Ensuring energy storage safety and accelerate to build a zero-carbon future

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TÜVRheinland®
Precisely Right.

Collaborating to build a zero-carbon future

Motivated to achieve the dual-carbon goals of peak emissions and carbon neutrality and the transition in energy systems, countries around the world are showing an increasing demand for energy storage solutions. Analyses by research institutions have estimated that the capacity of energy storage systems deployed globally may reach 741 GWh by 2030, with a compound annual growth rate of 31%, and the energy storage market value may be as high as US$ 426 billion.

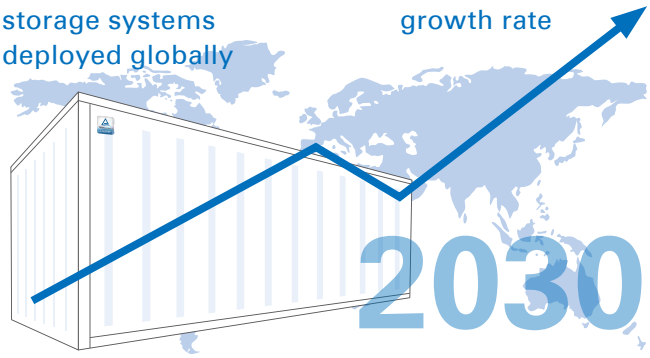
Countries and regions have introduced incentives and subsidies to support and fast-track the development of energy storage systems, with electrochemical energy storage emerging as the mainstream technology. Despite the unprecedented opportunities brought about by the leapfrog development of renewable energy and its high proportion in power systems, there are still many uncertainties surrounding the large-scale commercial application of energy storage. Such issues include the optimal configuration of energy storage technology, how energy storage costs can be reduced, safety guarantees, recycling of energy storage batteries and the establishment of standards for energy storage systems. In sum, how to promote the sound and sustainable development of the energy storage industry is an issue worthy of further study and careful consideration.

With decades of experience in photovoltaics, wind power and energy storage, TÜV Rheinland is firmly rooted in the field of renewable energy. To allay concerns and meet the needs of the industry, TÜV Rheinland can provide one-stop technical solutions to ensure the safety and highlight the value of energy storage, and thus play an active role in promoting and accelerating a zero-carbon future.

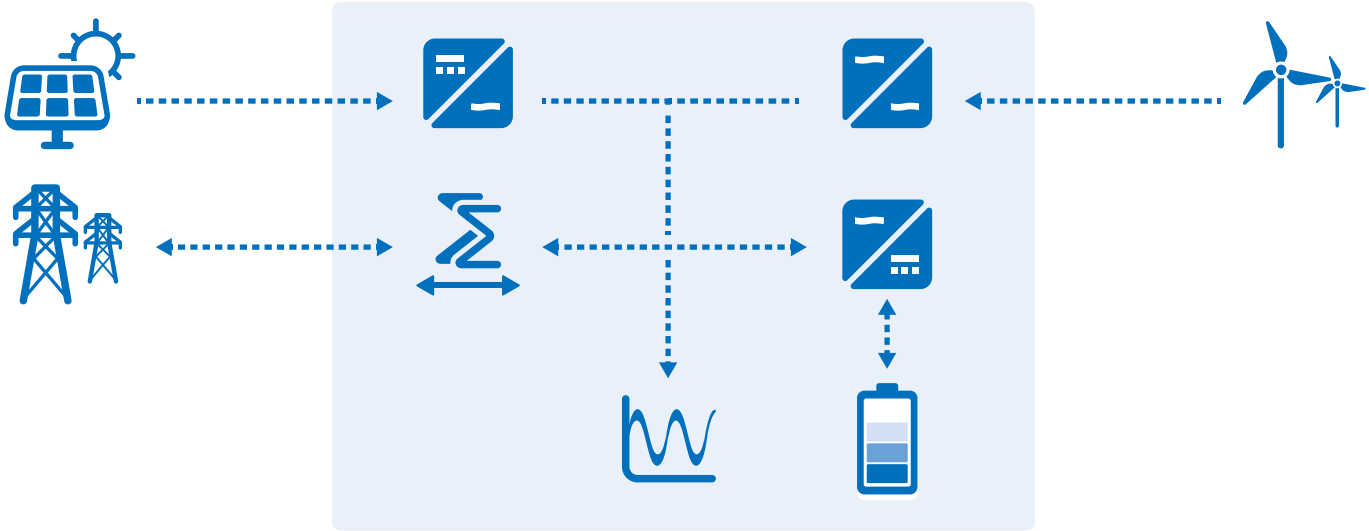
$426 billion
Energy storage market value

741 GWh
Capacity of energy storage systems deployed globally

31%
Compound annual growth rate



Architecture of Energy Storage Systems



Application scenarios and commercial value of energy storage

Energy management

It can promote the leapfrog development of renewable energy and ensure a high proportion of renewable energy in the power system. Based on energy storage technologies, forecasting of power generation, demand-side response and intelligent dispatch of the smart grid, a safe, efficient, stable smart energy management system featuring integration of generation-grid-load-energy storage and new power system will be built.

Internet of energy

With the smart grid and Internet of energy and based on energy storage technologies, a safe and reliable multi-energy complementary co-generation system for the generation, transmission, distribution, storage and consumption of electricity produced by traditional and renewable energy takes shape.

Energy trade

It's necessary to vigorously develop clean energy and build a long-term spot market of electricity and green energy trading mechanism based on the application of energy storage technologies and big data cloud platforms, so as to promote carbon trading and achieve a zero-carbon future.

Power generation side

Stabilizing fluctuations, output smoothing, black start, frequency modulation and voltage regulation, forecasting of power generation, peak clipping and valley filling

Grid side

Frequency modulation, peak load shifting, voltage regulation, voltage support, reactive powersupport, power capacity backup

Power consumption side

Virtual power plant, peak-valley arbitrage, demand response, improving the reliability of power supply, backup power, enhancing power quality

TÜV Rheinland one-stop technology solution

ESS Energy storage system

EMS Energy management system

Fire extinguishing system

PCE Power conversion equipment

BS Battery system

BMS Battery management system

BP Battery pack

BC Battery cell

Value chain services

	Consultation	Training	Audit	Inspection	Testing	Certification
Energy storage system	Sustainable energy solutions for the value chain	Standard training	Process audit	Production supervision	Electrical Safety	International certifications and global market access
Energy management system	Green energy management solution	Operation training	System audit	Outgoing quality control	Battery safety	EU certification
Power conversion equipment	Insurance and financial technology solution	Personnel training	Quality control	Installation inspection	Electromagnetic Compatibility	North American certification
Battery system	Treatment and recycling system service of waste batteries	Personnel qualification and certification	Factory audit	Operation inspection	Transport safety	Japanese certification
Battery management system	Evaluation of the performance and usability of echelon utilization batteries		Due diligence	Factory acceptance	Function safety	Korean certification
Battery cell	Resource utilization efficiency and material recycling goals		Supply chain audit	On-site acceptance	Information security	China Mark certification
			Supplier evaluation	Model comparison	Cybersecurity	CB scheme recognition system
			Risk assessment	Fire protection assessment	Grid connection	Global market access
			Failure analysis	Verification of renewable materials in batteries	Wireless testing	Product market listing
			Battery data and information verification		Benchmark testing	Compliance with Batteries Directive
			Carbon footprint in the life cycle		Performance testing	
					R&D testing	
					Life cycling testing	
					Aging testing testing	
					Penetration testing	
					Reliability testing	
					Thermal runaway testing	
					Heat spreading assessment	
					Verification sampling and testing	

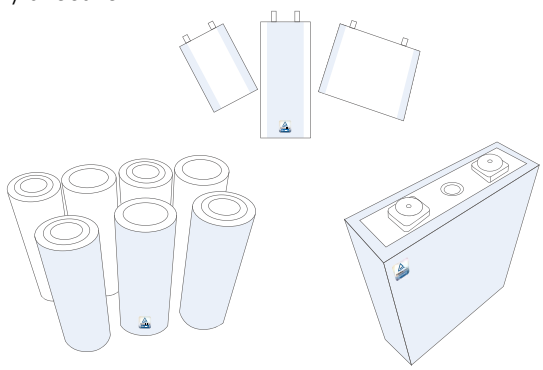
Supply chain services

	Development	Pre-production	Production	Post-Production
TÜV Rheinland expert team	▪ Supplier evaluation ▪ Technical advisory			
At factory	▪ Factory audits	▪ Capability assessment ▪ Pre-production inspection	▪ DuPro factory inspection ▪ Inline quality assurance	▪ Pre-shipment factory inspection ▪ Loading supervision
In TÜV Rheinland's laboratory	▪ Module benchmarking	▪ Reliability tests ▪ Reference module creation	▪ Fast verification sample test	▪ Final random sample test
On construction site				▪ Post-shipment inspection ▪ Pre-installation testing

Testing and certification services

BATTERY CELL

Since the battery cell is an important part of a battery system, its reliability and safety play a vital role in the entire system. The continuous improvement of the energy density and charge and discharge capacities has placed higher requirements on the service life and safety of the battery cell. TÜV Rheinland can provide multiple professional services regarding electrical safety, performance, environment and battery directive.

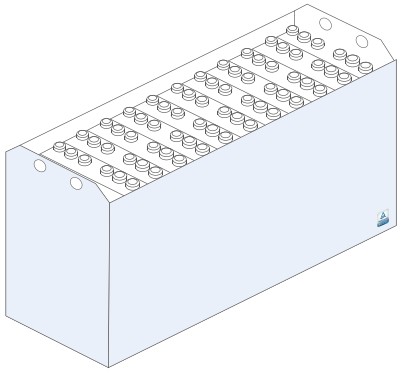


MARKET	STANDARD/REGULATION
China	Safety Regulation & Performance: GB/T 36276
Germany	Safety Regulation: EN 62619 Performance: EN 62620 Regulation/Chemical: EU Battery Directive
European Union	Safety Regulation: IEC/EN 62619 Performance: IEC/EN 62620 Regulation/Chemical: EU Battery Directive
North America	Safety Regulation: ANSI/CAN/UL 1973, UL 1642
Japan	Safety Regulation: JIS C 8715-2, SAE J 2464 (4.3.3 Penetration, 4.3.6 Crush)
Korea	Safety Regulation: SPA-KBIA-10104-03-7312, KS C 62619 Performance: KS C 62620
Australia	Safety Regulation: IEC 62619 Performance: IEC 62620

BATTERY SYSTEM

A battery system is mainly composed of two parts, i.e. a module or Pack (battery cells in series and parallel) and a battery management system (BMS).In terms of application, battery systems mainly fall into residential, industrial and commercial, power system and portable types.The safety of the battery system plays an important role in the entire system. With the continuous improvement in the voltage, current and capacity levels of the energy storage system, the requirements on corresponding charging, discharging and BMS systems have become more stringent, especially for battery thermal management.

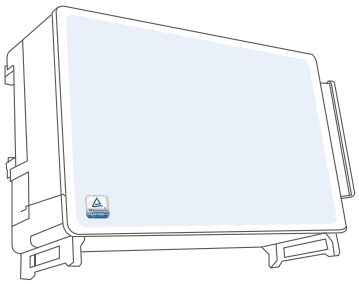
TÜV Rheinland can provide multiple professional services regarding electrical safety, EMC, battery safety, functional safety, fire fighting, transport safety and performance.



MARKET	STANDARD/REGULATION
China	Safety Regulation: GB/T 36276 EMC: GB/T 36558
Germany	Safety Regulation: 2PfG 2698, VDE-AR-N-2510-50, IEC 62933 Series Functional safety: IEC 60730-1 Annex H, IEC 61508 EMC: EN 61000-6-1, EN 61000-6-2, EN 61000-6-3, EN 61000-6-4
European Union	Safety Regulation: IEC 62933 Series, IEC/EN 62619, IEC/EN 62477-1 Functional safety: IEC/EN 60730-1 Annex H, IEC/EN 61508 EMC: IEC/EN 61000-6-1, IEC/EN 61000-6-2, IEC/EN 61000-6-3, IEC/EN 61000-6-4
North America	Safety Regulation: ANSI/CAN/UL 1973 Functional safety: UL 991+UL 1998, UL 60730-1 Annex H
Japan	Safety Regulation: JIS C 8715-2 Functional safety: IEC 60730-1 Annex H, IEC 61508, EMC: JIS C 4411-2
Korea	Safety Regulation: SPA-KBIA-10104-03-7312, KS C 62619 Functional safety: IEC 60730-1 Annex H, IEC 61508
Australia	Safety Regulation: IEC 62133-1/2, IEC 62619, IEC 62040 Functional safety: IEC 60730-1 Annex H, IEC 61508 EMC: IEC 61000-6-1, IEC 61000-6-2, IEC 61000-6-3, IEC 61000-6-4

POWER CONVERSION EQUIPMENT

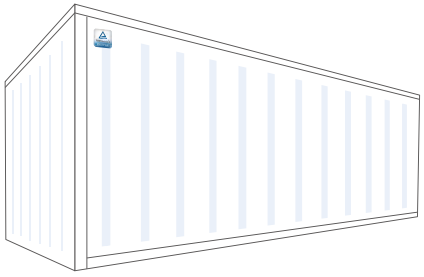
Power Conversion Equipment (PCE), power conditioner or power conversion system (PCS) refers to the equipment that uses power electronic technology to convert electrical energy from one form to another. According to the way of electric energy conversion, common PCE products can be classified as rectifier, inverter, frequency converter, uninterruptible power supply, DC chopper, EV charging device, energy storage converter, etc. With the development of power electronic converter and energy storage technologies, the power of energy storage converters has gradually increased, developed multiple working modes of on-grid, off-grid and the combination of the both, and gained the ability to control electric energy flow in both directions, thus greatly improving the flexibility of energy storage applications. Meanwhile, the energy storage converter with synchronous input of PV and energy storage batteries has emerged, which combines energy storage systems with new energy sources. The mutual complementation between the two has created more application scenarios.TÜV Rheinland can provide multiple professional services regarding electrical safety, EMC, grid connection, performance and environment.



MARKET	STANDARD/REGULATION
China	Safety Regulation & EMC & On-grid: GB/T 34120, GB/T 34133
Germany	Safety Regulation: EN 62477-1 EMC: EN 61000-6-1, EN 61000-6-2, EN 61000-6-3, EN 61000-6-4 On-grid: VDE-AR-N 4105, VDE-AR-N 4110, VDE-AR-N 4120
European Union	Safety Regulation: EC/EN 62477-1 EMC: IEC/EN 61000-6-1, IEC/EN 61000-6-2, IEC/EN 61000-6-3, IEC/EN 61000-6-4 On-grid: EN 50549-1, EN 50549-2
North America	Safety Regulation: UL 1741, CSA C22.2 No. 107.1 EMC: FCC On-grid: IEEE 1547, IEEE 1547.1
Japan	Safety Regulation: <50kW:JIS C 4412-1/JIS C 4412-2, >50kW: IEC 62109-1/IEC 62477-1 EMC: IEC 61000-6-1, IEC 61000-6-2, IEC 61000-6-3, IEC 61000-6-4, JIS C 4411-2 On-grid: <50kW:JETGR0002-1, JETGR0003-1, JETGR0003-4/-5/-6, >50kW:JEAC 9701
Korea	Safety Regulation & EMC & On-grid: SPS-SGSF-025-4-1972
Australia	Safety Regulation: IEC 62109-1/IEC 62477-1 EMC: IEC 61000-6-1, IEC 61000-6-2, IEC 61000-6-3, IEC 61000-6-4 On-grid: AS/NZS 4777.2

ENERGY STORAGE SYSTEM

Energy storage refers to the energy energy circulation process in which energy is stored in a certain form through energy media or equipment, and then released in a specific form of energy according to specific applications or needs. Energy storage systems that are widely used for now refer to electrochemical energy storage systems, which convert various kinds of energy such as solar energy, thermal energy, kinetic energy and chemical energy into electrical energy, store it up and then release it according to demand. The evaluation indicators of energy storage systems include safety, economic efficiency, reliability, high efficiency, easy operation and maintenance, etc. Among them, safety is the most important indicator and evaluation basis for all energy storage systems. TÜV Rheinland can provide multiple professional services regarding electrical safety, EMC, battery safety, functional safety, grid connection, fire fighting, transport safety, performance and environment.



MARKET	STANDARD/REGULATION
China	Safety Regulation & EMC: GB/T 36558, On-grid: GB/T 36547, GB/T 36548
Germany	Safety Regulation: 2PfG 2698, VDE-AR-N 2510-50, IEC 62933 series Functional safety: IEC 61508, IEC 60730-1 Annex H EMC: EN 61000-6-1, EN 61000-6-2, EN 61000-6-3, EN 61000-6-4 On-grid: VDE-AR-N 4105, VDE-AR-N 4110, VDE-AR-N 4120
European Union	Safety Regulation: EC 62933 series Functional safety: IEC/EN 61508, IEC/EN 60730-1 Annex H EMC: IEC/EN 62477-1, IEC/EN 61000-6-1, IEC/EN 61000-6-2, IEC/EN 61000-6-3, IEC/EN 61000-6-4 On-grid: EN 50549 series
North America	Safety Regulation: UL 9540, UL 9540A Functional safety: UL 60730-1 Annex H, UL 991+ UL 1998, EMC: UL 9540 On-grid: Same as inverter requirements
Japan	Safety Regulation: <50kW:JIS C 4412-1/JIS C 4412-2, >50kW: IEC 62109-1/IEC 62477-1, JIS C 4441 (IEC 62933-5-2) EMC: JIS C 4411-2 (JIS 61000-3-2), IEC 61000-6-1, IEC 61000-6-2, IEC 61000-6-3, IEC 61000-6-4 On-grid: <50kW:JETGR0002-1, JETGR0003-1, JETGR0003-4/-5/-6, >50kW: JEAC 9701
Korea	Safety Regulation: SPS-SGSF-025-4-1972 EMC & On-grid: <10kW:KS C 8564, >10kW:KS C 8565
Australia	Safety Regulation: IEC 62109-1/AS 62040-1,IEC 62109-2 EMC: IEC 61000-6-1, IEC 61000-6-2, IEC 61000-6-3, IEC 61000-6-4

Integrated solution of PV systems, battery storage and charging stations

The new energy infrastructure of the future will integrate PV systems, battery storage and charging stations. As the energy storage industry gains momentum, insiders are paying increasing attention to the potential of such integrated systems. Charging and swapping stations coupled with PV systems and battery storage have become a development focus in infrastructure planning. TÜV Rheinland will fully leverage its technological and resource advantages in this field to provide local one-stop services for industry chain enterprises and give new impetus to the industry.

Digital Solution for Smart Energy

The pattern of the energy industry in the digital era features a deep integration between the Internet and energy production, transportation, storage, consumption and the market. It is characterised by intelligence, transparency and openness, with energy storage as the core link. TÜV Rheinland is a market leader in the field of smart energy management and technological services, and provides local one-stop testing, certification and technological solutions.

Global service system and network

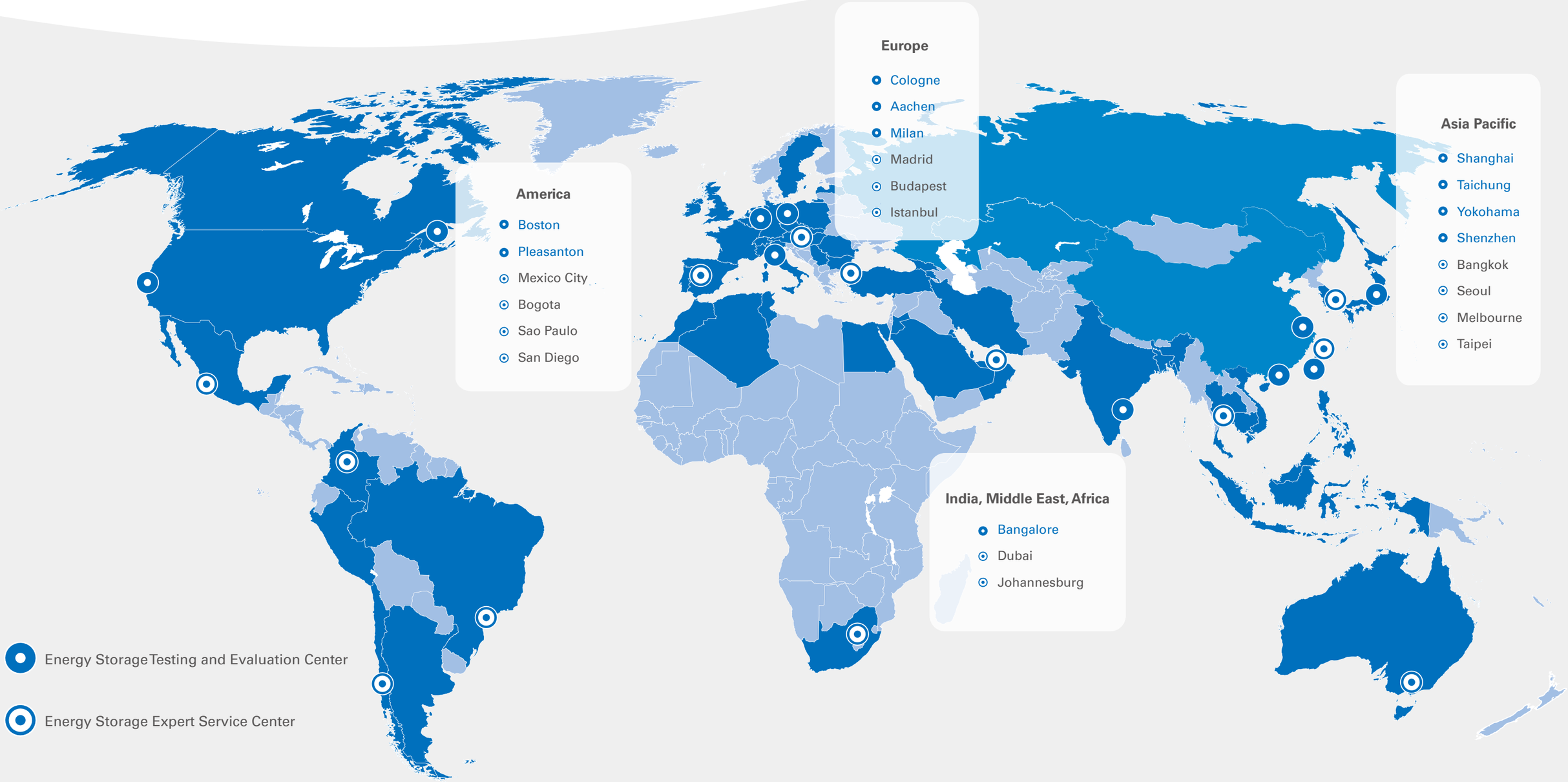
TÜV Rheinland's top ten testing centers in Cologne and Aachen, Germany, Milan, Italy, Shanghai, Shenzhen and Taiwan, China, Pleasanton and Boston, the United States, Yokohama, Japan, and Bangalore, India have perfect certification capabilities, the most advanced equipment and teams of experienced engineers. As a recognized leader in third-party testing and certification in the energy storage industry, we can quickly respond to the needs of local manufacturers, retailers and investors, trying our best to help them overcome challenges. With diversified technology capabilities and service portfolio, we are customers' trusted partner. We can provide advice and suggestions and the most comprehensive support to help you succeed in global markets.

100+ experts

10+ years of professional experience

500 regions

No.1 energy storage product testing and certification Institution



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