

STATEMENT OF QUALIFICATIONS

# VDE Renewables

## ESS Quality Assurances Services



July 2022

**VDE** RENEWABLES

**Executive Summary**

VDE is the Association for Electrical, Electronic & Information Technologies, the largest technology organization in the world to combine science, standardization, testing, certification, and engineering advisory services all under one umbrella. VDE’s core mission is to advance and promote the development of new technology, future generations of engineers and technologists, and lifelong learning. The VDE mark has been associated with the highest standards of safety and consumer protection for over 100 years.

VDE Renewables is a wholly owned subsidiary of VDE. Our goal is to advance the deployment of clean energy projects that are safe, bankable, investable, and insurable. We support this goal by offering neutral 3rd-party product certification and customized testing in addition to technical due diligence, engineering advisory services and forensic analysis services (accident investigations). We provide value for our customers by maximizing quality and reducing technical risks at both the component and system level.

Our organizational structure enables our knowledgeable and experienced core team of technology experts and professionals to also rely on a deep bench of contributing subject matter experts using personal connections and our 36,000+ member strong VDE Association which includes preeminent technology leaders from industry and academia. This approach has enabled us to establish a distributed network of talented and trustworthy resources across the world with diverse backgrounds and experience, while keeping administrative costs down. We are a learning organization passionately committed to helping our customers realize their project goals. Every project is an opportunity to learn and to continually improve in our ability to not only meet but exceed customer expectations.

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## 1. About VDE and VDE Renewables

For more than 125 years, VDE has been widely regarded as a synonymous for innovation and technological progress. Based in Offenbach am Main, Germany, VDE is the Association for Electrical, Electronic & Information Technologies (**V**erband **d**er **E**lektrotechnik, **E**lektronik und **I**nformationstechnologie), the largest technology organization in the world to combine science, standardization, testing, certification, and engineering advisory services all under one umbrella. Safety, quality, sustainability, and social responsibility are what VDE exemplifies and promotes.

VDE's aim is to advance and promote the development of new technology, future generations of engineers and technologists, and lifelong learning. This is achieved as an association of more than 36,000 members including over 1,300 member companies across a wide array of industries and applications, in addition to over 1,800 full time employees at over 60 locations worldwide, all dedicated to ensuring a future worth living.

The VDE mark has been associated with the highest standards of safety and consumer protection for over 100 years, the result of an unwavering commitment to our guiding principles, as follows:

- We stand for innovation, safety, and quality
- We are regionally well-positioned based on a strong international network
- We are independent
- We shape and interconnect education, research, and application
- We share our knowledge
- We promote and train
- We set standards
- We are the platform for the next generation.

A selection of key VDE milestones and achievements are presented below in Table 1.

Year	Description
2020	100th anniversary of the VDE mark
2018	125th anniversary of VDE The first VDE Tec Summit takes place in Berlin, Germany VDE receives the German Brand Award
2016	VDE and DKE organize the 80th General Meeting of the IEC (International Electrotechnical Commission)
2012	The VDE Institute celebrates the opening of its Battery Testlab in Offenbach, Germany
1995	100th anniversary of the first VDE standard "VDE 0100" 75th anniversary of the VDE Testing and Certification Institute
1970	VDE and DIN (the German Institute for Standardization) establish the "DKE German Commission for Electrical, Electronic, & Information Technologies" to streamline all national electrotechnical standards.
1920	A central VDE testing center is set up in Berlin to evaluate electrical products on their compliance with existing VDE standards, followed by the first legally protected registration of the "VDE mark". Within 10 years, 3,904 products bear the VDE mark.
1906	With the participation of VDE, the IEC is founded in London and joined by 24 countries
1904	VDE's first "book of standards" is published, containing 183 pages and 17 provisions

1895	The first VDE standard "VDE 0100" for the safe construction of electrical systems is passed
1893	VDE is formed by in Berlin

Table 1. Key VDE Milestones

The increasing market adoption of renewable energy poses novel challenges to independent power producers, utilities, and grid operators alike, with widespread implications for virtually all wholesale and retail electricity customers. Proper design and construction in compliance with interconnection requirements is an important prerequisite for ensuring the stability and performance of electricity grids. These are the types of challenges that VDE is uniquely well positioned to address. Having been a key participant in the development of international technical standards addressing the safety, reliability, performance, and cybersecurity of electrical systems and equipment (including solar, wind, and battery energy storage systems, aka BESS), VDE has the knowledge, experience, and ability to be your trusted quality partner in the world of clean energy.

There are four core competency pillars to the VDE Group, as indicated in Figure 1 below:

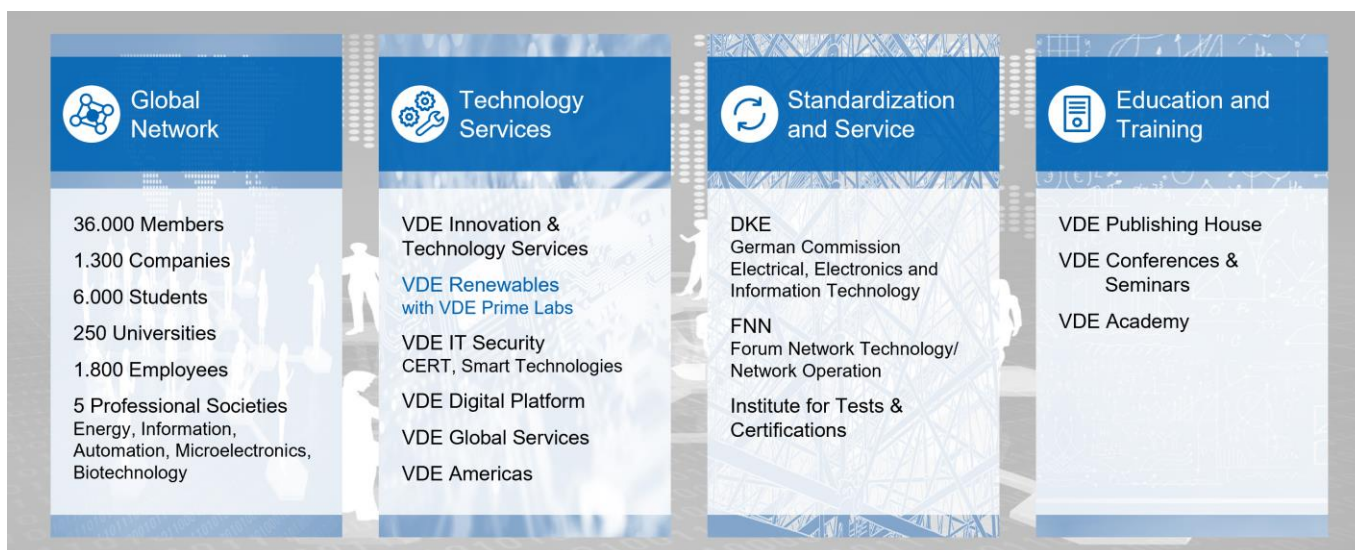


Figure 1: Four core pillars of the VDE Group

VDE Renewables GmbH and its fully owned subsidiary, VDE Renewables Asia Pte. Ltd., are part of VDE's business services. Our focus is renewable energy technology, particularly solar, wind, and energy storage, predominantly lithium-ion storage systems.

VDE Renewables adds value for customers by maximizing quality and reducing technical risks at both the equipment and system level. Our mission is to advance the implementation of clean energy projects that are bankable, investable, and insurable. We support this goal by offering neutral certification and testing, as well as technical due diligence and independent/owner's engineering services.

## 2. Our Partnerships

VDE works with various organizations in areas of research, finance, insurance, and testing & certification. Some of our partnerships are highlighted below:

### Business partnerships:

**Allianz Group** is one of the world's largest insurance companies. VDE and Allianz are partners in technical due diligence for renewable energy power plants, enabling the insurable and investable clean energy.

**Munich Re** is one of leading reinsurers globally. VDE is providing quality testing services as pre-requisite for warranty insurance underwritten by Munich Re.

**Wells Fargo** is US-based bank, which has been one of largest providers of tax equity financing to renewable energy projects in the United States. VDE has so far provided owner's engineering (OE) advisory on renewable energy projects throughout the United States.

### Testing and Certification partnerships (in Asia):

**Singapore Test Services (STS)**, part of ST Engineering Group: Collaboration in battery safety and performance testing for energy storage and electric vehicles.

**China Telecommunication Technology Labs (CTTL)**, Beijing: Extensive partnership in lithium-ion battery testing.

**National Centre of Supervision and Inspection on Solar Photovoltaic Products Quality (CPVT)**, Wuxi: Testing partnership for solar PV module certification and lithium-ion battery testing.

**Shanghai Solar Energy Research Center (SSERC)**, Shanghai: Testing partnership for supply chain quality assurance related projects.

### Research & Consulting project partnerships:

**Fraunhofer Institute for Solar Energy (ISE)**, Freiburg, Germany: Conducts public research as well as industrial projects for the private sector in the fields of solar energy, electrical energy storage as well as renewable energy systems.

**Energy Research Institute at Nanyang Technological University (ERI@N)**, Singapore: Integrates energy research across NTU and focuses on system-level research for tropical megacities, with the goal of enhancing the efficiency of energy systems while maximizing the synergies of alternative energy sources as well as knowledge creation and technology transfer by engaging with government agencies, research institutions and industry.

**A\*STAR Institute for Materials' Research and Engineering (IMRE)**, Singapore: research institute that has built strong capabilities in the areas of polymeric & organic materials, composite & structural materials, advanced materials characterization & fabrication, optics, and electronics, as well as electrochemical research on batteries and cell materials.

### 3. Relevant Competencies and Experience

#### 3.1. Project Technical Due Diligence, Bankability, and Insurability

Our team has extensive experience reviewing battery storage projects on behalf of project owners, investors and/or banks and insurance companies. Typically, our due diligence scope of work includes a selection of tasks as described in more detail in Table 2, and includes the provision of reports, certificates and supporting letters as required for the respective project.

Our colleagues around the world have similar project experience throughout Europe, the Americas, and the Middle East reviewing various utility-scale renewable energy projects & technologies, as well as having worked with leading financial institutions to help them understand and address unique and specific areas of technical risk that may be presented with BESS technology, particularly in the areas of safety and reliability.

Area	Description
Project Agreements	Review, comment and opine on: <ul style="list-style-type: none"> <li>▪ technical provisions of power sales/purchase agreement(s)</li> <li>▪ applicable performance guarantee requirements and how they compare against estimated power output</li> <li>▪ technical provisions of interconnection agreement (and system impact study, if applicable)</li> <li>▪ engineering, procurement and construction agreement and technical exhibits</li> <li>▪ operations and maintenance agreement(s) and technical provisions of asset management agreement</li> <li>▪ additional agreements as specific to the project (e.g., co-tenancy, shared facilities, site lease).</li> </ul>
Site Review	Review provided site data (e.g., ALTA survey, parcel info) and confirm accuracy as requested. Review, comment and opine on: <ul style="list-style-type: none"> <li>▪ environmental site assessments (ground-mount projects)</li> <li>▪ geotechnical investigations and supplemental test reports (ground-mount projects)</li> <li>▪ hydrology and/or wetlands reports (ground-mount projects)</li> <li>▪ building structural analysis</li> <li>▪ pre-construction electrical surveys (behind-the-meter projects).</li> </ul>
Technology, System Design & Major Equipment	Design review of construction drawings (preliminary through issued for construction and/or as-built) for civil, structural, and electrical (including SCADA and substation as necessary). Review structural calcs and confirm alignment between calcs/drawings and 3 <sup>rd</sup> -party report recommendations. Review equipment and component specifications and certifications as well as warranty provisions for major equipment, and delivery schedule (as requested). Discuss 3 <sup>rd</sup> -party lab characterization, lifetime, and performance testing. Review safety concept, installation, commissioning, operation and maintenance plans, schedules, and manuals.
Power Output Estimate	Review BESS performance models. Review control system that manages charging and discharging.

	Simulate power output for project using user-based independent design; comment on loss factors; conduct uncertainty analysis based on model/measurement error and interannual variability.
Permits, Plans and Approvals	<p>Review, comment on status and opine on:</p> <ul style="list-style-type: none"> <li>▪ conditional use or equivalent land use permits</li> <li>▪ applicable endangered species surveys and associated permits (ground-mount projects)</li> <li>▪ applicable cultural &amp; archaeological surveys and associated outreach, agreements, permits etc. (ground-mount)</li> <li>▪ applicable hydrological surveys and associated stormwater permits, stormwater pollution prevention plan etc.</li> <li>▪ construction-related permits (general construction, roads, easement crossings etc.)</li> <li>▪ other permits as applicable (e.g., aviation authorities or other AHJs) Review project against equator principles as requested.</li> </ul>
Financial Review	<p>Confirm pro forma revenue assumptions align with production estimate.</p> <p>Review pro forma operational expenses including major equipment maintenance/refurbishment.</p> <p>Conduct sensitivity analysis on operational expenses.</p> <p>Review decommissioning assumptions and comment in IE Report.</p>
Construction Oversight	<p>Visit project site to assess construction workmanship (or conduct desktop review of photographic evidence).</p> <p>Confirm status of construction including confirmation of mechanical completion; review/confirm schedules.</p> <p>Review EPC contractor reports and engage as requested.</p>
Acceptance	<p>Review acceptance test (e.g., capacity, availability etc.) reports/data.</p> <p>Review site walk/inspection reports, punch lists, spare parts lists, O&amp;M manuals etc..</p> <p>Review EPC contractor certificates of mechanical, substantial and final completion, as required.</p>

Table 2: Typical scope of work for project due diligence

### 3.2. System commissioning, inspection, and certification

We provide management and oversight of storage system and qualification in accordance with technical standards IEC 62485, VDE-AR 2510-50, IEC 60364 as well as based on our in-house developed premium criteria catalogues and checklists, as requested by system developers and potential buyers to assure the quality of system design and construction workmanship as well conformance with applicable codes and standards, and industry best practices. We have experience completing this work for a variety of system application types including both indoor and outdoor systems.

VDE has also created a “Checklist” for BESS installations, a unique quality assurance product specifically developed for investors and project owners to. The base evaluation program is comprised of a comprehensive design and documentation review, with more than 300 checkpoints which must be passed, as well as an optional on-site inspection (after facility installation). This independent assessment of the facility delivers significant advantages to project stakeholders above and beyond typical due diligence in 4 key areas:

- Electrical and mechanical safety

- System performance
- Proper system installation, commissioning, operation, and maintenance
- Independent verification for investors, lenders, insurance companies and other stakeholders by highly competent and reputable experts.

Associated services for this independent assessment are further discussed in Table 3. Clients can choose from a ‘toolbox’ of additional tests and services, which can be included in the certification report for the renewable energy facility.

Area	Description
Planning	Check of project management process. Quality check of project documentation.
Design	Suitability of component selection. Suitability of design to application/site.
Development and Engineering	Sizing of installation. Environmental stress review. Precise power output estimates. Simulation of system performance and lifetime forecast. Assessment of different energy storage management strategies.
Construction and Installation	Accessibility of site. Installation quality and workmanship. Conformance with plans, codes & standards, and equipment manufacturer requirements.
Commissioning and Acceptance	Reliability and performance tests for module samples. Site commissioning and acceptance testing. Visual inspection. Final acceptance test and report.
Operation	Review of operational procedures and adherence in the field (for existing facilities). Independent performance evaluation. Failure analysis and reporting. Long-term performance reporting.
Maintenance	Review of maintenance procedures. Inspection of maintenance logs and reports (for existing facilities).

*Table 3: Associated services for independent facility assessment*



### 3.3. Component testing and certification

VDE is an internationally active certification body, carrying out hundreds of thousands of component tests per year. In the area of battery energy storage, we work with many of the leading international manufacturers to certify conformance with a variety of IEC, UN, and VDE, as well as conduct testing based on other standards (e.g., UL).

Through our ongoing engagement of key stakeholders in the renewable energy industry, particularly financial institutions, and insurance firms, we recognize that existing standards requirements, although important, are insufficient to achieve bankability, investability and insurability for all projects and major equipment. These standards must be extended with additional criteria.

We have therefore developed our VDE Pyramid of Quality approach, which is our guiding principle for the development of products and services for all clean technologies. One of the important goals of this approach, which is especially important for financial stakeholders, is to achieve a significant reduction of operational risks, which is paramount to project valuation. Our experience shows that risk is reduced as you shift further up the pyramid, as shown in figure 2.

With regards to evaluating energy storage equipment, VDE operates multiple state-of-the-art testing facilities for batteries throughout the world, including test labs in Singapore, Germany, US, and China. The focus of our testing operations has been in the areas of product safety and reliability.

These resources enable us to support our customers more effectively and efficiently, who are engaged in the development and deployment of BESS systems or -modules and lithium-ion cells.

Testing can be done based on (international or national) standards and regulations, as well as based on customer requirements (customized testing), both for the purpose of certification as well as during product development (e.g., performance or lifetime testing of a product, comparative testing of multiple different brands for suitability in a client product or customized safety testing to evaluate safety behavior in more detail than what is done in the framework of standard-based testing).

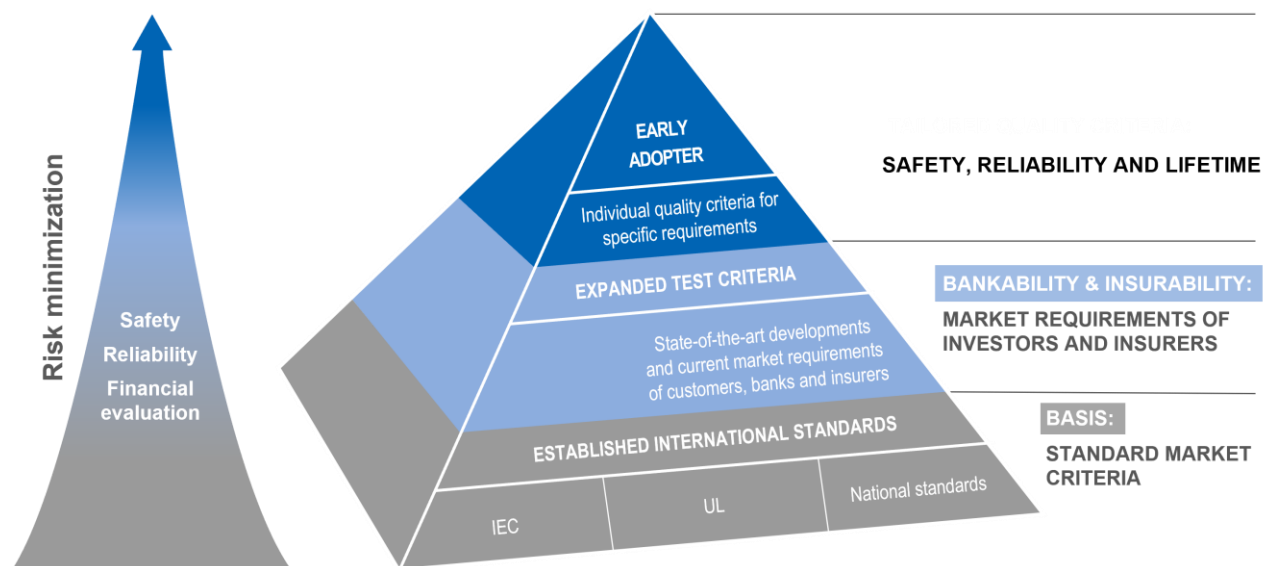


Figure 2: The VDE Pyramid of Quality

## 3.4. Accident investigations / battery forensics

There have been a large number of battery (energy storage) accidents in the past few years and with continued growth and adoption of batteries for stationary power supply and mobility applications, more incidents will occur. Battery accidents often result in lost revenue, system replacement costs and in the worst case in litigation and penalty payments to aggrieved parties as well as potential fines.



*Figure 3: Various battery incidents*

We leverage our testing capabilities, large network of partner labs as well as the knowledge of our battery experts to conduct forensic investigations or accident investigations into cells or battery systems, either stand-alone or in collaboration with other established surveyors (e.g., in the marine business) and relevant authorities.

Our services in this field include:

- Inspection of accident sites in the field as well as production facilities
- Catastrophic loss event survey
- Document reviews (QA procedures and logs, shipping documentation, etc.)
- Inspection of product packaging – conformity to regulations
- Electrochemical analysis of samples (dismantling of accident-adjacent but intact samples as well as new samples, and where possible of damaged samples) to check for lithium-plating, contaminations, or other abnormalities
- (Re-)Testing of samples, to confirm safety or determine accident root cause or to independently verify conformance with e.g., UN 38.3 or SoC requirements (for air transport)
- BMS HIL testing to reconstruct incident conditions (where applicable)
- Evidence storage in dedicated battery storage units.

## 3.5. Other technical advisory services

We leverage the knowledge and experience of our dedicated team and extended network of contributing subject matter experts to customize and deliver technical advisory services that are based upon the specific needs of our customers. In addition to serving project developers, sponsors, and the financial institutions they partner with, we also work directly with system designers, equipment manufacturers, power sales offtakers, utilities, and operators to evaluate technology, and to identify and mitigate technical risk.

These services include the following:

- Site feasibility studies
- Technical document review
- Technology review (IE Report for equipment manufacturers)
- Company due diligence (IP holdings, capabilities, market share, QA processes, product quality and USPs, supply chain management, competitive analysis)
- Factory inspections
- Subject matter training (e.g., basics of lithium-ion technology, correct handling, storage and disposal, transport regulations, HV battery systems, BMS basics and master class, etc.) and/or consulting.

## 4. Selected team member backgrounds

Our talented professionals have dedicated their careers to the advancement of renewable energy and have been working in the field for many years. The selected VDE team members below are regular contributors to project work.



**Burkhard Holder**  
Managing Director,  
VDE RE

Burkhard Holder possesses more than 30 years of strategy and leadership experience in the industry through positions in the photovoltaic industry, applied research area, and energy policy initiatives. He is the Managing Director of VDE Renewables. Previously, he was the Head of Division Energies and Power Electronics at the VDE Testing and Certification Institute in Germany. From 1996 to 2004, he was an appointed expert for renewable energy policies and industry development for the German government, which included various speaking engagements in United Nations conferences around the world. He was also the Advisor/Executive Liaison Officer to the President at the European Renewable Energy Centers Agency in Brussels.



**Dr. Jan Geder**  
Head ESS,  
VDE RE Asia

Dr. Jan Geder is a chemical engineer with extensive experience in energy storage and lithium-ion batteries. His focus is consulting, technical due diligence, and managing industrial R&D projects for various clients. In 2016, he and his team successfully spun off their academic research lab to become a commercial R&D and testing facility. Since 2017, Jan serves as Head of Energy Storage Systems at VDE Renewables Asia in Singapore and leads the VDE's Energy Storage activities in the field of technical consulting, testing, inspection, and certification for the Asia-Pacific region.



**Andreas Hauser**  
Deputy Head ESS,  
VDE RE Asia

Andreas Hauser is an electrical engineer with more than 10 years' experience in the field of energy storage and lithium-ion battery technology, first at BMW in Munich, Germany and later in Singapore at a large-scale research project of the Technical University of Munich, as well as at VDE Renewables Asia since 2017. He is focused on technical due diligence for energy storage installations, battery management systems and electromechanical system design for battery systems, consulting in the field of energy storage and lithium-ion technology, forensic investigations after lithium-ion cell- and battery incidents, as well as engineering projects for VDE's clients.



**Dr. Jochen Mähliß**  
Global Head ESS,  
VDE Renewables

Based in our Alzenau, Germany office, Dr. Jochen Mähliß is responsible for the management, strategic orientation and expansion of the business field of batteries and energy storage at VDE Renewables. Jochen holds a doctorate in chemistry and possesses deep expertise of the materials used and the chemical-physical processes in lithium cells. He worked in various R&D positions and was intensively involved in electrical, mechanical, environmental and abuse testing of lithium-ion cells and batteries. He has made several publications on fire and safety hazards, effective loss prevention and firefighting of lithium batteries. Jochen is an active member of various lithium battery working groups dealing with the creation of state-of-the-art standards. Jochen organizes the VDE Academy and offers in-house training on all relevant topics related to lithium-ion battery technology.



**Patrick Heining**  
Head of Projects,  
VDE Renewables

Patrick Heining is responsible for the management of national and international battery consulting projects within VDE Renewables GmbH. In his career, he gathered comprehensive experience in the field of quality optimization of lithium-ion batteries, particularly in the field of manufacturing and design. His expertise in automation technologies has been crucial for successful accomplishment of several optimization and automation projects he led for an automotive component supplier. Since joining VDE, he has co-published several studies in the field of battery technology and alternative propulsion of vehicles, as well as leading different projects to establish VDE Corporate Standards.



**Dominik Hennefeld**  
Head of Laboratory,  
VDE Renewables

Dominik Hennefeld is an electrical engineer with an experience of more than 10 years in the field of lithium-ion energy storage systems and drive technology. He is an outstanding expert in the design of parameters for battery management systems and the development of test cases for electrical, mechanical and environmental tests on lithium-ion batteries. Dominik is particularly concerned with the behavior of lithium-ion batteries under abuse conditions and with failure mechanisms which eventually could lead to fire development and propagation within battery storage systems. He has an in-depth knowledge and advises our customers on battery design and construction and manages testing and certification projects for our clients in Germany and Europe.



**Brian Grenko**  
VP and Senior Principal,

Brian Grenko has over two decades of engineering and operations experience mostly within the renewable energy industry. Since he started working at VDE Americas, he has provided over 40 BESS project with advisory services. Prior to joining VDE, Brian was a founding executive of the Yingli Green Energy Americas in 2009. As VP of Technology, Brian led Yingli's engineering organization, which provided customer service and leading-edge characterization, research, and development efforts via Yingli's Testing Lab.

VDE Americas



**Harvey Braswell**  
Principal Engineer,  
VDE Americas

Harvey Braswell is an advanced energy solutions leader with 40 years of experience developing expertise in operations and maintenance (O&M), system integration, and construction across a wide range of energy platforms. Harvey led the development team for the installation of Bloom Energy solid oxide fuel cells. He later went on and built and led the development and asset management teams at Advanced Microgrid Solutions for a portfolio totaling 63MW/345MWH of energy storage projects based on Tesla and Lockheed Martin Li-ion based energy storage systems. The systems broke new ground by simultaneously reducing host electricity costs and providing key capacity to the local electric utility, SCE.



**Dean Wen**

Manager of Great China,  
VDE Shanghai

Dean Wen is an electrical engineer with more than 20 years' experience in the field of industrial electrical equipment and system, 5 years with energy storage and lithium-ion battery technology, first at MCC Group in China at several large-scale engineering projects of Baosteel Group, as well as at VDE Global services China since 2005. He is focused on onsite inspection for energy storage system installations and leads a team of factory inspection for those critical components of BESS and system integration, as well as testing projects for VDE's clients.



**Raymond Zhou**  
Head ESS,  
VDE Shanghai

Raymond is a Senior Technical Manager, inspector, and auditor with VDE Global Services in Shanghai. He has more than 16 years' experience in quality assurance and R&D engineering for battery energy storage systems.

*Figure 4: Selected VDE team members*