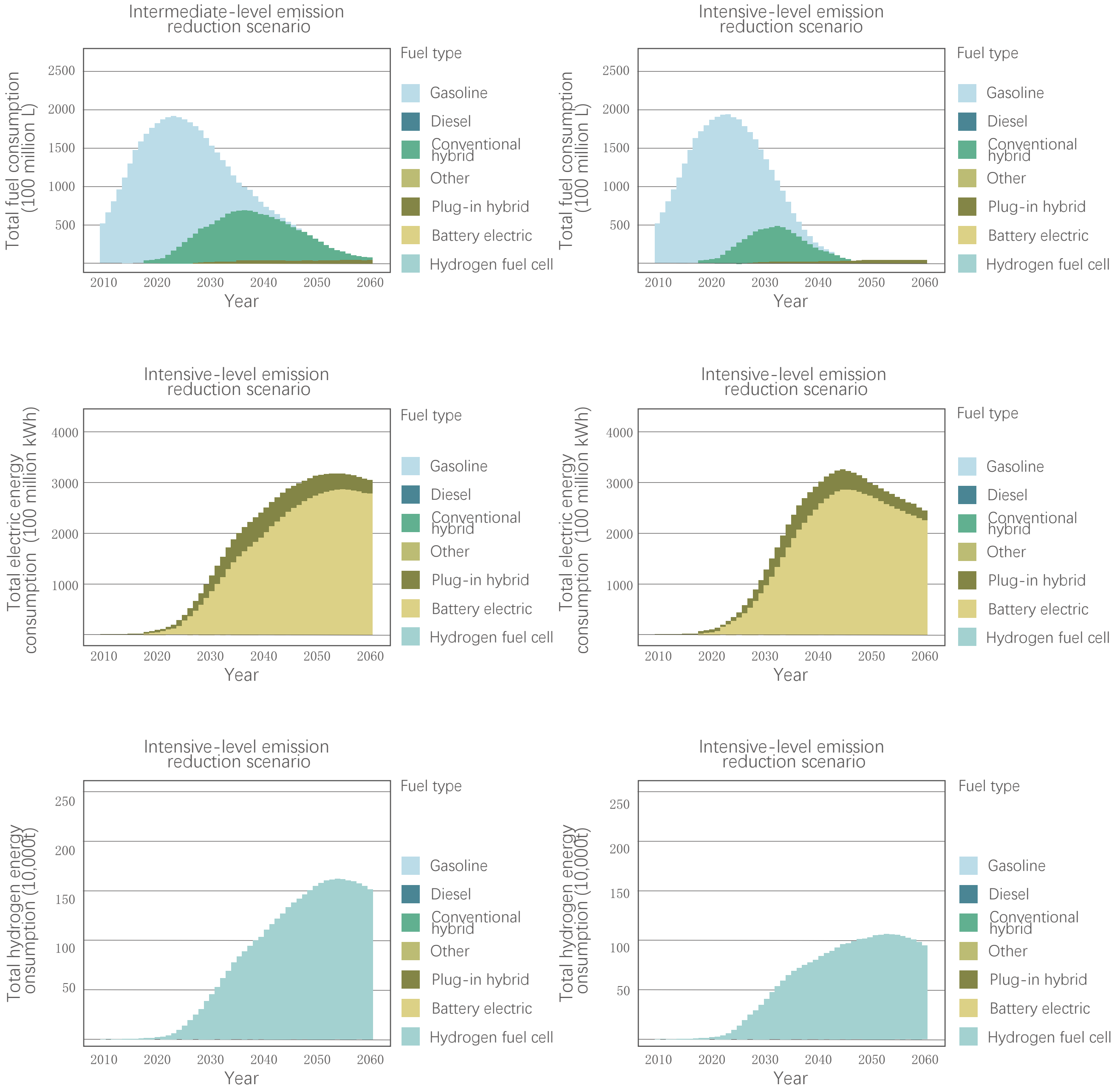
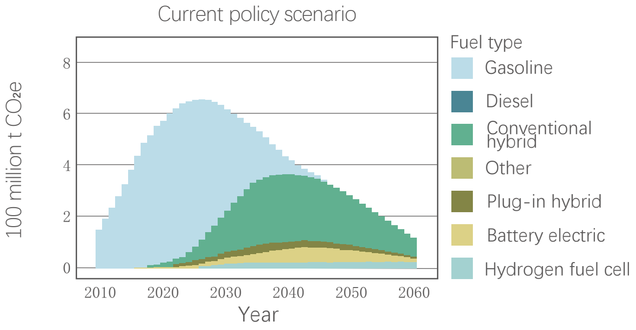
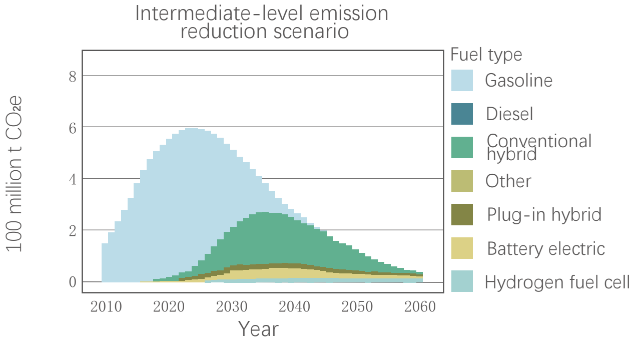


Figure 68 Fuel consumption, electricity consumption and hydrogen energy consumption of passenger vehicle fleet under three scenarios

After obtaining the annual vehicle driving range under different scenarios, the fuel consumption, electric energy consumption and hydrogen energy consumption of the passenger vehicle fleet under different scenarios can be calculated by combining the parameters set in the vehicle use energy efficiency, where fuel includes gasoline and diesel. As shown in Figure 68, under the current policy scenario, fuel consumption is expected to peak before 2030 and then decrease year by year, and there is still a certain amount of fuel consumption in 2060, while electricity consumption has been maintaining an increasing trend, which is mainly caused by the fact that the ratio of new energy vehicles in the stock still has room to rise, and hydrogen fuel consumption also rises with the growth of hydrogen fuel cell vehicles; under the intermediate-level emission reduction scenario, the trend of fuel consumption is consistent with the current policy scenario, but the rate of decline is faster after the peak of fuel consumption, and the fuel consumption is close to zero around 2060, while the electric energy consumption shows a trend of growth and then decrease, reaching a peak around 2054, and then gradually decreasing. The trend of hydrogen fuel consumption is also basically the same, but the peak of hydrogen fuel consumption decreases due to the reduction of vehicle fuel consumption; under the intensive-level emission reduction scenario, as traditional fuel vehicles are banned from sale in 2035, the traditional fuel vehicles in the stock are gradually phased out, and the fleet fuel consumption is basically close to zero in 2050. The peak of electric energy consumption is expected to arrive around 2045 and then start to decrease, and the consumption of hydrogen fuel is reduced significantly.


Current policy scenario


Intermediate-level emission reduction scenario

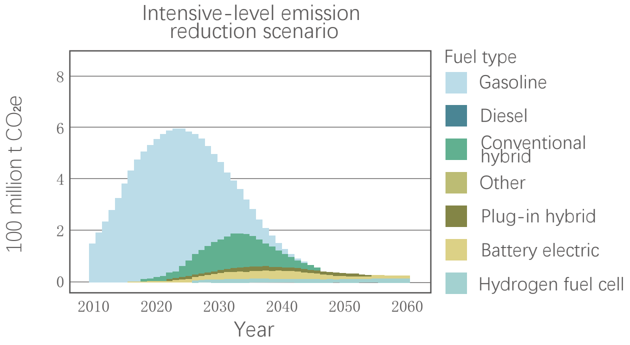

Intensive-level emission reduction scenario

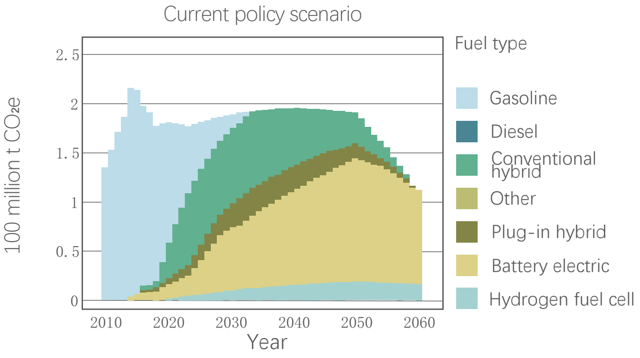
Figure 69 Fuel cycle GHG emissions of passenger vehicle fleet under three scenarios

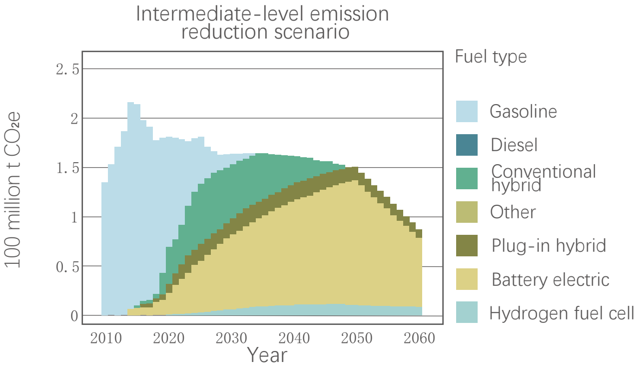
After calculating the passenger vehicle fleet fuel consumption data, the total GHG emissions from the fleet driving stage can be calculated by combining the set values of fuel cycle emission factors. As shown in Figure 69, under the current policy scenario, the total fleet fuel cycle GHG emissions are expected to peak at about 630 million t $CO_2e$ in 2028, and then the total fleet GHG emissions will decrease year by year with the increase of the ratio of new energy vehicles and the decrease of the electricity emission factor, but there will still be about 110 million t $CO_2e$ of GHG emissions in the vehicle fuel cycle until 2060. Most of them are generated by fuel consumption production and use, and a small portion is caused by electricity production. In the intermediate-level emission reduction scenario, the peak of GHG emissions of passenger vehicle fleet driving stage is advanced, and is expected to reach the peak around 2026, with total peak emissions of about 580 million t $CO_2e$. Compared with the current policy scenario, due to the higher ratio of fleet electrification, lower vehicle fuel consumption, and lower electricity emission factors, the GHG emissions of fleet fuel cycle in 2060 under this scenario has been reduced to below 40 million t $CO_2e$. In the intensive-level emission reduction scenario, the peak of GHG emissions in the fleet fuel cycle is also advanced and is expected to peak around 2025, with total GHG emissions of 570 million t $CO_2e$ at peak. With the rapid promotion of passenger vehicle fleet electrification and the reduction of GHG emission factors in the grid, GHG emissions from the passenger vehicle fleet use stage will decrease faster after the peak, and the total GHG emissions will be below 0.03 billion t $CO_2e$ in 2050.

## 5.4.2 Total GHG emissions of passenger vehicle fleet vehicle cycle under different scenarios

The GHG emissions of the passenger vehicle fleet vehicle cycle are mainly caused by the acquisition of raw materials for newly sold vehicles and vehicle production each year. Based on the GHG emission parameters related to vehicle manufacturing set in the three scenarios, combined with the forecast of future annual sales volume and the ratio by fuel type, the total GHG emissions of the future vehicle cycle can be calculated for each year. For the vehicle cycle emissions of the fleet until 2020, the parameters of 2020 are used for calculation.

As shown in Figure 70, the total vehicle cycle GHG emissions of passenger vehicle fleet in each year under three scenarios are shown. Since the vehicle cycle only needs to consider the vehicles sold in that year, its total emissions are influenced by the sales of passenger vehicles in that year, and the vehicle cycle GHG emissions always show a decreasing trend with the increase of time, so the peak of fleet vehicle cycle GHG emissions under three scenarios occurs in 2016. Under the current policy scenario, the GHG emissions in the vehicle manufacturing stage will decline to a limited extent, and a small GHG emission peak of about 190 million t CO2e will also occur in 2043 when the sales peak occurs after 2020, and for the other two scenarios, the GHG emissions of the fleet vehicle cycle show a decreasing trend over time.


Current policy scenario


Intermediate-level emission reduction scenario

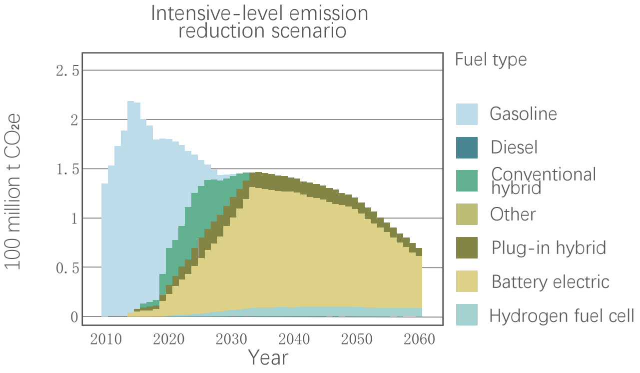
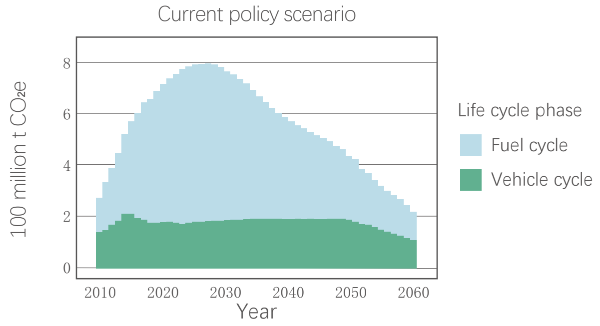
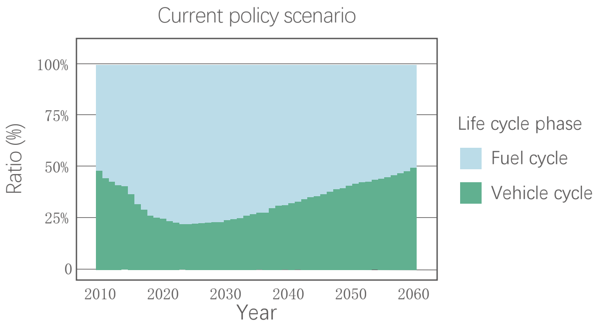

Intensive-level emission reduction scenario

Figure 70 Vehicle cycle GHG emissions of passenger vehicle fleet under three scenarios

## 5.4.3 Total passenger vehicle fleet life cycle GHG emissions under different scenarios


Current policy scenario


Current policy scenario

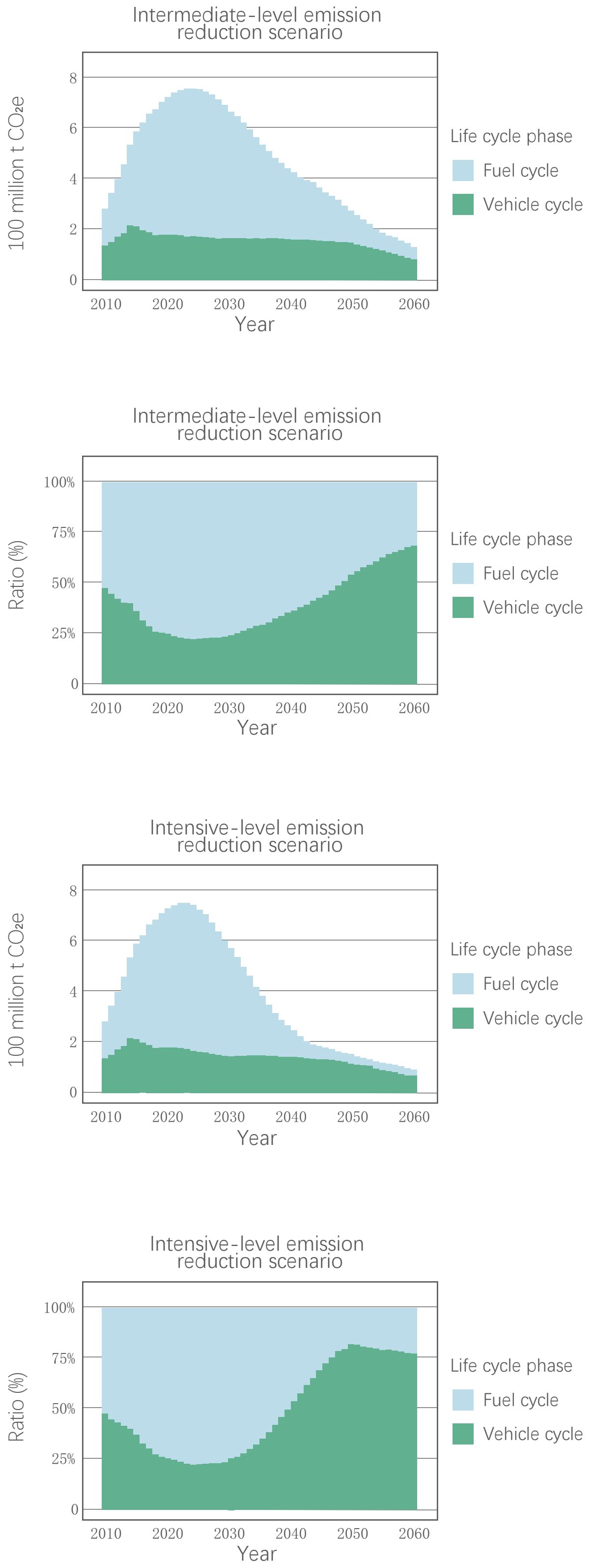


Figure 71 Total life cycle GHG emissions of passenger vehicle fleet under three scenarios

The total life cycle GHG emissions of the passenger vehicle fleet can be obtained by summing the GHG emissions of the vehicle cycle and fuel cycle under three scenarios, as shown in Figure 71. In all three scenarios, the ratio of fleet fuel cycle GHG emissions shows an increasing trend until 2025, mainly due to the increase of fuel vehicles in fleet stock and the increasing energy efficiency of vehicle production. The peak time of fleet life cycle GHG emissions under three scenarios is also largely determined by the peak time of fleet fuel cycle GHG emissions. After 2030, as the share of new energy vehicles in new vehicle sales and stock increases, the ratio of vehicle cycle emissions in fleet life cycle GHG emissions increases under all three scenarios. In the current policy scenario, the vehicle cycle share of fleet life cycle GHG emissions for the passenger vehicle fleet will reach more than 50% in 2060, and in the moderate and intensive-level emission reduction scenarios, the vehicle cycle share of fleet life cycle GHG emissions for the passenger vehicle fleet will be more than 50% earlier due to the adoption of more aggressive electrification strategies. The main reason for this phenomenon is that, as vehicle electrification advances, emissions from the fuel cycle of vehicles shift toward the electricity production side, and GHG emissions from the electricity production side gradually decrease with the increase in the ratio of renewable energy generation; in the vehicle cycle of passenger vehicle fleets, GHG emissions gradually shift from the fuel cycle to the vehicle cycle due to the increasing ratio of electrification in the fleet. The ratio of vehicle cycle GHG emissions in total life cycle GHG emissions is increasing but the total amount is on a decreasing trend.

Based on the above results, even in the most aggressive enhanced emissions reduction scenario, while fleet fuel cycle GHG emissions can be reduced to low levels, fleet vehicle cycle GHG emissions are still difficult to achieve carbon neutrality with the current portfolio of reduction options, unless negative carbon technologies are used to remove this portion of GHG emissions. Therefore, for the future low-carbon development of the automotive industry, the focus of carbon neutrality in the automotive industry needs to transition from the fuel cycle to the vehicle cycle. Relying on vehicle electrification and energy efficiency improvement alone is not enough for automotive industry's carbon neutrality. Instead, it needs to explore carbon reduction measures and negative carbon technologies for the whole life cycle of vehicles. In the next step, China should further strengthen the upstream and downstream linkage and system integration of carbon neutral solutions in the automotive industry chain, so that the carbon neutrality of the whole industry chain can be pushed and pulled by the carbon neutrality of the whole life cycle of the automotive industry, and the carbon neutrality of the whole industry can lead the whole industry to move towards net zero emissions.

### 5.4.4 Life Cycle Carbon Reduction Potential of E-Fueled PassengerVehicle Fleets

Electro-fuels (e-fuels), also commonly referred to as “$CO_2$-based synthetic fuels”, “liquid sunshine”, or “power-to-fuels”, have gained huge interest around the world as a promising solution to effectively decarbonize the transport sector [1] [2]. These alternative fuels are produced via chemical synthesis of carbon and hydrogen to form liquid or gaseous hydrocarbons. The $CO_2$ can be captured either from ambient (direct air capture, DAC) or concentrated sources (e.g. industrial exhaust gases), while hydrogen can be produced from water electrolysis with renewable electricity [3]. The recycling of $CO_2$ (i.e.non fossil-based carbon) and the utilization of renewable electricity distinguish sustainable e-fuels obtained from other types of synthesis processes such as coal-to-liquid (CtL) or gas-to-liquid (GtL), and it also excludes synthetic fuels derived using $CO_2$-intensive hydrogen.

The versatility of the conversion technology makes e-fuels an attractive solution for the global transport sectors. E-fuels can be tailored to minimize the criteria pollutant emissions from internal combustion engines (i.e. NOX and soot formation) [4]. The productions of synthetic e-gasoline and e-diesel allow them to be blended into regular gasoline and diesel fuels, with a drop-in capability of close to 100%. E-fuels can be perfectly compatible with existing infrastructures and vehicle fleet while allowing near-zero transport GHG emissions. Thus, many government agencies, automakers and relevant stakeholders are advocating for e-fuels as a realistic greenhouse gas (GHG) mitigation strategy. E-fuels, for the first time, are counted towards the renewables target of the recast Renewable Energy Directive (RED II) for 2021-2030 in the European Union (EU) [5]. Automakers are engaged in the production and development of e-fuels technologies to decarbonize their fleet, alongside electrification and efficiency improvement. As an example, over the past few years, Audi has embarked on a comprehensive plan for a range of e-fuels research (i.e. Audi e-gas, e-gasoline and e-diesel) to lower the $CO_2$ footprint of existing combustion engine vehicles [6]. Porsche, Siemens Energy and a lineup of international companies are developing a pilot project in Chile with expectation of around 130,000 liters of e-fuels to be produced as early as 2022 [7]. Similarly, China has rolled out a strategic plan for e-fuels. The vision and strategy for “liquid sunshine” were articulated by the Chinese academy of Sciences (CAS) [8]. Scientists led by the Dalian Institute of Chemical Physics (DICP) have begun a large-scale project to demonstrate synthetic methanol using solar energy and $CO_2$ from industrial plants in Lanzhou province, with a capacity of 1,000 tonnes of methanol per year.

#### 5.4.4.1 Whole life cycle GHG Emissions Analysis of E-Fuel

E-fuels production pathways consist of two main processes: syngas production, followed by fuel synthesis pathways to produce fuels in gaseous (methane) or liquid forms (methanol, gasoline, diesel and middle-distillates etc.). In this study, the life cycle GHG emissions of e-gasoline and e-diesel, produced through a combination of mature technologies, are assessed. The drop-in e-gasoline production involves the methanol synthesis process by reacting a mixture of $CO_2$ and H2 to produce methanol as an intermediary, which is then converted to gasoline using the well-known methanol-to-gasoline process (MTG). Fisher-Tropsh (FT) process, as a proven technology at a commercial scale, is adopted for e-diesel production, where fuel synthesis starts with conversion of the $CO_2$ to CO using the reverse water gas shift (RWGS) reaction. A syngas with a specific ratio of $H_2$ to CO is directed to the FT unit to produce synthetic feedstock, which can then be refined to produce finished products. The Well-to-Wheel (WtW) carbon intensity data in this study are obtained from Aramco, based on the company's in-house assessment. Additional information regarding e-fuels carbon intensity can be found in the 2020 CALCA report [6].

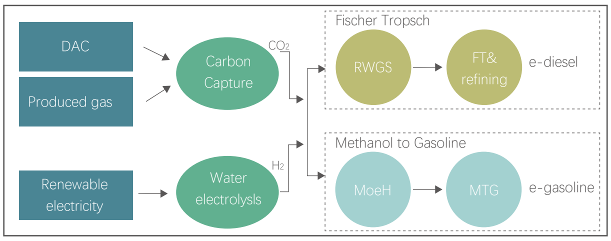


Figure 72 Block flow diagram for e-fuels production with FTs and MTG pathways (Image courtesy of Aramco)

Figure 73 compares the life cycle GHG emissions of BEV, e-diesel ICEV and e-gasoline HEV under the 2030 and 2050 stated policy scenario (SPS). Note that the results for each generic vehicle model (vehicle weight is presented) in this study are weighted average values based on current market structure in China. E-fuels have significantly lower carbon footprint compared to the conventional energy carriers. The GHG emissions associated with combustion are offset by the $CO_2$ capture during the fuel production phase, despite a large variation of fuel economy for each vehicle powertrain system. GHGs abatement potential of e-diesel powered ICEV and e-gasoline powered HEV can reach 35% and 53% compared to the BEV in 2030. Even in 2050, when the electricity is projected to be extensively decarbonized and the environmental load from battery productions is expected to be significantly reduced, e-diesel powered ICEV and e-gasoline powered HEV could still enable 18% and 40% GHG emissions reduction compared to the BEV.

Figure 73 Life cycle GHG emissions between BEV and e-fuels powered vehicles in 2030 and 2050 (current policy scenario, SPS)
(Image courtesy of Aramco)

### 5.4.4.2 GHG Emissions Assessment of Fleets

A key advantage of liquid e-fuels is that very little effort is required to make them drop-in fuels and fully compatible with existing infrastructure, storage, distribution and vehicle fleets. Thanks to similar physico-chemical properties compared to fossil fuels, liquid e-fuels are compatible with internal combustion engines, enabling all the advantages of conventional liquid energy sources such as ease of use (stable at room temperature), short refueling process, and high energy density with a long vehicle range. This makes e-fuels a compelling choice to benefit the transport sector from both an energy and GHG emissions perspective, since there is no need for slow and expensive fleet turnover, and the disposal or conversion of existing infrastructure can be avoided.

Figure 3 illustrates the impact of e-gasoline deployment on the annual life cycle GHG emissions of China's passenger vehicle fleet under the ). The e-gasoline blending ratio on conventional gasoline is assumed to increase linearly at different rates, from 0% in 2020 to 30%, 60% and 90% in 2060. Since the vehicle fleet is primarily composed of ICEVs, the deployment of e-gasoline lowers the GHG emissions from the sector significantly (Figure 3(a)), and more importantly, reaching a lower and sooner GHG emissions peak for the transport sector (Figure 3(b)). For the SPS without e-gasoline deployment, the annual GHG emissions will peak at 810 Million tonnes (Mt) in 2029. With increase of e-gasoline blending ratio, the year of peak annual GHG emissions will be shifted to an earlier date with lower amount. For example, meeting a hypothetical e-gasoline blending ratio target of 5% by 2027 will allow the peak annual GHG emissions to be reduced by 35 Mt, and it is likely to be achieved 2 years earlier than the base case. On the other hand, blending e-gasoline in larger volumes, achieving 11% by 2025, could lower the peak annual emissions by 89 Mt, where the GHG emissions peak can be achieved 4 years sooner.

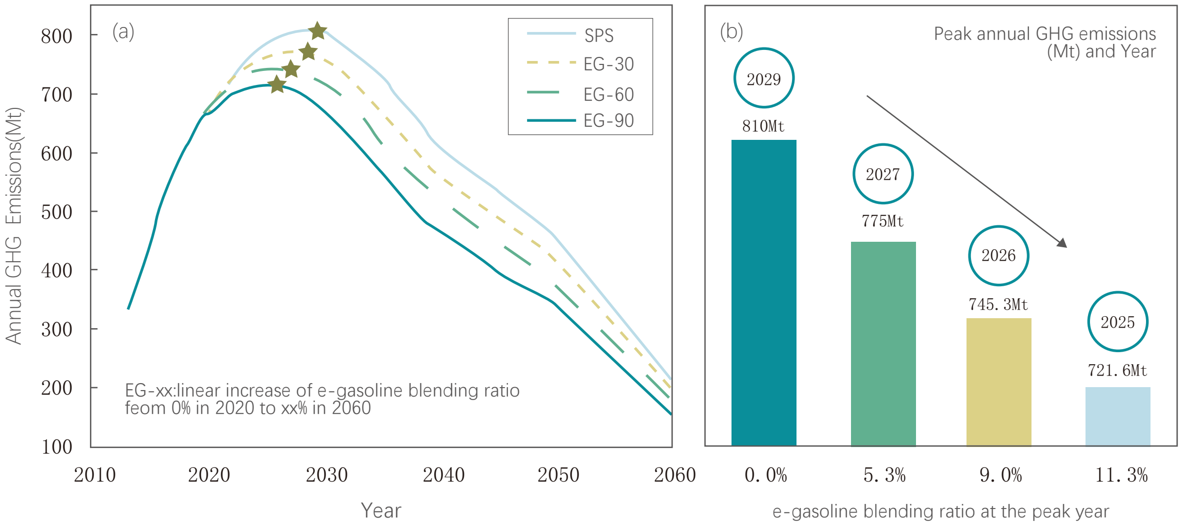


Figure 74 Impact of e-gasoline deployment on the annual life cycle GHG emissions of China's passenger vehicle fleet under the current policy scenario: (a) annual life cycle GHG emissions towards 2060 (b) annual GHG emissions vs e-gasoline blending ratio at the peak year
(Image courtesy of Aramco)

To put this into perspective, figure 75 illustrates the share of BEVs in the vehicle stock to achieve the respective peak GHG emissions, with and without e-gasoline blends. Achieving peak emissions of 775 Mt without the use of e-gasoline would require about 17% BEV stock share by 2032. This implies a significant investment to drive uptake of BEVs, retire older vehicles in the fleet, and deploy large quantities of charging infrastructures. On the other hand, with the use of e-gasoline at 5% blend, a similar peak GHG emissions level can be achieved by 2027 (5 year earlier) with only 7% BEV stock share. The discrepancy could be further magnified with enhanced e-gasoline penetration. This presents a significant opportunity to decarbonize the vehicle fleet by changing the energy source, rather than driving a complete overhaul of the transport ecosystem.

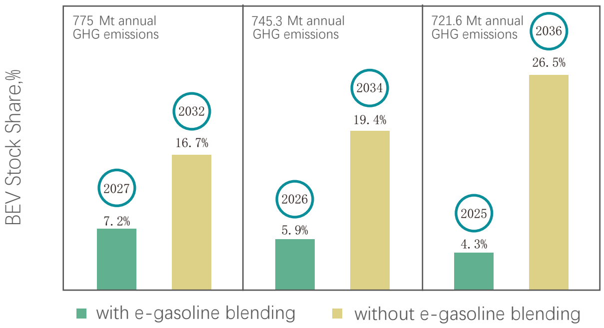


Figure 75 Comparisons on BEV stock share and model year of peak GHG emissions with and without e-gasoline blending for each e-gasoline penetration scenario.
(Image courtesy of Aramco)

However it is worth noting that the current technology for producing e-fuels is still at the demonstration scale since there are significant barriers to unlock the full potential of these low carbon fuels. The production costs for e-fuels remain high (2.2-4.8 times) compared with conventional fossil fuels [10]. The e-fuels production process is inherently inefficient, converting at best half of renewable energy into the liquid or gaseous fuels. The cost of renewable power generation and multiple conversion facilities associated with significant thermodynamic losses (therefore low yield of e-fuels production) are the key limiting factors of production costs. Nevertheless, the prices are likely to fall over time and become cost-competitive due to the economics of scale, optimized conversion facilities and reduction in the feedstock prices [11]. For instance, hydrogen productions are from regions with an abundance of renewable wind, tide or solar energy sources (declining cost). Equally, for e-fuels to be a success, a policy and regulatory intervention will be needed to drive the investment and commercialization. This includes a holistic framework for GHG accounting (i.e. LCA-based policy) to level the regulatory playing field and enable a lasting impact on GHG emissions mitigation. Ultimately, achieving China's ambitious climate protection goals will require a broad mix of policies and technologies, in which e-fuels, BEVs and advanced hybrids have important roles to play.

# 06

# SUGGESTED COUNTERMEASURES FOR FUTURE CARBON NEUTRALITY IN THE AUTOMOTIVE INDUSTRY

## 6.1 Near-term (to 2025)

Establish a sound GHG emission standard system for the automotive industry. The automotive life cycle GHG emission standard system is the basis for implementing automotive GHG emission management. It is recommended to take the key aspects of the whole life cycle GHG emission of automobiles as the entry point and gradually establish the life cycle GHG emission standard system including the whole vehicle, low-carbon materials, recycled materials, hydrogen fuel, hydrogen fuel cell, power battery, etc., so as to provide standard support for the national implementation of GHG emission management policy and also provide a basis for the car enterprises to strengthen GHG emission management capacity building.

Establish and improve the GHG emission management system for the automotive industry. During 2020-2021, it is expected to promote the establishment and publication of the technical specification for life cycle GHG emission accounting of passenger vehicles GB/T or HJ standard. From 2021 to 2022, based on GHG emission standards, it’s expected to promote the construction of a GHG emission public disclosure system, study the establishment of a carbon labeling system for automobiles, raise public awareness of low-carbon consumption, and urge enterprises to make low-carbon transformation. From 2023 to 2024, it’s expected to develop incentive measures such as a low-carbon technology catalog for passenger vehicles. In 2025, a series of binding policies will be launched, such as the management of GHG emissions in the automotive industry according to the life cycle GHG emission limits for passenger vehicles standard and the imposition of fines and orders for transformation if the limits are exceeded; the introduction of an “integration” carbon tax on models with high GHG emissions to guide the low-carbon development of the automotive industry, etc.

Accelerate the promotion of new consumption modes in the automotive industry. The current lack of consumer awareness of GHG emission reduction will inevitably offset the emission reduction efforts on the production side. On the one hand, OEMs are forced to shift to the production of electric vehicles due to the pressure of emission reduction, and on the other hand, consumers prefer traditional fuel vehicles, leading to increased risk of emission reduction in the OEM and upstream and downstream supply chains, reducing their enthusiasm for emission reduction. Moreover, production-side emission reduction cannot cover all GHG emission sources, and the unavoidable and irreplaceable GHG emission sources need to be coped with by the consumer side, so it is necessary to improve consumers’ awareness of GHG emission reduction, strengthen their low-carbon consciousness, change their consumption modes and further promote the consumption of BEV.

In the short term, through the development of technical specifications and limit standards for GHG emission accounting in the automotive industry and supporting policy measures, it’s expected to improve the GHG emission management capacity of enterprises and their awareness of emission reduction, force enterprises to make green and low-carbon transformation, shift traditional fuel vehicles to electric vehicles with lower GHG emissions, and reduce the transition costs of electric vehicles through consumer-side guidance, reduce the emission reduction pressure on OEMs and create a favorable policy environment for the subsequent R&D of low-carbon technologies and the popularization of electrification.

## 6.2 Mid-term (to 2030)

Promote the application of low-carbon materials. Compared with gasoline vehicles, the whole life cycle GHG emissions of electric vehicles shift to the vehicle cycle, with vehicle cycle and fuel cycle GHG emissions accounting for roughly half each, especially the power battery production and end-of-life recycling stage will generate more GHG emissions. Meanwhile, the European Union has proposed a series of mandatory requirements for the carbon footprint of batteries and the utilization rate of recycled materials in the proposed Law on European Battery and Waste Battery. Based on emission reduction and compliance considerations, the application of recycled materials and other low-carbon materials in electric vehicles has become more urgent.

Promote research and development of low-carbon technologies. Encourage vehicle enterprises to carry out low-carbon technology innovation, improve process flow, improve production energy efficiency, and design and develop low-carbon and zero-carbon components, so as to further reduce the GHG emissions of vehicle cycles. Meanwhile, power battery enterprises are encouraged to develop low-carbon and zero-carbon battery positive and negative key materials and improve the energy efficiency of battery production, so as to reduce the GHG emissions of power batteries; in addition, vehicle enterprises should promote upstream and downstream enterprises in the supply chain to collaborate to reduce pollution and reduce carbon and increase efficiency, so as to promote the wide application of low-carbon technologies in the entire automotive industry chain. Meanwhile, promote the development and uptake of low-carbon fuels via a low-carbon fuels standard (LCFS). This allows for the carbon intensity of fuels to be reduced through the use of lower emissions crude oils, innovative refining technologies, low-carbon hydrogen, renewable fuels and sustainable e-fuels. On the one hand, during the period of excessive electrification, the peak GHG emissions can be reduced by promoting the use of low-carbon technologies and improving the fuel efficiency of traditional gasoline vehicles. On the other hand, encourage technological innovation in low-carbon technologies and commercial productions of low-carbon fuels.

Increase the rate of vehicle electrification. As electric vehicles face the problems of short range, long charging time and few charging piles, the convenience of electric vehicle users needs to be improved, resulting in the low penetration rate and insufficient driving range of electric vehicles in China. Therefore, to improve the electrification rate of vehicles and popularize electric vehicles, on one hand, we need enterprises to continue to improve the technology of electric vehicles, including improving the range of electric vehicles and shortening the charging time. On the other hand, the government needs to improve EV infrastructure and deploy sufficient EV infrastructure such as charging piles in advance in urban planning.

Promote the change of travel mode. Optimize the existing public transportation system, build an urban intelligent bus system, realize functions such as automatic voice announcements, passenger flow statistics, and shuttle bus route management, actively improve the conditions for residents to travel by public transportation, and prompt more residents to choose public transportation to travel. Optimize the existing car-sharing supervision and management system, improve the safety and standardization of car-sharing, and promote the safe and healthy development of car-sharing in order to improve the efficiency of car use and reduce the stock of private cars. In addition, car-sharing oftentimes is a substitution for low emission transport (such as public transport). To have a positive effect, car-sharing should complement public transport and be connected to an efficient intermodal transport system based on public transport. To promote alternative vehicle ownership models, a seamless connection with other modes of transport is key. Additionally, incentivizing shared rides could be an option to increase average occupancy rates.Meanwhile, optimize the existing road design to protect the right-of-way for non-motorized vehicles such as bicycles and encourage residents to use green travel modes such as bicycles for short distances.

In the medium term, by continuously promoting technological innovation in electric vehicles, reducing GHG emissions in the vehicle cycle, overcoming problems faced by electric vehicles such as high cost, short range, slow charging speed, and high GHG emissions in the vehicle cycle, and rapidly improving product performance, quality, user experience, and emission reduction performance, we will gradually increase the rate of vehicle electrification and create good technical conditions for the next stage of the electric era. Meanwhile, by optimizing the existing public transportation system, road design and car-sharing supervision and management system, we encourage more residents to travel green and low-carbon, reduce the purchase and use of private cars, and reduce the pressure of emission reduction in the auto industry.

## 6.3 Long-term (to 2060)

Accelerate the transformation of grid cleaning. China's “coal-rich, oil-poor, and gas-poor” fossil energy resource endowment has led to a predominantly coal-based power structure and a high GHG emission factor for electricity production, which has hindered the electrification process to a certain extent. Meanwhile, from the above research results, it can be seen that the emission reduction contribution of grid cleaning is the largest under different scenarios. Therefore, promoting the transformation of grid cleaning can accelerate the process of carbon neutrality in the automotive industry. Currently, coal power is the main source of electricity supply in China, and in the short term, it is not feasible to phase out coal power in a “one-size-fits-all” manner. Therefore, on one hand, we need to promote the efficient and clean use of coal power, the application of carbon-negative technologies, and on the other hand, gradually increase the ratio of non-fossil energy generation, and eventually build a new energy power system based on non-fossil energy.

Promote the smooth transition of the electric era. Under the premise of mature development of electric vehicle technology and grid cleaning, the role played by electric vehicles in the carbon neutrality of the automotive industry will be further amplified, and in the future, electric vehicles will play the role of the main force of automotive carbon neutrality. During this period, the application of electric vehicles in various fields will be continuously promoted and the transition to the electric era will be smooth. Additionally, BEVs can contribute as decentralized storage facilities, further promoting the transition to the electric era.

Promote research and development of zero-carbon fuel cell vehicles. Accelerate the research and development of zero-carbon fuel cell vehicles for long-distance transportation applications that are difficult to electrify. The relatively high electricity consumption and short life cycle of long-distance transportation make it difficult to electrify this part of vehicles. Therefore, we can promote the application of zero-carbon fuels such as renewable hydrogen for long-distance transportation, which is difficult to electrify.

Accelerate the research and development of negative carbon technology. Negative carbon technologies can greatly reduce GHG emissions in the automotive industry. Because of technical conditions or cost constraints, some vehicles may not be fully electrified or certain parts of the life cycle cannot achieve net zero emissions, so negative carbon technology is necessary for this part of GHG emissions and is a great tool to achieve carbon neutrality. At present, negative carbon technology is still immature, costly and not yet commercially available. Therefore, in this stage, it's required to focus on promoting the research and development of negative carbon technology to reach the level of commercial application.

To sum up, in the long term, the main purpose is to achieve carbon neutrality in the automotive industry by accelerating the transition to cleaner power grids and electrification of vehicles, with the commercial application of negative carbon technologies.

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Table 1 Automotive life cycle low carbon development standards catalog

| No. | Subsystem | Subarea | Standard No. | Standard name |
|---|---|---|---|---|
| 1 | Low-carbon industry | Low-carbon technical route | GB/T 26989-2011 | Automotive recycling terminology |
| 2 | Low-carbon industry | Low-carbon technical route | GB/T 26988-2011 | Automotive components recyclability label |
| 3 | Low-carbon industry | Low-carbon technical route | GB/T19515-2015 | On-road vehicle Recycling rate and recyclable rate Calculation method |
| 4 | Low-carbon industry | Low-carbon technical route | GB/T 33460-2016 | End-of-life vehicle dismantling instruction manual preparation specification |
| 5 | Low-carbon industry | Low-carbon technical route | GB/T 30512-2014 | Requirements for banned substances in vehicles |
| 6 | Low-carbon industry | Low-carbon technical route | QC/T 943-2013 | Test methods for lead and cadmium in automotive materials |
| 7 | Low-carbon industry | Low-carbon technical route | QC/T 941-2013 | Test methods for mercury in automotive materials |
| 8 | Low-carbon industry | Low-carbon technical route | QC/T 942-2013 | Test method for hexavalent chromium in automotive materials |
| 9 | Low-carbon industry | Low-carbon technical route | QC/T 944-2013 | Test methods for polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs) in automotive materials |
| 10 | Low-carbon industry | Low-carbon technical route | QC/T 1131-2020 | Test method for polycyclic aromatic hydrocarbons in automotive materials |
| 11 | Low-carbon industry | Low-carbon technical route | GB/T 39897-2021 | Test method for volatile organic compounds and aldehydes and ketones in non-metallic components of vehicles |
| 12 | Low-carbon products | Limit/indicator | GB 27999—2019 | Evaluation method and index of fuel consumption of passenger vehicles |
| 13 | Low-carbon products | Limit/indicator | GB 19578—2021 | Fuel consumption limits for passenger vehicles |
| 14 | Low-carbon products | Limit/indicator | GB 20997—2015 | Fuel consumption limits for light-duty vehicles |
| 15 | Low-carbon products | Limit/indicator | GB 30510—2018 | Fuel consumption limits for heavy-duty vehicles |
| 16 | Low-carbon products | Limit/indicator | GB/T 36980—2018 | Electric vehicle energy consumption rate limit value |
| 17 | Low-carbon products | Label | GB 22757.1—2017 | Energy consumption labeling for light-duty vehicles Part 1: Gasoline and diesel vehicles |
| 18 | Low-carbon products | Label | GB 22757.2—2017 | Energy consumption labeling for light-duty vehicles Part 2: Externally rechargeable hybrid electric vehicles and battery electric vehicles |
| 19 | Low-carbon products | Test method | GB/T 19233—2020 | Fuel consumption test method for light-duty vehicles |
| 20 | Low-carbon products | Test method | GB/T 27840—2011 | Fuel consumption measurement method for heavy commercial vehicles |
| 21 | Low-carbon products | Test method | GB/T 12545.1—2008 | Test method for fuel consumption of vehicles Part 1: Test method for fuel consumption of passenger vehicles |
| 22 | Low-carbon products | Test method | GB/T 12545.2—2001 | Test method for fuel consumption of commercial vehicles |
| 23 | Low-carbon products | Test method | GB/T 18386—2017 | Test method for energy consumption and driving range of electric vehicles Part 1 |
| 24 | Low-carbon products | Test method | GB/T 18386.1—2021 | Test method for energy consumption and driving range of electric vehicles Part 1: Light-duty vehicles |
| 25 | Low-carbon products | Test method | GB/T 19753—2021 | Test method for energy consumption of light-duty hybrid electric vehicles |
| 26 | Low-carbon products | Test method | GB/T 19754—2015 | Test method for energy consumption of heavy-duty hybrid electric vehicles |
| 27 | Low-carbon products | Test method | GB/T 35178—2017 | Fuel cell electric vehicles Hydrogen consumption measurement method |

Continued Schedule 1

| No. | Subsystem | Subarea | Standard No. | Standard name |
|---|---|---|---|---|
| 28 | Low-carbon products | Test method | GB/T 29125—2012 | Test method for fuel consumption of compressed natural gas vehicles |
| 29 | Low-carbon products | Test method | QC/T1130-2020 | Test method for fuel consumption of methanol-fueled vehicles |
| 30 | Low-carbon products | China's driving cycle/conversion | GB/T 38146.1—2019 | Driving conditions of vehicles in China Part 1: Light-duty vehicles |
| 31 | Low-carbon products | China's driving cycle/conversion | GB/T 38146.2—2019 | Driving conditions of vehicles in China Part 2: Heavy commercial vehicles |
| 32 | Low-carbon products | China's driving cycle/conversion | GB/T 37340—2019 | Electric vehicle energy conversion method |
| 33 | New energy products | Basic and general | GB 18384-2020 | Safety requirements for electric vehicles |
| 34 | New energy products | On-board energy storage system | GB 38031-2020 | Safety requirements for power battery for electric vehicles |
| 35 | New energy products | Battery electric vehicle | GB 38032-2020 | Safety requirements for electric buses |
| 36 | New energy products | On-board energy storage system | GB/T 18333.2-2015 | Zinc air battery for electric vehicles |
| 37 | New energy products | Battery electric vehicle | GB/T 18385-2005 | Electric vehicle power performance test methods |
| 38 | New energy products | Basic and general | GB/T 18387-2017 | Limit values and measurement methods for electromagnetic field emission intensity of electric vehicles |
| 39 | New energy products | Battery electric vehicle | GB/T 18388-2005 | Electric vehicle shaping test regulations |
| 40 | New energy products | Conductive charging | GB/T 18487.3-2001 | Electric vehicle conductive charging system Electric vehicle AC/DC charger (Station) |
| 41 | New energy products | Electric drive system | GB/T 18488.1-2015 | Drive motor system for electric vehicles Part 1: Technical |
| 42 | New energy products | Electric drive system | GB/T 18488.2-2015 | Drive motor system for electric vehicles Part 2: Test methods |
| 43 | New energy products | Basic and general | GB/T 19596-2017 | Electric vehicle terminology |
| 44 | New energy products | Hybrid electric vehicle | GB/T 19750-2005 | Hybrid electric vehicle shaping test procedure |
| 45 | New energy products | Hybrid electric vehicle | GB/T 19752-2005 | Hybrid electric vehicle power performance test methods |
| 46 | New energy products | Basic and general | GB/T 19836-2019 | Electric vehicle instrumentation |
| 47 | New energy products | Conductive charging | GB/T 20234.1-2015 | Connection device for electric vehicle conduction charging Part 1: General requirements |
| 48 | New energy products | Conductive charging | GB/T 20234.2-2015 | Connection device for electric vehicle conduction charging Part 2: AC charging interface |
| 49 | New energy products | Conductive charging | GB/T 20234.3-2015 | Connection device for electric vehicle conduction charging Part 3: DC charging interface |
| 50 | New energy products | Other systems and components | GB/T 24347-2009 | DC/DC converter for electric vehicles |
| 51 | New energy products | Basic and general | GB/T 24548-2009 | Fuel cell electric vehicle terminology |
| 52 | New energy products | Fuel cell electric vehicle | GB/T 24549-2020 | Fuel cell electric vehicle safety requirements |
| 53 | New energy products | Hydrogen refueling | GB/T 24552-2009 | Performance requirements and test methods for electric vehicle windshield defrost and defogging system |
| 54 | New energy products | Fuel cell systems | GB/T 24554-2009 | Fuel cell electric vehicle Hydrogen filling port+[Revision Sheet] |
| 55 | New energy products | Hydrogen refueling | GB/T 26779-2021 | Fuel cell electric vehicle on-board Hydrogen system technical conditions+[Revision Sheet] |
| 56 | New energy products | Fuel cell systems | GB/T 26990-2011 | Fuel cell electric vehicle on-board Hydrogen system technical conditions+[Revision Sheet] |
| 57 | New energy products | Fuel cell electric vehicle | GB/T 26991-2011 | Fuel cell electric vehicle test method for maximum vehicle speed |

Continued Schedule 1

| No. | Subsystem | Subarea | Standard No. | Standard name |
|---|---|---|---|---|
| 58 | New energy products | Battery electric vehicle | GB/T 28382-2012 | Battery electric passenger vehicle technical conditions |
| 59 | New energy products | Fuel cell electric vehicle | GB/T 29123-2012 | Technical specifications on demonstration operation of hydrogen fuel cell electric vehicle |
| 60 | New energy products | Fuel cell electric vehicle | GB/T 29124-2012 | Supporting facilities specification of hydrogen fuel cell electric vehicle demonstration operation |
| 61 | New energy products | Fuel cell systems | GB/T 29126-2012 | Fuel cell electric vehicle on-board hydrogen system test method+[Revision Sheet] |
| 62 | New energy products | Electric drive system | GB/T 29307-2012 | Test method for reliability of drive motor system for electric vehicles |
| 63 | New energy products | Basic and general | GB/T 31466-2015 | Electric vehicle high-voltage system voltage level |
| 64 | New energy products | On-board energy storage system | GB/T 31467.1-2015 | Lithium-ion power battery packages and systems for electric vehicles Part 1: Test procedure for high power applications |
| 65 | New energy products | On-board energy storage system | GB/T 31467.2-2015 | Lithium-ion power battery packages and systems for electric vehicles Part 2: Test procedure for high energy applications |
| 66 | New energy products | On-board energy storage system | GB/T 31484-2015 | Cycle life requirements and test methods for power batteries for electric vehicles |
| 67 | New energy products | On-board energy storage system | GB/T 31486-2015 | Electrical performance requirements and test methods for power batteries for electric vehicles |
| 68 | New energy products | Basic and general | GB/T 31498-2015 | Post-crash safety requirements for electric vehicles |
| 69 | New energy products | Hybrid electric vehicle | GB/T 32694-2021 | Plug-in hybrid electric passenger vehicle Technical conditions |
| 70 | New energy products | Basic and general | GB/T 32960.1-2016 | Technical specification for electric vehicle remote service and management system Part 1: General |
| 71 | New energy products | Basic and general | GB/T 32960.2-2016 | Technical specification for electric vehicle remote service and management system Part 2: Vehicle mounted terminal |
| 72 | New energy products | Basic and general | GB/T 32960.3-2016 | Technical specification for electric vehicle remote service and management system Part 3: Communication protocol and data format |
| 73 | New energy products | On-board energy storage system | GB/T 34013-2017 | Product specifications and dimensions of power battery for electric vehicles |
| 74 | New energy products | On-board energy storage system | GB/T 34014-2017 | Vehicle power battery coding rules |
| 75 | New energy products | Hybrid electric vehicle | GB/T 34425-2017 | Fuel cell electric vehicle Hydrogen filling gun |
| 76 | New energy products | Battery electric vehicle | GB/T 34585-2017 | Battery electric truck Technical conditions |
| 77 | New energy products | Fuel cell systems | GB/T 34593-2017 | Fuel cell engine hydrogen emission test method |
| 78 | New energy products | Hybrid electric vehicle | GB/T 34598-2017 | Plug-in hybrid electric commercial vehicles Technical conditions |
| 79 | New energy products | Conductive charging | GB/T 34657.2-2017 | Electric vehicle conductive charging interoperability test specification Part 2: Vehicles |
| 80 | New energy products | Electric drive system | GB/T 36282-2018 | Electromagnetic compatibility requirements and test methods for drive motor systems for electric vehicles |
| 81 | New energy products | Other systems and components | GB/T 37133-2018 | Technical requirements for high-voltage and high-current wiring harnesses and connectors for electric vehicles |
| 82 | New energy products | Basic and general | GB/T 37153-2018 | Electric vehicle low speed beep |
| 83 | New energy products | Fuel cell electric vehicle | GB/T 37154-2018 | Fuel cell electric vehicle hydrogen emission test method for the whole vehicle |
| 84 | New energy products | Basic and general | GB/T 38117-2019 | Electric vehicle product use instructions Emergency rescue |
| 85 | New energy products | Basic and general | GB/T 38283-2019 | Emergency rescue guide for electric vehicle disasters |
| 86 | New energy products | Other systems and components | GB/T 38661-2020 | Technical conditions for battery management system for electric vehicles |
| 87 | New energy products | Wireless charging | GB/T 38775.1-2020 | Wireless charging system for electric vehicles Part 1: general requirements |

Continued Schedule 1

| No. | Subsystem | Subarea | Standard No. | Standard name |
|---|---|---|---|---|
| 88 | New energy products | Other systems and components | GB/T 39086-2020 | Functional safety requirements and test methods for battery management system for electric vehicles |
| 89 | New energy products | Fuel cell electric vehicle | GB/T 39132-2020 | Fuel cell electric vehicle final test procedure |
| 90 | New energy products | Battery replacement | GB/T 40032-2021 | Safety requirements for electric vehicle power exchange |
| 91 | New energy products | Basic and general | GB/T 4094.2-2017 | Electric vehicles marking of operating parts, indicators and signaling devices |
| 92 | New energy products | On-board energy storage system | QC/T 741-2014 | Ultra-capacitors for vehicles+[Revision Sheet] |
| 93 | New energy products | On-board energy storage system | QC/T 742-2006 | Lead-acid battery for electric vehicles |
| 94 | New energy products | On-board energy storage system | QC/T 743-2006 | Lithium-ion battery for electric vehicles |
| 95 | New energy products | On-board energy storage system | QC/T 744-2006 | Nickel metal hydride battery for electric vehicles |
| 96 | New energy products | Hydrogen refueling | QC/T 816-2009 | Technical conditions for hydrogen-filled vehicles |
| 97 | New energy products | Other systems and components | QC/T 837-2010 | Hybrid electric vehicle type |
| 98 | New energy products | Basic and general | QC/T 838-2010 | Super capacitor electric city bus |
| 99 | New energy products | Conductive charging | QC/T 839-2010 | Super capacitor electric city bus power supply system |
| 100 | New energy products | On-board energy storage system | QC/T 840-2010 | Product specification size of power battery for electric vehicle |
| 101 | New energy products | Electric drive system | QC/T 893-2011 | Electric vehicle drive motor system fault classification and judgment |
| 102 | New energy products | Hybrid electric vehicle | QC/T 894-2011 | Heavy-duty hybrid electric vehicle pollutant emission on-board measurement method |
| 103 | New energy products | Conductive charging | QC/T 895-2011 | Conductive on-board charger for electric vehicles |
| 104 | New energy products | Electric drive system | QC/T 896-2011 | Drive motor system interface for electric vehicles |
| 105 | New energy products | Other systems and components | QC/T 897-2011 | Battery management system technical conditions for electric vehicles |
| 106 | New energy products | Battery electric vehicle | QC/T 925-2013 | Super capacitor electric city bus shaping test procedure |
| 107 | New energy products | Electric drive system | QC/T 926-2013 | Test method for reliability of power unit for light-duty hybrid electric vehicle (ISG Type) |
| 108 | New energy products | Battery replacement | QC/T 989-2014 | General requirements for power battery box for electric vehicles |
| 109 | New energy products | Electric drive system | QC/T 1022-2015 | Technical conditions for reducer assembly for battery electric passenger vehicles |
| 110 | New energy products | On-board energy storage system | QC/T 1023-2015 | General requirements for power battery system for electric vehicles |
| 111 | New energy products | Electric drive system | QC/T 1068-2017 | Asynchronous drive motor system for electric vehicles |
| 112 | New energy products | Electric drive system | QC/T 1069-2017 | Permanent magnet synchronous drive motor system for electric vehicles |
| 113 | New energy products | Electric drive system | QC/T 1086-2017 | Range extender technical conditions for electric vehicles |
| 114 | New energy products | Battery electric vehicle | QC/T 1087-2017 | Technical conditions for battery electric urban sanitation vehicles |
| 115 | New energy products | Electric drive system | QC/T 1088-2017 | Technical conditions for charge/discharge motor controller for electric vehicles |
| 116 | New energy products | Basic and general | QC/T 1089-2017 | Electric vehicle regenerative braking system requirements and test methods |
| 117 | New energy products | Electric drive system | QC/T 1132-2020 | Electric powertrain noise measurement method for electric vehicles |

Continued Schedule 1

| No. | Subsystem | Subarea | Standard No. | Standard name |
|---|---|---|---|---|
| 118 | New energy products | Other systems and components | QC/T 1136-2020 | Environmental test requirements and test methods for insulated gate bipolar transistor (IGBT) modules for electric vehicles |
| 119 | Cyclic low carbon | Low-carbon technical route | GB/T 34015-2017 | Recycling of automotive power batteries and residual energy testing |
| 120 | Cyclic low carbon | Low-carbon technical route | GB/T 34015.2-2020 | Recycling of automotive power batteries and secondary use Part 2: Disassembly requirements |
| 121 | Cyclic low carbon | Low-carbon technical route | GB/T 33598-2017 | Recycling of automotive power batteries Dismantling specifications |
| 122 | Cyclic low carbon | Low-carbon technical route | GB/T 33598.2-2020 | Recycling of automotive power batteries Recycling Part 2: Material recycling requirements |
| 123 | Cyclic low carbon | Low-carbon technical route | GB/T 38698.1-2020 | Automotive power battery recycling management specification Part 1: Packaging and transportation |
| 124 | Cyclic low carbon | Low-carbon technical route | GB/T 34600-2017 | Technical specifications for the re-manufacturing of automotive components ignition, compression ignition engines |
| 125 | Cyclic low carbon | Low-carbon technical route | GB/T 39895-2021 | Re-manufactured automotive components and components product labeling specifications |
| 126 | Cyclic low carbon | Low-carbon technical route | GB/T 28672-2012 | Technical specifications for re-manufactured automotive components and components Alternators |
| 127 | Cyclic low carbon | Low-carbon technical route | GB/T 28673-2012 | Technical specifications for re-manufactured automotive components and components Starter |
| 128 | Cyclic low carbon | Low-carbon technical route | GB/T 28674-2012 | Technical specifications for re-manufactured automotive components and components Steering gear |
| 129 | Cyclic low carbon | Low-carbon technical route | GB/T 28675-2012 | Automotive components re-manufacturing Disassembly |
| 130 | Cyclic low carbon | Low-carbon technical route | GB/T 28676-2012 | Automotive components re-manufacturing Classification |
| 131 | Cyclic low carbon | Low-carbon technical route | GB/T 28677-2012 | Automotive components re-manufacturing Cleaning |
| 132 | Cyclic low carbon | Low-carbon technical route | GB/T 28678-2012 | Automotive components re-manufacturing Factory acceptance |
| 133 | Cyclic low carbon | Low-carbon technical route | GB/T 28679-2012 | Automotive components re-manufacturing Assembly |
| 134 | Cyclic low carbon | Low-carbon technical route | GB/T 39899-2021 | Technical specifications for re-manufactured automotive components and components Automatic transmission |
| 135 | Cyclic low carbon | Low-carbon technical route | QC/T 1070-2017 | Technical specifications for re-manufactured automotive components and components Cylinder block assembly |
| 136 | Cyclic low carbon | Low-carbon technical route | QC/T 1074-2017 | Technical specifications for re-manufactured automotive components and components Cylinder head |
| 137 | Cyclic low carbon | Low-carbon technical route | GB/T 34596-2017 | Technical specifications for re-manufactured automotive components and components Oil pump |
| 138 | Cyclic low carbon | Low-carbon technical route | GB/T 34595-2017 | Technical specifications for re-manufactured automotive components and components Water pump |
| 139 | Cyclic low carbon | Low-carbon technical route | QC/T 1139-2020 | Technical specifications for re-manufactured automotive components and components Connecting rod |
| 140 | Cyclic low carbon | Low-carbon technical route | QC/T 1140-2020 | Technical specifications for re-manufactured automotive components and components Crankshaft |

Table 2 Number of components replacement (Unit: times)

| No. | Material name | Applicable M1 vehicle except for battery electric passenger vehicles | Battery electric passenger vehicle |
|---|---|---|---|
| 1 | Tire | 2 | 2 |
| 2 | Lead battery | 2 | 2 |
| 3 | Lubricants | 29 | 8 |
| 4 | Brake fluid | 2 | 2 |
| 5 | Coolant | 2 | 2 |
| 6 | Refrigerant | Escape for one time and replace for one time | Escape for one time and replace for one time |
| 7 | Washing fluid | 14 | 14 |

Table 3 Vehicle cycle-related GHG emission factors

| No. | Name | Default value of GHG emission facto | Unit |
|---|---|---|---|
| 1 | Steel | 2.38 | kgCO$_2$e/kg |
| 2 | Cast Iron | 1.82 | kgCO$_2$e/kg |
| 3 | Aluminum and aluminum alloy | 16.38 | kgCO$_2$e/kg |
| 4 | Magnesium and magnesium alloys | 39.55 | kgCO$_2$e/kg |
| 5 | Copper and copper alloys | 4.23 | kgCO$_2$e/kg |
| 6 | Thermoplastics | 3.96 | kgCO$_2$e/kg |
| 7 | Thermosetting plastics | 4.57 | kgCO$_2$e/kg |
| 8 | Rubber | 3.08 | kgCO$_2$e/kg |
| 9 | Fabrics | 5.80 | kgCO$_2$e/kg |
| 10 | Ceramics / Glass | 0.95 | kgCO$_2$e/kg |
| 11 | Lead | 2.74 | kgCO$_2$e/kg |
| 12 | Sulfuric acid | 0.10 | kgCO$_2$e/kg |
| 13 | Glass fiber | 8.91 | kgCO$_2$e/kg |
| 14 | Lithium iron phosphate | 2.93 | kgCO$_2$e/kg |

| No. | Name | Default value of GHG emission facto | Unit |
|---|---|---|---|
| 15 | Lithium nickel cobalt manganate | 17.40 | kgCO2e/kg |
| 16 | Lithium manganate | 4.73 | kgCO2e/kg |
| 17 | Graphite | 5.48 | kgCO2e/kg |
| 18 | Electrolyte: Lithium hexafluorophosphate | 19.60 | kgCO2e/kg |
| 19 | Lubricant | 1.20 | kgCO2e/kg |
| 20 | Brake fluid | 1.20 | kgCO2e/kg |
| 21 | Coolant | 1.85 | kgCO2e/kg |
| 22 | Refrigerant | 15.10 | kgCO2e/kg |
| 23 | Washing fluid | 0.97 | kgCO2e/kg |
| 24 | Lithium nickel cobalt manganese acid battery pack | 87.78 | kgCO2e/kWh |
| 25 | Lithium iron phosphate battery pack | 73.51 | kgCO2e/kWh |
| 26 | Lithium manganate battery pack | 67.90 | kgCO2e/kWh |
| 27 | Complete vehicle production | 550 | kgCO2e/vehicle |

Table 4 GHG emission factors for fuel production

| Energy/Fuel Name | GHG emission | Unit | Accounting boundary |
|---|---|---|---|
| Electricity | 0.635 | kgCO2e/kWh | Including energy extraction, power production, power transmission process |
| Natural gas | 0.07 | kgCO2e/m3 | Including natural gas extraction, processing, transportation and other processes, without considering spillover emissions from production processes |
| Gasoline | 0.487 | kgCO2e/L | Including crude oil extraction, processing, transportation and other processes, without considering spillover emissions from production processes |
| Diesel | 0.535 | kgCO2e/L | Including crude oil extraction, processing, transportation and other processes, without considering spillover emissions from production processes |
| Coal | 0.08 | kgCO2e/kg | Including raw coal mining and washing process, without considering the spontaneous combustion of coal and gas spillover emissions from mining sites |
| Low-pressure steam (0.3MPa) | 0.31 | kgCO2e/kg | Use of coal as energy production, including raw coal mining, washing process, transportation and boiler steam production process |
| Medium-pressure steam (1MPa) | 0.38 | kgCO2e/kg | Use of coal as energy production, including raw coal mining, washing process, transportation and boiler steam production process |

Table 5 Common fossil energy specific parameter values

| Fuel variety | | Low level heat generation GJ/t，GJ/104Nm3 | Carbon content per unit calorific valu（tCO$_2$e/GJ） | Fuel carbon oxidation rate |
|---|---|---|---|---|
| Solid fuel | Anthracite | 26.700[a] | $27.40\times10^{-3}$[b] | 94% |
| | Anthracite | 19.570[c] | $26.10\times10^{-3}$[b] | 93% |
| | Lignite | 11.900[a] | $28.00\times10^{-3}$[b] | 96% |
| | Washed coal | 26.344[d] | $25.41\times10^{-3}$[b] | 90% |
| | Other washed coal | 12.545[d] | $25.41\times10^{-3}$[b] | 90% |
| | Anthracite | 17.460[c] | $33.60\times10^{-3}$[c] | 90% |
| Liquid fuel | Coal | 28.435[c] | $29.50\times10^{-3}$[b] | 93% |
| | Coke | 41.816[d] | $20.10\times10^{-3}$[b] | 98% |
| | Crude oil | 41.816[d] | $21.10\times10^{-3}$[b] | 98% |
| | Fuel oil | 43.070[d] | $18.90\times10^{-3}$[b] | 98% |
| | Gasoline | 42.652[d] | $20.20\times10^{-3}$[b] | 98% |
| | Diesel oil | 43.070[d] | $19.60\times10^{-3}$[b] | 98% |
| | General kerosene | 51.44[d] | $15.30\times10^{-3}$[b] | 98% |
| | Liquefied natural gas | 50.179[d] | $17.20\times10^{-3}$[b] | 98% |
| | Coal tar | 33.453[d] | $22.00\times10^{-3}$[a] | 98% |
| Gas fuel | Refinery dry gas | 45.998[d] | $18.20\times10^{-3}$[b] | 99% |
| | Coke oven gas | 179.81[d] | $13.58\times10^{-3}$[b] | 99% |
| | Blast furnace gas | 33.000[c] | $70.80\times10^{-3}$[a] | 99% |
| | Converter gas | 84.000[c] | $49.60\times10^{-3}$[c] | 99% |
| | Other gas | 52.270[d] | $12.20\times10^{-3}$[b] | 99% |
| | Natural gas | 389.310[d] | $15.30\times10^{-3}$[b] | 99% |

Notes.

a Data from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

b Data from the Provincial Greenhouse Gas Inventory Guidelines (Trial)

c Data from the China Greenhouse Gas Inventory Study (2007)

d Data from the China Energy Statistics Yearbook (2019)

Table 6 Model classification method

| | | Class A00 | Class A0 | Class A | Class B | Class C |
|---|---|---|---|---|---|---|
| Sedan | Wheelbase/mm | <2450 | 2350-2600 | 2600-2750 | 2700-2900 | 2850-3150 |
| | Length-two compartments/mm | <3750 | 3750-4400 | 4200-4700 | 4700-5000 | 4950-5150 |
| | Length-trim/mm | <4200 | 4100-4500 | 4350-4750 | | |
| SUV | Wheelbase/mm | | <2650 | 2600-2750 | 2750-2900 | >2900 |
| | Length/mm | | <4350 | 4350-4750 | 4700-5000 | >5000 |
| MPV | Wheelbase/m | | <2800 | 2800-2900 | >2900 | |
| | Length/mm | | <4600 | 4600-4800 | >4800 | |

Note: When the car length and wheelbase cannot match the above classification criteria, the wheelbase will be the only basis for classification.

Schedule 7 CO$_2$ Emissions Per Mileage of Various Models

| SN | Corporation Name | Model | Fuel | Category | Class | CO$_2$ Emission Per Mileage (gCO$_2$e/km) |
|---|---|---|---|---|---|---|
| 1 | Anhui Jianghuai Automobile Group Corp., Ltd. | Jiayue A5 | Gasoline | Sedan | B | 270.8 |
| 2 | Anhui Jianghuai Automobile Group Corp., Ltd. | Jiayue X7 | Gasoline | SUV | B | 314.1 |
| 3 | Anhui Jianghuai Automobile Group Corp., Ltd. | JAC iC5 | Battery electric | Sedan | B | 173.9 |
| 4 | Anhui Jianghuai Automobile Group Corp., Ltd. | JAC iEV6E | Battery electric | Sedan | A00 | 161.2 |
| 5 | Anhui Jianghuai Automobile Group Corp., Ltd. | JAC iEV7 | Battery electric | Sedan | A0 | 148.4 |
| 6 | Anhui Jianghuai Automobile Group Corp., Ltd. | JAC iEVA50 | Battery electric | Sedan | A | 184.1 |
| 7 | Anhui Jianghuai Automobile Group Corp., Ltd. | JAC iEVS4 | Battery electric | SUV | A0 | 197.5 |
| 8 | Anhui Jianghuai Automobile Group Corp., Ltd. | Refine M3 | Gasoline | MPV | A | 325.9 |
| 9 | Anhui Jianghuai Automobile Group Corp., Ltd. | Refine M4 | Diesel | MPV | B | 328.6 |
| 10 | Anhui Jianghuai Automobile Group Corp., Ltd. | Refine M4 | Gasoline | MPV | B | 384.1 |
| 11 | Anhui Jianghuai Automobile Group Corp., Ltd. | Refine S4 | Gasoline | SUV | A0 | 262.3 |
| 12 | Beijing Benz Automotive Co., Ltd. | Mercedes-Benz A-Class | Gasoline | Sedan | A | 260.3 |
| 13 | Beijing Benz Automotive Co., Ltd. | Mercedes-AMG A-Class | Gasoline | Sedan | A | 300.9 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e$/km) |
|---|---|---|---|---|---|---|
| 14 | Beijing Benz Automotive Co., Ltd. | Mercedes-Benz C-Class | Gasoline | Sedan | B | 270.7 |
| 15 | Beijing Benz Automotive Co., Ltd. | Mercedes-Benz EQC | Battery electric | SUV | B | 243.3 |
| 16 | Beijing Benz Automotive Co., Ltd. | Mercedes-Benz E-Class | Plug-in hybrid electric | Sedan | C | 250.3 |
| 17 | Beijing Benz Automotive Co., Ltd. | Mercedes-Benz E-Class | Gasoline | Sedan | C | 323.8 |
| 18 | Beijing Benz Automotive Co., Ltd. | Mercedes-Benz GLA | Gasoline | SUV | A | 270.2 |
| 19 | Beijing Benz Automotive Co., Ltd. | Mercedes-Benz GLB | Gasoline | SUV | B | 267.0 |
| 20 | Beijing Benz Automotive Co., Ltd. | Mercedes-Benz GLC | Gasoline | SUV | B | 308.0 |
| 21 | BAIC Motor Co., Ltd. | Beijing 40L | Diesel | SUV | A | 370.6 |
| 22 | BAIC Motor Co., Ltd. | Beijing 40L | Gasoline | SUV | A | 409.9 |
| 23 | BAIC Motor Co., Ltd. | Beijing 80 | Gasoline | SUV | B | 408.6 |
| 24 | BAIC Motor Co., Ltd. | Beijing U7 | Gasoline | Sedan | B | 253.0 |
| 25 | BAIC Motor Co., Ltd. | Beijing X3 | Gasoline | SUV | A0 | 258.5 |
| 26 | BAIC Motor Co., Ltd. | Beijing X5 | Gasoline | SUV | A | 276.5 |
| 27 | BAIC Motor Co., Ltd. | Beijing X7 | Gasoline | SUV | B | 270.5 |
| 28 | BAIC Motor Co., Ltd. | Shenbao Zhixing | Gasoline | SUV | A | 276.5 |
| 29 | Beijing Hyundai Auto Co., Ltd. | LAFESTA | Battery electric | Sedan | A | 159.7 |
| 30 | Beijing Hyundai Auto Co., Ltd. | LAFESTA | Gasoline | Sedan | A | 228.8 |
| 31 | Beijing Hyundai Auto Co., Ltd. | Elantra Lingdong | Gasoline | Sedan | A | 226.3 |
| 32 | Beijing Hyundai Auto Co., Ltd. | Elantra Lingdong | Plug-in hybrid electric | Sedan | A | 160.7 |
| 33 | Beijing Hyundai Auto Co., Ltd. | MISTRA | Gasoline | Sedan | B | 270.8 |
| 34 | Beijing Hyundai Auto Co., Ltd. | Verna | Gasoline | Sedan | A0 | 217.8 |
| 35 | Beijing Hyundai Auto Co., Ltd. | SANTAFE | Gasoline | SUV | A | 348.0 |
| 36 | Beijing Hyundai Auto Co., Ltd. | Sonata | Gasoline | Sedan | B | 257.5 |
| 37 | Beijing Hyundai Auto Co., Ltd. | Sonata IX | Plug-in hybrid electric | Sedan | B | 204.1 |
| 38 | Beijing Hyundai Auto Co., Ltd. | Tucson | Gasoline | SUV | A | 325.7 |
| 39 | Beijing Hyundai Auto Co., Ltd. | ENCINO | Battery electric | SUV | A0 | 172.7 |
| 40 | Beijing Hyundai Auto Co., Ltd. | Hyundai ENCINO | Battery electric | SUV | A0 | 228.0 |
| 41 | Beijing Hyundai Auto Co., Ltd. | Hyundai ix25 | Gasoline | SUV | A0 | 257.0 |
| 42 | Beijing Hyundai Auto Co., Ltd. | Hyundai ix35 | Gasoline | SUV | A | 281.8 |
| 43 | Beijing Hyundai Auto Co., Ltd. | Elantra | Gasoline | Sedan | A | 203.4 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 44 | Beijing Hyundai Auto Co., Ltd. | Elantra Yuedong | Gasoline | Sedan | A | 233.3 |
| 45 | Beijing Hyundai Auto Co., Ltd. | Solaris | Gasoline | Sedan | A0 | 219.7 |
| 46 | Beijing Electric Vehicle Co., Ltd | BAIC ARCFOX αT | Battery electric | SUV | B | 228.2 |
| 47 | Beijing Electric Vehicle Co., Ltd | BAIC EC Series | Battery electric | Sedan | A00 | 125.5 |
| 48 | Beijing Electric Vehicle Co., Ltd | BAIC EU7 | Battery electric | Sedan | B | 178.4 |
| 49 | Beijing Electric Vehicle Co., Ltd | BAIC EU Series | Battery electric | Sedan | A | 179.9 |
| 50 | Beijing Electric Vehicle Co., Ltd | BAIC EX3 | Battery electric | SUV | A0 | 175.6 |
| 51 | BYD Auto Co., Ltd. | BYD D1 | Battery electric | MPV | A0 | 154.5 |
| 52 | BYD Auto Co., Ltd. | BYD E1 | Battery electric | Sedan | A00 | 114.9 |
| 53 | BYD Auto Co., Ltd. | BYD E2 | Battery electric | Sedan | A0 | 147.6 |
| 54 | BYD Auto Co., Ltd. | BYD E3 | Battery electric | Sedan | A | 147.7 |
| 55 | BYD Auto Co., Ltd. | BYD E5 | Battery electric | Sedan | A | 162.9 |
| 56 | BYD Auto Co., Ltd. | BYD F3 | Gasoline | Sedan | A | 225.2 |
| 57 | BYD Auto Co., Ltd. | BYD M3 | Battery electric | MPV | A0 | 173.9 |
| 58 | BYD Auto Co., Ltd. | BYD S2 | Battery electric | SUV | A0 | 148.3 |
| 59 | BYD Auto Co., Ltd. | BYD Han | Battery electric | Sedan | C | 196.4 |
| 60 | BYD Auto Co., Ltd. | BYD Han | Plug-in hybrid electric | Sedan | C | 200.5 |
| 61 | BYD Auto Co., Ltd. | BYD Qin | Battery electric | Sedan | A | 175.2 |
| 62 | BYD Auto Co., Ltd. | BYD Qin | Plug-in hybrid electric | Sedan | A | 210.4 |
| 63 | BYD Auto Co., Ltd. | BYD Qin | Gasoline | Sedan | A | 240.0 |
| 64 | BYD Auto Co., Ltd. | BYD Song | Battery electric | SUV | A | 210.2 |
| 65 | BYD Auto Co., Ltd. | BYD Song | Plug-in hybrid electric | SUV | A | 217.5 |
| 66 | BYD Auto Co., Ltd. | BYD Song | Gasoline | SUV | A | 301.3 |
| 67 | BYD Auto Co., Ltd. | BYD Song MAX | Plug-in hybrid electric | MPV | A | 202.2 |
| 68 | BYD Auto Co., Ltd. | BYD Song MAX | Gasoline | MPV | A | 281.9 |
| 69 | BYD Auto Co., Ltd. | BYD Song PLUS | Gasoline | SUV | B | 258.0 |
| 70 | BYD Auto Co., Ltd. | BYD Tang | Battery electric | SUV | A | 226.4 |
| 71 | BYD Auto Co., Ltd. | BYD Tang | Plug-in hybrid electric | SUV | A | 245.7 |
| 72 | BYD Auto Co., Ltd. | BYD Tang | Gasoline | SUV | A | 330.3 |
| 73 | BYD Auto Co., Ltd. | BYD Tang | Battery electric | SUV | A0 | 162.7 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e$/km) |
|---|---|---|---|---|---|---|
| 74 | Changan Ford Automobile Co., Ltd. | Fox | Gasoline | Sedan | A | 218.3 |
| 75 | Changan Ford Automobile Co., Ltd. | Fox Active | Gasoline | Sedan | A | 226.2 |
| 76 | Changan Ford Automobile Co., Ltd. | Escort | Gasoline | Sedan | A | 217.8 |
| 77 | Changan Ford Automobile Co., Ltd. | Mondeo | Gasoline | Sedan | C | 284.1 |
| 78 | Changan Ford Automobile Co., Ltd. | Mondeo | Gasoline | Sedan | B | 293.1 |
| 79 | Changan Ford Automobile Co., Ltd. | ESCAPE | Gasoline | SUV | A | 282.6 |
| 80 | Changan Ford Automobile Co., Ltd. | Edge | Gasoline | SUV | B | 330.6 |
| 81 | Changan Ford Automobile Co., Ltd. | Explorer | Gasoline | SUV | C | 338.0 |
| 82 | Changan Mazda Motors Co., Ltd. | Mazda 3 Axela | Gasoline | Sedan | A | 234.0 |
| 83 | Changan Mazda Motors Co., Ltd. | Mazda CX-30 | Gasoline | SUV | A | 230.9 |
| 84 | Changan Mazda Motors Co., Ltd. | Mazda CX-5 | Gasoline | SUV | A | 285.2 |
| 85 | GWM Co., Ltd. | HAVAL F5 | Gasoline | SUV | A | 242.8 |
| 86 | GWM Co., Ltd. | HAVAL F5 | Gasoline | SUV | A | 254.0 |
| 87 | GWM Co., Ltd. | HAVAL H5 | Diesele | SUV | A | 304.1 |
| 88 | GWM Co., Ltd. | HAVAL H6 | Gasoline | SUV | A | 269.1 |
| 89 | GWM Co., Ltd. | HAVAL H6 Coupe | Gasoline | SUV | A | 251.8 |
| 90 | GWM Co., Ltd. | HAVAL H7 | Gasoline | SUV | B | 278.3 |
| 91 | GWM Co., Ltd. | HAVAL H9 | Diesele | SUV | B | 352.5 |
| 92 | GWM Co., Ltd. | HAVAL M6 | Gasoline | SUV | A | 248.3 |
| 93 | GWM Co., Ltd. | HAVAL Big Dog | Gasoline | SUV | A | 254.1 |
| 94 | GWM Co., Ltd. | ORA iQ | Battery electric | Sedan | A | 148.9 |
| 95 | GWM Co., Ltd. | ORA Bai Mao | Battery electric | Sedan | A00 | 108.4 |
| 96 | GWM Co., Ltd. | ORA Bai Mao | Battery electric | Sedan | A | 149.5 |
| 97 | GWM Co., Ltd. | ORA Bai Mao | Battery electric | Sedan | A00 | 107.7 |
| 98 | GWM Co., Ltd. | WEY VV5 | Gasoline | SUV | A | 256.1 |
| 99 | GWM Co., Ltd. | WEY VV7 | Gasoline | SUV | B | 284.3 |
| 100 | Chongqing Changan Automobile Co., Ltd. | Benni | Battery electric | Sedan | A00 | 133.1 |
| 101 | Chongqing Changan Automobile Co., Ltd. | COS1° 5 | Gasoline | SUV | A0 | 246.6 |
| 102 | Chongqing Changan Automobile Co., Ltd. | COS1° GT | Gasoline | SUV | B | 314.9 |
| 103 | Chongqing Changan Automobile Co., Ltd. | COSMOS | Battery electric | MPV | A | 165.1 |

Continued Schedule 7

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 104 | Changan Ford Automobile Co., Ltd. | COSMOS | Gasoline | MPV | A | 289.3 |
| 105 | Chongqing ChanganAutombile Co., Ltd. | Ounuo S | Gasoline | MPV | A0 | 252.3 |
| 106 | Chongqing ChanganAutombile Co., Ltd. | Oushang A600 | Battery electric | MPV | A0 | 167.3 |
| 107 | Chongqing ChanganAutombile Co., Ltd. | Oushang A600 | Gasoline | MPV | A0 | 270.6 |
| 108 | Chongqing ChanganAutombile Co., Ltd. | Oushang A800 | Gasoline | MPV | A | 265.8 |
| 109 | Chongqing ChanganAutombile Co., Ltd. | Oushang COS1 | Gasoline | SUV | B | 296.3 |
| 110 | Chongqing ChanganAutombile Co., Ltd. | Oushang X5 | Gasoline | SUV | A | 231.0 |
| 111 | Chongqing ChanganAutombile Co., Ltd. | Oushang X7 | Battery electric | SUV | B | 180.4 |
| 112 | Chongqing ChanganAutombile Co., Ltd. | Oushang X7 | Gasoline | SUV | B | 273.4 |
| 113 | Chongqing ChanganAutombile Co., Ltd. | Oushang X70A | Gasoline | SUV | A | 255.4 |
| 114 | Chongqing ChanganAutombile Co., Ltd. | Oushang X70A | Gasoline | Sedan | B | 261.2 |
| 115 | Chongqing ChanganAutombile Co., Ltd. | Ruicheng CC | Gasoline | Crossove | - | 284.9 |
| 116 | Chongqing ChanganAutombile Co., Ltd. | Ruixing M60 | Gasoline | MPV | A | 288.8 |
| 117 | Chongqing ChanganAutombile Co., Ltd. | Ruixing S50 | Gasoline | Sedan | A | 242.3 |
| 118 | Chongqing ChanganAutombile Co., Ltd. | EADO | Battery electric | Sedan | A | 163.8 |
| 119 | Chongqing ChanganAutombile Co., Ltd. | EADO | Gasoline | Sedan | A | 240.6 |
| 120 | Chongqing ChanganAutombile Co., Ltd. | EADO DT | Battery electric | Sedan | A | 163.2 |
| 121 | Chongqing ChanganAutombile Co., Ltd. | ALSVIN | Gasoline | Sedan | A0 | 221.7 |
| 122 | Chongqing ChanganAutombile Co., Ltd. | Changan CS15 | Battery electric | SUV | A0 | 160.6 |
| 123 | Chongqing ChanganAutombile Co., Ltd. | Changan CS15 | Gasoline | SUV | A0 | 237.5 |
| 124 | Chongqing ChanganAutombile Co., Ltd. | Changan CS35 | Gasoline | SUV | A0 | 263.2 |
| 125 | Chongqing ChanganAutombile Co., Ltd. | Changan CS55 | Battery electric | SUV | A | 189.4 |
| 126 | Chongqing ChanganAutombile Co., Ltd. | Changan CS55 | Gasoline | SUV | A | 281.7 |
| 127 | Chongqing ChanganAutombile Co., Ltd. | Changan CS75 | Plug-in hybrid electric | SUV | A | 231.6 |
| 128 | Chongqing ChanganAutombile Co., Ltd. | Changan CS75 | Gasoline | SUV | A | 340.1 |
| 129 | Chongqing ChanganAutombile Co., Ltd. | Changan CS85 | Gasoline | SUV | A | 301.4 |
| 130 | Chongqing ChanganAutombile Co., Ltd. | Changan CS95 | Gasoline | SUV | B | 357.1 |
| 131 | Chongqing ChanganAutombile Co., Ltd. | Changan CX70 | Gasoline | SUV | B | 287.2 |
| 132 | Chongqing ChanganAutombile Co., Ltd. | Changan UNI-T | Gasoline | SUV | A | 251.7 |
| 133 | Chongqing ChanganAutombile Co., Ltd. | Changan V3 | Gasoline | Crossover | - | 237.1 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 134 | Chongqing Changan Automobile Co., Ltd. | Star of Changan 9 | Gasoline | Crossover | - | 260.8 |
| 135 | Chongqing Changan Automobile Co., Ltd. | Changxing | Battery electric | MPV | A0 | 158.7 |
| 136 | Chongqing Changan Automobile Co., Ltd. | Changxing | Gasoline | MPV | A0 | 270.6 |
| 137 | Chongqing Changan Automobile Co., Ltd. | Lixiang ONE | Plug-in hybrid electric | SUV | C | 236.1 |
| 138 | Daqing Volvo Automobile Co., Ltd. | Polestar2 | Battery electric | Sedan | A | 212.6 |
| 139 | Daqing Volvo Automobile Co., Ltd. | Volvo S60L | Plug-in hybrid electric | Sedan | B | 233.3 |
| 140 | Daqing Volvo Automobile Co., Ltd. | Volvo S60L | Gasoline | Sedan | B | 289.6 |
| 141 | Daqing Volvo Automobile Co., Ltd. | Volvo S90 | Plug-in hybrid electric | Sedan | C | 242.1 |
| 142 | Daqing Volvo Automobile Co., Ltd. | Volvo S90 | Gasoline | Sedan | C | 272.0 |
| 143 | Daqing Volvo Automobile Co., Ltd. | Volvo XC40 | Gasoline | SUV | A | 285.1 |
| 144 | Daqing Volvo Automobile Co., Ltd. | Volvo XC60 | Plug-in hybrid electric | SUV | B | 256.7 |
| 145 | Daqing Volvo Automobile Co., Ltd. | Volvo XC60 | Gasoline | SUV | B | 306.7 |
| 146 | Dongfeng Honda Automobile Co., Ltd | Elysion | Conventional hybrid | MPV | B | 243.4 |
| 147 | Dongfeng Honda Automobile Co., Ltd | Elysion | Gasoline | MPV | B | 343.3 |
| 148 | Dongfeng Honda Automobile Co., Ltd | Honda CR-V | Conventional hybrid | SUV | A | 225.9 |
| 149 | Dongfeng Honda Automobile Co., Ltd | Honda CR-V | Gasoline | SUV | A | 290.1 |
| 150 | Dongfeng Honda Automobile Co., Ltd | Honda INSPIRE | Conventional hybrid | Sedan | B | 188.2 |
| 151 | Dongfeng Honda Automobile Co., Ltd | Honda INSPIRE | Gasoline | Sedan | B | 230.9 |
| 152 | Dongfeng Honda Automobile Co., Ltd | Honda UR-V | Gasoline | SUV | B | 321.2 |
| 153 | Dongfeng Honda Automobile Co., Ltd | Honda XR-V | Gasoline | SUV | A0 | 247.8 |
| 154 | Dongfeng Honda Automobile Co., Ltd | JADE | Gasoline | Sedan | B | 259.4 |
| 155 | Dongfeng Honda Automobile Co., Ltd | Ciimo X-NV | Battery electric | SUV | A0 | 166.9 |
| 156 | Dongfeng Honda Automobile Co., Ltd | Civic | Gasoline | Sedan | A | 244.0 |
| 157 | Dongfeng Honda Automobile Co., Ltd | ENVIX | Gasoline | Sedan | A | 207.3 |
| 158 | Dongfeng Honda Automobile Co., Ltd | ENVIX | Conventional hybrid | Sedan | A | 172.1 |
| 159 | Dongfeng Liuzhou Motor Co., Ltd. | FORTHING CM7 | Gasoline | MPV | B | 384.3 |
| 160 | Dongfeng Liuzhou Motor Co., Ltd. | FORTHING SX6 | Gasoline | SUV | A | 283.7 |
| 161 | Dongfeng Liuzhou Motor Co., Ltd. | FORTHING T5 | Gasoline | SUV | A | 287.5 |
| 162 | Dongfeng Liuzhou Motor Co., Ltd. | FORTHING T5 EVO | Gasoline | SUV | A | 249.1 |
| 163 | Dongfeng Liuzhou Motor Co., Ltd. | FORTHING T5L | Gasoline | SUV | B | 290.5 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | CO2 Emission Per Mileage (gCO2e/km) |
|---|---|---|---|---|---|---|
| 164 | Dongfeng Liuzhou Motor Co., Ltd. | Jingyi S50 | Battery electric | Sedan | A | 167.7 |
| 165 | Dongfeng Liuzhou Motor Co., Ltd. | Lingzhi | Battery electric | MPV | B | 198.7 |
| 166 | Dongfeng Liuzhou Motor Co., Ltd. | Lingzhi | Gasoline | MPV | B | 330.8 |
| 167 | Dongfeng Motor Corporation Passenger Vehicle Company | Aeolus AX7 | Gasoline | SUV | A | 280.2 |
| 168 | Dongfeng Motor Corporation Passenger Vehicle Company | Yixuan | Gasoline | Sedan | A | 233.2 |
| 169 | Dongfeng Motor Corporation Passenger Vehicle Company | Yixuan GS | Gasoline | SUV | A | 244.4 |
| 170 | Dong-Nissan Passenger Vehicle Company | Kicks | Gasoline | SUV | A0 | 213.7 |
| 171 | Dong-Nissan Passenger Vehicle Company | Bluebird | Gasoline | Sedan | A | 201.2 |
| 172 | Dong-Nissan Passenger Vehicle Company | Loulan | Gasoline | SUV | B | 306.0 |
| 173 | Dong-Nissan Passenger Vehicle Company | Loulan | Conventional hybrid | SUV | B | 318.5 |
| 174 | Dong-Nissan Passenger Vehicle Company | x-trail | Gasoline | SUV | A | 283.0 |
| 175 | Dong-Nissan Passenger Vehicle Company | TIIDA | Gasoline | Sedan | A | 201.3 |
| 176 | Dong-Nissan Passenger Vehicle Company | Venucia D60 | Gasoline | Sedan | A | 212.7 |
| 177 | Dong-Nissan Passenger Vehicle Company | Venucia D60 | Battery electric | Sedan | A | 156.8 |
| 178 | Dong-Nissan Passenger Vehicle Company | Venucia D60 | Battery electric | SUV | A | 174.5 |
| 179 | Dong-Nissan Passenger Vehicle Company | Venucia D60 | Gasoline | SUV | A | 232.5 |
| 180 | Dong-Nissan Passenger Vehicle Company | Venucia D90 | Gasoline | SUV | B | 244.2 |
| 181 | Dong-Nissan Passenger Vehicle Company | TEANA | Gasoline | Sedan | B | 249.9 |
| 182 | Dong-Nissan Passenger Vehicle Company | Qashqai | Gasoline | SUV | A | 234.7 |
| 183 | Dong-Nissan Passenger Vehicle Company | STAR | Gasoline | SUV | A | 252.1 |
| 184 | Dong-Nissan Passenger Vehicle Company | Sylphy | Battery electric | Sedan | A | 151.4 |
| 185 | Dong-Nissan Passenger Vehicle Company | Sylphy | Gasoline | Sedan | A | 222.4 |
| 186 | Dongfeng Xiaokang Automobile Co., Ltd. | Dongfeng Xiaokang C36 | Battery electric | Crossover | - | 182.2 |
| 187 | Dongfeng Xiaokang Automobile Co., Ltd. | Dongfeng Xiaokang C36 | Gasoline | Crossover | - | 256.8 |
| 188 | Dongfeng Xiaokang Automobile Co., Ltd. | Dongfeng Xiaokang K07S | Gasoline | Crossover | - | 226.1 |
| 189 | Dongfeng Xiaokang Automobile Co., Ltd. | Fengguang | Gasoline | MPV | A0 | 259.5 |
| 190 | Dongfeng Xiaokang Automobile Co., Ltd. | Fengguang 370 | Gasoline | MPV | A0 | 244.4 |
| 191 | Dongfeng Xiaokang Automobile Co., Ltd. | Fengguang 500 | Gasoline | SUV | A | 252.5 |
| 192 | Dongfeng Xiaokang Automobile Co., Ltd. | Fengguang 580 | Plug-in hybrid electric | SUV | B | 210.2 |
| 193 | Dongfeng Xiaokang Automobile Co., Ltd. | Fengguang 580 | Gasoline | SUV | B | 278.5 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 194 | Dongfeng Xiaokang Automobile Co., Ltd. | Fengguang E1 | Battery electric | Sedan | A00 | 112.3 |
| 195 | Dongfeng Xiaokang Automobile Co., Ltd. | Fengguang ix5 | Gasoline | SUV | B | 316.5 |
| 196 | Dongfeng Xiaokang Automobile Co., Ltd. | Fengguang ix7 | Gasoline | SUV | B | 342.5 |
| 197 | Dongfeng Xiaokang Automobile Co., Ltd. | Fengguang S560 | Gasoline | SUV | A | 272.4 |
| 198 | Dongfeng Infiniti Motor Co., Ltd. | Infiniti Q50L | Gasoline | Sedan | B | 285.1 |
| 199 | Dongfeng Infiniti Motor Co., Ltd. | Infiniti QX50 | Gasoline | SUV | B | 307.2 |
| 200 | Dongfeng Yueda Kia Motors Co., Ltd. | Forte | Gasoline | Sedan | A | 218.4 |
| 201 | Dongfeng Yueda Kia Motors Co., Ltd. | Pegas | Gasoline | Sedan | A0 | 205.4 |
| 202 | Dongfeng Yueda Kia Motors Co., Ltd. | ALL NEW | Gasoline | Sedan | B | 258.3 |
| 203 | Dongfeng Yueda Kia Motors Co., Ltd. | Kaishen | Gasoline | Sedan | B | 256.9 |
| 204 | Dongfeng Yueda Kia Motors Co., Ltd. | Kia K2 | Gasoline | Sedan | A0 | 209.7 |
| 205 | Dongfeng Yueda Kia Motors Co., Ltd. | Kia K3 | Gasoline | Sedan | A | 228.1 |
| 206 | Dongfeng Yueda Kia Motors Co., Ltd. | Kia K3 | Battery electric | Sedan | A | 161.0 |
| 207 | Dongfeng Yueda Kia Motors Co., Ltd. | Kia K3 | Plug-in hybrid electric | Sedan | A | 169.6 |
| 208 | Dongfeng Yueda Kia Motors Co., Ltd. | Kia K5 | Plug-in hybrid electric | Sedan | B | 184.4 |
| 209 | Dongfeng Yueda Kia Motors Co., Ltd. | Kia K5 | Gasoline | Sedan | B | 300.0 |
| 210 | Dongfeng Yueda Kia Motors Co., Ltd. | Kia KX Cross | Gasoline | Sedan | A0 | 228.5 |
| 211 | Dongfeng Yueda Kia Motors Co., Ltd. | Kia KX3 | Gasoline | SUV | A0 | 260.4 |
| 212 | Dongfeng Yueda Kia Motors Co., Ltd. | Kia KX5 | Gasoline | SUV | A | 276.1 |
| 213 | Dongfeng Yueda Kia Motors Co., Ltd. | KX1 | Gasoline | SUV | A0 | 218.3 |
| 214 | Dongfeng Yueda Kia Motors Co., Ltd. | Sportage R | Gasoline | SUV | A | 280.5 |
| 215 | Southeast (Fujian) Motor Co., Ltd. | A5 Yiwu | Gasoline | Sedan | A | 248.1 |
| 216 | Southeast (Fujian) Motor Co., Ltd. | Southeast DX3 | Battery electric | SUV | A0 | 167.7 |
| 217 | Southeast (Fujian) Motor Co., Ltd. | Southeast DX3 | Gasoline | SUV | A0 | 270.3 |
| 218 | Southeast (Fujian) Motor Co., Ltd. | Southeast DX5 | Gasoline | SUV | A | 270.3 |
| 219 | Southeast (Fujian) Motor Co., Ltd. | Southeast DX7 | Gasoline | SUV | A | 304.5 |
| 220 | Fujian Benz Automotive Co., Ltd. | Mercedes-Benz V-Class | Gasoline | MPV | B | 357.2 |
| 221 | Fujian Benz Automotive Co., Ltd. | Vito | Gasoline | MPV | B | 344.6 |
| 222 | Qoros Auto Co., Ltd. | Qoros 3 | Gasoline | Sedan | A | 244.5 |
| 223 | Qoros Auto Co., Ltd. | Qoros 5 | Gasoline | SUV | A | 281.3 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 224 | Qoros Auto Co., Ltd. | Qoros 7 | Gasoline | SUV | A | 266.0 |
| 225 | GAC Honda Motor Co., Ltd. | Oddesey | Conventional hybrid | MPV | A | 240.7 |
| 226 | GAC Honda Motor Co., Ltd. | Oddesey | Gasoline | MPV | A | 300.2 |
| 227 | GAC Honda Motor Co., Ltd. | VEZEL | Gasoline | SUV | A0 | 241.2 |
| 228 | GAC Honda Motor Co., Ltd. | Fit | Gasoline | Sedan | A0 | 202.6 |
| 229 | GAC Honda Motor Co., Ltd. | AVANCIER | Gasoline | SUV | B | 321.2 |
| 230 | GAC Honda Motor Co., Ltd. | BREEZE | Conventional hybrid | SUV | A | 213.1 |
| 231 | GAC Honda Motor Co., Ltd. | BREEZE | Gasoline | SUV | A | 272.6 |
| 232 | GAC Honda Motor Co., Ltd. | Everus VE1 | Battery electric | SUV | A0 | 182.6 |
| 233 | GAC Honda Motor Co., Ltd. | CRIDER | Gasoline | Sedan | A | 233.4 |
| 234 | GAC Honda Motor Co., Ltd. | CRIDER | Conventional hybrid | Sedan | A | 170.8 |
| 235 | GAC Honda Motor Co., Ltd. | ACURA CDX | Conventional hybrid | SUV | A | 206.2 |
| 236 | GAC Honda Motor Co., Ltd. | ACURA CDX | Gasoline | SUV | A | 266.3 |
| 237 | GAC Honda Motor Co., Ltd. | ACURA CDX | Gasoline | SUV | B | 328.6 |
| 238 | GAC Honda Motor Co., Ltd. | Shirui | Plug-in hybrid electric | SUV | A | 185.7 |
| 239 | GAC Honda Motor Co., Ltd. | Accord | Conventional hybrid | Sedan | B | 189.8 |
| 240 | GAC Honda Motor Co., Ltd. | Accord | Gasoline | Sedan | B | 280.3 |
| 241 | GAC AION New Energy Vehicle Co., Ltd. | Trumpchi AION LX | Battery electric | SUV | B | 224.3 |
| 242 | GAC AION New Energy Vehicle Co., Ltd. | Trumpchi AION V | Battery electric | SUV | B | 196.7 |
| 243 | GAC AION New Energy Vehicle Co., Ltd. | Trumpchi AION.S | Battery electric | Sedan | B | 165.1 |
| 244 | GAC Motor Co., Ltd. | Trumpchi GA6 | Gasoline | Sedan | B | 240.1 |
| 245 | GAC Motor Co., Ltd. | Trumpchi GM6 | Gasoline | MPV | A | 280.0 |
| 246 | GAC Motor Co., Ltd. | Trumpchi GM8 | Gasoline | MPV | B | 304.6 |
| 247 | GAC Motor Co., Ltd. | Trumpchi GS3 | Gasoline | SUV | A0 | 231.6 |
| 248 | GAC Motor Co., Ltd. | Trumpchi GS4 | Gasoline | SUV | A | 244.2 |
| 249 | GAC Motor Co., Ltd. | Trumpchi GS4 | Plug-in hybrid electric | SUV | A | 182.7 |
| 250 | GAC Motor Co., Ltd. | Trumpchi GS4 Coupe | Gasoline | SUV | A | 247.3 |
| 251 | GAC Motor Co., Ltd. | Trumpchi GS8 | Gasoline | SUV | B | 318.7 |
| 252 | GAC Motor Co., Ltd. | Trumpchi GS8 S | Gasoline | SUV | B | 289.8 |
| 253 | GAC Fiat Chrysler Automobiles Co., Ltd. | Grand Commander | Gasoline | SUV | B | 328.3 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 254 | GAC Fiat Chrysler Automobiles Co., Ltd. | Commander | Plug-in hybrid electric | SUV | B | 245.2 |
| 255 | GAC Fiat Chrysler Automobiles Co., Ltd. | Commander | Gasoline | SUV | B | 326.3 |
| 256 | GAC Fiat Chrysler Automobiles Co., Ltd. | Compass | Gasoline | SUV | A | 311.4 |
| 257 | GAC Fiat Chrysler Automobiles Co., Ltd. | Renegade | Gasoline | SUV | A0 | 307.5 |
| 258 | GAC Toyota Motor Co., Ltd. | Toyota C-HR | Battery electric | SUV | A | 165.7 |
| 259 | GAC Toyota Motor Co., Ltd. | Toyota C-HR | Gasoline | SUV | A | 221.9 |
| 260 | GAC Toyota Motor Co., Ltd. | GAC iA5 | Battery electric | Sedan | B | 165.1 |
| 261 | GAC Toyota Motor Co., Ltd. | Highlander | Gasoline | SUV | B | 334.3 |
| 262 | GAC Toyota Motor Co., Ltd. | Camry | Conventional hybrid | Sedan | B | 181.2 |
| 263 | GAC Toyota Motor Co., Ltd. | Camry | Gasoline | Sedan | B | 234.2 |
| 264 | GAC Toyota Motor Co., Ltd. | Levin | Gasoline | Sedan | A | 218.8 |
| 265 | GAC Toyota Motor Co., Ltd. | Levin | Plug-in hybrid electric | Sedan | A | 162.2 |
| 266 | GAC Toyota Motor Co., Ltd. | Levin | Conventional hybrid | Sedan | A | 174.6 |
| 267 | GAC Toyota Motor Co., Ltd. | Wildlander | Conventional hybrid | SUV | A | 208.0 |
| 268 | GAC Toyota Motor Co., Ltd. | Wildlander | Gasoline | SUV | A | 247.8 |
| 269 | GAC Toyota Motor Co., Ltd. | Zhixiang | Gasoline | Sedan | A0 | 192.0 |
| 270 | GAC Toyota Motor Co., Ltd. | Zhixiang | Gasoline | Sedan | A0 | 194.9 |
| 271 | GAC Mitsubishi Motors Co., Ltd. | Jinxuan ASX | Gasoline | SUV | A | 269.7 |
| 272 | GAC Mitsubishi Motors Co., Ltd. | Outlander | Gasoline | SUV | A | 295.6 |
| 273 | GAC Mitsubishi Motors Co., Ltd. | Qizhi EV | Battery electric | SUV | A0 | 172.6 |
| 274 | GAC Mitsubishi Motors Co., Ltd. | Eclipse Cross | Gasoline | SUV | A | 286.0 |
| 275 | GAC NIO New Energy Automobile Technology Co., Ltd. | Hechuang 007 | Battery electric | SUV | B | 217.8 |
| 276 | Guangzhou Xpeng Motors Technology Co., Ltd. | Xpeng G3 | Battery electric | SUV | A0 | 175.3 |
| 277 | Guangzhou Xpeng Motors Technology Co., Ltd. | Xpeng P7 | Battery electric | Sedan | C | 208.9 |
| 278 | BMW Brilliance Automotive Ltd. | BMW 1-Series | Gasoline | Sedan | A | 245.8 |
| 279 | BMW Brilliance Automotive Ltd. | BMW 3-Series | Gasoline | Sedan | B | 271.6 |
| 280 | BMW Brilliance Automotive Ltd. | BMW 5-Series | Plug-in hybrid electric | Sedan | C | 246.8 |
| 281 | BMW Brilliance Automotive Ltd. | BMW 5-Series | Gasoline | Sedan | C | 295.3 |
| 282 | BMW Brilliance Automotive Ltd. | BMW iX3 | Battery electric | SUV | B | 212.2 |
| 283 | BMW Brilliance Automotive Ltd. | BMW X1 | Plug-in hybrid electric | SUV | A | 249.2 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 284 | BMW Brilliance Automotive Ltd. | BMW X1 | Gasoline | SUV | A | 279.9 |
| 285 | BMW Brilliance Automotive Ltd. | BMW X2 | Gasoline | SUV | A | 255.6 |
| 286 | BMW Brilliance Automotive Ltd. | BMW X3 | Gasoline | SUV | B | 304.1 |
| 287 | Renault Brilliance Jinbei Automotive Co., Ltd. | Grace | Gasoline | MPV | B | 408.8 |
| 288 | Renault Brilliance Jinbei Automotive Co., Ltd. | Huasong 7 | Gasoline | MPV | B | 355.4 |
| 289 | Brilliance Xinyuan Chongqing Automobile Co., Ltd. | SWM G01 | Gasoline | SUV | A | 286.0 |
| 290 | Brilliance Xinyuan Chongqing Automobile Co., Ltd. | SWM G05 | Gasoline | SUV | A | 293.6 |
| 291 | Brilliance Xinyuan Chongqing Automobile Co., Ltd. | SWM X3 | Gasoline | SUV | A | 267.3 |
| 292 | Brilliance Xinyuan Chongqing Automobile Co., Ltd. | SWM X7 | Gasoline | SUV | B | 294.5 |
| 293 | Brilliance Xinyuan Chongqing Automobile Co., Ltd. | Little Sea Lion X30 | Battery electric | Crossover | - | 144.7 |
| 294 | Brilliance Xinyuan Chongqing Automobile Co., Ltd. | Little Sea Lion X30 | Gasoline | Crossover | - | 239.8 |
| 295 | Brilliance Xinyuan Chongqing Automobile Co., Ltd. | Little Sea Lion X30L | Battery electric | Crossover | - | 178.5 |
| 296 | Brilliance Xinyuan Chongqing Automobile Co., Ltd. | Little Sea Lion X30L | Gasoline | Crossover | - | 264.1 |
| 297 | JAC-Volkswagen Automotive Co., Ltd. | Sihao E20X | Battery electric | SUV | A0 | 167.0 |
| 298 | JAC-Volkswagen Automotive Co., Ltd. | Sihao X8 | Gasoline | SUV | B | 294.5 |
| 299 | Jiangling Motors Corporation Ltd. | Everest | Gasoline | SUV | B | 377.9 |
| 300 | Jiangling Motors Corporation Ltd. | Territory | Battery electric | SUV | A | 178.5 |
| 301 | Jiangling Motors Corporation Ltd. | Territory | Gasoline | SUV | A | 254.2 |
| 302 | Chery Jaguar Land Rover Automotive Co., Ltd. | Discovery Shenxing | Gasoline | SUV | A | 319.7 |
| 303 | Chery Jaguar Land Rover Automotive Co., Ltd. | Discovery Sport | Gasoline | SUV | A | 297.9 |
| 304 | Chery Jaguar Land Rover Automotive Co., Ltd. | Jaguar E-PACE | Gasoline | SUV | A | 293.6 |
| 305 | Chery Jaguar Land Rover Automotive Co., Ltd. | Jaguar XEL | Gasoline | Sedan | B | 258.6 |
| 306 | Chery Jaguar Land Rover Automotive Co., Ltd. | Jaguar XEL | Gasoline | Sedan | C | 322.5 |
| 307 | Chery Jaguar Land Rover Automotive Co., Ltd. | Range Rover Evoque | Gasoline | SUV | A | 303.0 |
| 308 | Chery Automobile Co., Ltd. | Arrizo 5 PLUS | Gasoline | Sedan | A | 250.1 |
| 309 | Chery Automobile Co., Ltd. | Arrizo 5e | Battery electric | Sedan | A | 168.3 |
| 310 | Chery Automobile Co., Ltd. | Arrizo EX | Gasoline | Sedan | A | 257.8 |
| 311 | Chery Automobile Co., Ltd. | Arrizo GX | Gasoline | Sedan | A | 257.5 |
| 312 | Chery Automobile Co., Ltd. | JETOUR X70 | Gasoline | SUV | A | 296.3 |
| 313 | Chery Automobile Co., Ltd. | JETOUR X70M | Gasoline | SUV | A | 276.0 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 314 | Chery Automobile Co., Ltd. | JETOUR X70S | Battery electric | SUV | A | 168.5 |
| 315 | Chery Automobile Co., Ltd. | JETOUR X90 | Gasoline | SUV | B | 299.5 |
| 316 | Chery Automobile Co., Ltd. | JETOUR X95 | Gasoline | SUV | B | 296.9 |
| 317 | Chery Automobile Co., Ltd. | ANT | Battery electric | SUV | B | 187.7 |
| 318 | Chery Automobile Co., Ltd. | Chery eQ1 | Battery electric | Sedan | A00 | 126.7 |
| 319 | Chery Automobile Co., Ltd. | Chery eQ2 | Battery electric | Sedan | A0 | 147.7 |
| 320 | Chery Automobile Co., Ltd. | TIGGO 3 | Gasoline | SUV | A0 | 271.8 |
| 321 | Chery Automobile Co., Ltd. | TIGGO 3X | Gasoline | SUV | A0 | 247.3 |
| 322 | Chery Automobile Co., Ltd. | TIGGO 5X | Gasoline | SUV | A | 246.2 |
| 323 | Chery Automobile Co., Ltd. | TIGGO 7 | Gasoline | SUV | A | 255.2 |
| 324 | Chery Automobile Co., Ltd. | TIGGO 8 | Gasoline | SUV | A | 273.3 |
| 325 | Chery Automobile Co., Ltd. | TIGGO E | Battery electric | SUV | A | 168.7 |
| 326 | Chery Automobile Co., Ltd. | EXEED LX | Gasoline | SUV | A | 255.0 |
| 327 | Chery Automobile Co., Ltd. | EXEED TX | Gasoline | SUV | A | 282.7 |
| 328 | Chery Automobile Co., Ltd. | EXEED TXL | Gasoline | SUV | B | 284.0 |
| 329 | SAIC Motor Corporation Passenger Vehicle Company | MARVEL R | Battery electric | SUV | B | 177.7 |
| 330 | SAIC Motor Corporation Passenger Vehicle Company | MG HS | Plug-in hybrid electric | SUV | A | 213.1 |
| 331 | SAIC Motor Corporation Passenger Vehicle Company | MG HS | Gasoline | SUV | A | 312.4 |
| 332 | SAIC Motor Corporation Passenger Vehicle Company | MG ZS | Battery electric | SUV | A0 | 157.4 |
| 333 | SAIC Motor Corporation Passenger Vehicle Company | MG ZS | Gasoline | SUV | A0 | 240.6 |
| 334 | SAIC Motor Corporation Passenger Vehicle Company | MG5 | Gasoline | Sedan | A | 239.7 |
| 335 | SAIC Motor Corporation Passenger Vehicle Company | MG6 | Plug-in hybrid electric | Sedan | A | 168.2 |
| 336 | SAIC Motor Corporation Passenger Vehicle Company | MG6 | Gasoline | Sedan | A | 274.7 |
| 337 | SAIC Motor Corporation Passenger Vehicle Company | HS | Gasoline | SUV | A | 313.0 |
| 338 | SAIC Motor Corporation Passenger Vehicle Company | Roewe e950 | Plug-in hybrid electric | Sedan | B | 204.0 |
| 339 | SAIC Motor Corporation Passenger Vehicle Company | Roewe Ei5 | Battery electric | Sedan | A | 166.3 |
| 340 | SAIC Motor Corporation Passenger Vehicle Company | Roewe ei6 | Plug-in hybrid electric | Sedan | A | 160.5 |
| 341 | SAIC Motor Corporation Passenger Vehicle Company | Roewe ei6 MAX | Plug-in hybrid electric | Sedan | A | 167.7 |
| 342 | SAIC Motor Corporation Passenger Vehicle Company | Roewe ER6 | Battery electric | Sedan | A | 175.4 |
| 343 | SAIC Motor Corporation Passenger Vehicle Company | Roewe eRX5 | Plug-in hybrid electric | SUV | A | 204.7 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | CO2 Emission Per Mileage (gCO2e/km) |
|---|---|---|---|---|---|---|
| 344 | SAIC Motor Corporation Passenger Vehicle Company | Roewe ERX5 EV | Battery electric | SUV | A | 166.0 |
| 345 | SAIC Motor Corporation Passenger Vehicle Company | Roewe i5 | Gasoline | Sedan | A | 213.5 |
| 346 | SAIC Motor Corporation Passenger Vehicle Company | Roewe i6 | Gasoline | Sedan | A | 220.7 |
| 347 | SAIC Motor Corporation Passenger Vehicle Company | Roewe i6 MAX | Gasoline | Sedan | A | 220.7 |
| 348 | SAIC Motor Corporation Passenger Vehicle Company | Roewe iMAX8 | Gasoline | MPV | B | 315.9 |
| 349 | SAIC Motor Corporation Passenger Vehicle Company | Roewe RX3 | Gasoline | SUV | A | 240.3 |
| 350 | SAIC Motor Corporation Passenger Vehicle Company | Roewe RX5 | Gasoline | SUV | A | 308.2 |
| 351 | SAIC Motor Corporation Passenger Vehicle Company | Roewe RX5 eMAX | Plug-in hybrid electric | SUV | A | 223.6 |
| 352 | SAIC Motor Corporation Passenger Vehicle Company | Roewe RX5 MAX | Gasoline | SUV | A | 323.6 |
| 353 | SAIC Motor Corporation Passenger Vehicle Company | Roewe RX8 | Gasoline | SUV | B | 364.1 |
| 354 | SAIC Motor Corporation Passenger Vehicle Company | SAIC Clever | Battery electric | Sedan | A00 | 108.7 |
| 355 | Shanghai NIO Motors Co., Ltd. | NIO EC6 | Battery electric | SUV | B | 233.4 |
| 356 | Shanghai NIO Motors Co., Ltd. | NIO EC6 | Battery electric | SUV | B | 239.0 |
| 357 | Shanghai NIO Motors Co., Ltd. | NIO EC6 | Battery electric | SUV | C | 250.1 |
| 358 | SAIC Maxus Automotive Co., Ltd. | NIO ES8 | Gasoline | SUV | B | 274.6 |
| 359 | SAIC Maxus Automotive Co., Ltd. | SAIC Maxus D60 | Diesel | SUV | C | 349.2 |
| 360 | SAIC Maxus Automotive Co., Ltd. | SAIC Maxus D90 | Battery electric | MPV | A | 178.3 |
| 361 | SAIC Maxus Automotive Co., Ltd. | SAIC Maxus EUNIQ 5 | Plug-in hybrid electric | MPV | A | 207.7 |
| 362 | SAIC Maxus Automotive Co., Ltd. | SAIC Maxus EUNIQ 5 | Diesel | MPV | B | 337.6 |
| 363 | SAIC Maxus Automotive Co., Ltd. | SAIC Maxus G10 | Diesel | MPV | B | 332.2 |
| 364 | SAIC Maxus Automotive Co., Ltd. | SAIC Maxus G20 | Gasoline | MPV | B | 354.5 |
| 365 | SAIC Maxus Automotive Co., Ltd. | SAIC Maxus G50 | Gasoline | MPV | A | 274.8 |
| 366 | SAIC VOLKSWAGEN Automotive Co., Ltd. | VW Polo | Gasoline | Sedan | A0 | 218.7 |
| 367 | SAIC VOLKSWAGEN Automotive Co., Ltd. | PHIDEON | Gasoline | Sedan | C | 338.0 |
| 368 | SAIC VOLKSWAGEN Automotive Co., Ltd. | KAROQ | Gasoline | SUV | A | 225.7 |
| 369 | SAIC VOLKSWAGEN Automotive Co., Ltd. | KAMIQ | Gasoline | SUV | A | 229.9 |
| 370 | SAIC VOLKSWAGEN Automotive Co., Ltd. | KAMIQ GT | Gasoline | SUV | A | 224.1 |
| 371 | SAIC VOLKSWAGEN Automotive Co., Ltd. | LAVIDA | Battery electric | Sedan | A | 157.0 |
| 372 | SAIC VOLKSWAGEN Automotive Co., Ltd. | LAVIDA | Gasoline | Sedan | A | 246.5 |
| 373 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Lamando | Gasoline | Sedan | A | 222.3 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 374 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Octavia | Gasoline | Sedan | A | 235.2 |
| 375 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Octavia Wagen | Gasoline | Sedan | A | 221.0 |
| 376 | SAIC VOLKSWAGEN Automotive Co., Ltd. | PASSAT | Plug-in hybrid electric | Sedan | B | 206.9 |
| 377 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Gran Santan | Gasoline | Sedan | A | 223.2 |
| 378 | SAIC VOLKSWAGEN Automotive Co., Ltd. | SUNA Santana | Gasoline | Sedan | A | 220.0 |
| 379 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Superb | Gasoline | Sedan | B | 259.8 |
| 380 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Touran | Gasoline | MPV | A | 263.7 |
| 381 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Teramont | Gasoline | SUV | C | 370.2 |
| 382 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Tiguan L | Plug-in hybrid electric | SUV | A | 227.6 |
| 383 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Tiguan L | Gasoline | SUV | A | 268.6 |
| 384 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Tiguan X | Gasoline | SUV | B | 285.9 |
| 385 | SAIC VOLKSWAGEN Automotive Co., Ltd. | T-Cross | Gasoline | SUV | A | 218.6 |
| 386 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Tharu | Gasoline | SUV | A | 262.0 |
| 387 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Viloran | Gasoline | MPV | B | 314.3 |
| 388 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Spaceback | Gasoline | Sedan | A | 223.2 |
| 389 | SAIC VOLKSWAGEN Automotive Co., Ltd. | Rapid | Gasoline | Sedan | A | 223.2 |
| 390 | SAIC General Motors Corporation Limited | Encore | Gasoline | SUV | A0 | 264.7 |
| 391 | SAIC General Motors Corporation Limited | Encore GX | Gasoline | SUV | A | 246.2 |
| 392 | SAIC General Motors Corporation Limited | ENCLAVE | Gasoline | SUV | B | 310.3 |
| 393 | SAIC General Motors Corporation Limited | ENVISION | Gasoline | SUV | A | 321.1 |
| 394 | SAIC General Motors Corporation Limited | ENVISION S | Gasoline | SUV | B | 292.2 |
| 395 | SAIC General Motors Corporation Limited | BUICK GL6 | Gasoline | MPV | A | 247.3 |
| 396 | SAIC General Motors Corporation Limited | BUICK GL8 | Gasoline | MPV | B | 391.6 |
| 397 | SAIC General Motors Corporation Limited | BUICK Velite 6 | Battery electric | Sedan | A | 162.4 |
| 398 | SAIC General Motors Corporation Limited | BUICK Velite 6 | Plug-in hybrid electric | Sedan | A | 182.6 |
| 399 | SAIC General Motors Corporation Limited | BUICK Velite 7 | Battery electric | SUV | A | 169.6 |
| 400 | SAIC General Motors Corporation Limited | MENLO | Battery electric | Sedan | A | 165.9 |
| 401 | SAIC General Motors Corporation Limited | Trailblazer | Gasoline | SUV | A | 249.0 |
| 402 | SAIC General Motors Corporation Limited | TRAX | Gasoline | SUV | A0 | 275.5 |
| 403 | SAIC General Motors Corporation Limited | Regal | Gasoline | Sedan | B | 296.3 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e$/km) |
|---|---|---|---|---|---|---|
| 404 | SAIC General Motors Corporation Limited | Lacrosse | Gasoline | Sedan | B | 280.1 |
| 405 | SAIC General Motors Corporation Limited | Blazer | Gasoline | SUV | B | 302.8 |
| 406 | SAIC General Motors Corporation Limited | Cadillac CT4 | Gasoline | Sedan | B | 254.5 |
| 407 | SAIC General Motors Corporation Limited | Cadillac CT5 | Gasoline | Sedan | C | 271.2 |
| 408 | SAIC General Motors Corporation Limited | Cadillac CT6 | Gasoline | Sedan | C | 341.8 |
| 409 | SAIC General Motors Corporation Limited | Cadillac XT4 | Gasoline | SUV | B | 285.6 |
| 410 | SAIC General Motors Corporation Limited | Cadillac XT5 | Gasoline | SUV | B | 321.4 |
| 411 | SAIC General Motors Corporation Limited | Cadillac XT6 | Gasoline | SUV | B | 313.9 |
| 412 | SAIC General Motors Corporation Limited | Cadillac XT6 | Gasoline | Sedan | C | 319.7 |
| 413 | SAIC General Motors Corporation Limited | Excelle | Gasoline | Sedan | A | 265.9 |
| 414 | SAIC General Motors Corporation Limited | Monza | Gasoline | Sedan | A | 218.8 |
| 415 | SAIC General Motors Corporation Limited | Cavalier | Gasoline | Sedan | A | 214.3 |
| 416 | SAIC General Motors Corporation Limited | Malibu XL | Gasoline | Sedan | B | 251.0 |
| 417 | SAIC General Motors Corporation Limited | Equinox | Gasoline | Sedan | A | 303.5 |
| 418 | SAIC General Motors Corporation Limited | verano | Gasoline | Sedan | A | 231.2 |
| 419 | SAIC General Motors Corporation Limited | ORLANDO | Gasoline | Sedan | B | 249.9 |
| 420 | SAIC General Motors Corporation Limited | Excelle GT | Gasoline | Sedan | A | 224.0 |
| 421 | SAIC General Motors Corporation Limited | EXCELLE GX | Gasoline | Sedan | A | 219.4 |
| 422 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun 310 | Gasoline | Sedan | A0 | 211.7 |
| 423 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun 310W | Gasoline | Sedan | A | 240.6 |
| 424 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun 360 | Gasoline | MPV | A | 262.5 |
| 425 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun 510 | Gasoline | SUV | A0 | 239.6 |
| 426 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun 530 | Gasoline | SUV | A | 288.8 |
| 427 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun 730 | Gasoline | MPV | A0 | 289.6 |
| 428 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun E100 | Battery electric | Sedan | A00 | 106.0 |
| 429 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun E200 | Battery electric | Sedan | A00 | 106.7 |
| 430 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun E300 | Battery electric | Sedan | A00 | 122.7 |
| 431 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun RC-5 | Gasoline | Sedan | A | 249.7 |
| 432 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun RC-5W | Gasoline | Sedan | A | 250.0 |
| 433 | SAIC-GM-Wuling (SGMW) Co., Ltd. | Baojun RC-6 | Gasoline | Sedan | B | 268.4 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 434 | SAIC-GM-Wuling (SGMW) Co., Ltd | Baojun RM-5 | Gasoline | MPV | A | 272.5 |
| 435 | SAIC-GM-Wuling (SGMW) Co., Ltd | Baojun RS-3 | Gasoline | SUV | A0 | 247.7 |
| 436 | SAIC-GM-Wuling (SGMW) Co., Ltd | Baojun RS-5 | Gasoline | SUV | A | 292.0 |
| 437 | SAIC-GM-Wuling (SGMW) Co., Ltd | Hongguang mini | Battery electric | Sedan | A00 | 89.4 |
| 438 | SAIC-GM-Wuling (SGMW) Co., Ltd | Victory | Gasoline | MPV | A | 292.9 |
| 439 | SAIC-GM-Wuling (SGMW) Co., Ltd | Wuling 730 | Gasoline | MPV | A0 | 249.7 |
| 440 | SAIC-GM-Wuling (SGMW) Co., Ltd | Wuling Hongguang PLUS | Gasoline | MPV | A | 264.9 |
| 441 | SAIC-GM-Wuling (SGMW) Co., Ltd | Wuling Hongguang S | Gasoline | MPV | A0 | 247.6 |
| 442 | SAIC-GM-Wuling (SGMW) Co., Ltd | Wuling Hongguang S3 | Gasoline | SUV | B | 279.4 |
| 443 | SAIC-GM-Wuling (SGMW) Co., Ltd | Wuling Hongguang V | Gasoline | MPV | A0 | 241.5 |
| 444 | SAIC-GM-Wuling (SGMW) Co., Ltd | Wuling Rongguang | Battery electric | Crossover | - | 163.2 |
| 445 | SAIC-GM-Wuling (SGMW) Co., Ltd | Wuling Rongguang | Gasoline | Crossover | - | 256.0 |
| 446 | SAIC-GM-Wuling (SGMW) Co., Ltd | Wuling Rongguang S | Gasoline | Crossover | - | 243.5 |
| 447 | SAIC-GM-Wuling (SGMW) Co., Ltd | Wuling Rongguang V | Gasoline | MPV | A0 | 249.0 |
| 448 | SAIC-GM-Wuling (SGMW) Co., Ltd | Wuling Zhiguang | Gasoline | Crossover | - | 220.2 |
| 449 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | eElysée | Battery electric | Sedan | A | 143.4 |
| 450 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | Elysée | Gasoline | Sedan | A | 233.4 |
| 451 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | Peugeot 308 | Gasoline | Sedan | A | 262.5 |
| 452 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | Peugeot 4008 | Gasoline | SUV | A | 248.2 |
| 453 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | Peugeot 408 | Gasoline | Sedan | A | 228.0 |
| 454 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | Peugeot 5008 | Gasoline | SUV | B | 256.5 |
| 455 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | Peugeot 508L | Gasoline | Sedan | B | 237.9 |
| 456 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | AIRCROSS | Plug-in hybrid electric | SUV | A | 215.1 |
| 457 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | AIRCROSS | Gasoline | SUV | A | 256.9 |
| 458 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | Citroen C3-XR | Gasoline | SUV | A0 | 242.3 |
| 459 | Dongfeng Peugeot Citroen Automobile Co., Ltd. | Citroen C6 | Gasoline | Sedan | C | 253.0 |
| 460 | Tesla (Shanghai) Co., Ltd. | Tesla Model 3 | Battery electric | Sedan | B | 182.2 |
| 461 | WM Motor Technology Group Company Limited | WM EX5 | Battery electric | SUV | A | 179.3 |
| 462 | WM Motor Technology Group Company Limited | WM EX6 | Battery electric | SUV | A | 179.8 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e$/km) |
|---|---|---|---|---|---|---|
| 463 | Weichai (Chongqing) Motors Co., Ltd. | Weichai U70 | Gasoline | SUV | B | 301.5 |
| 464 | FAW-Volkswagen Automotive Co., Ltd. | Audi A3 | Gasoline | Sedan | A | 234.0 |
| 465 | FAW-Volkswagen Automotive Co., Ltd. | Audi A4L | Gasoline | Sedan | B | 277.8 |
| 466 | FAW-Volkswagen Automotive Co., Ltd. | Audi A6L | Plug-in hybrid electric | Sedan | C | 262.8 |
| 467 | FAW-Volkswagen Automotive Co., Ltd. | Audi A6L | Gasoline | Sedan | C | 340.1 |
| 468 | FAW-Volkswagen Automotive Co., Ltd. | Audi Q2L | Battery electric | SUV | A0 | 157.7 |
| 469 | FAW-Volkswagen Automotive Co., Ltd. | Audi Q2L | Gasoline | SUV | A0 | 229.5 |
| 470 | FAW-Volkswagen Automotive Co., Ltd. | Audi Q3 | Gasoline | SUV | A | 299.2 |
| 471 | FAW-Volkswagen Automotive Co., Ltd. | Audi Q3 Sportback | Gasoline | SUV | A | 287.0 |
| 472 | FAW-Volkswagen Automotive Co., Ltd. | Audi Q5L | Gasoline | SUV | B | 286.7 |
| 473 | FAW-Volkswagen Automotive Co., Ltd. | Bora | Battery electric | Sedan | A | 152.4 |
| 474 | FAW-Volkswagen Automotive Co., Ltd. | Bora | Gasoline | Sedan | A | 244.4 |
| 475 | FAW-Volkswagen Automotive Co., Ltd. | Volkswagen CC | Gasoline | Sedan | B | 289.1 |
| 476 | FAW-Volkswagen Automotive Co., Ltd. | Golf | Battery electric | Sedan | A | 149.1 |
| 477 | FAW-Volkswagen Automotive Co., Ltd. | Golf | Gasoline | Sedan | A | 229.9 |
| 478 | FAW-Volkswagen Automotive Co., Ltd. | Golf Sportsvan | Gasoline | Sedan | A | 235.7 |
| 479 | FAW-Volkswagen Automotive Co., Ltd. | Jetta VA3 | Gasoline | Sedan | A | 207.8 |
| 480 | FAW-Volkswagen Automotive Co., Ltd. | Jetta VS5 | Gasoline | SUV | A | 247.7 |
| 481 | FAW-Volkswagen Automotive Co., Ltd. | Jetta VS7 | Gasoline | SUV | A | 250.2 |
| 482 | FAW-Volkswagen Automotive Co., Ltd. | Magotan | Plug-in hybrid electric | Sedan | B | 221.0 |
| 483 | FAW-Volkswagen Automotive Co., Ltd. | Magotan | Gasoline | Sedan | B | 300.5 |
| 484 | FAW-Volkswagen Automotive Co., Ltd. | SAGITAR | Gasoline | Sedan | A | 246.7 |
| 485 | FAW-Volkswagen Automotive Co., Ltd. | T-Rock R | Gasoline | SUV | A | 259.1 |
| 486 | FAW-Volkswagen Automotive Co., Ltd. | TACQUA | Gasoline | SUV | A | 220.0 |
| 487 | FAW-Volkswagen Automotive Co., Ltd. | TAYRON | Plug-in hybrid electric | SUV | A | 228.1 |
| 488 | FAW-Volkswagen Automotive Co., Ltd. | TAYRON | Gasoline | SUV | A | 296.4 |
| 489 | FAW-Volkswagen Automotive Co., Ltd. | TAYRON X | Gasoline | SUV | A | 282.3 |
| 490 | FAW-Volkswagen Automotive Co., Ltd. | C-TREK | Gasoline | Sedan | A | 235.1 |
| 491 | FAW Toyota Motor Sales Co., Ltd. | Toyota RAV4 | Conventional hybrid | SUV | A | 209.3 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e$/km) |
|---|---|---|---|---|---|---|
| 492 | FAW Toyota Motor Sales Co., Ltd. | Toyota RAV4 | Gasoline | SUV | A | 248.3 |
| 493 | FAW Toyota Motor Sales Co., Ltd. | Corolla | Gasoline | Sedan | A | 230.1 |
| 494 | FAW Toyota Motor Sales Co., Ltd. | Corolla | Plug-in hybrid electric | Sedan | A | 162.2 |
| 495 | FAW Toyota Motor Sales Co., Ltd. | Corolla | Conventional hybrid | Sedan | A | 173.9 |
| 496 | FAW Toyota Motor Sales Co., Ltd. | VIOS | Gasoline | Sedan | A0 | 202.0 |
| 497 | FAW Toyota Motor Sales Co., Ltd. | VIOS FS | Gasoline | Sedan | A0 | 198.3 |
| 498 | FAW Toyota Motor Sales Co., Ltd. | AVALON | Conventional hybrid | Sedan | B | 188.0 |
| 499 | FAW Toyota Motor Sales Co., Ltd. | AVALON | Gasoline | Sedan | B | 240.6 |
| 500 | FAW Toyota Motor Sales Co., Ltd. | IZOA | Battery electric | SUV | A | 164.3 |
| 501 | FAW Toyota Motor Sales Co., Ltd. | IZOA | Gasoline | SUV | A | 221.9 |
| 502 | FAW Car Co., Ltd. | Benteng B30 | Battery electric | Sedan | A | 160.4 |
| 503 | FAW Car Co., Ltd. | Benteng B70 | Gasoline | Sedan | B | 302.9 |
| 504 | FAW Car Co., Ltd. | Benteng T33 | Gasoline | SUV | A0 | 255.9 |
| 505 | FAW Car Co., Ltd. | Benteng T77 | Gasoline | SUV | A | 262.1 |
| 506 | FAW Car Co., Ltd. | Benteng T99 | Gasoline | SUV | B | 294.5 |
| 507 | FAW Car Co., Ltd. | Benteng X40 | Battery electric | SUV | A0 | 179.5 |
| 508 | FAW Car Co., Ltd. | Benteng X40 | Gasoline | SUV | A0 | 255.1 |
| 509 | FAW Car Co., Ltd. | Hongqi E-HS3 | Battery electric | SUV | A | 171.5 |
| 510 | FAW Car Co., Ltd. | Hongqi H5 | Gasoline | Sedan | B | 267.5 |
| 511 | FAW Car Co., Ltd. | Hongqi H7 | Gasoline | Sedan | C | 330.6 |
| 512 | FAW Car Co., Ltd. | Hongqi H9 | Gasoline | Sedan | C | 334.0 |
| 513 | FAW Car Co., Ltd. | Hongqi HS5 | Gasoline | SUV | B | 309.9 |
| 514 | FAW Car Co., Ltd. | Hongqi HS7 | Gasoline | SUV | C | 401.5 |
| 515 | FAW Car Co., Ltd. | Mazda 6/ Atenza | Gasoline | Sedan | B | 263.7 |
| 516 | Yibin Cowin Auto Co., Ltd. | Mazda CX-4 | Gasoline | SUV | A | 271.3 |
| 517 | Yibin Cowin Auto Co., Ltd. | Cowin E3 | Gasoline | Sedan | A0 | 245.9 |
| 518 | Yibin Cowin Auto Co., Ltd. | Cowin E5 | Battery electric | Sedan | A | 163.9 |
| 519 | Yibin Cowin Auto Co., Ltd. | Cowin X3 | Gasoline | SUV | A0 | 273.3 |
| 520 | Yibin Cowin Auto Co., Ltd. | Cowin X5 | Gasoline | SUV | A | 280.1 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 521 | Yibin Cowin Auto Co., Ltd. | showjet | Gasoline | SUV | A | 267.3 |
| 522 | Zhejiang Hozon New Energy Automobile Co., Ltd. | Nezha N01 | Battery electric | SUV | A0 | 144.8 |
| 523 | Zhejiang Hozon New Energy Automobile Co., Ltd. | Nezha U | Battery electric | SUV | A | 175.7 |
| 524 | Zhejiang Hozon New Energy Automobile Co., Ltd. | Nezha V | Battery electric | Sedan | A0 | 129.6 |
| 525 | Zhejiang Geely Holding Group Co., Ltd. | Benry | Gasoline | Sedan | A | 227.8 |
| 526 | Zhejiang Geely Holding Group Co., Ltd. | Coolray | Plug-in hybrid electric | SUV | A0 | 184.4 |
| 527 | Zhejiang Geely Holding Group Co., Ltd. | Coolray | Gasoline | SUV | A0 | 233.8 |
| 528 | Zhejiang Geely Holding Group Co., Ltd. | Borui GE | Plug-in hybrid electric | Sedan | B | 202.0 |
| 529 | Zhejiang Geely Holding Group Co., Ltd. | Borui GE | Gasoline | Sedan | B | 273.1 |
| 530 | Zhejiang Geely Holding Group Co., Ltd. | Boyue | Gasoline | SUV | A | 285.7 |
| 531 | Zhejiang Geely Holding Group Co., Ltd. | Emgrand | Plug-in hybrid electric | Sedan | A | 172.7 |
| 532 | Zhejiang Geely Holding Group Co., Ltd. | Emgrand | Gasoline | Sedan | A | 225.1 |
| 533 | Zhejiang Geely Holding Group Co., Ltd. | Emgrand ev | Battery electric | Sedan | A | 165.8 |
| 534 | Zhejiang Geely Holding Group Co., Ltd. | Emgrand GL | Plug-in hybrid electric | Sedan | A | 197.0 |
| 535 | Zhejiang Geely Holding Group Co., Ltd. | Emgrand GL | Gasoline | Sedan | A | 228.4 |
| 536 | Zhejiang Geely Holding Group Co., Ltd. | Emgrand GS | Gasoline | SUV | A | 231.2 |
| 537 | Zhejiang Geely Holding Group Co., Ltd. | Emgrand GSe | Battery electric | SUV | A | 166.9 |
| 538 | Zhejiang Geely Holding Group Co., Ltd. | Haoyue | Gasoline | SUV | B | 300.0 |
| 539 | Zhejiang Geely Holding Group Co., Ltd. | Geely icon | Gasoline | SUV | A | 252.5 |
| 540 | Zhejiang Geely Holding Group Co., Ltd. | Geometry A | Battery electric | Sedan | A | 167.3 |
| 541 | Zhejiang Geely Holding Group Co., Ltd. | Geometry C | Battery electric | SUV | A | 172.4 |
| 542 | Zhejiang Geely Holding Group Co., Ltd. | Jiaji | Plug-in hybrid electric | MPV | A | 202.5 |
| 543 | Zhejiang Geely Holding Group Co., Ltd. | Jiaji | Gasoline | MPV | A | 276.7 |
| 544 | Zhejiang Geely Holding Group Co., Ltd. | LYNK 01 | Conventional hybrid | SUV | A | 203.7 |
| 545 | Zhejiang Geely Holding Group Co., Ltd. | LYNK 01 | Plug-in hybrid electric | SUV | A | 221.1 |
| 546 | Zhejiang Geely Holding Group Co., Ltd. | LYNK 01 | Gasoline | SUV | A | 291.4 |
| 547 | Zhejiang Geely Holding Group Co., Ltd. | LYNK 02 | Plug-in hybrid electric | SUV | A | 224.3 |
| 548 | Zhejiang Geely Holding Group Co., Ltd. | LYNK 02 | Gasoline | SUV | A | 264.2 |
| 549 | Zhejiang Geely Holding Group Co., Ltd. | LYNK 03 | Plug-in hybrid electric | Sedan | A | 206.4 |

Schedule 7 (Continued)

| SN | Corporation Name | Model | Fuel | Category | Class | $CO_2$ Emission Per Mileage ($gCO_2e/km$) |
|---|---|---|---|---|---|---|
| 550 | Zhejiang Geely Holding Group Co., Ltd. | LYNK 03 | Gasoline | Sedan | A | 283.1 |
| 551 | Zhejiang Geely Holding Group Co., Ltd. | LYNK 05 | Gasoline | SUV | A | 292.1 |
| 552 | Zhejiang Geely Holding Group Co., Ltd. | LYNK 06 | Plug-in hybrid electric | SUV | A0 | 200.1 |
| 553 | Zhejiang Geely Holding Group Co., Ltd. | LYNK 06 | Gasoline | SUV | A0 | 246.5 |
| 554 | Zhejiang Geely Holding Group Co., Ltd. | Xingrui | Gasoline | Sedan | B | 251.7 |
| 555 | Zhejiang Geely Holding Group Co., Ltd. | Xingyue | Plug-in hybrid electric | SUV | A | 197.4 |
| 556 | Zhejiang Geely Holding Group Co., Ltd. | Xingyue | Gasoline | SUV | A | 298.9 |
| 557 | Zhejiang Geely Holding Group Co., Ltd. | Vision | Gasoline | Sedan | A | 222.3 |
| 558 | Zhejiang Geely Holding Group Co., Ltd. | Vision SUV | Gasoline | SUV | A | 255.2 |
| 559 | Zhejiang Geely Holding Group Co., Ltd. | Vision X3 | Gasoline | SUV | A0 | 222.5 |
| 560 | Zhejiang Geely Holding Group Co., Ltd. | Succe | Battery electric | MPV | A0 | 182.7 |
| 561 | Zhejiang Geely Holding Group Co., Ltd. | Terra | Gasoline | SUV | B | 348.9 |

Note: For cars under the same model name, the maximum value of the carbon emission per mileage is used.

## CHINA AUTOMOBILE LOW CARBON ACTION PLAN (CALCP)

China Automobile Low carbon Action Plan (CALCP) aims to establish a sound research system on the vehicle life cycle GHG emission analysis, support the formulation of national GHG emission policies and standards, promote the R&D and application of low-carbon technologies in the enterprises, lead the automotive industry to move toward life cycle carbon neutrality, and jointly build higher quality, more efficient and more sustainable future.

CACP

SINCE 2018

**CHINA AUTOMOBILE LOW CARBON ACTION PLAN**

CHINA AUTOMOTIVE TECHNOLOGY AND RESEARCH CENTER CO., LTD.
AUTOMOTIVE DATA OF CHINA CO., LTD

Tel：022-84379771/84379781
Email: sunxin@catarc.ac.cn
Add:No.68, East Xianfeng Road, Dongli District, Tianjin
Post Code: 300300