

STUDY

E-mobility Index

Q2 2017

Roland Berger – Automotive Competence Center &
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1 Key takeaways from the E-mobility Index for 2017

- > China is underscoring its position as a lead market and has, for the first time, moved into pole position in the E-mobility Index.
- > France has taken the lead in **technology**, while higher production volumes and more value added keep China out in front in terms of **industry**. As far as the **market** is concerned, the seven leading automotive nations continue to converge.
 - **China** will dominate both the market and the industry in the foreseeable future. Having rolled out 350,000 PHEVs and BEVs in 2016, double-digit sales growth continues. Key drivers include government subsidies and simpler licensing procedures.
 - Chinese automotive start-ups for electric vehicles are actively positioning themselves on the market right now. Providers work on the basis of large volumes for the Chinese market, put the considerable scope of local value added to good use and have deep pockets.
 - The rapid introduction of autonomous driving functions should ensure that these start-ups are able to compete, as they draw on R&D expertise in countries and regions that lead the technological field. Local research units concentrate on developing electric drivetrains.

2 Summary comparison of the competitive positions of the world's seven leading automotive nations

In terms of **technology**, France has edged past Germany into top spot. The growing proportion of plug-in hybrid vehicles (PHEVs) in the high-volume portfolios of German OEMs is causing the technological capability of electrified vehicles to recede slightly. That is primarily because the whole concept of plug-in vehicles gives them a smaller electric range and a lower electrical top-speed. Given their lower battery capacity, most of them also are equipped with basic charging technology.

Japanese OEMs, who occupy third place in terms of technology, are providing vehicles that combine a high technological level with good value for money. Changes are implemented mainly by modernizing existing model series and enhancing them by adding extra variants with more battery capacity. Comparatively modest investment in R&D for electro mobility keeps Japan from achieving a higher ranking on technology. PHEVs and BEVs are gradually being added to Korean OEMs' hitherto relatively narrow product range. The technological capabilities of Korea, which currently occupies fourth place, will therefore have to be assessed more selectively in the future.

Only a mild improvement is observable among Chinese OEMs. Although lots of new models will come onto the market in the next few years, the majority of them will be positioned in segments where the technology does not rate so highly. As the sales figures attest, however, that is definitely a smart strategy for the Chinese market, as the top five BEV and PHEV models in China are all produced by Chinese manufacturers.

American OEMs are abandoning their lighthouse strategy in the high-price segment and instead using fully electric vehicles to position themselves primarily in the mid-range segments, although actual vehicle availability is subject to delays. The continuing dominance of expensive cars in the portfolio leads to comparatively weak technological performance due to a poorer cost/benefit ratio. In future, the market launch of more attractively priced vehicle concepts is expected to boost technology scores (Figure 4).

Although the expiry and relaunch of individual funding programs is bringing minor alterations, there is little change in the overall structure of funding for e-mobility – measured in terms of GDP – across the seven leading automotive nations. All the countries analyzed continue to invest in programs aimed at optimizing the technological system (Figure 5).

In **industry**, China is extending its lead. Three main factors are contributing to this development: rapid market growth, strong demand for home-grown vehicles due to continued and pronounced regional market differentiation, and the associated sizeable volumes produced by Chinese OEMs. Furthermore, locally made lithium-ion cells are used in more than 90% of the vehicles produced by Chinese manufacturers. Both in vehicle production and in terms of the national share of global cell production, these two trends are working against Japan, whose industry score still leaves it in third place. The US is benefiting from this development. Having moved up into second place in the last index, it has now successfully defended this position.

German OEMs too are realizing strong growth in vehicle production. However, their lack of cell production puts them behind Japan in fourth place in the industry rankings. Korean OEMs trail them in fifth place, but are expanding their model range to boost e-vehicle production figures by more than 200%. Italy – the only country in which there is no sign of a significant increase in expected production – brings up the rear (Figure 6).

In cell manufacturing, the industry weighting continues to shift strongly toward China, which now has a larger share of global cell production than Japan. Korean and Japanese cell manufacturers have already completed their localization projects in the USA and are now announcing similar plans for Europe in 2018/2019 (Samsung SDI in Hungary, LG Chem in Poland). Stronger demand for cells is nevertheless accompanied by huge price declines, resulting in only moderate net market growth (Figure 7).

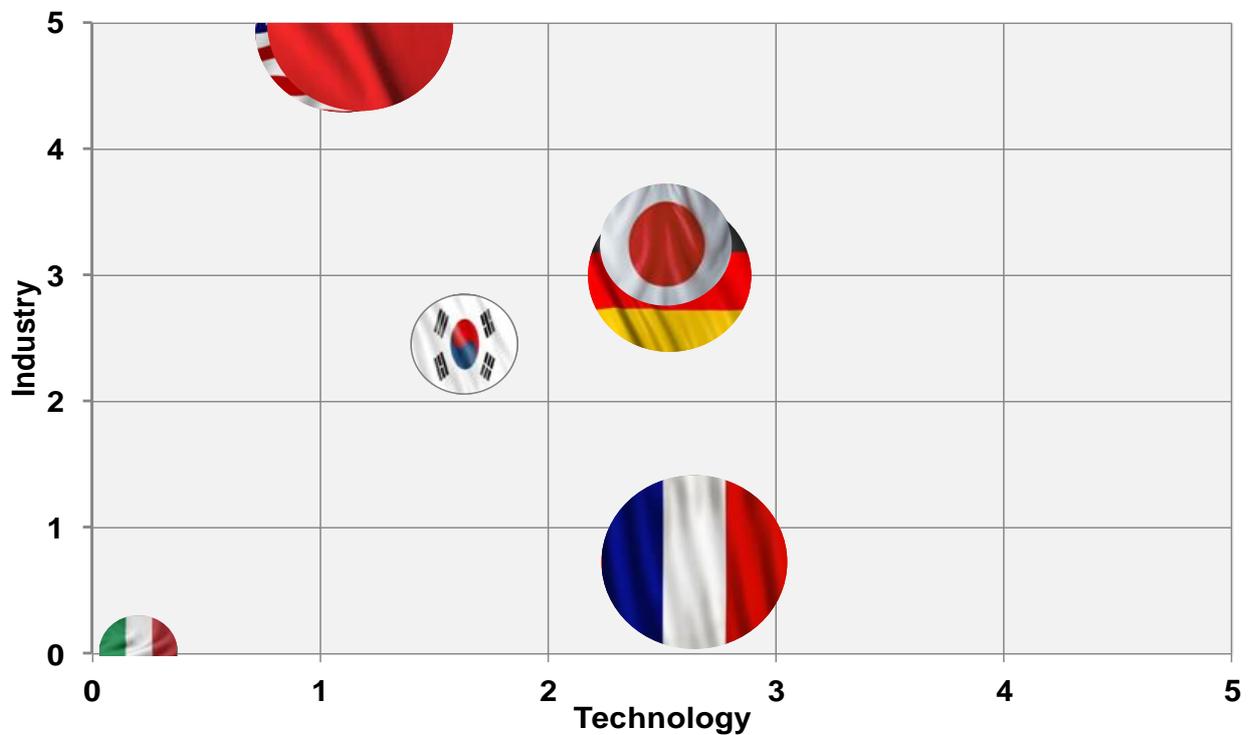
In terms of the **market**¹, China has seen a further sharp jump and has nearly doubled its sales volume. It now ranks second behind France, which has a bigger market share despite its considerably lower absolute volumes. In third place comes the US with a market share of less than 1%. New registration figures are experiencing double-digit

¹ The measurement threshold for the market indicator was also modified in the E-mobility 2017 index update. The fact that BEVs and PHEVs are increasingly penetrating the market made this step vital to focused assessment in the value range from 0.5. A relative market share of only 1% is now needed to reach a maximum score of 5.0 for this indicator. The higher threshold also reduces countries' market values compared to previous editions of the index.

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growth in Germany, France and the US. Japan has witnessed low double-digit shrinkage in its absolute market volume and has thus slipped behind Germany. Korea seems to have shaken off the decline that appeared to be taking hold last year: Its market volume is now growing by nearly 100%. Overall, the share of partially and fully electrified vehicles exceeded the 1% mark only in China and France in 2016. Europe is therefore still a long way off the market share of partial or fully electric drive systems that it needs to meet its fleet emission targets as of 2021 (Figure 8).

Figure 1: China and USA show similar index rating; France slightly leading the field of technology, followed by Germany

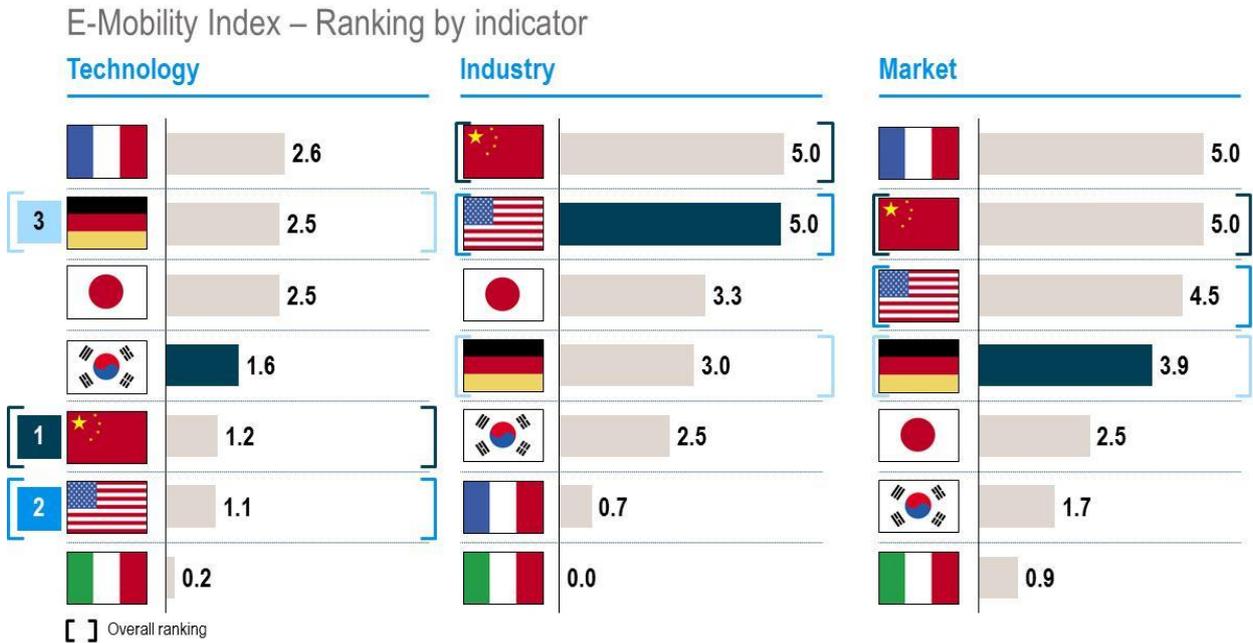


Note: Circle size shows EV/PHEV share of total vehicle market

Source: fka; Roland Berger

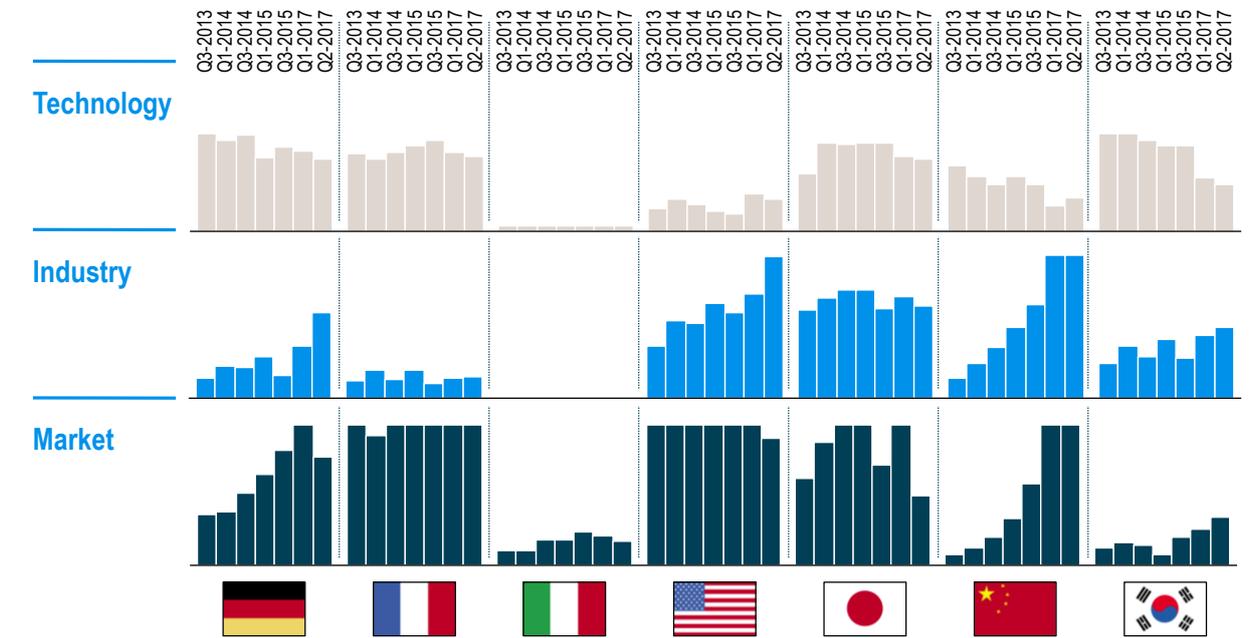
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Figure 2: Japan loses its overall pole position to China, while 2nd placed USA increase their industry; Germany on overall third place



Source: fka; Roland Berger

Figure 3: Changes in competitive positions of leading automotive nations by indicator



Source: fka; Roland Berger

3 Detailed analysis

3.1 China tightens the rules for vehicle and battery manufacturers and will extend its global lead in both areas, despite declining subsidies

Nearly twice as many pure EVs and plug-in hybrids as in the previous year – over 350,000 in all – were sold in China in 2016. The market share rose from 0.8 to 1.3%. Of the seven countries analyzed, electrified vehicles have a slightly higher market share only in France. Rapid sales growth has been facilitated above all by generous government subsidies and many cities' strict regulations governing the issue of number plates for vehicles with combustion engines. In 2015 alone, government subsidies for e-vehicles added up to the equivalent of roughly EUR 1.1 billion.

However, 20% was shaved off government subsidies for e-vehicles at the end of last year, partly because of the number of cases of fraud and abuse in the past. Essentially, the subsidy amount is linked to individual vehicle properties. For example, an e-vehicle with a range of over 250 km qualifies for subsidies of around EUR 5,500 – more than twice the figure available for vehicles whose range is under 150 km. Additionally, the buyers of BEVs with an energy density of more than 120 Wh/kg receive 10% higher subsidies than for batteries with lower ratios. In this way, the government is seeking to create incentives for further technological improvements, especially in batteries. The requirements for listing as a recommended new energy vehicle (NEV) have likewise been tightened. For instance, the battery pack now has to have an energy density of more than 90 Wh/kg to be eligible for government subsidies.

China has set itself the target of having e-vehicles account for 15-20% of all cars sold in 2025 and 40-50% of those sold in 2030. To reach these ambitious goals, the government is complementing purchase incentives with sanctions for OEMs who fail to meet minimum quotas. The China Association of Automobile Manufacturers (CAAM) has proposed targets of 5% for 2018, 8% for 2019 and 10% for 2020. These figures are lower than the transport ministry's original plans, because several foreign OEMs believe the initial goals are unreachable. The finalized minimum quotas are expected to be published in June of this year.

For battery cell manufacturers, the national target adds up to annual production totaling 100 GWh in 2020. This figure underscores China's ambition to further strengthen its position as the global leader in cell production. The aim is for local manufacturers to be able to realize a production volume of 3-5 GWh, although this figure has not yet been finalized. Such steep targets will ask a lot of local cell manufacturers in particular, as foreign suppliers will be unable to meet them in the near future due to a lack of development and production capacity on the ground in China. Moreover, the government is planning to back the development of global leading manufacturers with production capacity of 40 GWh per year. On the technology side, lithium-ion cells are to have a specific energy density of more than 300 Wh/kg and cost less than RMB 1/Wh (approx. EUR 0.13/Wh) by the end of the decade. In the long term, energy density is expected to top 500 Wh/kg.

Although the targets have been adjusted, it is reasonable to assume that e-vehicles and the production of battery cells will see their market share continue to increase forcefully in China. In the next few years, the world's two biggest cell manufacturers will come from Japan (Panasonic/Sanyo) and Korea (LG Chem). On balance, however, most battery

cells will still come from China. The largest producers will be BYD, CATL, Lishen and Wanxiang. On the vehicle side, incumbent Chinese OEMs such as BYD and BAIC will contribute to further market growth, but so too will new players.

3.2 Chinese start-ups are positioning themselves in the premium segment and pooling their innovative strength, backed by lavish funding

Tesla is no longer the only automotive start-up to sell technically sophisticated electric vehicles with attractive designs. The Californians' competition comes in particular from China, where a number of new firms have sprung up in recent months and years. Offering high-quality vehicles (especially in the premium segment), all these players want to stand up both to pioneers such as Elon Musk and to the incumbent OEMs. Aware that they have no hope of catching up with the OEMs' lead in combustion engine technology, these ambitious Chinese start-ups focus solely on electric motors and target the early volume roll-out of autonomous driving.

Many of these newcomers have their roots in the IT industry, and many share similar structures and approaches: Well-heeled investors fund the rapid growth of these companies, which are led by managers, developers and designers head-hunted from elsewhere in the industry. Their vehicles are developed at several facilities around the world – in Silicon Valley, China and, in many cases, in Germany too – before being manufactured in China.

We recently had the opportunity to interview the managers of NIO (one of these start-ups) and the associated investment fund NIO Capital.

INTERVIEW WITH PADMASREE WARRIOR – CEO OF NIO U.S.

At Auto Shanghai in April, NIO made its China debut and impressed with three vehicles: the ES8, a battery-electric SUV with planned SOP in 2018, the EP9, the fastest electric car in the world, and the EVE, a futuristic concept vehicle with Level-4 automation.

Roland Berger Partner Dr. Wolfgang Bernhart met with Padmasree Warrior, CEO of NIO U.S. at their headquarters in San Jose, California, and spoke with her about NIO's vehicles, their strategy and organization.

Wolfgang Bernhart (WB): NIO started out building racing cars for Formula E. What kind of essential technology transfer do you envisage between Formula E racing and (future) production models?

Padmasree Warrior (PW): From the very beginning, we had a detailed plan for participating in the FIA Formula E Championship. When we made the decision to participate, our goal was to win the championship and receive worldwide recognition for our technological capabilities. With hard work and a bit of luck, we secured the inaugural FIA

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Formula E drivers' championship in July 2015. The primary technology that will be transferred from our Formula E racecars will be our developments in aerodynamics, the e-powertrain, and battery management systems.

WB: EP9 made headlines mainly because it's a very fast e-car. What's the intended positioning of the other two cars you exhibited in Shanghai?

PW: The ES8 is being developed in China for the Chinese market. It is an all-electric SUV with 7 seats that will be marketed to families in China's tier one and tier two cities, where the high level of air pollution is definitely a major issue. In fact, this problem is one of the main reasons why we founded NIO. But one of the key reasons why Chinese consumers are currently purchasing electric vehicles is because of the generous government subsidies. On top of that, many big cities like Shanghai offer other incentives, like free license plates. In China's big cities, obtaining a license plate is very costly due to the high number of vehicles on the road.

The choice to use electric vehicles will certainly decrease air pollution. At the same time, there are a number of other factors causing air pollution in our cities. Emissions from gas powered vehicles are only one factor. We can't expect our users to purchase electric vehicles solely for environmental reasons. We have to produce cars that people really enjoy driving. By providing experiences that exceed expectations, electric vehicles will simply become everyone's natural choice, leading to a more sustainable future. The ES8 does exactly that. It is comparable to top EVs in terms of performance, while offering a distinctly better service, user experience, and value.

WB: But what NIO seems to aim at in the long run is an enhanced user experience via automation and digitization...

PW: Car usage today causes three big problems for society and their users: pollution, accidents with a tremendous number of injuries and deaths, and, especially in the US and Europe where people who buy premium vehicles typically do not have a driver, a loss of productivity from being stuck in traffic jams every day. With our concept car, NIO "Eve", we show how to address all three problems at the same time.

WB: So a future production model of the "Eve" will be targeted at the US and Europe primarily?

PW: Yes. By 2020, we will introduce in the US a vehicle with Level-4 autonomous features which is close to the concept we took to the show.

WB: You once said, "We're not building a car, we're building a robot that looks like a car." Do you see NIO more as a software firm or an auto company?

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PW: NIO is more than either a software firm or an automotive company. We are a user enterprise. Being a user enterprise means manufacturing products from the users' perspective. We are user oriented rather than business or product oriented. Our aim is to provide a premium experience and to manufacture a car in which users' needs are the key determinant for R&D and production.

We want to provide productivity, peacefulness and discovery. A high level of automation, e.g. on longer highway trips or in traffic jams, along with connectivity allows time spent in the car to be used in a more productive way, for example by taking video conference calls. Alternatively, our interior concept will provide peacefulness – using the time in the car to relax. To facilitate new discoveries, our digital companion NOMI understands your needs and preferences and uses that to guide you. Our vehicles will therefore utilize our intelligent, user-friendly interactional design concept, which provides a joyful experience for users with digital interaction.

WB: In October 2016, NIO and Mobileye, an Israeli technology company that develops vision-based advanced driver assistance systems, agreed on a strategic partnership. Earlier last year, NIO signed an agreement with Chinese automaker Anhui Jianghuai Automobile. What does NIO do in-house and where do you seek partnerships?

PW: NIO has research and development, design, manufacturing facilities and offices in San Jose, Munich, London, Shanghai and eight other locations. We also have a workforce comprised of talent from world-renowned automotive, technology and user experience companies. We produce our vehicles' core components in-house at our factories in Nanjing and Changshu.

With regard to partnerships, we seek partners with strong manufacturing capabilities that meet our strict requirements and understand our company values. JAC Motors, officially Anhui Jianghuai Automobile, is an example of our manufacturing partners. Their manufacturing and supply chain management expertise will greatly help us as we get ready to roll out our first production vehicle.

WB: How do the teams in China and here in California work together?

PW: The Chinese team is working on vehicles for China, having full development capabilities there, and our design studio in Munich provides support with car design. Here in California, we are developing L4/L5 vehicles for the US and EU markets. We are designing for fully automated vehicles from the ground up, and are also responsible for software components for China. Software and "software-defined" hardware, e.g. ADAS systems, come from here. In this sense, the China team is the customer. But in order to focus on the two different customer groups in a targeted manner, we have quite an independent organization, leveraging manufacturing and supply as well as development competencies globally.

WB: Padma, thank you for taking the time to talk to us.

INTERVIEW WITH JUNYI ZHANG – FOUNDING PARTNER OF NIO CAPITAL

Roland Berger Senior Consultant spoke to Junyi Zhang, founding partner of NIO Capital. The investment fund was co-established by NextEV, Sequoia Capital, and Hillhouse Capital and raised RMB 10 billion (US \$1.45 billion) in its first round of funding for NIO Capital.

Stephan Schickram (SS, Roland Berger): In an earlier interview with us, Lihong Qin (co-founder of NIO) described NIO as neither an automotive nor a software company, but rather a user enterprise. What does that mean with regard to the development process for the cars?

Junyi Zhang (JZ): Wherever a car is developed, you start from the viewpoint of the manufacturer and then you sell the car to the customer. Technically, the manufacturer asks the customer to accept what the OEM has developed. But you can't ask somebody to buy a BEV just because it is a BEV. The customer will buy the car because of its performance and because it fulfills his or her wishes and individual needs.

At NIO, our approach is to start from the customer point of view and to offer a car which really fulfills the customer's wishes. NIO is more than just a car manufacturer and focuses on the whole customer experience, including aftersales and charging.

We learned a lot from Starbucks and applied their philosophy on creating a unique user experience when developing NIO cars. This leads to some design features that are not commonly found in cars but improve user experience and show customer care. For example, many ladies in China wear shoes which they take off when they drive. We provide suitable storage space for these items. Added to that, people who suffer from motion sickness won't feel any discomfort in our cars and can even lie down without feeling unwell.

SS: What does your focus on user experience mean when it comes to charging?

JZ: For EV drivers, the charging process is the slightly annoying part of owning an electric car. We want to make charging as easy as possible. That is why we have developed some solutions to improve the charging experience, the details of which I can't release at the moment. In addition to conventional charging (slow and fast charging), the first two NIO models will also be equipped with battery swapping capabilities, allowing the battery to be exchanged within a very short time.

SS: Which charging standard is implemented in the NIO ES8?

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JZ: The car uses the Chinese national charging standard, which was released recently and which differs slightly from the European standard. It supports both slow and fast charging. Details will be released when the vehicle is ready to go on sale.

SS: How is the current situation with charging stations in China?

JZ: The Chinese government supports the installation of public charging stations and also issued an order last year stating that every new building needs to have charging facilities. In addition, there are many private investors already operating public charging stations. That is why we don't see a major issue with charging an electric vehicle in big cities such as in Shanghai, Guangzhou, Shenzhen or Beijing by 2020.

SS: Besides classic vehicle ownership, will there be other sales options such as battery leasing or all-inclusive leasing flat rates?

JZ: I think buying or leasing the car will be one option. But I don't think it is fair for the consumer to pay 1/3 of the price of the car for the battery alone. NIO will own the battery and lease it to the consumer with certain other services.

SS: NIO announced plans to sell self-driving cars in the US by 2020. How do you foresee the speed of AV development and deployment? Will our children need driving licenses at all?

JZ: I think the vehicle situation will vary between different cities and areas. The speed of deployment of autonomous vehicles will vary locally and will very much depend on regional governments and their speed of determining the legal regulations, which is not going to be done overnight.

The technology for autonomous driving will be ready or at least at a very good level by 2020. We as NIO will push as much as possible and we will equip the cars with as many autonomous functions as possible. The first batch of cars will have Level-2 and Level-3 autonomous driving. And our concept cars already show the feeling and user experience you will have with fully autonomous cars.

SS: Tesla will produce its own battery cells; most other OEMs use standardized cells from suppliers. What is NIO's strategy on battery cells?

JZ: NIO is still a small company and will purchase battery cells from known suppliers such as CATL or Samsung, etc. Battery cells are certainly the key component of an electric vehicle but we still need to increase the production volume.

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That's why we follow our industry's general philosophy and share suppliers with other OEMs. It is best for the industry that we form alliances now, so that the suppliers can become stronger, which will ultimately make battery costs come down faster. NIO does not intend to invest in its own battery cell production but it might be an interesting option for NIO Capital.

SS: There are several automotive start-ups entering the EV and AV market in the coming years. How does NIO distinguish themselves from the other newcomers?

JZ: Although NIO is a new company, we have the advantage that two thirds of China's large internet enterprises are behind NIO and have shares in the company. This includes engagements from Baidu and Tencent, the latter also having invested in Tesla recently. Many other qualified Asian investors such as Sequoia, Temasek, GIC and Warburg Pincus have bought shares too.

Most importantly, NIO is planning its progress step by step and we are completely on track. We are keeping our promises for every step!

SS: Junyi, thank you very much for the interview.

4 Methodology

The relative competitive position of individual automotive nations is compared to that of others on the basis of three key indicators:

- > **Technology:** The current status of technological development in vehicles made by indigenous OEMs and the support for vehicle development provided by national subsidy programs
- > **Industry:** The regional value added in the automotive industry by national vehicle, system and component production
- > **Market:** The size of the national market for electric vehicles based on current customer demand

Roland Berger and fka weight the individual indicators (value range 0-5) and combine them to form the E-mobility Index (Figure 10). The E-mobility Index makes it possible to compare the competitive positions of the world's seven leading automotive nations (Germany, France, Italy, the US, Japan, China and South Korea), assessing their individual automotive markets on the basis of uniform global standards. The index also reveals the extent to which individual nations are able to benefit from the market that e-mobility is creating. The criteria applied are assessed as discussed below.

Technology

- > The technological performance (efficiency, range, charging technology, vehicle concept and safety) and value for money of electric vehicles that are currently available on the market or soon to be launched
- > National e-mobility R&D programs. Only research grants and subsidies are taken into account (not credit programs for manufacturing, budgets for purchase incentives, etc.)

Industry

- > Cumulative national vehicle production (passenger cars, light commercial vehicles) for the period 2015-2019, taking account of BEVs and PHEVs
- > Cumulative national battery cell production (kWh) for the period 2015-2019

Market

- > Electric vehicles' current share of the overall vehicle market (over a 12-month period)

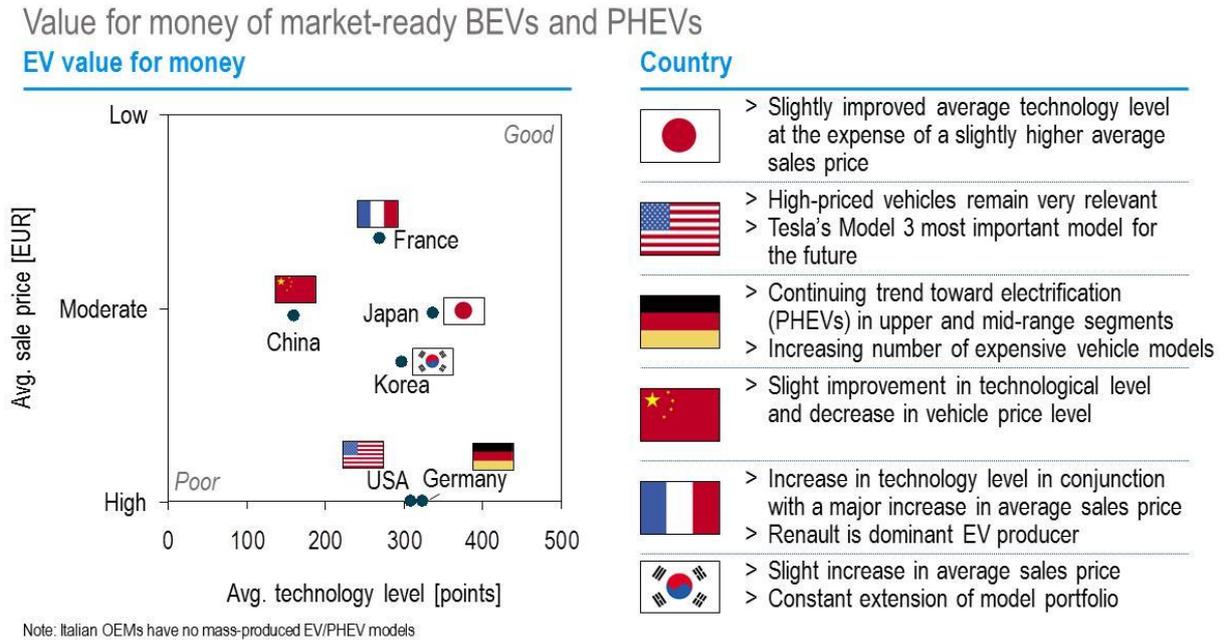
The technology indicator was updated in the Q4 2016 E-mobility Index. Individual aspects of the methodology used to measure technological performance (safety features, active safety) were adjusted, while on-board charging technology was added as a new criterion. Overall, these adjustments alter the level of the technology indicator compared to previous editions of the E-mobility Index. The new charging technology criterion also results in shifts between individual countries.

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The Q4 2016 index was also the first to include projections for 2018, while the 2017 index is the first to include projections for 2019. The additional volume is reflected in higher scores for industry in all markets. However, this does not affect the shifts between markets, and the E-mobility Index's comparability with previous indices is thus not compromised.

The measurement threshold for the market indicator was also modified in the Q2 2017 index. The fact that BEVs and PHEVs are increasingly penetrating the market made this step vital to focused assessment in the value range from 0-5. A relative market share of only 1% is now needed to reach a maximum score of 5.0 for this indicator. The higher threshold also reduces countries' market values compared to previous editions of the index.

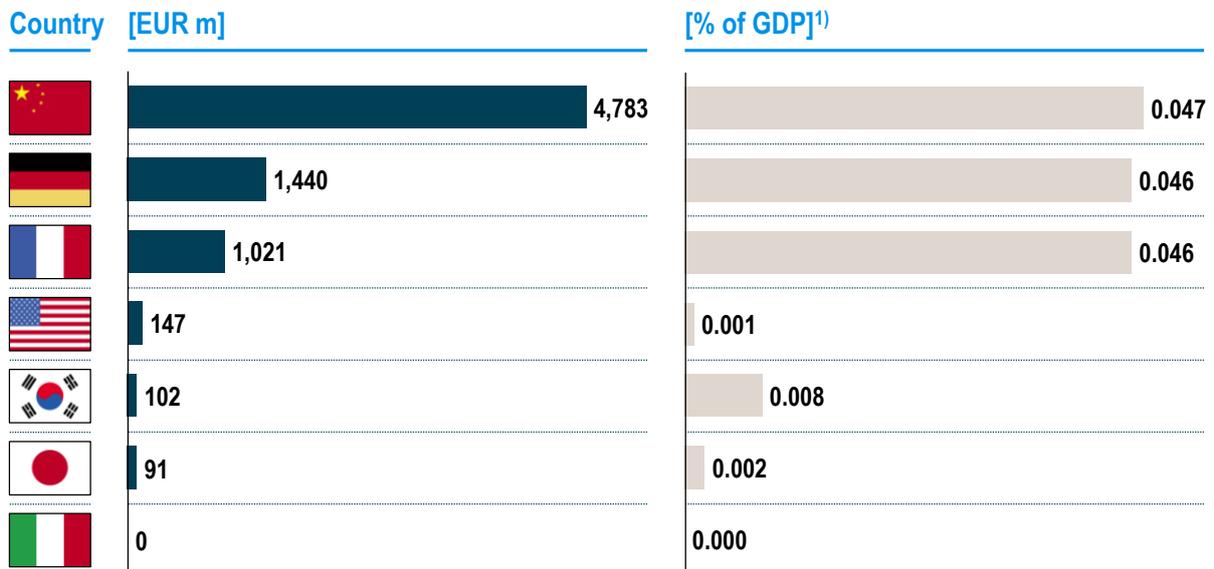
Figure 4: France with increase in average sales price; In Germany and USA high-priced vehicles remain relevant



Source: fka; Roland Berger

Figure 5: R&D subsidies are fairly constant in most automotive nations – China is still a long way ahead in terms of subsidies

State R&D funding for e-mobility

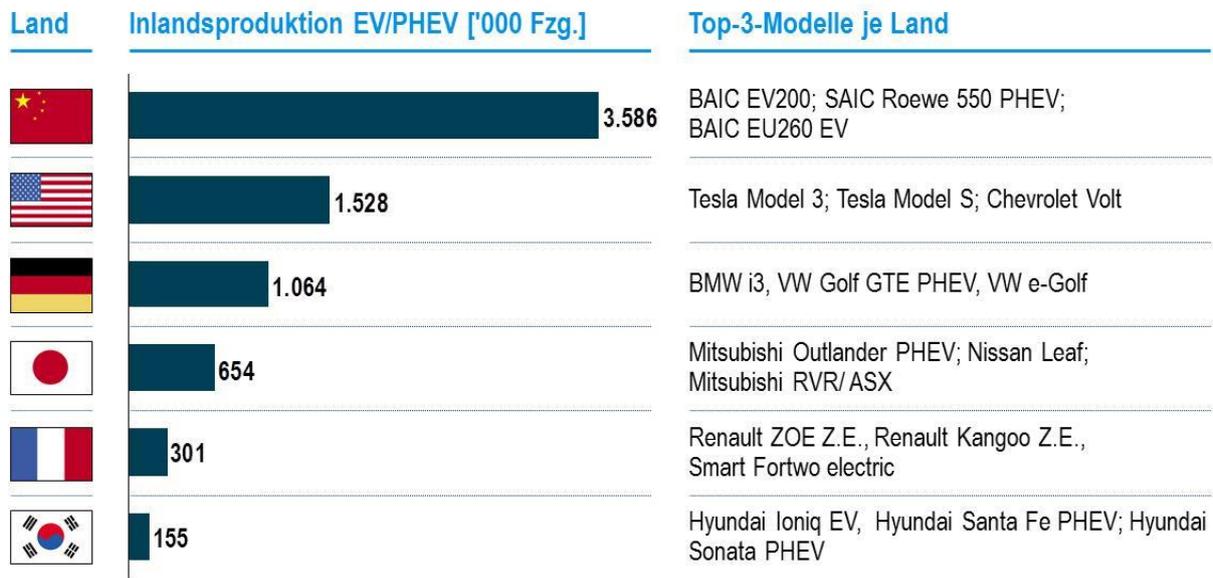


1) Subsidies expressed as a proportion of current GDP (2016)

Source: fka; Roland Berger

Figure 6: China will keep clear leadership in EV/PHEV production with USA staying on second place; Germany catching up

Projected production of EVs and PHEVs through 2019

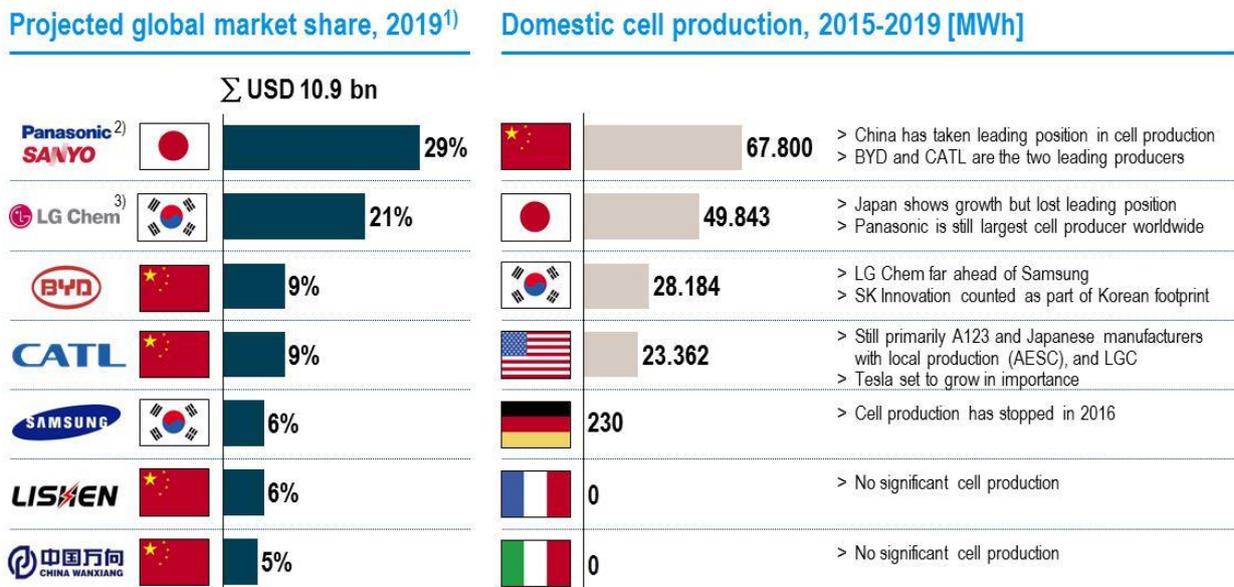


Hinweis: Keine signifikante EV/PHEV-Produktion in Italien erwartet

Source: fka; Roland Berger

Figure 7: China has overtaken Japan and become leader in battery cell production – strong growths also in Korea and USA

Cell manufacturers and production, by country, through 2019

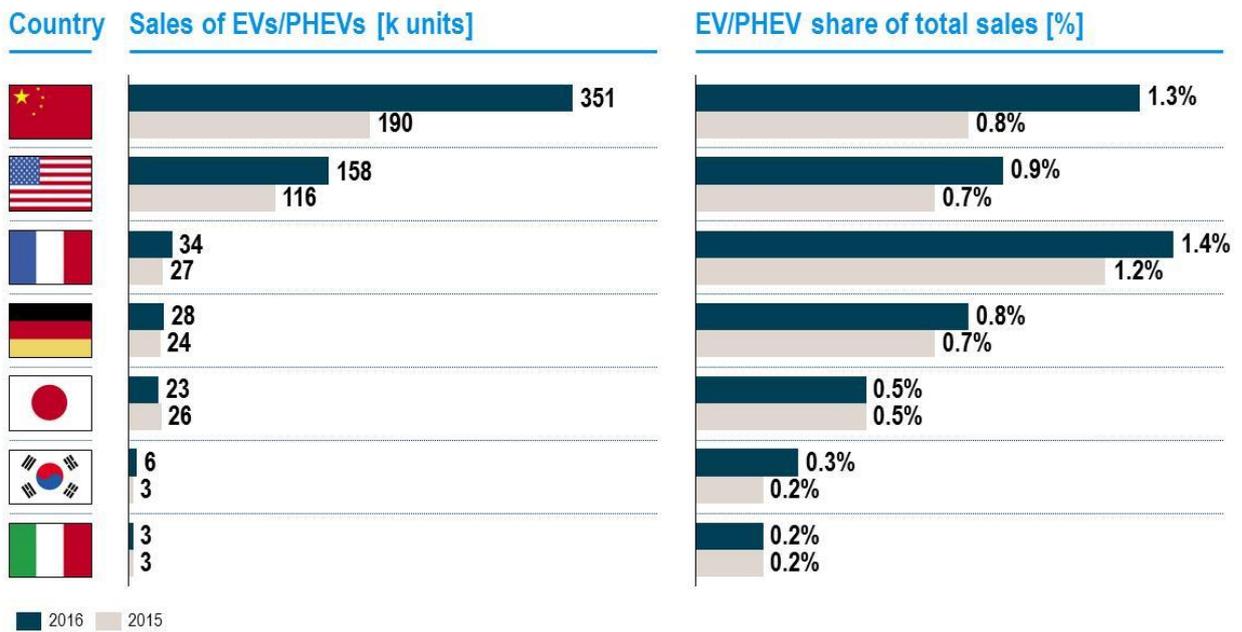


1) 2019 market value in USD calculated as follows: 210 USD/kWh for PHEVs and 150 USD/kWh for BEVs; shift from single to dual sourcing strategies expected mid-term
 2) Including Primearth's market share 3) Including AESC market share

Source: fka; Roland Berger

Figure 8: China has almost doubled its EV-sales in 2016 and is clear leading market for electrified vehicles; Japans market decreases

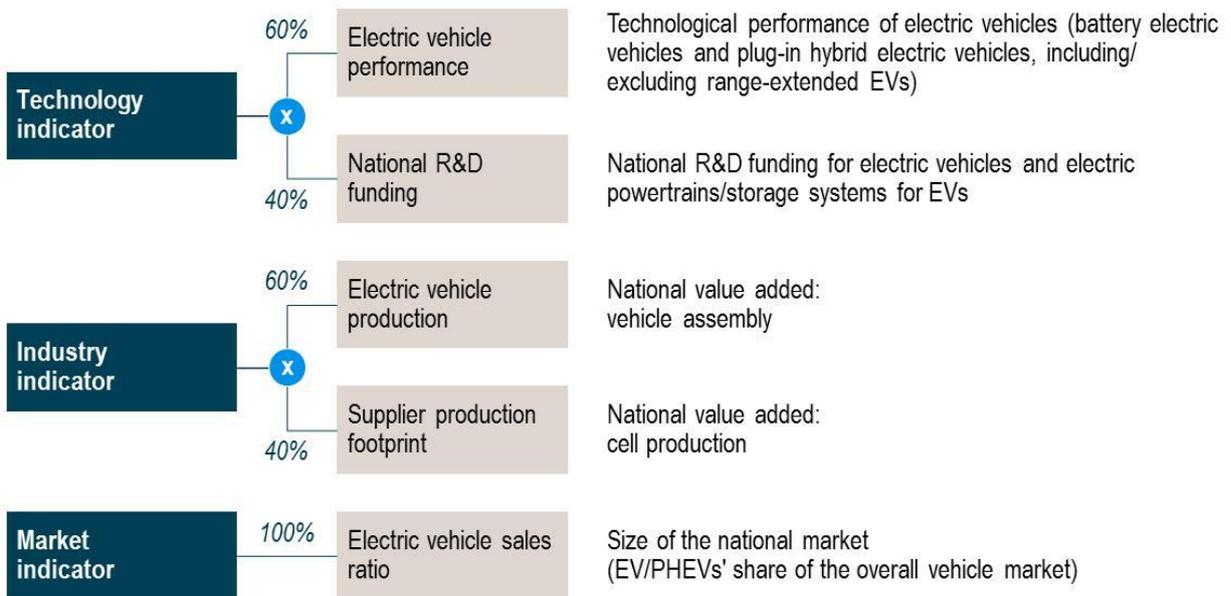
Sales figures and market share of EVs/PHEVs, 2015 and 2016



Source: fka; Roland Berger

Abb. 9: The E-Mobility Index compares automotive nations on the basis of three parameters

E-Mobility Index – Three parameters: Technology, industry, market



Source: fka; Roland Berger

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