Breakthrough of electric vehicle threatens European car industry

ING Economics Department • July 2017

ING

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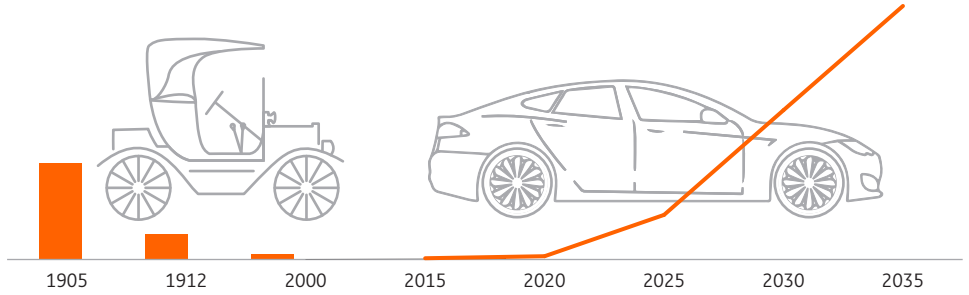
Electrification isn't new for the industry

At the turn of the 20th century, electric cars accounted for 38% of US registrations. But their share soon declined. Sales peaked in 1912 in the US at 6,000. By contrast, in that same year over 80,000 Ford Model T's, with an internal combustion engine, were sold. In 1912 an average petrol car cost $ 650 vs. $ 1,750 for an average electric car. Today, after more than a century, electric cars are back and ready to stay.

Historic and forecast market share trend of BEVs



Source: IEEE, The rise and fall of electric vehicles in 1828-1930 - lessons learned, C.C. Chan.

Abbreviations

Powertrain	Components that generate power and deliver it to the road
ICE	Internal combustion engine vehicle, operating on fuel.
HEV	Hybrid electric vehicle. Operates on internal combustion engine, assisted by a battery (charged by braking energy). Short distances on battery alone.
PHEV	Plug-in hybrid electric vehicle. Also combines ICE with battery power, but can be charged (plugged in to grid) to drive 30-60 km's on its battery.
BEV	Battery electric vehicle, fully operating on battery electric power.

Executive summary

Electric shift challenges Europe's car industry

Battery electric car breakthrough

The car industry is at a turning point. Battery electric vehicles (BEV) are becoming increasingly competitive. The major barriers to demand – charging infrastructure, range and pricing - are about to be broken:

- Charging infrastructure: ultra fast charging of batteries will enable a 300km charge in 20 minutes. This will further improve over time.
- Range anxiety: New battery technology should improve range to increasingly meet consumer expectations from 2020 onwards.
- Pricing and total cost of ownership: Battery costs continue to decline. Although purchase prices will remain relatively high for quite some time, electric vehicles have low costs of operation. This should enable a high range battery electric vehicle to become cost competitive (on total cost of ownership) with a comparable petrol car in 2024.

Towards a 100% battery electric car market in 2035

Once BEVs beat internal combustion engine cars (ICEs) on price and quality, transition can move fast. A growth path in which BEVs near a 100% share in new cars by 2035 is increasingly realistic. This challenges Europe's Automotive industry, which holds close to 25% of global car production.

Battery electric vehicle increases competition, reduces value and jobs

European manufacturers are at the forefront of internal combustion engine development, which has grown into one of their competitive advantages. But this will disappear as engines, transmissions and exhausts - representing 1/3 of the value in Automotive supply - are swapped for electric motors and battery packs. Furthermore electric vehicles will change the characteristics of the powertrain market:

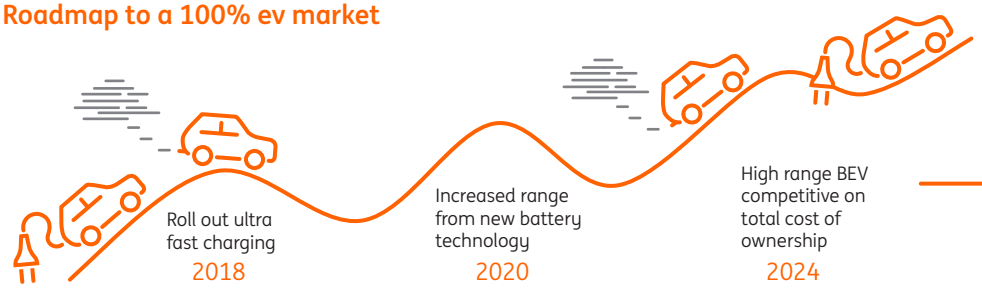
- Production is more automated and less labor intensive, jobs will be reduced.
- Outsourcing rises as control of powertrain development and production shifts from car manufacturers to generic Automotive and/or battery suppliers.
- Competition from Asia and North America will increase. Both are increasing EV battery production. Europe's share in this market is only 3%.

There will be less room to differentiate, while pressure on prices and margins rises. This 'commoditization' results in a loss of value in powertrains and thus the entire car.

Value shifts from product to services

The challenge for Europe's Automotive industry will be to move from a traditional business model in which value is drawn from production and sales of cars to a business model that offers value in facilitating efficient and affordable car usage. Opportunities lie in mobility as a service solutions, such as (private) car lease and car sharing. Electric cars, which offer low costs of operation, can boost these services. Equally, the low rates of electric car leasing and sharing should stimulate the adoption of battery electric vehicles.

Roadmap to a 100% ev market



- Europe's competitive advantage in powertrains disappears.
- More outsourcing and stronger competition in BEV powertrains.
- Commoditization of powertrains and loss of value and jobs.

- New opportunities in sustainable energy, charging infrastructure and mining.
- Value in automotive moves from hardware to services. Clean and cost efficient transports boost (private) leasing and car sharing.

1. Electric breakthrough 2017-2024

Electric breakthrough 2017-2024

1.1 Barriers limit demand for BEVs

Renewed interest in electric cars

Concern about the environmental impact of cars, emission regulations and improved battery technology have led to renewed interest in electric cars. A number of battery electric cars have been released such as the Nissan Leaf, Renault ZOE, BMW i3 and Tesla Model S. The Tesla in particular has demonstrated that rethinking the concept of a battery electric car, can lead to a more competitive vehicle. This has convinced other car manufacturers that BEVs are the way forward.

Accelerated development of electric cars

As a result, a lot of car makers are now driving the EV market. Opel launched the Ampera-e. Tesla itself plans to launch the Model 3 in 2017. Ford wants 40% of it's models to have an electric version by 2020. VW plans 10 models by the end of 2018 and 30 by latest 2025.

Still a niche

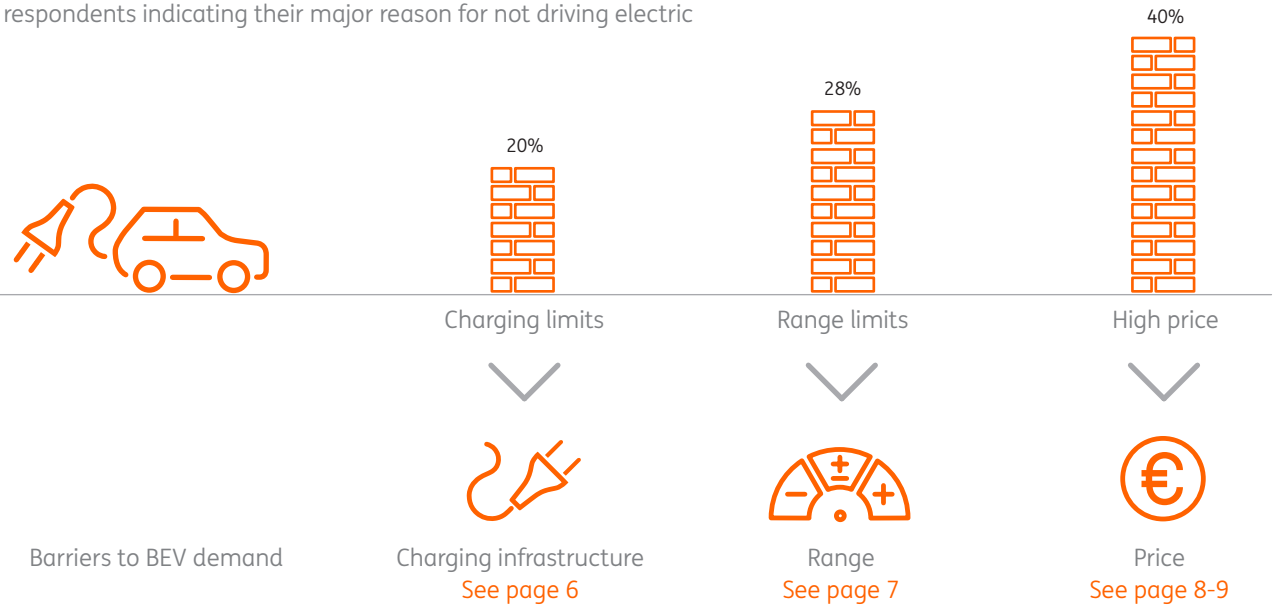
Although the focus on electric vehicles is increasing, their current share in the car market is still very limited. In Europe (EU + Norway) 1.3% of passenger cars sold in 2016 were electric (battery electric BEV and plugin hybrid PHEV). Of the total car fleet 0.2% is electric. In China, where over 40% of global EVs (BEV and PHEV) are sold, the share in sales is just under 1.5%.

Barriers to driving electric

To end the dominant position of ICEs, BEVs will have to work on the 3 major barriers for demand. According to consumers the most important reasons not to choose an electric car are:

Consumers mention 3 major barriers to BEV demand

% respondents indicating their major reason for not driving electric



Source: ING Question of the day – 47,000 respondents in the Netherlands (remaining 12% chose other reasons)

Barrier 1

Electric breakthrough 2017-2024

Charging infrastructure – ultra fast in 2018

Explosive growth in charging infrastructure

Access to (quicker) charging infrastructure is a requirement for BEV demand. In 2010 the number of charging stations globally was minimal. In 2015 there were close to 1.5 million charging points. The growth in EV infrastructure has been explosive. In Europe, the total number of charging points (public or semi-public) has risen to 112,500.

Number of charging points almost equal number of gas stations in Europe

121,000
gas stations* (2016)

112,500
charging points* (2017)

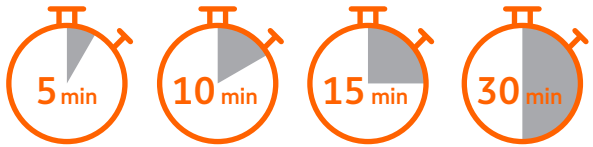
Sources: *Fuelseurope (1 station can have multiple tank points), EAFO

Competition fueling further growth

To stimulate growth in electric vehicles, national and local governments subsidize charging infrastructure. At the same time market parties are seeing charging infrastructure as an interesting growth market. Demand for charging points has risen sharply in countries such as the Netherlands and Norway. Major markets like France and Germany are catching up. The charging infrastructure market should become even more interesting as BEV numbers and battery sizes (more kWh) grow. In the Dutch market, companies have been fighting over highway locations. Furthermore there is an increasing number of parties, such as retailers (supermarkets), offering free charging to (attract) customers.

Maximum acceptable time for charging en route of people considering BEV

% of respondents



14% 23% 37% 25%

Source: ING Question of the day, 44,000 Dutch respondents, 2/3 considering BEV

Charging speed is essential

Although the number of charging points has grown, the majority of these points are 'normal' or 'slow' charging. The speed of charging is however just as important. Especially for those without the ability to charge at home or people driving long distances.

Ultra fast charging

Consumer research shows the speed of charging will need to improve. A number of companies, including infrastructure providers and car manufacturers, are involved in an ultrafast charging corridor project. This should enable BEVs to charge 300 kilometres in 20 minutes from 2018 onwards. Technological advancements, mainly cooling related issues, will have to further decrease charging times in the future. The Porsche Mission E, set for launch in 2020, is targeting a 400km range in less than 15 minutes.

Barrier 2

Electric breakthrough 2017-2024

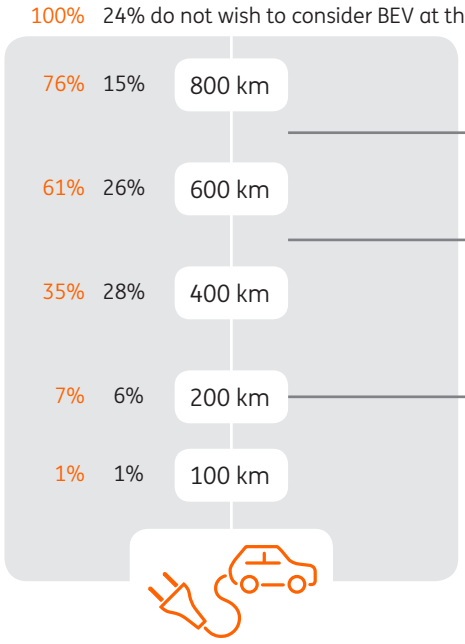
Range anxiety – fears vanish from 2020 onwards

Majority of consumers want over 400km range from BEV

Most BEVs on today's market have a range of 200 to 300 kilometres, depending on driving style and weather conditions. Rationally, looking at average daily driving distances, this should be enough. Research by ING however shows most consumers expect more. New BEVs will have to jump this barrier.

Minimum distance I want to be able to drive on 1 charge to consider a BEV

Cumulative % in orange



2020 onwards: next generation featuring new battery technology

To get towards ultra high ranges and completely eliminate range anxiety, further developments in BEV technology are needed. More efficiently designed cars, more scale in production, more efficient electric motors and, above all, more efficient batteries.

2016-2020: new generation - towards acceptable mileage

Tesla has shown that its models can touch ranges up to 600km, be it at a high price. New models and lower battery prices should bring ranges of 350-500 km to more affordable cars in the next few years.

Pre 2016: first generation with limited appeal

1st generation BEVs with 100km-200km ranges have remained niche vehicles. This despite limited daily needs in terms of driving. An average German car owner drives 36.5km per day[1] and the increasingly aging population could bring this down further. Range anxiety, however, prevents people from settling for a low range.

Source: ING Question of the day with over 52,000 Dutch respondents.

Improving energy density

Improvements in battery cell density, meaning more energy per cell (more energy in Wh per kg), helps increase range and decrease battery pack weight and cost. In 2011 the Nissan Leaf reached 90 Wh/kg per pack[2]. In 2017, the Opel Ampera-e is close to 140 Wh/kg. Tesla leads with an estimated 170 Wh/kg and is introducing an improved cell type. Meanwhile battery manufacturers are working on other chemistries, such as solid state batteries, to increase energy density by a factor of 2 to 3. Toyota plans to market solid state batteries as early as 2020. News reports have indicated Bosch, VW and Samsung also look set to further develop these batteries for BEV use.

Sources:

1 Kraftfahrt-Bundesamt

2 Bloomberg New Energy Finance

Barrier 3

Electric breakthrough 2017-2024

Declining battery costs reduces price

Battery pack costs decrease rapidly

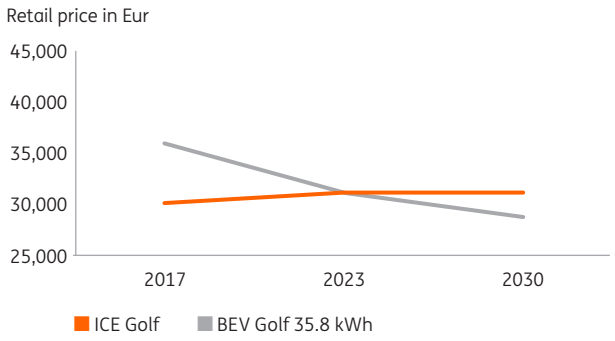
Battery prices for BEVs have decreased quickly. Costs went from an average $1000/kWh in 2010 to around $300 in 2016. Current cost leaders are already moving towards $150 per kWh.

Price gap still remains

The price gap between BEV and ICE however still exists. For example the VW Golf, the best selling car in Europe and available as ICE and BEV, shows that the BEV version retail price in Germany is almost 20% higher than a comparable petrol version. Continued improvement in battery chemistry and production methods should however bring down battery pack prices towards $100/kWh in 2025[1]. This could theoretically see the retail price of the current e-Golf equate to that of a (petrol) ICE Golf in 2023. But consumers will also demand a higher range than the 200-300km currently available on a 36 kWh battery. If theoretically equipped with a 60 kWh battery, range could be pushed towards 500km, but the break-even point moves to 2028.

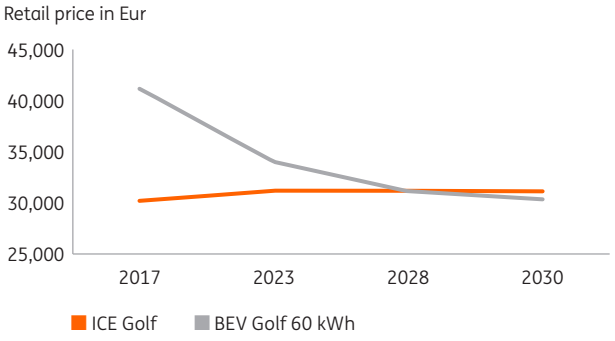
BEV VW Golf breaks even with ICE price in 2023

German retail prices (excl. government incentives) 2017
VW Golf ICE vs e-Golf 35.8 kWh*



Equipped with a longer range battery, break-even point moves to 2028

E-Golf if equipped with a 60 kWh battery vs ICE GolF



* e-Golf compared with TSI 125hp DSG 5dr. Comfortline. ICE price corrected. for extra equipment e-Golf (nav pro, LED light, media control / usb, climatronic, driving profiles). ICE added 1,000 euro for expected emission regulations costs from 2021. Forecasted battery pack cost based on Bloomberg New Energy Finance. Calculated with 10% margin and 19% VAT into German retail price.

BEV - higher costs and lower margins

The electric powertrain itself (electric motor including a simple 1 ratio gearbox) of a BEV is currently estimated to cost €1,500** on average. This is about half the average cost of an ICE powertrain (combustion engine, gearbox, exhaust etc) of €3,000. However, once the battery pack is added (close to €8,000 for a 36 kWh pack at 2017 average battery price) costs rise above those of an ICE. To make retail prices more palatable, manufacturers generally accept lower margins on BEVs.

BEV costs have downward potential, while ICE costs are expected to rise

BEVs however have potential to decrease in cost. Simpler design, easier manufacturing and increased volume should decrease production costs. Bloomberg New Energy Finance forecasts battery prices at just over $70 / kWh in 2030. At the same time ICEs will face higher costs due to stricter emission regulations. This could add an average €1,000 to the cost of an ICE after 2020.

Source:

1 Bloomberg New Energy Finance

** Sources: Technische Universität München, McKinsey, Roland Berger

Barrier 3

Electric breakthrough 2017-2024

Cost competitive in 2024

Total cost of ownership BEV strongpoint

When purchasing a car it is important to look beyond the purchase price. Running costs can make a big difference to the total cost of ownership (tco). BEVs benefit from a lower tco than ICEs thanks to:

- Electricity costs being lower than fuel costs, hence a BEV will save money based on cost per km.
- With a less complex powertrain, a BEV will generally require less repair and maintenance than an ICE.

Other tco components will vary per car and per market. Road tax is an example of this. Depreciation, which is the main tco component, is difficult to determine, although long range cars (in particular the Tesla) have shown favourable residual values. High range BEVs should be attractive to consumers buying second hand, as it reduces their operational costs.

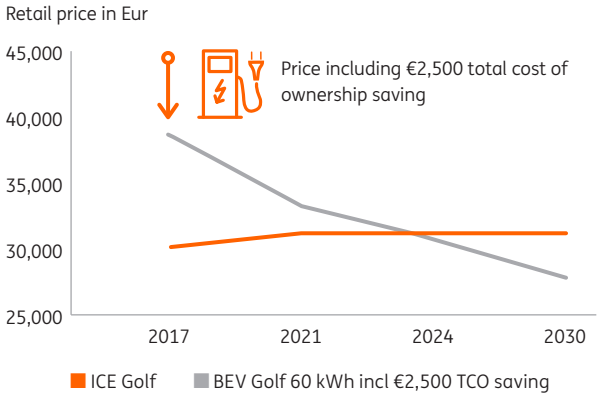
Energy savings

As stated on page 8, a long range BEV thus needs more time to reach break even when comparing retail prices. However, we estimate a 60 kWh e-Golf will save money on its total cost of ownership. A German customer, capable of charging at home, can save €500 per year on energy costs alone. If we assume average car ownership of 5 years (at 15,000 km / year), this results in a €2,500 saving.

Total cost of ownership helps long range BEV

As stated on the left it is difficult to forecast all costs of ownership. A high range BEV is however expected to be competitive on all cost factors, while saving on energy costs. If we take into account the €2,500 tco saving and subtract this from the calculated retail price, the high range BEV is able to achieve tco parity with a comparable petrol car in 2024. The year of tco parity will vary by market. Electricity prices are relatively high in Germany. Other European markets could hit tco parity earlier.

Total cost of ownership parity for 60 kWh BEV in 2024



Taking into account the total cost of ownership advantage (as described left) the price is reduced by €2,500. These total cost of ownership savings were calculated using the advantage of charging at home vs. refuelling a petrol car. Calculation is based on 5 year ownership in Germany of a BEV driving 15,000 km / year.

Electric breakthrough 2017-2024

1.2 Breakthrough in 2024

Broken down barriers

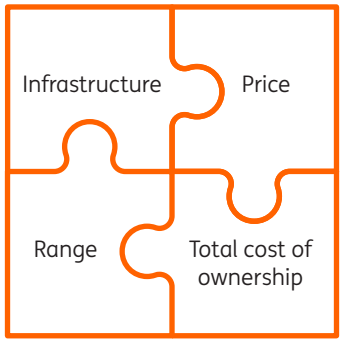
We expect that in the period 2017-2024 the barriers to BEV demand, infrastructure, range, purchase price and total costs of operation will be broken and that BEVs will become the rational choice for motorists in Europe.

Potential show stoppers

BEVs will be able to stand on their own feet from 2024 onwards. The run-up to that point is however important. Market parties will have to work hard to make BEVs competitive. Government support is needed in the early stages to safeguard future success.

1. Manufacturers and suppliers will in practice need to utilise economies of scale. Prices of BEV powertrains, mainly batteries, have to decline further.
2. Breakthroughs in battery development are needed in order to increase battery energy density and range and reduce manufacturing cost.
3. The introduction of strict emissions regulations for ICEs and government support for BEVs is needed to trigger further investment and stimulate supply and demand in BEVs. Fuel and energy price developments and taxation will also be decisive factors.

Puzzle fits together in 2024



2018 Ultra fast charging means a 300 km range in 20 minutes

2020 Higher energy density battery technology meets consumers range expectations from 2020 onwards

2024 High range BEV total cost of ownership parity with ICE

Why battery electric beats hydrogen to 2035

Sales of BEVs will pass ICEs within ten years. But what about plug-in hybrids (PHEVs) or (hydrogen) fuel cell cars? We expect PHEVs to disappear rapidly once BEVs become more competitive. A combined ICE and BEV powertrain makes it impossible to be cost competitive. The hydrogen fuel cell also faces several key issues:

1. Fuel cell vehicles are very expensive. They are complex to build using high pressure hydrogen tanks and fuell cells next to batteries and electric motors. Prices could be reduced, but we think BEVs have greater potential in this area.
2. Hydrogen infrastructure is very limited and requires significant investment to be build. Furthermore hydrogen production requires a lot of energy. It is an expensive fuel. Total cost of ownership cannot compete with a BEV.
3. Although some car manufacturers are developing hydrogen fuel cell vehicles, investments and R&D are limited compared to battery electric cars. Hydrogen looks like a solution for (heavy) commercial vehicles, but not for passenger cars.

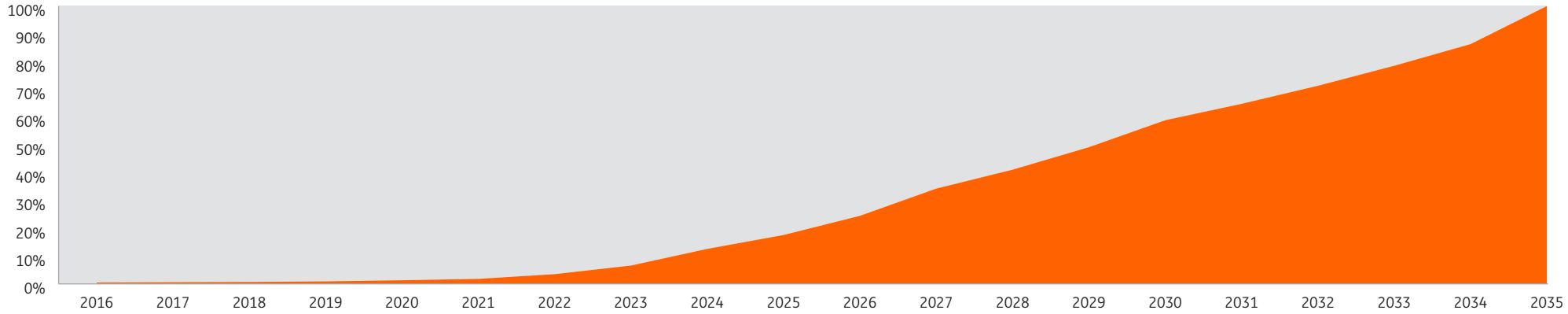
Electric breakthrough 2017-2024

1.3 Growth path to a 100% European BEV market 2035

With all pieces of the puzzle coming together, the market share of BEVs in Europe's new passenger car market is set to rise. The first part of the 20s will see fast growth in BEV sales, market share becomes substantial late 20s. Car platforms, which we estimate have a 6 year lifecycle, will by then become increasingly BEV only. By mid 30s we expect BEVs to dominate the market.

Market share of BEVs in Europe rises to 100% in 2035

share of BEV in European new passenger car registrations

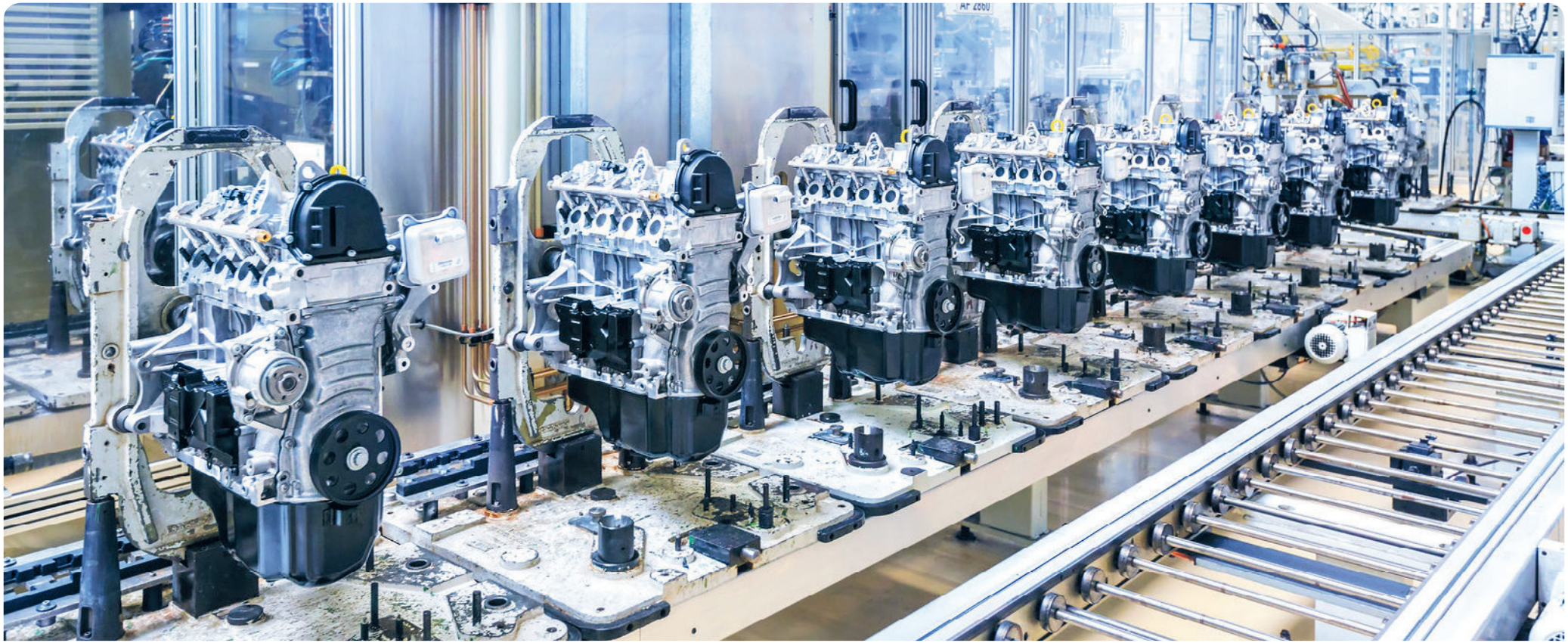


6 year platform lifecycle

- Government supported market to stimulate transition to electric vehicles.
- Premium (niche) BEVs gaining in upper segments. Key products create first 'volume' BEV s.
- (Ultra) fast charging roll-out.
- Next gen batteries increase energy density, lower BEV cost.
- Economies of scale for BEV.

- High range BEVs reach total cost of ownership parity with ICE.
- BEVs become the rational choice.
- R&D fully focussed on BEV development.

- BEV purchase price and TCO below ICE.
- New platforms / models increasingly 'BEV only'.
- Phase-out of ICE.
- BEV dominant in European new car sales.



2. The impact on Europe's Automotive industry

2.1 Electric car changes the value chain

A market dominated by battery electric cars has huge consequences for all parties in the value chain. This requires Europe's Automotive industry and its employees to prepare for change.

Different parts, different value chain

The powertrain of a car involves components generating power and delivering this to the wheels. A BEV powertrain differs considerably from an ICE powertrain. Exhausts, transmissions and engine components are exchanged for electric motors, battery packs and power electronics (to control electric power). It is estimated a BEV powertrain has around 200 components while an ICE carries 1,400 components[1]. Almost a third of the value of the Automotive supply chain is powertrain related and threatened by the shift to electric powertrains.

Combustion engines in Europe

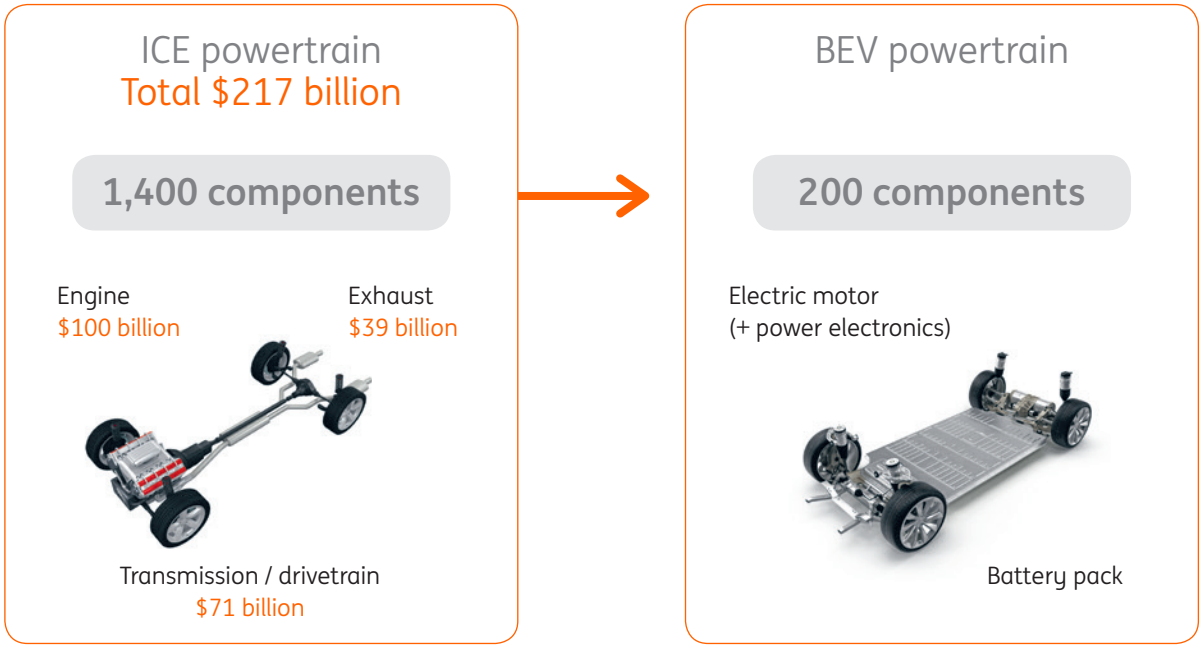
Europe has been at the forefront of internal combustion engines for passenger cars since the end of the 19th century. In 2016 there were over 90 locations for engine and transmission production in Europe (incl. Russia and Turkey). Europe produces around 22 to 23 million engines and gearboxes per year[2]. This is close to 25% of the total global light vehicle engine and gearbox production and represents a value of 65 to 70 billion euro.

Sources:

[1] Friedricht Ebert Stiftung (The future of the German Automotive Industry)

[2] based on IHS data

Change from ICE to BEV results in global USD 217 billion[3] powertrain segment swapped for BEV components



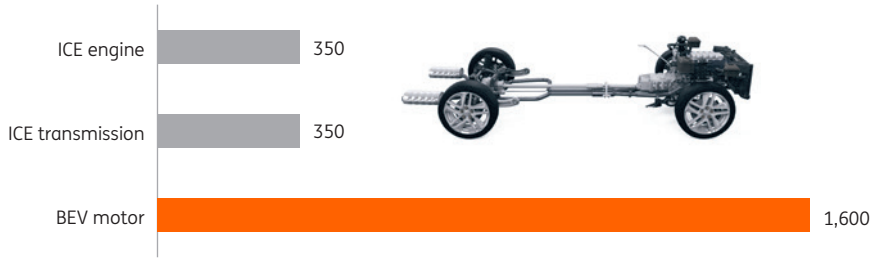
[3] Roland Berger 2015 turnover, note that $7 billion out of $217 billion is hybrid and BEV related

The impact on Europe's Automotive industry

More raw materials, less labour

Less labour required for BEV powertrain production

Estimated average components per employee per year



Data from various ICE and BEV car manufacturing plants shows that the number of electric engines/ motors produced per employee is significantly higher than for internal combustion engines. We expect this to rise further as BEV volumes increase. Although there is still little data on battery pack production, this process is also highly automated.

Source: ICE Estimates based on production plant info from BMW, VW, Daimler and Nissan

BEV needs raw materials

While a BEV does not carry a significant number of (moving) parts, it does require additional raw materials, mainly for its batteries. Besides lithium, materials used include nickel, cobalt, graphite, manganese and aluminium.

Raw materials not seen as future constraint

Although exact amounts per manufacturer are unknown it is estimated[1] that a 70 kWh Tesla battery pack holds 63kg of lithium and 54kg of graphite. This is still only part of the story as the total battery pack weight is around 450kg. Demand for raw materials will rise in a BEV dominated market. Supply is generally not considered as a future constraint.

Geopolitical risks can influence prices

Price swings in case of over- or undersupply are however possible. Geopolitical risks exist as mining of some materials is sometimes concentrated in certain countries. For example, around half of global cobalt production is in the Democratic Republic of the Congo. Location of raw materials can also benefit the manufacture of BEVs in some countries over others. China for example has lithium reserves and mining, while the US and Europe have only just begun to look at building a lithium mining industry.

Less dependent on labour

BEV manufacture might require a lot of raw materials, but a BEV requires less labour in production. Electric motors are smaller and less complex than internal combustion engines. Highly automated production is possible for battery packs and electric motors.

1 Electrek.co

Powertrain control shifts to suppliers

Manufacturers more reliant on suppliers

Traditionally ICE manufacturers develop and assemble engines and transmissions themselves based on a vertical integration model. The situation is different in BEV powertrains. A lack of knowledge and production capacity means car manufacturers are relying on suppliers to help them build BEVs. Although many European manufacturers are now also developing BEV components themselves, the transfer from ICE to BEV can threaten their position in powertrains.

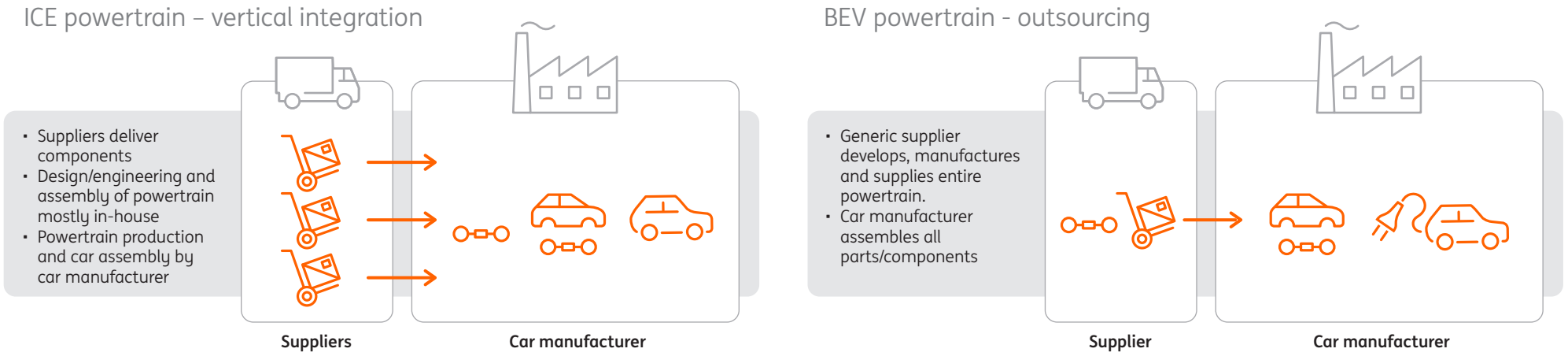
One stop shopping for BEV powertrain

Major battery suppliers and 'traditional' generic suppliers such as Bosch and Continental have moved into electric powertrain development. Unlike with ICEs, where they supply parts, this gives them the opportunity to become a one-stop shop by supplying entire BEV powertrains. The electric motor, featuring less components and more automated production, replaces the more complex ICE engine and (separate) transmission.

Integration vs. outsourcing

The recent case of the new Chevrolet Bolt/Opel Ampera-e is a good example of how BEV production could lead to more outsourcing. General Motors outsourced the entire powertrain to its supplier, LG Chem. Most BEV models have battery packs from major suppliers such as LG, Samsung and Panasonic. In electric motors we currently see a lot of outsourcing, although some manufacturers aim to develop their own motors in the near future.

BEV powertrain more likely to be outsourced



2.2 Europe's position - important advantage disappears

Internal combustion engine differentiating factor

The ICE powertrain has been one of the important differentiators for European car manufacturers. Europe has been at the forefront of internal combustion engine development and has dominated the International Engine of the Year awards in recent years. It has helped them gain a competitive edge and boost export of cars. This is also reflected in the global share (nearly 25%) in production of powertrain components (engine / gearbox).

Rational and emotional choice

European manufacturers' lead in combustion engine development has on the one hand helped them target rational customers looking for low running costs and fuel efficiency. On the other hand it has enabled them to become popular with car enthusiasts by relating to emotional aspects such as performance, sound and driveability.

Advantage under threat

These advantages are however threatened. BEVs have shown that their motors are capable of beating ICEs on performance and smoothness. The emotional value of powerful internal combustion engines is therefore under attack. Furthermore, as noted in chapter 1, BEVs are expected to become competitive on costs of ownership. This will eventually also make them the rational choice of consumers.

Experts see pressure on Europe's auto industry rising

Quotes collected during interviews with Automotive experts on electrification and powertrain development

"China is betting heavy on electric engines."

"Generic suppliers are all targeting electric motors."

"There's not a lot needed for electric motors."

"Electric motors are a growth market but extremely margin driven."

"China's electric busses are already ahead of the Europeans."

"OEM's are afraid to become outsiders."

Electric motor passes internal combustion engine

Besides being the choice of environmentalists, BEVs have also shown they are more than a match for ICEs when it comes to performance. An electric motor is able to provide instant torque, which enables it to generally accelerate faster than ICEs. Electric cars have also made their way into racing. Formula E (battery electric racecars) has presented itself as the electric alternative next to Formula 1.

Competition rising

Europe lacks battery production

Although European manufacturers are trying to catch up in BEV development, their current position in BEV powertrains isn't very strong. A lot of manufacturers outsource motors. When it comes to batteries, most are completely reliant on major battery suppliers. Europe's market share in li-ion production is only 3%. A big contrast to its share of 25% in ICE powertrains.

Asia and North America in front row

Looking at planned increases in battery production capacity, Europe's share is not likely to rise soon. Out of all planned capacity or capacity under construction only 3.5% is in Europe. Asia has moved into pole position and North America, with Tesla, is also expanding rapidly.
European car manufacturers are considering investing in their own production capacity. Daimler has already taken the plunge. Most investments in Europe are however coming from major battery suppliers such as LG and Samsung, both building battery plants in Europe.

China looking to dominate

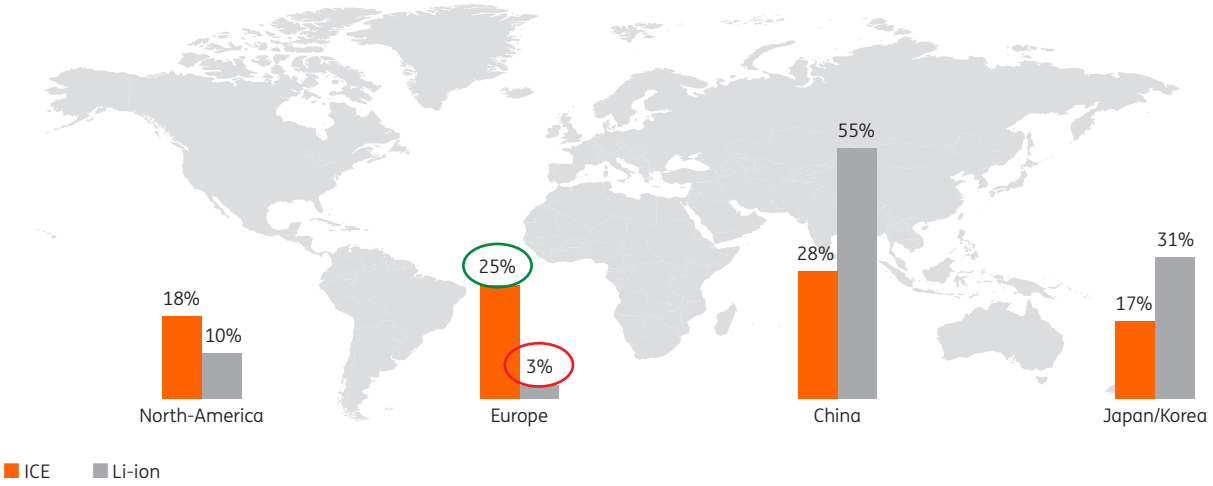
Close to 30% of all cars produced globally are from China[1]. Most of these remain in the Chinese market. A market that has become the biggest car market in a relatively short period of time. China is aiming to increase the share of ev's in its own market. The Chinese market dominates global ev sales with a share close to 43% in 2016. China is stimulating BEV production and has a number of rapidly expanding battery and car makers. In electric busses we are already seeing China benefit from its early lead, as it fulfils growing European demand for these vehicles. Chinese manufacturers dominate this market.

Europe will face stronger competition

Whether China can do the same in passenger cars remains to be seen. Their fast growing expertise in electric powertrains is however likely to make them a stronger competitor in passenger cars and certainly in powertrain components. Tesla has already shown what can be done in this respect. If Tesla is able to put its expansion plans in practice it can also start to hurt sales of European competitors. Leaders in BEVs will benefit once BEVs pass ICEs.

Europe dependent on others for batteries

Market share in production ICE engines and li-ion batteries



Sources: Bloomberg New Energy Finance Remaing share in ICE is 12% (Asia, South-America, Africa and Middle East).
li-ion battery production bases on large format batteries (mainly ev's).

[1] Source: OICA

2.3 Powertrain value and jobs decline

A different world

In this chapter we have described how the rise of BEVs can impact the powertrain market. Internal combustion engines, transmissions and exhausts will be exchanged for batteries, electric motors and power electronics. Perhaps even more important are the changes to the characteristics of the market:

- Production is more automated and less labour intensive. The input of raw materials rises.
- Traditional vertical integration of ICE powertrains is swapped for outsourcing in BEV powertrains.
- This shifts control of powertrain development and production to generic (Automotive and/or battery) suppliers.
- Europe's competitive advantage in ICE powertrains disappears with the shift to BEVs.
- Asia and North America dominate the EV battery market. China especially is looking to play a more dominant role in electric vehicle production. Europe will face more competition in BEVs.

New opportunities in energy and mining

Fortunately, the switch to BEVs also brings opportunities in other sectors. Besides growth in BEV powertrain components such as batteries, the mining industry should also benefit. Demand will boost exploration and mining of certain raw materials. Value and jobs rise could also rise in the Energy sector, as BEVs boost demand for (sustainable) energy and charging infrastructure.

Commoditization will decrease value of car

Mid-term, the powertrain market will benefit from a rise in global car sales and tightening of emission regulations. ICE powertrain value grows. Long term this will change as BEVs take over. The BEV powertrain market will be characterised by strong competition, a focus on pricing and margins, more outsourcing and less room to differentiate. Commoditization is likely, which can ultimately lead to a loss of value in the powertrain supply chain and thus also the entire car.

Loss of jobs in powertrain production

Furthermore employment in Europe's Automotive industry will be affected. Jobs in ICE powertrain related production will decrease. This will only partly be offset through production of battery electric powertrains (and components) as these require far less input of labour.

Electric + autonomous strenghtens shift from product...

The European Automotive sector thus faces a loss of value in 'hardware'. BEVs commoditize the powertrain. This coincides with the development of autonomous driving, which has the potential to further commoditize the driving experience. Once these technologies are improved and costs reduced, car transportation can become more efficient, cleaner, safer and more affordable. The Automotive sector might lose value in its products, but consumers will benefit.

...to mobility as a service

BEVs will, over time, help reduce the costs of car usage. Total cost of ownership should become competitive from 2024 onwards and will further improve through time. Mobility as a service solutions such as leasing and car sharing, where fees are based on costs of operation, will be beneficial to BEVs. Equally, the popularity of these mobility service solutions are likely to be stimulated because of the low operational costs offered by BEVs. Opportunities for the Automotive sector will thus lie in facilitating mobility as a service. The biggest challenge for Europe's Automotive sector will be to move from the traditional business model in which value is drawn from production and sales of cars to a business model that offers value in facilitating efficient and affordable car usage.

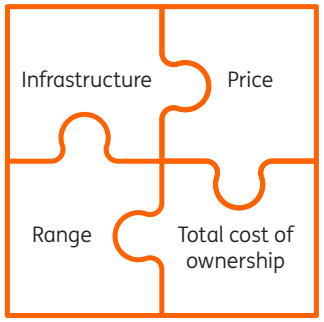
The impact on Europe's Automotive industry

2.4 Value in Automotive shifts from product to services

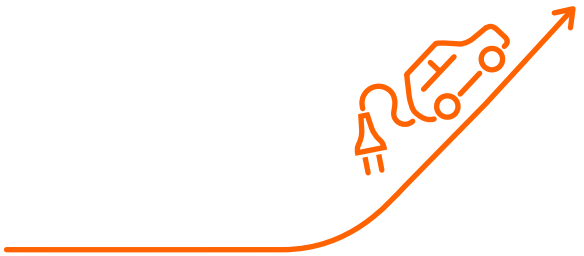
Barriers to BEVs broken one by one

Barriers broken
- Charging infra 2018
- Range 2020 onwards
- Price / Cost of ownership 2024

Puzzle fits in 2024



Growth path will bring BEVs near 100% market share in 2035



Change in components as BEVs replace ICEs

From internal combustion engine, transmission and exhaust....
...to electric motor, battery pack and power electronics

Powertrain from differentiator to commodity

+ automation
+ raw materials
– labour
+ outsourcing
+ competition
– differentiation

Europe's advantage disappears, decreases powertrain value and reduces jobs.

Value shifts to services

BEVs help consumers with more affordable transport as costs of operation decrease. Mobility as a service solutions, such as leasing and sharing, can facilitate this.

Colophon

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