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Patents and progress; intellectual property showing the future of electric vehicles

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Short Abstract

This paper uses patenting activity to shed light on worldwide innovation trends in the electric vehicle industry. Using the patent publication collection of the European Patent Office (EPO), the authors present an analysis of worldwide patenting activity covering technologies in and around electric vehicles. They confirm that Europe is an important market for electric vehicle technologies and present options for gaining high-quality patent protection in the region.

Keywords: market, incentive, EV, HEV, PHEV

1 Introduction

Electric vehicles (EV) embrace a huge range of technologies including vehicle architecture, new components, e.g., electric motors, batteries, etc., and new infrastructure, e.g., related to charging. Those working in rapidly expanding, active technological fields such as electric vehicle technologies have to make decisions at an early stage when developing new products, taking into account the activities of the worldwide competitors. They also have to identify, early on with a high degree of certainty which innovations are real, in order to avoid financing projects that have no future.

Patenting is a key element of the innovation strategy for industrial players in any of these areas as it offers an efficient way of protecting inventions, offering a 20-year right to stop anyone from practicing the protected invention without prior agreement. As a counterweight the inventions are made available to the public in the form of published applications disclosing the invention, embodiments of the invention, and the scope of the claimed protection. An early search in patent databases can reveal similar work, and help companies avoid duplicating work already done elsewhere. Analysing worldwide patenting activity can allow innovators to identify growth areas, and niches of opportunity, and it can highlight competitors' R&D behaviour.

In this article, after disclosing the used methodology, the authors offer an analysis of worldwide patenting activity covering technologies in and around electric vehicles per country.

2 Used Methodology

The first step of the study is to define a relevant data set for performing the analysis. Subsequently, patent classifications systems as a way to extract data relevant to specific technical areas is briefly explained.

2.1 Patent data

Worldwide patent data – compared to other publications as for example scientific papers – is remarkably well harmonised and is therefore particularly suitable for statistical analyses on a global or pan-technological level. The European Patent Office (EPO) maintains what is possibly the world's largest patent database, bringing together more than 90 million patent documents worldwide [1].

The information presented in this article has been largely obtained by using PATSTAT [2], a sophisticated statistical analysis tool of bibliographical and legal status patent data using the European Patent Office database (PATSTAT Edition 2015 Autumn Edition – Amended, database snapshot of DOCDB from 2015 week 31).

2.2 Patent classification

One of the reasons which render patent data a unique source of information with respect also to the specific area of technology it is treating, is the use of patent classification schemes. The classification codes, which are attributed to the patents, make it possible to analyse technologies at varying levels of detail. As a result, patents can be used to compare whole industrial sectors to each other, or at the other end of the scale, examine exactly which details of a particular field are growing or receding, and which companies/individuals/academic institutions dominate innovation on a very specific level.

2.1.1 Classification schemes

Different classification schemes exist and are maintained by respective patenting authorities. However, there are two main classification schemes used at the international level, namely the Cooperative Patent Classification (CPC) [3] scheme, which was jointly introduced by the EPO and the US Patent Office (USPTO), and is since being adopted by further patenting authorities, and the International Patent Classification (IPC) [4] scheme, which is maintained by the World Intellectual Property Organisation (WIPO).

While the CPC scheme offers a better granularity in terms of identification of relevant technological fields compared to the IPC scheme, the IPC scheme offers a wider coverage in terms of patenting authorities using it.

To ensure a complete geographical coverage for their study, the authors decided to use classification codes of both schemes to define the relevant set of data for their analysis.

2.1.2 Relevant classification codes for electric vehicles (EV)

In this paper, the following classification codes have been considered using the CPC scheme as well as the IPC scheme: B60L, B60K6/20 and B60W20. The study is thus considering most of the patent applications relating to propulsion of purely electric, hybrid and plug-in hybrid vehicles, as well as patent applications of other electric vehicle (EV) specific components including charging equipment. The study is also, in part, considering patent applications relating to batteries, as long as the focus of the invention is on the integration of these batteries in the electric vehicles. Batteries in general are covered by other CPC and IPC classification codes, which are not used for this analysis. These covered technological fields will be referred to in the rest of the article as “EV fields”.

2.1.3 Other classification codes used in this study

To identify innovation related to the automotive sector in its entirety, including the vehicles solely propelled by internal combustion engines, the statistical classification of economic activities in the European Community, commonly referred to as NACE (for the French term *"**n**omenclature statistique des **a**ctivités économiques dans la **C**ommunauté **e**uropéenne"*) in its current version 2 [5] is used to identify the relevant classes (CPC and IPC). More precisely NACE 2 code 29 – Manufacture of Motor Vehicles, Trailers and Semi-Trailers – is used to cover the whole automotive sector. Finally, classification code F02B (CPC and IPC) is used as representative of innovations in combustion engines.

2.3 Measure of the patenting activity

The patenting activity has been measured in this study by looking at the number of annual publications of patent applications and granted patents having the requested classes in the EPO Patstat database.

3 Detailed analysis of patenting activity in and around electric vehicles

In this section, different analyses are carried out in order to illustrate the development of patenting activities in the field of electric vehicles over the past years, to identify the relevance the related R&D activities have in certain regions, and to investigate the availability or lack thereof of the documentation in other regions or languages.

3.1 Importance of electric vehicle development in the automotive industry sector

In a first step, it is tried to highlight the growing importance of R&D activities concerning electric vehicles with respect to classical vehicle, being solely propelled by internal combustion engines.

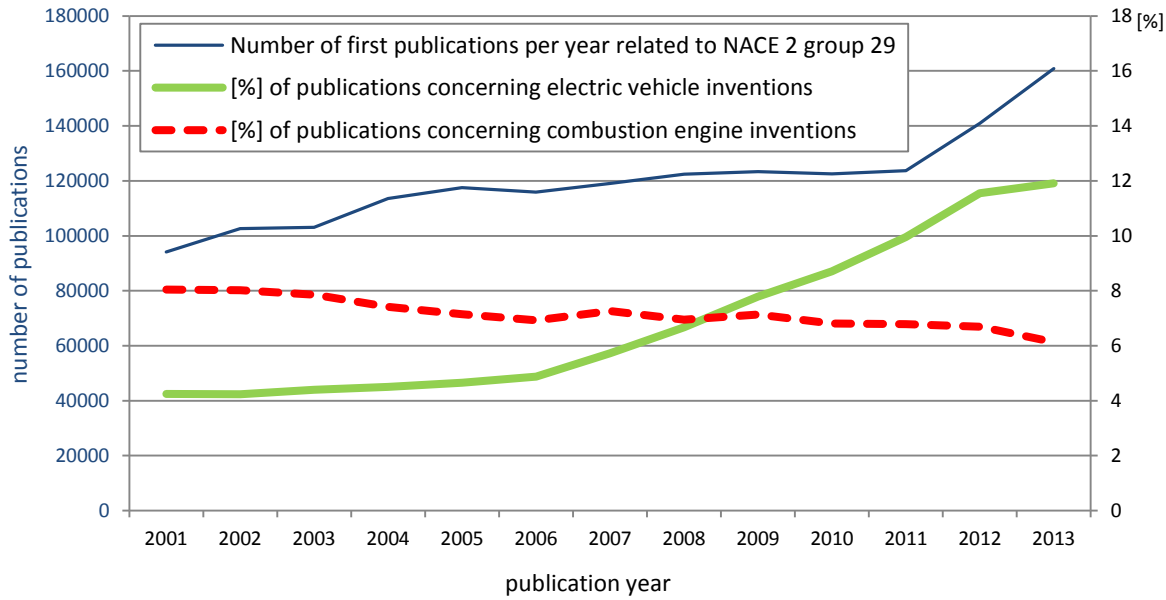

Figure 1: Number of first publications (applications and patents) per year

Figure 1 shows that worldwide patenting activity in the technological fields corresponding to the automotive industry sector is increasing yearly, passing from less than 100,000 first publications (applications and patents) annually in 2001 to more than 160,000 in 2013, see the blue bold trace uppermost in Figure 1.

Note, that the number of first publications is used, i.e., if the same application has been published several times by the same publication authority, e.g. once during examination and once at grant stage, only the first publication is counted.

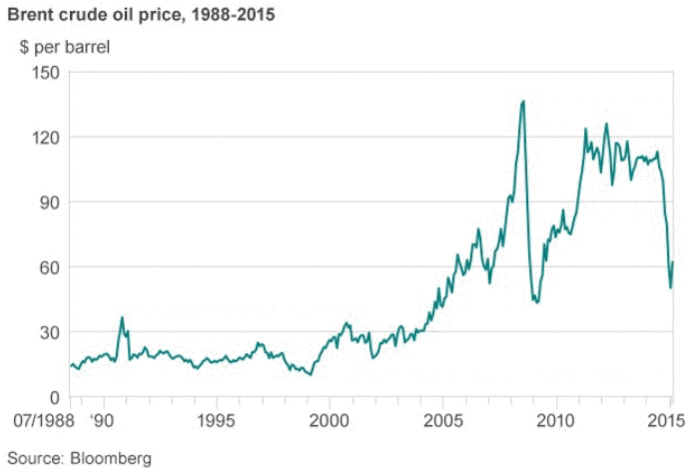

Figure 2: Development of the crude oil price, 1988-2015

Analysing the share of these publications relating to electric vehicle technologies and being classified in the "EV fields" reveals a steady growth over the years from 4% to close to 12%, see the green bold trace that starts as the lowest trace in 2001 in Fig. 1. This finding is even more noteworthy, since the oil price, which is frequently considered as a major driver for innovation in the electric vehicle technology, has shown quite erratic changes with notable highs and lows during the same period, see Figure 2.

The share of these publications concerning innovation in combustion engines, however, has reduced from 8% to 6%, see the red dotted trace in Figure 1. This illustrates the growing importance of electric vehicle specific technologies and the corresponding increase in R&D activity compared to "classical" vehicle technologies.

3.2 Claimed geographical region for patent protection

In this section, it is more closely analysed, for which regions patent protection is sought and tried to conclude on the relevance, now and in the future, of the corresponding markets to the players which are active in this field.

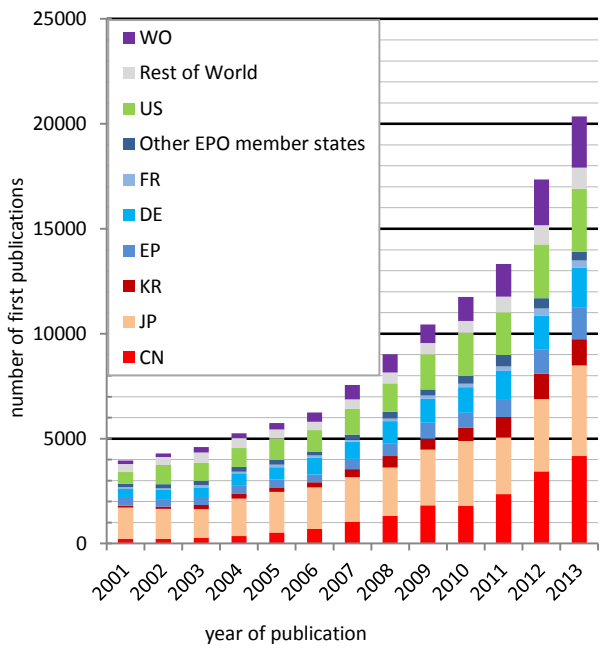

Figure 3a: Yearly first publications per publication authority in EV fields

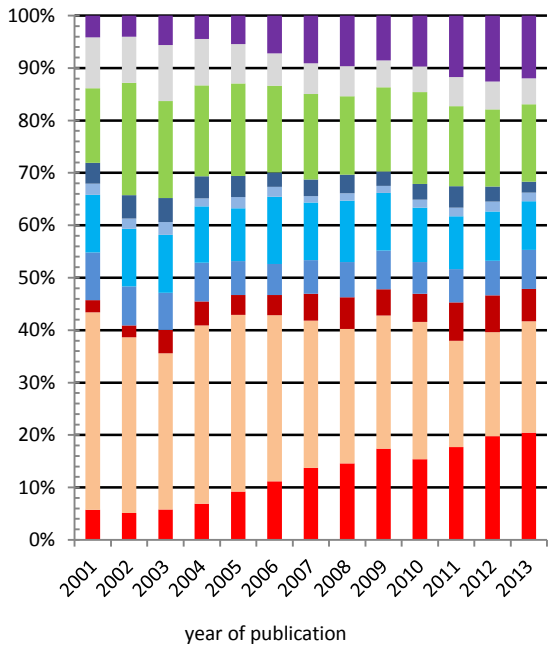

Figure 3b: Yearly first publications per publication authority in EV fields in percentage of total yearly first publications in EV fields

Figure 3a illustrates the number of annual first publications, from 2001 through 2013, for the top 7 publication authorities and in total, in terms of numbers of publications in EV fields. It clearly confirms that patenting activity, which is usually linked to the investment in the concerned areas of technology, has been steadily rising in the fields related to electric and hybrid vehicles.

The numbers of first publications in Figures 3a and 3b are further split up into the respective publication authorities, with an emphasis on the seven most relevant ones, namely the national Chinese (CN), Japanese (JP), South Korean (KR), German (DE), French (FR), and US patent offices, as well as the EPO (EP), which is a regional one. The most significant remaining publication authority is the WIPO, whose publications, identified by the code WO, refer to international application filings, also called PCT filings, which are published by the WIPO, but are searched and examined by another authority.

The publication authority of an application is, apart from PCT filings, an indicator for the geographical protection claimed for an invention. From the shares of each publication authority of the total number of annual publications in EV fields, specifically shown in Figure 3b, it can be seen that the relative importance of publication authorities stays quite constant over the years, with roughly half of the publications coming from Asia, 15% from the USA, and 20% from Europe.

PCT filings are also more and more frequently used by the applicants in these EV fields, reaching more than 12% of the annual publications in 2012-2013, (see top section of year bars in Figures 3b. This is an indicator that more and more inventors are planning to protect their inventions in several different geographical regions at an early stage of development.

Around a third of all the patent applications published in Europe are treated by the EPO, which also treats approximately 40% of the PCT filings. This makes the EPO the most important patent office for Europe and the 4th most chosen patenting authority in the world for EV fields.

3.3 Where does innovation come from?

Apart from the question, where protection is sought for a specific technological field, it might also be interesting to ask, where inventions originate, for example to see, which countries are particularly active in the field or stimulate R&D in it. In order to investigate this question, the country of residence of the inventors or applicants attributed to a publication is more closely looked into. Note, that if no country of residence for the inventors or applicants is recorded in the used database, the country of the application authority of the priority document is used.

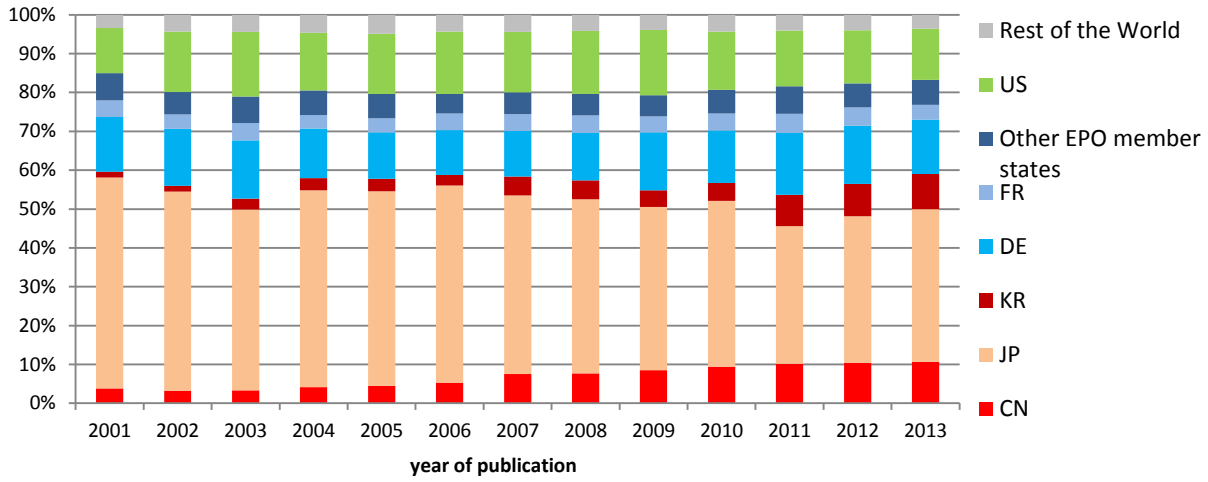

Figure 4: Yearly publications per country of origin of the applicant or publication authority in percentage of total yearly publications in EV fields

What can be observed from Figure 4 is a regional distribution of inventors and applicants (originating country), which differs significantly in both share and development over time to what can be observed for the yearly publications per country/region in Figure 3b.

At first, it is to be noted, that Japan maintains a very important share of the inventors and applicants, even if this share has been reduced from 55% in 2001 to 40% in 2013. Combined with the teachings of Figures 3a and 3b, showing a decrease in the total share of publications, see Figure 3b by the Japanese publication authority despite an increase in the absolute number of publication as can be seen from Figure 3a, this indicates that Japanese companies that are still quite active in the development of EV related technology, are spreading the region of protection sought beyond Japan. Of course, care should be taken when interpreting these results as there is an interference-effect with Japanese publications that have an inventor or applicant originating from outside Japan. However, this has been ignored in the first instance.

Secondly, the share of inventors or applicants originating from China, see the lowest bar section in the graphs above, is much lower, only 10% in 2013, see Figure 4, than the share of applications being published in China, which was 20% in 2013, see Figure 3b,. A similar effect but on a smaller scale can be seen for the US, see the green bar section in the graphs above. This indicates that applicants from other regions/countries are choosing to patent their inventions in these countries.

Korea, see the dark red bar section in the graphs above, is also emerging as a new region of importance for innovation, see the steady increase in yearly publications having a Korean inventor or applicant from Figure 4, and a strategical market for innovation in electric vehicle technologies, as can be seen by the increasing absolute number and relative share of publications filed in Korea in Figures 3a and 3b, with major applicants in the domain of vehicle manufacturing and battery development.

European countries account for 20% of the annual worldwide first publications, see the dark blue bar sections in Figure 3b, and they are the country of residence of approximately 25% of the applicants/inventors, see the blue bar sections in Figure 4, over the whole period of 2001-2013.

3.4 Language of innovation

Another interesting parameter of patent publications concerns the language in which the applications are published, since this impacts on the accessibility for relevant prior art search of both interested companies and patent offices, in particular, if no publication in English of the respective application is available.

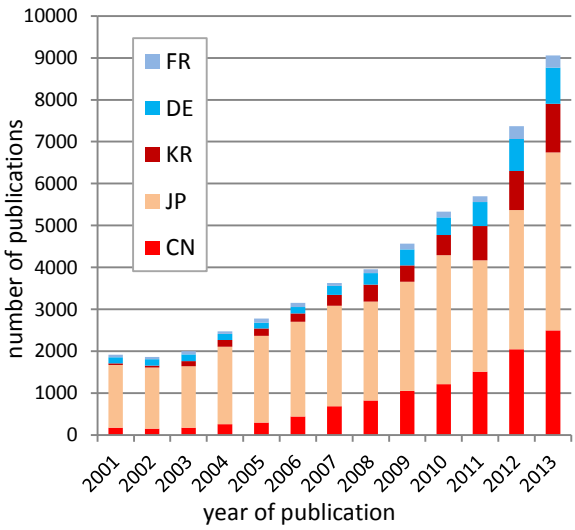

Figure 5a: Yearly publications in EV Fields per publication authority having no equivalent publication in English

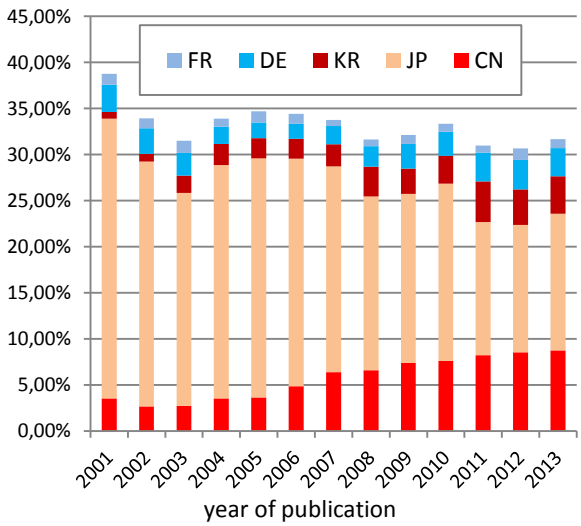

Figure 5b: Part of yearly publications in EV fields having no equivalent publication in English from the total publications in EV field

In Figure 5a and 5b, when counting the number of publications, both the initial application and the grant are counted as one publication, which can result in certain discrepancies when comparing the numbers of

publications presented in the other figures contained in this article to the numbers presented in Figures 5a and 5b. This does not, however, impact on the teachings than can be taken from these figures.

Figures 5a and 5b illustrate the rapidly increasing number of publications concerning EV fields having no equivalent publication in English. Between 30% and 40% of the total annual publications have no equivalent publication in English, meaning that a large part of the documentation relating to the latest technological developments in the EV fields is only available in Japanese, Chinese, Korean, German, and French. When the information from Figures 5a and 5b is taken in the light of the information from the previous paragraph, notably Figure 4, it can be observed that an important proportion, i.e., roughly 50%, of inventions originating from Asia are only patented in Asia and not pursued for patent protection outside Asia, otherwise there would be an available English publication of this applications.

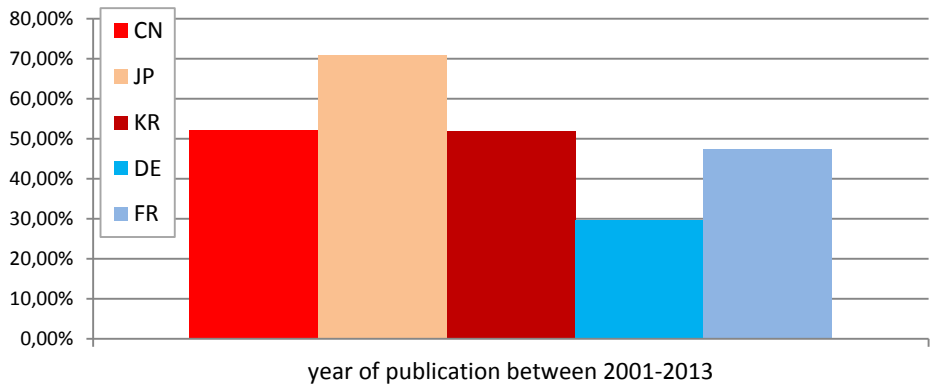

Figure 6: Average percentage of publications per publication authority having no equivalent publication in English during the period 2001-2013

The impact of the findings of Figures 5a and 5b with respect to the accessibility in English of the publications issued by the respective publication authorities appears to be confirmed by Figure 6: There it becomes apparent that on average over the period from 2001 through 2013 more than 50% of all publications of one of the Asian patent offices (CN, JP, KR) has no equivalent in English, with Japan being the most extreme case with 70%.

It is immediately clear that this renders the identification and access to this available knowledge very complicated not only for a majority of the applicants/inventors in these technological fields, but also for a majority of examiners working in patenting authorities, especially outside Asia, and having to search the available prior art and to decide on the patentability of an invention. How especially the EPO is dealing with this issue is explained in Section 4.

3.5 PCT applications

In section 3.2 it has been shown that a growing number of inventors are using the PCT route. A closer look is given to these filings in this section, trying to find out who and how this route is used through the analysis of the country of origin of the applicants for PCT filings processed by the 5 biggest search authorities worldwide, see Figure 7, known as IP5 offices, handling together 95% of PCT filings [6].

Figure 7 suggests that most of the applicants looking for a worldwide protection though the PCT route are originating from Europe and Japan, these two entities representing more than two third of all PCT applications

Interesting to note is that applicants from all over the world are for example choosing the EPO to handle their PCT filing. On the other hand some European applicants are using one of the other IP5 offices to handle their PCT application.

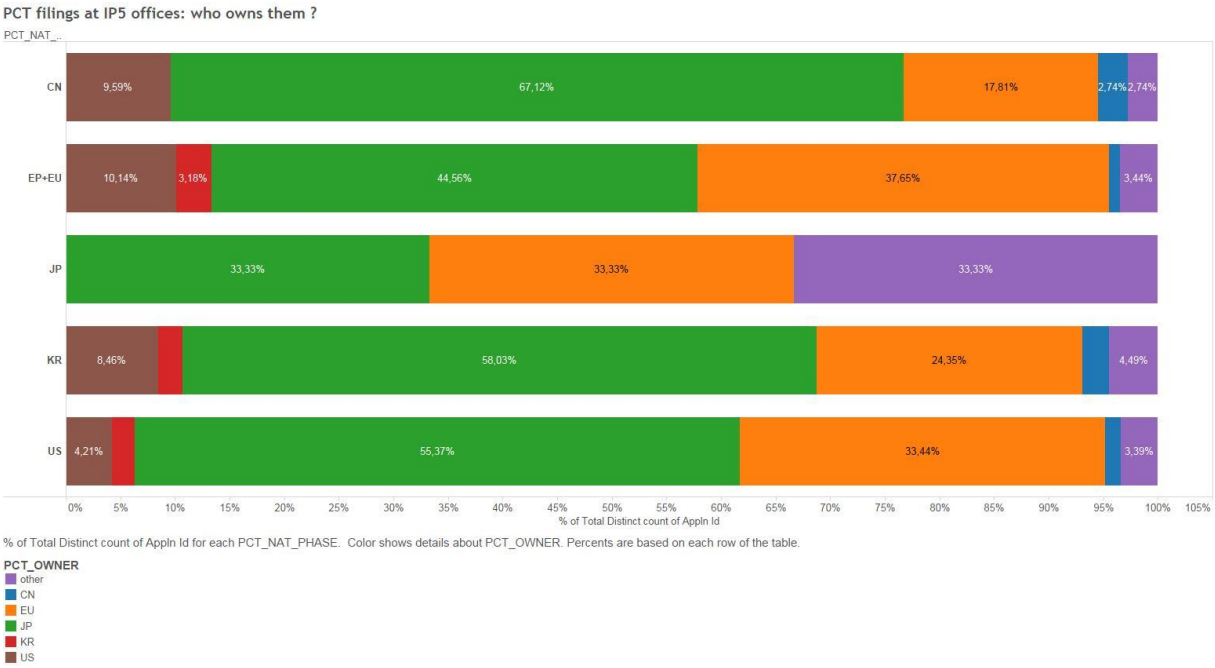

Figure 7: The origin of patent applications (PCT) in electric vehicles in the five main patent offices

3.6 Identification of the most active technological fields inside of the EV fields

Next to providing a basis for analysis of the origin and aimed region of protection as it was carried out in previous sections, patent data, and in particular the rather finely granulated CPC classification scheme, also allow for an identification of trends in certain sub-fields within a larger technological area.

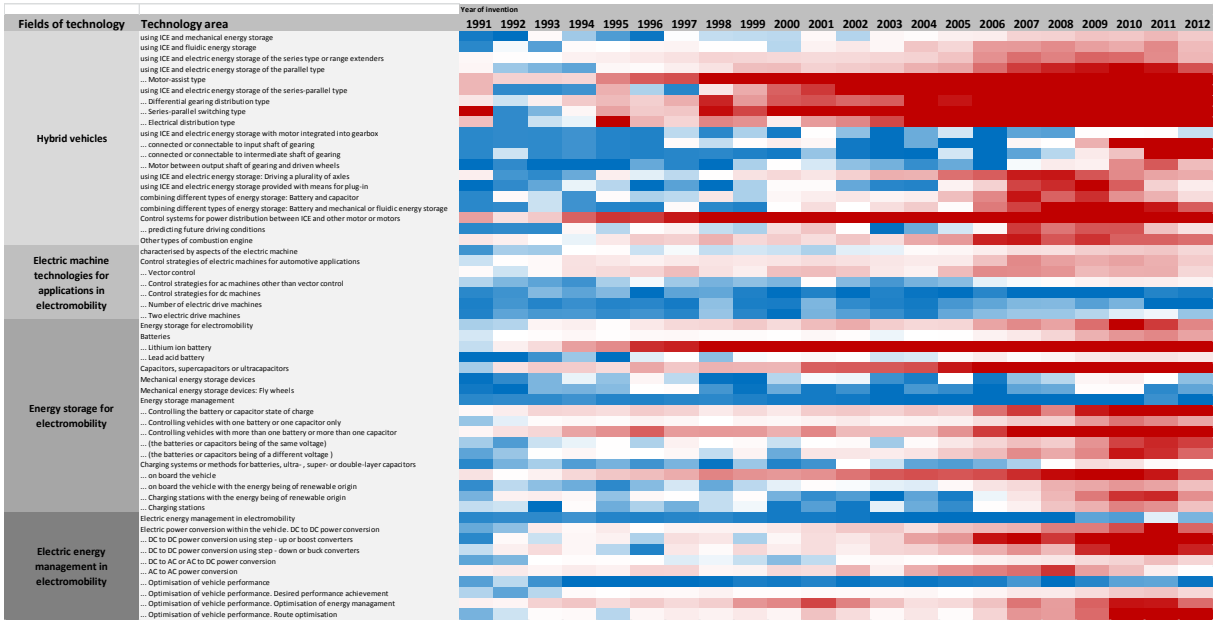

Figure 8: Detailed patenting activity heat map for electric vehicles and related fields

The chart in Figure 8 offers a detailed analysis of the patenting activity in parts of the relevant technological fields in and around electric vehicles. Starting with normalised data for 1990, the red areas show above-average patenting activity in a given year, and the blue areas show below average patenting activity; the deeper the colour, the greater the deviation is from the average. Activity in the development of parallel and series-parallel type hybrid vehicles or lithium batteries for example, is above average. The "cool" areas include for example development of mechanical energy device storages.

4 Patenting in Europe – the options

Europe is, it would appear, a business critical market for electric vehicles. It follows that anyone who wants to compete on the European market will need to consider patenting as a method of innovation protection or risk being squeezed out.

Europe has a variety of options for protecting innovation through patents. At national level, there are the various national patent offices. To file for a patent with them, submission of the application in the local language, often using a local patent attorney as an intermediary is compulsory. Furthermore, the outcome of the procedure may vary from one national patent office to another. The EPO was created to provide a single procedure for trans-national patenting in Europe. With a single application in English, French or German, patent protection in up to 42 countries can be applied for.

Once an application arrives at the EPO, it is important for the EPO to give applicants early certainty with respect to this application. The applicant normally receives a search report detailing related publications (prior art) to his invention within 6 months. Accompanying this is a written opinion from the examiner detailing whether the application meets the legal provisions of the European Patent Convention (EPC) such as novelty, inventive step, clarity, conciseness, disclosure of invention and so on.

After this, the applicant then enters into dialogue with a three-man examining division with a view to remedying defects, e.g., modifying the claims to take account of prior art, in the application so that it can proceed to be granted. If the defects cannot be overcome, the applicant either withdraws the application or the examining division refuses it.

If an application is granted, then third parties are given 9 months to provide grounds to oppose it. If an application is refused, the applicant has the right to appeal this decision. The ultimate decision is then made by the Boards of Appeal.

Recent measures at the EPO reinforce the credo that strong, high quality, patents are important for innovation. Applicants value a procedure that gives confidence that a possibly granted patent will withstand a challenge before the courts. Already recognised worldwide for its quality, the EPO's is investing further still in measures to improve quality and service:

- Improved search tools to include an automatic pre-search; more options in the full text database searching; a concept searching tool to complement text searching
- A harmonised classification in co-operation with the US, Korea and China
- Increased data acquisition from major countries in Asia; world-wide non-patent literature and information from many standards bodies
- Full text search in machine translations of Asian documentation easily available to the EPO examiner
- Special training of EPO’s Examiners in the use of Japanese Classification scheme, the so called File Index and FTerms, used by the Japanese patenting authority for the published JP applications
- Early legal certainty by delivering a search report and written opinion within 6 months of receiving an application informing him on what defects need to be overcome in order to have the application granted.
- PACE (programme for accelerated prosecution of European Patent Applications) requests to allow applicants to proceed at the speed that suits them and their applications

On top of this, EPO examiners work systematically in the 3 official languages of the EPO (English, French and German). This coupled with the work done on tools and the Machine translated documents from China, Korea and Japan ensure that the EPO is uniquely positioned to retrieve prior art from all around the World.

5 Conclusion

The authors established that a steady rise can be seen in patent related publications in EV fields. This rise in patent publications appears to be evident despite a fluctuating oil price and subsequently this is understood as a sign that investors have a firm belief in a future that incorporates EV technology. The authors also looked at the originating countries for innovation in EV fields and the availability of access to

these publications in English. This showed the importance of innovations originating in Asia and indeed Asia as an increasingly important market place in itself. The authors then emphasised the fact that a large part of the relevant documentation in these fields is not available in English, especially the documentation originating from Asia, limiting thereby access to relevant prior art. Having regard to the regional importance of patent protection in Europe the EPO was reviewed to illustrate the patenting process. Certain qualities of the EPO were also highlighted, especially those relating to field specific language constraints during the search and examination process, stressing also the fact that it is possible to benefit from these services when seeking protection in other regions of the world by choosing the EPO as a search authority during a PCT procedure.

Acknowledgments

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Jeremy Scott was born in the Lake District in England in 1967 and went to Stirling University where he graduated with a degree in Chemistry with French. In 1989 he joined the EPO in the pharmacy department, and also went on to work in biotech. He was a trainer and coach for many newcomers over 10 years, also responsible for designing training material. He has been heavily involved in several change processes at the EPO and was part of the Mission Implementation Team. He was also part of the Scenarios for the Future group. At the start of 2005 he was nominated director in Audio, Video, Media. In 2008 he was appointed the director in charge of the cabinet of the Vice-President for DG1. In 2013 he returned to a line director role in Electricity and Electronic Technology. He was responsible for starting the Asian Patent Examiner Group in DG1 and still sponsors it. He is also the sponsor for the Continuous Knowledge Transfer network at the EPO. He has given many lectures to applicants, attorneys, NPOs, EPIDOS, EPOPIC, search groups, ICIC etc.

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