Analysis of challenges and opportunities in the development of new energy vehicle battery industry from the perspective of patents

Xiumei Tan a and Tianyu Li b, *
Law School, Shenzhen University, 518060, China.

a 175269668@qq.com, b Corresponding author email: 2017031236@email.szu.edu.cn

Abstract. Thanks to China's "three verticals and three horizontals" strategy and the important deployment of new energy policies, the new energy vehicle industry has developed rapidly. The rapid development has also led to some problems. From a macro point of use, patent is an important index to reflect the technological innovation of the industry, which can provide reference for the long-term development of the industry. From the microcosmic point of office, patent is the embodiment of the strength of research and development and core competitiveness of an enterprise, and is the weather vane of its innovation layout. Therefore, this paper will use patent analysis method, collect domestic 2002-2019 new energy vehicle patent data, analyze the current situation of China's new energy vehicle industry technology innovation from China's new energy vehicle patent application number, patent application trend, patent technology features, patent application geographical distribution, patent application body and other dimensions, comprehend the automotive industry in the face of new challenges and opportunities in the process of new energy vehicle transformation, and provide some ideas for the development of China's new energy vehicle industry on the basis of analysis of relevant issues.

Key words: New energy; Patent; Industry.

1. Statement of Issues
New energy vehicles refer to the use of unconventional vehicle fuels as the power source (or the use of conventional vehicle fuels, the use of new on-board power devices), the integration of advanced technologies in vehicle power control and driving, and the formation of advanced technical principles and cars with new technology and new structure. There are currently three types of new energy vehicles commonly used on the market, hybrid vehicles, pure electric vehicles and fuel cell vehicles. In order to vigorously develop the new energy automobile industry, in June 2012, the State Council issued the "Energy-saving and New Energy Vehicle Industry Development Plan (2012-2020)". Under the influence of the policy of strengthening the country with science and technology, China's new energy vehicle industry has developed rapidly. While developing rapidly, the new energy vehicle industry is also facing some opportunities and challenges. Patent is an important evaluation indicator of technological innovation. This article will start from the perspective of patent analysis, analyze and grasp the
sustainable development direction of the industry, and put forward some suggestions for the problems existing in the current industrial development.

2. Analysis on The Development Trend of Chinese New Energy Vehicle Industry

2.1. The Number of Patent Applications Accelerates Year by Year

This article selects China's new energy vehicle technology innovation patent applications in the past 20 years from 2002 to 2019 (Figure 1). From the figure, it can be found that the development of China's new energy vehicle technology innovation network can be divided into: strategic planning stage (2001-2008); market introduction stage (2009-2015); Comprehensive growth stage (2016 to present). In 2001, China launched a major scientific and technological project for new energy vehicles, forming a "three vertical and three horizontal" development pattern. [1] The new energy vehicle industry is developing rapidly. In 2008, the number of related patents increased year by year due to the influence of policies such as the power of science and technology. After 2008, it was a period of rapid development of the new energy vehicle industry. In 2015, China basically established the formation of the basic technical system of "three verticals and three horizontals" for electric vehicles. On December 3, 2019, the Ministry of Industry and Information Technology issued a public consultation on the "New Energy Vehicle Industry Development Plan (2021-2035)" (Draft for Solicitation of Comments), which will usher in a new development period for the new energy vehicle industry. The number of China's new energy vehicle technology innovation patent applications in the past 20 years from 2002 to 2019 is given in Fig.1.

![Fig 1. The number of China's new energy vehicle technology innovation patent applications in the past 20 years from 2002 to 2019](image)

Note: Due to the time required for patent disclosure, it is normal for the number of patent applications to decline in 2019.

2.2. Regional Development of New Energy Vehicle-related Companies Is Uneven

Due to the different levels of economic development in various regions, the registration volume of new energy vehicle-related companies also presents an uneven situation (Figure 2). Generally speaking, regions with more developed economies have registered new energy vehicle-related companies. According to the data from the enterprise investigation, there are 190000 new energy vehicle-related enterprises in China. In terms of geographical distribution, Guangdong Province has the largest number of related companies, followed by Jiangsu Province and Shandong Province. In general, the number of related companies in coastal areas is greater than in inland areas. The number of New energy vehicle-related company registrations is given in Fig.2.
2.3. Patent Application Status of Main Patent Applicants

The research and development subjects of new energy vehicle patents are diverse. The research and development subjects are mainly universities, enterprises, scientific research, and organizations. However, enterprises are the main research and development subjects, and enterprises account for two-thirds of the total research and development subjects. The new energy vehicle industry has two development models: private enterprises and state-owned enterprises. Compared with private enterprises, state-owned enterprises have more core patents, more funds, and greater advantages. However, private enterprises respond faster to the market, and relevant strategic adjustments can better adapt to market needs. Proportion of R&D personnel for new energy vehicle patents is given in Fig.3.

2.4. The Direction of Technology Research and Development Is Mainly Concentrated in the Field of Power Batteries

In general, the power battery system is a very critical part of the development of new energy vehicles. New energy vehicle patented technology is mainly based on the growth of power battery systems. The development of new charging technologies such as wireless charging in the middle of the industrial
chain, smart technology in the downstream of the industrial chain, and battery recycling are all extremely slow. This is important for China’s future new energy vehicles. The technological innovation and sustainable development of the industry will have a certain negative impact. [2] Although the trend of patent applications for general technology of new energy vehicles is showing a continuous upward one, but the technical bottleneck has not been broken in the key technologies of the whole vehicle part and core components, and there is still a big gap with the international leading level. Situation of technology research and development direction is given in Fig.4.

![Fig 4. Situation of technology research and development direction](image)

### 3. Challenges of Patent Development in New Energy Vehicle Industry

Under the guidance and support of the Chinese government, the new energy vehicle industry is showing a trend of rapid development, which benefits from a series of policy support in China. However, some problems and challenges also appeared in the process.

First of all, in the field of hybrid electric vehicles, although China is one of the largest markets for hybrid electric vehicles, it has almost no performance in its main technical direction and lacks core patents. This is mainly because the hybrid electric vehicle field has been occupied ahead of time by companies in powerful vehicle countries such as Japan and Germany. China has achieved some patent breakthroughs by relying vigorously on developing plug-in hybrid electric vehicles. [3] The regional development of new energy vehicle patents of enterprises is uneven, and the distribution of new energy vehicle patents is uneven. At present, Chinese main patents are concentrated on technologies such as motors and electronic control, while core technologies such as battery life, battery recycling and smart technologies are still slightly lacking. Secondly, due to differences in the level of regional economic development, both the number of registrations of new energy vehicle-related companies and the number of patents owned by companies show an uneven regional distribution. Finally, the cooperation and gathering effects are not prominent. It can be seen from the above figures that the research and development personnel of the new energy vehicle industry include enterprises, universities and scientific research institutions, but the cooperation between universities and research institutes, or cooperation between universities and enterprises is rarely seen. These research personnel can strengthen cooperation with scientific research institutions and universities, make full use of the advantages of all parties in industry, university and research, and strengthen the ability to transform cooperation results. [4].
3.1. New Energy Vehicle Technology Patent Strategy Suggestions

Promote the research and development of common technologies in the new energy vehicle industry. Common technologies mean that such technologies can be used as key technologies in multiple fields to restrict the development of this field, and can promote the progress of the comprehensive technical field by promoting the development of this technology. [5] The research and development of new energy vehicles is crucial to the development of the new energy automobile industry, and the amount of research and development funds that need to be invested is not affordable by ordinary enterprises. The government can give appropriate financial support to support the research and development of such technologies and drive the development of the entire industry.

Vigorously promote the process of patent industrialization. From the above analysis, it can be seen that some of the new energy vehicle technology patents are held in universities or research institutes. If the cooperation between universities and enterprises can be promoted, universities can use their own patented theoretical advantages, and enterprises can use their own capital and facility advantages to integrate the resources of the two, which can improve the efficiency of industrial chain integration in the process of technological industrialization.

Strengthen the research and development capabilities of core technologies and cultivate relevant research and development talents. The essence of competition in the new energy vehicle industry is the competition of core patents. Through the above analysis, we can see that Chinese enterprises as a whole lack the research and development capabilities of core patents, the efficiency of patent achievement transformation is low, and there is no good integration mechanism of production, education and research. Most of the existing patents are improvements or extensions of existing technologies, and there are few substantial improvements to core patents. Universities and other R&D institutions should also take part of the responsibility of cultivating relevant talents, making breakthroughs in existing core patent gaps and seizing relevant markets. Make plans for China's new energy auto industry's leading position in the world.

Strengthen inter-regional cooperation and promote the common development of all regions. From the above data, it can be seen that the patent authorization of new energy vehicles varies greatly from region to region. Due to the uneven economic development in various regions, the development of the new energy automotive industry is also uneven. In order to make full use of our country’s rich regional resources, the government should allocate market resources reasonably and flexibly, take high-speed development areas as the leader, establish new energy vehicle industry clusters, use the technological advantages of high-speed development regions to drive low-speed development regions, and guide each region to exert regional advantages. Adjust measures to local conditions, learn from each other's strengths, and work together to promote technological innovation and progress in new energy vehicles. [6]

4. Conclusion

Patent is an important indicator of technological innovation in emerging technologies and knowledge-intensive industries. The essence of competition in the new energy automobile industry is also a dispute over technology, standards, and paths. Cultivating and developing the new energy vehicle industry is an urgent task to alleviate the dual pressures of energy and environment, promote the transformation and upgrading of the automobile industry, and realize sustainable development. It is also an urgent task to cultivate new economic growth points in the future, seize the commanding heights of a new round of technological and economic development, and enhance international competition, which are strategic moves. Therefore, Chinese electric vehicle industry should pay more attention to new energy battery technology, gradually improve its own research and development capabilities, and promote the common progress of our society and science and technology.

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