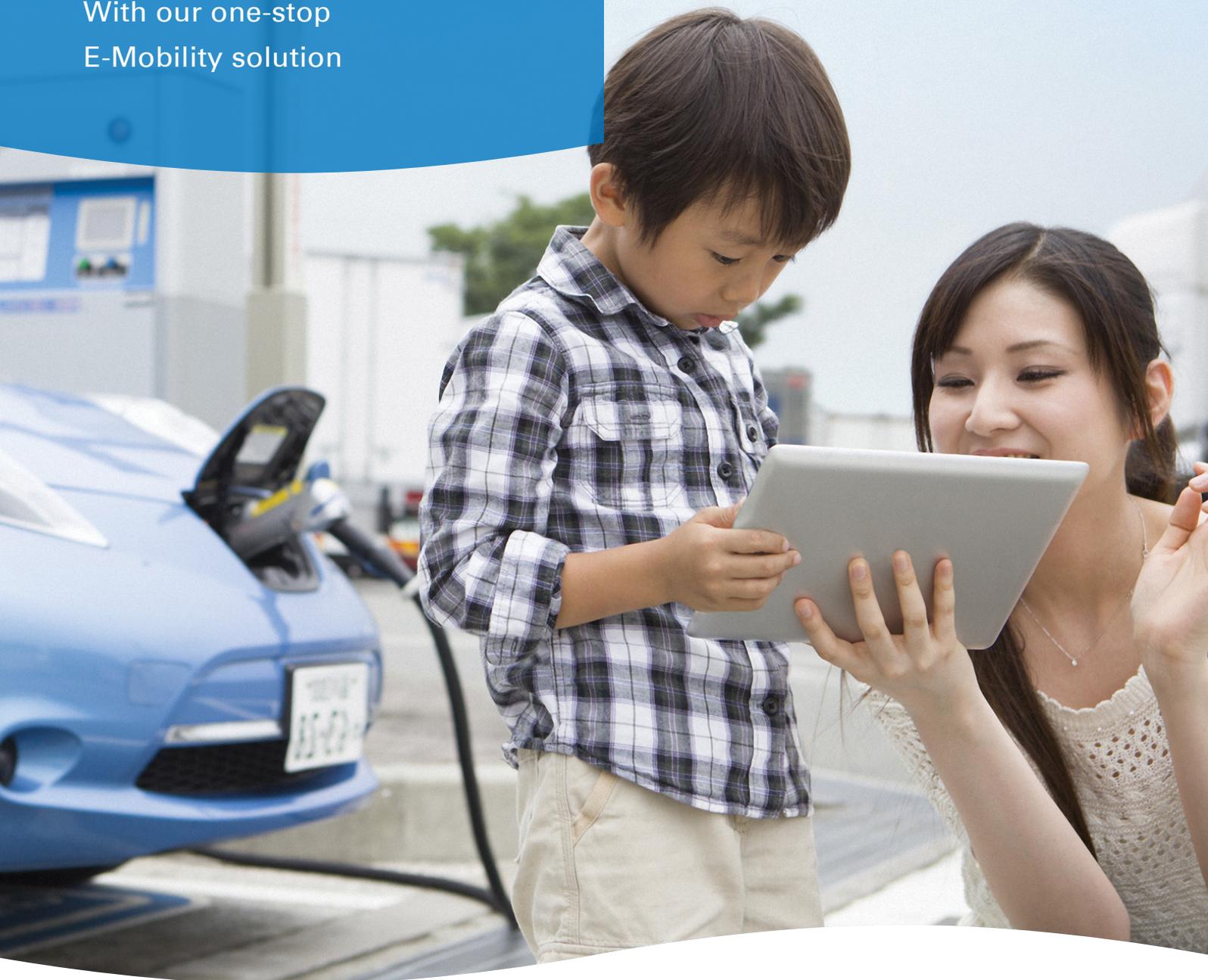


Maximising Electric Vehicle Quality and Product Safety

With our one-stop
E-Mobility solution





Electric Vehicles – Past, Present and Future!

ELECTRIC VEHICLES – PAST, PRESENT AND FUTURE!

The first electric vehicles (EVs) were created in 1840, pre-dating petrol-powered internal combustion cars by four decades.

Since then, electricity has remained the go-to solution for a variety of transportation options, and EVs are proliferating. In 2005, there were a few hundred on the roads, but by 2015 that number had increased to around 1.25 million.

Industry players, governments and early adopters have succeeded in lowering the cost of electric vehicles and improved range and performance. With the assistance of independent inspection services, they have also demonstrated that electric cars are practical, sustainable and – above all – safe.

THE EV ADVANTAGE

Electric Vehicles offer compelling benefits. They produce no exhaust and are up to three times as energy efficient as a petrol-powered car.¹ Technologies such as regenerative braking can even convert momentum back into electricity, extending the vehicle's range and reducing wear on brake systems.

While a petrol engine burns fuel whenever it is idling, EVs use no energy when stationary. The environmental footprint is even better when municipal power grids switch from fossil fuels to renewable energy sources such as solar, hydro or wind power.

THE MARKET

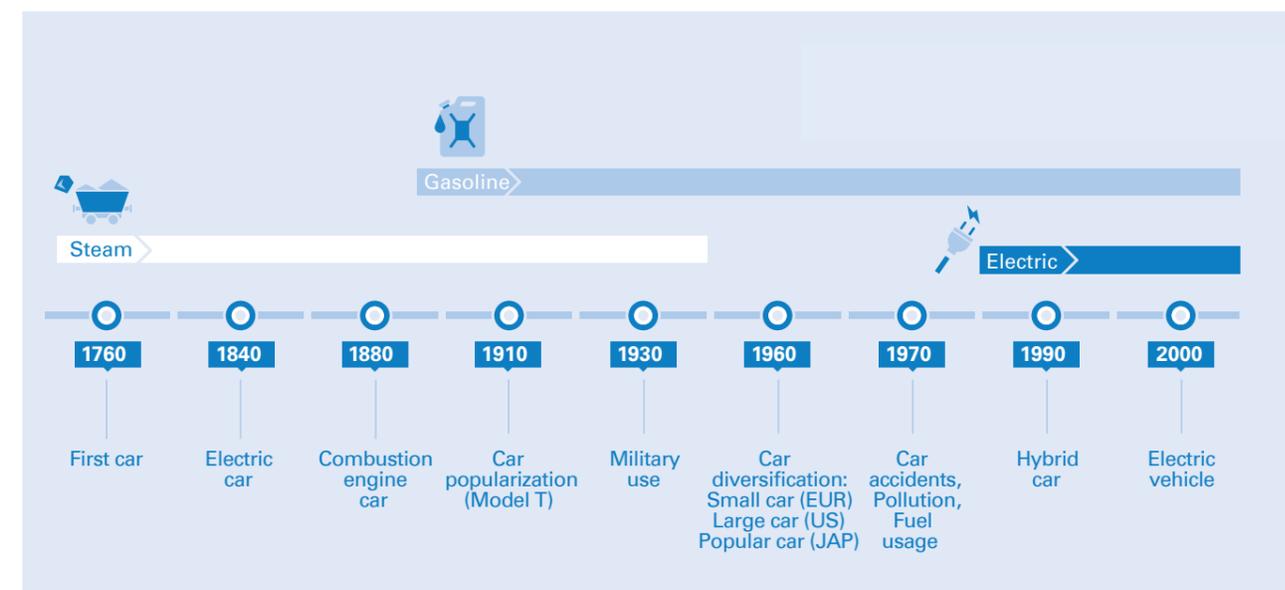
Cars powered by plugging into the electricity grid still cost more to purchase than their petrol counterparts. Estimates suggest they account for less than 1 per cent of the global car market.² However, things are changing rapidly and it looks like the 2020s will

be the decade of the electric car.

In 2015, global EV sales grew by about 60 percent compared with the previous year. This was fueled by a 35 percent drop in the price of the single most expensive component in many EVs – the battery.³

However, while lower cost, higher performance lithium-ion batteries will increase popularity and accelerate adoption, they also pose some challenges for manufacturers. For example, it is technically feasible to increase energy density by as much as five times current levels, but the attendant dangers make safety evaluations even more important. According to an analysis of the electric-vehicle market by Bloomberg New Energy Finance (BNEF), the rapid pace of development could make EVs as affordable as petrol vehicles within five to six years and stimulate mass-market adoption everywhere!

History of the Automobile



¹ All-Electric Vehicles - Fuel Economy
² Bloomberg New Energy Finance (BNEF)
³ Bloomberg New Energy Finance (BNEF)



FUNCTIONAL SAFETY EVALUATION & CERTIFICATION

Preventive safety functions such as driving safety support and vehicle performance control are becoming more sophisticated – this requires automobile hardware and systems to be designed more failure-proof.

ISO 26262

- Functional safety evaluation
- Functional safety management system evaluation
- Training, workshops to improve skills and competencies

Safety standards driving EV development

Charging, safety and the environment are some of the most important factors influencing the growth of the EV market. Standards are playing an important role in these and other areas, as well as becoming essential for market entry.

HARMONIZATION & HOMOLOGATION

Uniform standards will make it easier to design and operate EVs and associated infrastructure, such as charging stations. Indeed, the motor vehicle industry has been working towards this goal for over five decades.

The 1958 UNECE (United Nations Economic Commission for Europe) agreement has gone a long way to harmonize international standards, with 50 countries and one region (the EU) currently following it. Comprising over 130 UN rules, the agreement has not only accelerated international trade in motor vehicles, but also contributed to environmental protection and vehicle safety.

PRODUCT SAFETY FIRST & ALWAYS

The safety landscape is vast, but products are a good place to start. For example, the lithium-ion batteries and high voltages used in electric vehicles have a high energy density and flammable electrolyte. The UN regulations on REESSs (Rechargeable Energy Storage Systems) address these issues, with regulation No.100 ensuring the safety of drivers, passengers and the car's mechanical systems. It includes testing mechanical integrity, resistance to mechanical shock, and resistance, during operation and when the vehicle is parked.

UN Regulations 12, 94 and 95, also

cover safety and driver protection during and after a crash, and include mitigating the risk of electric shocks and battery fires. The comprehensive rules even define factors such as the time it takes for battery electrolyte to spill out, which can impact the safety of the driver, maintenance personnel and rescue workers.

Like most modern products, EVs are subject to electromagnetic compliance (EMC) testing. This covers in-car electronics such as GPS, PTC heaters, Bluetooth, keyless entry, immobilizers and millimeter-wave radar devices that emit electromagnetic waves, as well as other key safety components – such as

air-bags, ABS and engine controllers – that must remain unaffected.

A special product safety feature in Japan is the issue of noise. EVs are quiet, which makes it difficult to hear them approaching. That can be dangerous for visually impaired people. To resolve the issue, the Ministry of Land, Infrastructure and Transport has set out guidelines that require EVs to have an alarm and generate the same noise volume as a conventional combustion engine car.

PERSONNEL SAFETY

The high-voltages used in EVs can make producing and servicing them potentially dangerous. It is essential to protect personnel during these processes by building awareness and developing skills and safe working practices.

TÜV Rheinland's electric vehicle, high-voltage safety training courses are designed to do just that. Covering three different levels, it involves personnel who work with non-electrical work, electrical work in a non-live environment, and on high voltage live system. This is conducted based on international standards, BGI/GUV-I 8686 E, we help manufacturers and service

providers to train their employees to avoid such dangers during R&D, testing, production and repair.

CHARGING SAFETY

Electric vehicles require special verification, especially with regard to safety while being charged. That protection extends beyond the vehicle to charging safety. This relies on the quality of the EV charger itself, as well as how well it is installed. Poor installation poses potential risks to end-users. TÜV Rheinland has taken the lead in introducing testing and certification services for EV charging systems.

Drawing on installation guidelines from car manufacturers, TÜV Rheinland trains installers to ensure they fully understand the requirements and possess the correct skills to safely install the charging facilities for the car users.

Third-party installation companies can be certified with regards to high standard of operation management and technical capability by TÜV Rheinland.

STANDARDIZATION IS NOT THE END OF THE ROAD

At present, there is no single global EV standard. Many of the major EV

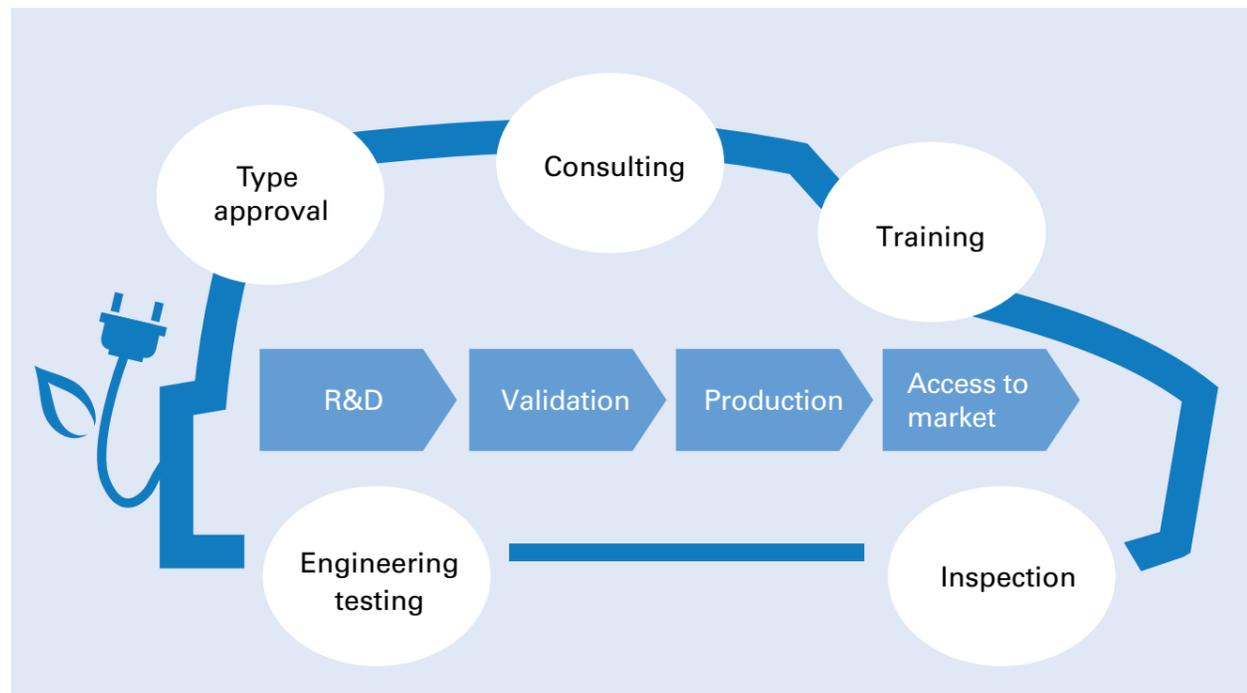
production centers – including Japan, Europe, North America, and China – are promoting their own ideas in a variety of areas.

These laws and regulations are like a passport that grants manufacturers access to the marketplace. They stipulate basic guidelines for safety and environmental compliance, but they usually follow, rather than precede technology. So, for the foreseeable future, manufacturers will continue to rely on accredited certification bodies to keep track of requirements and certify their products.

TÜV Rheinland experts provide information on the latest trends in standards and can confirm conformity to the relevant standards at the draft stage. TÜV Rheinland is also playing an active role in the standardization process, and has joined a variety of standardization committees.

Uniformity of standards will make owning an EV safer and more convenient. It will also make it easier to design and operate associated infrastructure, such as charging stations. And this will, in turn, lead to an explosion in the pace of adoption.

With our global qualification and many years of experience, we support your product's smooth entry into local and global markets



TÜV Rheinland is the ideal partner right from the beginning, providing one-stop service with a single point of contact. Our services and solutions portfolio covers the entire value chain, including inspection, engineering testing, type approval, training and consulting.

It starts right at the beginning, with the R&D process and validation in terms of conformity to the applicable standards. And it continues all the way to the production process (actually manufacturing the vehicle). After the vehicle has been launched in the market, factory audits are conducted for conformity with the applicable laws and standards.

Our experts are well versed in a variety of approval requirements, offering a one-stop-solution to get your equipment to conform with national regulations in almost any country.

WHY TÜV RHEINLAND?

- INVISIBLE BUT ADDED VALUE**
 With more than 30 years of successful experience in vehicle certification testing, we have gained recognition and appreciation from both domestic and foreign enterprises.
- QUALITY BRAND**
 Our brand and marks are well recognized in international markets, serving as a guarantee of the safety and quality of your products and systems.
- ONE TEAM**
 Our team of experts worldwide supports you and your product development with available knowledge, experience and information.
- EFFICIENT AND RELIABLE SUPPORT & SOLUTION**
 Throughout the lifecycle of your product development, we are here to support and provide appropriate service for your needs.

SERVICE FLOW

PROVIDING INFORMATION

Standard requirements and necessary tests for your products and for your designated markets.



HEARING

Confirming your requests and needs.



SERVICE PROPOSALS

Proposal of either a package service or individual testing/ certification. We provide you with a detailed plan for your project.



TESTING / CERTIFICATION

Performed either at TÜV Rheinland testing facility and/ or the manufacturer's testing facility.



ISSUING OF CERTIFICATE

We support you in acquiring local certificates for your target market.



Electromagnetic Compatibility
Regular Production Surveillance

www.tuv.com
ID 400000000



Type Approved Safety
Regular Production Surveillance

www.tuv.com
ID 200000000

* We are notified as technical service within seven European countries.

Our solutions portfolio covers the entire value chain

1 CHARGING SYSTEMS, CONNECTORS & CABLES



CHARGING SYSTEMS

Electric vehicle and fuel-cell vehicle charging facilities

Certification and assessment test according to EU (2014/35/EU), IEC and North American standards

- EN/IEC 61851-1/-21/-22/-23/-24
- EN/IEC 62752
- UL 2202
- SPE 1000*
- NFPA 70*
- UL 2231-1/-2
- UL 2594
- C22.2 No.107*

*US/Canadian Field Labels



NON-CONTACT CHARGING SYSTEMS

Non-contact charging systems, field labeling and technical consultation

Certification and assessment test according to EU (2014/35/EU), IEC and North America standards

- IEC 61890-1/-2/-3
- UL 2202
- UL 2231-1/-2
- UL 2750
- SAE J 2954
- NFPA 70*
- SPE 1000*
- C22.2 No.107*

*US/Canadian Field Labels



ELECTRIC VEHICLE CONNECTORS AND CABLES

Electric Vehicle connector Electric Vehicle cable

- EN/IEC 62196-1/-2/-3
- UL 2251
- EN 50525
- IEC 60227
- JCS 4522*
- prEN50620
- VDE-AR-E2283-5
- UL 2734

*(Cables designated by CHAdeMO)



OTHER ELECTRIC VEHICLE TESTING & CERTIFICATION

Wide range of electricity-powered vehicles and peripheral equipment, including construction machinery



CHADEMO (FAST CHARGING SYSTEMS)

Fast charging units operated on the CHAdeMO protocol. This includes certification according to the EN/IEC 61851-23 safety standard, which has been standardized in the EU and internationally.



CHARGING SAFETY

EV charging safety relies on the quality of the EV charger and the quality of EV charger installation. We offer EV charging installation inspection to ensure it is installed safely and according to specifications.

2 V2X TESTING & CERTIFICATION



V2X (V2H, V2L, V2G)

V2H (Vehicle to Home)
Electric supply from EV or Fuel cell vehicle to home

V2L (Vehicle to Load)

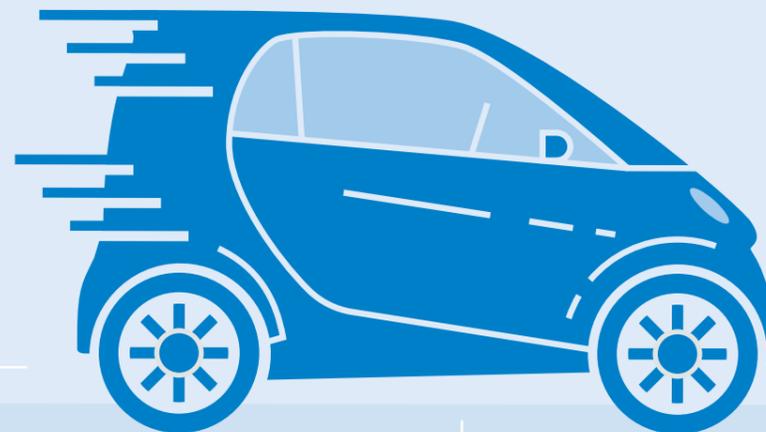
Electric supply from EV or Fuel cell vehicle to load direct

V2G (Vehicle to Grid)

Electric supply from EV or Fuel cell vehicle to electric power transmission system

Standard of conformity

- EN/IEC 61851-1
- UL 458A, IEEE etc.



3 HOMOLOGATION, ENERGY STORAGE SYSTEM



VEHICLE & PARTS HOMOLOGATION

Homologation and testing for EVs and automotive components.

UNECE regulations

- R10 (EMC)
- R12 (Steering mechanism – Electric safety after crush)
- R85 (Electric drive trains)
- R94 (Frontal collision)
- R95 (Side collision)
- R100 (Electric safety, Battery-passenger car)
- R101 (Electric energy consumption and electric range)
- R136 (Electric safety, Battery-two wheel vehicle)

E/e-Mark Certification



All powered vehicles that run on public roads in the EU, including all vehicle components and motorcycles, are required to acquire E/e-Mark certification to ensure traffic safety.

* We are notified as technical service within seven European countries



ENERGY STORAGE SYSTEMS (BATTERIES & CAPACITORS)

We assess energy storage systems, including automotive lithium ion batteries, according to the international safety standards of high-energy batteries. Our CB testing laboratories are accredited by the IECEE CB Scheme and we issue CB certificates and reports.

- UNECE R100
- IEC 62660-1 & -2
- Freedom CAR
- SAE J 2464
- UL 2580
- CAN/ULC S-2580
- UNECE R136
- ISO 12405
- DIN V VDE V510-11
- GB/T 31485
- UN Manual of Tests and Criteria, Part III, subsection 38.3

4 EMC & WIRELESS TESTING



ELECTROMAGNETIC COMPATIBILITY (EMC)

For EVs automotive components and charging stations to the following regulations:

- EU EMC Directive (CE Marking)
- North America FCC/IC
- UN Regulation R10 (EMC)
- VCCI and Electrical Appliances and Materials Safety Act in Japan

Certification and assessment testing according to EU (2014/30/EU) and IEC standards

- EN/IEC 61000 series
- CISPR series
- FCC Part 15



WIRELESS COMMUNICATION

For wireless communication products in Japan, Europe and North America

- Accredited certification body by Ministry of Internal Affairs and Communications (MIC)
- Notified body for R&TTE Directive
- Telecommunication Certification Body for FCC/TCB
- Wi-Fi Alliance accredited test laboratory
- Three BQEs (Bluetooth Qualification Expert)
- BQTF (Bluetooth Qualification Test Facility)

5 OTHER SERVICES



RESEARCH AND INFORMATION SERVICE ON REGULATIONS WORLDWIDE

Our global network enables us to reach the latest information on the necessary certification procedure and export regulations. We can support the customers with the certification procedures and act as representative when they apply for certification.



FUNCTIONAL SAFETY EVALUATION & CERTIFICATION - ISO 26262 (THE AUTOMOTIVE FUNCTIONAL SAFETY STANDARD)

In the automotive industry, systems are becoming increasingly complicated, because preventive safety functions such as driving safety support and vehicle performance control are becoming more sophisticated.

This requires automobile hardware and systems to be made more failure-proof. TÜV Rheinland supports car manufacturers and component suppliers to audits the conformity of management systems.



TRAINING & CONSULTING

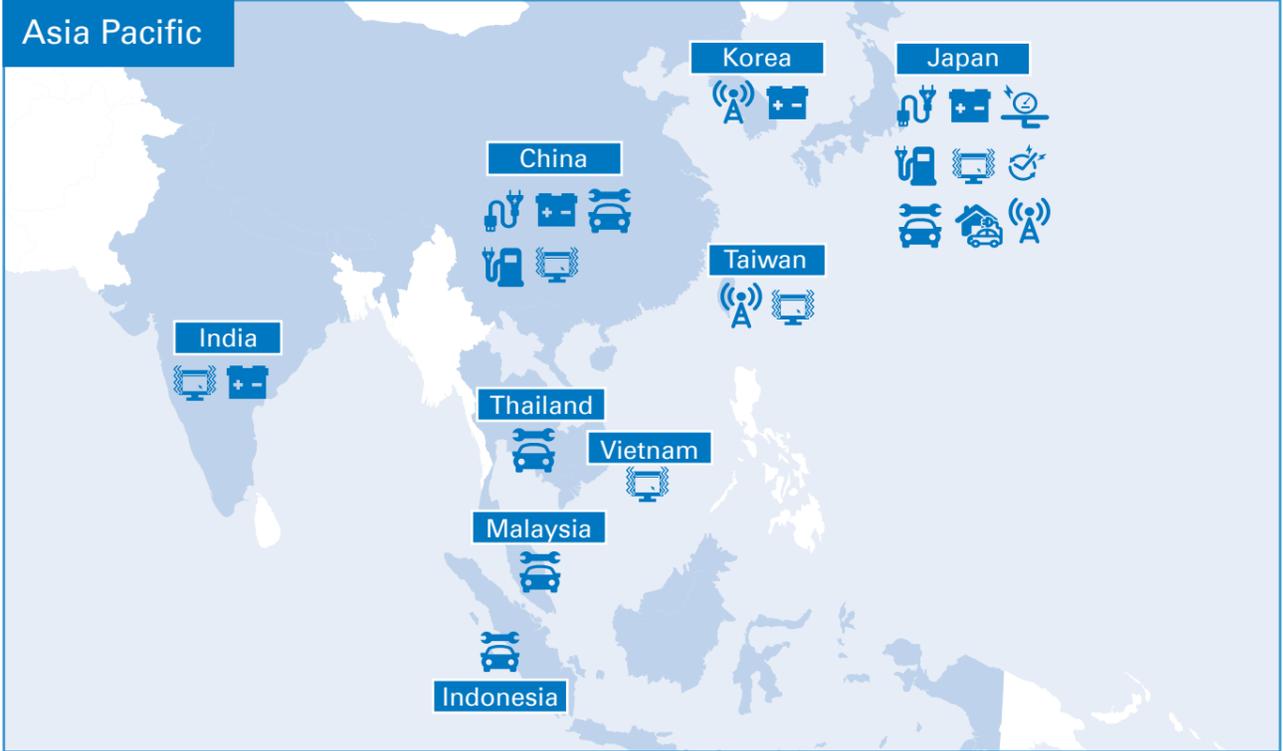
We offer in-house seminars on standards that are customized specifically for the customer's products. Preliminary assessments for conformity to the correct safety and quality standards are also offered.

- Product testing standard
- Electric vehicle high voltage training for engineers
- Functional safety engineer training offered in open seminar or in-house seminars.

Global network of laboratories supports EV testing services



With sophisticated laboratory facilities, TÜV Rheinland's global E-Mobility team plays an indispensable role in the sustainable development of the EV industry.



| Legend | | | | | |
|--------|---|--|------------------------------|--|---------------------------------|
| | Vehicle & Parts Homologation | | Charging Systems | | V2X (V2H, V2L, V2G) |
| | Energy Storage Systems (Batteries & Capacitors) | | Non-Contact Charging Systems | | Wireless Testing |
| | Electromagnetic Compatibility (EMC) | | EV Connectors & Cables | | CHAdeMO (Fast Charging Systems) |

Gaining the right know-how

Working on EVs can be dangerous due to the growing use of AC voltages between 30V-1,000V and DC voltages from 60V-1,500V. Developments in fuel cells, hybrid technology and EVs have also given rise to hazards in the form of electric shocks and arcing during work on vehicles. Accordingly, manufacturers and services providers have a responsibility to train their employees to avoid such dangers during R&D, testing, production and repair.

When it comes to high-voltage safety, there are three levels of training. They start with Level 1, which covers non-electrical work. Level 2 focuses on electrical work on non-live equipment. The highest qualification is Level 3, which certifies employees for live work on high voltage EV systems.



FUNCTIONAL SAFETY CONSULTING AND CERTIFICATION

BENEFITS

- Risk reduction as well as a high safety standard can be achieved.
- Learning to optimize the design so that it meets functional safety requirements and avoid problems during approval process.

COURSE OUTLINE

- ISO 26262 Standard Basic Training
- ISO 26262 Functional Safety Engineer Qualification Training
- ISO 26262 Functional Safety Manager Qualification Training
- Customized Training

ELECTRIC VEHICLE HIGH VOLTAGE SAFETY TRAINING

BENEFITS

- Learn the safe operation of electric vehicles (EVs)
- Acquire knowledge of the high-voltage systems used in EVs

COURSE OUTLINE

- Basic electrical knowledge
- Electrical hazards and first aid
- Protective measures against electric shocks and fault arcs
- High-voltage systems in EVs
- Five safety rules
- Laying and securing wiring
- Functional testing of digital switching devices and circuits
- Troubleshooting and other practical work on EVs

Remark: The training course is based on international standards, e.g. BGI/GUV-I 8686 E.

ELECTRIC VEHICLE TRAINING

BENEFITS

- Acquire knowledge of high-voltage systems used in EVs
- Learn to diagnose and repair EVs

COURSE OUTLINE

- Structure and theory of EVs
- Protective measures against electric shocks and fault arcs
- Drive motors and control systems
- Electric air-conditioning compressors and control systems
- Inverters
- Power batteries and battery management systems
- Charging systems
- Troubleshooting and other practical work on EVs

ELECTRICIAN PERSONNEL CERTIFICATE FOR EV (AC) CHARGING STATION INSTALLATION

Installation excellence is one of the keys to EV charging station success. TÜV Rheinland's training and certification offers employers an opportunity to provide their staff with in-depth instruction on EV charging systems.

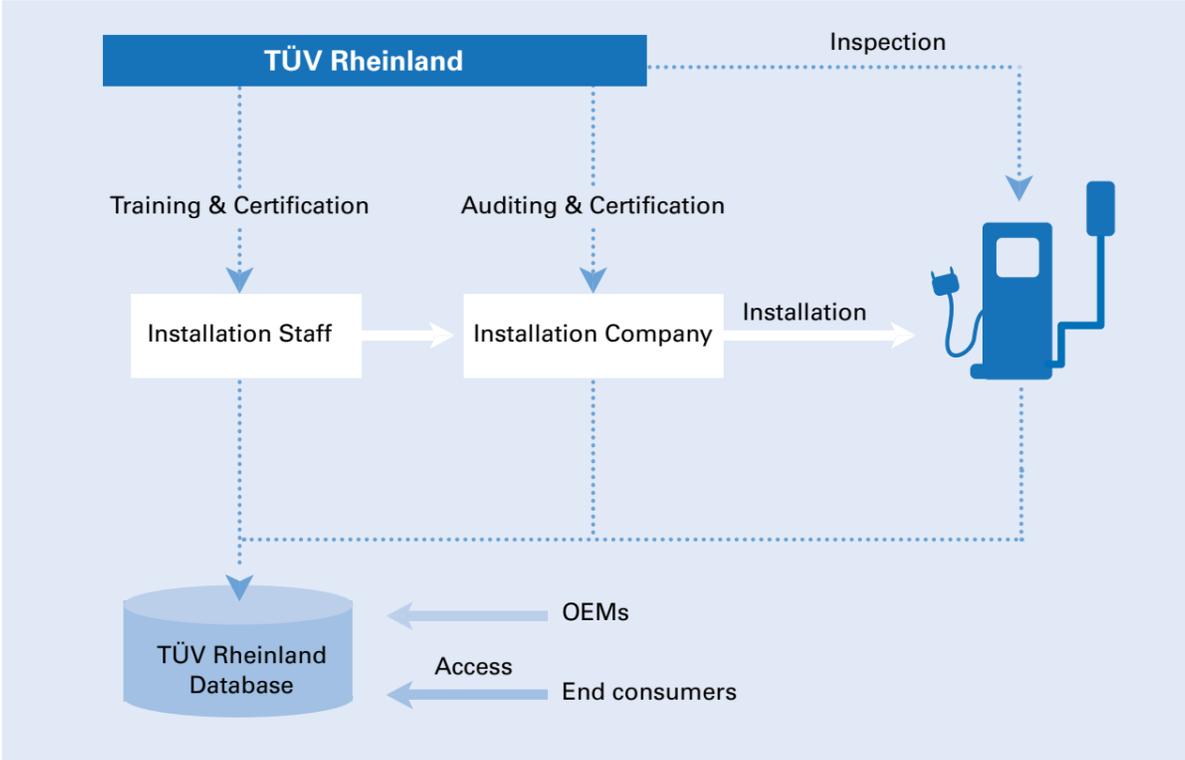
BENEFITS

- Obtain know-how on EV AC charging station installation
- Learn acceptance inspection techniques
- Personnel safety

COURSE OUTLINE

- Basic safety concepts for reliable charging station installation
- Installation procedures
- Acceptance inspection
- Case study and discussion
- Practical training
- Written examination
- Practical installation examination

EV Charger installation qualification



PERSONNEL QUALIFICATION FOR EV CHARGING SYSTEM INSTALLATIONS

Installation excellence is one of the keys to EV charging success. There are shock hazards associated with these high-voltage devices and a sub-standard installation can be dangerous to EV users as well as station personnel. Therefore, safety training and periodic inspections for the certified service providers can help minimize these risks of incorrect installation.

TÜV Rheinland takes a holistic approach to EV charging system installation safety. Based on a comprehensive set of guidelines, services range from personnel qualifications to service provider auditing, through to installation inspection. In addition, TÜV Rheinland's certification database provides a single, easily accessible location for OEMs and end users to review.

EV CHARGER INSTALLATION SERVICE PROVIDER AUDITING

The e-mobility market is booming, but the use of non-professional electricians and unqualified service providers can reduce the quality of charger installations. Proper auditing of such infrastructure is essential.

The TÜV Rheinland's auditing services include:

- Charger installation inspection
- Technical auditing
- Operational auditing

An EV Charger Installation Service Provider Certificate will be issued once the provider passes the auditing process. The test mark can then be used on the provider's web site and various communications, but not on products. The certificate is valid for 2 years.



EV CHARGER INSTALLATION INSPECTION

- Supply protection
- Wiring
- Connections
- Fixtures
- Verification

Once all safety requirements are fulfilled and a field evaluation conducted, TÜV Rheinland will post an inspection mark on the installation. The mark is valid for 1 year.



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