Analysis of New Energy Vehicles Industry under the Vision of Carbon Neutrality in China

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Abstract—China is the world's largest consumer of automobiles and has the most prominent position in the new energy vehicle market in terms of carbon neutrality. New energy vehicles need to be developed to bring about a revolution and transformation in the automotive industry and a sustainable economy. On the basis of data related to new energy vehicles, systematically analyzes the state and problems of the Chinese auto industry on new energy sources in terms of policy, supply, demand, industry and car manufacturers.

Keywords-Carbon Neutrality; NEVs; Innovation

1. INTRODUCTION

A study by the Intergovernmental Panel on Climate Change (2018) shows that: in order to reach the 1.5 ℃ target, the world has adopted a low-carbon development model in recent years and aims to achieve zero net greenhouse gas emissions by 2050[1]. China's share of global carbon emissions increased from 11% in 1990 to 29% in 2019. President Xi has announced an ambitious post-2030 climate target: China will aim to reduce carbon emissions by 2060[2]. The automotive industry puts tremendous pressure on the environment. However, the automotive industry is the backbone of the national economy and is an industry with high emissions and consumption.

Haze and particulate matter (PM) have become a social problem [3]. Potential dangers to energy security, such as CO_2 exceeds standard emissions, exacerbates traffic congestion, are not suitable for the sustainable development of our economy and the environment. China has become a car consuming country around the world in recent decades, but not good enough at traditional car production without particularly sophisticated equipment. Moreover, technological advances in important areas have been monopolized by several developed countries. The automotive industry is both a challenge and an opportunity for China. This opens up a new opportunity for the automotive industry to change its brand. If China seizes

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the opportunity for a revolutionary and transformative new trend in the automotive industry, China will compete more fairly with foreign countries, develop large emerging markets, and become a powerful automotive power. Thus, the new energy automotive industry plays an important role in the sustainable development of China. This document analyzes the current situation and challenges of the Chinese NEV industry and provides specific recommendations.

2. Materials and Methods

This article makes extensive use of the theories and principles of macroeconomics, microeconomics and industrial economics, combining macro, middle and micro levels. Quantitatively, using a large amount of descriptive statistics at the macro level, analyzes the new energy vehicle industry using the WTW model and the NEV core technology innovation model from the middle level and microscopic level, allowing to understand the changes in the attitude of consumers towards vehicles on new energy sources.

3. Results & Discussion

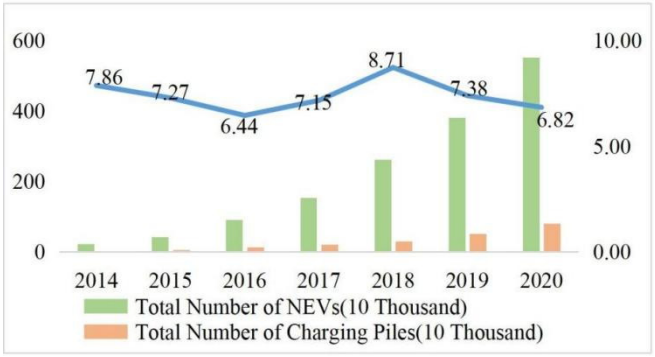
3.1 Summary of the current situation

Until 2017, the Chinese new energy vehicle market was in its infancy due to the low level of technology in the production of new energy vehicles and the misunderstanding and acceptance by most people. Consequently, the sales of NEV was below expectations at the time. After 2017, as China's economic growth returned to normal, the economy suffered from the trade war with the United States, and auto sales growth continued to be weak in the face of an overall slowdown in macroeconomic growth. Additionally, a double credit policy a reduction of green subsidies were implemented, which led to the fact that it entered the stage of correcting fluctuations. High sales dynamics began to decline. In 2020, China sold 1.367 million new energy vehicles[4]. In 2019, sales decreased by 4%, and in 2020 the growth rate was 13%. (see Picture 1).

Pic. 1. Sales Volume and Penetration Rate of NEV.
Data Source: Ministry of Industry and Information Technology
Note: penetration rate of new energy vehicles = output of new energy vehicles/output of traditional vehicles

In addition, the penetration of new energy vehicles was low, only 5.42% in 2020. Moreover, the growth rate of the penetration rate of new energy vehicles and sales volume showed the

same trend. Nevertheless, to achieve the target of 25% penetration rate by 2025, the state, is supposed to provide the supporting guidelines for research and development, production and promotion of new energy vehicles based on the current situation of different regions. In the downstream chain of the new energy vehicle industry, the construction of a loading point is essential. China strongly supported the development of charging stacks. In 2015, the National Development and Reform Committee gave the guidelines for the "Development of Electrical Vehicle Charging Infrastructure (2015-2020)", which has announced the general purpose: by 2020, more than 120000 central charging stations and more than 4.8 million distributed charging stations would be added to meet the charging demand of 5 million electric vehicles in China [5]. According to the promotion of the new policies of the charging stack release in China, the charging stations from 28000 in 2014 to 800,000 in 2020, with average annual growth of 78%. Due to the scarcity of public charging stations, the limitation of the technique is always the problem at the center of social attention [6]. In addition, the development of new energy vehicles and charging stations in China is enormously unbalanced. In 2020, the number of stations in China loaded 800000, while the number of new energy vehicles was 5,510,000 and the pile ratio of the vehicle was nearly 7:1, which was significantly different than the 1: 1 vehicle pile ratio target in 2020. The development of vehicle piles is not coordinated and the distribution of charging stations is unevenly, which are concentrated on coastal and other first-class cities. Therefore, the demand for foundational construction of charging piles is still rising (see Picture 2).



Pic. 2. Pile Ratio of NEV in China.
Data Source: Wind

3.2 Current policies on new energy vehicles

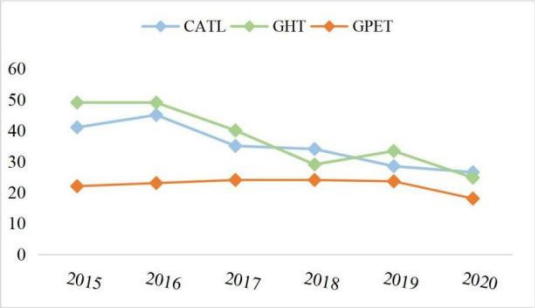
3.2.1 Cut green subsidy

In 2017, new energy vehicles received a ladder promotion from 20,000 to 44,000 yuan with a driving of 100,400 km. In 2018, the government reduced average and low mileage of subsidies. For small BEVs whose driving ranges are higher than 300 km, subsidies even account for 40-50% of production costs [7]. Since 2019, the subsidy for new energy vehicles has been cut more. The driving range has changed from five to two gears. Currently, the subsidies for new energy vehicles are relatively stable. The subsidies from 2020 to 2022 will be 10%, 20% and 30% lower than the previous [8]. With the decline of new energy subsidies, the survival situation of the vehicle manufacturers is called into question. To control the cost and upgrade

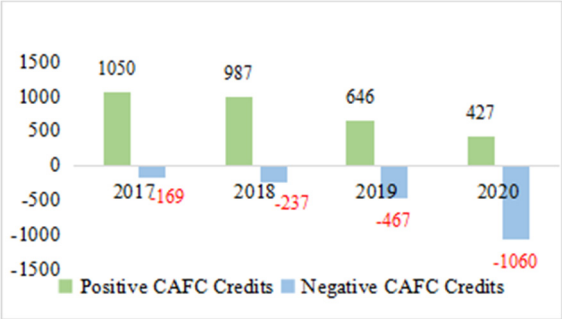
product quality, a fundamental problem has become effective. A new energy energy battery is good for around 45% of the total cost of the entire vehicle, which is the most valuable component unit. The concentration of the Power Battery Market has gradually increased. Under the background of the reduction of subsidies, the gross profit of major companies fell gradually and by degree due to overcapacity and rising commodity prices. Wang (2021) showed that the impact on upstream firms' financial performance is greater in comparison to the firms operating at midstream and downstream levels. In addition, the negative effect of the aid for the company in the middle west of the region and not non-state-owned companies is stronger than state-owned companies and firms in eastern regions [9]. The profit of the industry is also confronted with significant pressure. The paper has three main companies for the production of power batteries and uses data of gross profit rate on power battery business from their reports. The companies are contemporary Amperex Technology Co., Limited (Catl), Gotion High-Tech (GHT) and Great Power Energy & Technology Co., Ltd (GPET). In 2016, the gross profit rate of the power battery business in CATL was 46% and then experienced an annual profit decreasing of 7.7%. According to its report in 2020, the gross profit rate of power batteries was 26.56%. GHT fell by 11.34% per year, and gross profit was reduced from 49% in 2015 to 24.72% in 2020 (see Picture 3).

3.2.2 Dual-credit policy

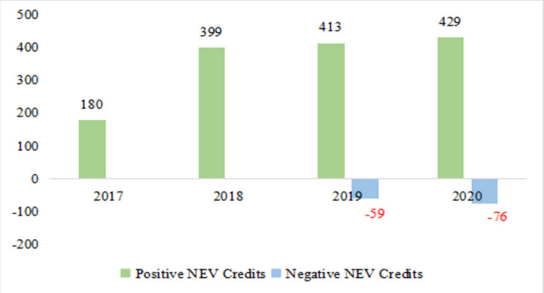
Government subsidies cannot drive the development of the new energy vehicle industry for a long time, so the market is supposed to play a significant role. Therefore, the incentive policy of new energy vehicles transits from the inclusive policy to the market-oriented incentive policy gradually. Pictures 4 and 5 show corporate average fuel consumption credit and new energy vehicle credit of China from 2017 to 2020.



Pic. 3. Gross Profit Rate of Power Battery Enterprises.
Data Source: Annual Reports of Listed Companies



Pic. 4. CAFC Credits of China (10 Thousand)
Data Source: Ministry of Industry and Information Technology



Pic. 5. NEV Credits of China (10 Thousand).
Data Source: Ministry of Industry and Information Technology

From 2017 to 2019, the positive credits of CAFC exceeded the negative credits so far, but the positive credits decreased year by year, while the negative credits increased year by year. In 2020, the negative credits of CAFC exceeded the positive credits for the first time and were 2.48 times the positive credits. NEV's positive credits are enough, but negative credits appeared for the first time in 2019 and reached 760000 in 2020, showing structural deficiency. These data show that new energy vehicles are growing steadily, which means that China's new energy vehicle market is developing rapidly. However, Zhao (2018) pointed out that the regulation likely faces risks of losing this positive effect in 2025 or even earlier[10].

Moreover, the pressure of CAFC of Chinese passenger car enterprises in 2021 is more incredible. The negative credits in 2020 can be offset by the positive credits left from previous years, but there are still some gaps. In 2021, if there are not enough positive credits to offset, they can only cover NEV credits or purchase CAFC credits from other enterprises. Therefore, in 2021, China's passenger car enterprises need to adjust the automobile production structure and develop new energy vehicles to avoid national punishment vigorously.

3.3 Status quo of supply-side

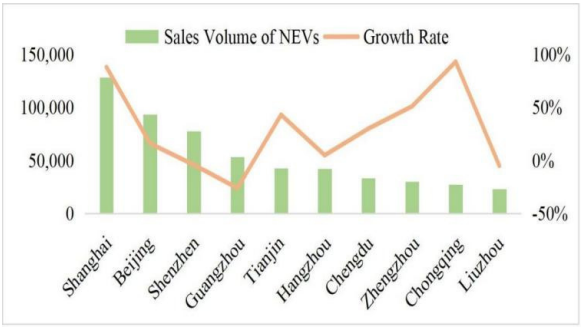
Traditional automakers are transforming to new energy vehicles, and new forces are joining the market. In 2018, after China canceled the restrictions on the share ratio of foreign investment in new energy vehicles, many international automobile companies accelerated the layout of the new energy vehicle industry in China. With the entry of foreign brands such as

Volkswagen, BMW, and Daimler into the Chinese new energy vehicle market, the Chinese new energy vehicle market was divided into joint ventures, China's brands, and new car building forces. The proportion of joint ventures in new energy vehicle sales has increased yearly, from 4% in 2018 to 24% in 2020. At the same time, new automobile manufacturing forces represented by Tesla, NIO, Xpeng, Li Auto, and other brands have emerged in China. The sales volume grew continuously, from 6% in 2018 to 33% in 2020, occupying more market share of new energy vehicle sales. However, the sales market share of Chinese independent brands (BAIC BJEV, BYD, ROEWE, Chery) has reduced from 90% in 2018 to 43% in 2020.

3.4 Status quo of demand-side

3.4.1 Greater acceptance of consumers in new energy vehicles—Big cities with limits on auto purchases are the main force of consumption growth.

To advocate green modes of transportation, reduce carbon emissions, urban pollution, and release traffic congestion, China has implemented purchasing motor vehicles in many first-tier cities, imposing limits on auto purchases in cities. Among the types of subsidies, the financial subsidy is most effective on the residents' purchase willingness[11]. However, there is no limit on new energy vehicle purchases and encourages the families who buy a new energy vehicle as the first car and provides relevant subsidies. In China's first-tier cities, limits on license plate quotas making it a typical circumstance that many car owners "having a car without a license." Since 2018, Shanghai has issued a policy that new energy vehicles can get a license free of charge, greatly enhancing the enthusiasm of citizens to buy new energy vehicles. Since then, Guangzhou, Shenzhen, and other cities have also supported new energy vehicle buyers, making new energy vehicles proliferate in China's big cities. In 2020, Shanghai was the city with an enormous sales volume of new energy vehicles in China. The sales volume of Beijing and Shenzhen were the second and third. Chongqing's sales growth rate reached 93%, was the fastest growing city of new energy vehicle sales in China in 2020 (see Picture 6)

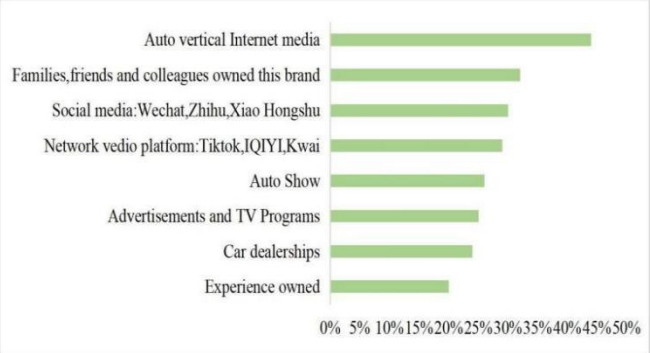


Pic. 6. Top 10 Cities of New Energy Vehicle Sales in 2020.
Data Source: Chinese Association of Automobile Manufacturers

3.4.2 The main channel for consumers to acquire information is online.

2021 McKinsey automotive consumer insight report noted that after consumers have the will to buy a car, they would form their own "brand list" according to the information collected

online and offline. When they buy the car, they go straight to the products in the "brand list", and nearly half of the consumers' final brands were chosen from the list. With the development of network technology, collecting information is not limited to the traditional offline ways, but the combination of online and offline mode. It provides access to information conveniently, comprehensively, and deeply. Picture 7 shows the information acquisition channels of new energy vehicles.



Pic. 7. Information Acquisition Channels of NEVs.
Data Source: *2021 McKinsey automotive consumer insight report* [12]

In the survey, the most important source of information for consumers has changed from the introduction and recommendations by relatives and friends to the vertical online media of cars. New energy vehicle owners prefer video and social media due to their visual display, perfect evaluation experience, and accurate purchasing evaluation. Especially during the epidemic, websites such as Auto Home have become the critical source of information.

3.5 Challenges of the new energy automobile industry

3.5.1 Bottlenecks in products and technologies are supposed to be improved.

China has been developing new energy vehicles for more than 20 years and has 0.295 million automobile patents disclosed[13]. Xie (2016) pointed out some deficiencies in China's personnel training and team-building of new energy vehicle technology. Most of the new energy vehicle technologies put into use were developed many years ago. Many of these technologies have been out in the market competition, which were not suitable for developing the new energy vehicle industry and restricted the speed and scale of development [14]. In automated driving technology, vehicle electronic control and computing power requirements have been greatly improved, and the electronic and electrical architecture and software algorithms are the core areas.

At present, the global vehicle electronic architecture technology route has become apparent. However, the accumulation of technology among domestic leading engine manufacturers is relatively weak, and they are in the follow-up and understanding stage and lack innovation and application methods. There is a big gap between China and developed countries in the automated driving technology and computing platform, and it is now in the catch-up stage of independent research and development[15]. China still has a large room for improvement in the independent research and development of crucial technology. In addition, semiconductor

products now account for 35% of the cost of automobile manufacturing. Automotive semiconductors are widely used in automotive power control systems, safety systems, and auxiliary driving systems. However, the total output value of automotive semiconductors in China is low, and the industrial scale is small. The total output value of automotive semiconductors in Europe, the United States, and Japan accounted for more than 95% of the world in 2020. The global automotive semiconductor has high barriers. Domestic enterprises are difficult to form scale due to restrictions by foreign technology monopolies.

3.5.2 New energy vehicles have increasing profit pressure with the post-subsidy era.

Financial subsidies for new energy vehicles enable large enterprises to reduce the pressure of shortage on R&D funds and rapidly grow as national and global enterprises. However, many small and medium-sized enterprises have increasing profit pressure with the post-subsidy era. Yuan (2020) mentioned that several new energy automobile enterprises were still in difficulties after receiving subsidies. Among them, FAW Haima Automobile has made huge losses for two consecutive years, Jinma shares have acquired ZOTYE AUTO, and ZHIDOU Electric Vehicle's equity has been auctioned due to huge debts [16]. After the new subsidy policy in March 2019, the sales volume of new energy vehicles has experienced a decline for six consecutive months since the implementation of the policy in July 2019 due to a substantial reduction in the amount of subsidy. The sales volume of new energy vehicles dropped by 4% in 2019, and the overall scale of the industry was far less than that of traditional fuel vehicles.

Vehicle manufacturers downstream of the industrial chain have fierce competition in the industry, with an average gross profit rate of no more than 20% [17]. After the decline of subsidies, vehicle sales declined, and the profit level was further compressed. The decreasing sales volume means that the depreciation of fixed assets, manufacturing costs, and R&D expenses are brutal to cover. Moreover, raw material prices continue to fluctuate. Costs continue to increase, profit pressure rises. Therefore, the scale effect in the new energy vehicle industry is shrinking.

3.6 Suggestions on new energy automobile industry

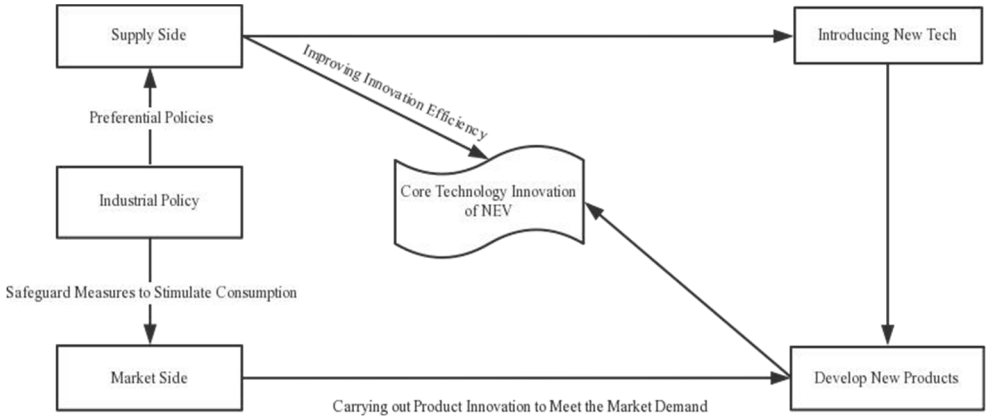
NEV industrial policy supports core technology on the market side and supply side, which plays a supportive role in the development of the NEV industry. With state subsidies and other preferential policies, companies can achieve the purpose of NEV core technology innovation by improving the efficiency of innovation directly or introducing new technologies and developing new products. Meanwhile, the government protects the interests of consumers through a series of political measures such as consumer subsidies and aftersales maintenance to stimulate consumption of new energy vehicles, and companies will carry out product innovations to meet market demand. Table 1 shows the new innovation model of the new energy vehicle. The following gives new energy vehicle development suggestions from the government, industry, and supply-side to promote the technological innovation of NEVs and realize the sustainable development of the NEV industry.

3.6.1 Government insists on the construction of charging piles and charging station layout.

Currently, the government pays more attention to the support of the infrastructure, such as charging stacks, and the number and extent of the charging piles constantly improve and

expand. At the same time, the government has to focus on improving technology to formulate the structural specification of new loading facilities for the energy vehicle and promote the standardization structure. The government needs change the current situation of "emphasis on construction, but the research of maintenance". For the guilt of charging stations, the municipalities need repair and replace them in good time, solve zombie stack and improve the control level.

TABLE 1. NEW ENERGY VEHICLE CORE TECHNOLOGY INNOVATION MODEL



For some districts with good parking conditions, but not loading, the relevant guidelines for improving convenience must be granted. In addition, the separation of vehicles and electricity has become an important trend in the development of new energy vehicles. BAIC New energy and NIO have successfully completed separation sales of vehicles and electricity, which has improved the consumer's intention. The separation method of vehicles and electricity promotes the construction of powerful stations enormously. The government must plan as soon as possible, make a consistent planning in cities and intercity roads and build an economical and comfortable energy center to create a good basis for promoting the separation of the vehicle and electricity. The overall trend of NEV safety studies is increasing, and the development process can be divided into two periods: preliminary (2000 to 2011) and rapid (2012 to present) [18].

3.6.2 Breakthrough bottlenecks in technological advancement by fiscal means.

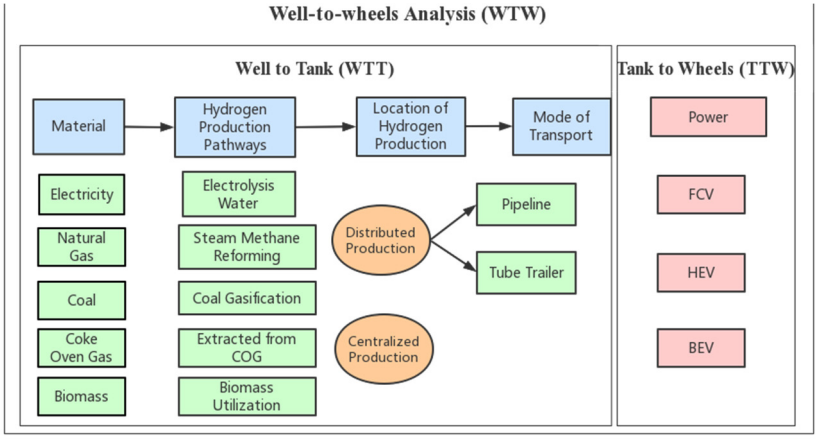
The government should provide targeted subsidies, focusing on developing critical technologies such as autonomous driving technology and automotive semiconductor for new energy vehicles. T[18]o achieve accurate subsidy is necessary to establish the evaluation and screening mechanism of subsidy projects, reducing information asymmetry in the subsidy process. The preferential tax policy should emphasize innovative projects. Moreover, be combined with the current challenging technical projects so that enterprises can enjoy the benefits of preferential tax from the promotion of critical technologies and other fields. Meanwhile, speeding up government guiding funds for emerging strategic industries is beneficial to solve the financing problems for R&D in high-end materials, chips, equipment, and other technologies of new energy vehicles.

3.6.3 Developing Fuel Cell Vehicles，promoting the application of hydrogen energy

Clean hydrogen is the second most important technology, which means that potential 20% of the decarbonization is controlled, especially in industry and heating [19]. Primary energy consumption and greenhouse gas emissions in the vehicle life cycle is the well to wheels (WTW), divided into two phases: well to tank (WTT) and the tank to the wheels (TTW). The former phase analyzes energy consumption and emissions of pollutants from raw material mining stage to the transport process and the latter phase studies energy consumption and fuel consumption in the vehicle processing phase. Picture 8 shows WTW analysis of resource usage and pollutant emissions from different automotive power supply systems. Since (Yang 2020) has detected, hydrogen energy has many advantages,such as the high calorific value of combustion, high efficiency of power generation, clean and contaminating, practical storage and transport, extensive sources, different forms of use, good security performance. The countries have begun the global exploration of hydrogen energy and the industrialization of hydrogen energy realized, accelerated their application in the automotive industry [20]. Lin (2018) found that renewable-energy-based electrolysis of water and biomass gasification are two potential hydrogen production paths, which can help FCVs reduce fossil energy consumption and CO_2 emissions by around 90% more than BVS [21]. However, different production modes and paths have various characteristics, energy consumption, and CO_2 emissions. From China's resource endowment and current technological development, hydrogen production from traditional energy is the direct approach. Furthermore, coke oven gas (COG), the coking product in steel plants, has the best effect on energy conservation and emission reduction. China is the largest COG producer in the world. However, the enterprise recovery rate of COG is low, causing a lot of energy waste and pollutant emissions. Extracting Hydrogen from COG not only conforms to the current situation but also has outstanding resource advantages and climate benefits. However, the top-level design of China's hydrogen energy industry was still insufficient, and there was a lack of overall consideration of sustainable strategy and plan of the whole hydrogen energy industry (Sun, 2020) [22]. The government should participate in the formulation of international standards and conduct active international exchanges and cooperation to promote the professional development and system integration of hydrogen energy, hydrogen fuel cells, and hydrogen energy vehicles.

3.6.4 Automakers should seize the "electric, connected and intelligent" opportunity for industrial transition and upgrading.

Whether they are vehicle enterprises, parts enterprises, cross-border enterprises, they are beneficial to evaluate their positioning and value in the new supply chain to accelerate the pace of transformation and lay a more solid foundation for building a world-class leading automobile enterprise. From the perspective of "electric," it is essential for automakers to increase investment in research and development of power batteries and introduce relevant talents to master the production technology of core parts to reduce production costs and expand production scale to achieve scale effect.



Pic 8: Well-to-wheels Model

Moreover, implement the new energy platform strategy and perfect the platform structure at the same time. As for "connected," under the development direction of networking, the new energy vehicle industry has more comprehensive and extensive requirements on all aspects. Its core competence has changed from traditional mechanical design and manufacturing to emerging capabilities in non-automotive fields as software algorithm research and development. Therefore, higher requirements and challenges are put forward for new energy vehicle enterprises, which need to continuously introduce talents in related fields, build software and algorithm research teams, adjust the team to adapt to the existing R&D process and mode, and build user experience automotive intelligence network. In terms of "intelligent," auto-makers are supposed to accelerate the vertical integration of the electrical system, which reduces the volume and mass, makes the vehicle's layout more convenient, and increases the riding space in the car effectively. Internet development affects the energy consumption structure through economic growth, R&D investment, human capital, financial development, and the industrial structure[23]. In addition, the system's energy loss is further reduced, and the overall efficiency is improved.

Moreover, cooperate globally to improve the standardization level of automatic driving. As advanced automatic driving technology requirements are very similar, the technology can be transferred in different times and spaces between different regions and markets. With its global layout and outstanding professional ability, multinational companies have significant advantages in the structure of automated driving technology. The traditional automobile industry giants are supposed to go out of the "comfort zone" and cooperate with the participants at all levels of the whole value chain and technical structure to ensure the accuracy of the technical elements of automatic driving to meet the arrival of the automatic driving era.

4. CONCLUSION

This article analyzes the current situation with new energy vehicles in China in line with a carbon neutral vision in terms of policy, supply and demand, and finds that many companies in the energy vehicle auto industry are facing declining gross profit rate due to cutting

subsidies. New energy vehicles are becoming more popular with consumers and the information sources influencing their purchase are being updated. It faced many challenges, however, such as product and technology bottlenecks, the arrival of international auto giants, and growing profit pressures in the post-subsidy era. Finally, based on the NEV core technology innovation model, the WTW model, the article presents proposals for the development of the NEV industry from government, industry and enterprises.

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REFERENCES

[1] IPCC. Summary for Policymakers. In: Global Warming of 1.5°C[R].Geneva, Switzerland: World Meteorological Organization, 2018.

[2] Energy Foundation China (2020). “Synthesis Report 2020 on China’s Carbon Neutrality: China’s New Growth Pathway: from the 14th Five Year Plan to Carbon Neutrality.” Energy Foundation China, Beijing, China. https://www.efchina.org/Reports-en/report-lceg-20201210-en.

[3] Zhao, F.; Hao, H.; Liu, Z. Technology strategy to meet China’s 5 L/100 km fuel consumption target for passenger vehicles in 2020. Clean Technol. Environ. Policy 2016, 18, 7–15.

[4] CAAM (2021) Press conference. https://baijiahao.baidu.com/s?id=1688755602093199593&wfr=spider&for=pc

[5] "Notice of the Ministry of Finance, Ministry of Science and Technology, Ministry of Industry and Information Technology, Development and Reform Commission, and National Energy Administration on the "Thirteenth Five-Year" New Energy Vehicle Charging Infrastructure Reward Policy and Strengthening the Promotion and Application of New Energy Vehicles." Ministry of Finance of the People's Republic of China. 03, 37-41 (2016)

[6] Shen Wei, et al. "The Development Status and Prospect of China’s New Energy Automobile Industry." Automobile Applied Technology, 2020, 45(22):239-242.

[7] Chen K, Zhao F, Hao H, Liu Z. Synergistic Impacts of China’s Subsidy Policy and New Energy Vehicle Credit Regulation on the Technological Development of Battery Electric Vehicles. Energies.2018;11(11):3193.

[8] MOF; MIIT; MOST; NDRC. Notice on adjusting and improving the financial subsidy policy for the promotion and application of new energy vehicles.2021 http://bj.mof.gov.cn/ztdd/czysjg/jyjl/202102/t20210222_3660395.htm

[9] Wang Xiaoli, Li Zhiqiang, Shaikh Ruqia, Ranjha Adeel Riaz, Batala Lochan Kumar. Do government subsidies promote financial performance? Fresh evidence from China's new energy vehicle industry [J]. Sustainable Production and Consumption, 2021 (prepublish):

[10] Fuquan Zhao, Kangda Chen, Han Hao, Sinan Wang, Zongwei Liu. Technology development for electric vehicles under new energy vehicle credit regulation in China: scenarios through 2030 [J]. Springer Berlin Heidelberg, 2019,21(2):

[11] Tian Xueqing, Zhang Qingling, Chi Yuzhu, Cheng Yu. Purchase willingness of new energy vehicles: A case study in Jinan City of China[J]. Regional Sustainability,2021,2(1):

[12] McKinsey & Company. "2021 McKinsey Automotive Consumer Insights." (2021)

[13] CAAM. "Annual Report on the Development of China Automotive Industry (2021)." 2021

[14] Xie Pingping. "Strategic Thinking on the Development of China's New Energy Automobile Industry." China Business Forum .36, 131-132 (2016)

[15] Yanfei Li, Qiang Ji, Dayong Zhang. Technological catching up and innovation policies in China: What is behind this largely successful story? Technological Forecasting & Social Change,2020,153.
[16] Yuan Bo. "Research on the Development of China's New Energy Automobile Industry in the Post-Subsidy Era." Regional Economic Review .03,58-64 (2020)
[17] Roland Berger. "China new energy vehicle supply chain white paper (2020)" (2020)
[18] Wang Han, Liu Hui, Yao Jieyu, Ye Dong, Lang Zhihui, Glowacz Adam. Mapping the knowledge domains of new energy vehicle safety: Informetrics analysis-based studies[J]. Journal of Energy Storage, 2021,35:
[19] The Goldman Sachs Group, (2020) Carbonomics China Net Zero: The clean tech revolution. https://research.gs.com.
[20] Yang Zhihuang, and Yang Nanlong. "Main directions for the development of my country's hydrogen energy vehicle industry." Open Herald .01, 99-103 (2020)
[21] Lin Ting, et al. "Well-to-Wheels Fossil Energy Consumption and CO2 Emissions of Hydrogen Fuel Cell Vehicles in China." Environmental Science. 2018, 39(08):3946-3953.
[22] Sun Yuling, et al. "Analysis of Global Hydrogen Energy Industry Development Strategy and Technology Layout." World Science and Technology Research and Development 42(04), 455-465 (2020)
[23] Ren Siyu, Hao Yu, Xu Lu, Wu Haitao, Ba Ning. Digitalization and energy: How does internet development affect China's energy consumption? [J]. Energy Economics, 2021