

## ANALYSIS OF PATENTS INFORMATION IN THE ELECTRIC VEHICLE TECHNOLOGY OF CHINA

WU FEI-FEI;HUANG LU-CHENG

SCHOOL OF ECONOMICS &amp; MANAGEMENT, BEIJING UNIVERSITY OF TECHNOLOGY, P.R.CHINA,

**Abstract** In order to hold Olympics in 2008, the Chinese government puts forward the concept of “High-Tech Olympics”, and implements “Technology Action Plan for Olympics (2008)” which have fund many researches projects. Beijing municipal S&T Commission and National natural science foundation of China have funded hundreds of researches projects. Being one of the most important areas, the electric vehicles research has got lots of achievement. Based on relative information collected from Olympic electric vehicle projects with project principals as keywords, this paper searched patents of Olympic electric vehicle from SIPO<sup>[1]</sup> and analyzed the parents information such as application time, technology domain, legal-status information, and citation information, then put forward some suggestions for facilitating to commercialize these patents. These suggestions may be help for development of electric vehicle industry.

**Keywords** Electric Vehicle, High-tech, Patent, Technology Commercializing

## 1 Introduction

Since bidding Olympic game successfully in 2001, Chinese government have invested large amount of R&D sources into 12 areas for instance, ICT, environment protection, new material, in order to hold a perfect Olympic game and realize its high-tech Olympic permit. And it is essential for the government to permit production of clean-fuel vehicles, making electric vehicle one of the most important research domains, which could facilitate to realize Green Olympic permit. Jawad Faiz and M. B. B. Sharifian proposed in Optimal design of an induction motor for an electric vehicle<sup>[2]</sup> that electric vehicles could help to solve pollution and noise problems caused by petrol driven autos. C.C.Chan and K.T.Chau pointed out serious environment and energy problems aroused scholars' interest in electric vehicles<sup>[3]</sup>. GE auto pushed its first electric vehicle into market in the early 1900s<sup>[4]</sup>. Toyota started to research electric vehicles in 1971 and developed a serial of products from EV10 to EV40 style between 1983 and 1989<sup>[5]</sup>. Practical experiences achieved from market operation remind us that support of government policy is indispensable for the development of electric vehicles. Long Wei and Lili Wu introduced supporting policies and development programs made by USA, Japan, France and German government in another article revelation to China from development process of electric vehicles industry in developed countries<sup>[6]</sup>. Xiang Fu, Ningning Wang and BinXiang Hu listed and compared economic incentives, R&D policies and marketing policies in United States, Japan and European countries in their book study on foreign promotion policies in electric car industry<sup>[7]</sup>. Chinese government also has great investment in researching electric vehicle technologies. One billion Yuan was invested by government and another 1.4 billion Yuan was poured by local government and enterprises, illuminating from major science and technology special plans for electric vehicle industry<sup>[8]</sup>. As a key research area in High-tech Olympics, electric vehicles domain has received sufficient financial support. And how could these kind of support be applied should be well analyzed and summarized. At the same time, in order to improve China's independent R&D and production capacity, it is necessary to analyze patents resulted from government support. Markman, through empirical studies on 85 companies, found that patents are valuable, scarce, irreplaceable and irreplaceable resources<sup>[9]</sup>. And analyzing these irreplaceable resources became an important step to determine the corporate strategy<sup>[10]</sup>. Japanese scholar Chihiro Watanab considered patent data, in particular, inventions and citation information analysis, could provide important information for decision-making support<sup>[11]</sup>. Indian scholar Biju Paul Abraham thought information achieved from Indian patent data analysis could help to assess technological progress and innovation fields for strategic planning<sup>[12]</sup>. Consensus have been reached by many scholars that patent data information could be used to crack economic growth, technology development problems and make R&D strategy, technology management strategies and so on<sup>[13][14][15][16]</sup>.

In a certain period of time, different channels of investment in science and technology can result to a substantial patent output. In this paper, basic patent data achieved in the field of High-tech Olympic electric vehicle domain were analyzed, which could contribute to summarize input and output in field of

High-tech Olympic electric vehicles and understand Chinese electric vehicle technology development process. Our purpose is not to research and develop electric vehicles for Olympic Games hosted In Chinese, but transfer ‘High-tech Olympics’ into ‘Olympic science and technology’<sup>[17]</sup>, and industrialize ‘Olympic science and technology’.

## 2 How to Get Data of the Electric Vehicle Patents

First, materials of relative projects are collected from the ministry of S&T of China, Beijing municipal S&T Commission and National natural science foundation of China etc. Project cards are made from these materials. Then, 30 relative projects in electric vehicles domain were picked out from about 1000 projects. According to information on project principals, 111 patents are found out in State intellectual Property Office of China between 2002 and 2007. From the perspective of researchers revolved in High-tech Olympic electric vehicles projects, most of them are charged by universities and research institutes. Therefore retrieved patent applicants are universities and research institutes primarily. However, with development in electric vehicles industry, corporations have poured increasing investment. Changan motor, Dongfeng motor, Chery, FAW group have also done many R&D jobs and achieved many patents. This part of patents will be analyzed in other papers.

## 3 Content of Analyzing Patents Information of the Electric Vehicle Patents

### 3.1 Patented Application Time

After bidding Olympic successfully, Chinese government started to set up electric vehicle domain as research object. And 111 patents are retrieved between 2002 and 2007. Fig 1 shows its distribution with time.

Fig 1 shows except that number of application decreased slightly in 2003 and data in 2007 is affected by time lag of patent applications, the number of patents application is increasing gradually.

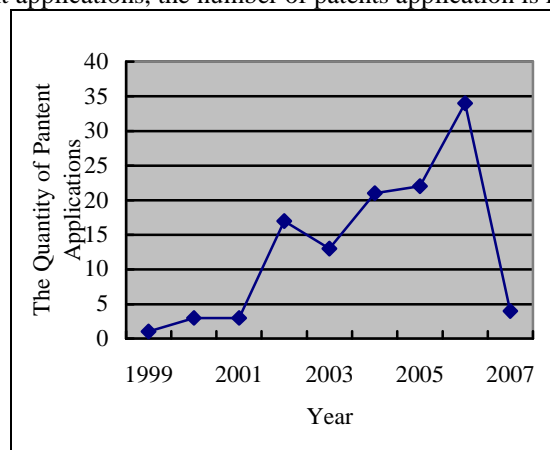


Fig.1 Application time of electric vehicles patents

A booming increase occurred in 2006, which resulted from that most of the 30 projects analyzed applied since 2003. Jianrong Li in his patent information and usage once used B60L as retrieval words, which is IPC number of main technology domain in electric vehicles, to summarize patent application number In Chinese between 1985 and 2005 and analyze electric vehicle technology life cycle (Tab 1). Because of different retrieval samples and key words, the number of patents can not be compared, but the rapidly increasing trend after 2000 is quite obvious, convinced a close relationship with great investment of High-tech Olympic and Green Olympic promise.

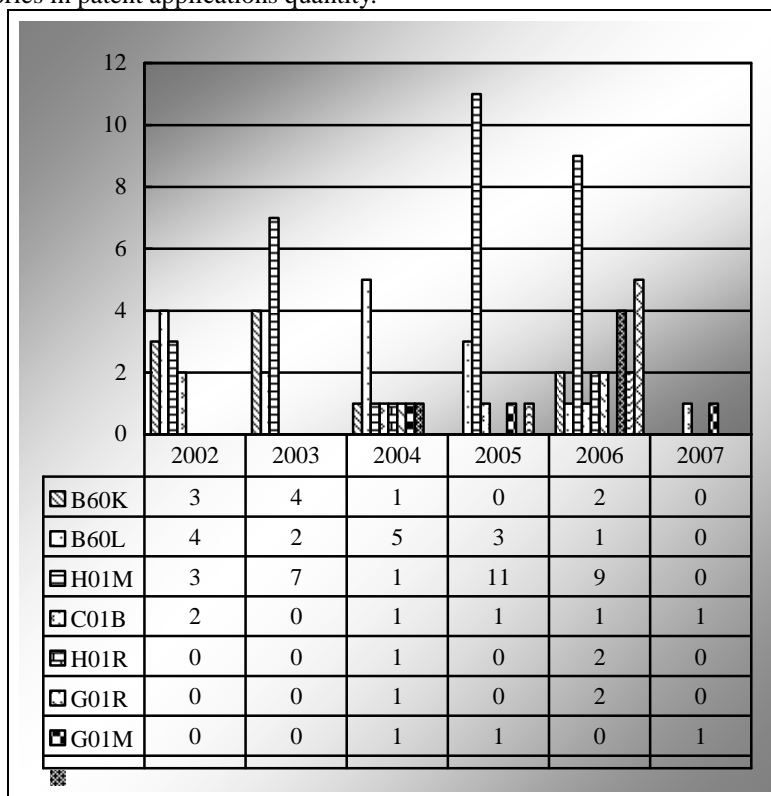
Tab.1 The quantity of patent applications of Chinese electric vehicles ( Year 1985-2005 )<sup>[18]</sup>

Year	The quantity of patent applications	Year	The quantity of patent applications
1985	5	1996	36

1986	14	1997	67
1987	19	1998	35
1988	42	1999	94
1989	31	2000	187
1990	30	2001	187
1991	49	2002	174
1992	33	2003	304
1993	42	2004	294
1994	37	2005	139
1995	36		

### 3.2 Patent Technology Domain

The International Patent Classification (IPC), established by the Strasbourg Agreement 1971, provides for a hierarchical system of language independent symbols for the classification of patents and utility models according to the different areas of technology to which they pertain. Utility models of technology classify technology themes according to intrinsic characters and functions. For examples, B25J represents robots technique and H03K represents Pulse technique<sup>[19]</sup>. 29 technology categories were involved in patents from high-tech electric vehicles domain according to IPC. Fig 2 gives top 10 technology categories in patent applications quantity.



**Fig.2 Patent technology categories**

As shown above, H01M, B60L and B60K technology category have large cumulative amount of patent applications. H01M represents Battery technology, containing batteries, fuel cells and battery charging technology; B60L represents power plant equipment technology of electric vehicles for vehicle magnetic suspension and regular motor power brake system; B60K represents arrangement or installation of vehicles power devices and Gear devices, more than two different layout or installation of the original motivation and combining arrangement of vehicle power plant, cooling, air intake, exhaust or fuel supply etc.

Yan Chen studied electric vehicles technology in Anhui Science & Technology, 2003(9), research patent technology development trend with patent intelligent and pointed out that currently, key technologies in electric vehicles domain are battery technology containing lead-acid batteries, fuel cells, as well as hydrogen fuel cell technology and energy storage system technology; motor technologies, including motor speed or torque control technology and start-up technology, and mechanical and electrical converter technology; dynamic controller technology; Energy management and system control technology; Battery charge and discharge technology; Emission control technology<sup>[20]</sup>.

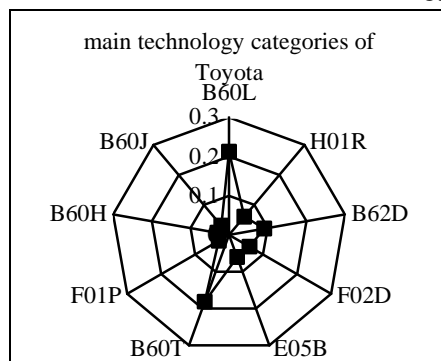
Electric vehicle technology is mainly possessed by Toyota and General Electric Company, because numbers of their electric vehicles patents held rank far ahead of other corporations (Tab 2).

**Table 2 Significant EV patent owning companies<sup>[21]</sup>**

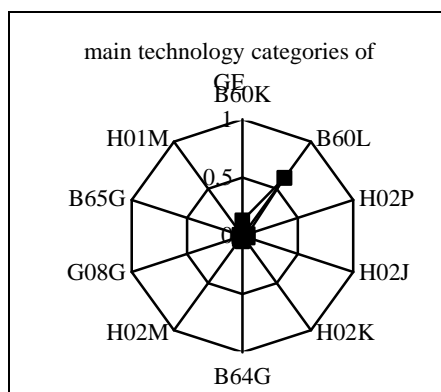
Assignee company	Number of patents held
Toyota Jidosha Kabushiki Kaisha	24
General Electric Company	14
Mitsubishi Jidosha Kogyo KK	5
Ford Motor Company	4
Nippondenso Co.Ltd.	4
Nissan Motor Co. Ltd.	4
Aisin Aw Co. Ltd.	3
Daimler-Benz AG Chrysler	3
Fuji Electric Co.Ltd.	3
General Motors Corporation	3
Honda Giken Kogyo Kabushiki Kaisha	3
Lucas Industries Limited	3
Newport News Shipbuilding and Dry Dock Company	3
USA Government	3
ABB	2
Brunswick Corporation	2

Isuzu Ceramics Research Institute Co.Ltd.	2
Kabushikikaisha Equos Research	2
Kvaerner ASA	2
Mannesmann Aktiengesellschaft	2
Nippon Soken Inc.	2
Seiko Epson Corporation	2
Shinko Electric Co.Ltd.	2
SMH Management Services AG	2
Tokyo Shibaura Electric Company Ltd.	2
Westinghouse Electric Corp.	2
Zebco Corporation	2

Main technology categories of Toyota and GE could be retrieved by searching patents with these two companies as applicant and electric vehicles as key word (Fig 3 and 4). Technology categories of Toyota lie in B60K, B60L and B60T, while B60L and B60K are technology categories of GE.



**Fig.3 Main technology categories of Toyota**



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**Fig.4 Main technology categories of GE**

Yan Chen compared internal and external key technology domains in research patent technology development trend with patent intelligent and found key domain of electric vehicles in foreign countries also concentrate in Vehicle power supply technology (B60L1/00, B60L1/02 and B60L1/14 etc.), Use of vehicles inside and outside of the electric traction power supply technology ( B60L11/02, B60L9/00, B60L11/00, B60L11/18, B60L11/12 etc. ), Power controller technology ( B60L7/00, B60K1/00, B60L15/20, B60L7/10 etc. ) battery technology ( H01M10/46, H02J7/00, B60R16/04, H01M10/44 etc. ) and electric motor technology ( H02P7/00, H02P1/00 etc. ), which are almost the same as domestic situation. But among foreign patents, proportion of rechargeable battery pack ( H02J7/00 ) technology and storage battery technology ( H01M10/46 ) were booming up to the top rank ; foreign institutes took more proportion in use of vehicles within the electric traction power supply relative technologies ( B60L11/02 ) than domestic institutions. To be the most important of all , motor control technology ( H02P7/00 , H02P1/00 ) and Electric conductive connection technology etc. ( H01R13/64, H01R4/60 ) have been poured a lot of resources in developed countries, which should arouse domestic corporations' attention<sup>[22]</sup>.

We could draw a conclusion that researching direction is coherent with international developing trend, which is advantageous for domestic corporations to master technology frontier in coming years.

### **3.3 Analysis of Legal Condition for the Patent**

In a further analysis of 111 patents retrieved, 89 invention patents make up 80%, while 22 utility patents make up 20%. There are 43 licensing invention patents, making up 48%; 21 patents are published and withdrawn later, taking up 24%; 22 of them passed substantive examination and finally took effect, taking up 25%; 3 patents are forced to be terminated, taking up 3%. 19 patents are licensing utility patents, making up 86%; 3 of them are forced to be terminated.

Our analysis of the legal condition for the patent is benefit for deciding how to obtain a return from the research we have done. For the licensing patent, it seems the patent assignment is a good way to gain payback; but as long as the patent are deemed to be withdrawn (not apply to reissue) or to be terminated, the technical knowledge are known to the public, which means we can get nothing from patent exchange. Nevertheless, the market value of the technologies may still exist, and thus invalid patent is also an information resource corporation could use to develop itself. When the corporation tries to take advantage of the open technology, the research staff could be the technical conductor. in which could promote more return from resources paid already by government and corporations. For instance, the IPC H01M2/02 is the method or device to convert the chemical energy into electrical energy, e.g. the battery box or cover, the structural parts or manufacturing methods of non-active components in battery pack. In the 111 patents, 31 patents related to H01M and 6 of them are classified into H01M2/02, withdrawn after publishing. After a further study of these patents, the innovative technology may improve efficiency and performance.

### **3.4 Analysis of the Quotation Condition of the Patent**

89 patents are invention, and 43 of them obtained patent right. These 43 authorized invention patents were further analyzed by patent number in the database of European Patent Office. We found that among the 43 patents only 4 have been quoted, making up 9.3%, and 27 of them have quoted from others, making up 62.8%. The patents cited included 32 from Japan, 26 from USA, 54 from China, 1 from England, 1 from European Patent Office, and 1 from World Intellectual Property Organization. Innovations in High-tech Olympic field of Electric vehicle technology didn't create enough patent results and need further improvement. While many patents referred to innovation results of Japan and USA, reflecting in the field of electric vehicles Japan and the United States have certain technical advantages. Of course, big number of self-cited could convince to a certain extent that we have strong independent innovation capability and good outcome in the High-tech Olympic electric vehicles domain. If the citation of citations could continue to be analyzed, we can find the technical roadmap of independent innovation. But such work is not discussed in this paper because of space restriction.

## **4 Suggestions for Electric Vehicle Commercializing**

Patent is an important indicator which could point out direction and level of technological

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development. In addition, patent information can facilitate to make strategy for technological R&D and industrialization. So, we put forward some suggestions for electric vehicle commercializing as follows based on analyzing Electric vehicle patents

(1) Overall, number of patents has a steady increase between 2002 and 2006 in High-tech Olympic electric vehicles domain, indicating input of High-tech Olympic investment have achieved a visible effect, as a solid foundation for industrialization of electric vehicles. Therefore, relevant institution and industrial policy need to be promulgated in time from governments. According to experience of industry development in other countries, support of government plays an important role in promoting R&D and market exploring. And high standard request of green environment could maintain long-term progress in electric vehicle domain.

(2) Domestic patent technology catalog in High-tech Olympic electric vehicle domain have kept in line with international frontier, indicating key problems in process of electric vehicles industrialization become clear and visible. Thus, one who achieves more patents and technology breakthrough in key technology catalog will gain priority in industrialization of electric vehicles. This kind of situation stimulates us to seek how to focus on technological advantages, synergic operations and strive to obtain initiative in the development of electric vehicles in short term.

(3) Legal status of patents in High-tech Olympic electric vehicle technology domain shows that invention patents stand in a dominant position. And invention patents could profit corporations from transferring and execution in R&D process. Thus, further study should be taken in this domain on how to optimize organization profitable form in broad profit space.

(4) From analysis of usage on patents in High-tech Olympic electric vehicle domain, application of domestic patents is quite limited, while citation frequency of Japanese and American patents maintains in a high level, implying a wide gap exists between domestic technology level of electric vehicles and foreign technology level. Based on this large gap, domestic enterprises and research institutions engaged in electric vehicle research and development should strive to improve technology advantage in electric vehicle domain and grasp the forefront of international research and competitor's patent strategy through analysis on existing electric vehicle patents, in order to determine the direction and path of development, and ultimately achieve more independent intellectual property rights with high-quality. At the same time, government should also pay attention to research of utility patents.

## 5 Conclusions

Although input of High-tech Olympic electric vehicle domain has achieved many patent results, triggered innovative activity in field of electric vehicle and support the process of industrialization, technology advantage of domestic patents stays low and many technical problems are still waiting to be solved. In order to promote technology development and industrialization of electric vehicles, effective countermeasures and suggestions should be studied and implemented from national industrial policy level, electric vehicle industry level, as well as the level of enterprises respectively.

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