

JANUARY 2022 - N. 3

TESTINGLY

Testing, Inspection & Certification Magazine

Innovative
Tests for
Resilient Grids

magazine by

KEMA Labs

Testingly

Editorial Supervision

Paolo Chighine

Luca Luciano Pincelli

Editorial Board

Domenico Villani

Alessandro Bertani

Frank Cielo

Gerd Enoch

Paolo Miolo

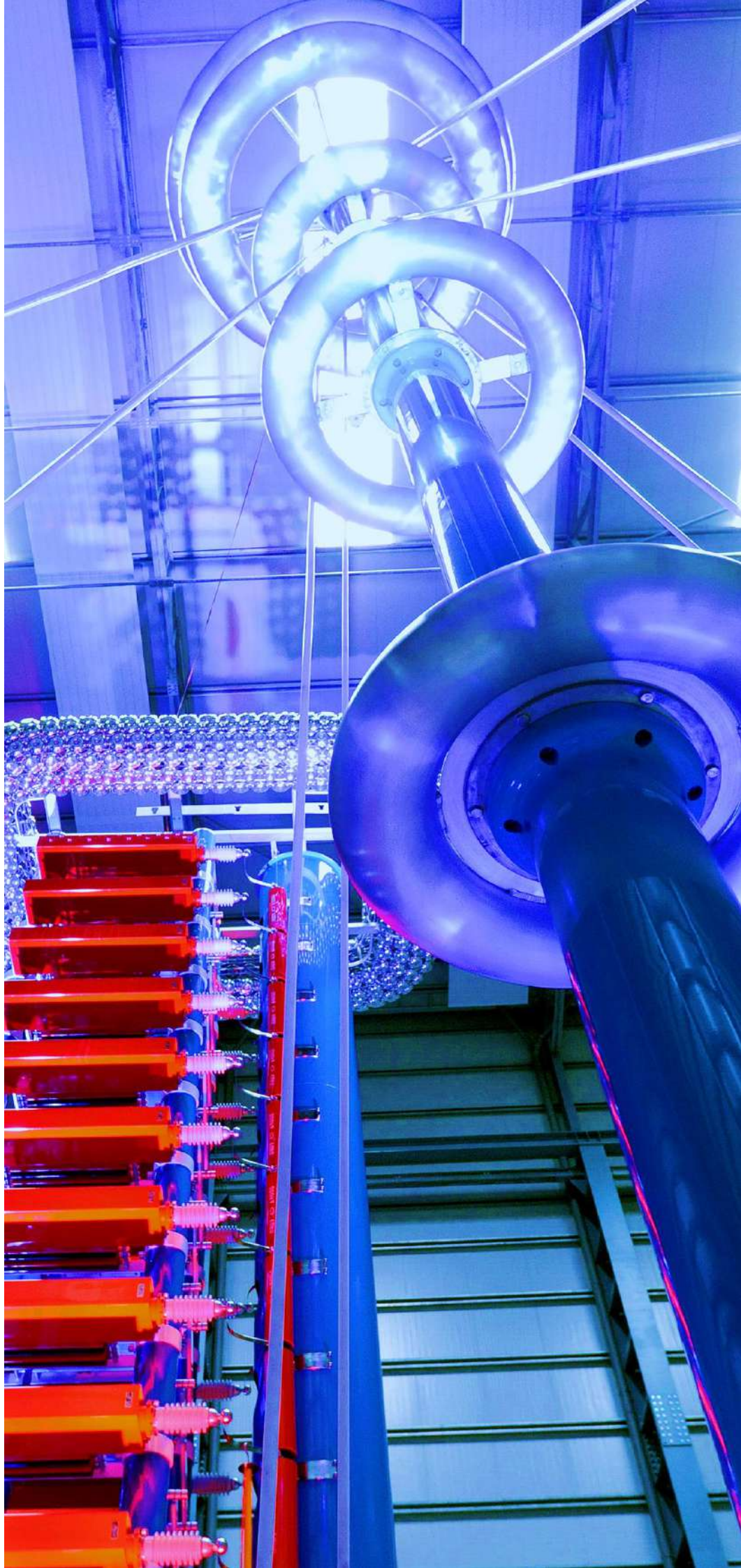
Shankar Subramany

Bas Verhoeven

KEMA Labs

www.kema.com

While all efforts have been made to contact relevant copyright holders with respect to the materials included in this publication, we invite any person whose rights have not been cleared yet, to contact the us for the necessary arrangements.



Index

CONTENT

Editorial

The tests of today for the resilience of tomorrow

01



Latest from TIC

Latest news from the TIC industry

02

Innovative Technologies

Battery storage and its role for power grid resilience

03

Interview With...

Peter Vaessen, Innovation Manager at KEMA Labs

04

Testing Facilities

Testing of HVDC cable systems

05

Case History

Temperature rise test of three-phase reactors

06

Join the Conversation

Testing components in the digital era

07

Testing, Inspection and Certification events

Upcoming events, conferences, seminars and more

08



“

Digital, Emulation, and the combination of Cyber and Physical tests represent the new way of Testing.

”

Matteo Codazzi
CESI Group CEO

The tests of today for the resilience of tomorrow

Modern, highly digitized and decarbonized economies will be increasingly dependent on electricity as their preferred energy carrier and, therefore, will require a huge improvement of the level of resilience and continuity of supply of power grids.

Electric networks already constitute the backbones of our modern world.

They are, however, susceptible to physical attacks, natural disasters, cyber-attacks and extreme weather: the list of potential threats has increased exponentially in the last few years –due to climate change and digitalization. Therefore, **power systems' Resilience** is increasingly becoming the new “mantra”.

In this respect, the role of independent **testing, inspection and certification (TIC)** industry is increasingly crucial.

As a matter of facts, in an environment where complexity and uncertainty are drastically growing, an independent verification of the level of performance, reliability and adaptability of power-grid's key components is needed, in order to ensure that power systems can withstand **disasters, minimize disruptions** and quickly recover to normal operational conditions. **Digital, Emulation, and the combination of Cyber and Physical tests represent the new way of Testing.**

This is the reason why we have decided to focus this issue of **Testingly, the KEMA Labs magazine**, around the topic of **power grid resilience**, analyzing the specific reasons that make independent TIC laboratories paramount for electric networks.



“

Testing, inspection and certification activities cannot be replaced when it comes to guaranteeing grid resilience

”

*Domenico Villani – KEMA Labs,
Executive Vice President*

In order to do so, the **Innovative Technologies** section presents the strong connection between **battery storage and grid resilience**, showcasing how (by using lithium-ion batteries) power supply can become more resilient, both at a system level and at communities or single customer level.

In the **Interview with...** section, **Peter Vaessen (Innovation Manager at KEMA Labs, Arnhem)** describes the key role of testing in high-voltage engineering to guarantee power grid resilience. As he puts it, “I have seen an 800-kV transformer fail, because of a small detail. A very small plastic cap that was missing caused a failure during the lightning impulse testing. If this would have happened in service, the failure in this 10-million-worth object would cause an outage of the transmission link!”

The importance of testing is clearly evidenced in the article *Testing of HVDC cable systems: Current market situation and future trends*, in the **Testing Facilities** section, which analyzes how various test activities can impact the HVDC cable market, providing customers with resilient components that can improve the reliability of the whole grid. In this respect, new facilities and equipment designed for specific HVDC tests are presented in the article.

In addition, the **Case History** section focuses on a ground-breaking temperature rise test of three-phase current-limiting reactors, which shows how maintaining a continuous power supply is a challenging task, as the complex and interconnected nature of the electricity grid makes the safety and reliability of each single component an extremely valuable issue, in order to guarantee the whole power network’s resilience.

Finally, in **Join the Conversation** you will be able to start a conversation with KEMA Labs experts and ask them questions, specifically on the topic of testing components in the digital era.

We are sure you’ll enjoy the reading.

Matteo Codazzi – CESI Group CEO

Domenico Villani – Executive Vice President CESI TIC Division – KEMA Labs

Latest news from the TIC industry



KEMA Labs ISO 17025 accreditation for payment energy meters

KEMA Labs is now ISO 17025 accredited by the national Dutch accreditation council for all testing activities required to prove compliance with the IEC 62055-31 and IEC 62054-21 standards. To this end, KEMA Labs has set up various test facilities, including a laboratory where tests with high currents of up to 10,000 amps can be carried out to test the source and load control switches.

Endurance switching tests at different power factor values as well as short circuit current making, carrying, and breaking tests can be performed.

The correct operation of the internal switches and of the time synchronization is to be verified during all kind of external conditions like electromagnetic disturbances (EMC), different power quality phenomena and change in temperature and humidity. All necessary tests and assessments are performed by trained personnel at KEMA Labs.



Product safety testing energy meters

The international standardization committee IEC TC13 drew up standard IEC 62052-31 in 2015, which sets the requirements regarding the product safety of energy meters. Even though this standard has been available for some time, it usually takes several years before this standard is integrated into the sector.

KEMA Labs has carried out a first project for an international manufacturer to test the product safety of an energy meter. To this end, KEMA Labs has set up various test facilities, including a laboratory where tests with high currents of up to 10,000 amps can be carried out to test the internal switches. All necessary tests and assessments are performed by trained personnel at KEMA Labs.



High Energy Arc-Fault Testing for International Nuclear Power Plant Safety

High Energy Arc Faults (HEAF) events are defined as energetic or explosive electrical equipment faults, characterized by a rapid release of energy in the form of heat, light, vaporized metal and pressure increase due to high current arcs between energized electrical conductors or between energized electrical components and neutral or ground. HEAF events may also result in projectiles being ejected from the electrical component or cabinet of origin and result in fire.

The energetic fault scenario consists of two distinct phases. The first one is characterized by short, rapid release of electrical energy which may result in projectiles (from damaged electrical components or housing) and/or fire(s) involving the electrical device itself, as well as any external exposed combustibles, such as overhead exposed cable trays or nearby panels, that may be ignited during the energetic phase. The second phase (the ensuing fires) is treated similarly to other postulated fires as specified in [NUREG/CR-6850, EPRI 1011989](#).

In this respect, the United States Nuclear Regulatory Commission (NRC) has been conducting High Energy Arc Fault testing at the KEMA Labs Chalfont facility since 2015. International HEAF testing was performed at KEMA Labs Chalfont by the NRC Office of Nuclear Regulatory Research (RES) in collaboration with 7 other member countries, including Canada, France, Finland, Germany, Korea, Japan and Spain.

The recent international tests suggest that HEAF scenarios involving certain components may have a zone of influence that is not bounded by the current regulatory guidance, thereby underestimating the risk from HEAF events.



The new KEMA Labs battery laboratory, in Milan, is now in full operation

INNOVATIVE TECHNOLOGIES

Battery storage and its role for power grid resilience

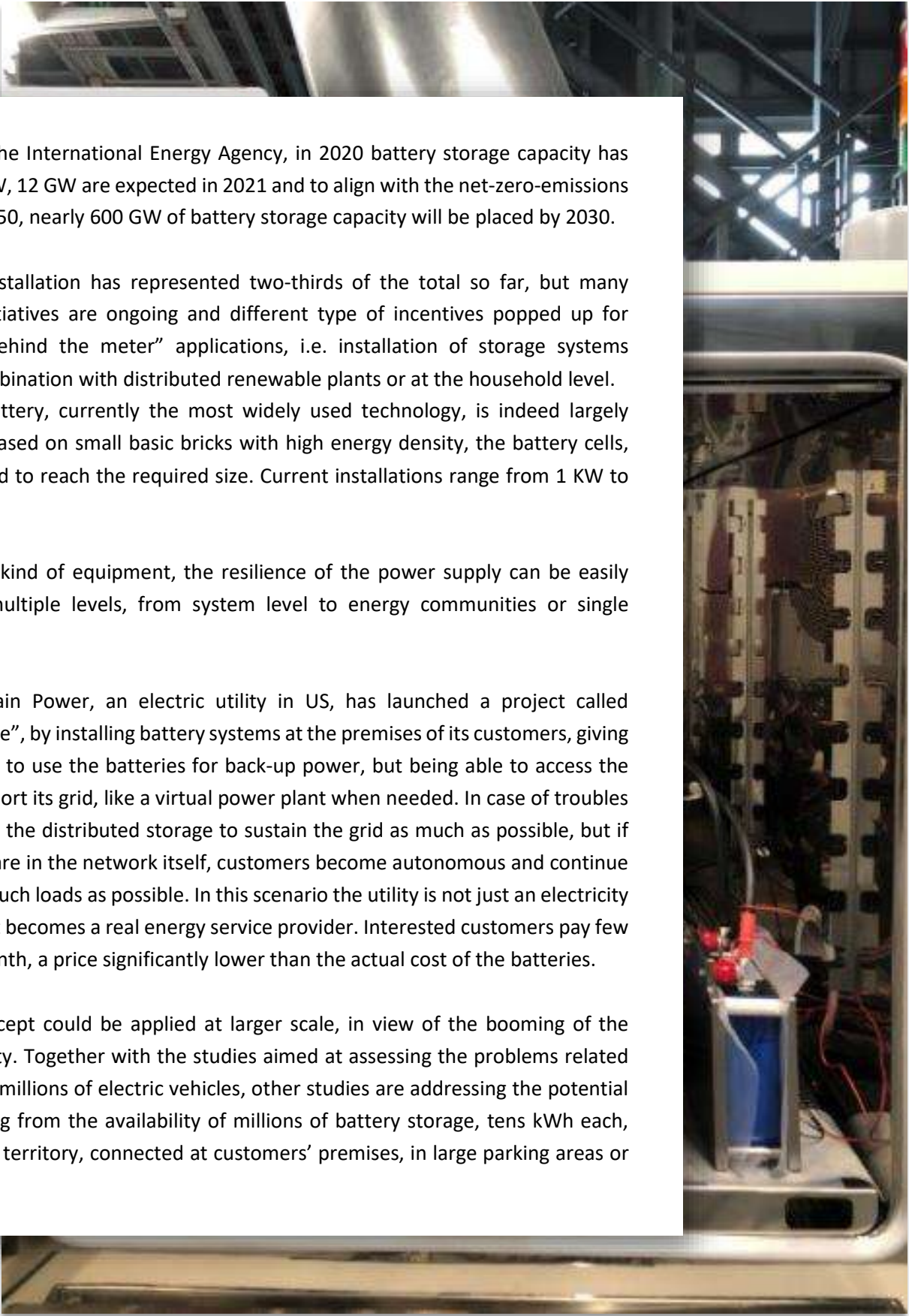
Electricity is a marvelous form of energy, environmentally friendly, safe and easy to use. But it is one of the first lessons learnt by young engineers that electricity cannot itself be stored, it can only be converted to other forms of energy which can be stored and later reconverted to electricity.

Moreover, electricity can be quickly transmitted and reach in few milliseconds the most remote places but, at the same time, electric systems require perfect balance and synchronization between generation and consumption.

These two elements have opened in the last decade a large debate about the energy storage technologies that can be used in combination with the electricity: the resilience of the predicted “Electricity Age” will depend on them.

Pumped storage hydropower plants have always represented crucial resources for the electric system, able to absorb and give-back large amount of energy when needed. In the past only few customers, for whom continuity of supply was of paramount importance, were used to install independent storage or power units in their own premises, usually inefficient but useful to overcome the issues of the electric network.

With the advent of renewables generators, perfectly fitting the policies against climate change but often small sized, not controllable and distributed on the territory, the scenario has changed dramatically, opening the door to new threats and opportunities. Rapidly scaling up energy storage systems have become crucial to address the hour - to - hour variability of wind and solar plants.



According to the International Energy Agency, in 2020 battery storage capacity has increased 5 GW, 12 GW are expected in 2021 and to align with the net-zero-emissions scenario by 2050, nearly 600 GW of battery storage capacity will be placed by 2030.

Utility-scale installation has represented two-thirds of the total so far, but many interesting initiatives are ongoing and different type of incentives popped up for small-scale “behind the meter” applications, i.e. installation of storage systems directly in combination with distributed renewable plants or at the household level. Lithium-ion battery, currently the most widely used technology, is indeed largely scalable and based on small basic bricks with high energy density, the battery cells, that are packed to reach the required size. Current installations range from 1 KW to 100 MW.

By using such kind of equipment, the resilience of the power supply can be easily obtained at multiple levels, from system level to energy communities or single customer.

Green Mountain Power, an electric utility in US, has launched a project called “Resilient Home”, by installing battery systems at the premises of its customers, giving them the right to use the batteries for back-up power, but being able to access the energy to support its grid, like a virtual power plant when needed. In case of troubles the utility uses the distributed storage to sustain the grid as much as possible, but if the problems are in the network itself, customers become autonomous and continue supplying as much loads as possible. In this scenario the utility is not just an electricity provider, but it becomes a real energy service provider. Interested customers pay few dollars per month, a price significantly lower than the actual cost of the batteries.

The same concept could be applied at larger scale, in view of the booming of the electric mobility. Together with the studies aimed at assessing the problems related to re-charging millions of electric vehicles, other studies are addressing the potential benefit deriving from the availability of millions of battery storage, tens kWh each, spread over at territory, connected at customers’ premises, in large parking areas or main streets.

Picture on the right: *Detail of a lithium-ion battery test carried out at KEMA Labs*

This is now called vehicle to everything (V2X), including services like vehicle to grid (V2G), vehicle to home (V2H), vehicle to building / business (V2B) and vehicle to vehicle (V2V). Further improvements are expected, but battery storage is already considered a ready-to-use technology, able to allow the beginning of a resilient energy transition, waiting for evaluating the potential of other forms of energy storage either electro-chemical or hydrogen-based.

Due to the more and more important role played by batteries for the resilience of the electric system, it is necessary to test the reliability of such kind of equipment in terms of performances, safety and degradation during time. This is what KEMA Labs, CESI Testing, Inspection and Certification Division, does in its facilities around the globe.

For example, our new battery laboratory, in Milan, is now in full operation. It has been designed for reproducing environmental and operating conditions of the battery cells, acquiring their vital parameters and modelling their behavior to predict aging and performance degradation. The KEMA Labs battery laboratory is equipped with climatic chambers, cyclers and data acquisition systems, which are the tools to simulate and reproduce the behavior of battery cells in the real world. Understanding how such batteries could cope with the increasing amount of energy, dispensing it to the power grid, is a key part of our tests, as it will allow utilities to understand how to improve grid resilience under several different circumstances.

Moreover, given the continuous evolution of the energy sector, the availability of accurate models of battery storage systems is fundamental for predicting their behavior in new potential scenarios: in KEMA Labs we are carrying out projects where laboratory tests are performed to identify the main parameters of batteries and create suitable models.



For further information on this topic, please contact:
Alessandro Bertani, Services & Smart Technologies Director – CESI
alessandro.bertani@cesi.it

Peter Vaessen

INNOVATION MANAGER



Peter Vaessen

Innovation Manager at KEMA Labs, Arnhem.

- Grid resilience
- High-voltage T&D
- Power electronics lifetime and reliability



Can you please introduce yourself to the audience?

“My name is Peter Vaessen, I have a background in power engineering, and started working at KEMA— key goal at for power engineers at the time and sometimes still is— 36 years ago. Before that, I was awarded a cum laude MSc degree in electrical power engineering from Eindhoven Technical University, The Netherlands, in 1985. The same year I joined KEMA (now a CESI brand).

In my long career, I held research positions in the field of large power transformers and high-voltage measurement and testing. I headed the Transmission & Distribution high-voltage department and managed realization projects, amongst the most challenging and satisfying ones were the construction of Dutch 400kV substations and (international) laboratory test facilities. As a principal consultant, I have 25 years’ experience in (U)HVDC technology and Transmission & Distribution grids with high shares of renewables.

Furthermore, I am Chairman of the board of the European Distributed Energy Resources Laboratories association (DERlab) and member of several national and international working groups. I am, also, part-time professor of Hybrid Transmission Systems at Technical University Delft, where I teach high-voltage technology and HVDC.”

What is your role in KEMA Labs?

Currently, I am Innovation Manager at KEMA Labs (CESI's Testing, Inspection and Certification Division) and actively involved in the technology strategy. Being responsible for innovation at the KEMA Labs in the Netherlands, I have been involved in several key projects that are important in terms of innovative testing of components for power grids. In particular, I am presently involved in the development of a new KEMA Lab facility: our laboratories are extremely cutting-edge, but due to the new requirements of customers with regard to especially digitalization, we have updated the existing labs and invest for future demand.

What is the role of the TIC industry in guaranteeing the resilience of power grids?

It is a very important role. Let me start by saying that the world is heading towards more digitalization, virtualization and simulation, but even if someone may say otherwise testing will never become obsolete.

High-voltage engineering and technology, for example, do not scale: you cannot just make things bigger and double the voltage, because that is not the way the physics work. Also, the higher the voltage, the more important small details become. I have seen an 800-kV transformer fail, because of a small detail. A very small plastic cap that was missing caused a failure during the lightning impulse testing. If this would have happened in service, the failure in this 10-million-worth object would cause an outage of the transmission link!

Therefore, testing is extremely valuable to assure that every detail, every component works as it should do before installing it into the power system. Otherwise, we can experience blackouts and other inconveniences, which have a huge negative impact on business and people. Furthermore – and this is also something that is not spoken about enough – interruptions in the power supply cannot be prevented, they will occur, and you should either build a redundant system or have a fast response ready to mitigate the power outage.



Flex Power Grid Laboratory – Arnhem

Aside from his role as Innovation Manager at KEMA Labs, Peter Vaessen is also Chairman of the board of the European Distributed Energy Resources Laboratories association (DERlab) and member of several national and international working groups. Furthermore, he works as part-time professor of Hybrid Transmission Systems at Technical University Delft, where he taught high-voltage technology and HVDC.

Can you please give us some examples on the importance of testing in this regard?

Grid companies will utilize the grid assets more and more due to the increasing demand for electricity, therefore it has become very important to prevent equipment failure. Old equipment needs to be replaced in time. To do that, a planned outage need to be scheduled, these outages must be coordinated and planned well in advance and are often last-minute canceled by system operations due to the grid's high load status and power flows to be accommodated: therefore, for some refurbishment, crews are waiting, sometimes for years to perform the maintenance. This is also true for expansion of existing substations and installations.

The reliability and lifetime of power electronics (think e.g., of a large solar inverter), which are installed more and more in the grid, is also a big question mark. There is not much experience yet, we are gathering operational experience, so life-time testing needs to be developed.

What do you and your team do to increase the resilience of power grids?

In power grids a double risk is present caused by an increased use and dependency on a reliable electricity supply in combination with the substitution of other energy sources with variable renewables. To mitigate this double risk trend in an aging infrastructure independent quantitative equipment and system assessments are required, as new, old or modified T&D equipment and systems can have either a positive or negative effect on availability and reliability.

We are involved in projects, partly as advisors for TSOs, to help them to configure equipment that can be used



Work in progress in the high-voltage laboratory –
KEMA Labs, Arnhem

to quickly fix an outage or as temporary solution for a bottle-neck in the grid. Think of mobile stations and mobile equipment as a backup usable in case when things go wrong or tend to go wrong.

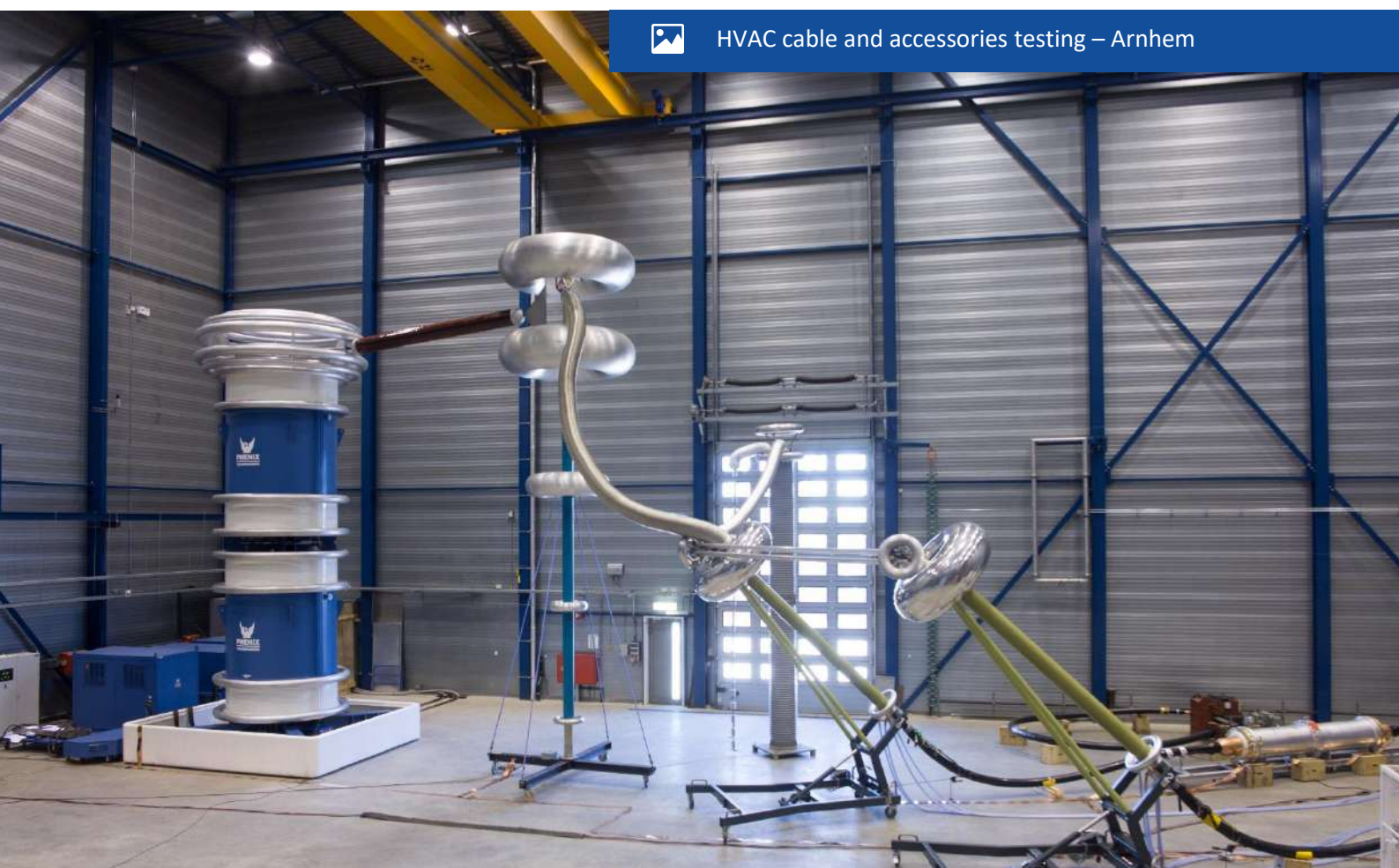
We also collaborate with university PhD-candidates and Master-students on diagnostics tools that can serve as add-ons to our testing, you can think of space charge measurements (indicator for quality) in HVDC cables, partial discharge detection and analysis with a new magnetic sensor in (DC)GIS, aging of insulation due to higher harmonics and DC.

We are also working on a MV test generator based on power electronics for dielectric testing that can generate arbitrary waveshapes and further development of our hardware and control in the loop test facility for system testing in the FLEX power grid lab.

Can you mention a couple of projects that could exemplify that?

We performed tests on MV switchgear installations and current transformers that were already in operation for many years to assess whether or not they still comply with the standard and are able to fulfill the required duties. In our FLEX power grid lab battery systems that act as no-break and emergency supply for critical operations have been tested with respect to operational functionality, as well as model verification of MW-scale inverters that allow grid owner and operators to perform system studies and reliability analysis.

A different league are large mobile GIS and transformer substations that are used for fast outage recovery, temporary grid bottleneck relief or installation in remote and challenging areas. Such equipment should be very robust and function always when deployed. As such equipment is also road-transportable, a set of special tests with respect to e.g., mechanical vibration, short circuit withstand capability, (plug-in) connectors, (voltage) readiness tests are advisable.



HVAC cable and accessories testing – Arnhem



 XLPE extruded cable with the Polarity Reversal tests performed up to 525 kV at KEMA Labs in Milan

TESTING FACILITIES

Testing of HVDC cable systems: Current market situation and future trends

Laboratory tests make it possible to expose an equipment to realistic conditions that mimic both normal operation and fault situations, but in a controlled environment, providing the most complete picture of how it will behave in the field.

Independent tests and certifications based on accepted international standards are one of the best ways to improve the quality of components and therefore represent a fundamental step to reduce the incidence of the main disturbances in service delivery. It also ensures that the equipment meets the basic levels of safety, reliability and performance required for use on the network.

The proof of why independent testing is so important can be found in result that approximately 25% of the components that are tested in a laboratory initially fail

to meet the IEC standards. T&D components are 'high tech' components that cannot just be ordered from a catalogue and require a careful process of type testing in combination with tendering, overseeing product manufacturing, FAT and SAT. Only then, high-quality products in the network can be guaranteed with is the base of network performance and grid resilience.

According to the IEA, in 2021 electricity demand is anticipated to grow by 3% (around 700 TWh) in total, which means that global demand would be higher than in 2019. The greatest uncertainty for electricity demand in 2021 is the further development of the COVID-19 pandemic, the measures taken by governments to prevent it spreading and the availability, speed of distribution and effectiveness of vaccines.

This will significantly affect the commercial and services sector, which was hit hard by repeated lockdown measures towards the end of 2020.

“*At the September 2014 symposium that precede the opening of HVDC new test lab in Mannheim, different international TSO emphasized a lack of multi-year experience with HVDC technology. Among European TSOs, Terna also pointed out shortcomings and did played an important role for the development of the reliability of XLPE extruded cable with the Polarity Reversal tests performed up to 350 kV at KEMA Labs in Mannheim*”

As far as Europe is concerned, already in 2030 the ten-year development plan of the EU grid foresees 58% of electricity from renewable sources in the EU mix to be tackled with 166 new grid development projects and 15 storage projects, for a total investment of 144 billion Euro, which will result in annual savings of from 2 to 5 million Euro, due to the cut in generation costs and due to the greater flexibility of the system.

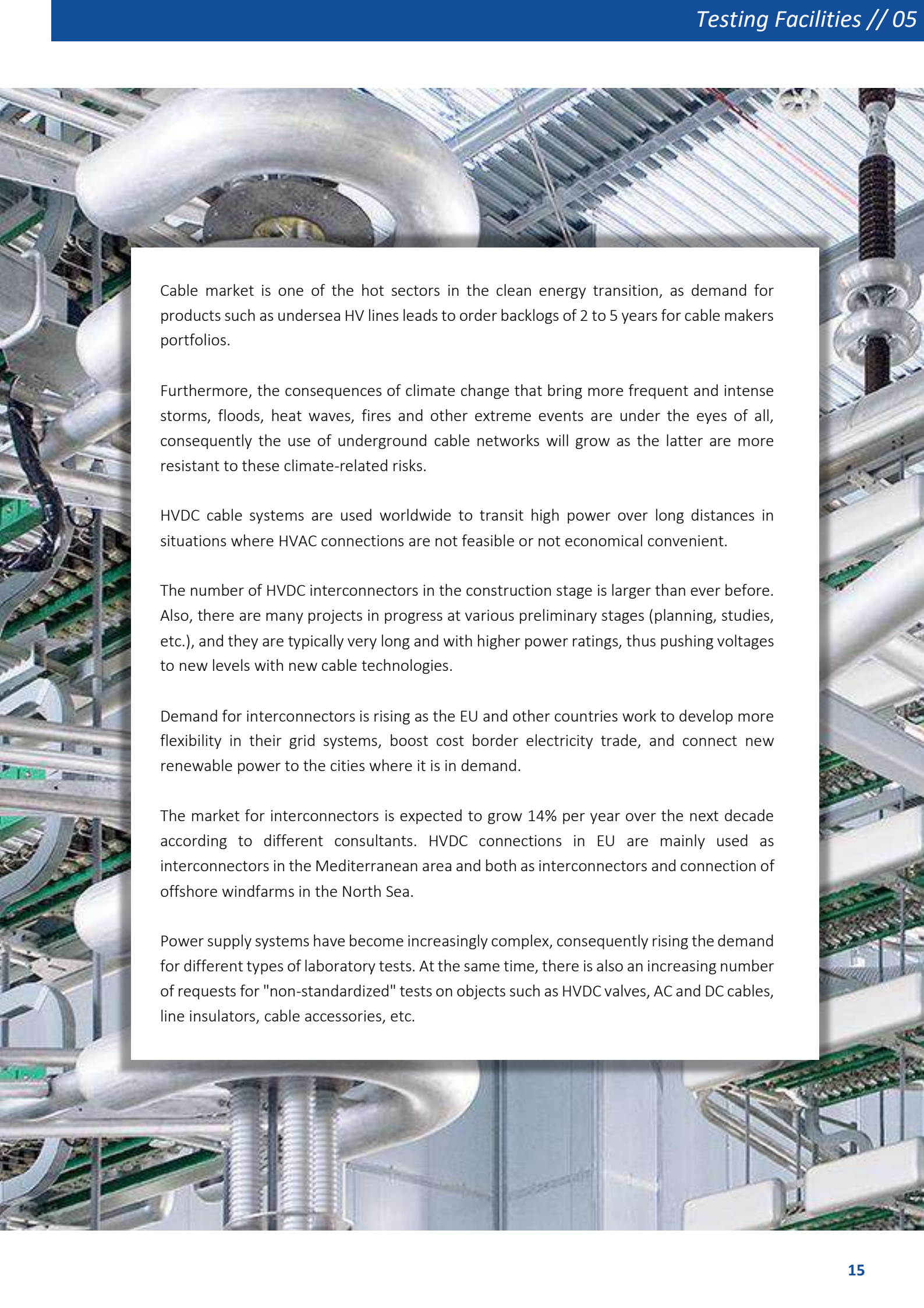
For example, Germany alone will need a capacity of between 235 and 276 GW of renewable energy by 2035 (more than double the 116GW at the end of 2018) and over the next few years German Ministers announced they have to build over 7,500 kilometers of transmission networks, including strengthening of interconnectors with European neighbors.

Electricity grids will, therefore have to equip themselves to instantly convey the production of energy from the wind and the sun (e.g. Baltic Sea or southern Europe) to the areas where this electricity is needed (e.g. Rhine Valley and South Germany), even thousands of kilometers away. We need shifting power across EU from where it is not needed to where it is and electricity storage, flexible demand, interconnectors could help to cut the costs of the green transition.

Typical drivers of this phenomena are the “political” change toward green energy production (i.e. EU Green Deal and the Biden administration’s clean energy drive) as well as the differential cost of energy between countries/areas that make viable and desirable the interchange of energy in parallel or in substitution of new generation plants. Power generation from Renewable Energy Sources (RES) and interconnection among networks are, in fact, the two main areas where energy links is developing massively and – as such – are driving technological evolution.

HVDC connections in the EU





Cable market is one of the hot sectors in the clean energy transition, as demand for products such as undersea HV lines leads to order backlogs of 2 to 5 years for cable makers portfolios.

Furthermore, the consequences of climate change that bring more frequent and intense storms, floods, heat waves, fires and other extreme events are under the eyes of all, consequently the use of underground cable networks will grow as the latter are more resistant to these climate-related risks.

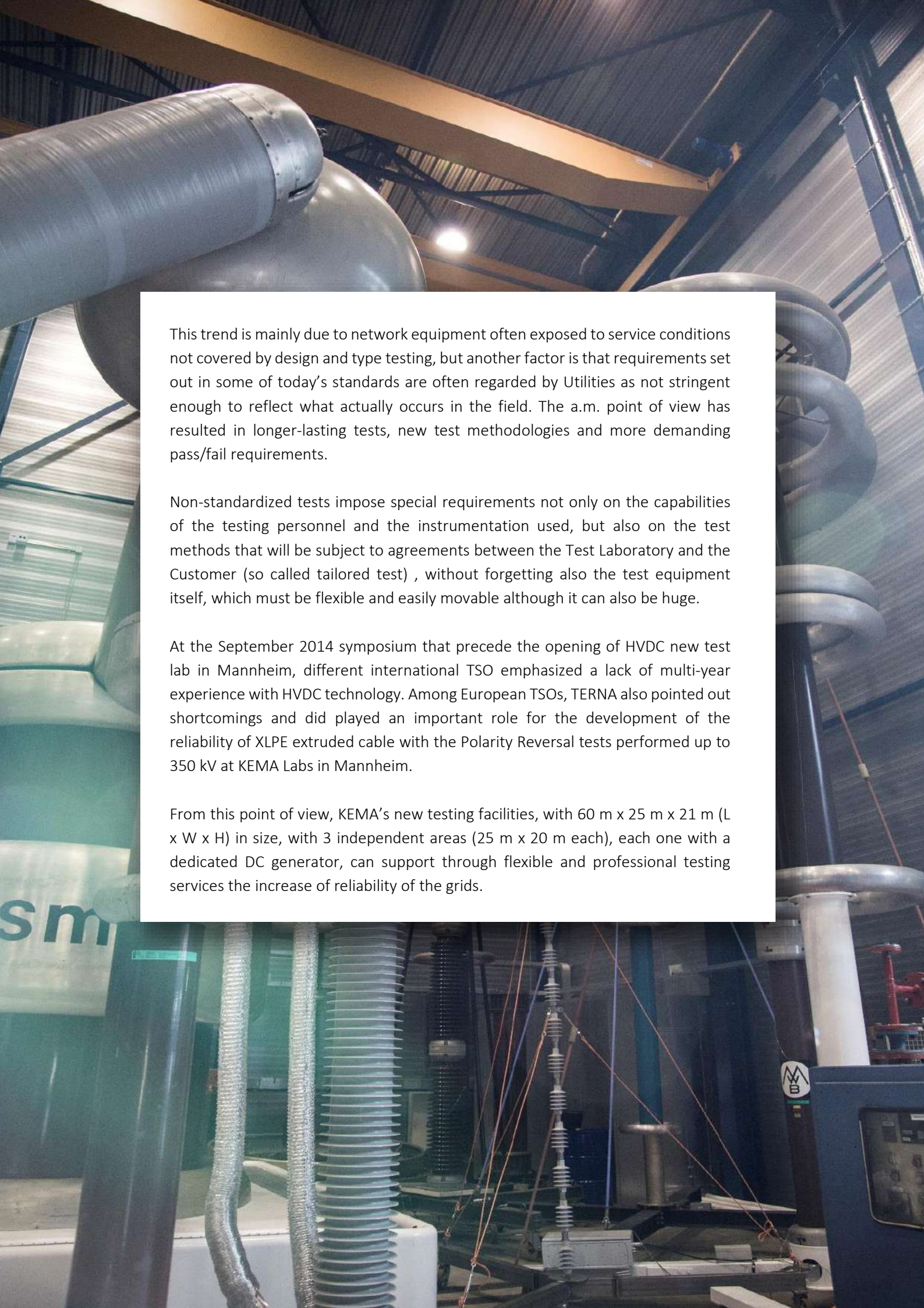
HVDC cable systems are used worldwide to transit high power over long distances in situations where HVAC connections are not feasible or not economical convenient.

The number of HVDC interconnectors in the construction stage is larger than ever before. Also, there are many projects in progress at various preliminary stages (planning, studies, etc.), and they are typically very long and with higher power ratings, thus pushing voltages to new levels with new cable technologies.

Demand for interconnectors is rising as the EU and other countries work to develop more flexibility in their grid systems, boost cost border electricity trade, and connect new renewable power to the cities where it is in demand.

The market for interconnectors is expected to grow 14% per year over the next decade according to different consultants. HVDC connections in EU are mainly used as interconnectors in the Mediterranean area and both as interconnectors and connection of offshore windfarms in the North Sea.

Power supply systems have become increasingly complex, consequently rising the demand for different types of laboratory tests. At the same time, there is also an increasing number of requests for "non-standardized" tests on objects such as HVDC valves, AC and DC cables, line insulators, cable accessories, etc.



This trend is mainly due to network equipment often exposed to service conditions not covered by design and type testing, but another factor is that requirements set out in some of today's standards are often regarded by Utilities as not stringent enough to reflect what actually occurs in the field. The a.m. point of view has resulted in longer-lasting tests, new test methodologies and more demanding pass/fail requirements.

Non-standardized tests impose special requirements not only on the capabilities of the testing personnel and the instrumentation used, but also on the test methods that will be subject to agreements between the Test Laboratory and the Customer (so called tailored test) , without forgetting also the test equipment itself, which must be flexible and easily movable although it can also be huge.

At the September 2014 symposium that precede the opening of HVDC new test lab in Mannheim, different international TSO emphasized a lack of multi-year experience with HVDC technology. Among European TSOs, Terna also pointed out shortcomings and did played an important role for the development of the reliability of XLPE extruded cable with the Polarity Reversal tests performed up to 350 kV at KEMA Labs in Mannheim.

From this point of view, KEMA's new testing facilities, with 60 m x 25 m x 21 m (L x W x H) in size, with 3 independent areas (25 m x 20 m each), each one with a dedicated DC generator, can support through flexible and professional testing services the increase of reliability of the grids.

In order to have higher thermal and electrical performance (e.g. operating temperature and higher power deliverable), the German Transmission System Operators (GTSO), in the frame of the Energiewende, was looking for the first set of cable manufacturers able to supply at least 3000km of 525 kV DC extruded cables systems.

In order to fulfil this need, an ad hoc qualification process was established by GTSO (Type Tests and Pre-Qualification Tests) where KEMA Labs was deeply engaged and 4 cable loops were under test in FGH. For the first time ever for HVDC cable systems, the cable loops of the PQT were not tested on the floor of a laboratory but mainly underground, representing real network situations like urban tunnel, pipelines and joint bays.

The positive test experience acquired using a real layout during the execution of the PQT, according to the request of GTSO to be performed for the first time on extruded cable systems at 525 kV DC, has however revealed a remarkable complexity and efforts in all phases of tests.

In order to ensure the required reliability of the test results, particular attention was paid to all aspects relating to the preparation of the layout, the procedure and methods of testing, the final verification tests and the validation of the results.



XLPE extruded cable with the Polarity Reversal tests performed up to 525 kV at KEMA Labs in Mannheim

Amongst several activities, attention was paid to measuring the temperature in the circuits and to the application of the final superimposed impulses. For these latter aspects, the present standards give ample space to different interpretations.

Further requests coming from the market (cable manufacturers and utilities) were recently presented to the test laboratories in order to verify the performance of the HVDC cable system to withstand dynamic voltage stresses, which are non-standard in nature (e.g. polarity reversals and TOV).

With the appearance of technical specifications with different values for voltage quantities and time parameters, it seems necessary to define the requirements if it is intended to standardize these new types of tests, e.g. tolerances on test parameters, calibration procedures and so on must be provided.

The positive experiences gained from the tests carried out for the GTSO project and the growing requests from European and Far East manufacturers and Utilities, have prompted KEMA Labs to invest in the Milan laboratory.



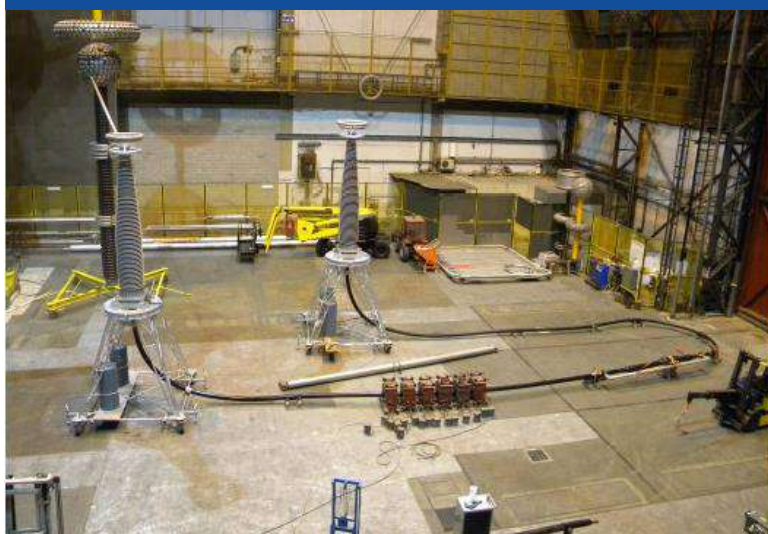
In fact, its dimensions rightly correspond to the name by which it is recognized:

EHV/UHV TEST HALL

- 45x40x35
- 4,800 kV - 240 kJ (impulse)
- 2x800 kV & 1x800 kV (power frequency)

The substantial interventions carried out for two test lines for HVDC cable systems up to 525kV (both land and submarine cables), according to the most up-to-date international requests. In the Milano situation, long-term tests cannot be carried out outside (as per GTSO request). The new market demands relating for example to Superimposed Impulses, Polarity Inversions etc. on HVDC cable systems place the tests that can be carried out both in Milan and Mannheim.

The photos in this page represent HVAC cables



For further information on this topic, please contact:
Uberto Vercellotti, Product Development Manager Cables
 KEMA Labs – CESI
uberto.vercellotti@kema.com



Aerial view of the KEMA Labs facilities in Prague, Czech Republic

Temperature rise test of three-phase current-limiting reactors

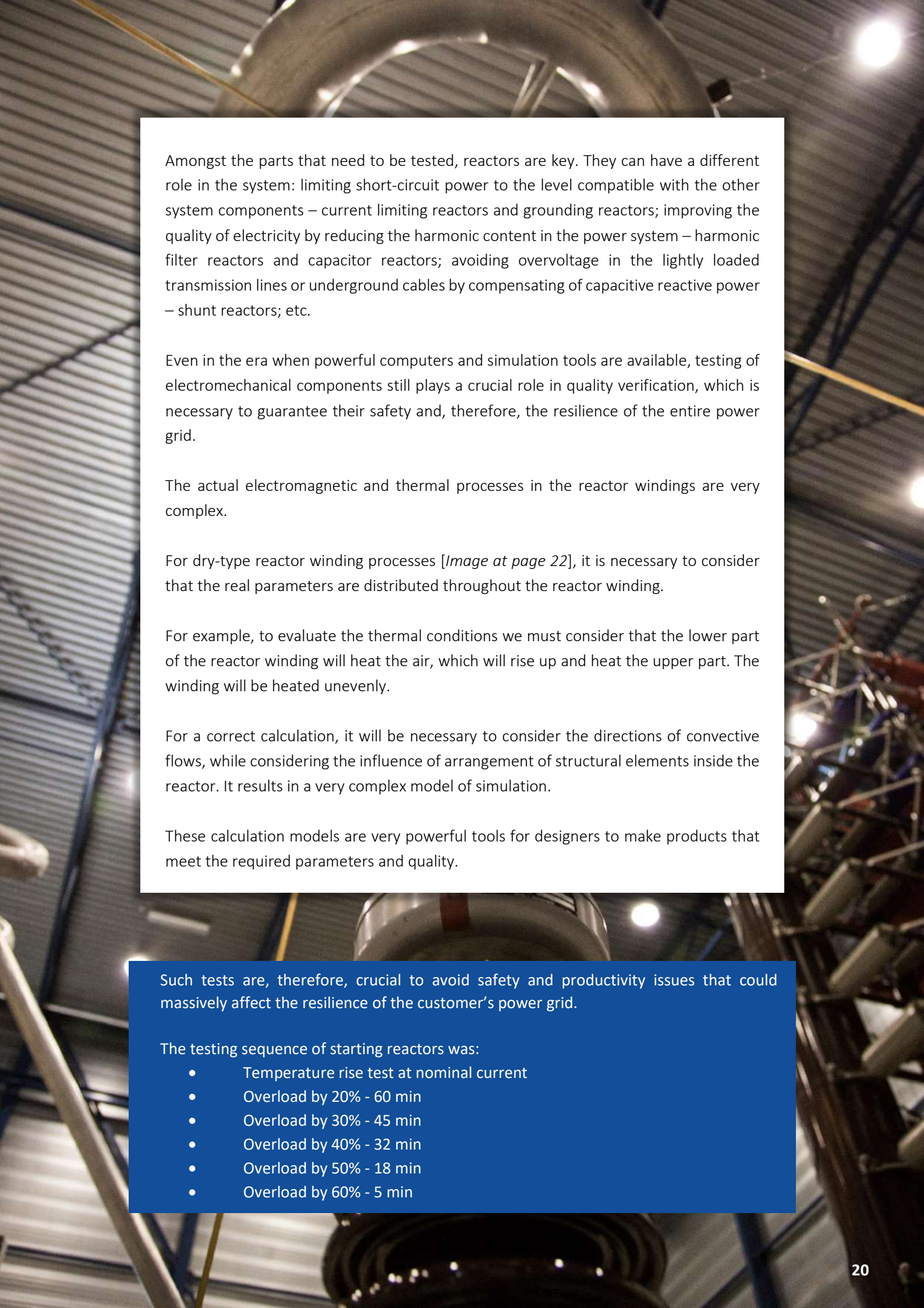
Electricity transmission and distribution systems are a very complex chain of several components. Such chain is built from the elements that directly influence the transmitted electricity, such as transformer, circuit breakers and other types of switches, busbar systems, conductors, insulation components, etc.

Besides these components, the power system features the equipment that improves the quality of electricity and safety of the system in general. A critical infrastructure such as the power grid is usually interdependent to ensure efficient services offered.

PRAGUE

While it is positive to have this interdependency, it also increases the vulnerability level of the complex system as a failure in one part might cause disruptions to the other parts.

Maintaining a continuous power supply is a challenging task as the complex and interconnected nature of the electricity grid makes the safety of each component extremely valuable, as it is paramount to guarantee the resilience of the whole power network.



Amongst the parts that need to be tested, reactors are key. They can have a different role in the system: limiting short-circuit power to the level compatible with the other system components – current limiting reactors and grounding reactors; improving the quality of electricity by reducing the harmonic content in the power system – harmonic filter reactors and capacitor reactors; avoiding overvoltage in the lightly loaded transmission lines or underground cables by compensating of capacitive reactive power – shunt reactors; etc.

Even in the era when powerful computers and simulation tools are available, testing of electromechanical components still plays a crucial role in quality verification, which is necessary to guarantee their safety and, therefore, the resilience of the entire power grid.

The actual electromagnetic and thermal processes in the reactor windings are very complex.

For dry-type reactor winding processes [Image at page 22], it is necessary to consider that the real parameters are distributed throughout the reactor winding.

For example, to evaluate the thermal conditions we must consider that the lower part of the reactor winding will heat the air, which will rise up and heat the upper part. The winding will be heated unevenly.

For a correct calculation, it will be necessary to consider the directions of convective flows, while considering the influence of arrangement of structural elements inside the reactor. It results in a very complex model of simulation.

These calculation models are very powerful tools for designers to make products that meet the required parameters and quality.

Such tests are, therefore, crucial to avoid safety and productivity issues that could massively affect the resilience of the customer's power grid.

The testing sequence of starting reactors was:

- Temperature rise test at nominal current
- Overload by 20% - 60 min
- Overload by 30% - 45 min
- Overload by 40% - 32 min
- Overload by 50% - 18 min
- Overload by 60% - 5 min

In particular, KEMA Labs Prague has successfully conducted temperature rise tests of two three-phase current-limiting dry-type reactors with natural air cooling and vertical arrangement of phases for our customer KPM LLC, Russia. Such tests are very important, as they guarantee service continuity and resilience to components, which are subjected to extremely harsh operating elements.

After completing tests at rated currents 630 A and 1600 A, the reactors were supplemented by special overload modes up to 1.6 times the rated current. In order to obtain such parameters, the equipment of both high-voltage and high-power laboratory had to be combined for the tests.

Due to the size of test circuit, the test object had to be placed in such a way that all circuit elements, including auxiliary switches, disconnectors, busbar systems etc., were able to carry out continuous currents up to 2,560 A.

In the facilities in Prague (Czech Republic), KEMA Labs experts recently tested two types of starting reactors according to IEC 60076-6 and GOST 14794-79. Starting reactors are used to control starting current of electrical machines as synchronous and asynchronous motors. Starting current may be equal to 5 to 6 even 10 times of the rated current. Thus, starting reactor must withstand series of temporary overloading.



KEMA Labs facility in Prague, Czech Republic

The uniqueness of this technical solution consisted of compensating the reactive power by capacitor banks connected via short-circuit transformers, in order to reduce the required capacity for compensation, at the cost of higher voltage on capacitor banks.

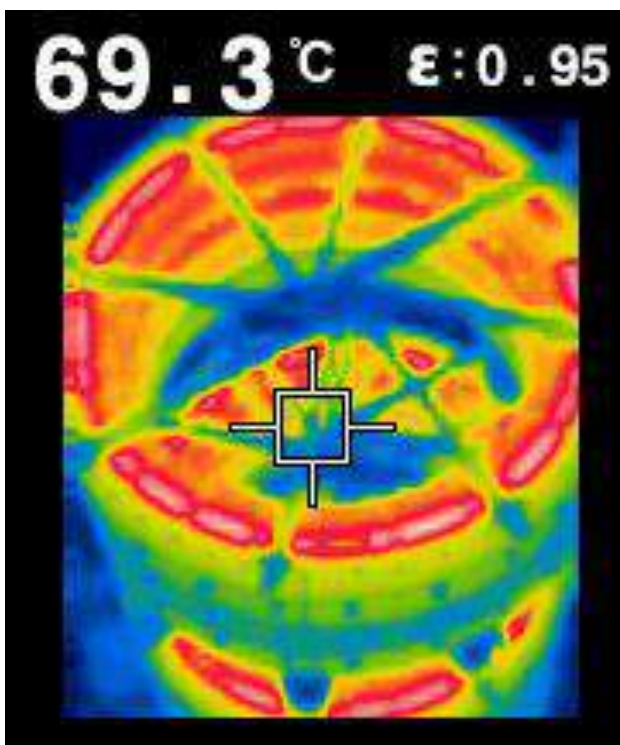
The key condition for trouble-free compensation of reactive power is the symmetry of three-phase connection, which is not simple in case of vertically arranged three-phase reactors, as their mutual inductance plays an important role here.

In this case, circuits must be symmetrized, which is possible by adding other passive elements, able to carry continuous currents to the circuit. Another option is possible by using three single-phase independently regulated sources capable of delivering required power. In terms of required parameters, both options were used in this test.



Another challenge the KEMA Labs experts faced and overcame consisted of the measurement of temperatures at potential and measurement of temperatures exceeding 180 °C with regards to fixation of thermocouples. This was achieved by data loggers operating in a special mode, using insulating thermometers powered by their own batteries. Additionally, a thermal camera was used to monitor temperatures and possible hot spots [Fig. on the left].

All technical challenges were overcome, and both cases resulted in valuable and recognized KEMA Type Test Certificate of Temperature Rise Performance according to IEC 60076-6.



For further information on this topic, please contact:
Shankar Subramany, High Power Labs Director –
KEMA Labs
Shankar.Subramany@kema.com

Testing components in the digital era: A new challenge for grid resilience



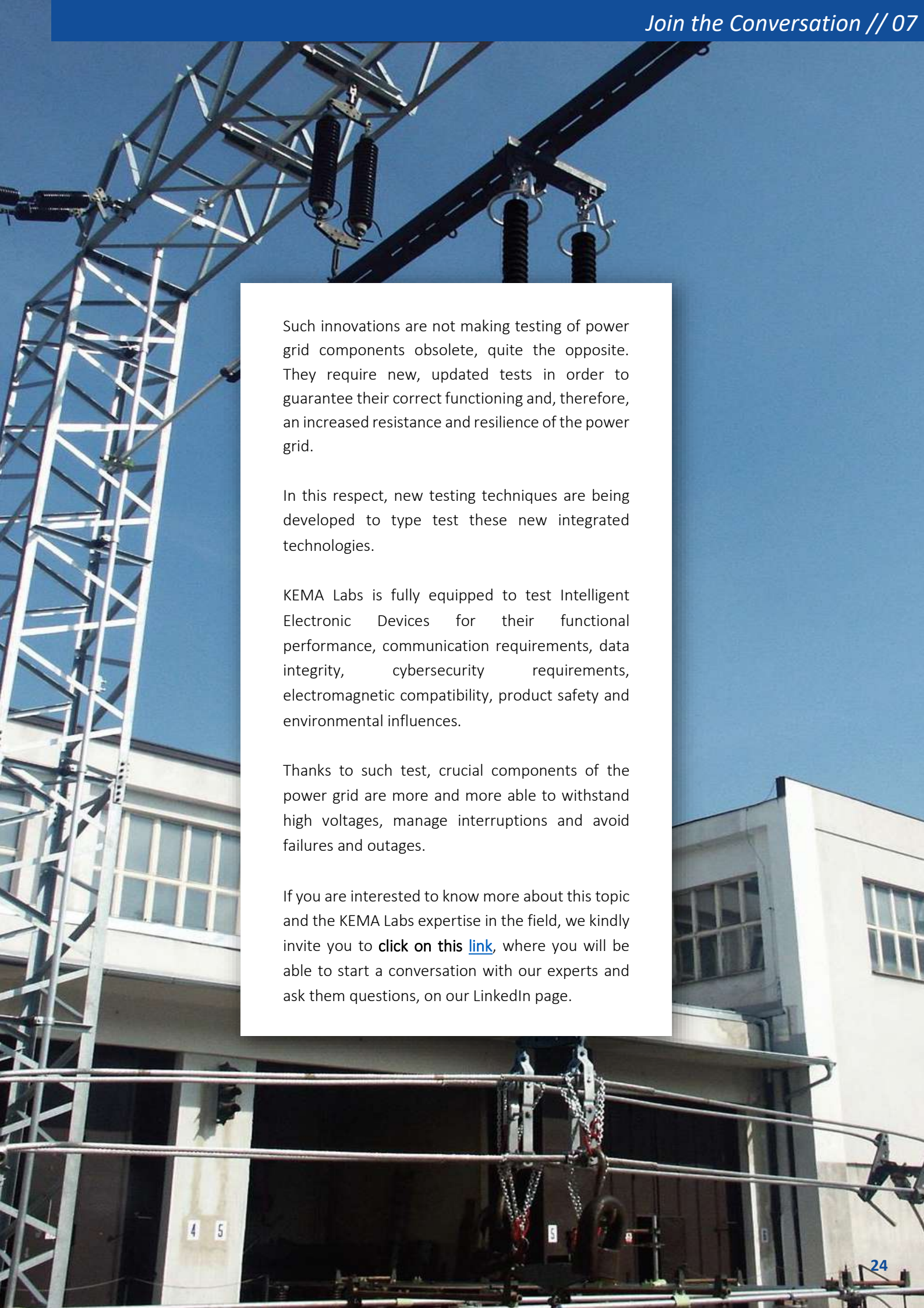
JOIN THE CONVERSATION

Now more than ever before, electric networks rely on the correct operation of intelligent electronic devices for energy metering, protection and control.

As the world is becoming more and more digital, in fact, the Internet of Things (IoT) is expanding and changing the way power stations and substations are managed.

Consequently, new technologies are being introduced to develop digital substations and T&D components: non-conventional instrument transformers with digital sampled value outputs are replacing conventional analogue devices and circuit breakers are integrating electronic devices for metering, protection and control.





Such innovations are not making testing of power grid components obsolete, quite the opposite. They require new, updated tests in order to guarantee their correct functioning and, therefore, an increased resistance and resilience of the power grid.

In this respect, new testing techniques are being developed to type test these new integrated technologies.

KEMA Labs is fully equipped to test Intelligent Electronic Devices for their functional performance, communication requirements, data integrity, cybersecurity requirements, electromagnetic compatibility, product safety and environmental influences.


Thanks to such test, crucial components of the power grid are more and more able to withstand high voltages, manage interruptions and avoid failures and outages.

If you are interested to know more about this topic and the KEMA Labs expertise in the field, we kindly invite you to **click on this [link](#)**, where you will be able to start a conversation with our experts and ask them questions, on our LinkedIn page.

Upcoming events

POWERGEN International

January 26-28, 2022

 Dallas, Texas, USA

Power producers, utilities, EPCs, consultants, OEMs and large-scale energy users gather at POWERGEN International to discover new solutions as large centralized power generation business models evolve into cleaner and more sustainable energy sources.

ISGT North America

February 21-24, 2022

 Washington, D.C., USA

This year's Conference on Innovative Smart Grid Technologies (ISGT 2022) focuses on Decarbonized, Democratized, Decentralized smart grids. The Conference will feature keynote and plenary sessions, panel sessions, and technical papers presented in poster sessions, as well as pre-conference tutorials.

ICPSEE 2022

March 3-4, 2022

 Bangkok, Thailand

The International Conference on Power Systems and Electrical Engineering aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Power Systems and Electrical Engineering.

SGRE 2022

March 20-22, 2022

 Doha, Qatar

SGRE 2022 is the 3rd International Conference on Smart Grid and Renewable Energy, focusing on contemporary industry topics ranging from the smart grid, renewable energy, power electronics, controls, manufacturing, to communications and computational intelligence.

KEMA Labs is the CESI Testing, Inspection and Certification Division

Through its Division KEMA Labs, CESI is the world leader for the independent Testing, Inspection and Certification activities in the electricity industry. With a legacy of more than 60 years of experience, CESI operates in 70 countries around the world and supports its global clients in meeting the energy transition challenges. CESI also provides civil and environmental engineering services.

The company's key global clients include major utilities, Transmission System Operators (TSOs), Distribution System Operators (DSOs), power generation companies (GenCos), system integrators, financial investors and global electromechanical and electronic manufacturers, as well as governments and regulatory authorities.

CESI is a fully independent joint-stock company headquartered in Milan and with facilities in Arnhem (NL), Berlin (DE), Prague (CZ), Mannheim (DE), Dubai (AE), Rio de Janeiro (BR), Santiago de Chile (CL), Knoxville (US) and Chalfont (US).

www.kema.com