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TESTINGLY

Testing, Inspection & Certification Magazine

Testing revolution: skills and know-how

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Testingly
Editorial Supervision
Paolo Chighine
Luca Luciano Pincelli

KEMA Labs

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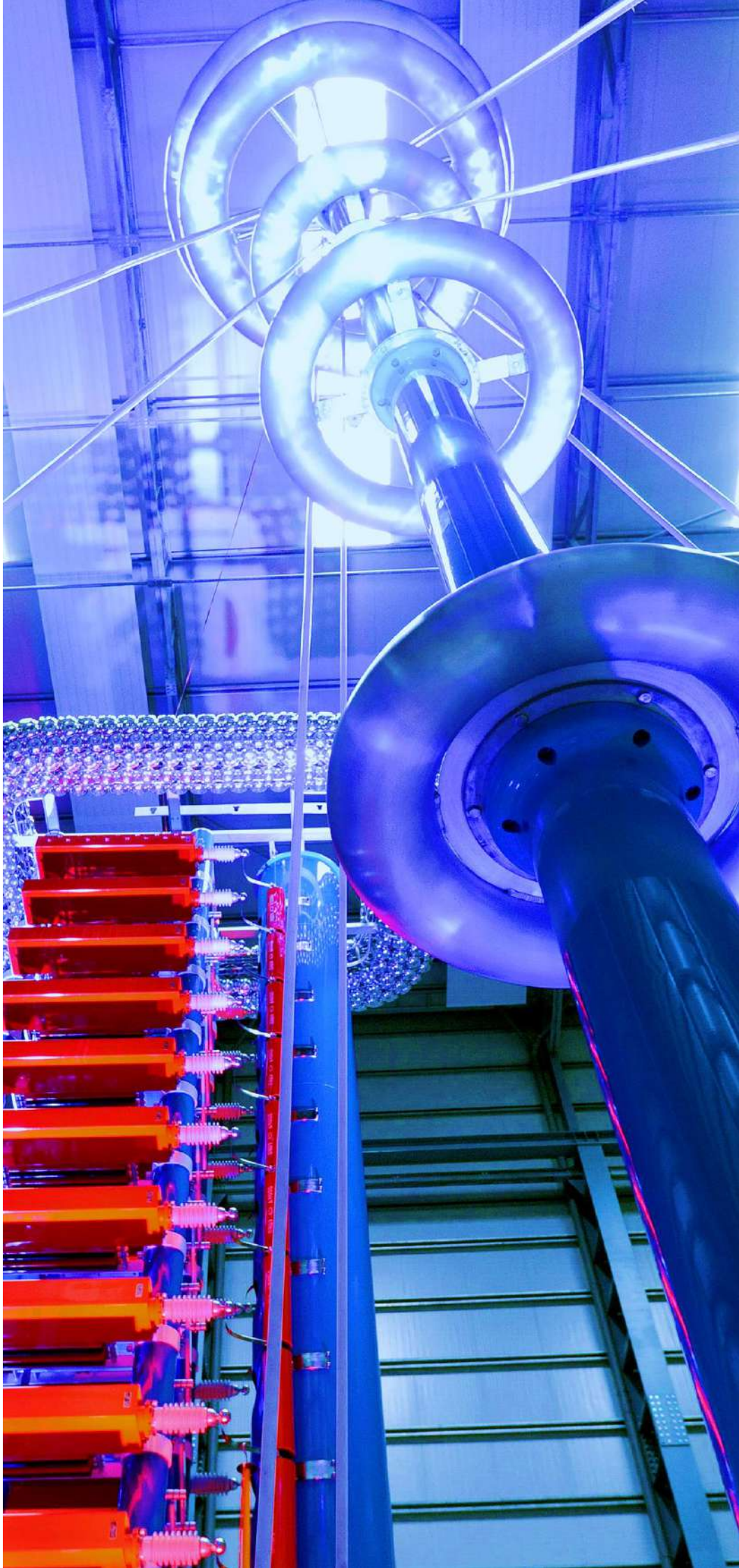

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Filling the skill gap in the TIC industry

"Real generosity towards the future lies in giving all to the present" is a quote by **Albert Camus**, winner of the Nobel Prize in Literature in 1957, that perfectly applies to the **Testing, Inspection, and Certification (TIC) industry**.

As in many other sectors, the TIC industry is fully involved in integrating new technologies that will transform the existing paradigm and support the **transition towards a carbon-free world**.

In the past few years, from the **digitalization** of transformers and substations to the development of **smart grids**, from the adoption of more **sustainable** means of mobility to the need to integrate **V-RES** into the power grid, from **remote testing (**through augmented and virtual reality) to the spreading of **HVDC transmission** systems, we are experiencing some of the major changes ever occurred to the TIC sector.

So many changes, all of a sudden, pose tremendous challenges, but it also opens up new opportunities for innovative approaches and technologies. However, there is one central element that cannot be overlooked, people.

On the one hand, **TIC experts' knowledge** is fundamental to meet the needs of customers all around the globe; on the other, customer requirements are evolving at a pace never seen before which compels expertise to evolve and update fast.

In this respect, the **second issue of *Testingly*** – the new **KEMA Labs magazine** – aims to present you with an overview of the **skillset** required to achieve the ambitious goals of the TIC industry, in light of the continuous evolution of the sector.

> Through the analysis of such technologies, the skills needed to work on them will also be explored

Domenico Villani – KEMA Labs, Executive Vice President

In the present issue, you will find the article *Innovative, feasible, and technically suitable HVDC Circuit Breakers tests* in the **Innovative Technologies section**. The article assesses how HVDC transmission offers a viable and efficient alternative to convey power from remotely located renewable generation through submarine cables. This solution will help countries generate, and smoothly integrate into the existing grids, several hundred GWs of renewable offshore power by 2050. By analyzing such technologies, the article also addresses the skills needed to develop and work with them.

Moreover, the **Interview with…** section features several interviews with TIC experts, who describe their industry experience and share their opinions about the future of testing, inspection, and certification.

In addition, the **Testing Facilities** section will be dedicated to new and cutting-edge laboratories in which electrotechnical components are tested to meet the most modern customer with a special focus on the skills of the experts operating in these facilities. Furthermore, the **Case History** will present you with the chronicles of formidable tests on DC components of e-vehicles, considering that those components will be used not only in cars, but also for trucks and public transport.

Last, but certainly not least, the **People** section summarizes the overarching theme of the present issue, by analyzing the main skills currently required in the TIC industry, offering useful opinions and suggestions to electric engineers around the world.

We hope you will find useful information along the way. Enjoy the read!

Matteo Codazzi – CESI Group CEO
Domenico Villani – Executive Vice President CESI TIC Division – KEMA Labs

Latest news from the TIC industry

Full-Power Test of HVDC Circuit-Breakers with AC Short-Circuit Generators Operated at low Power Frequency

The *Full-Power Test of HVDC Circuit-Breakers with AC Short-Circuit Generators Operated at low Power Frequency* paper by KEMA Labs experts has been given by IEEE an award as IEEE PES best prize paper of 2021. The paper introduces and demonstrates an innovative test method for HVDC circuit breakers.

A fault current interruption test method utilizing available AC high-power installations is proposed for DC. The method avoids significant investment needed for the development of test circuits for HVDC circuit breakers. The paper links the critical stages of the fault current interruption process, identified from system studies, to performance requirements that need to be verified during a test.

Finally, a complete and adequate test circuit that can, in one step, apply all the necessary stresses to an HVDC CB and hence, to its internal components, has been developed, verified, and demonstrated by testing a prototype of an 80 kV, 16 kA HVDC active current injection breaker. Results of complete HVDC CB tests, executed for the first time at an independent test facility, were analyzed.

The paper, subsequently, led a foundation work for the testing of three different technologies of HVDC circuit breakers, rated up to 350 kV, which were carried out in 2020.

New battery laboratory now operational

The 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 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. First tests for Lithium-ion batteries are currently ongoing.

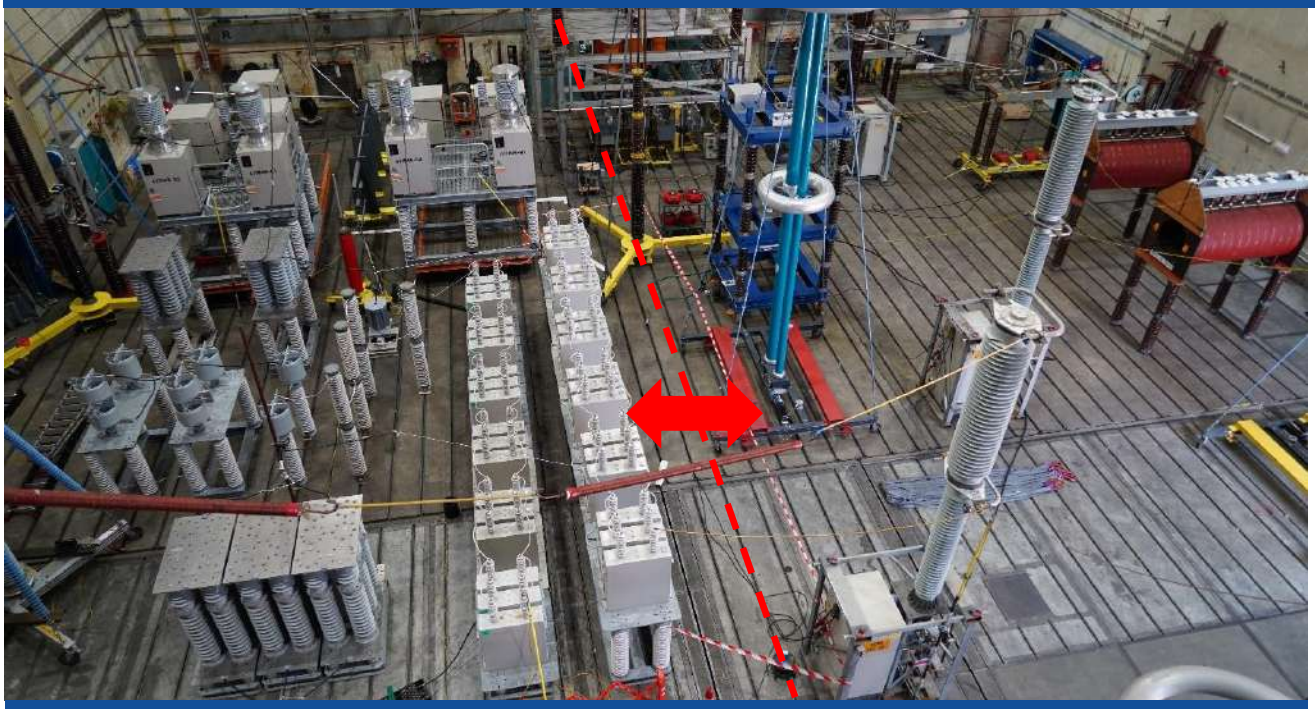
Internal arc fault test on instrument transformers

In general, internal arc tests (IAT) are not mandatory Type Tests, just defined as “mandatory where applicable” (HV switchgears acc. to IEC 62271-200) or as “special tests” (instrument transformers according to IEC 61869-1). Nevertheless, the final users of such devices require these tests, because it relates to personal safety (for HV switchgears) or protection of other devices placed in substations (for instrument transformers).

For instrument transformers, the IAT is initiated on location with the highest dielectric stressed area by fusible wire or/and by equivalent device simulating the failure. Only for instrument transformers submitted for IAT (special test) is the protection class and protection stage defined. Protection class and stage then define the permitted effects during the test and conditions after the test.

The IAT on instrument transformers is a relatively young test and it is expected, that the procedure will be improved as stated also in IEC 61869-1. Next to the IAT on instrument transformers, the IAT on cable terminations and on power transformer bushings are increasingly required, although such tests are not described in the IEC standards.

KEMA Labs Prague has a rich history and experience with internal arc fault tests. Recently they have performed this test with a positive result for our customer Hitachi ABB Power Grids on an 800-kV current transformer.



HVDC CB test setup at KEMA high-power laboratory. Left side: HVDC CB, right side: test circuit components.

INNOVATIVE TECHNOLOGIES

Innovative, feasible and suitable HVDC Circuit Breakers tests

Nowadays the world is facing an existential threat from the consequences of the adverse climatic changes caused by emissions of the greenhouse gases (GHGs). The energy sector is one of the major contributors of the GHGs. Countries have set targets to transition towards renewable energy sources such as wind and solar, while phasing-out conventional fossil fuel-fired generation. For example, Europe targets to generate up to 300 GW renewable offshore power by 2050.

HVDC transmission offers viable and efficient alternative to evacuate power from remotely located renewable energy resource sites via submarine cables. Today, several point-to-point offshore HVDC projects are in operation and many more are in operation/planning/permission/construction.
Submarine cables are prone to failures for many reasons[1]. A failure of such a cable leads to the complete loss of offshore generated power since there is no alternative route to evacuate, and this severely impacts the return on investment especially since it takes months to repair submarine cables.

A possible way to ensure security of supply is by creating a meshed grid like AC grids. This is currently under serious consideration. In Europe considerable research and developments are undergoing. In China a 5 GW demonstration project will operate before the Winter Olympic Games in 2022.

One of the main challenges hampering the realization of multi-terminal meshed HVDC grid is the lack of proven protection in case of, for example, a cable failure. HVDC circuit breakers (CBs) are essential for rapid isolation of a faulted section while keeping the remaining part of the grid intact. Compared to HVAC CBs, HVDC CBs have more stringent requirements in terms of the current breaking operation, and the speed with which such operation is achieved. HVDC CBs are naturally complex systems of components, designed to operate in a predefined sequence, compared to a single mechanical contact system.

Most of these components are standard components proven in their respective (mostly AC) applications.

However, the application in HVDC CBs subjects the components to non-standard stresses for which they are not proven yet. It is, therefore, essential to verify their performance under new stress conditions. In fact, this is easier said than done since, in the absence of operating HVDC grids, much of these new stresses are practically unknown. In the absence of practical applications, software simulations are used to identify the operation and fault stresses on the components.

At KEMA Labs, the CESI testing, certification and inspection Division, we develop innovative test methods at our various laboratories. We took a step to perform system simulations to identify the requirements of HVDC CB for testing in our high-power laboratory. A natural question, at this point, is how one can test HVDC CBs if there is no test facility built and prepared for this purpose? On the one hand, one can imagine that high-power DC sources are needed for testing HVDC CB just like AC short-circuit generators are needed for testing HVAC CBs. On the other hand, the investment costs to build a high-power DC source at a test facility are insurmountable. On the contrary, do we need such a source for testing HVDC CBs?

Innovative, economically feasible and technically adequate alternative test methods must be sought to test HVDC CB to foster its development towards application. This is what KEMA Labs innovation and test engineers have developed at its high-power laboratory in Arnhem. The method uses the existing installation, which is available at most test facilities, and is based on operating the AC short-circuit generators at low power frequency to capture an opportunity window in which the generated voltage wave looks like “DC” for the duration of HVDC CB testing. A complete and adequate test circuit that can, in one step, apply all the necessary stresses to an HVDC CB and hence, to its internal components, has been developed and demonstrated with three different HVDC CB technologies, rated up to 350 kV. The photo below shows one of the HVDC CB tested at KEMA Labs in 2020.

Other HVDC switchgear such as HVDC transfer switches, disconnecting, earthing, and paralleling switches are in use in existing HVDC projects for many years. However, because of the lack of standards specifying the test requirements, and because so far, HVDC projects have been turn-key projects, these components are installed without an independent verification. However, HVDC projects built by (and using components supplied by) multiple vendors are foreseen and an independent testing and verification of these components is essential.

For this reason, standards covering all HVDC switchgear components are being developed. In this regard, KEMA Labs’ IPH Berlin laboratory has proven testing of HVDC transfer switches up to 10 kA transfer capability.

Picture on the right: *detail of HVDC transfer switch set up for testing at KEMA high-power laboratory, IPH Berlin*

The other crucial component for offshore HVDC development is the HVDC cable. Given the current modular construction of HVDC converters, the cable is the bottleneck determining the transmission voltage level. Today offshore HVDC transmission at 525 kV is viable and is becoming the new trend. Similarly, cables must be subjected to adequate pre-qualification testing before installation in service. With respect to the application condition, new over-voltage stresses including superimposed impulses and oscillations have been identified in studies performed in collaboration with a TSO and based on recommendation from the latest CIGRE working group findings. Also, in this regard, KEMA Labs has designed special tests, at its Mannheim high-voltage laboratory, that can subject HVDC cables rated up to 525 kV to the identified new operational stresses. A photo of a 525-kV cable test installation is shown in the figure below.

In addition, long-term (>1 year) testing of a complete HVDC GIS prototype installation at KEMA high-voltage laboratory has recently been completed to prove its reliability under actual operation conditions, and the technology readiness of the equipment, similar to a cable pre-qualification test. For this, test requirements, procedures and methods were developed based on simulation analysis, real HVDC onshore and offshore experiences of TSOs and based on the latest CIGRE working group recommendations. The results obtained and the experience gathered during the long-term testing have been useful inputs to the ongoing international standardization activities related to HVDC GIS, to improve models and develop understanding of failure modes.

Moreover, the major lessons learned from our innovation activities are disseminated through publications in international journals and conferences. The test methods and procedures along with the potential issues identified are recommended to and taken over by the international standardization working groups.

Dielectric testing of a 525-kV HVDC cable in a high-voltage laboratory of KEMA Labs, Mannheim Germany

Marten Dekker

HEAD OF HIGH-POWER LAB

Hi Marten, can you tell us about your profile and role in KEMA Labs?

"I am Marten Dekker and, in 2009, I started at KEMA Labs as test engineer. Starting to perform short-circuit test for medium voltage (MV) products and after some period high-voltage and ultrahigh-voltage. As test engineer I was responsible for preparation and execution of the tests often in the presence of the customer, leading the team during the shifts and reporting the results. Since I always had an interest for the business side of my work, in this period I also attended a master's degree in Business Administration. When I started in 2018 as manager for MV, both the technical side and business side of the job were included in my daily activities. In this role for MV, and my new role for the entire lab, I am responsible for the day-to-day operation of the lab, safety, quality, reporting and technical advice for our sales department to make the best possible customer experience. Leading the team of the High-Power Lab Arnhem consisting of test engineers, operators, fitters, reporting team and operation support is a challenge and opportunity, but I trust it will be a success through people in these teams and their experience and knowledge."

What can the lab and your team offer to the customer? What skillset does your team offer to the client?

The High-Power Lab in Arnhem is the most important High-Power Lab in the world. Technical reasons are the availability of 15.000 MVA in power, combined with a synthetic installation for testing UHV circuit-breakers up to 1200kV. The team operating the laboratories has long term experience and knowledge in the short-circuit tests, executed according to international standards. Experts from the lab contribute to development of the standards to specify test methods and keep the tests as close as possible to the real-life applications. In the current COVID situation the tests can be witnessed from remote, where the customer has the same data available as in the lab from any loca-

-tion. The field of electrical energy transport/distribution is closely followed by the experts to develop the lab for future needs from customers, for example testing at UHV level, HVDC or alternative gasses. Our reports open the market for manufacturers all over the world to deliver their product to utilities.

Could you give us a sneak peek into some innovative projects you are currently working on?

There are several projects which have are very innovative, for example tests for PROMOTioN (HVDC) or a project to develop a method to perform gas tightness tests for alternative gasses. Next to these, another kind of innovation was implemented when an experienced colleague was due for retirement. In our department we planned to capture his knowledge for future test engineers.

This is done through recording training video's where he explained difficult topics and fundamental knowledge for test engineers. After he retired also other test engineers contributed. These videos are shared with the colleagues from all testing platforms by Microsoft Stream, which is like YouTube for inside the organization.

These videos are transcribed automatically and thereby it can serve as real knowledge database as well, since it has the possibility to search for certain topics/words which are treated inside the videos. (Starting) test engineers in any platform can use these video's as starting point for their training to become an independent test engineer, providing the same information and quality to anyone starting at any location. Simultaneously knowledge from experts is retained within the organization forever and presented to the new generation of test engineers in a form which is commonly used nowadays.

High Power Laboratory switchyard 3 – Arnhem

Given the context of the ever-evolving skills for the electrical power engineering sector, in this section we have included several interviews with sector engineers and experts. The objective of the interviews is to provide you with practical knowledge on the main challenges and hot topics of the testing sector, in order to analyze what characteristics are required to work on such delicate equipment. In this respect, the interviewees come from different backgrounds, geographical areas and age brackets: this way, you will be able to have a 360° overview on the required skills to face the challenges of the energy transition and meet the demands of customers worldwide.

Hello Marco. Would you mind introducing yourself for the audience?

I'm Marco Gobbi, head of EMC dept in Milan since 2020. I started working with CESI Group about 25 years ago, when I was studying to become electronic engineer at the Politecnico University in Milan. At that time, a Robotics Laboratory was hosted in CESI. Therefore, having the possibility to apply what I had studied on real hardware and interacting with both experienced and young colleague produced a strong imprinting, which linked me to the company in a tight way. Along the years, I left CESI a couple of times, but finally I always came back. About 10 years ago, I begun to share my knowledge with clients, becoming a consultant, mainly working abroad in the smart meter and smart grid fields. Finally, last year I came back to the roots, the laboratories – now part of the KEMA Labs Division of CESI – as I was appointed to head the EMC labs in Milan. Here, we are innovating and expanding our competencies, following and possibly anticipating the clients' needs.

According to your expertise, how do you think the skillset in the power and electric engineering sector is changing?

In the last decades, the "pure" power and electrical engineering sector has changed due to the newer information and communication technologies: interactions among the various technological disciplines are more and more frequent and the benefits are clearly visible. Ranging from the old electromechanical protections to the metering devices, power converters, the HVDC, any electromechanical devices, are nowadays managed and operated by electronics and huge amount of data are collected, transmitted, and analyzed. In some cases, for example protections with IEC 61850, the proper behavior and interaction among different devices is fully based on communication which

Marco Gobbi, Head of EMC Lab, KEMA Labs - Milan

are derived from the ones typically used by the IT sectors. The Big Data approach is catching on even in traditional sectors such as the power and electrical sectors, even though with a slight delay with respect to other recent sectors. The pervasive use of electronic, information and communication technologies in the power and electrical engineering sector requires additional competences and the capability of merging such competences in a broader view, to cover the wide horizon and reaching the goal of a fully integrated and cooperating set of different devices. Cybersecurity is a key topic to be considered, as different systems are now interconnected and potentially vulnerable to hacker attacks from remote.

We would like to get to know more about your role in KEMA Labs. Could you tell us about some of the key projects you are currently involved in? What are the skills required to face the challenges in these projects?

I have been leading the EMC laboratories in Milan since last year, but during the last 10 years I collaborated with the labs and many exchanges of experiences took place. Two key projects must be mentioned. The first is the "long term project" of smart metering in Italy, where KEMA Labs had and still have a key role, working side by side with the R&D Department.

Our laboratories are often used for testing prototypes and samples taken from production, to assure the high levels of quality required by the Client. The smart metering project is continuously evolving, with new requirements from the Regulatory Authority for Energy and from the market. New features and performances arise and KEMA is always ready to collaborate on the old and new topics. The second key Project I'd like to mention is the new battery lab, specifically designed to test high capacity lithium cells for energy storage and, in the next future, for automotive applications.

The laboratory includes new Climatic chambers with integrated safety devices for Lithium cells. Tightly related to the testing activities, we created a new working team for developing and tuning semi-empirical models for estimating the cells performances and degradation with use and aging. The new laboratory is a good example where practical and theoretical activities are fully integrated, to achieve a solid result.

What would you like to say to a young test engineer who is just starting his/her career?

Enthusiasm is the propeller for facing the unavoidable issues that we all can meet in our life and at work. If you don't like or if you don't find the solid motivation in what you are doing, you will certainly face hard times. Be ready to change your perspective, to increase your knowledge and to exchange experiences with others; open-minded people can better adapt to a quick moving world around us.

At each age, we can always learn new things; we are old only when don't dare to learn!

Andreas Petersen, Test Engineer at Low-Voltage Laboratory, IPH, KEMA Labs - Berlin

Hello Andreas. Would you mind introducing yourself for the audience?

My name is Andreas Petersen and I have been working as a test engineer for the low-voltage test field (S&ST LV) at IPH Berlin since December 2018. Before joining the low-voltage test field, I studied electrical engineering at the HTW Berlin. In addition to my studies, I worked as a student trainee in the high-voltage test field at IPH, where I also wrote my master's thesis. In the low-voltage test field, I initially started as a test engineer for temperature rise tests.

In the meantime, I am in the process of becoming a test engineer for low-voltage high-power testing. With the beginning of the project planning of the "Automotive Test Lab", at KEMA Labs, I became a part of the project team. After the completion of the test lab, I am now one of the test engineers working in this test lab.

According to your expertise, how do you think the skillset in the power and electric engineering sector is changing? What would you like to say to a young electric engineer who is just starting his/her career?

The energy transition poses new challenges for all areas of energy technology, but especially for electrical engineering. Because of these challenges, we see a rapid development of new products flooding the market. For us, this means that we must find ways to test these products and thus help our customers to develop even better products.

I can only advise young colleagues, and I still count myself among them, to take on these challenges and try to grow with them.

We would like to get to know more about your role in KEMA Labs. Could you tell us about some of the key projects you have been involved in? What are the skills that were required to face the challenges in these projects?

I am currently in further development to become a test engineer for low-voltage high-power testing. In addition to my working in the "Automotive Test Lab", I will then also work in "Test Room 1" of the low-voltage test field in the future. The work here is very exciting, as "Test Room 1" is one of the most powerful test benches for DC testing in the world.

In order to give the readers an impression of the possible test settings, I would like to give a few DC parameters at different voltages, such as DC 100kA-1800V / 50kA-3600V / 30kA-7200V AC and three-phase tests up to 50 kA: all of these can be carried out in our facility. In addition, a special test circuit enables surge protection devices to be tested with lightning impulse currents of 8/20µs up to 70 kA with line follow currents up to 50 kA, simultaneously applied.

In short, it can be said that the “Test Room 1” is extremely complex and therefore requires a longer and intensive training. When working as a test engineer, but also in different projects, it is important to be able to familiarize yourself quickly with complex issues and not lose sight of details even in stressful situations.

Can you please tell us more about the new “Automotive Test Lab”? What was your role in its implementation and what skillset was required for this task?

The development of the "Automotive Test Lab" was necessary to meet the requirements of our customers for high short-circuit currents (up to 35kA at 1500 V) with a small test circuit inductance (<10µH).

These requirements result from the rapid development in the field of E-mobility. Due to the increasing battery capacity in combination with short cable lengths, the current rises can be very steep (i.e. 240 kA/ms).

I was involved in all phases of the technical planning and implementation of the project, as one of two test engineers. Starting with the specification of our requirements for the overall system and the individual components, through the evaluation, to the planning and construction of the overall system.

The main components we had to plan, select and build included the surge current source, the measurement and control technology with a state-of-the-art transient recorder system, but also safety equipment such as a suitable system for extracting smoke from the laboratory during daily operation, to name just three examples.

In addition to the necessary electrical engineering skills, it was helpful to have a good imagination of how the individual system components could later interact optimally.

Nadew Adisu Belda, Innovation Engineer, KEMA Labs – Arnhem (The Netherlands)

Hello Nadew. Would you mind introducing yourself for the audience?

My name is Nadew Belda, I studied M.Sc. in electrical power engineering at Royal Institute Technology (KTH), Sweden and Eindhoven University of Technology (TU/e). Since 2015, I am innovation engineer at KEMA Labs focusing on the development of test methods particularly for HVDC components. Combined with my work at KEMA Labs, I have been working towards my PhD degree at Technical University of Darmstadt, Germany, as an external candidate, which I am looking forward to defending on September 22, 2021.

According to your expertise, how do you think the skillset in the power and electric engineering sector is changing?

Like many other fields, the electrical power engineering landscape is changing quite rapidly to address the unprecedented challenges that we face today. Energy transition is the major challenge that lie ahead of us which requires multidisciplinary innovation. Digitalization is one of the fronts where significant change is taking place. To accelerate these changes, we need to adapt our skillsets accordingly. For example, more and more powerful tools that can facilitate the understanding, design and development of new solutions are coming into the market. I am happy these tools are available today, but the users must be careful about how far these tools can be used and understand their limitations as well.

We would like to get to know more about your role in KEMA Labs. Could you tell us about some of the key projects you are currently involved in? What are the skills required to face the challenges in these projects?

I am working on the development of test methods and designing of test circuits particularly for HVDC switchgear. For example, my work has culminated in the testing of HVDC circuit breakers at KEMA Labs for the first time the past few years. My role is to define test requirements for these developments by researching what is expected of these devices in service. Sometimes service experience is non-existent, and we had to rely on system simulations. That was the case for HVDC circuit breakers, and I did system simulation studies. It is also equally important to translate the system simulation results into the test requirements and find out how this could be fulfilled or tested in our laboratory. I am proud to mention that we have developed an innovative test method for testing HVDC circuit breaker in our laboratory.

Dielectric testing of a 525-kV HVDC cable in high-voltage laboratory of KEMA Labs, Germany

In addition, I participate in many international working groups such as CIGRE' and IEC on behalf of KEMA labs to ensure that we are up to date with latest developments and our views on these developments are properly reflected.

> *Currently, I am active member of two CIGRE' and one IEC working groups*

Together with colleagues, I have been disseminating the results of our laboratory activities to the international community via publication in well-respected peer-reviewed journals such as IEEE transaction on power delivery, and presentations at relevant international conferences such as at CIGRE'. As an example, I would like mention with great pride that a few weeks ago I was informed that one of our publication won the "best IEEE PES prize paper" for the year 2020-2021 where a maximum of two articles are selected each year.

What would you like to say to a young electric engineer who is just starting his/her career?

Today the world is facing multifaceted challenges. My advice to the young engineers who are entering their career is that they must dare to accept new challenges, take their chance to learn and collect experience as quickly as possible.

Also, I suggest exploring their best interest before affixing to specific area. As mentioned earlier the power system landscape is changing quite rapidly and the fresh engineers are in unique position to adapt to these new changes.

Emmanuel Nii Ankrah, Test Engineer, KEMA Labs – Chalfont (Pennsylvania, USA)

Hello Emmanuel. Would you mind introducing yourself for the audience?

I am Emmanuel Ankrah, an electrical engineer of Ghanaian origin and a certified project management professional. I was educated both in Ghana and Germany. I started my professional career with Electricity Company of Ghana – an electricity distribution company as a project engineer in 2007. I immigrated to the U.S. in 2016 and have since June of that same year been working with KEMA-Powertest LLC (Chalfont) as a test engineer. I am married with three children. I love watching soccer but love to play pickleball.

According to your expertise, how do you think the skillset in the power and electric engineering sector is changing?

The skillset requirement is changing because of the need for new technologies in the sector. The traditional grid as we have known is undergoing modernization and that calls for engineers from various disciplines. The need for real-time power grid status for ensuring grid stability has led to a lot of sensor applications and IT infrastructure for data processing.

So, in the sector that appeared in the past to be a sole preserve of engineers with background in power engineering, we are now beginning to see a greater need for engineers with expertise in power electronics and of course big data analysts.

We would like to get to know more about your role in KEMA Labs. Could you tell us about some of the key projects you are currently involved in? What are the skills required to face the challenges in these projects?

I am a test engineer with principal responsibility for medium and low voltage short-circuit tests at Chalfont. One of the key products I work on is expulsion fuses. These are subjected to short-circuit interruption tests as per IEEE Std C37.41. In 2017, corrigenda were issued for the referenced standard expanding the number of tests and in effect test circuits. The expansion presented a challenge that required research into the lab's capability to determine if these circuits could be built.

With help from engineers in Prague and Arnhem labs I was able to design and build the required circuit to meet the new requirements. The challenge required a better understanding of linear circuits analysis and a willingness to open up to others and take on suggestions.

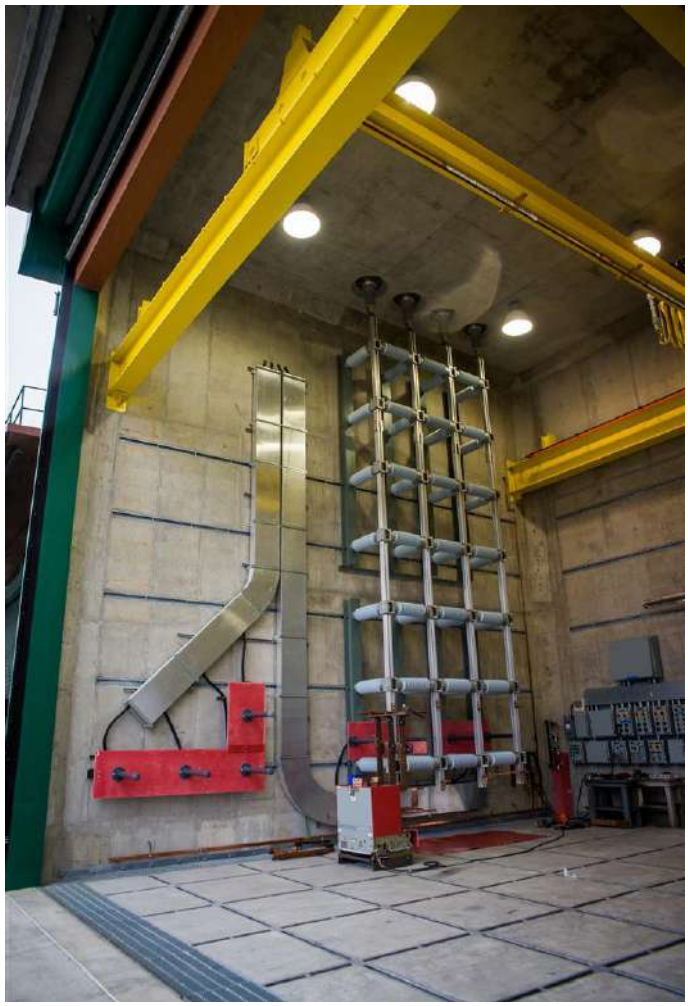
With these skills I was able to overcome these challenges and I can say that KEMA Chalfont is in a position to test expulsion fuses up to 27kV, 16kA rms asymmetrical rating.

What would you like to say to a young test engineer who is just starting his/her career?

I will say – ask questions and don't be afraid to ask seemingly unintelligent questions. What may sound like an unintelligent question will offer you an opportunity to broaden your understanding.

Keep refreshing your technical knowledge in subject matters that relate to your current work. Seek and pursue ways to grow. Look for opportunities to give back to society because without others we are nobody.

In conclusion, have an emergency fund because you may never know when you will temporarily lose your job.



Picture on the right: *A glimpse into the inside of Chalfont facilities, specifically Cell 9, where several types of test are carried out*

Aerial view of KEMA Labs facilities and CESI offices in Milan, Italy

TESTING FACILITIES

The future of testing:

New requirements, new facilities

The TIC industry has been undergoing several changes over the past few months: the pandemic has posed new challenges for utilities and for B2B businesses alike, whilst the renewed strive for sustainable solutions to help customers through the ongoing energy transition has showcased the need for cutting-edge facilities and highlighted the importance of expertise in the sector.

To meet new global targets on climate change and decarbonization, the electricity sector is facing a transition phase towards a more sustainable energy system, while trying to remain reliable and affordable. High-voltage direct current (HVDC), smart grids and storage are the three pillars for the future electricity system with high renewable energy sources: once these technologies are established, we could see very substantial reductions (80%) in the emissions expected from the electricity sector by 2050 (about 7-10% of global emissions) along with job opportunities in industrial hubs, according to a report by the Institute for Sustainable Development and International Relations (IDDRI).

The current times are also posing the strong challenge to make power grids more resilient to both extreme weather phenomena and cyber risks, that come with the increasing digitalization of electric networks. Actions to mitigate the risk of power outages will address the main critical factors that affect the network: the impact of ice on overhead power lines during the winter months, the effects of wind and trees falling on overhead lines, and the consequences of heat waves during the summer months. Such plans include surveillance and protection activities for critical power stations and actions to secure IT infrastructure from break-ins, unauthorized access attempts and cyber-attacks. Due to this scenario tes-

- ting the various components that comprise a power grid are fundamental in the process of both safeguarding and modernizing networks.

> *In this respect, KEMA Labs is at the forefront of innovative and cutting-edge services and technologies offered to customers all around the globe, which are provided through several laboratories located in different continents*

For instance, the activities carried out in the KEMA Labs Italian laboratories are paramount in meeting customers' needs in terms of both increasing their green footprint and improving grid resilience.

The High-Power Laboratories in Milan, for example, provide short circuit, switching testing and short time current testing based on international and regional standards, to utilities and equipment manufacturers all over the world. The facilities at the disposal of the Division, together with the know-how of the KEMA Labs experts, allow to adopt groundbreaking and innovative approaches.

KEMA Labs have pioneered the synthetic test methods, achieving the most powerful short-circuit and synthetic test capabilities ever in the independent testing and certification laboratory, which can short-circuit test 1,200 kV power equipment, with the highest short-circuit power of up to 15,000 MVA.

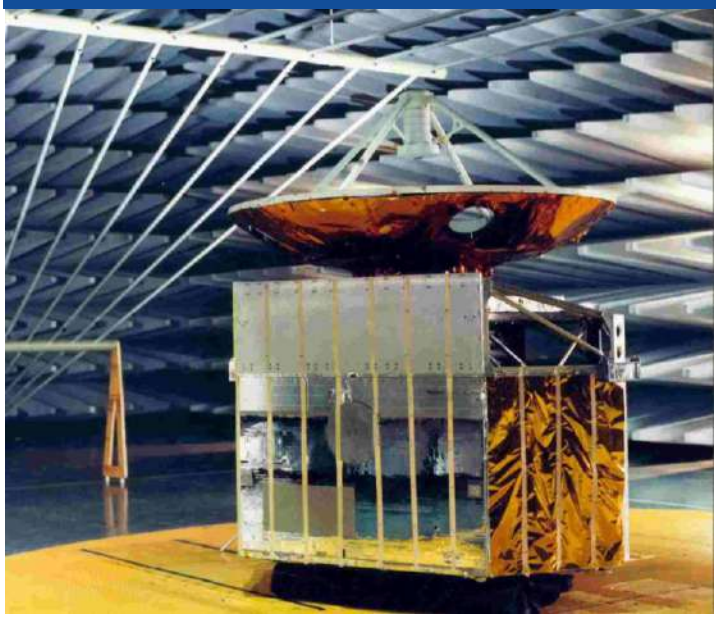
In this regard, reaching the high short-circuit powers that are achieved in actual transmission networks is only possible using a synthetic test method with the right combination of two different circuits that individually each have a relatively low power. Such tests guarantee the correct functioning of crucial grid components, preventing faults and outages that may occur during extreme weather events.

Furthermore, as power transformers are the key components in the power production, transmission and distribution sectors, KEMA Labs play a crucial role in guaranteeing a precise and effective monitoring of the power grid's behavior and in keeping high reliability of such systems, particularly in the case of extreme faults.

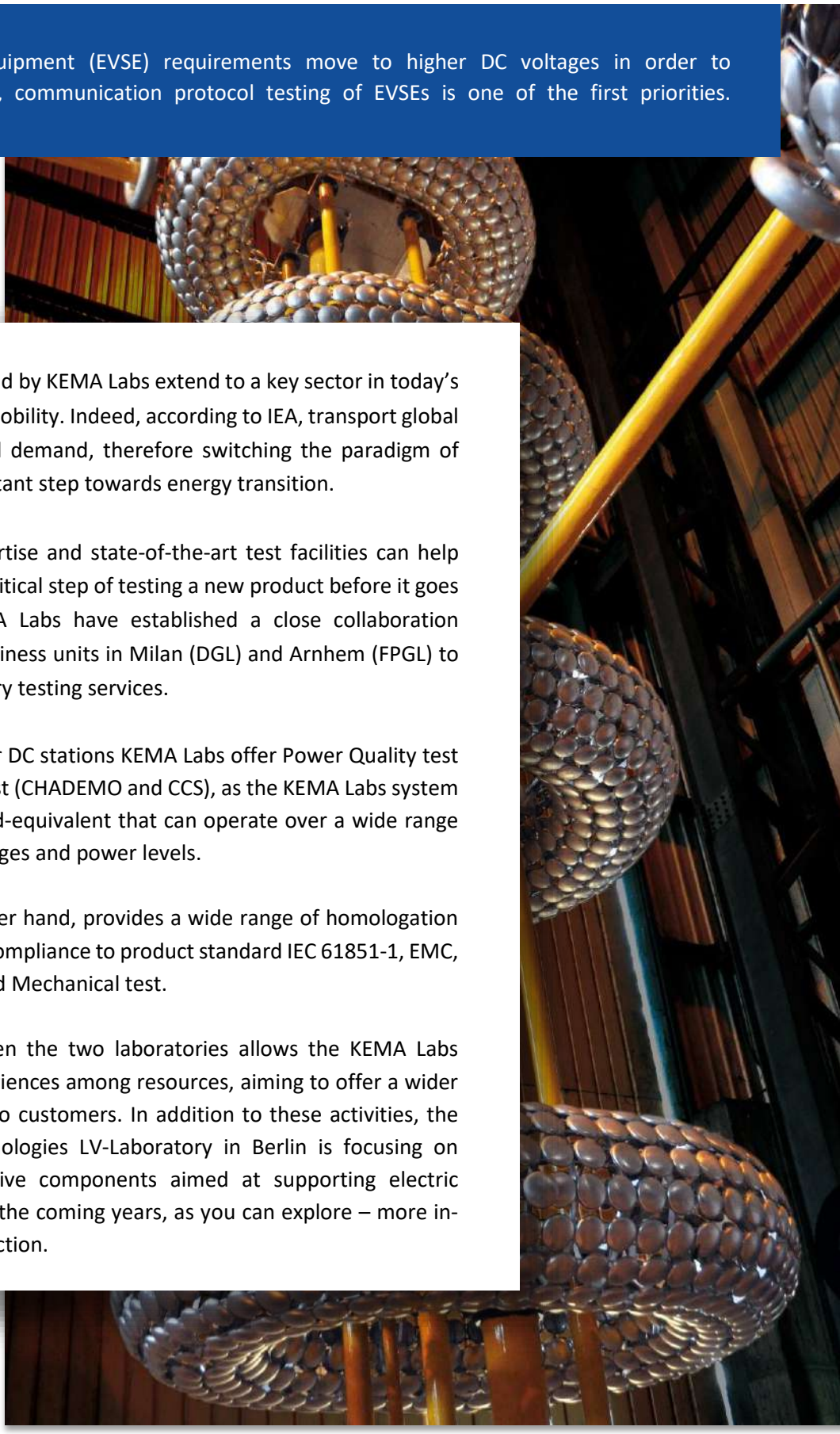
In the Milan laboratory, the KEMA Labs experts carry out complete type tests on Category I oil-immersed and dry-type transformers, short-circuit tests on Category II transformers up to 220-kV and on Category III transformers up to 600 MVA, 220-kV and 400-kV, structural tests (vibration and seismic) on all kind of transformers up to 30 tons, according to recognized international and national standards.

Due to the need of testing for cables – a need increased by their importance in HVDC, key in making the power system more sustainable – KEMA Labs have developed its three platforms, becoming one of the biggest Prequalification Test Facilities for Extra High Voltage Power Cable Systems worldwide, offering the customer a tailor-made loop layout for each need i.e. buried in soil, concrete covered duct system, joint in sand and salt water, concrete tunnel system.

Anechoic Chamber in Milan – tests for space applications



As Electric Vehicle Supply Equipment (EVSE) requirements move to higher DC voltages in order to accommodate heavier vehicles, communication protocol testing of EVSEs is one of the first priorities.



Furthermore, the services offered by KEMA Labs extend to a key sector in today's energy landscape: sustainable mobility. Indeed, according to IEA, transport global accounts for around 60% of oil demand, therefore switching the paradigm of transportation is another important step towards energy transition.

In regard with E-mobility, expertise and state-of-the-art test facilities can help various clients to take the last critical step of testing a new product before it goes to market. Under S&ST, KEMA Labs have established a close collaboration between two different local business units in Milan (DGL) and Arnhem (FPGL) to offer a wider and complementary testing services.

In Arnhem, The Netherlands, for DC stations KEMA Labs offer Power Quality test and communication protocol test (CHADEMO and CCS), as the KEMA Labs system provides a fully controllable grid-equivalent that can operate over a wide range of frequencies, harmonics, voltages and power levels.

KEMA Labs in Milan, on the other hand, provides a wide range of homologation test including electrical safety, compliance to product standard IEC 61851-1, EMC, Climatic Environmental tests and Mechanical test.

This cross-collaboration between the two laboratories allows the KEMA Labs experts to share skills and experiences among resources, aiming to offer a wider and more competitive service to customers. In addition to these activities, the KEMA Services & Smart Technologies LV-Laboratory in Berlin is focusing on innovative testing of automotive components aimed at supporting electric mobility as a strategic pillar for the coming years, as you can explore – more in-depth – in the "Case History" section.

Aerial view of the KEMA Labs facilities in Berlin, Germany

New DC High current lab for E-mobility

R&D activities of the manufacturers have highlighted a fundamental technical requirement for the DC components of e-vehicles

BERLIN

Electric mobility (e-mobility) is undoubtedly one of the most interesting innovations of the last years. The fundamental motivation that is driving the sector consists of a substantial reduction of the environmental emissions: the traditional OEM manufacturers, initially against such development, are now competing to be front-runners.

There are several ongoing R&D initiatives that typically refer to the following strands:

- development of vehicles with increasingly light efficient batteries and, novelties of recent years, available for exchanging energy with electrical grids;
- setting up of a charging infrastructure characterized by suitable large presence on the territory, ease access (smart cards) and short charging time;
- improving safety of critical components installed on board the vehicles, especially the ones most exposed to electrical and fire risks, and again batteries are usually taken as examples.

However, despite being the core element of e-mobilty technologies, batteries are not the only new electric components of electric cars.

In this regard, many manufacturers are developing electrical protection equipment which sometimes exploit well-known technologies, such as switches or direct current contactors, while in other cases they rely on more innovative solutions, among which the so-called hybrid switches.

Especially new components, which can make the difference for EVs, require at the current stage new

new testing capabilities, different from those of the manufacturers due to the need of independent verifications and, also, different from those of the traditional testing laboratories, because of specific technical requirements and performances.

CESI group, thanks to its historical presence in Germany with Berlin laboratories, has been at the side of the main manufacturers of these components since the first requests for R&D tests.

During those initial tests, technical limitations of the test circuits emerged, to the extent that they were not able to support further development of the components under evaluation.

Testing DC components according to new requirements

The R&D activities of the manufacturers have highlighted a fundamental technical requirement for the DC components of e-vehicles, considering that those components will be used not only in cars, but also for trucks and public transport: circuits crossed by short currents in automotive applications show a very low inductance, sometimes equal to or less than 5 µH, which must be simulated by the test benches to properly test devices such as fuses, switches and contactors.

In this respect, the usual direct current (DC) test benches in KEMA Labs have a circuit inductivity of more than 10 µH, which leads to overloading the interrupting capacity of the tested devices.

For that reason, OEM manufacturers started using their own test benches, but they are generally equipped with lower ratings than necessary in terms of voltage and current (below 800 VDC and 20 kA), due to the complexity to deal with high power ratings.

Inside the Berlin facilities

Challenges and opportunities

Once the high-level characteristics for the new test circuit had been identified, technical work teams were organized, aimed at the engineering study of the solution.

These teams were formed by KEMA Labs test engineers supported also by potential component suppliers and manufacturers.

The most critical issue that emerged from these studies consisted of the dangerousness of the test circuit, which requires energy storage solutions, either through batteries or capacitor banks, in order to deliver the high required capacity (2.0 F).

Both potential solutions present critical aspects, from technical, safety and, finally, economic point of view.

Using lithium batteries appeared the most economical choice, but safety implications (high risk of fire), maintenance and end-of-life (disposal of the same), led the technical team to evaluate this solution as very risky and therefore not feasible.

The solution with capacitor banks looked immediately safer but showed decidedly critical aspects both from an economic point of view and, above all, in terms of availability of components and ease of installation, considering the high number of capacitors to be used to reach the required capacity.

Being an innovative project, unique on the market, another challenge has been to identify qualified suppliers, able to provide innovative reliable solutions, never realized before.

Innovation means success

The new system consists of 14 control cabinets with bidirectional DC power supply for charging and discharging the device under test up to a maximum of 1500 VDC, a capacitor bank up to 2 F to provide the necessary energy for a “shot”, an impulse generator, resistances and safety systems to set the current up to 35 kA.

The unicity of this system is exactly the capability to provide high current (35 kA) at constant voltage (1500 VDC) for several milliseconds with an inductance < 10 µH. Furthermore, to ensure tests under severe environmental conditions, the test object can be placed within an explosion-proof climatic chamber.

This new test system allows to switch the full current “on” and “off” several times without completely discharging the capacitor bank; in case the test object fails the circuit absorbs the entire energy of the capacitor bank without risks.

The unicity of this system is exactly the capability to provide high current (35 kA) at constant voltage (1500 VDC) for several milliseconds with an inductance < 10 µH. Furthermore, to ensure tests under severe environmental conditions, the test object can be placed within an explosion-proof climatic chamber.

Skill gap in the TIC industry

PEOPLE

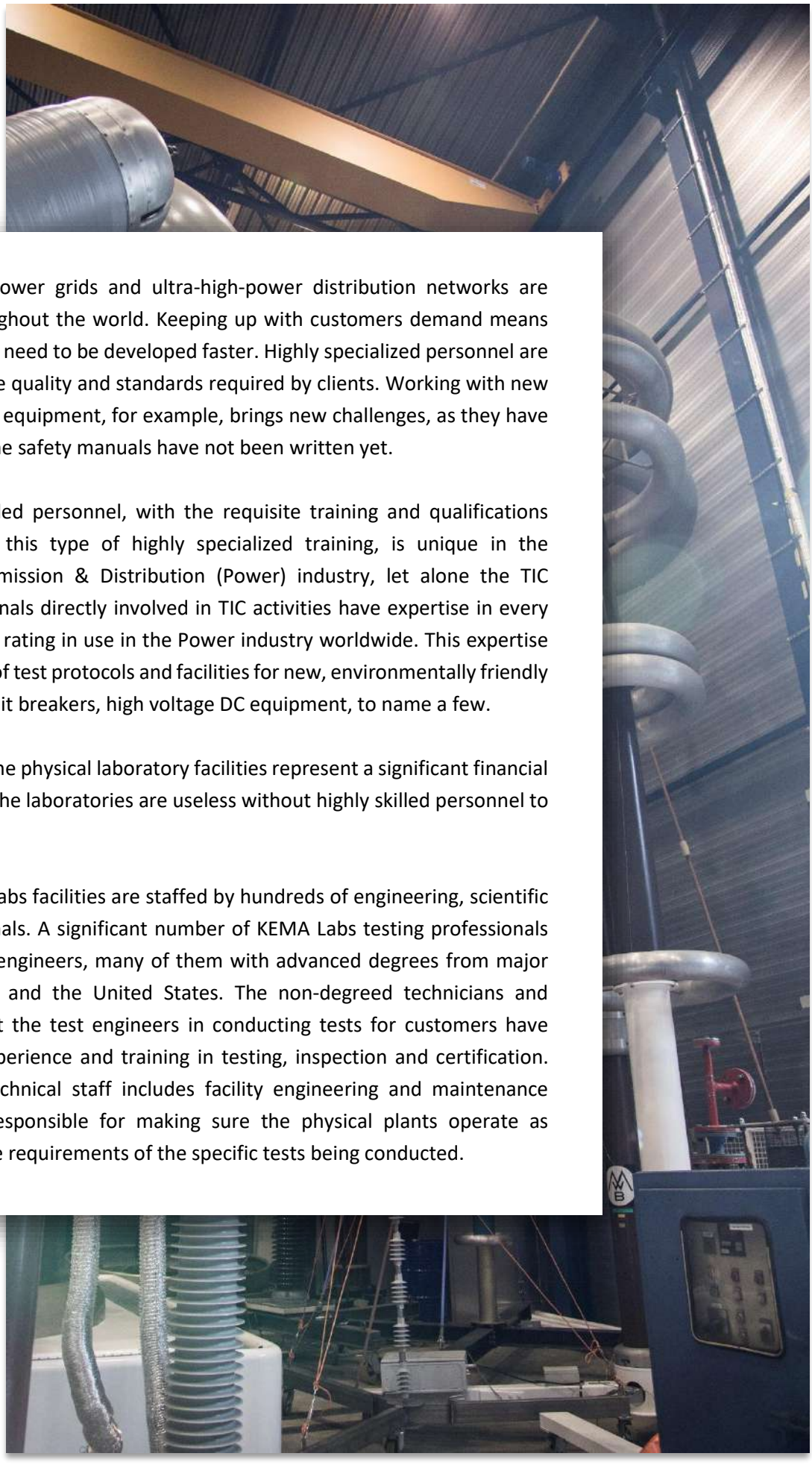
The Testing. Inspection & Certification (TIC) industry is unlike any other industry in the world. The services provided by the TIC industry serve to protect the integrity of national and international design and operational standards for equipment that is vital to modern life. These testing services protect human health, the environment and property throughout the world.

Indeed, electricity products must guarantee safe operating standards, which is why governments and agencies have developed rigorous requirements for electrical products that are sold world-wide. That's where testing services operate: thanks to specific and accurate tests, they analyze products and components certifying their quality and safety. Today, such activities have multiplied due to new customers' requirements and to the increasing digitalization: smart sensors, big data, cybersecurity and blockchains become even more central. The Boston Consulting Group, for example, estimates that over the next decade, such digital technologies will concern approximately 40% to 60% of the current TIC market.

In this respect, companies like CESI, which offers TIC services through its KEMA Labs Division, provide a non-governmental, quasi regulatory enforcement function, thanks to the expertise and commitment of their experts.

Indeed, regardless of the progress of testing facilities and cutting-edge laboratories, the know-how of sector experts and the technical skills of test engineers is at the core of the TIC Industry.

As our society grows and evolves, the need for sustainable and clean energy becomes bigger and bigger. This, also, affects the equipment that needs to be tested, with manufacturers rising to the challenge of making a better and cleaner world.



Complicated flexible power grids and ultra-high-power distribution networks are being developed throughout the world. Keeping up with customers demand means that new test protocols need to be developed faster. Highly specialized personnel are necessary to uphold the quality and standards required by clients. Working with new mixed gasses in certain equipment, for example, brings new challenges, as they have not been proven and the safety manuals have not been written yet.

The investment in skilled personnel, with the requisite training and qualifications necessary to conduct this type of highly specialized training, is unique in the Generation and Transmission & Distribution (Power) industry, let alone the TIC industry. The professionals directly involved in TIC activities have expertise in every type of equipment and rating in use in the Power industry worldwide. This expertise includes development of test protocols and facilities for new, environmentally friendly insulating gases in circuit breakers, high voltage DC equipment, to name a few.

In all these examples, the physical laboratory facilities represent a significant financial investment; however, the laboratories are useless without highly skilled personnel to operate them.

In this respect, KEMA Labs facilities are staffed by hundreds of engineering, scientific and support professionals. A significant number of KEMA Labs testing professionals are degreed electrical engineers, many of them with advanced degrees from major Universities in Europe and the United States. The non-degreed technicians and operators who support the test engineers in conducting tests for customers have extensive hands-on experience and training in testing, inspection and certification. The balance of the technical staff includes facility engineering and maintenance personnel, who are responsible for making sure the physical plants operate as designed to achieve the requirements of the specific tests being conducted.

Challenges can also come from the technical side, for instance a full-scale prototype of a hybrid HVDC circuit breaker was successfully tested at KEMA Labs as part of the PROMOTioN HVDC technology demonstration program. The installation originally designed for AC is now used for DC testing. In this specific program, 20kA of DC fault current was interrupted and energy up to 10 MJ suppressed. Months of preparation and research all came together in a test program never performed at any laboratory before. This meant reinventing protection protocols, site safety and the way tests are normally executed.

The extensive training of all the staff members working in KEMA Labs make it possible to perform these tests in a safe, regulated, and professional manner. Meeting the future demands and standards manufacturers and grid operators are expecting.

The individual and collective expertise represented by the staff of KEMA Labs has taken decades to develop and is built upon generations of experts and the cumulative knowledge and experience accumulated since the first testing evolutions conducted in the 1930's. Such knowledge base cannot be replicated by modeling or machine algorithms as it relies on the art of human creativity and problem solving.

> *Therefore, this unique, priceless, human resource must be preserved and nurtured through careful mentoring, training and development. Opportunities for growth, personal and professional creativity and development are the hallmarks of the KEMA Labs organization.*

The talent pool represented by the KEMA Labs testing professionals is an invaluable resource to the Power industry and will assure that CESI retains its position as a global leader in developing a better energy future for the world. This resource complements the technical staffs of OEMs and end users without compromising the integrity of the independence required by KEMA Labs' ISO/IEC Independent Test Laboratory accreditations.

Upcoming events

E-mobility and Energy Transition: The sustainable mobility revolution CESI and EF webinar

October 20, 2021

Online

In this webinar, CESI and Elettricità Futura will analyze the challenges and opportunities of E-mobility for the energy transition, together with the main Italian and European associations and operators in the sector.

Register, for free, by clicking on this **link**.

KEMA Labs webinar Importance of innovation and R&D

November, 2021

Online

In this webinar, the preparation and readiness for innovations in T&D equipment testing at KEMA Labs is presented. Testing, inspection and certification is a critical part of the value chain to successfully introduce these new innovations without causing safety, control and stability issues.
Register, for free, by clicking on this **link**.

Workshop on Attacks and Solutions in Hardware Security

November 19, 2021

Seoul, South Korea

The main goal of the ASHES workshop is to provide a speedy and focused venue for hardware security solutions and research, covering both theory and practice. ASHES is mainly interested in developing and molding new challenges throughout the early stages of development.

SEERC Conference

November 29-December 02, 2021

Vienna, Austria

The aim of the conference is not only to share the latest research, but also to give an outlook of the future of electricity grids and electricity markets within the SEERC Region. This conference should also be a place to strengthen existing partnerships and start new cooperation.

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).

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