



THE ELECTRIC VEHICLES R-EV-OLUTION: FUTURE RISK AND INSURANCE IMPLICATIONS

SCOPE OF THE REPORT

Around the globe, the take-up of electric cars is expected to accelerate rapidly in future, driven by consumer demand and government policies aimed at tackling climate change. It is estimated that there could be more than 100 million such vehicles on the roads in 2030 compared with around seven million today.

The future of transport is clearly electric, but the transition from fossil fuels will not be easy, and will lead to a fundamental change in risk for car manufacturers, suppliers and insurers alike.

While motor insurance for electric cars is well established, there are emerging risks and challenges from a product liability insurance perspective. These need to be addressed to pave the way for e-mobility on our roads.

As an industrial insurer, AGCS — and this report — is primarily concerned with questions of product liability with regards to e-mobility — in other words, how manufacturers and suppliers are liable if, for example, certain components of an electric vehicle lead to product defects, accidents or damage.

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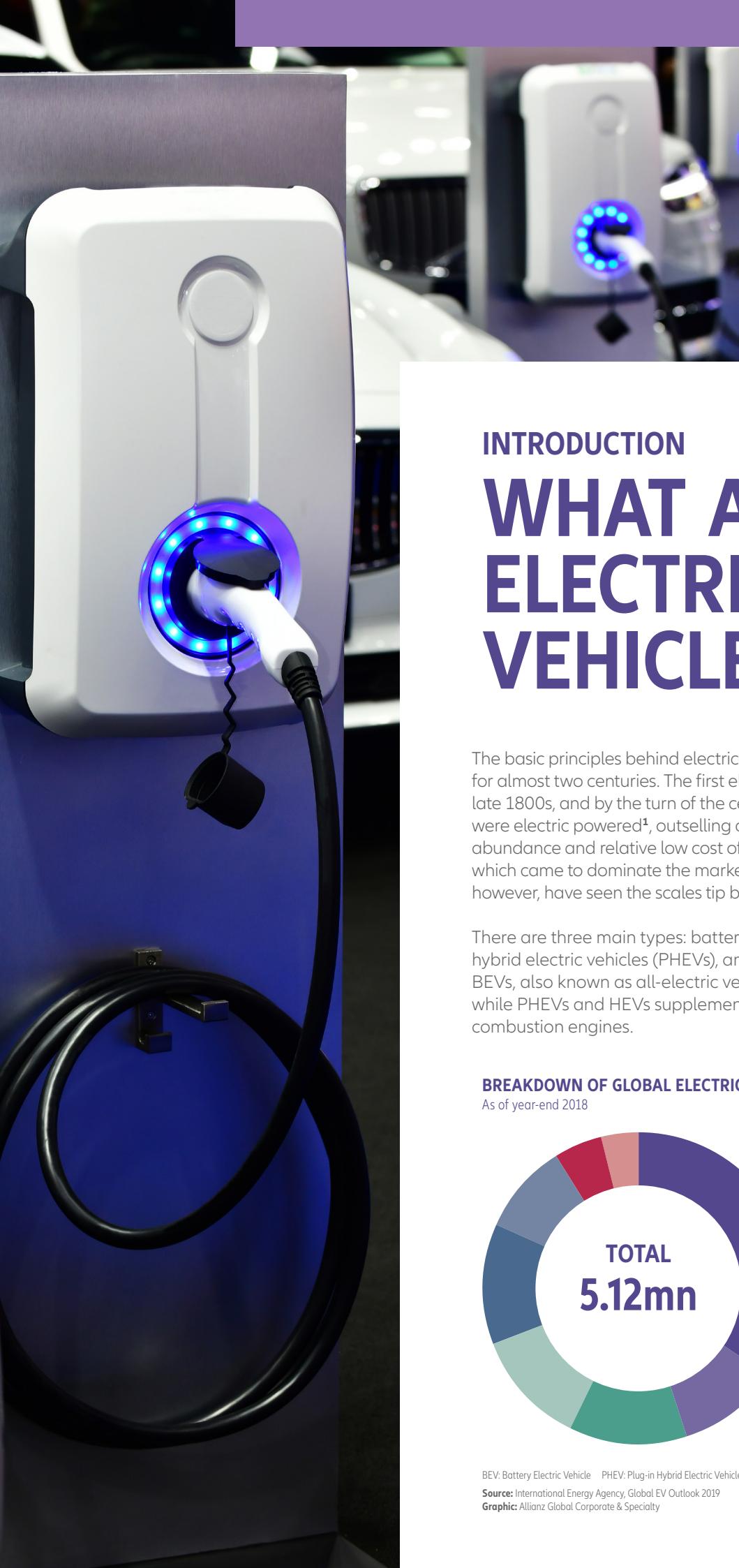
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INTRODUCTION

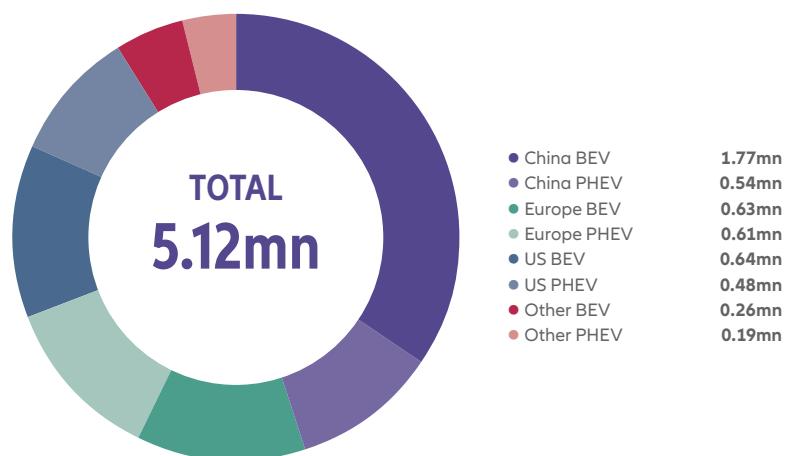
WHAT ARE ELECTRIC VEHICLES?

The basic principles behind electric vehicles (EVs) have been well-known for almost two centuries. The first electric cars were developed in the late 1800s, and by the turn of the century almost a third of cars in the US were electric powered¹, outselling combustion vehicles. However, the abundance and relative low cost of oil eventually favored petrol models which came to dominate the market in the 20th century. Recent years, however, have seen the scales tip back in favor of EVs.

There are three main types: battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs). BEVs, also known as all-electric vehicles, rely 100% on battery power, while PHEVs and HEVs supplement electric power with conventional combustion engines.

BREAKDOWN OF GLOBAL ELECTRIC CAR DEPLOYMENT

As of year-end 2018



BEV: Battery Electric Vehicle PHEV: Plug-in Hybrid Electric Vehicle

Source: International Energy Agency, Global EV Outlook 2019

Graphic: Allianz Global Corporate & Specialty

WHAT MAKES A BEV?

Today, virtually all battery electric cars have the same layout with a high voltage battery and a charger point. Key features of BEVs include:

- **Battery** — High voltage batteries are the defining feature of BEVs. They consist of a group of cells within an armored housing, typically located underneath the passenger compartment. They are available in various shapes and chemistries, usually lithium ion, and include a battery management system to maintain voltage and temperature
- **Motor and drivetrain** — Electric motors are smaller and lighter than the combustion engines they replace. BEV drivetrains, which deliver power from the motor to the wheels, typically have fewer mechanical components than conventional vehicles, and tend to be more integrated and compact
- **Electric systems** — Unlike conventional vehicles, BEVs require a separate high voltage electrical system — to power the electric motors — in addition to the low voltage system that powers controls, lights and entertainment systems etc. An ‘inverter’ converts direct current electricity from the battery into alternating current used to power the vehicle.

STATE OF THE MARKET

Electric car deployment has been growing rapidly over the past 10 years with some five million electric passenger cars on the road in 2018 (of which BEVs accounted for 3.29 million), double the number in the previous year, according to the International Energy Agency (IEA)². The global electric car fleet exceeded 5.1 million in 2018, up by 2 million since 2017. By the end of 2019, it was expected to have totaled around 7.5 million. 2020 had been expected to be a landmark year for EV sales in Europe alone, with projected sales of one million³, according to forecasts, consolidating the European Union’s (EU) status as the world’s second largest electric car market. However, this forecast was made before the global outbreak of coronavirus (COVID-19) at the end of December 2019 took effect. Amid COVID-19,

the outlook for 2020 global EV sales becomes more difficult, given prolonged disruption to dealers, buyers and supply chains. The number of EVs sold in China plummeted 54% in January 2020, according to data from the China Association of Automobile Manufacturers⁴.

Nevertheless, China is the world’s largest market for EVs in total, accounting for around 45%, while a quarter (24%) are in Europe and 22% in the US. However, Norway is the world leader in terms of uptake — EVs accounted for 56% of all new car sales in 2019, according to data from ev-volumes. Germany is the largest European market for EVs overall, while the Netherlands and Ireland are the fastest growing markets for BEV sales.

TOP 10: ELECTRIC CARS MARKET SHARE BY COUNTRY

Year-end 2018. Includes BEVs and PHEVs. Share of cars within each country.

| | |
|----------------|-------|
| 1. Norway | 46.4% |
| 2. Sweden | 7.92% |
| 3. Netherlands | 6.57% |
| 4. Finland | 4.74% |
| 5. China | 4.48% |
| 6. Portugal | 3.92% |
| 7. US | 2.45% |
| 8. Canada | 2.32% |
| 9. Korea | 2.21% |
| 10. France | 2.15% |

Source: International Energy Agency, Global EV Outlook 2019
Graphic: Allianz Global Corporate & Specialty



GROWTH DRIVERS AND FUTURE FORECASTS

EVs are becoming more attractive to consumers as their cost declines and new models are released — prior to the coronavirus outbreak the number of EV models available to European buyers was expected to rise from around 100 to 175 by the end of 2020⁵ — which make EVs a more realistic alternative to conventional vehicles. For example, the latest Tesla Model S can achieve distances of 630km on a single charge. However, climate change is the biggest single driver behind the push for EV sales going forward.

The need to reduce carbon emissions is driving both government policy and consumer demand for greener vehicles. According to a 2018 EEA study⁶, a typical electric car in Europe produces less greenhouse gases and air pollutants across its life cycle, compared with its petrol or diesel equivalent. Today, EVs in Europe produce between 17% and 30% fewer emissions than petrol and diesel cars. However, as more electricity is generated by green sources, the life-cycle emissions of a typical electric vehicle could be cut by at least 73% by 2050.

Government policy is critical with measures ranging from incentives and subsidies for low-emission vehicles, through to proposed bans on combustion vehicles in urban areas or nation-wide. The switch to electric vehicles is seen as essential if governments are to meet emissions commitments, such as the Paris Climate Agreement, which aims

to limit the global temperature rise this century to below 2 degrees Celsius.

California and a number of other US states have adopted zero-emissions vehicle mandates while the EU tightened its vehicle emissions targets in 2019 — requiring new cars to emit 15% less by 2025 and 37% less by 2030. The UK government announced in February 2020 that it intends to bring forward by five years a proposed ban on sales of new petrol and diesel cars to 2035, while targets are also in place in Norway, Germany, France and Denmark.

Such policies are likely to have a significant effect on the pace of EV take-up. For example, UK industry figures show that 6,500 new electric cars were sold in the first two months of 2020, more than triple a year earlier. Current policy decisions around the globe are forecast to result in more than 100 million electric cars on the roads in 2030, according to the IEA, with annual sales in the region of 20 million. Such a scenario would contribute to cutting demand for oil products by 127 million tons (about 2.5 million barrels a day).

A more ambitious target, such as the **EV30@30** campaign for 30% of vehicles sold being EVs by 2030⁷ — would see electric car sales and stock nearly double to around 40 million annual sales and over 200 million vehicles in total in 2030, driven by growth in China, Europe, Japan, Canada, the US and India in particular.

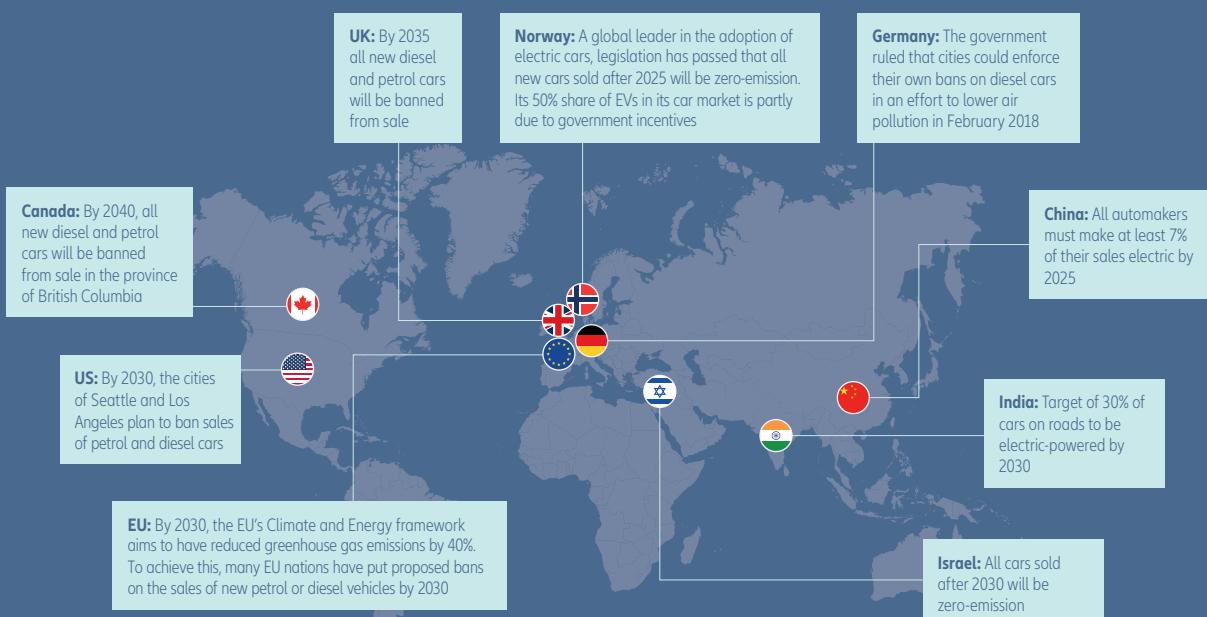
⁵ The Guardian, 2020 Set To Be The Year Of The Electric Car Say Industry Analysts, December 2019

⁶ European Environment Agency, EEA Report Confirms Electric Cars Are Better For Climate And Air Quality

⁷ Clean Energy Ministerial, EV30@30 Increasing Uptake Of Electric Vehicles

DRIVETIME: THE LEGISLATION AND TARGETS STEERING THE ELECTRIC R-EV-OLUTION

Globally, the 2015 Paris Agreement has been the catalyst for a number of country- and region-specific regulations focusing on the environment. Below is a snapshot of some of the targets behind the auto industry accelerating its adoption of EVs.



A BUMPY ROAD AHEAD?

The development of EVs is likely to be a bumpy ride, with some notable obstacles in the road ahead, not least being the surge in demand for power that an all-electric market will bring. Electricity demand to serve EVs is projected to reach almost 640 terawatt-hours (TWh) in 2030, more than a ten-fold increase compared to 2018 levels and equivalent to the combined final electricity consumption of France and Spain in 2016. Demand almost doubles again (to 1,110 TWh) where EVs account for 30% of vehicles⁸.

Electric cars will also require huge changes in power infrastructure to deliver high voltage charging points into homes and public spaces. Manufacturers will need to balance growing demand and government policy against their ability to ramp up production and create sustainable supply chains for the future. Environmental challenges also lay ahead, from recycling of batteries to the responsible sourcing of raw materials.

⁸ International Energy Agency, Global EV Outlook 2019, Scaling Up The Transition To Electric Mobility

PARALLEL DEVELOPMENTS

At present, the majority of EVs are aimed at the passenger market, but light commercial vehicles, buses and trucks are also growth markets. While we are still in the early stages, the technology could open up new forms of vehicles, in particular when combined with developments in autonomous vehicles.

EVs and autonomous vehicles are separate, but interrelated trends. **The focus of this report is on the risks for EVs only, and specifically cars,** although autonomous technology will have important implications for the development of EVs. Autonomous technology may affect the design of electric vehicles, while artificial intelligence and smart cities could affect the way in which vehicles are controlled and driven in future.





RISK EXPOSURES

For more than 150 years, the combustion engine has been the dominant source of vehicle power, over which time vehicle design, manufacturing, reliability and safety have been optimized. Compared with the well-established technology and manufacturing processes of conventional vehicles, EVs bring a wide range of technical, environmental and operational risks from a product liability perspective.

*"From supply chain networks to production processes to the product itself — the automotive industry will have to respond to many emerging risks to make e-mobility happen, including data quality, weather issues and cyber risks, to name just a few," says **Daphne Ricken, Senior Underwriter Liability at AGCS.***



SAFETY AND RELIABILITY

EVs still look much like conventional vehicles, and in many respects they draw on the same technology and design. However, they combine existing technologies from other sectors and put them to new uses, which can increase the risk of defects or performance issues. Testing of technology as applied to EVs will therefore be critical for reliability and safety.

Tests conducted by the Allianz Center for Technology (AZT) have shown that the high voltage components of electric cars can be well protected and will not be affected in most crashes. Statistical evaluation of Allianz claims has also shown that electric vehicles are less likely to be involved in accidents today, although this reflects their current usage — they typically drive short distances with limited mileage overall.

However, the damage caused by EVs today is, on average, more expensive than for conventional cars.

*"If the battery has to be replaced it can result in a total loss in many cases. In addition, the low average age of the vehicle and the fact that owners can only go to specialist branded repair shops contribute to costs. The design of electric vehicles could be improved in regard to deformation behavior and ease of repair. All in all, Allianz investigations show that, today, electric vehicles create loss volumes comparable to that of conventionally-operated cars — given lower frequency but higher severity/loss volume of accidents," says **Carsten Reinkemeyer, Head Of Vehicle Technology And Safety Research at AZT.***



FIRE

A number of fires involving EVs have attracted headlines in recent years, although there is no evidence to suggest that EVs pose a higher fire risk than conventional vehicles. However, there are aspects of the technology that present different, and as yet undetermined, risks.

As with conventional vehicles, defective electrical and short circuits can spark a fire, while lithium-ion batteries may combust when damaged, overcharged or when subjected to high temperatures. When they do burn, high voltage batteries can experience a chain reaction known as thermal runaway, where one cell ignites another, causing yet higher temperatures and further cells to combust. Improved battery control systems and cell technology, however, have made batteries safer and more resistant to thermal runaway, and battery management systems are designed to prevent overcharging.

Once ignited, high voltage battery fires can be very intense and difficult to extinguish, and can also release high levels of toxic gases. Fires involving EVs are typically hotter, take longer to control and are prone to reigniting — an EV fire can take 24 hours⁹ or longer to control and be made safe enough to move the vehicle. Due to the relative rarity of EV fires, first response and rescue services have limited experience dealing with such incidents, and good data and information on dealing with an EV fire event is lacking.

"Analysis of claims from production electric vehicles conducted by the AZT shows that the causes of fire are typically not to be found in the high-voltage system but are often from external ignition. Our analysis of reported claims from electric vehicles does not confirm that the technology is unsafe. However, an accident-related fire is reported much more frequently for EVs than for conventional cars, as this is more newsworthy," says Reinkemeyer.

WHAT IS THE AZT?

Established in 1932 as a general material test center, the Allianz Center for Technology (AZT) expanded into vehicle technology research in 1971. The AZT Automotive GmbH, hosted by Allianz Germany, serves as Allianz's center of competence for automotive technology, repair research, training and damage prevention. Current projects include topics in the field of repair technology and safety campaigns, as well as modern technologies in the fields of driver assistance systems, IT-security, vehicle data and electro-mobility. For more information: <https://www.azt-automotive.com>

⁹ British Parking, The Risks Of Lithium-Ion Electric Vehicles And Considerations For The Parking Industry



BATTERY ISSUES

Battery life and performance are a critical issue for EVs. High voltage battery cells have a limited lifespan, which today is around eight to 10 years in service. However, battery life is dependent on a variable number of factors, such as how they are charged and discharged, operating temperature and cell chemistry. The regular use of rapid charging, for example, shortens the life of a battery.

Given the high cost of replacement, the health of batteries is one of the most challenging issues for claims handling, especially in terms of residual value or warranted characteristics. The concern for insurers, however, is a lack of data on the speed at which a battery's capacity declines. A failure to live up to performance guarantees will pose questions around liability for manufacturers and suppliers, as well as the cost of repair or replacement of battery units. If the defective part in the battery pack can be clearly identified, the liability then will fall back to the supplier or sub-supplier of the defective part. However, if this cannot be proven, the issue of replacing and

disposing of the battery pack would then stay with the car manufacturer.

Testing conducted by the AZT shows that batteries are to some degree protected from temporary changes in external temperature, for example, in a heated paint booth, but there is evidence from US studies that battery life corresponds to the general climate where a car is used: EVs in Arizona have been shown to suffer earlier range reduction than vehicles driven in colder parts of the US. However, driving in cold temperatures reduces the range of an electric car, as cold batteries use more energy to maintain operating temperature.

"Battery producers are under pressure to promise longer warranties but we know it will take time to develop and test the technology in field conditions. As we already see with our mobile phones, battery performance can vary greatly depending on how they are charged, usage and on updates. As yet, the best charging strategy for EVs has not been determined," says Ricken.



ENVIRONMENTAL IMPACT

Despite their outward green credentials, there are a number of environmental issues for EVs that represent a potential liability and reputational risk for vehicle manufacturers and suppliers. High voltage batteries are the main area of concern. There is currently no standardized process to recycle lithium-based batteries — although there are initiatives underway to convert used electric car batteries into energy storage units to power homes — and the long term environmental and health impacts of battery disposal are unknown at present. Battery production is energy intensive and requires certain raw materials — such as lithium and cobalt — that require a rigorous extraction process. High voltage batteries could also pose a pollution risk if not properly disposed of, or where vehicles are exposed to flood waters.

Such battery production has already received much environmental criticism. Local water shortages caused by lithium sourcing in South America, where up to a third of the world's supply is captured in underground water pools and put through a rigorous extraction process, is causing

shortages — not to mention pollution problems — in active mining areas.

The carbon footprint of EVs is also an important consideration. According to the European Environment Agency (EEA), emissions from battery electric vehicle production are generally higher (some 59% higher)¹⁰ than for combustion vehicles. Once an EV takes to the road, however, the lifecycle carbon footprint reduces.

"Electric cars have a better carbon footprint, but this is dependent on a sufficient vehicle lifespan and a corresponding mileage, including economical repair. For batteries, adequate diagnosis and evaluation criteria for repairs have to be developed by manufacturers so that they are primarily repaired if possible — and not unduly replaced. Replacing the battery typically results in a total loss and is not economically viable on a large scale. Therefore, AZT discusses battery diagnosis with vehicle manufacturers to promote the development of non-proprietary assessment standards for measuring a battery's lifetime consumption and state of health," says Reinkemeyer.

¹⁰ Comparative Study in Life Cycle Co₂ Emissions From The Production Of Electric And Conventional Vehicles In China



SPEED TO MARKET BRINGS CHALLENGES

Some industry experts view the rapid shift to EVs with some trepidation. While the concept of EVs is far from new, widespread adoption is. Adding to the technical challenges, manufacturers are under pressure to accelerate the transition to electric power and live up to political promises and targets to phase out fossil fuels.

The fast-paced development of EVs could put manufacturers and supply chains under pressure. While original equipment manufacturers (OEMs) are highly experienced in vehicle and manufacturing processes, the competency and supply chains for start-ups is less well developed.

The combination of new technology and a rush to meet demand for EVs could also result in an increase in product recalls for the automotive industry, which are already among the largest and most complex of any sector.

"Everyone supports the move to electric vehicles, but there is always the risk that we want it too much and too quickly. Shorter development cycles can result in problems further down the line. They can put manufacturing processes and supply chains under pressure, which can cause problems if the technology is not properly thought through and tested," says Ricken.



NEW SUPPLY CHAIN EXPOSURES

The transition to EVs will mean changes to the automotive industry supply chain, which is already vulnerable to disruption at a small number of specialist producers. While just-in-time manufacturing is here to stay, new processes, materials and ways of working will create exposures along the supply chain, including environmental, legal, cyber and political risks.

A rapid uptake in EVs will require manufacturers to source sustainable supplies of critical components and raw materials as they ramp up production. For example, battery technology will drive a huge increase in demand for critical raw materials like cobalt and lithium — lithium supply is set to triple by 2025¹¹ — which would outstrip current supply. Effective recycling and reuse of

materials will therefore be essential to reduce dependency on critical raw materials and to limit risks of shortages. Environmental and social concerns will also put emphasis on the traceability and transparency of raw material supply chains if manufacturers are to foster sustainable sourcing of minerals.

"The transition to electric vehicles will require closer cooperation between manufacturers and suppliers to co-develop technology and establish a new sustainable supply chain. This could result in further vulnerabilities in the supply of critical components and materials, but there is an opportunity for the automotive industry to diversify the supply chain across a larger number of suppliers and encourage a new generation of producers," says Ricken.



@ CYBER CONCERN

As EVs evolve they are likely to have increased connectivity and reliance on data, sensors and software, including artificial intelligence, to manage vehicle systems, as well as aid driving. Some estimates suggest software is expected to account for as much of 30% of a BEV's makeup in the near future compared with around 10% within a car today. However, increased connectivity is likely to give rise to cyber vulnerabilities, including the threat of malicious attacks, system outages, bugs and glitches. Of course, this is an increasing risk for all types of automobiles in future, not just EVs.

Software updates, for example, could lead to significant changes in risk during the lifetime of a vehicle. Insurers are concerned about how a failure to install updates, or how a faulty update, could compromise safety or damage hardware. There have already been product recalls in the automotive sector on the grounds of cyber security.

"Risks associated with conventional vehicles change little over their lifetime. But electric vehicles will require regular software updates that could make significant changes to a vehicle, adding new capabilities or adjusting existing systems," says Ricken.

¹¹ S&P Global, Lithium Supply Is Set To Triple By 2025. Will It Be Enough, November 2019

INSURANCE IMPLICATIONS

The transition to electric vehicles will have many implications for insurance and claims, as technology creates new risks and exposures, and as liability shifts within the supply chain. In particular, EVs will have a significant impact on automotive product liability insurance, although there will also be consequences for regular commercial property and casualty insurance products.

PRODUCT LIABILITY

New and existing technologies will be put to the test by real-life and extreme driving conditions, while new production processes like 3D or 4D printing could change the characteristics of products.

EVs will consist of fewer but more integrated parts. What might have been three parts in a conventional car could be only one part in an electric car. However, the lower number of parts is increasingly connected through sensors and embedded software, adding complexity, and raising questions around how these parts interact and who is liable for any defect.

At the same time, EVs use more micro products, which may be designed and produced separately. If the life cycle of various parts within a component does not match, the repair costs could be significant.

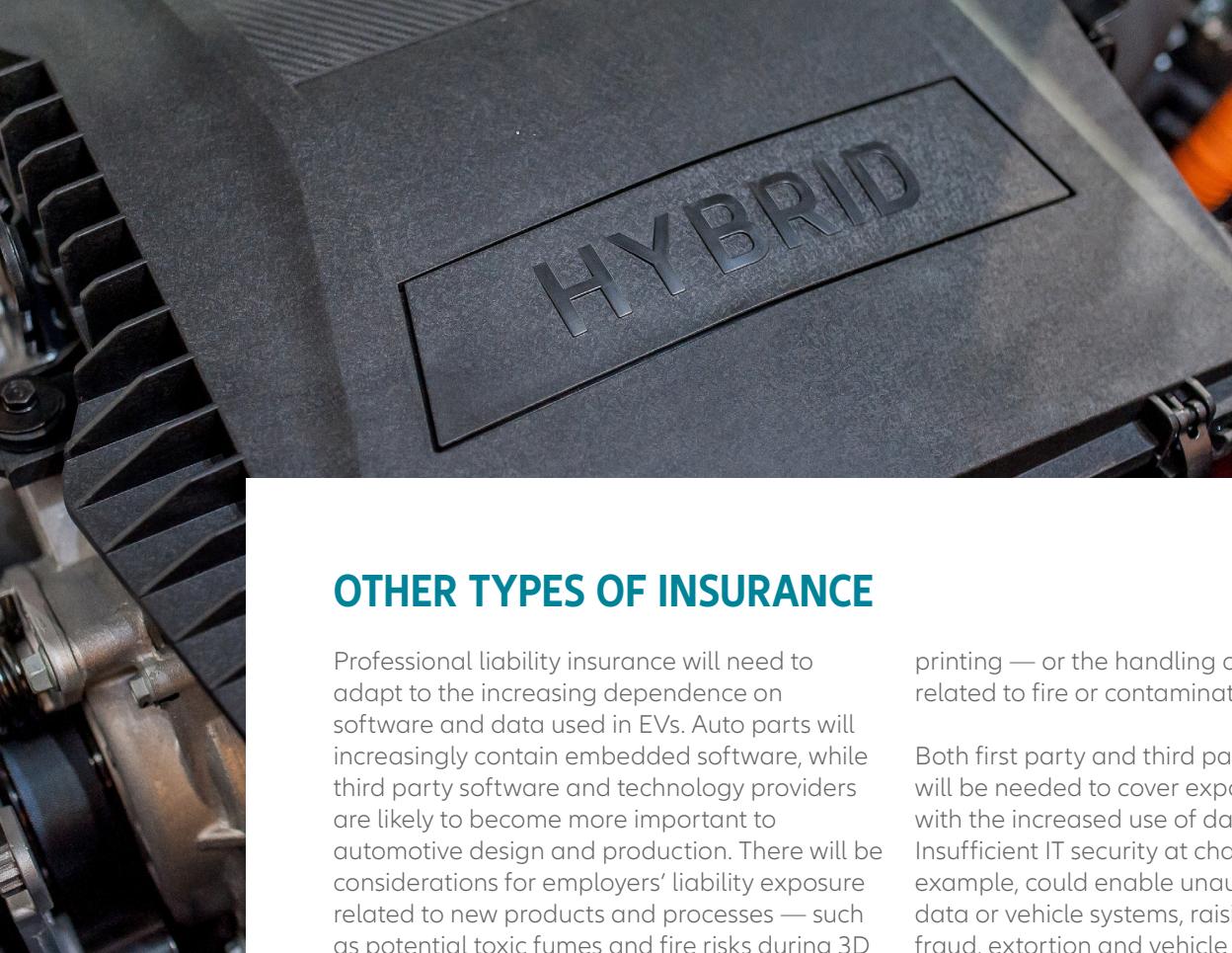
The increasing relevance of software and data to EV operation will also create new exposures and liabilities. For example, faulty updates could damage hardware or corrupt software, while unsupported software used by sub-components would need to be replaced to avoid gaps in cyber security. Product guarantee insurance could prove particularly challenging, given the life cycle of products and uncertainties surrounding the performance and value of high voltage batteries.

New technology applications and methods of manufacturing will challenge insurers' risk assessment. Potentially faster product development cycles and shortened testing periods will have to be closely evaluated. The creation of new supply chains and contractual relationships further complicates matters for insurers, especially where there are contractual mismatches at various stages of the product chain.

PROPERTY COVERAGE

The fire and explosion risks associated with high voltage batteries could give rise to claims for property insurers, with the increased fire risks of handling and storing batteries. Marine insurers have already experienced container ship fire losses from mis-declared cargos of

lithium batteries. Overcharging of batteries or issues with power connection could spark fires resulting in residential or commercial property claims, a particular concern where multiple vehicles are charged in underground car parks.



OTHER TYPES OF INSURANCE

Professional liability insurance will need to adapt to the increasing dependence on software and data used in EVs. Auto parts will increasingly contain embedded software, while third party software and technology providers are likely to become more important to automotive design and production. There will be considerations for employers' liability exposure related to new products and processes — such as potential toxic fumes and fire risks during 3D

printing — or the handling of lithium batteries related to fire or contamination.

Both first party and third party cyber insurance will be needed to cover exposures associated with the increased use of data and connectivity. Insufficient IT security at charging stations, for example, could enable unauthorized access to data or vehicle systems, raising the prospect of fraud, extortion and vehicle theft.

CLAIMS COMPLEXITY

Claim scenarios are manifold and AGCS, in cooperation with AZT, has reviewed a number of these in order to discuss the propensity and possible frequency with the automotive industry, be it OEMs or suppliers.

Potential claims scenarios range from overheated battery leads resulting in fires and property damage to breakdown — leading to fire or even bodily injury — as a result of electronic failure of the battery management system.

Claims severity could likely increase. Higher values of high voltage batteries, and the growing prevalence of sensors and more integrated components could result in more complex and costly repairs, and potentially a greater likelihood of a total loss.

The increased complexity of the automotive supply chain and the reliance on software and technology producers will lead to new exposures and split liabilities in the value chain. Such developments need to be evaluated and rated by insurers and are likely to result in an increase in claims complexity. Therefore, insurance companies will have to review their claims handling abilities and processes to be able to manage these changes in risk caused by EVs. Contract certainty, including the design of insurance, will be vital to triggering insurance and establishing cause and liability.

Insurers may also expect to see a potential increase in product recall/liability claims from new technologies, components, faster development times and shorter testing periods.

THE ROLE OF INSURANCE

Insurers are supporting the automotive industry, whether it be for traditional manufacturers with very complex supply chains and numbers of components, or for EV manufacturers, with slightly less complex mechanics but equally complex supply chains, with a full-range of property, third-party and product liability, marine, financial services and other insurance products. Although exposures and responsible parties may shift somewhat, most insurance products will be available for EV exposures. In time, new products are likely to be introduced to cover specific EV exposures. For more information www.agcs.allianz.com/solutions/liability-insurance.html

CONTACT US

For more information contact your local Allianz Global Corporate & Specialty Communications team.

Africa

Lesiba Sethoga
lesiba.sethoga@allianz.com
+27 11 214 7948

Asia Pacific

Wendy Koh
wendy.koh@allianz.com
+65 6395 3796

Central and Eastern Europe

Daniel Aschoff
daniel.aschoff@allianz.com
+49 89 3800 18900

Mediterranean

Florence Claret
florence.claret@allianz.com
+33 158 858863

North America

Sabrina Glavan
sabrina.glavan@agcs.allianz.com
+1 646 472 1510

South America

Camila Corsini
camila.corsini@allianz.com
+55 11 3527 0235

UK, Middle East, Nordics

Ailsa Sayers
ailsa.sayers@allianz.com
+44 20 3451 3391

Global

Hugo Kidston
hugo.kidston@allianz.com
+44 203 451 3891

Heidi Polke-Markmann
heidi.polke@allianz.com
+49 89 3800 14303

Editorial: Greg Dobie and Joel Whitehead.

Credits: Daphne Ricken, Carsten Reinkemeyer, Burghard Schulz, Wolfram Schultz and Harald Wuesteney

Design: Kapusniak Design

For more information contact
agcs.communication@allianz.com

Follow Allianz Global Corporate & Specialty on

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Allianz Global Corporate & Specialty SE,
Fritz-Schäffer-Strasse 9, 81737 Munich, Germany
Commercial Register: Munich, HRB 208312.