

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



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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 onestop 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



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 generationgrid-load-energy storage and new power system will be built.

Power generation side -

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

Internet of energy -

With the smart grid and Internet of energy and based on energy storage technologies, a safe and reliable multienergy 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 platform, so as to promote carbon trading and achieve a zero-carbon future.

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 TH

BS

BMS

BP

BC

TÜV Rheinland one-stop technology solution

ESS Energy storage system



S Energy management system



Fire extinguishing system

206

Value chain services

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

Supply chain services

Power conversion

system

PCE

A

	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 ■ Iaboratory	 Module benchmarking 	 Reliability tests Reference module creation 	 Fast verification sample test 	 Final random sample test
On construction site				 Post-shipment inspection Pre-installation testing

Battery system

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Battery management system

Battery pack



Battery cell

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.



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, electrical 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 & 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

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

500 regions No.1 energy storage product testing and certification Institution



10+ years of professional experience

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