European Commission

Science for Environment Policy

Innovative batteries struggle to move from research to application, finds study into start-up companies

Innovatively designed batteries offer a way for vehicles to move away from their dependence on fossil fuels. There has been little mass-market uptake of new battery design, however. In the last century, only four types of battery have been used: manganese oxide; lead acid; nickel; and lithium ion, which is a relative newcomer, introduced in 1991. To understand how innovation moves from research and development (R&D) to application and the mass market, scientists perform technology lifecycle (TLC) analyses, often focusing on R&D and basic research. This study adds an additional indicator — start-up companies — to explore the early phases of how batteries transition from science into industry.

The researchers chose to perform a TLC analysis of the lithium ion battery (LIB). Although introduced in 1991, LIBs have only been developed more widely on the market since 2000. The data period, therefore, runs from 2000 to 2014, to allow for a lag of 18 months in publishing patents. The industrial patents were mainly filed in Korea, Japan and Germany, and the academic patents in the US and China.

In terms of energy and power density, the researchers suggest that the performance of LIBs seems sufficient for competitive all-electric cars, but the cost and price model of the original equipment manufacturer (OEM) hinders mass-market adoption. Alternatives to LIBs need to deliver on low costs, rather than energy density, which makes the entry very challenging. The researchers say there is nothing on the horizon to challenge mainstream LIB technology for the next decade.

The study uses the classical indicators of scientific publications, patents, and new product launches along with an additional 'start-ups' indicator to characterise how batteries are used in start-up companies prior to official product launches. The indicators were analysed using keywords in four different databases: the abstract and citation database, SCOPUS (research activities), global patent database, PatBase (applied research via patents), the Crunchbase global platform for innovative business (identification of start-ups) and the Nexis business news service (product launches). Both start-up companies and new-product launches were classified according to the steps of the battery value chain (BVC): materials, cell (components), battery (system) and application. This classification method allows the identification of potential hurdles for technology transfer.

The TLC analysis describes and analyses patterns of technology evolution and industry 'clock speed' (the time lag before indicators appear for a given technology). Battery improvements are slow and occur over decades, as opposed to the one or two years taken for the number of transistors on a circuit chip to double. When considering the TLC of a battery, 'clock speed' is, therefore, a major consideration.

A total of 28 129 papers were published on LIBs between 2000 and 2014; the 300 most-cited papers were from the US, China, South Korea, Japan and Germany. The number of individual patents increased by over 45 000, although these are mostly limited to South Korea and Japan. This reflects the structure of the battery industry — the main cell and battery manufacturers are based in Asia.

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Source: Sick, N., Bröring, S., & Figgemeier, E. (2018). Start-ups as technology life cycle indicator for the early stage of application: An analysis of the battery value chain. *Journal of Cleaner Production*, 201, pp.325–333.

Contact:
nathalie.sick@uts.edu.au

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Thirty-seven start-up companies were identified in the LIB field, but, of these, 32 are involved with incremental changes to existing LIB, and only five go on to develop and manufacture — for example, super capacitors for lithium batteries. There were 62 product launches, but only one linked to a specific application — most were related to cells and components, a few to raw materials, and one third to battery systems. The major gap in the LIB lifecycle lies between R&D and application, rather than other phases.

Start-ups face several barriers in innovating LIB technology: firstly, the price of LIBs has dropped, increasing financial pressure along the BVC; secondly, most start-ups are ruled out due to long, costly development times, coupled with the desire of mass battery producers for reliable, stable materials suppliers.; and thirdly, most cell producers are based in Asia, meaning that materials start-ups in the US and Europe cannot access this part of the BVC.

As cell manufacturers are protective of their core processes, start-ups are not given access to existing workflows and thus struggle to innovate. Manufacturers in the automotive industry often produce their own battery systems or work with existing suppliers, preventing new start-ups from entering the sector. However, new market players focus entirely on electric batteries, so this may change. In addition, existing manufacturers have not developed all of the skills required for electric vehicle drives, so there is potential for start-ups to be involved in the future.

Due to the high costs of calculating the full life expectancy of a new battery during the application stage of the BVC, large operators are better placed to do this. They also have the bulk buying power to secure batteries and, therefore, to out-compete start-ups. Start-ups may be better off seeking opportunities further along the BVC — e.g. when integrating cells to battery systems or developing applications that rely on innovative battery technology.

The transfer to market of new, sustainable technology is often hindered by better established and more cost-efficient technologies, and so policy measures, subsidies, or quotas may be required to help drive uptake and transfer of such technologies. Further analysis of drivers and barriers for start-ups along the BVC will show how start-ups can best engage with, and foster, battery innovation.

This research is relevant in technology forecasting and can be applied to any sustainable technological field in which R&D and application are closely interlinked. In these cases, early information on possible and upcoming applications is critical to successfully bringing new technologies to market.

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