CACP | 5 YEARS

Carbon-Neutrality-Oriented Automotive Industry Low-carbon Development Strategy and Transformation Path

China Automotive Low Carbon Action Plan (2022)

Executive Summary

China Automotive Low Carbon Action 2022

中汽中心 | 数据
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As the first industrial energy conservation and green development evaluation center in the automotive industry, Automotive Data of China Co., Ltd. of China Automotive Technology & Research Center (hereinafter referred to as CATARC-ADC) was entrusted by relevant departments to organize the launch of the China Automotive Low Carbon Action Plan (CALCP) in 2018 and led the establishment of World Automotive Life Cycle Assessment Working Group (WALCA) in the same year. Over the years, CATARC-ADC has made research successively through cooperation with authoritative experts from more than 30 well-known institutions at home and abroad, including the United Nations Environment Programme (UNEP), the World Business Council for Sustainable Development, the World Business Council for Sustainable Development (WBCSD), the World Resources Institute (WRI), the World Steel Association (WSA), the National Centre for Climate Change Strategy and International Cooperation (NCSC), the Foreign Environmental Cooperation Center of the Ministry of Ecology and Environment, the Transport Planning and Research Institute, Ministry of Transport, the World Economic Forum (WEF), the China Electricity Council (CEC), Tsinghua University, etc.

Up to now, the CALCP has been successfully implemented for five years, when the lifecycle carbon emissions have been calculated for a total of 15,000 passenger and commercial vehicles, covering the production and sales of hundreds of millions of vehicles. The relevant research results have been adopted by the Ministry of Industry and Information Technology (MIIT), the Ministry of Ecology and Environment of China (MEE), and other relevant departments, highly recognized by the automotive industry, cited by many internationally renowned universities and institutions such as Cambridge University, Yale University, and the Energy Foundation, and in mainstream media such as CCTV, China Automobile News, with public communication for more than 10,000 times in mainstream media such as CCTV, China Automobile News, and China Environment News.

Fifth release of the CALCP research results by the Automotive Data of China Co., Ltd.

This research is made with the lifecycle assessment method and based on the China Automotive Life Cycle Database (CALCD), the China Automotive Life Cycle Assessment Model (CALCM) and the China Automotive Life Cycle Assessment Accounting Tool - OBS, under the support of the China Industrial Carbon Emissions Information System (CICES).

Firstly, lifecycle carbon emissions are calculated for single vehicles, enterprises and fleets for passenger and commercial vehicles sold in China in 2021, and the lifecycle carbon emission levels of China's current automotive products, enterprises and industries are analyzed and publicized.

Secondly, in order to promote the green and low-carbon development of the automotive industry, this research puts forward ten different transformation paths, including clean electricity, vehicle electrification, fuel decarbonization, low-carbon material, production digitalization, transportation intelligence, shared mobility, resource recycling, carbon capture, utilization and storage, and product ecologicalization, sets up three scenarios, namely reference scenario, carbon neutrality before 2060 scenario and carbon neutrality before 2050 scenario, and based on this, fully discusses the carbon emission reduction potential of different paths in different scenarios.

Finally, based on these research results and the challenges faced by the automotive industry at home and abroad in achieving the carbon peak and carbon neutrality goals, policies and measures and strategic suggestions for the low-carbon development of China's automotive industry are put forward, with purpose of leading the automotive industry to achieve the carbon neutrality goal and building a more brilliant, efficient and sustainable future.

This research data is obtained before April 28, 2022.

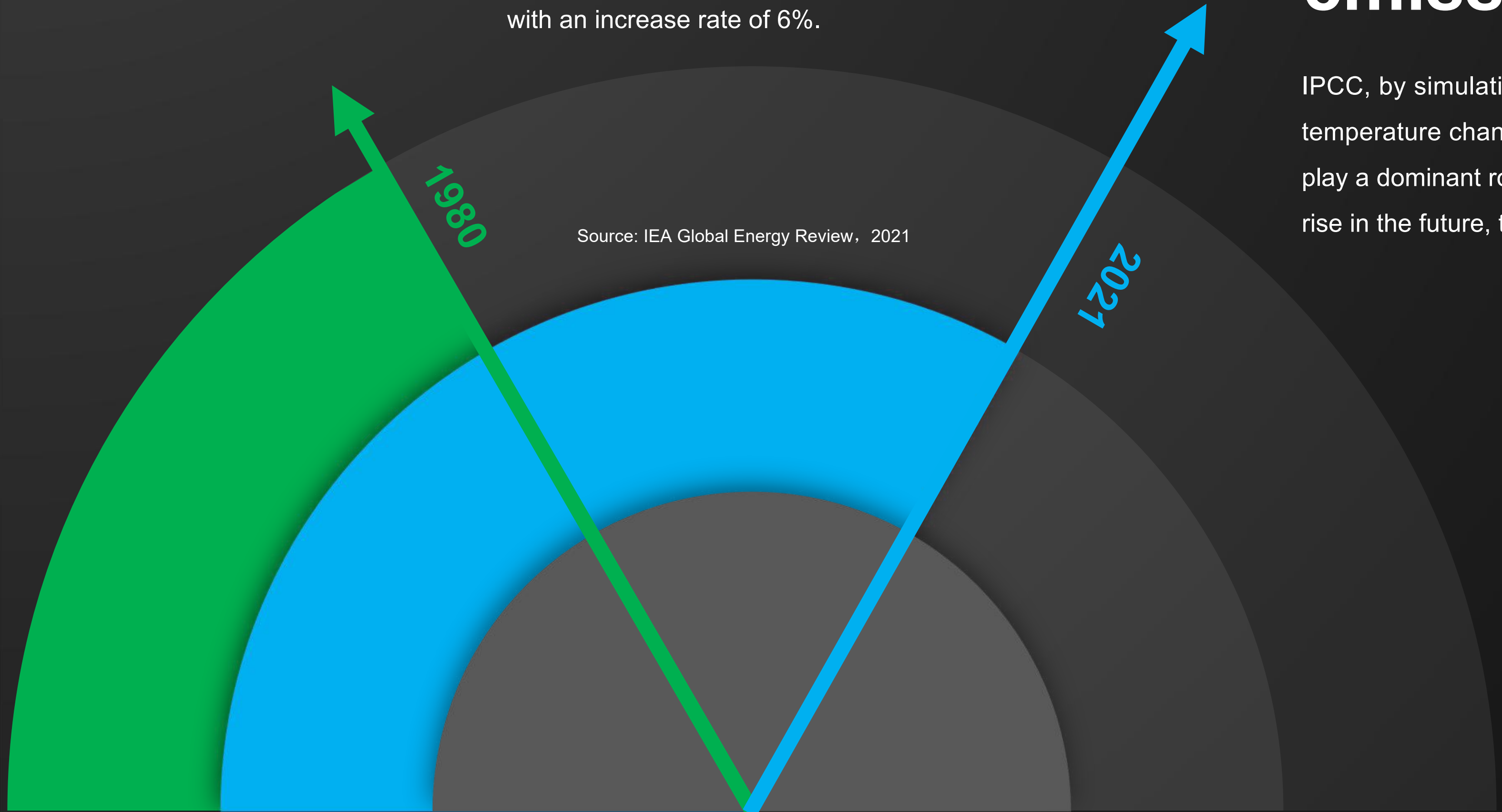
1

1980-2021

Rising and significantly increased global CO_2 emissions

From 1980 to 2021, the global CO_2 emissions were rising and significantly increased. In 2021, CO_2 emissions saw a YoY growth of 2.04 billion tons, the highest over the years, with an increase rate of 6%.

IPCC, by simulating the human and natural factors that led to global temperature changes in the past, demonstrated that human activities play a dominant role in climate warming. If GHG emissions continue to rise in the future, the climate warming trend will further intensify.



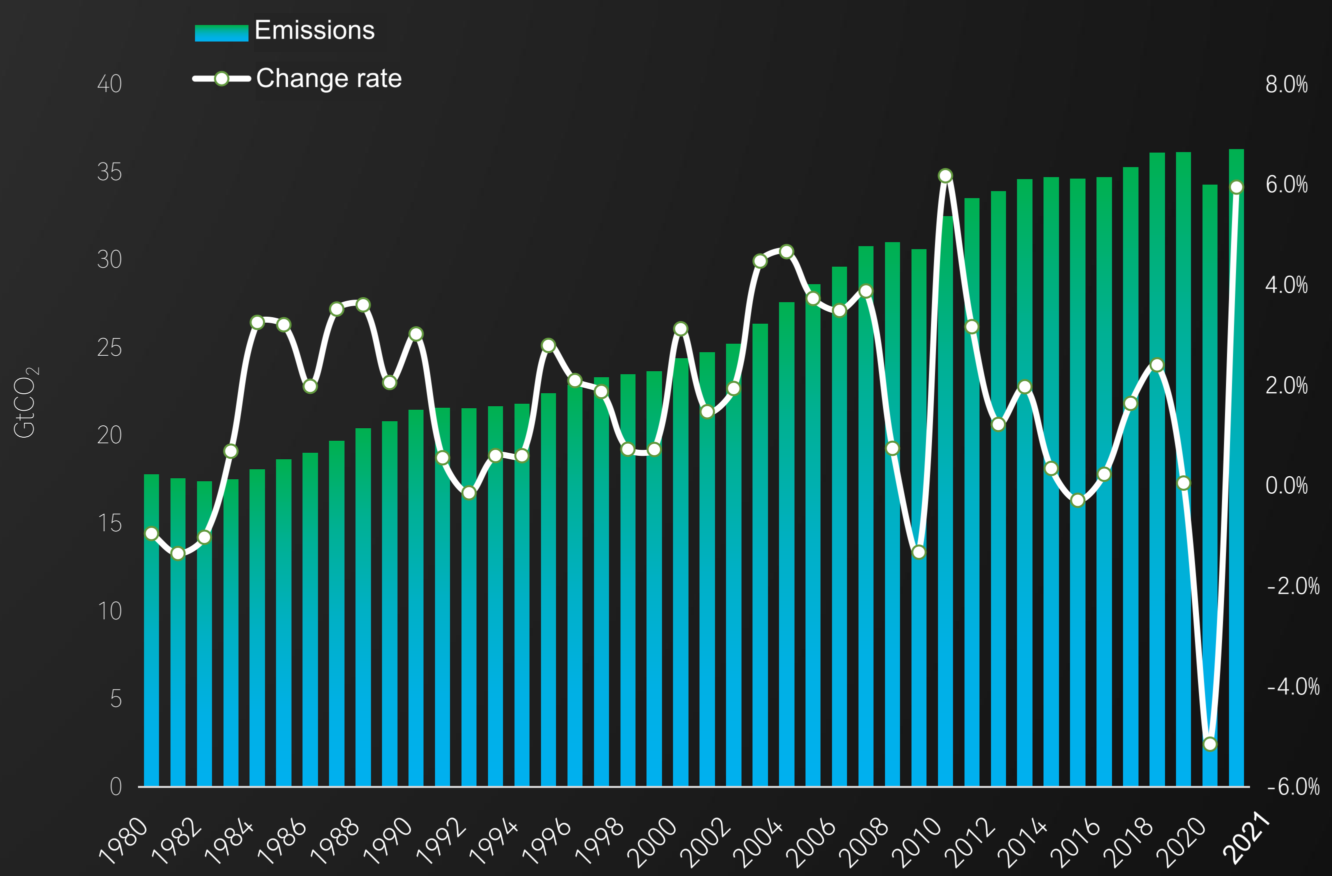
Source: IEA Global Energy Review，2021

1980-2021
Annual variations in carbon emissions from energy combustion and industrial processes

Notes:

From 1980 to 2021, CO_2 emissions decreased slightly in only 6 years, namely 1980-1982, 1992, 2008, and 2020. Among them, the sharp decline in 2020 was mainly caused by the COVID-19.

CO_2 emissions in 2021 is higher than the level in 2019 when the COVID-19 did not break out, thus completely offsetting the impact of emission reduction caused by the COVID-19.



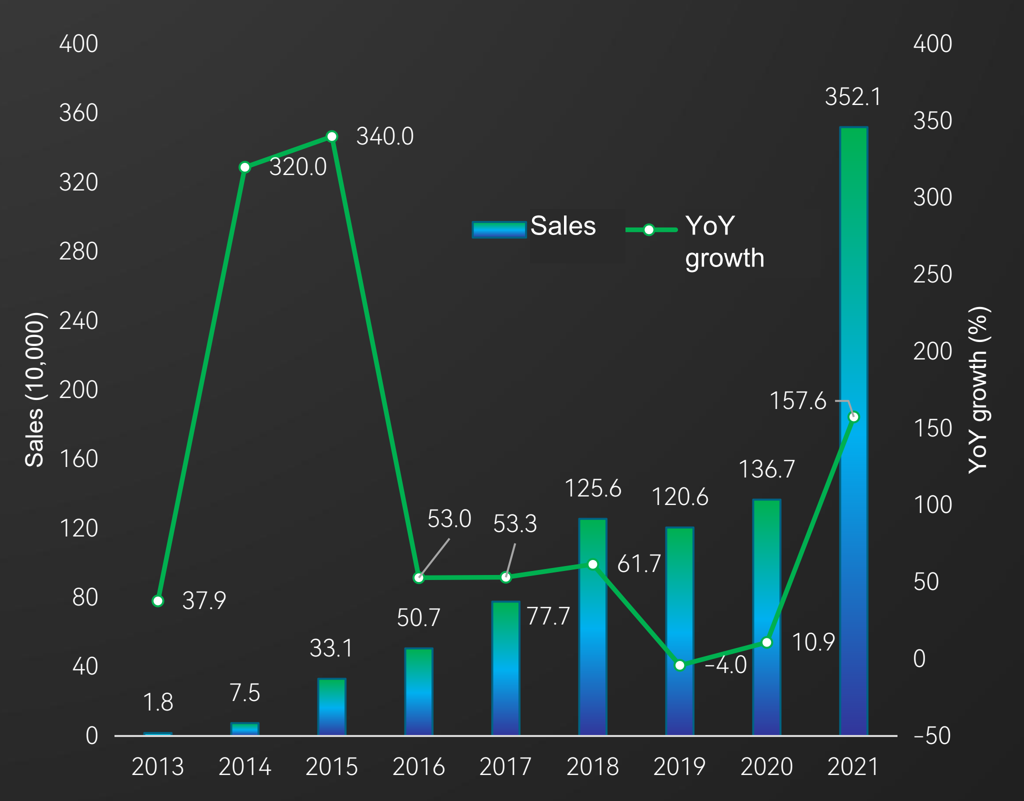
Source: IEA Global Energy Review，2021

2

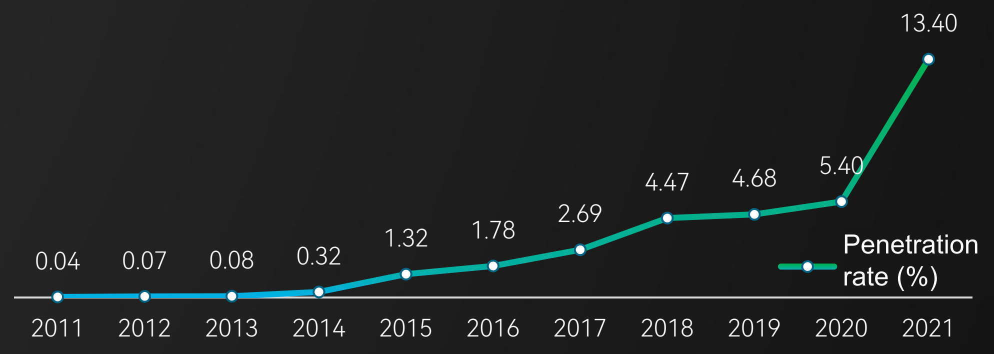
Remarkable achievements in China's vehicle electrification
Steadily increasing market penetration rate of NEVs and faster industrial scale development

Policy-driven NEV market has been shifted to market-oriented NEV in China

Annual sales volume of NEVs in China



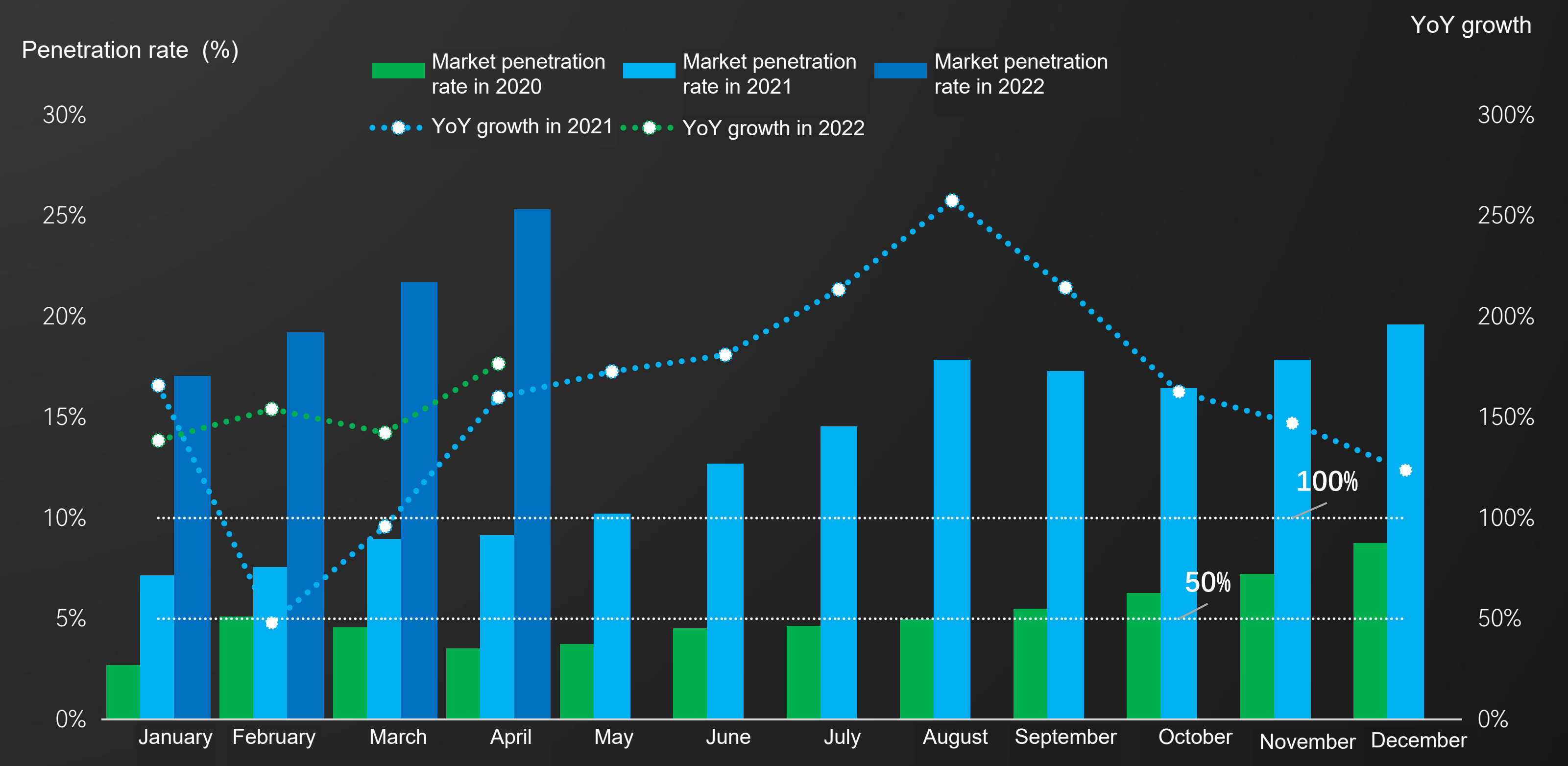
Annual market penetration rate of NEVs in China



Source: China Association of Automobile Manufacturers (CAAM)

In 2021, China's vehicle production and sales, showed a year-on-year growth, putting an end to the three consecutive years of decline since 2018. Among all vehicle types, NEV became the brightest star with a sales volume of more than 3.5 million and a market share increased to 13.4%, further indicating that the driving force of NEV market has shifted from policy to market demand.

Monthly penetration rate and YoY growth rate of NEVs from 2020 to 2022 (April)



Source: China Association of Automobile Manufacturers (CAAM)

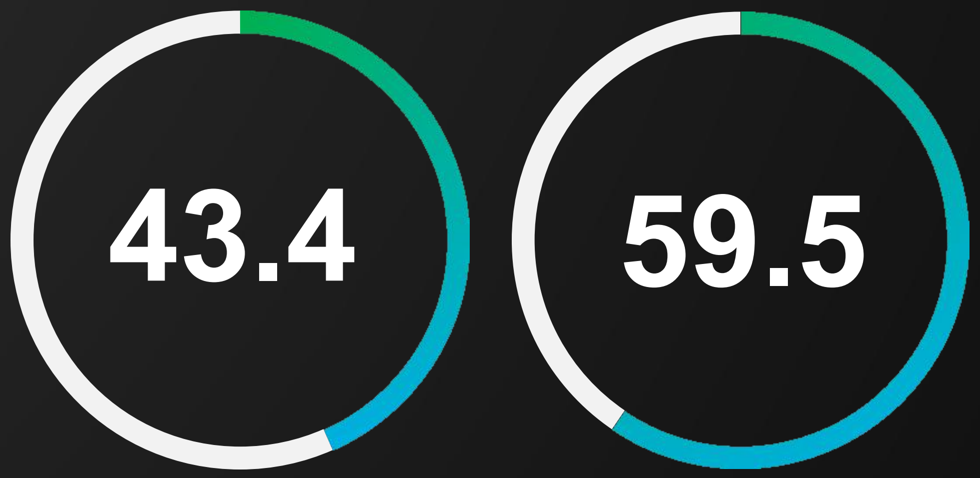
From 2020 to April 2022, the market penetration rate in most months increased sharply, with a YoY growth of over 100%. In September 2021, a substantial growth of 214% was achieved, and the average market penetration rate of NEVs for the whole year was 13.4%. 2022 had a good start again, with an average market penetration rate of over 20% from January to April.

Comments
Except for January and February, the monthly market penetration rate of NEVs in 2021 exceeded the highest monthly market penetration rate in 2020.

3 Passenger vehicles: battery electric passenger vehicles see the lifecycle carbon emission reduction by 43.4%, compared with gasoline counterparts

The passenger vehicles with the highest to lowest lifecycle mean carbon emissions in 2021 are diesel passenger vehicles, gasoline passenger vehicles, NOVC hybrid electric passenger vehicles, plug-in hybrid electric passenger vehicles, and battery electric passenger vehicles.

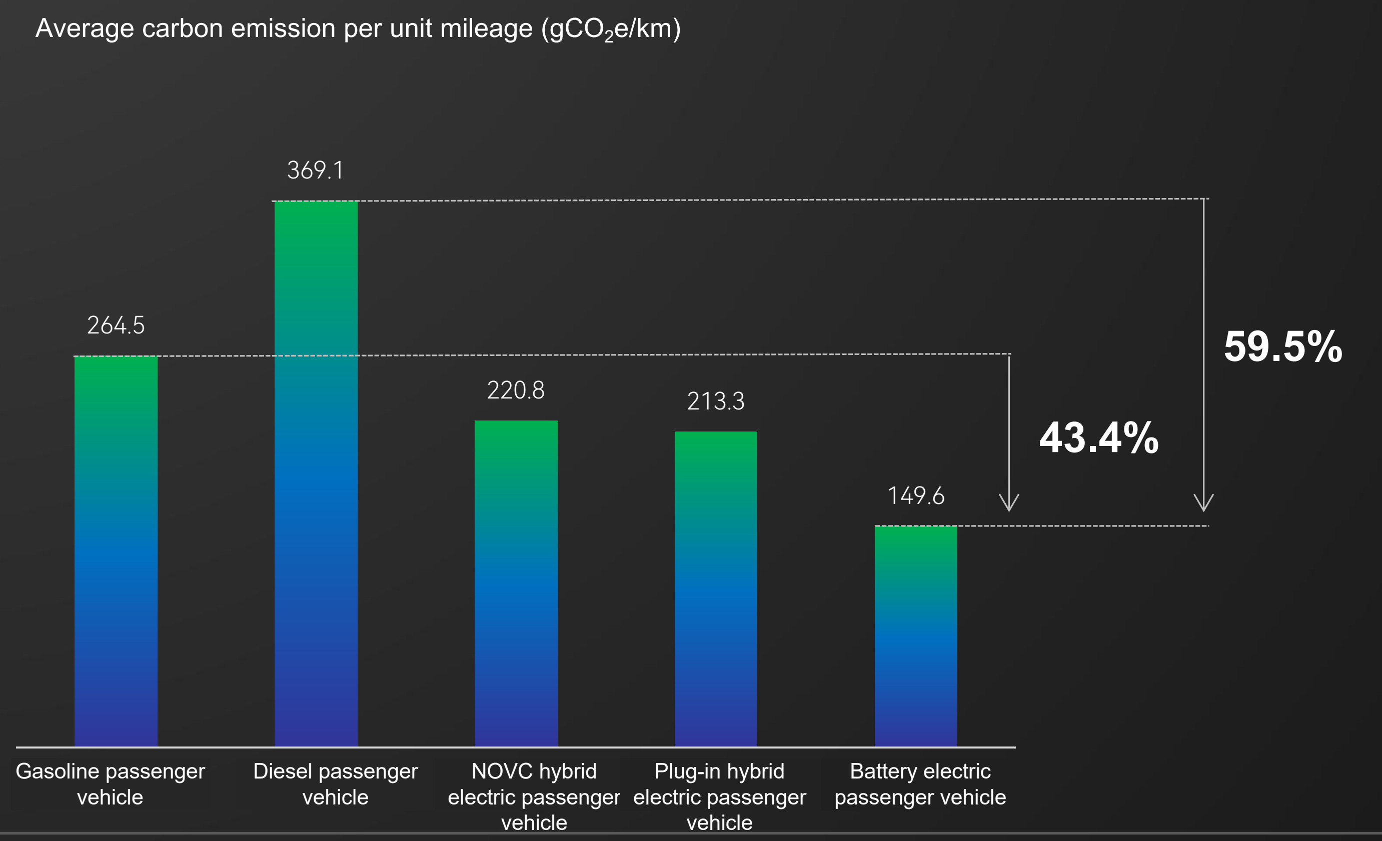
Battery electric passenger vehicles have significant advantages in lifecycle carbon reduction over conventional energy passenger vehicles. Compared with gasoline and diesel counterparts, battery electric passenger vehicles see lifecycle carbon emission reduction by 43.4% and 59.5% respectively.



Battery electric passenger vehicles VS Gasoline passenger vehicles

Battery electric passenger vehicles VS Diesel passenger vehicles

Differently fueled passenger vehicles in 2021

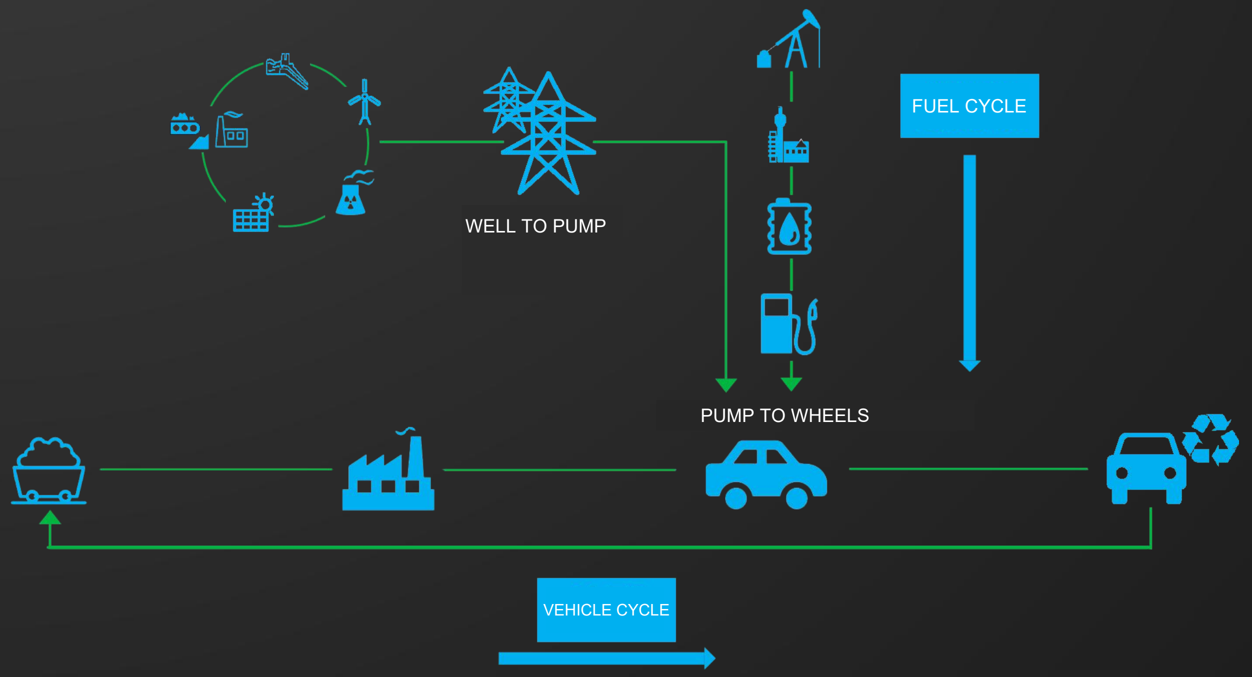


NOVC hybrid electric passenger vehicles and plug-in hybrid electric passenger vehicles boast certain advantages in carbon emission reduction over conventional energy vehicles and can be used as technical options for vehicle carbon reduction.

Comments
1. Only the carbon emissions of 5313 versions of 981 passenger vehicle models from 115 automobile enterprises, which account for 98.7% of total passenger vehicle sales in 2021, are considered.
2. The carbon emissions of differently fueled passenger vehicles are the sales-weighted average results, covering different vehicle types (sedan, SUV, MPV, etc.) and segments (A00, A0, A, B, C, etc.).

4 Passenger vehicles: Proportion of vehicle cycle carbon emissions increases with degree of electrification

Lifecycle system boundary



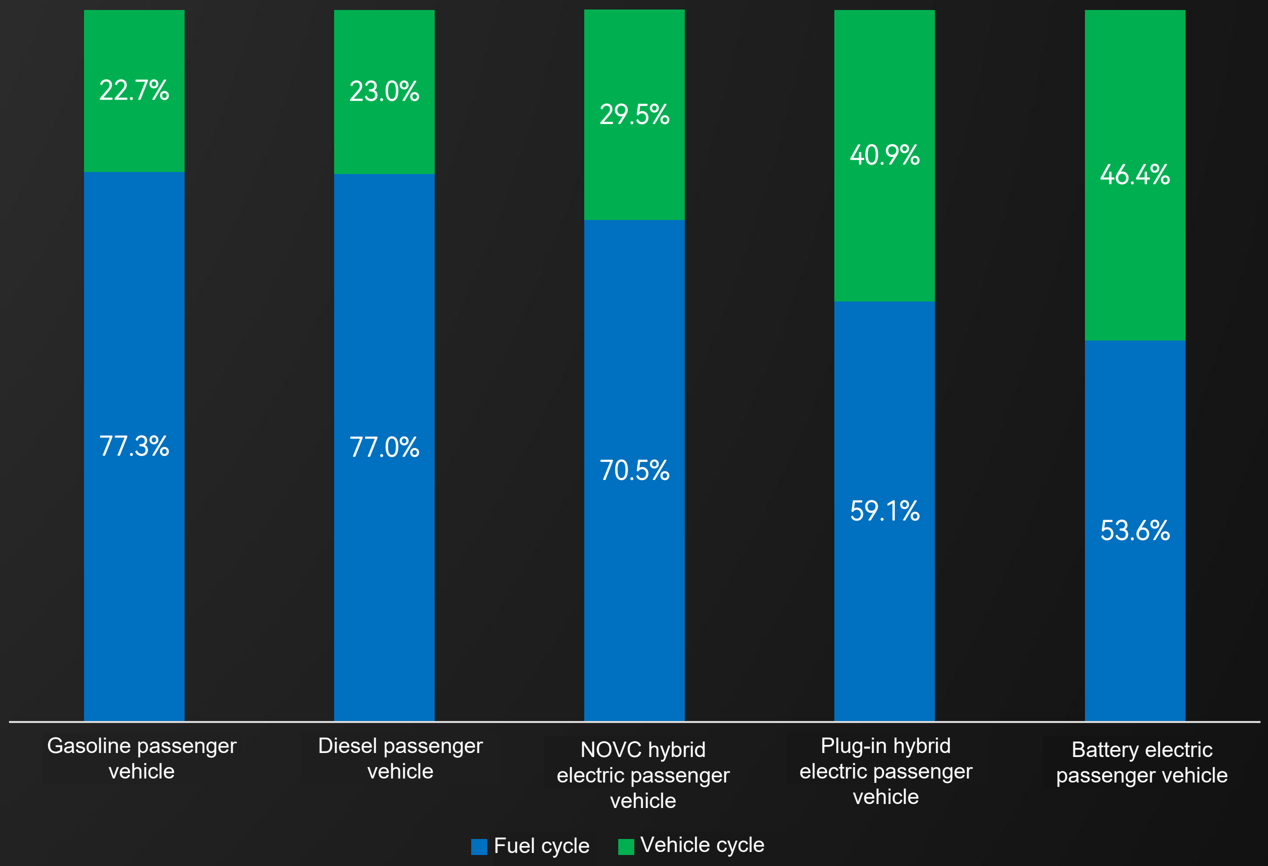
Degree of electrification: Battery electric passenger vehicle > plug-in hybrid passenger vehicle > NOVC hybrid passenger vehicle > diesel/gasoline passenger vehicle. For these passenger vehicles powered by five different types of fuels, the fuel cycle carbon emissions are greater than the vehicle cycle carbon emissions.

Comments:
The vehicle cycle covers material production, vehicle production, repair and maintenance (including tyre replacement, lead-acid battery replacement, fluid replacement, and refrigerant escape) and other stages; the fuel cycle includes fuel production and transportation (Well to Pump) stage and fuel use (Pump to Wheels) stage.

Proportion of carbon emissions in all lifecycle stages of differently fueled passenger vehicles

With the increase of the degree of electrification, the proportion of vehicle cycle carbon emissions gradually increases, while that of the fuel cycle carbon emissions gradually decreases. The carbon emissions of gasoline passenger vehicles and diesel passenger vehicles mainly come from the fuel cycle, accounting for as high as 77%; the proportion of fuel cycle carbon emissions of battery electric passenger vehicles is reduced, while that of vehicle cycle carbon emissions reaches 46.4%, which is twice that of the conventional fuel vehicles.

Material acquisition and manufacturing of batteries for battery electric passenger vehicles and zero carbon emission during vehicle use are the main reasons for the gap.

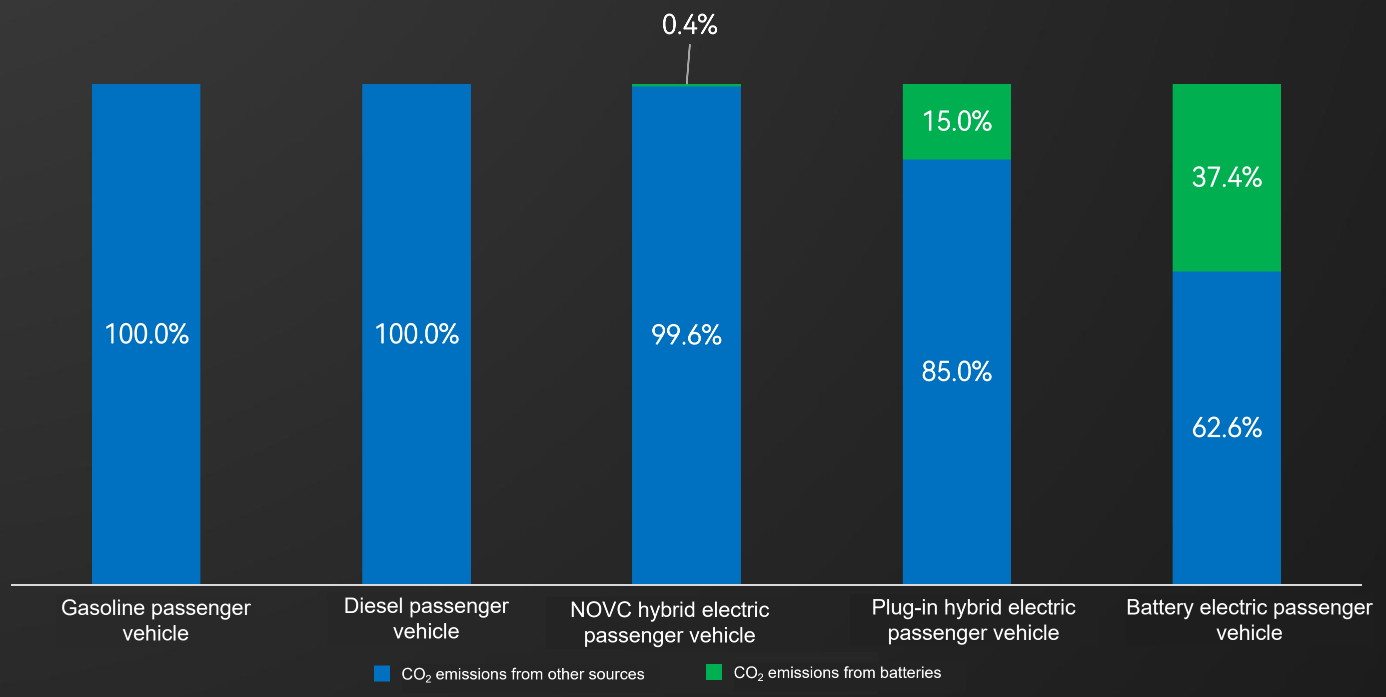


5 Passenger vehicles: Proportion of battery carbon emissions in vehicle cycle carbon emissions increases with the degree of electrification

In battery electric passenger vehicles, battery carbon emissions account for more than 1/3 of vehicle cycle carbon emissions.

Taking the ternary lithium nickel cobalt manganate battery as an example, about 23% of its carbon emissions come from the electrolyte, about 32% from the ternary positive electrode material, and about 35% from the aluminum alloy in the battery pack case.

Proportion of battery carbon emissions in vehicle cycle carbon emissions



The proportion of battery carbon emissions in the vehicle cycle carbon emissions increases with the degree of electrification, being 0.4% for NOVC hybrid passenger vehicles, 15.0% for plug-in hybrid passenger vehicles, and 37.4% for battery electric passenger vehicles.

Comments: Generally speaking, the battery of a NOVC hybrid passenger vehicle has less energy, and makes up a small proportion of the vehicle cycle carbon emissions.

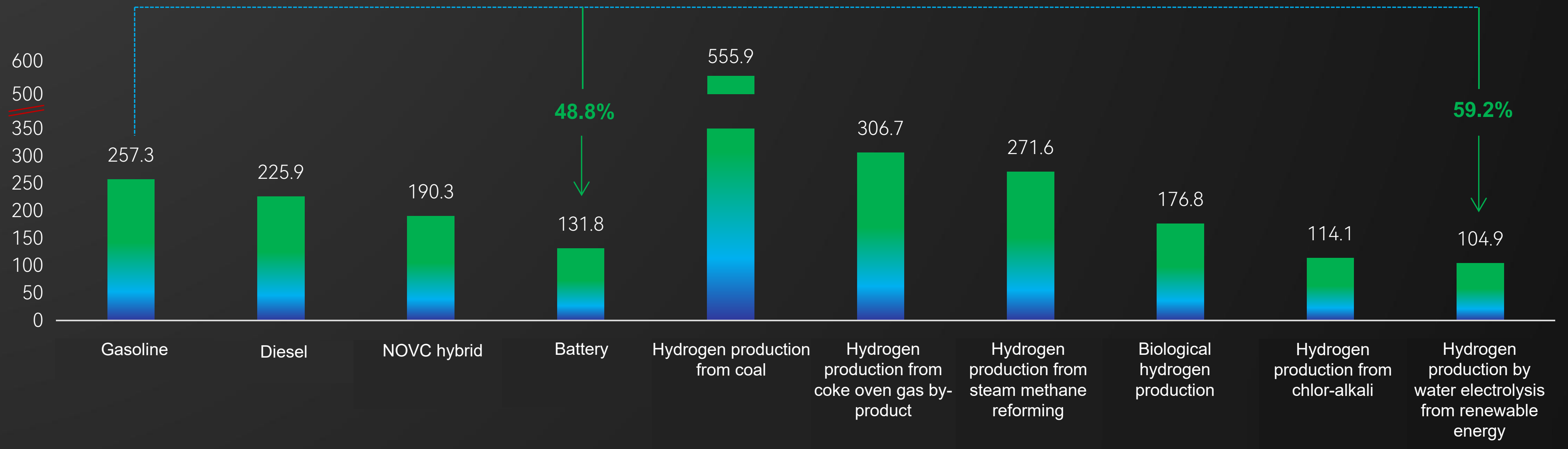
6 Commercial vehicles: Electric light-duty trucks and fuel cell electric light-duty truck based on hydrogen production by water electrolysis from renewable energy have significant advantages in carbon emissions.

In 2021, the carbon emissions per unit turnover of differently fueled light-duty trucks in China gradually decreased in the order of gasoline light-duty trucks, diesel light-duty trucks, NOVC hybrid electric light-duty trucks, battery electric light-duty trucks, and fuel cell electric light-duty trucks (hydrogen production by water electrolysis from renewable energy).

Compared with conventional fuel light-duty trucks, battery electric light-duty trucks and fuel cell electric light-duty trucks (hydrogen production by water electrolysis from renewable energy) have significant advantages in lifecycle emission reductions. Compared with gasoline counterparts, they see a lifecycle carbon emission reduction by 48.8% and 59.2% respectively.

Carbon emissions per unit turnover of differently fueled light-duty trucks in 2021

Lifecycle carbon emissions from different hydrogen production processes



Comments: The carbon emission data of gasoline light-duty trucks, diesel light-duty trucks and battery electric light-duty trucks is selected from actual models with similar applications and loads, while that of NOVC hybrid electric light-duty trucks and fuel cell electric light-duty trucks is based on simulation results. Diesel light-duty trucks have a larger payload than gasoline light-duty trucks, thus boasting more advantages in carbon emissions.

The lifecycle carbon emissions of fuel cell electric vehicles of different hydrogen production processes vary greatly. Among them, the carbon emissions from chlor-alkali hydrogen production and hydrogen production by water electrolysis from renewable energy are lower than those from battery electric vehicles, and the carbon emissions from biological hydrogen production are also lower than those from conventional light-duty trucks equipped with internal combustion engines.

7

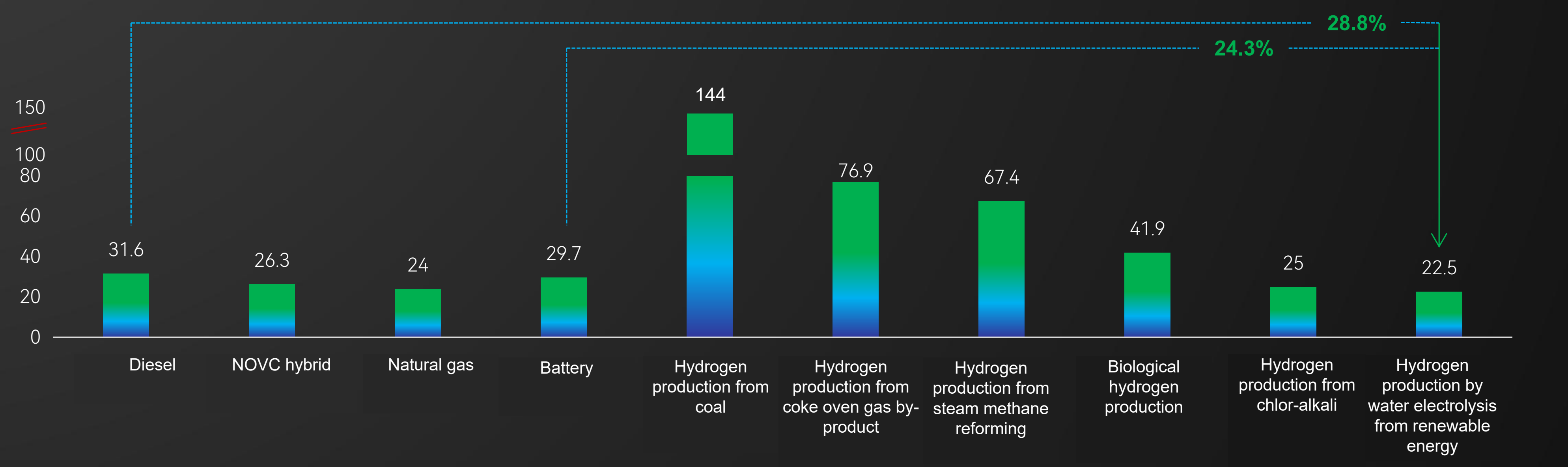
Commercial vehicles: In the context of hydrogen production by water electrolysis from renewable energy, fuel cell electric heavy-duty tractors have relative advantages in emissions

In 2021, the carbon emissions per unit turnover of differently fueled heavy-duty tractors in China gradually decreased in the order of diesel heavy-duty tractors, battery electric heavy-duty tractors, NOVC hybrid electric heavy-duty tractors, natural gas heavy-duty tractors and fuel cell electric heavy-duty tractors (hydrogen production by water electrolysis from renewable energy).

Compared with conventional fuel heavy-duty tractors and battery electric heavy-duty tractors, fuel cell electric heavy-duty tractors (hydrogen production by water electrolysis from renewable energy) have significant advantages in lifecycle emission reduction, and see a lifecycle carbon emission reduction by 28.8% and 24.3% respectively.

Carbon emissions per unit turnover of differently fueled heavy-duty tractors in 2021

Lifecycle carbon emissions from different hydrogen production processes



Comments: To ensure comparability between different models, model selection of heavy-duty tractors ensures that differently fueled models are relatively similar in kerb mass and maximum towing total mass.

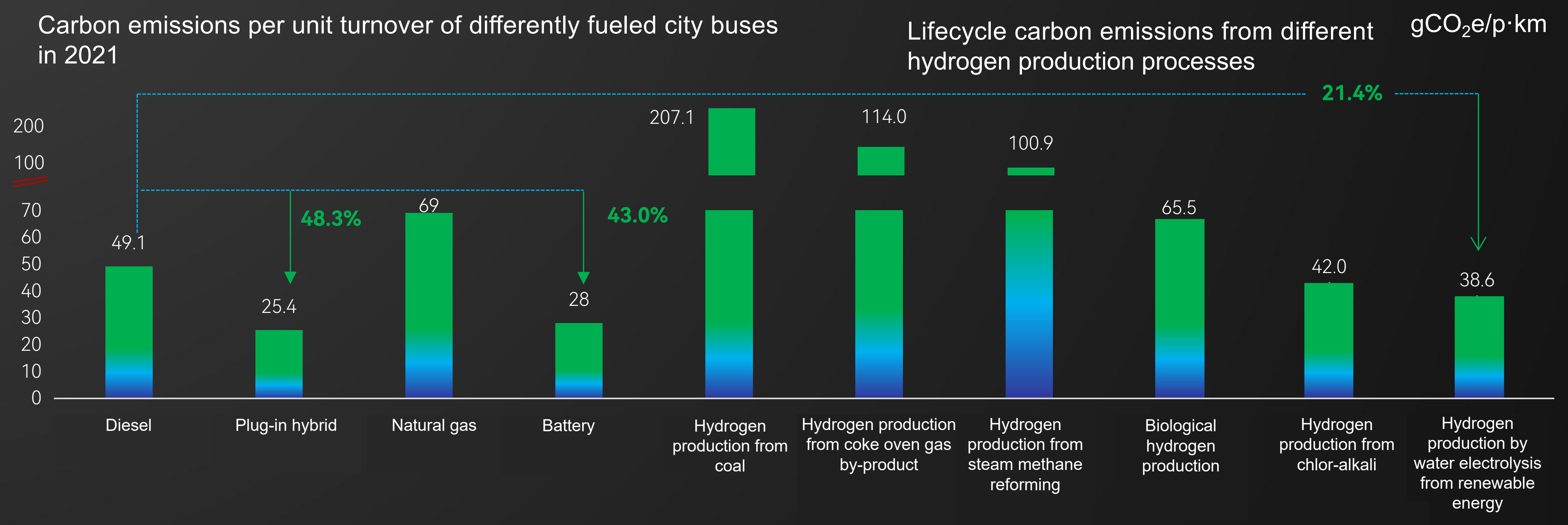
Different from light-duty trucks, heavy-duty tractors have higher requirements on power and driving range. The heavier battery compressive load and the higher power consumption per 100 km lead to weak advantage of battery electric vehicles.

8

Commercial vehicles: Plug-in hybrid and battery electric city buses have relatively low carbon emissions, and carbon emissions of the fuel cell electric city buses are greatly affected by the hydrogen energy structure.

The way of hydrogen production has a huge impact on the carbon emissions of fuel cell electric city buses.

The plug-in hybrid electric city bus has the carbon emission of 25.4gCO_2e/p·km, being a relatively low-carbon model, and the battery electric city bus has a low carbon emission of 28.0gCO_2e/p·km.
Fuel cell electric city buses are greatly affected by the hydrogen energy structure, with the carbon emission of 13.5gCO_2e/p·km due to the way of hydrogen production by water electrolysis from renewable energy.

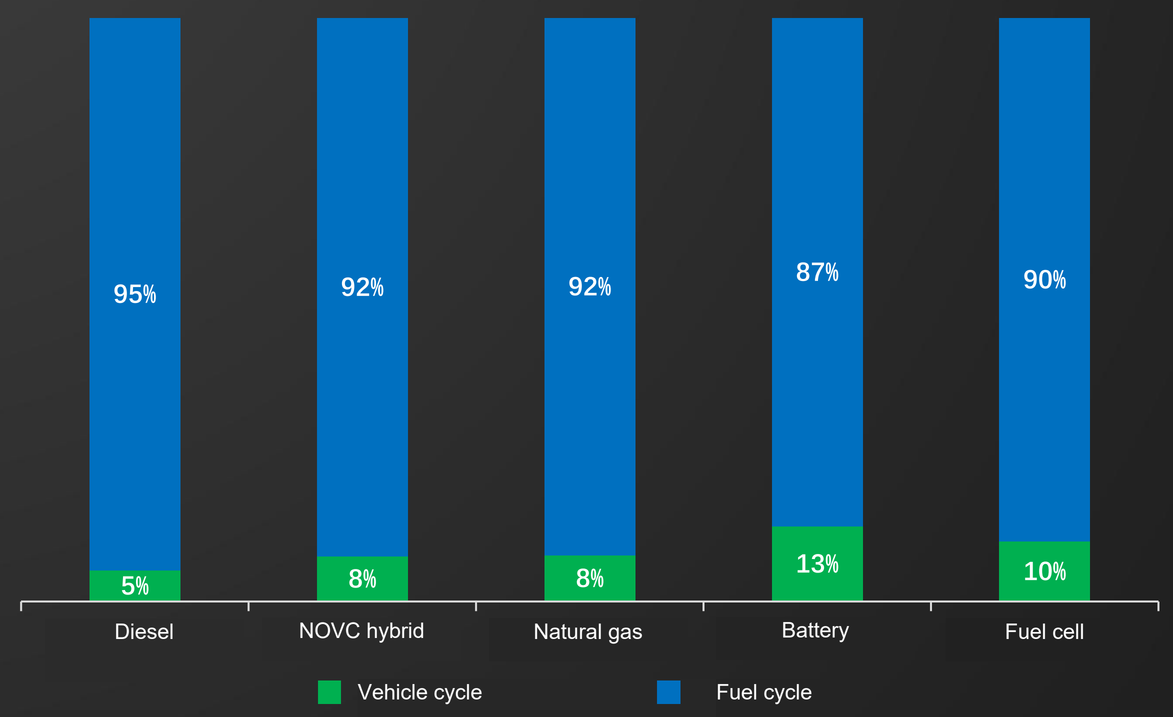


Comments: The number of passengers carried is also an important factor for the lifecycle carbon emissions per unit turnover of city buses. The increase in the number of passengers per bus is beneficial to reduction of the lifecycle carbon emissions per unit turnover.

Ranking of carbon emissions of differently fueled city buses: fuel cell < plug-in hybrid < battery electric < diesel < natural gas.

9 Commercial vehicles: The lifecycle carbon emissions of heavy-duty tractors is dominated by the fuel cycle carbon emissions.

Fuel cycle carbon emissions dominate the lifecycle carbon emissions per unit turnover of heavy-duty tractors, mainly due to the large load of heavy-duty tractors, with a lifecycle mileage of 700,000 km.



The fuel cycle carbon emissions of conventional heavy-duty tractors equipped with internal combustion engine account for more than 90% of the lifecycle carbon emissions, and the proportion of fuel cycle carbon emissions of battery electric heavy-duty tractors is slightly lower than that of heavy-duty tractors of other fuel types. The vehicle cycle carbon emissions of battery electric heavy-duty tractors and fuel cell electric heavy-duty tractors are larger than those of conventional fuel heavy-duty tractors, differing by 2% to 8%.

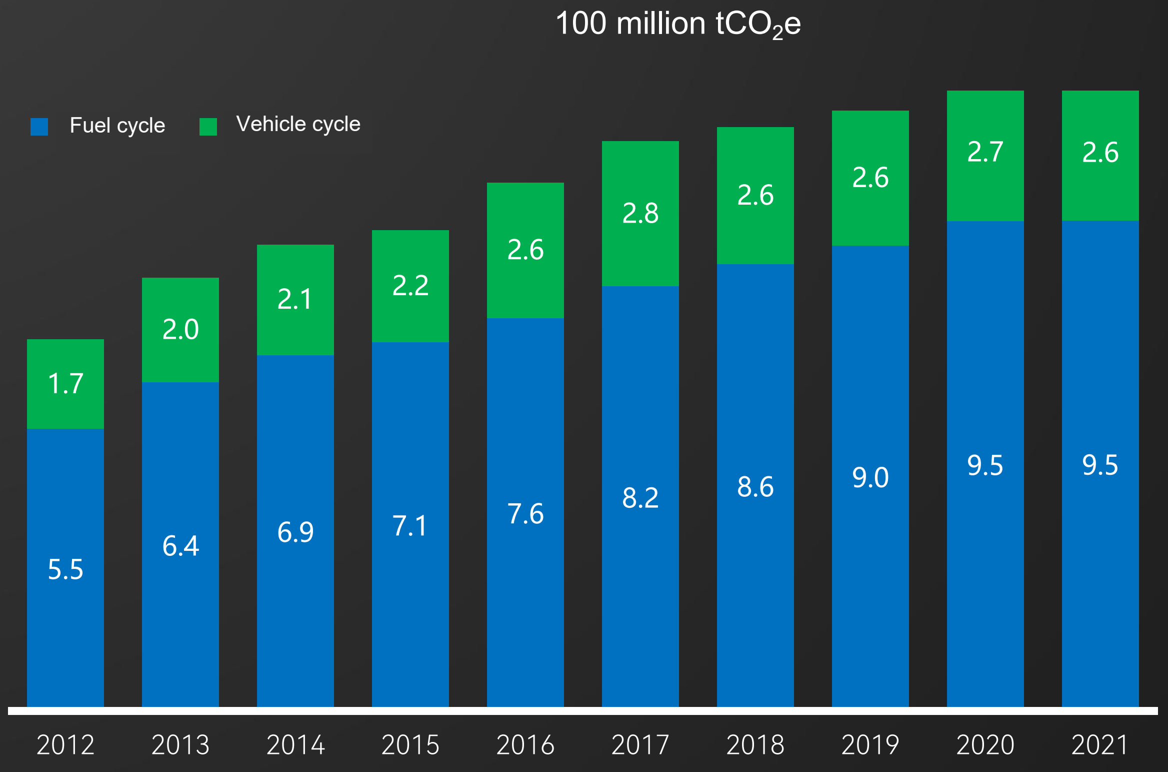
Comments: The vehicle cycle carbon emissions of battery electric heavy-duty tractors are more than twice those of diesel heavy-duty tractors, mainly due to new energy components such as batteries.

The proportion of vehicle cycle carbon emissions of diesel heavy-duty tractors, NOVC hybrid heavy-duty tractors and natural gas heavy-duty tractors is smaller than that of battery electric heavy-duty tractors and fuel cell electric heavy-duty tractors.

10 Carbon emissions of vehicle fleets continue to increase and the rising vehicle population still contributes to carbon emissions

With the rapid growth of vehicle population in China, the carbon emissions of the automotive industry are increasing year by year, which is mainly due to the use of fuel in the fuel cycle.

Lifecycle carbon emissions of China's vehicle fleets



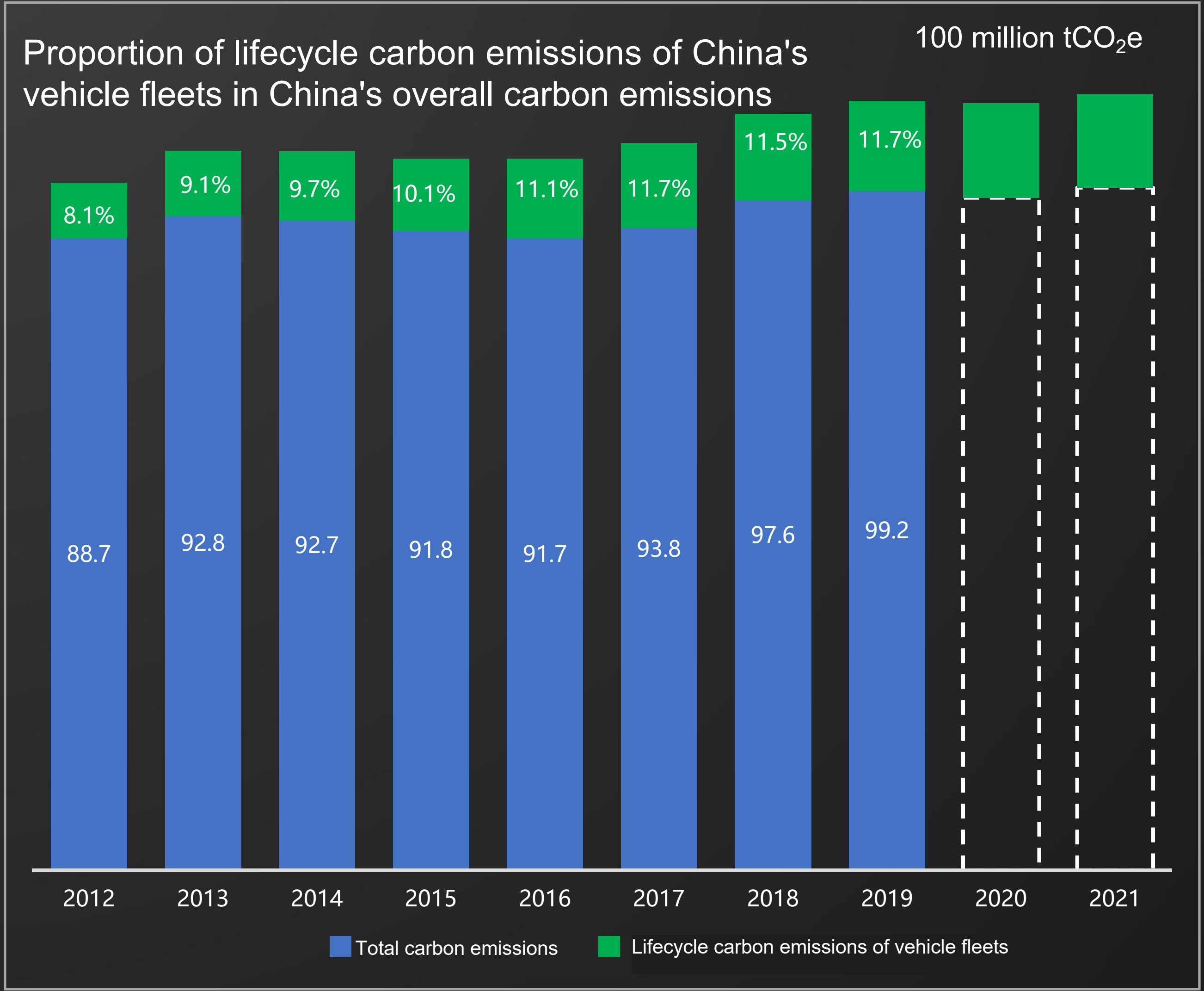
Comments: Vehicle sales declined from 2018 and rebounded in 2021.

From 2012 to 2021, the lifecycle carbon emissions of China's vehicle fleets increased from 700 million tCO_2e to about 1.2 billion tCO_2e, and the carbon emissions generated in the fuel cycle increased from 550 million tCO_2e to 950 million tCO_2e, an increase of 400 million tCO_2e.

Conventional fuel vehicles still dominate the vehicle population, so due to the high carbon emissions from fuel use, it is necessary to vigorously promote new energy vehicles to alleviate this problem.

11 The contribution of lifecycle carbon emissions of China's vehicle fleets to China's overall carbon emissions is on the rise.

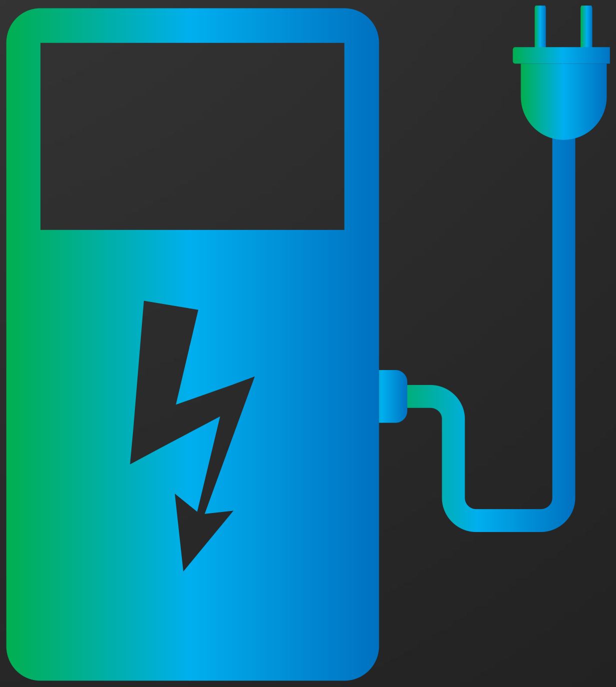
From 2012 to 2019, the proportion of lifecycle carbon emissions of China's vehicle fleets in the China's overall carbon emissions increased from 8.1% to about 11.7%, showing an overall rising trend.



Compared with developed countries, the proportion of carbon emissions of China's automotive industry in the China's overall carbon emissions is still relatively low. Deep decarbonization of the automotive industry plays an increasingly important role in realizing China's carbon peak and carbon neutrality goals in the future.

Comments:
China's carbon emission data from 2012 to 2019 is based on the IEA statistics, data for 2020 and 2021 is not yet available.

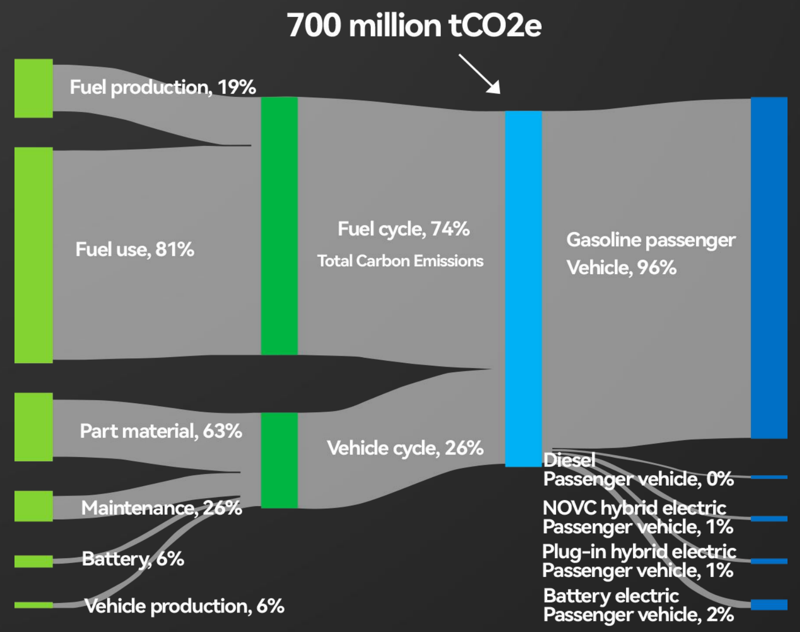
12 In 2021, the lifecycle carbon emissions of vehicle fleets were mainly generated in the fuel cycle.



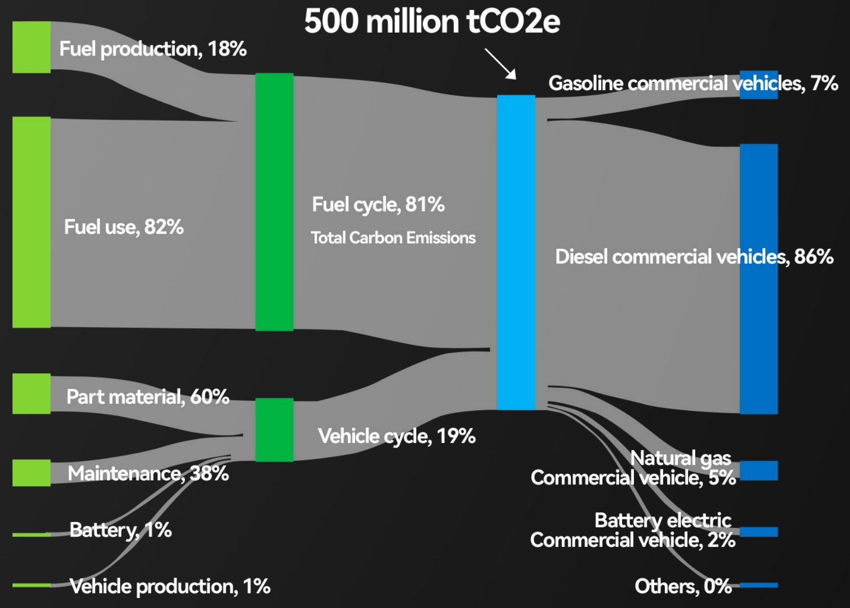
In 2021, the lifecycle carbon emissions of China's vehicle fleets reached 1.2 billion tCO_2e, of which 77% were generated by the production and use of fuel.

In 2021, the lifecycle carbon emissions of the passenger vehicle fleets in China reaches 700 million tCO_2e, of which the fuel cycle carbon emissions accounted for 74%, and the carbon emissions of the commercial vehicle fleets reached 500 million tCO_2e, of which the fuel cycle carbon emissions accounted for 81%.

Composition of lifecycle carbon emissions of China's passenger vehicle fleets in 2021



Composition of lifecycle carbon emissions of China's commercial vehicle fleets in 2021

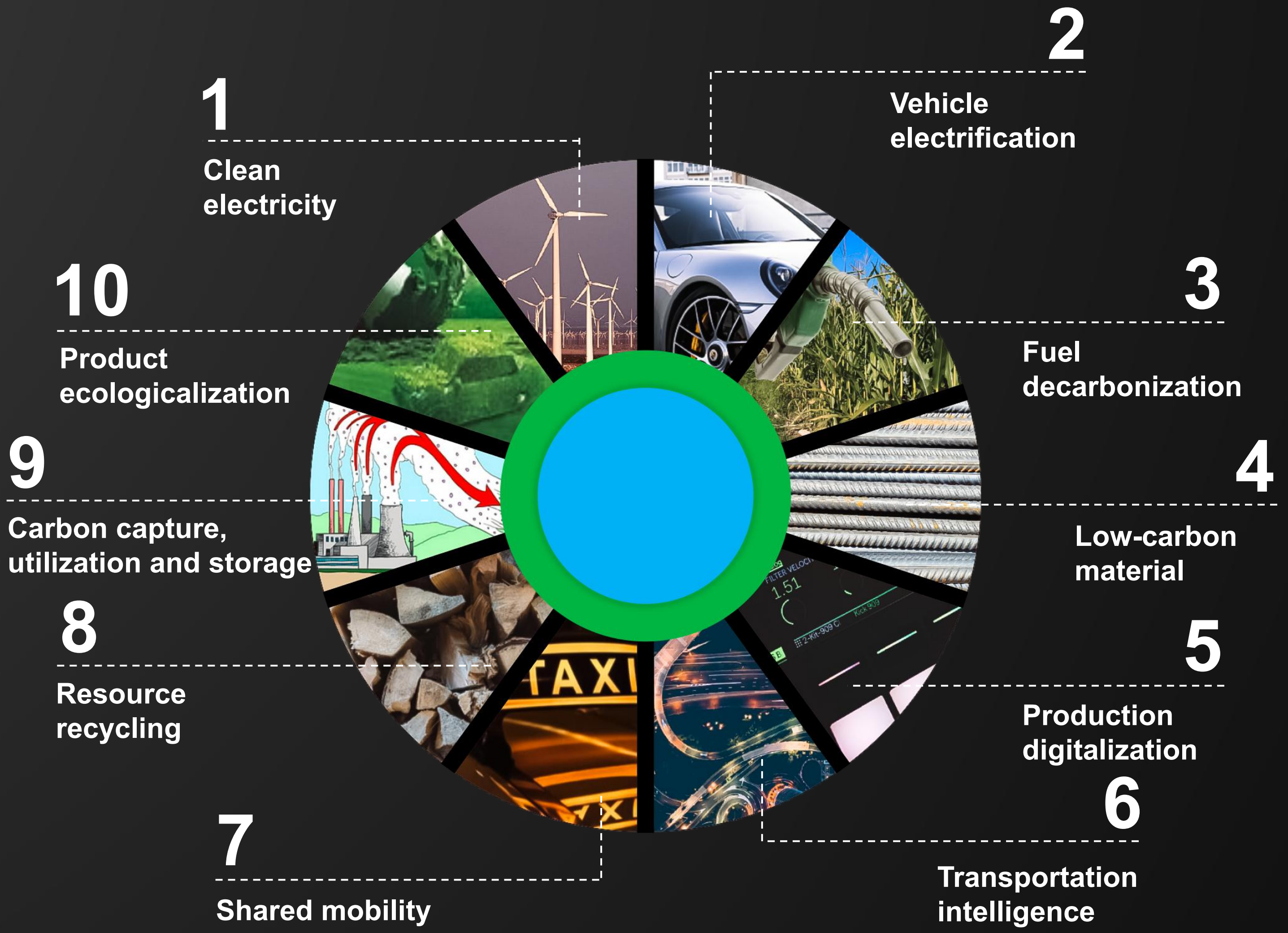


Comments: The carbon emissions of the passenger vehicle fleets are mainly generated by gasoline passenger vehicles, accounting for 96%; the carbon emissions of the commercial vehicle fleets are mainly generated by diesel commercial vehicles, accounting for 88%.

The population of commercial vehicles is much smaller than that of passenger vehicles, but due to the factors of large driving range, heavy load and high fuel consumption of commercial vehicles, the fuel cycle carbon emissions of commercial vehicles are comparable to those of passenger vehicles.

13

Ten transformation paths for carbon neutrality in the lifecycle of vehicles, coordinating upstream and downstream to reduce carbon emissions



Co-authoring institutions

25 industry experts from 23 institutions

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中共中央党校（国家行政学院）

Path 1: clean electricity

Path 2: vehicle electrification

Path 3: fuel decarbonization

Path 4: low-carbon material

Path 5: production digitalization

Path 6: transportation intelligence

Path 7: shared mobility

Path 8: resource recycling

Path 9: carbon capture, utilization and storage

Path 10: product ecologicalization

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14 Focusing on carbon neutrality in the automotive industry Setting three scenarios

In three scenarios, the effect of ten emission reduction paths on lifecycle carbon emission reduction of passenger vehicles and commercial vehicles is evaluated.

Reference scenario

- In 2030 and 2060, the proportion of non-fossil energy power generation will be 45% and 94%, respectively
- Full electrification is expected to be realized in 2060
- Material carbon emission factor is gradually reduced

→ **The relevant parameters are close to historical parameters, with a relatively moderate annual change**

Carbon neutrality before 2060 scenario

- In 2030 and 2060, the proportion of non-fossil energy power generation will be 51% and 96%, respectively
- Full electrification is expected to be realized in 2050
- Annual vehicle mileage will decrease slightly

→ **All emission reduction parameters have been improved to a certain extent**

Carbon neutrality before 2050 scenario

- In 2030 and 2060, the proportion of non-fossil energy power generation will be 52% and 97%, respectively
- Full electrification is expected to be realized in 2035
- The proportion of recycled materials will increase significantly year by year

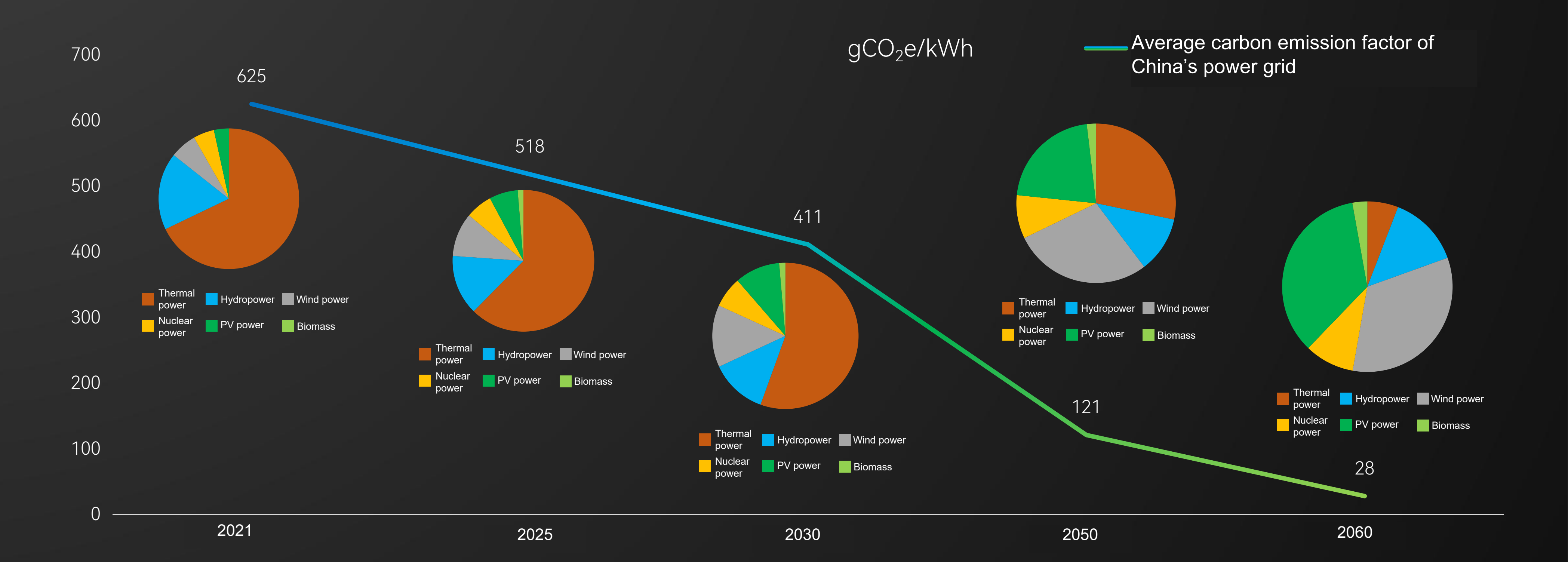
→ **For the carbon neutrality before 2050 scenario, the relevant parameters are all set at the maximum emission reductions**

15 Enabling electricity to support the automotive industry to reach its carbon peak as soon as possible while reducing its own emissions

The implementation paths include building a diversified energy supply system, giving full play to the role of the basic platform of the power grid, vigorously improving the level of electrification, promoting the efficient and coordinated utilization of source, grid, and load, vigorously promoting technological innovation, strengthening the awareness of power security, and improving and perfecting the market mechanism.

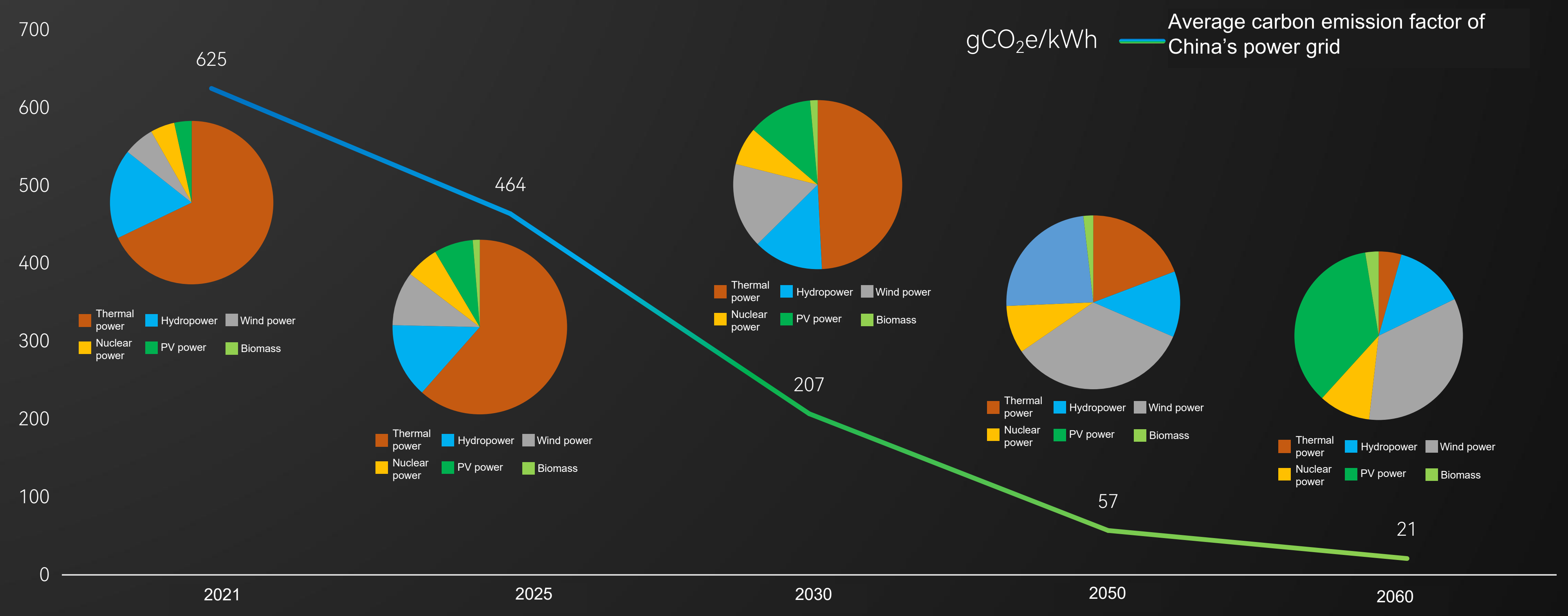
In 2020, the CO_2 emission per unit thermal power generation in China was about 832 g/kWh with a decrease of 20.6% over 2005; the CO_2 emission per unit thermal power generation in China was about 565g/kWh, with a decrease of 34.1% over 2005.
From 2006 to 2020, the power industry has, with 2005 as base, achieved about 18.53 billion tons of CO_2 emission reduction by developing non-fossil energies, reducing coal consumption and reducing transmission loss rate. The increase in electricity CO_2 emissions was effectively slowed down.

Reference scenario: By 2030, thermal power will still account for more than 50%. After 2050, the proportion of non-thermal power will increase significantly, the proportion of photovoltaic and wind power in the grid will increase significantly (both more than 20%), the proportion of hydropower and nuclear power will be maintained (about 10% respectively), and the proportion of thermal power will be reduced below 30%. The carbon emission factor of power generation in 2060 is 95.6% lower than that of current power generation.



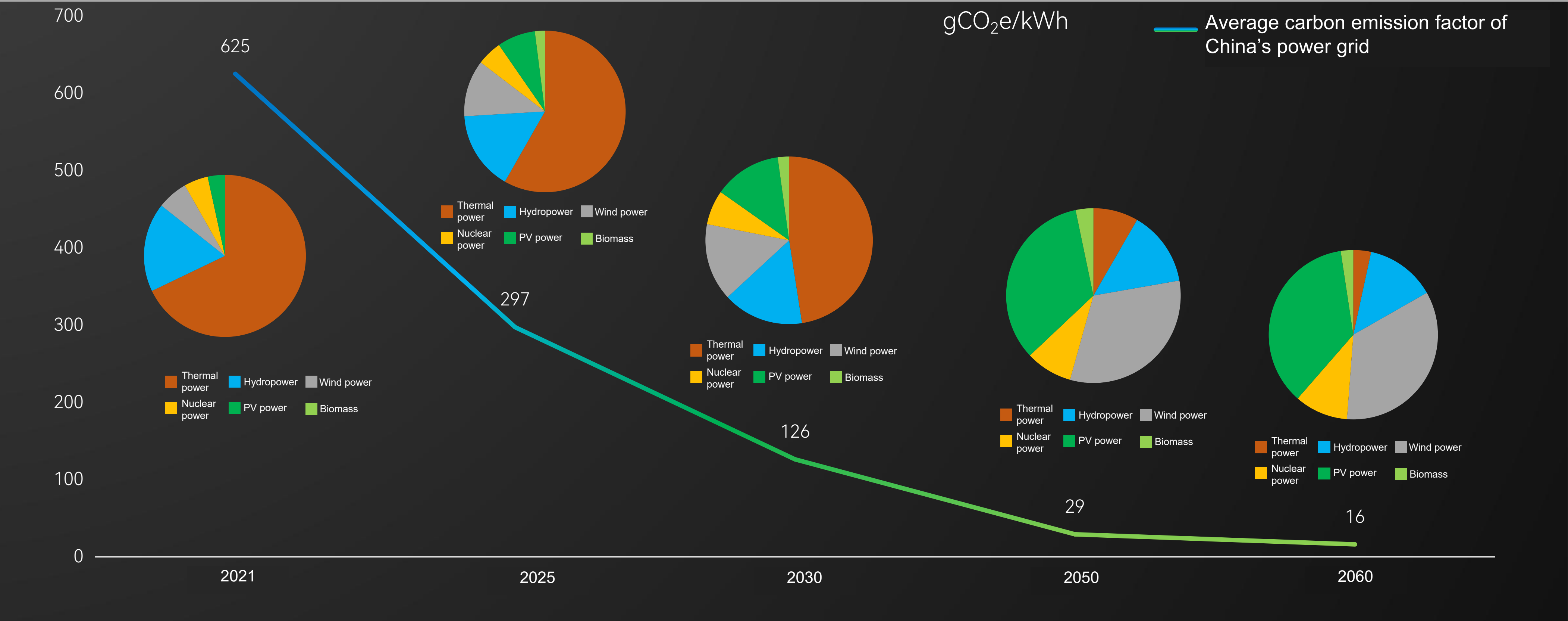
Source: the National Centre for Climate Change Strategy and International Cooperation (NCSC), the Energy Research Institute of National Development and Reform Commission, the China Electricity Council (CEC), CALCD Database,
China's Energy and Power Development Planning Research in 2030 and Outlook in 2060, Fifth Assessment Report of IPCC, etc.

Carbon neutrality before 2060 scenario: By 2030, the proportion of thermal power will be slightly below 50%. After 2050, the proportion of photovoltaics in the power grid will increase significantly to 24%, that of wind power will exceed 30%, while that of thermal power will decrease below 20%. The carbon emission factor of power generation in 2060 is 96.6% lower than that of current power generation.



Source: the National Centre for Climate Change Strategy and International Cooperation (NCSC), the Energy Research Institute of National Development and Reform Commission, the China Electricity Council (CEC), CALCD Database,
China's Energy and Power Development Planning Research in 2030 and Outlook in 2060, Fifth Assessment Report of IPCC, etc.

Carbon neutrality before 2050 scenario: By 2030, the proportion of thermal power will be slightly reduced to 47.5%. After 2050, the proportions of photovoltaic and wind power in the power grid will be increased significantly (both more than 30%), the proportion of thermal power will be reduced to less than 9%, and the carbon emission factor of power generation in 2060 will be reduced by 97.4% compared with the current carbon emission factor of power generation.



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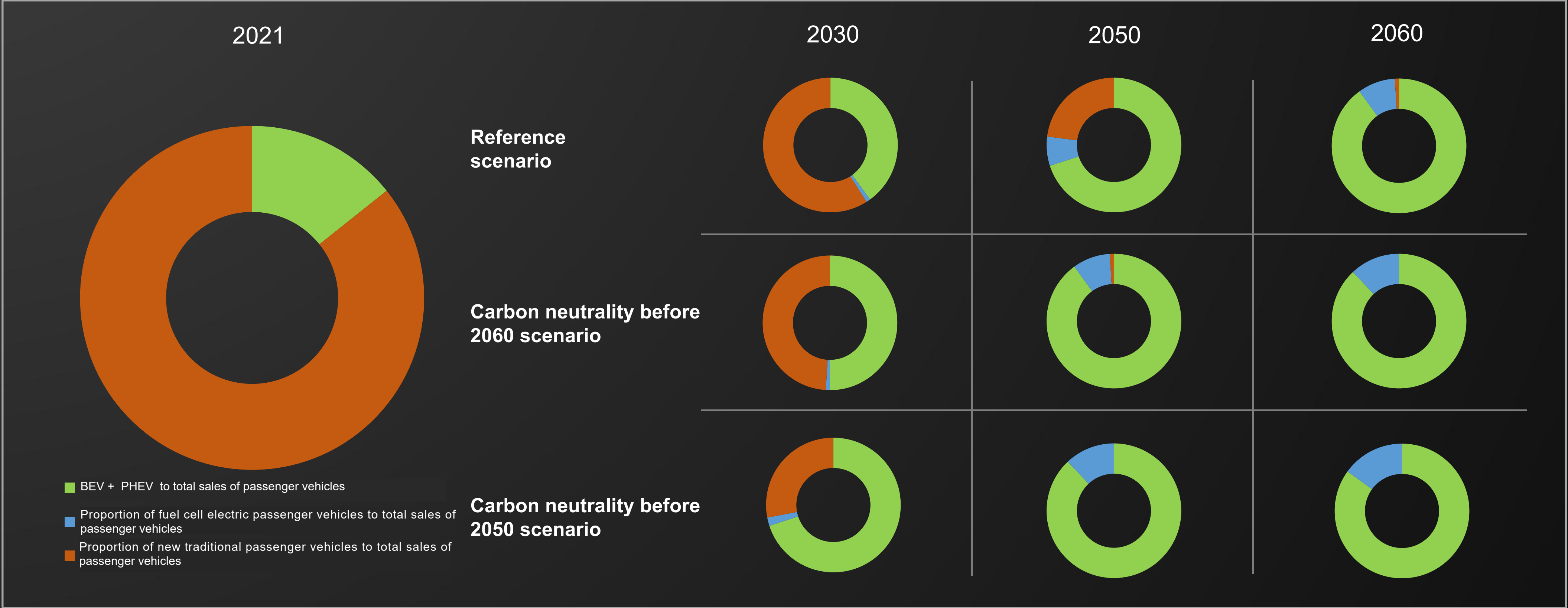
China's Energy and Power Development Planning Research in 2030 and Outlook in 2060, Fifth Assessment Report of IPCC, etc.

16 Vehicle electrification and low carbonization complement each other. Electrification is crucial in tackling climate change.

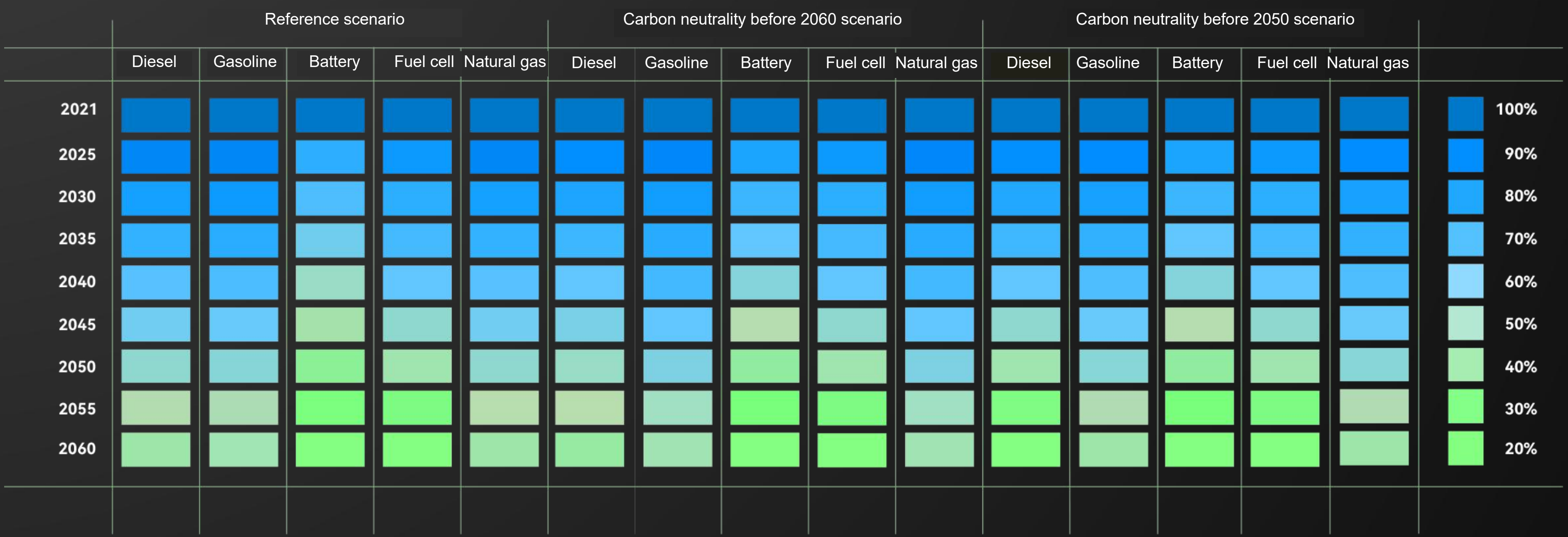
On one hand, dynamically adjust the corresponding policies and regulations according to the development stage of electrification in China, adopt the low-carbon strategy most suitable for China's national conditions, and strengthen the harmonization with international rules; on the other hand, enhance the research and development of low-carbon core technologies, further promote the research on the carbon footprint of the whole automotive industry chain, and realize the carbon neutrality of the whole automobile value chain.

In the reference scenario, the proportion of electric passenger vehicles (BEV + FCEV + PHEV) will reach 41% in 2030 and 99% in 2060, and that of electric commercial vehicles (BEV) will reach 5.2% in 2030 and 16.9% in 2060; in the carbon neutrality before 2060 scenario, the proportion of electric passenger vehicles will reach 51% in 2030 and 100% in 2060, and that of electric commercial vehicles will reach 7.6% in 2030 and 28.3% in 2060; in the carbon neutrality before 2050 scenario, the proportion of electric passenger vehicles will reach 72% in 2030 and 100% in 2060, and that of electric commercial vehicles will reach 10.8% in 2030 and 49.5% in 2060.



Source: Energy-saving and New Energy Vehicle Technology Roadmap 2.0 and Automotive Data of China Co., Ltd.

Parameter setting of passenger vehicle energy efficiency improvement: Compared with the influence of different scenarios on the energy efficiency of various fuel types, the effect of time is relatively more remarkable. Based on the energy efficiency level in 2021, the energy consumption level of all types of passenger vehicles in 2060 will experience a significant fall under the 2050 carbon neutrality scenario, while the fuel consumption level of hydrogen fuel cell passenger vehicles will reduce by 80%. The decline induced by different scenarios but different periods will not exceed 20%.



17 Decarbonization of vehicle fuels focuses on reducing carbon emissions from petroleum-based vehicle fuels

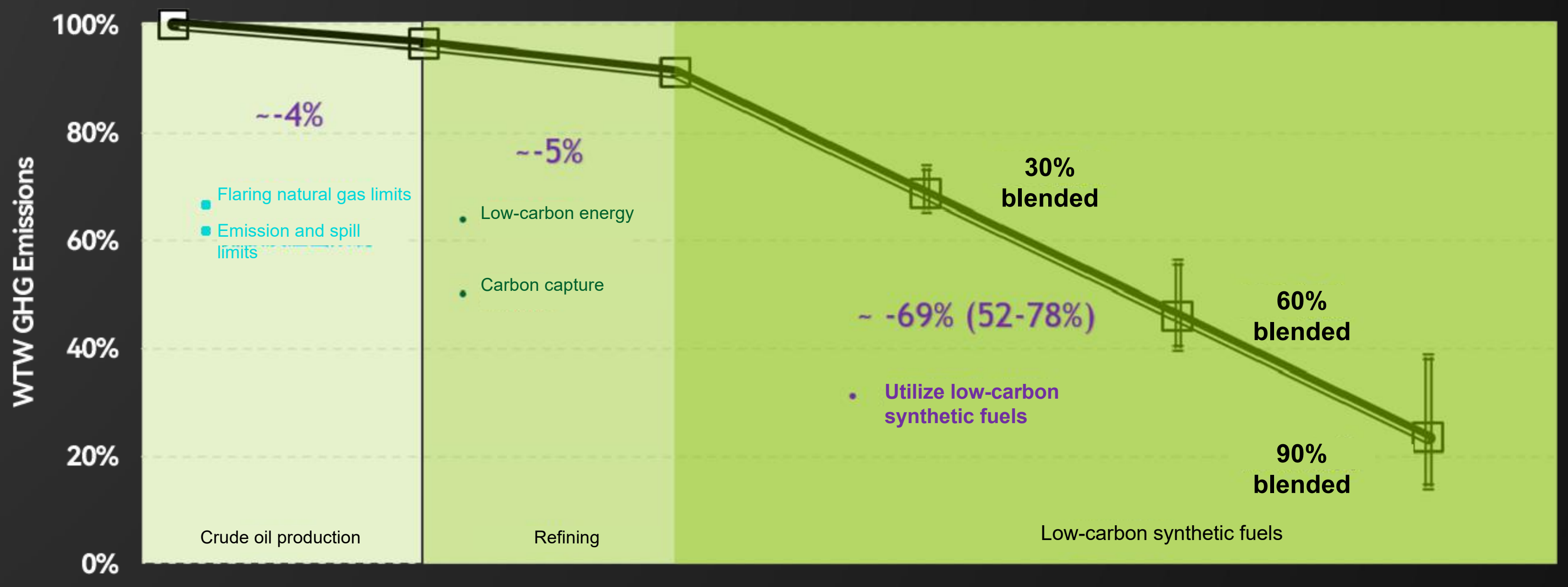
While alternative powertrains have an increasing share in recent sales, internal combustion engines, which primarily use liquid hydrocarbon fuels, will still be the dominant powertrains in the overall automotive industry due to low vehicle replacement rate. Therefore, reducing GHG emissions from petroleum products (gasoline and diesel) is of great significance to support the decarbonization of China's automotive industry.

Possible decarbonization paths for petroleum-based transportation fuels:

(1) Reduce emissions due to combustion, emission and escape by improving operating methods and reducing leakage during crude oil production;

(2) Use carbon capture technology within the refinery and low-carbon utilities;

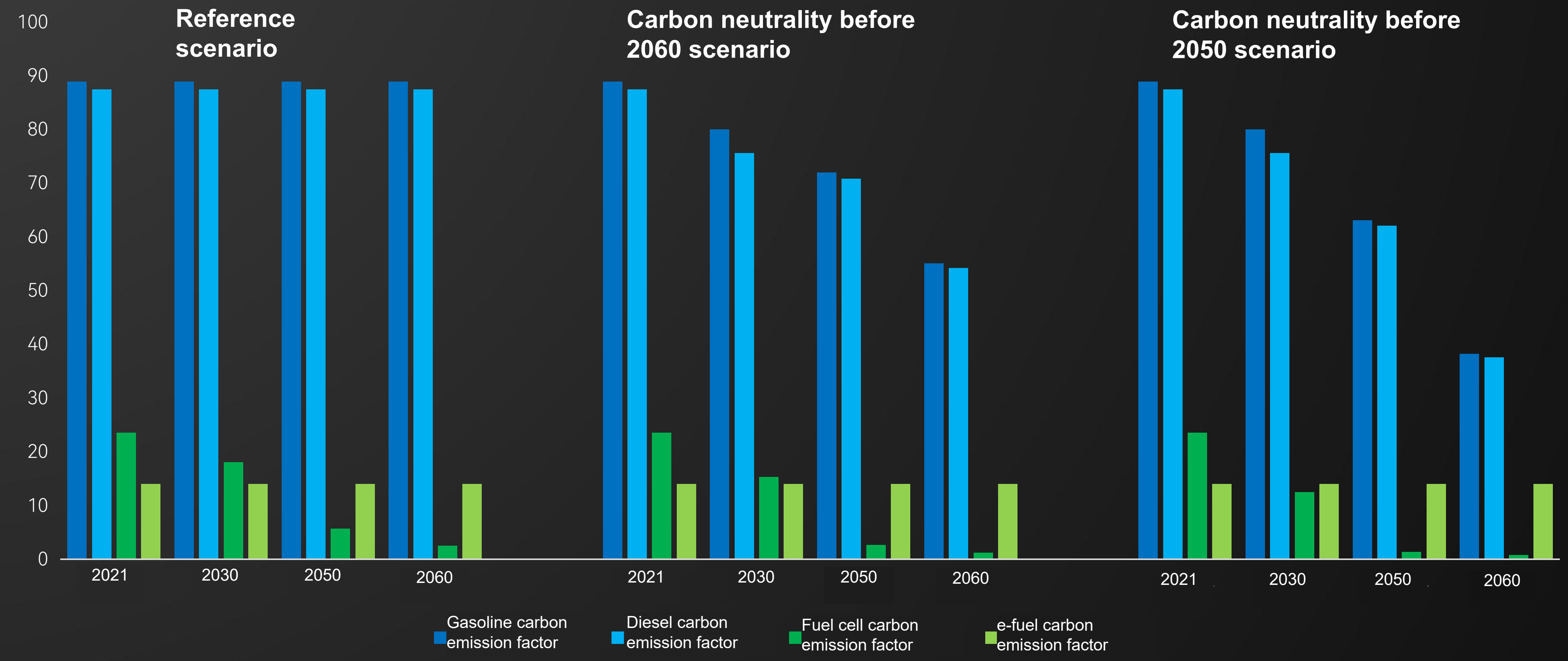
(3) Gradually increase the content of low-carbon synthetic fuels in the final blend (error contour reflects changes in the GHG emission intensity of synthetic fuels).



Source: Aramco Asia

The possible paths for liquid fuel decarbonisation due to the deployment of emission reduction measures throughout the fuel life cycle are obtained based on analysis. However, the successful implementation of these measures requires to formulate an appropriate policy framework to attract investment in low-carbon technologies, to make effective life cycle assessment-oriented policy decisions, and to integrate all technologies and all energy sources, so as to ensure that China moves toward a low-carbon future.

Fuel carbon emission factors: In the carbon neutrality before 2050 scenario, diesel and gasoline carbon emission factors will decline by more than 35% in the next 30 years, and fuel cell carbon emission factors will decrease significantly in all scenarios.

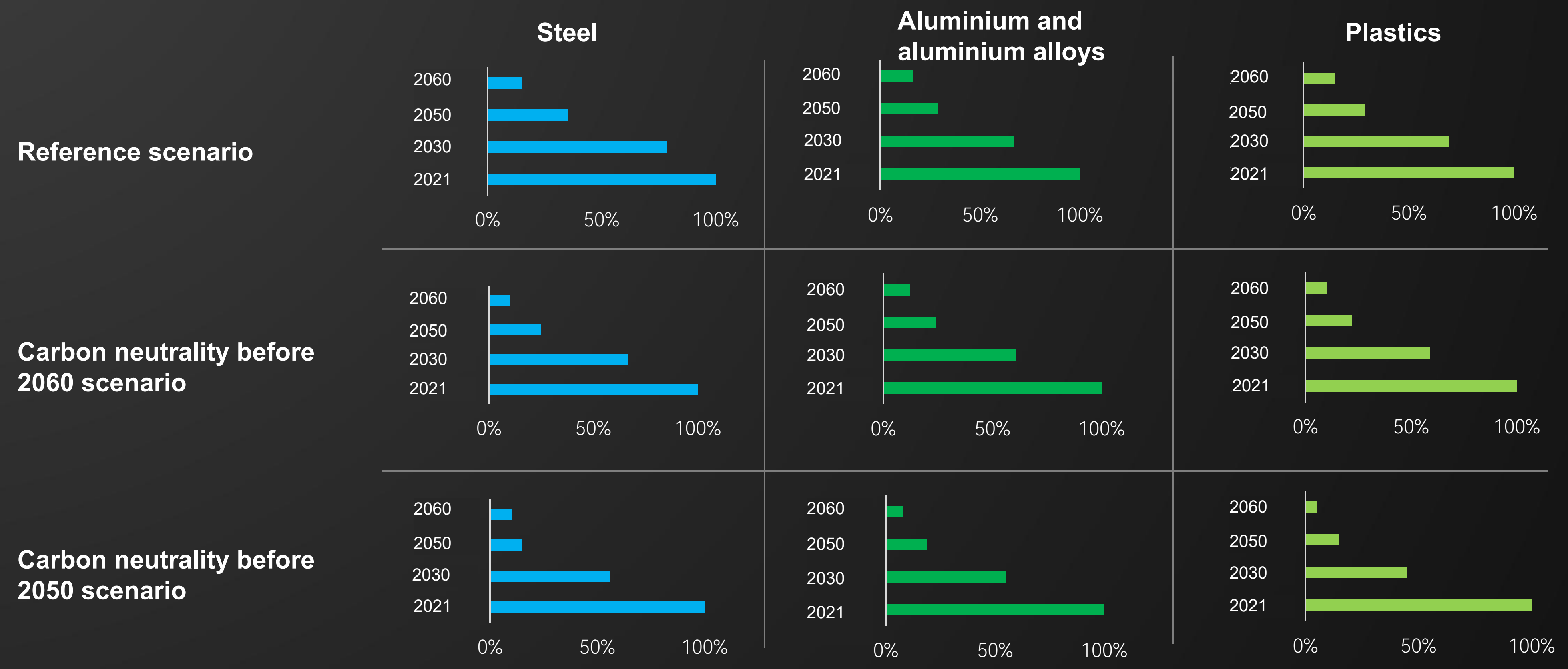


Source: Aramco Asia

18 Transformation to low-carbon materials is an important link in reducing carbon emissions in the manufacturing stage of vehicles.

Providing "zero" carbon emission materials for the automotive industry is the goal that raw material manufacturers strive to achieve. Leading enterprises in the industry are innovating and developing products for this purpose.

Material carbon emission factors: By 2030, the carbon emission factors of steel, aluminum and aluminum alloys, and plastics will decline by more than 20% in different scenarios, and the decline will be as high as 85% in 2060.



Source: the China Automotive Life Cycle Database (CALCD), the World Steel Association (WSA), the European Aluminium (EA), the Material Economic Institution, the CRU Circular Aluminium Action Plan 2030, etc.

19 Low-carbon transformation of the automotive industry with the aid of digitalization technology is the only way for the low-carbon development of the industry.

The digitalization technology helps the automotive industry and parts industry to transform from extensive energy management to precise energy management, to build the process low-carbon optimization capability and the low-carbon product innovation capability.

Industrial digitalization refers to the use of new-generation information technologies such as big data, cloud computing and artificial intelligence to fully connect human, machine, material, process, environment and other elements involved in the industry together and to realize the optimal allocation of resources in the whole industry chain and value chain through carbon data quantification, carbon data optimization and intelligent control. It is a necessary transformation path for the low-carbon development of the automotive industry.

Management level

Extensive management → Precise energy control

Production level

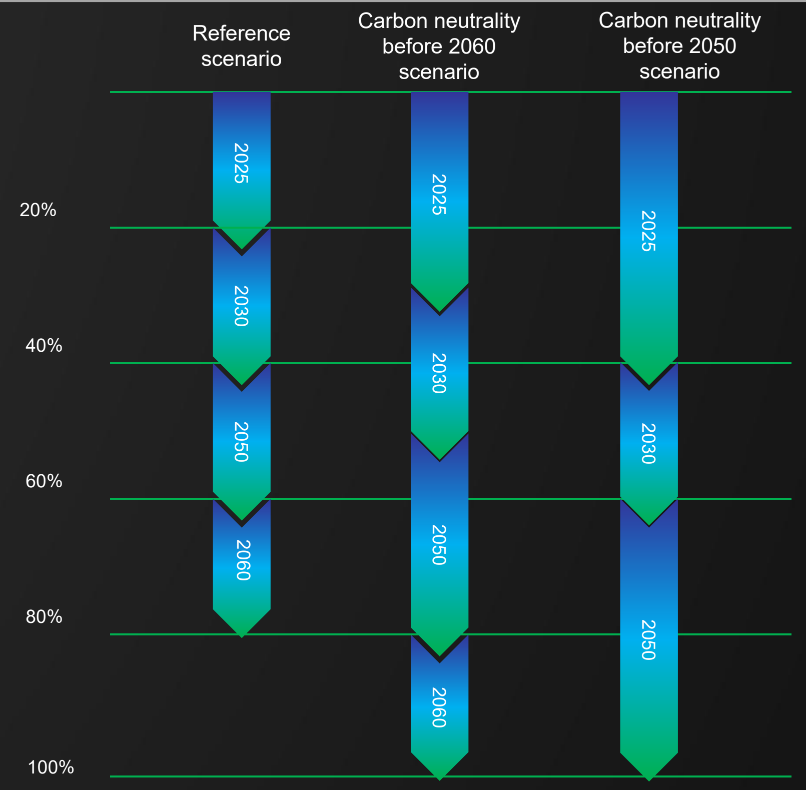
Experience & process → Low-carbon production optimization

Innovation level

High-carbon product → Product low-carbon innovation

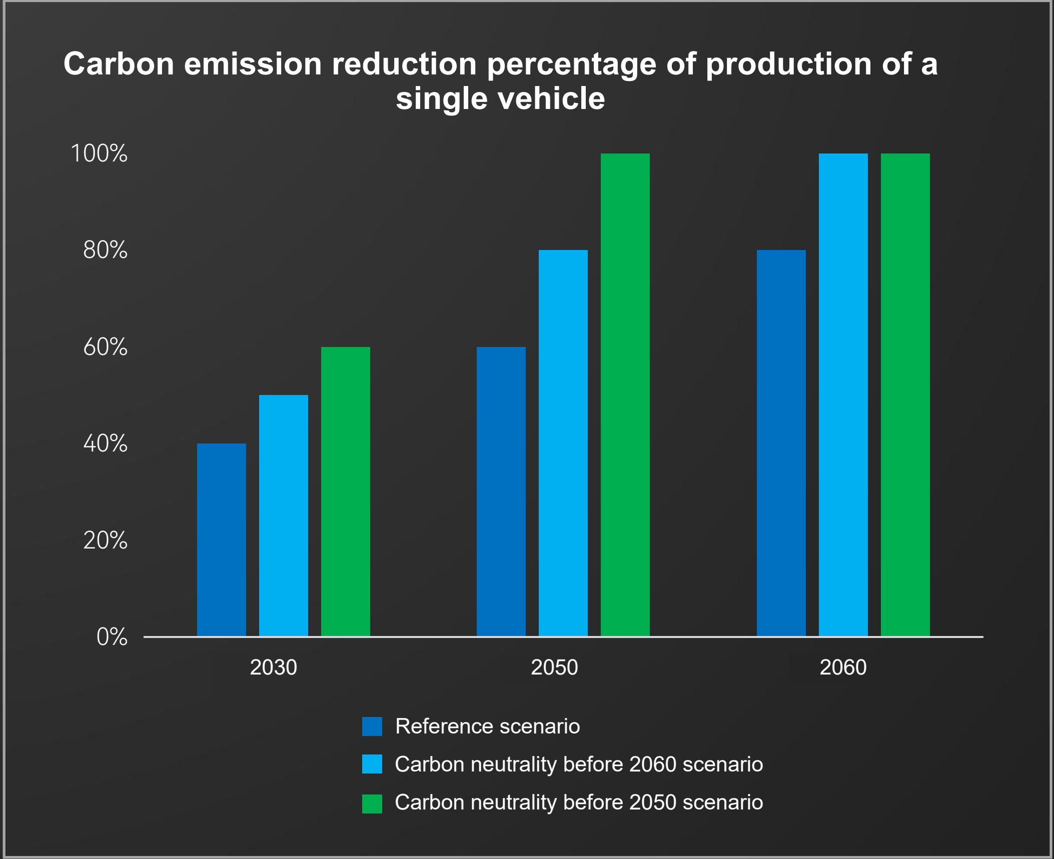
Producti on level ↑

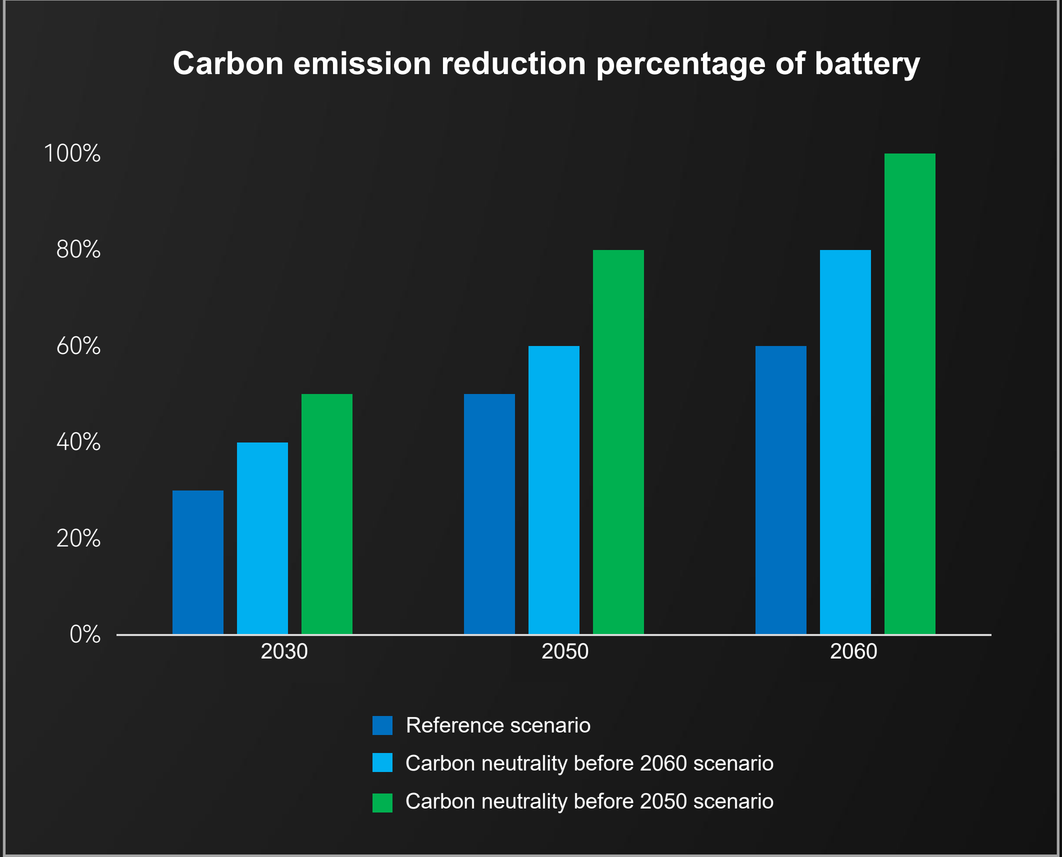
Digitalization technology ↑



Comments: With the adoption of industrial digitalization technology, it is expected that, the carbon emissions from production of a single vehicle will be reduced by more than 30% by 2025, reduced by more than 80% by 2050, and reduced by 100% by 2060.

The digitalization technology realizes the low-carbon development of the automotive industry in terms of precise energy management, low-carbon process production and low-carbon product innovation, and helps achieve the carbon peak and carbon neutrality strategy.





The industrial digitalization technology will help the automotive industry to achieve precise energy control, low-carbon process production and low-carbon product innovation, and is the only way for the low-carbon development of the automotive industry. With the adoption of industrial digitalization technology, it is expected that, the carbon emissions from production of a single vehicle and the carbon emissions from the battery will be reduced by more than 30% and more than 20% respectively by 2025, reduced by more than 80% and more than 60% respectively by 2050, and reduced by 100% and more than 80% by 2060. Therefore, under the background of carbon peak and carbon neutrality, it is recommended to vigorously promote the transformation to digitalization of the automotive industry.

20 Digitalization, connection, intelligence, sharing and low-carbon development of transportation have become an irresistible trend.

The integrative development of intelligent transportation, intelligent vehicle, intelligent energy and intelligent city will promote cross-sector collaborative development and social and economic eco-integration, optimize the transportation structure, improve the overall safety and efficiency of the road network, and reduce energy consumption and environmental pollution.

They build for people a transportation system with higher safety, efficiency, intelligence, environment friendliness and economic efficiency that effectively connects the production, distribution, circulation and consumption to allow the smooth mobility of people and smooth transportation of cargoes.

Transformation of transportation mode

- Online mobility appointment will become normal, shared mobility will be widely popularized, and technologies including biometric identification, frictionless access and frictionless payment will be widely used.
- The intelligent multimodal freight transport technology will be popularized, the proportion of urban joint distribution will exceed 50%, and the whole process of logistics will be visualized.

Optimization of transportation structure

- Intercity transportation: railways and intercity rail transit will become the main modes of transportation; the means for long-distance bulk cargo transportation gradually will shift from highway to railway and waterway.
- Urban transportation: significantly increase the share of green transportation, vigorously develop socialized joint distribution.

Construction of new road facilities

- The road infrastructure will be digitalized in all elements and all cycles;
- The high-power charging facilities for super fast charging of electric vehicles will fully cover the expressways in city clusters.

Improvement of traffic capacity

- Before 2035, the role of autonomous driving in the improvement of the overall road capacity is limited.
- The new generation of road traffic control network and traffic brain will realize the intelligence and accuracy of overall traffic scheduling and management.

Change of transportation management mode

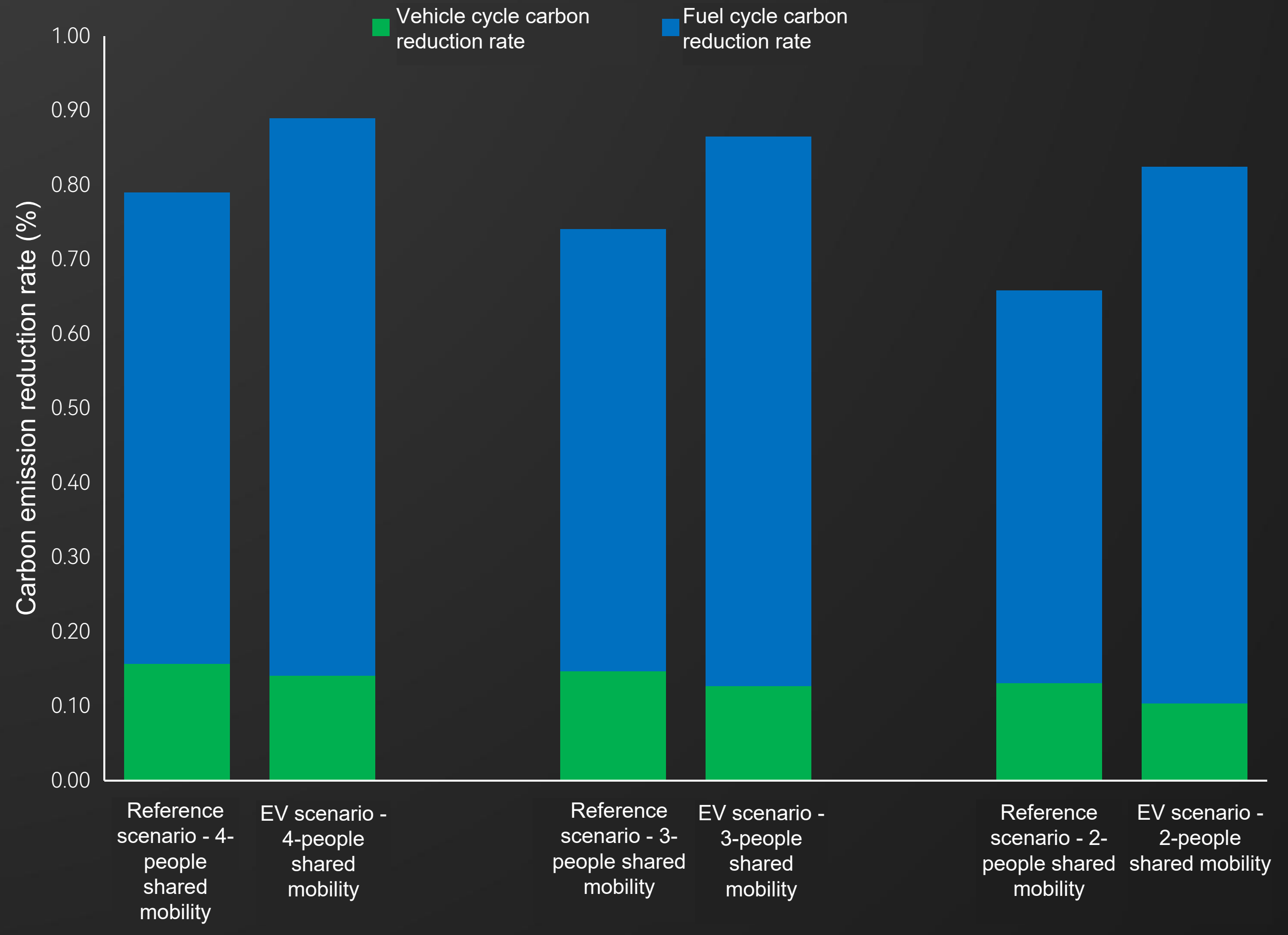
- S3 level conditional vehicle-to-infrastructure interaction technology will be popularized on a large scale.
- The new generation of road traffic control network and traffic brain with multi-subject cooperation will be applied on a large scale in expressway network and urban road network in economically developed areas.

Improvement of energy efficiency

- It will also realize dynamic coordinated operation and control of the transportation network and the energy network, thus contributing to the improvement of energy efficiency.
- Vehicle-to-vehicle and vehicle-to-infrastructure interaction make the vehicle travel at higher speed or a constant speed, thus reducing energy consumption and exhaust emissions.

21 Combination of electric vehicles and multi-person shared mobility achieves a high carbon emission reduction rate.

Horizontal comparison of different shared mobility modes shows that about another 5% of the carbon emission reduction rate will be expected for each increase of 1 person participating in the shared mobility; the average carbon emission reduction rate of comprehensive electrification under policy background is 13% higher than that under reference background.



In the six simulation scenarios, the carbon emission reduction effect of shared mobility is mainly reflected in the fuel cycle. Specifically, the average carbon emission reduction rate in the fuel cycle is about 66%, and that in the vehicle cycle is about 13%.

Comments: The carbon emission reduction effect of shared mobility is characterized by its carbon emission reduction rate relative to traditional mobility mode, where the reduced carbon emissions are the difference between the carbon emissions of traditional mobility mode and shared mobility mode, and the carbon emission reduction rate is the proportion of reduced carbon emissions of shared mobility mode to the reduced carbon emissions of traditional mobility modes.

The average carbon emission reduction rate in EV scenario under policy background is 13% higher than that under reference background.

22 China's vehicle population is far below the peak level and the vehicle recycling industry is now growing rapidly.

With the introduction of carbon peak and carbon neutrality, vehicle recycling becomes particularly important. The carbon emission reduction benefits of a large number of recyclable resources such as steel, non-ferrous metals, plastics, and rubber involved in vehicles are significant.

The proportion of recycled vehicles (2.975 million) to vehicle population (302 million) in 2021 was about 1%. It is estimated that the number of vehicles recycled will reach 37.66 million by 2060. There is huge potential for vehicle resource recycling and emission reductions, and reduced carbon emissions of material recycling of a single fuel vehicle is 4.9 t CO_2 (calculation formula: emission reductions = emission reduction effect * recovery amount/depreciation ratio)

Figure 1 Forecast of China's vehicle population and recycled vehicles in the future

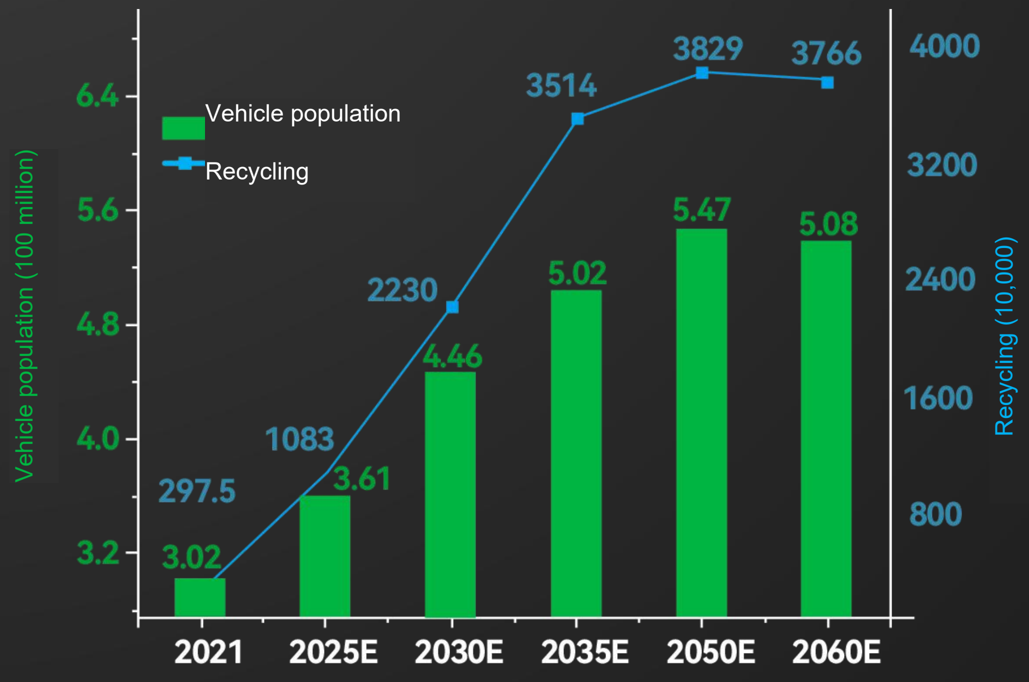


Table 1 Carbon emission reductions of material recycling

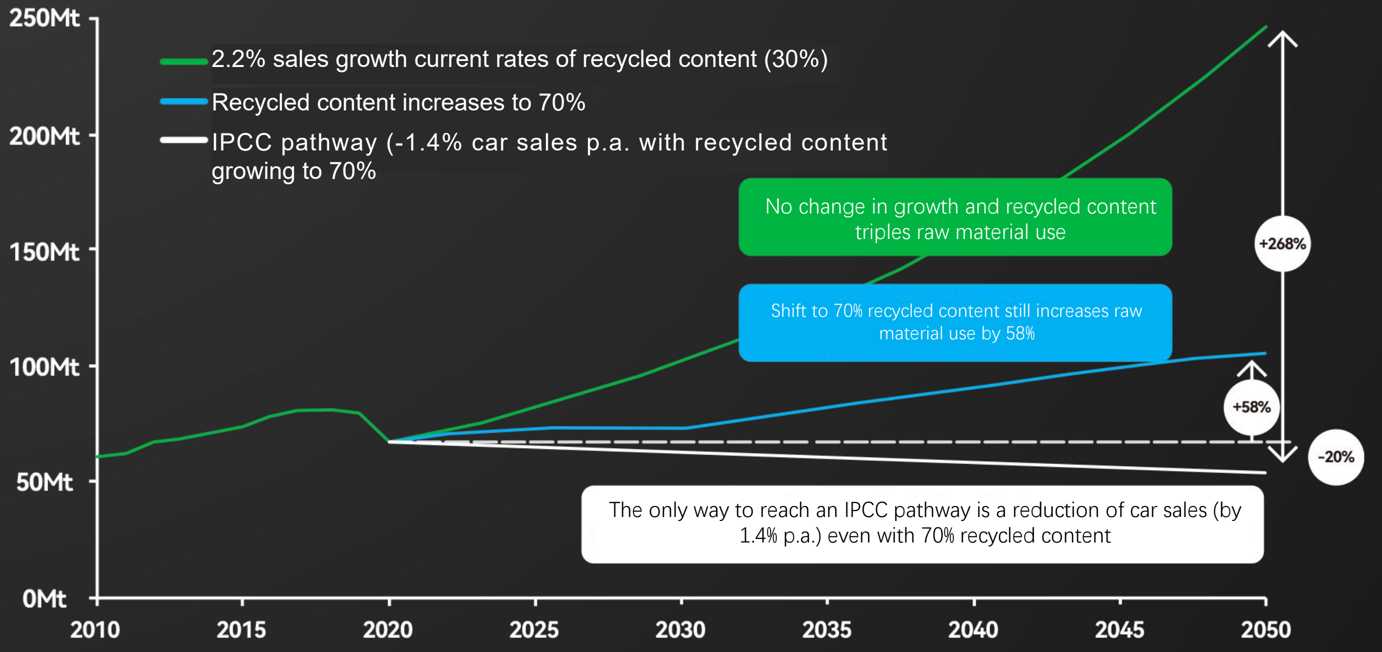
	Carbon emission reduction effect (tCO_2/ton of material)	Material recovery amount of a single fuel vehicle (kg)	Depreciation ratio
Steel	1.9	2534.48	1.08
Aluminum	14.7	28.95	1.18
Plastics	3.4	21.73	1.19

23 Recycling is essential for climate and resource protection– but not sufficient for a circular economy

Recycling is an established technology to recover materials and reduce embedded emissions, but current end-of-life processes are insufficient to provide high-quality materials for the automotive industry. Coupled with increasing global vehicle sales, climate targets will not be met and call for more productive uses of vehicles through new business models and a shift to more sustainable modes of transportation.

Due to increasing global passenger vehicle sales, automotive virgin material consumptions is set to almost triple (268%) until 2050. Even ambitious uptake of recycled content (70%) is insufficient for climate pathways, requiring a more systemic circular economy approach.

Raw materials (million tons)

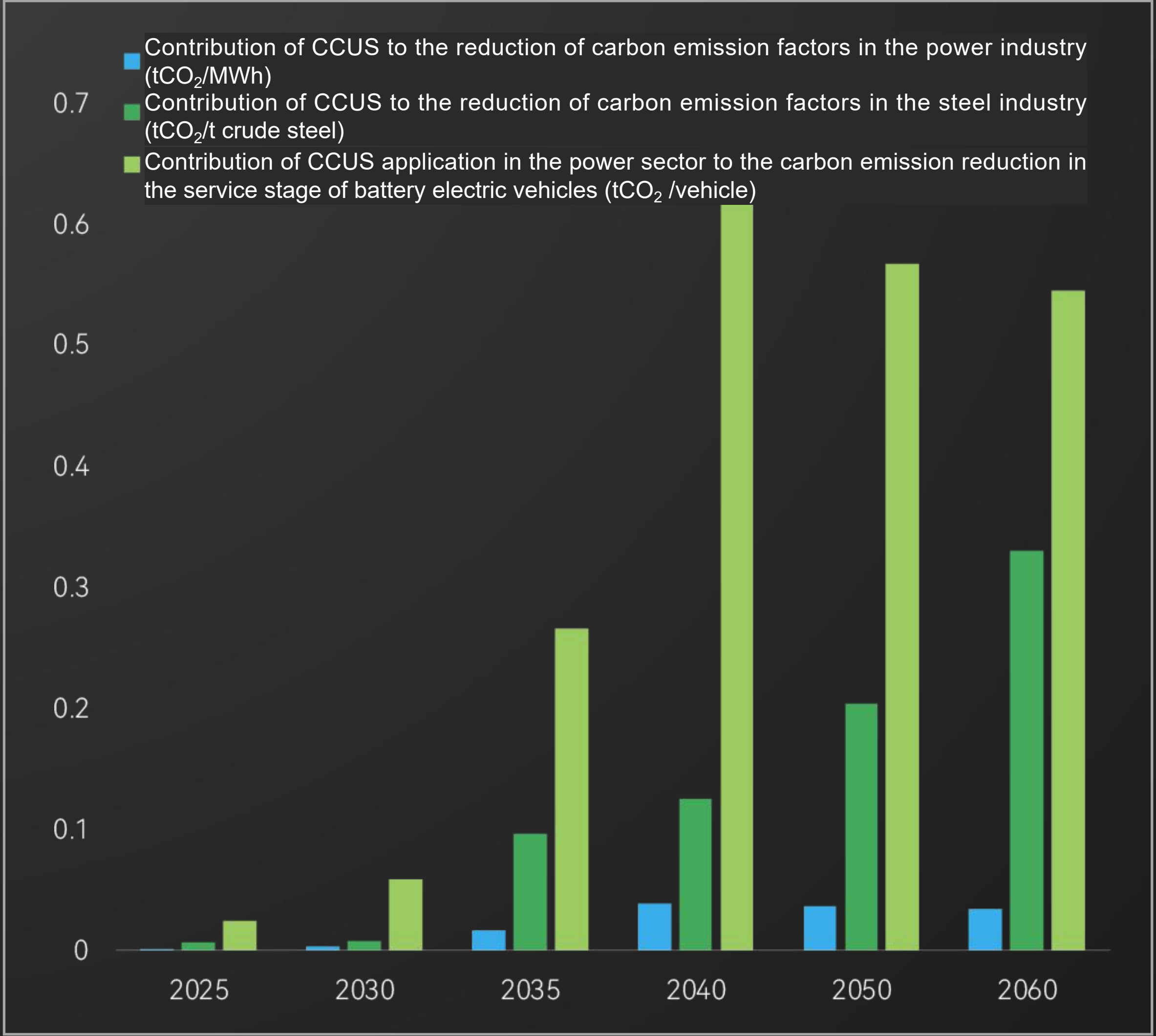


Assumptions: vehicle sales and stock as per the IEA (2022). Average European vehicle mass as reference weight factor from ICCT (2021); To reach the IPCC LED scenario, absolute virgin material consumption needs to decrease by close to 20% and hence is assumed as target line (Grubler et al. 2018). Recycled material increase modelled from 20% by 2010 to 30% by 2021 to 50% by 2030 and steady increase to 70% until 2050.

A circular economy integrates but goes beyond recycling. It optimizes end-of-life value, utilization, occupancy and operational life – building on dematerialized business models.

24 CCUS technology increases the carbon emission reduction benefits of the automotive industry chain by reducing carbon emissions from electricity and steel, etc.

China's power demand in the power industry is expected to increase to 12 trillion to 15 trillion kWh per year by 2050. Even if the proportion of thermal power is greatly reduced to about 10%, net zero emissions in the power system can only be realized by reducing emissions of hundreds of millions of tons of CO_2 based on CCUS. In the steel industry, production reduction, energy-saving technologies, steel scrap recycling, and new substitution energy can all reduce the carbon footprint of steel production. However, the emission reductions achieved through these traditional emission reduction measures are limited, so it is necessary to deploy CCUS to achieve CO_2 emission reduction goals of the steel industry in the carbon neutrality context.



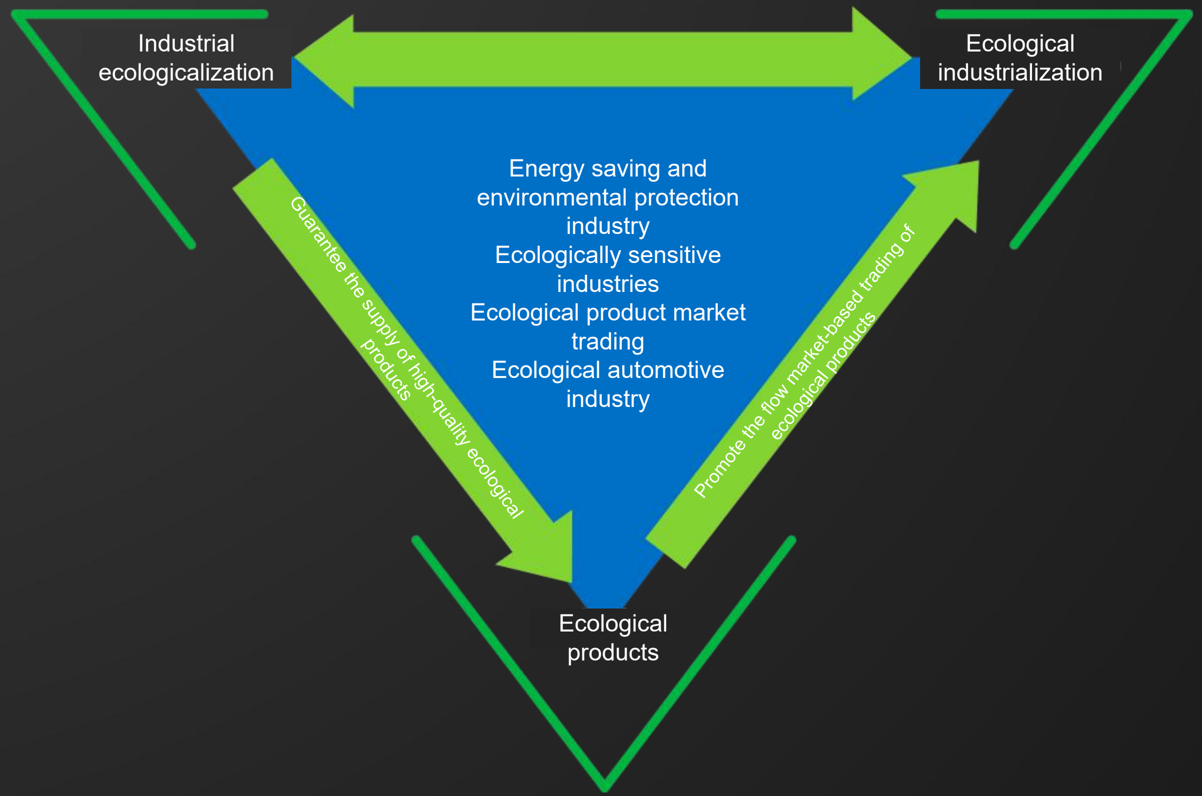
It is estimated that in the carbon neutrality before 2060 scenario, after CCUS is used, the reduction of the carbon emission factor of power industry is about 0.0349 tCO_2/MWh, and the reduction of the carbon emission factor of steel industry is about 0.3297 tCO_2/t crude steel.

Comments: According to the forecast data in the China Carbon Dioxide Capture, Utilization and Storage (CCUS) Annual Report, the emission reductions in China through BECCS are expected to reach 200-500 million tCO_2/year in 2050, and 300-600 million tCO_2/year in 2060; emission reductions through DACCS are expected to reach 50-100 million tCO_2/year in 2050, and 200-300 million tCO_2/year in 2060.

The automotive industry has a long industrial chain and involves many fields, and some emission sources are scattered, making it difficult to completely reduce emissions. It is expected that carbon neutrality will be achieved by combining negative emission technologies such as DACCS and BECCS.

25 Form a virtuous circle of "industrial development - ecological products - ecological health” Achieve the goal of carbon neutrality with automotive industry ecologicalization.

The automotive industry ecologicalization generates two types of ecological products. One type is the ecologicalization of vehicles, which provides ecological industrial products such as vehicles, and the other type is the ecological products provided by the natural ecosystem due to the automotive industry ecologicalization, which can deliver rich ecological product value.

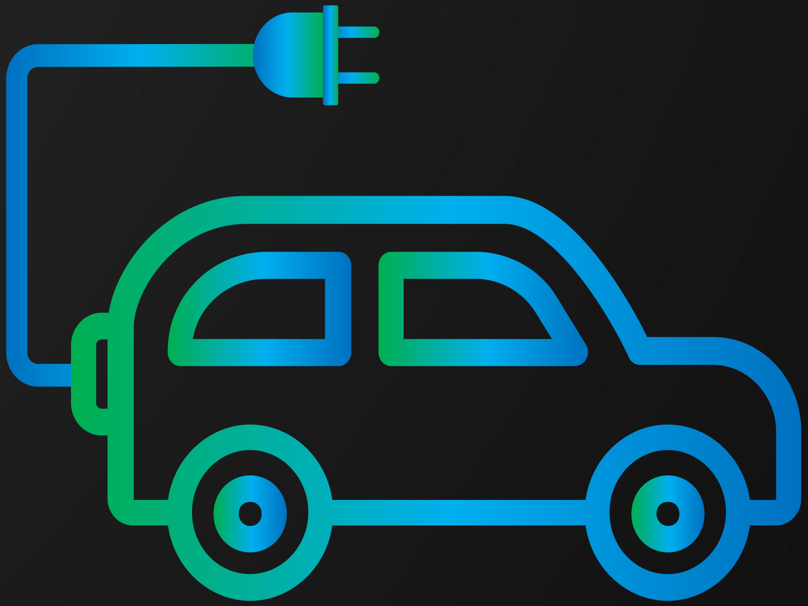


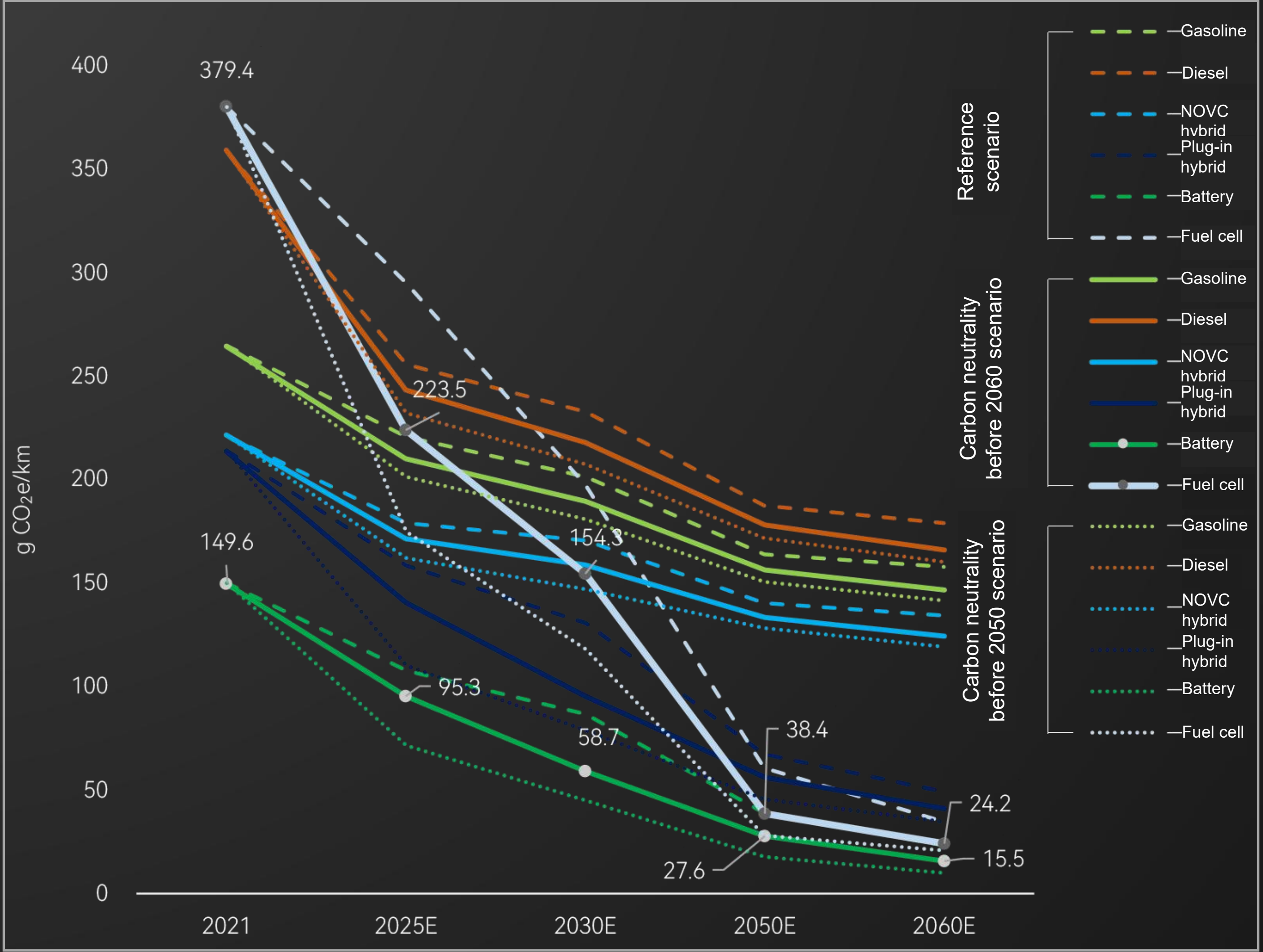
The automotive industry ecologicalization is not only an important link to realize the green, ecological and low-carbon industrial products such as vehicles, but also benefit to improve the quality of the natural ecosystem and the environment, and helps to promote the realization of the value of ecological products. It is an important part of the ecological economic system with industrial ecology and ecological industrialization as the main bodies and also is of great significance for the realization of the carbon neutrality goal.

Facing the future, it is recommended to further define the connotation of automotive industry ecologicalization, clarify the ecological characteristics of its products, and carry out value accounting for the contribution of ecological products to the automotive industry.

26 In the future, battery electric passenger vehicles will always be the models with the lowest carbon emission. Fuel cell electric passenger vehicles have huge potential for carbon reduction.

In the carbon neutrality before 2060 scenario, the carbon emissions of battery electric passenger vehicles in 2060 will be only 15.5gCO_2e/km, making them the models with the lowest carbon emission in the future; the carbon emissions of fuel cell electric passenger vehicles are expected to be reduced by 94%, making them the models with the greatest emission reduction potential in the future.





Among the four common types of passenger vehicles: gasoline, NOVC hybrid, plug-in hybrid and battery electric, gasoline passenger vehicles and NOVC hybrid passenger vehicles are always the models with higher carbon emission, while battery electric passenger vehicles and plug-in hybrid passenger vehicles are always the models with lower carbon emission.

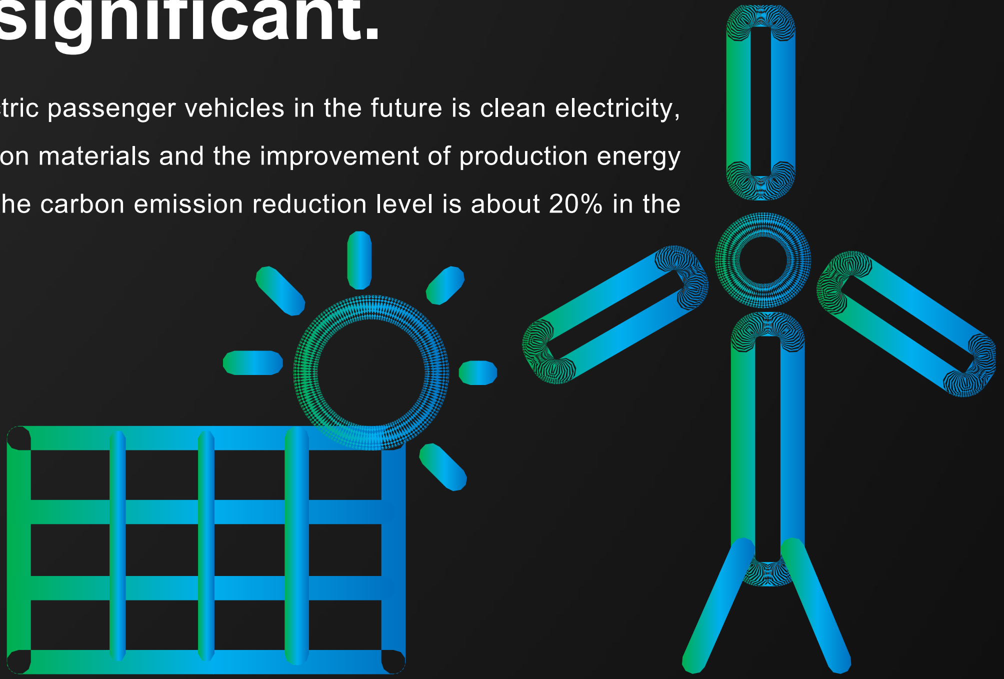
Plug-in hybrid passenger vehicles, as a low-carbon option second only to battery electric passenger vehicles, have the advantages of long driving range and lower carbon emission driving. It is expected that by 2025, they will get more attention as transitional models for gasoline passenger vehicles and battery electric passenger vehicles.

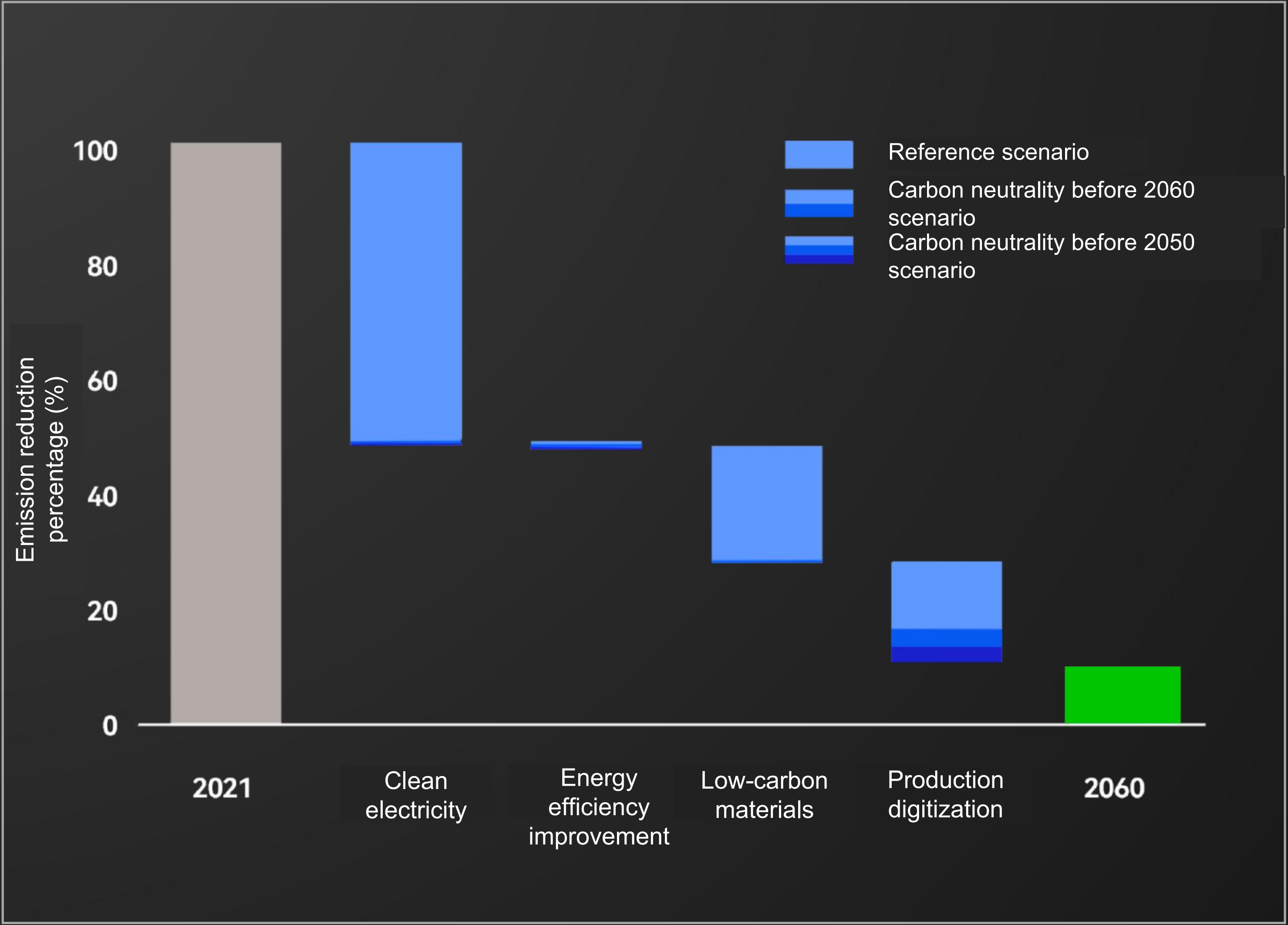
Comments: In the reference scenario, the carbon neutrality before 2060 scenario, and the carbon neutrality before 2050 scenario, the effects of clean electricity, fuel decarbonization, low-carbon materials, production energy efficiency, and energy efficiency improvement to different extents are all taken into account.

Carbon emission trend of different types of passenger vehicles: fuel vehicles generally have a high carbon emission, fuel cell electric passenger vehicles have a gradually decreasing carbon emission, plug-in hybrid passenger vehicles have a relatively low carbon emission, and battery electric passenger vehicles always have the lowest carbon emission.

27 Passenger vehicles: in the future, clean electricity will have the greatest carbon emission reduction effect on battery electric passenger vehicles. The carbon emission reduction effect of low-carbon materials is significant.

The main carbon emission reduction path for battery electric passenger vehicles in the future is clean electricity, which will contribute more than 50%. The use of low-carbon materials and the improvement of production energy efficiency have significant carbon reduction effects, and the carbon emission reduction level is about 20% in the carbon neutrality before 2050 scenario .





In the three scenarios, the carbon emissions of battery electric passenger vehicles in 2060 will be reduced to 85%, 90% and 94% respectively of the level in 2021, and the largest contribution is clean electricity, more than 50%.

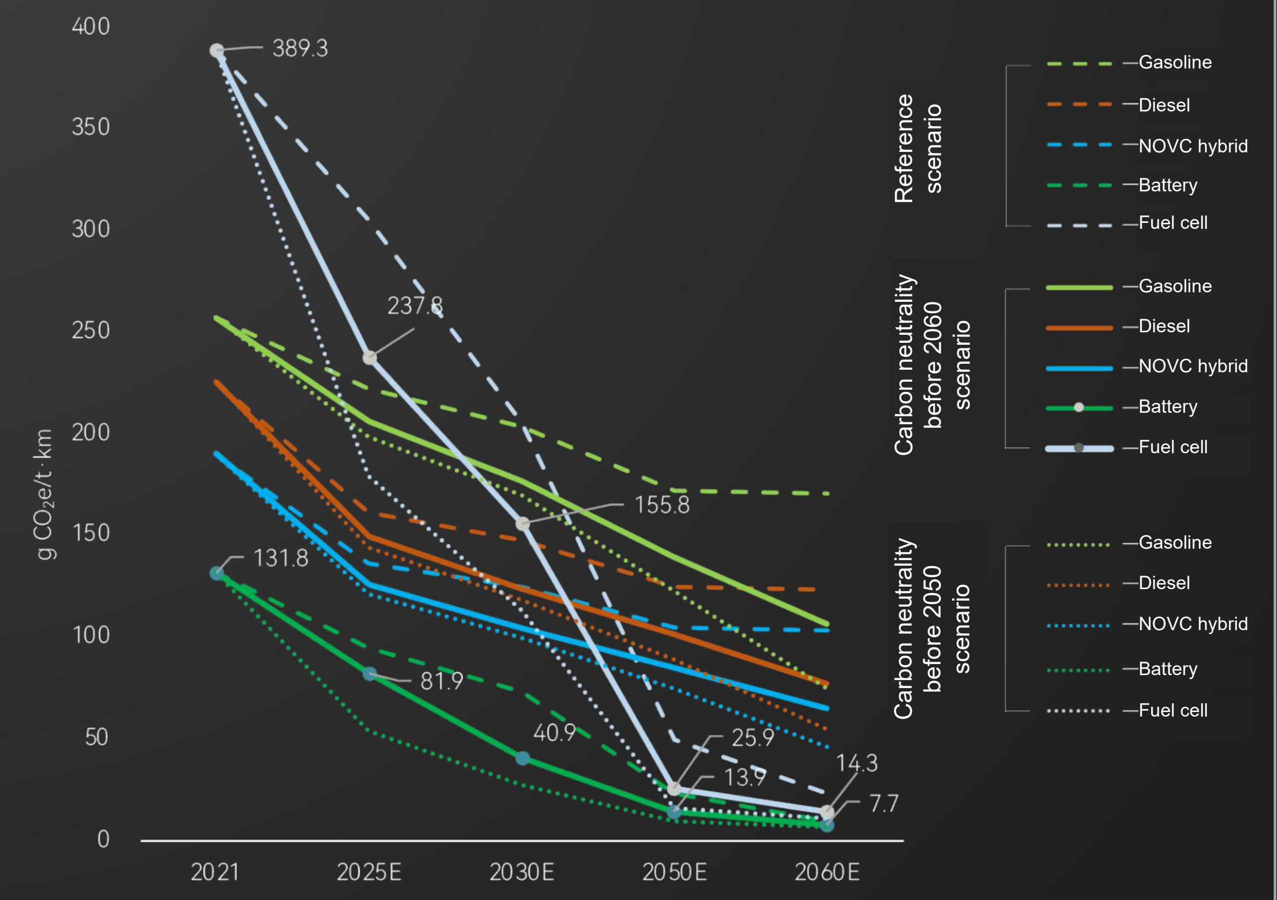
In the carbon neutrality before 2060 scenario, the clean electricity contributes the most to the carbon reductions of battery electric passenger vehicles by 52%, and it is difficult to improve energy efficiency, so its emission reduction effect is the weakest. The two paths, low-carbon materials and production digitization, can respectively reduce about 20% of carbon emissions.

Comments: In the reference scenario, the carbon neutrality before 2060 scenario, and the carbon neutrality before 2050 scenario, the effects of clean electricity, fuel decarbonization, low-carbon materials, production energy efficiency, and energy efficiency improvement to different extents are all taken into account.

In the carbon neutrality before 2050 scenario, the carbon neutrality before 2060 scenario and the reference scenario, carbon emissions in 2060 will be reduced to 6%, 10% and 15% respectively of the level in 2021.

28 Commercial vehicles: Battery electric light-duty trucks are always the models with the lowest carbon emission in the light-duty trucks. Fuel cell electric light-duty trucks have huge potential for carbon reduction.

In the carbon neutrality before 2060 scenario, the carbon emissions of battery electric light-duty trucks in 2060 will be only 7.7gCO_2e/t·km, making them the models with the lowest carbon emission in the future; the carbon emissions of fuel cell electric light-duty trucks are expected to be reduced by 96%, making them the models with the greatest emission reduction potential in the future.



Comments: In the reference scenario, the carbon neutrality before 2060 scenario, and the carbon neutrality before 2050 scenario, the effects of clean electricity, fuel decarbonization, low-carbon materials, production energy efficiency, and energy efficiency improvement to different extents are all taken into account.

In all scenarios, battery electric light-duty trucks have absolute low-carbon emission advantages in the light-duty trucks of all fuel types, while fuel cell electric light-duty trucks gradually have carbon emission advantages with low carbon development of the hydrogen production process.

In the reference scenario, after 2030, the carbon emission of fuel cell electric light-duty trucks will be gradually lower than that of fuel light-duty trucks;

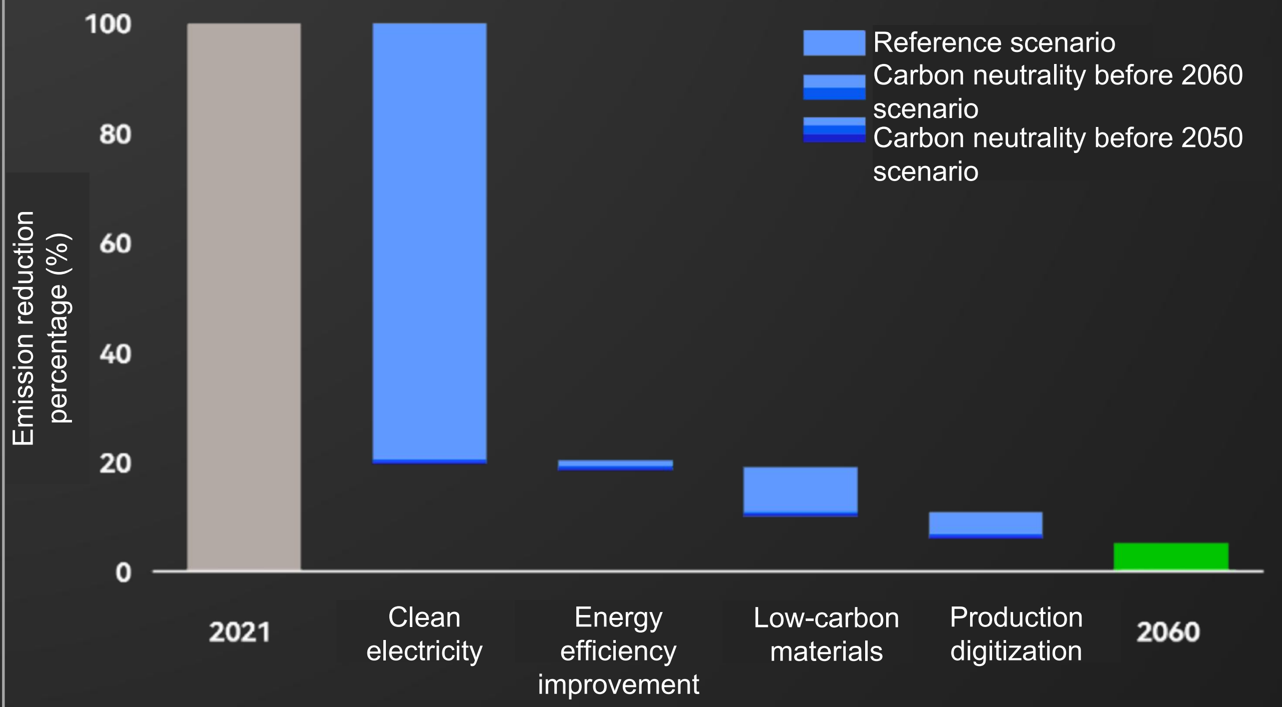
In the carbon neutrality before 2060 scenario, the carbon emission of fuel cell electric light-duty trucks will be lower than that of gasoline light-duty trucks from 2025 to 2030, and lower than that of diesel light-duty trucks and NOVC hybrid light-duty trucks after 2030;

In the carbon neutrality before 2050 scenario, the carbon emission of fuel cell electric light-duty trucks will be lower than that of gasoline light-duty trucks from 2021 to 2025, lower than that of diesel light-duty trucks from 2025 to 2030, and lower than that of NOVC hybrid light-duty trucks after 2030.

Carbon emission trend of light-duty trucks of different fuel types: fuel light-duty trucks generally have a high carbon emission, fuel cell electric light-duty trucks have gradually decreasing carbon emission, and battery electric light-duty trucks always have the lowest carbon emission.

29 Commercial vehicles: In the future, clean electricity will have the greatest carbon emission reduction effect on battery electric light-duty trucks.

The main carbon reduction path for battery electric light-duty trucks in the future is clean electricity, which will contribute about 80%. The use of low-carbon materials has carbon reduction effects up to 9% in the carbon neutrality before 2050 scenario.



Comments: In the reference scenario, the carbon neutrality before 2060 scenario, and the carbon neutrality before 2050 scenario, the effects of clean electricity, fuel decarbonization, low-carbon materials, production energy efficiency, and energy efficiency improvement to different extents are all taken into account.

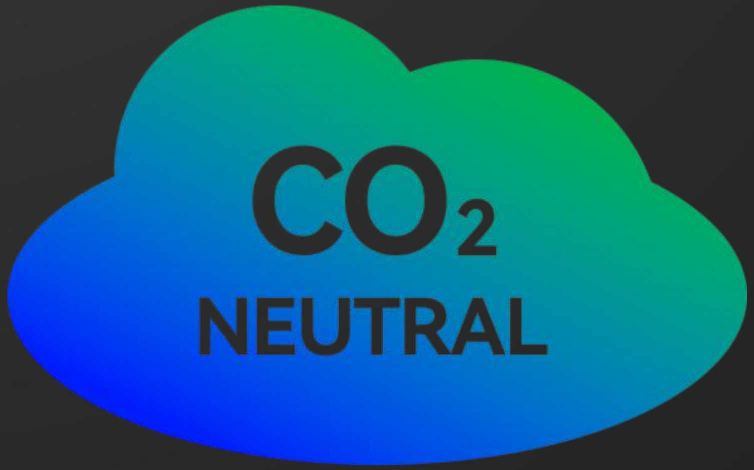
In the three scenarios, in 2060, the carbon emissions of battery electric light-duty trucks will be reduced by 93%, 94% and 95% of the level in 2021, and the largest contribution is clean electricity, about 80%.

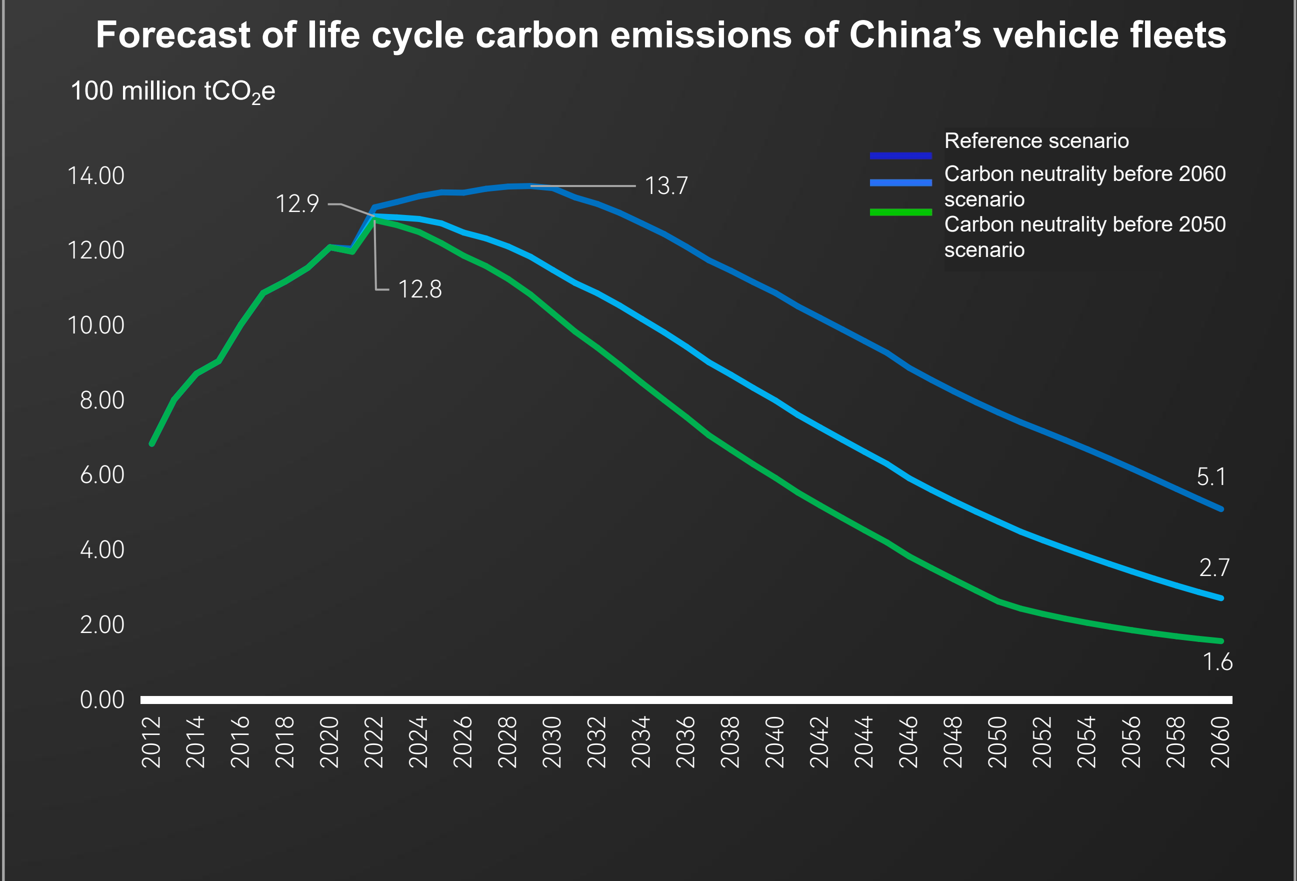
In the carbon neutrality before 2050 scenari o, the clean electricity contributes the most to the carbon reductions of battery electric l ight-duty trucks, up to 81%, and it is difficult to improve energy efficiency, so its emissio n reduction effect is the weakest. The two p aths, low-carbon materials and production d igitization, can respectively reduce about 9 % and 4% of carbon emissions.

In the carbon neutrality before 2050 scenario, the carbon neutrality before 2060 scenario and the reference scenario, carbon emissions in 2060 will be reduced to 5%, 6% and 7% respectively of the level in 2021.

30 Carbon emissions of vehicle fleets will peak before 2030, and the realization of carbon neutrality in 2060 still requires the joint efforts of the industry chain.

With the adoption of various transformation paths such as clean electricity, vehicle electrification, fuel decarbonization, low-carbon materials and production digitalization, the carbon emission in the full life cycle of the automotive industry can peak before 2030.





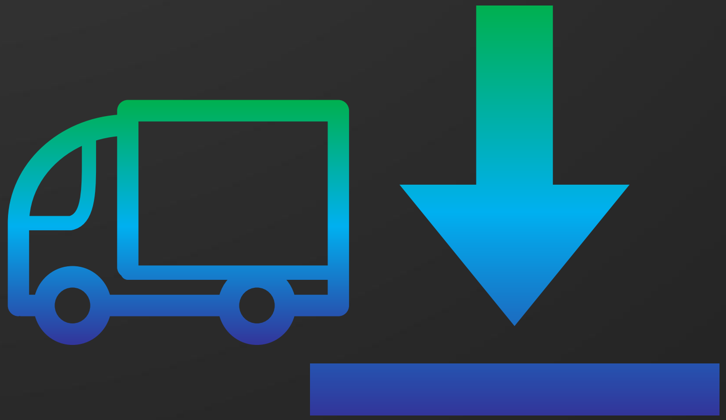
Comments: In the reference scenario, it is difficult to achieve full life cycle carbon neutrality of the vehicle fleets by 2060, but in the carbon neutrality before 2060 scenario and the carbon neutrality before 2050 scenario, the possibility of carbon neutrality by 2060 can be increased.

In different scenarios, the carbon emission peak of China's vehicle fleets in the full life cycle is between 1.28 and 1.37 billion tCO_2e, and there is some room for efforts to achieve deep decarbonization in the later stage of peaking.

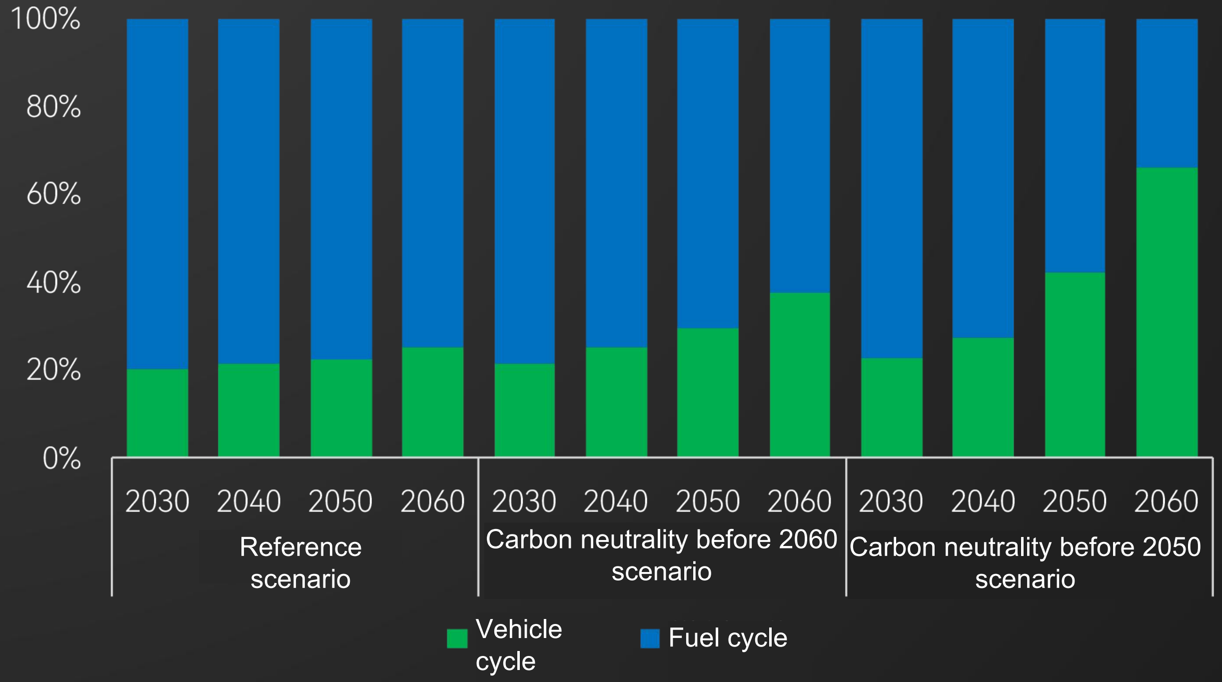
As the proportion of new energy vehicles increases, vehicle cycle carbon emissions will gradually occupy a dominant position in life cycle carbon emissions of vehicle fleets.

31 Fuel cycle carbon emissions from vehicle fleets will continue to decline, gradually shifting to the upstream supply chain.

With the increase of the total number of electric vehicles and the gradual decline of China's electricity carbon emission factor, the proportion of fuel cycle carbon emissions in the life cycle carbon emissions of fleets will gradually decrease, and the proportion of vehicle cycle carbon emissions will gradually increase.



Forecast of life cycle carbon emissions of China's vehicle fleets



Comments: In the reference scenario, the vehicle cycle carbon emissions of vehicle fleets in 2060 will account for about 25% of the life cycle carbon emissions, and in the carbon neutrality before 2060 scenario, this proportion will rise to about 38%.

In the future, new energy vehicles will be in high demand. Compared with the fuel cycle, it will be more difficult to realize decarbonization in the upstream supply chain. It is estimated that in the carbon neutrality before 2050 scenario, the proportion of vehicle cycle carbon emissions will reach 66% by 2060.

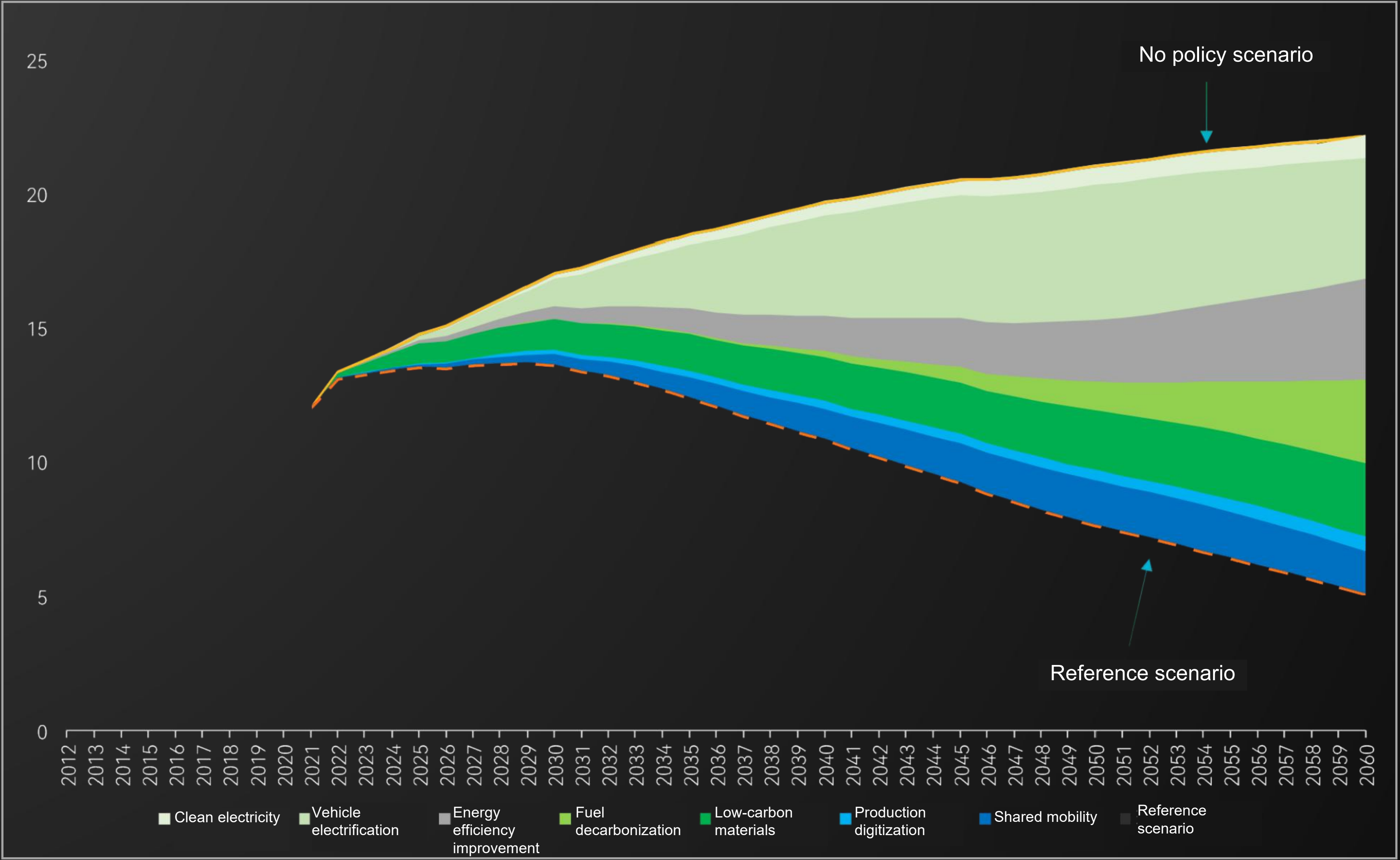
In the late stage of carbon emission reduction in the automotive industry, the deep decarbonization of the upstream supply chain is one of the great challenges to achieve carbon neutrality in the full life cycle.

32 Promoting the transformation to vehicle electrification can effectively reduce the life cycle carbon emissions of vehicle fleets

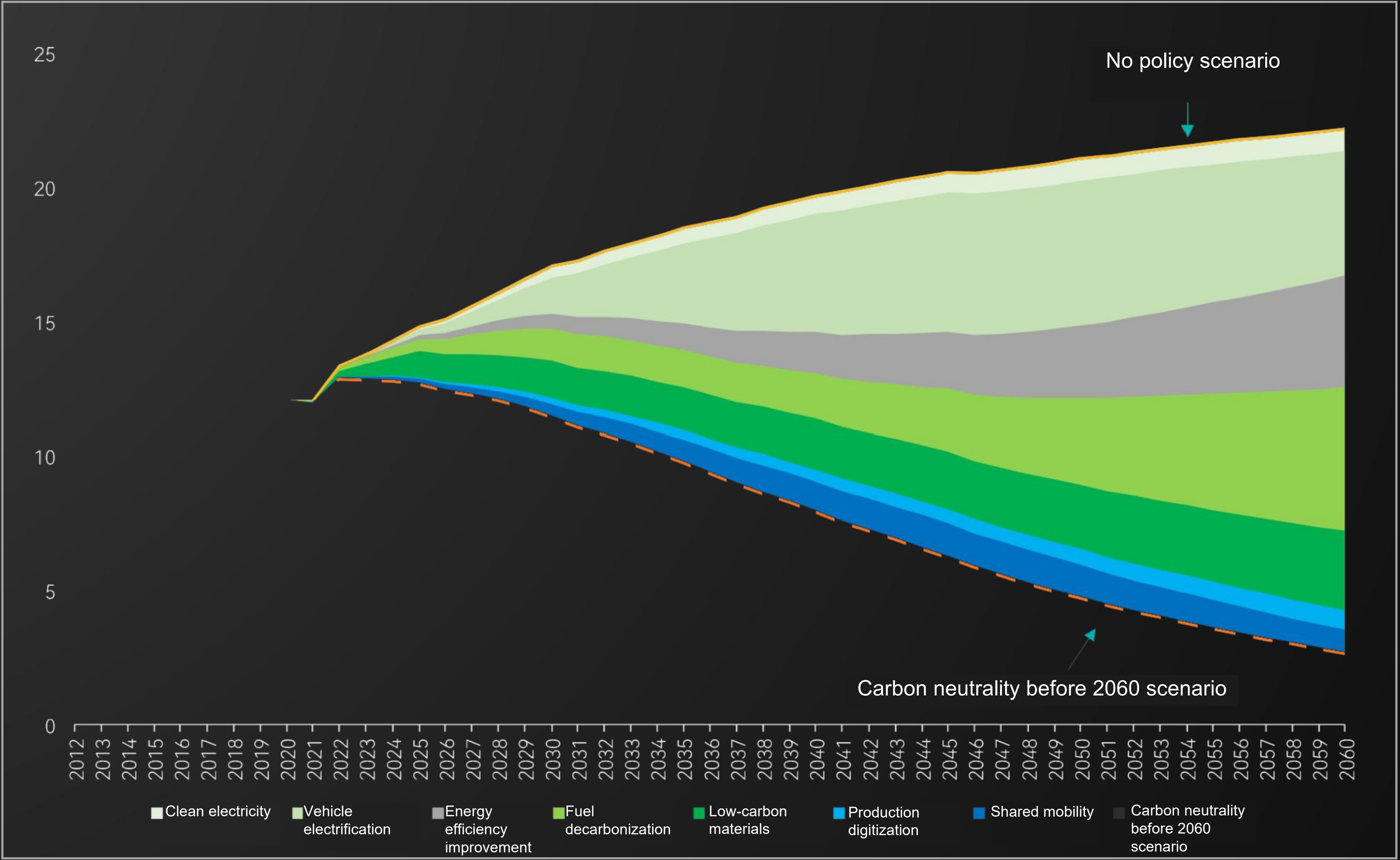
If no emission reduction measures are implemented, the life cycle carbon emissions of the vehicle fleets will increase to 1.71 billion tCO_2e by 2030 and to 2.22 billion tCO_2e by 2060.

Through the transformation to vehicle electrification and related emission reduction measures, life cycle carbon emissions of China's vehicles can be reduced to 1.03 billion tons in 2030, and can be reduced to 160 million tons by 2060.

In the reference scenario, the vehicle electrification in the future can produce the emission reduction effect to the greatest extent, the emission reduction potential due to the low-carbon materials does not change much over time, the emission reduction effect produced by the energy efficiency improvement increases over time, and the emission reduction effect of fuel decarbonization is more significant in the later stage.

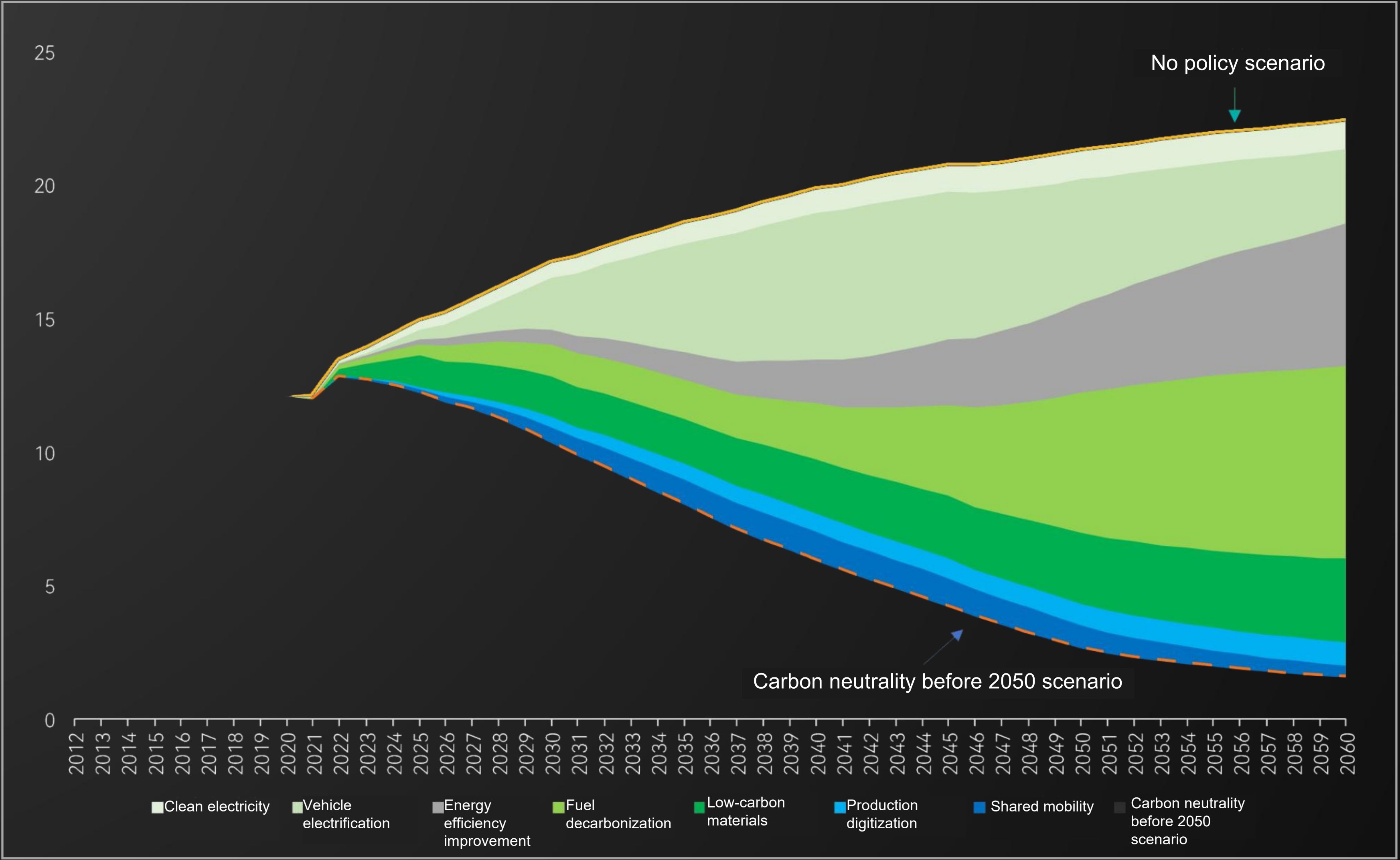


In the carbon neutrality before 2060 scenario, vehicle electrification still has the largest emission reduction potential. In addition, the emission reduction potential due to energy efficiency improvement, fuel decarbonization and low-carbon materials has increased.



In the carbon neutrality before 2050 scenario, vehicle electrification still has the largest emission reduction potential. In the later stage, the main emission reduction potential is reflected in the three transformation paths of vehicle energy efficiency improvement, fuel decarbonization and low-carbon materials.

Comments:
On the basis of promoting the transformation to vehicle electrification, the energy efficiency improvement, the fuel decarbonization, and the decarbonization of the supply chain are more effective means of reducing emissions.



33 To archive the carbon peak and carbon neutrality goals, the automotive industry faces dual challenges of domestic management and international competition.

Through benchmarking and analyzing the low-carbon management system of China's automotive industry and the experiences of international advanced countries, the urgent problems and challenges to be solved are drawn from the domestic and international perspectives.

In terms of domestic management, the specific information for carbon emissions is not complete, the existing policies and standard systems have some limitations, and the supply chain and enterprise information disclosure mechanisms are immature. In terms of international competition, limited by the policies of various regions, the compliance cost in the process of exporting Chinese products continues to rise, and the carbon emission disclosure power needs to be strengthened.

Under the carbon peak and carbon neutrality goals, the challenges faced by China's automotive industry are multi-faceted, and addressing the challenges is a systematic project.

Reference scenario management

Effect saturation: Carbon emission effect of reference scenario taking fuel consumption and pollutants as management objects tend to be saturated.

Unclear standards: Accounting standards do not involve the whole automotive industry chain, no enough leading standards are provided, and industry work efficiency is low.

Complex data: The basic database of carbon emissions in China is still a work in progress and the complexity of supply chain data is relatively high.

Low transparency: The disclosure of environmental information in the automotive supply chain is still at a relatively low level, and the industrial chain has high environmental and carbon risks.

International competition and challenges

Export restricted: The EU has set limits on indicators such as carbon footprint and recycled materials, which may affect the export of Chinese products.

Due diligence: The enterprises who have business in Europe to a certain scale should ensure the lowest supply chain environmental risks and issue reports.

Rising costs: Policies such as carbon border adjustment mechanism (CBAM) will increase the direct and management costs of products exported to the EU.

Weak carbon emission disclosure power: The international carbon emission system is mature, and there is a gap between Chinese enterprises and international enterprises, and it is difficult to improve the carbon emission disclosure power.

34 Carbon emissions in production and consumption levels shall be taken into account for low-carbon development of the industry, and incentive policies shall be formulated for the full life cycle.

A low-carbon development policy toolkit with "two perspectives and four links" is proposed by considering the resource procurement, production optimization, information disclosure, fiscal and tax incentives, etc.

Green materials and green electricity are taken as safeguard measures for resource procurement;
Technology application optimization and low-carbon certification promote green transformation of production links;
Increase public supervision on carbon information and enterprise environmental information;
Encourage low-carbon development in terms of production and consumption through fiscal and tax policies.

Multi-link joint governance can accelerate the transformation and upgrading of the automotive industry, help China to implement the carbon peak and carbon neutrality goals, and enhance the international competitiveness of products.

Production level

Resource procurement

Green resource supply and guarantee for exporting enterprises
Circular material supply; green electricity supply
Information collection and statistics mechanism for supply chain
Information analysis and screening of remote suppliers in supply chain

Production optimization

Development of a green and low-carbon technology library for the automotive industry
Strengthen industry leadership; standardize market applications; promote international cooperation

Information disclosure

Disclosure system of carbon footprint information of automotive products
Social supervision promotes enterprises to carry out relevant work
Industry environmental information disclosure and assessment system
Promote green transformation in all aspects

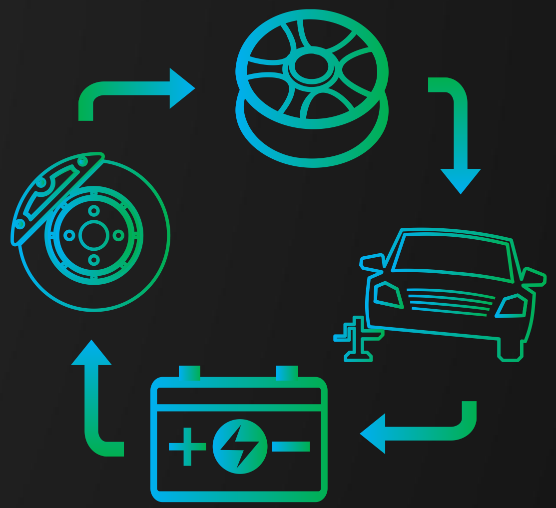
Fiscal and tax incentives

Fiscal and tax policies for carbon emissions in the automotive industry
Encourage low-carbon R&D through fiscal and tax subsidies; carbon pricing mechanism forms a radiation drive

Consumption level

Labeling of carbon footprint of automotive products
Encourage the promotion of low-carbon products and change the consumption concept
Environmental information disclosure platform of automotive industry
Encourage the promotion of low-carbon products and change the consumption concept

Carbon tax policy for automotive products
Promote low-carbon consumption of automotive products and encourage R&D of low-carbon products



35 Whole automotive industry chain, upstream-downstream linkage, and coordinated carbon emission reduction through multiple measures

According to the emission characteristics of the whole automotive industry chain and the emission reduction potential of each path, strategic points such as clean electricity, vehicle electrification, resource recycling system construction, and negative carbon technology are proposed.

According to the existing problems of the automotive industry and the emission reduction potential of each transformation path, a scientific and feasible low-carbon development strategy is proposed. Comprehensive low-carbon development strategic points covering vehicle chain, fuel chain, negative carbon technology, transportation, etc. can effectively promote the emission reduction of the whole automotive industry chain.

Long automotive industry chain covers a wide range. It is necessary for multiple bodies coordinate and take multiple measures to promote the carbon emission reduction of the automotive industry.

Identify key issues in China's automotive industry chain

Identify ten transformation paths

Analyze emission reduction potential of transformation paths

Clean electricity

Build a clean electricity supply system

- Increase the proportion of renewable electricity
- Take multiple measures to improve the cleanliness of thermal power

Electrification development

Steady and sound promotion of the development of vehicle electrification

- Strengthen policy guarantees
- Enterprises do a good job in R&D investment and early warning

Resource recycling system

- Quality and carbon reduction assessment standards for recycled materials
- Sound vehicle recycling system
- Innovative resource extraction technology

Low-carbon alternative fuels

- Diversified application scenarios of alternative fuels
- Clean supply system for alternative fuels
- Basic guarantee system for alternative fuels

Low-carbon mobility modes

- Good basic guarantee mechanism for low-carbon mobility
- Personal mobility "carbon account"

Application of negative carbon emission technology

- Perfect research on theories and methods of negative carbon technology
- Guarantee infrastructure construction
- Emission reduction trading for negative carbon projects

36 Outlook

In the future, the China Automotive Low Carbon Action Plan will deepen research, take the automotive industry as the starting point, and combine pollution reduction and carbon reduction, energy system, path cost-effectiveness, etc., to explore and give full play to the combined carbon reduction effect of the automotive industry chain.

Pollution reduction and carbon reduction

Considering the synergistic effect of carbon emission reduction in the full life cycle of vehicles on pollutant control, it will help achieve the goal of the "14th Five-Year Plan", the basic realization of a beautiful China by 2035, and the goal of building a great modern socialist country in 2050.

Power system

Interaction between the vehicles and the power grid, impact of the large-scale electric vehicle promotion and application on the power system, and adverse effects of V2G and V2X on the vehicles.

Economic benefits

In different carbon neutrality scenarios in the automotive industry, economic efficiency analysis of corresponding technology paths is carried out to evaluate the effect of phased implementation and achievement of carbon neutrality in the automotive industry.

Breakthrough technologies

The impact of future technological leap-forward progress is taken int consideration, such as the impact of battery technology, energy storage technology, and hydrogen production processes on the low-carbon transformation of the automotive industry chain.

Thank You For Watching

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