Transformer innovation in a changing energy landscape – Part II

5. Pursuing efficiency, reliability and resilience

Reliability and resilience are two different concepts but closely related. Power grids need to be prepared to secure a continuous sourcing energy, and at the same time, be ready to react in case of incidents or events.

The integration of renewables also possess challenges to the efficiency and reliability of the transmission grids and distribution networks.

Digitalization is a powerful tool to strengthen the power and distribution systems, but other traditional alternatives are also used with good results.

For example, in transmission grids, the reactive power needs to be managed or compensated in order to run the power system efficiently. That can be done with a variety of technical solutions with different features, advantages and applicability, specifically, those where transformers and reactors are used, i.e., synchronous compensators, shunt reactors, static VAR compensators (SVCs), flexible alternating current transmission system (FACTs) and static compensators (STATCOMs). Phase-shifting transformers are another alternative used successfully to control the power flow in high voltage transmission systems.

An example in distribution networks is line voltage regulators that are helping in the shift to a more decentralized power generation where distribution grids not only experience voltage drops due to loads, but also large variations of voltage caused by local generation.

Shunt reactors

As the complexity of the systems is increasing, the use of shunt reactors is more common since they are a cost-effective and reliable solution. The active power flow and the balance of reactive power in the grid must be controlled to maintain voltage stability, with the voltage level being maintained within a range in different operating conditions.

Shunt reactors improve voltage stability and power quality and support the integration of renewable energy.

Although some may think that the shunt reactors are a simpler version of a transformer, they have their own set of challenges – some of those are related to vibrations and noise coming from the magnetic field existing inside, impacting maintenance, reliability and long-term

life expectancy. As a reference, the magnetic field in the gaps is in the range of 1.3-1.5 Tesla and depending of the size of the reactor, the resulting forces in these gaps can be up to 50 t, forces that appear 100 times per second over the reactor's lifetime in a 50 Hz systems, 120 times in the 60 Hz systems [2].

As the complexity of the systems is increasing, the use of shunt reactors is more common since they are a cost-effective and reliable solution

Some of the developments of the past years went to secure a safe and reliable operation by controlling vibrations and noise (for example the use of air-gapped cores is extended) but was also associated to design and manufacturing process optimization (to make optimum use of the material and to use a simple and efficient assembly process).

High-voltage shunt reactors can be built either as single- or three-phase units; the three-phase units have lower direct cost but also lower total losses and require less space in a substation.

Single-phase reactors are selected for reliability in some regions, where the cost of keeping a spare unit is lower than a redundant three-phase unit. Shunt reactors at or above 765 kV are predominantly single-phase, but today they can also be built as three-phase units.

Traditionally, shunt reactors have fixed ratings with no means of voltage regulation. If regulation is needed, fixed reactors are switched in and out along with load variations. However, the resulting large steps in reactance lead to step changes in the system voltage level, especially if the grid is weak. This creates power quality issues and places stress on the breakers.

Wherever power quality is essential, Variable Shunt Reactors (VSR) are an attractive alternative to fixed reactors as they interact with other regulating devices such as Static Var Compensators (SVC).

A variable shunt reactor is based on the same concept as fixed shunt reactors adding one or more regulating windings in combination with a tap changer.

FACTS provide a more dynamic way to control reactive power by taking advantage of power electronics; they normally have a power transformer for connection to the grid

In contrast with transformers, they have a substantially larger regulation range, normally up to between 50 and 60 percent. Larger regulation ranges up to 80 percent at 400 kV can also be achieved, at higher complexity and cost.

The variable shunt reactors have also experienced significant advances. The main function of a variable shunt reactor is to provide a regulation function in situations where the need for reactive power compensation varies with time.

There exist several situations when this occurs and where such a reactor can bring direct benefits. In addition, long-term strategic motives can also be a driver behind the introduction of controllable reactors.

The flexibility provided by a VSR allows the grid owner to adapt to future changes in load and generation patterns, as well as to be a part of future "smart grids" where a higher degree of controllability will be required.

They are used, for example, in wind power where the main challenge comes from large installations, often offshore, connected to the transmission or sub-transmission grid. An important difference between such wind parks and conventional large generation is the unpredictable and fluctuating active-power exchanges causing turn fluctuations in reactive power, which are of serious concern for the operational security of the grid.

Variable shunt reactors provide a way to control fluctuations in reactive power that requires too many switching actions for a standard reactor or capacitor but where the advanced control possibilities of a static VAR compensator are not needed.

FACTS, SVC, STATCOMs

FACTS (Flexible Alternating Current Transmission Systems) provide a more dynamic way to control reactive power by taking advantage of power electronics. Those include Static Var Compensation (SVC), Static Synchronous Compensation (STATCOM), series compensation and thyristor-controlled series compensators, with multiple advances and technology behind.

Static Var Compensators (SVCs) are devices that can quickly and reliably control line voltages. SVC, STATCOMs

Figure 1. Shunt reactor

and FACTS systems, in general, can improve power system transmission and distribution performance in a number of ways. Installing an SVC at one or more suitable points in the network can increase transfer capability and reduce losses while maintaining a smooth voltage profile under different network conditions. The dynamic stability of the grid can also be improved, and active power oscillations mitigated.

SVCs and STATCOMs normally have a power transformer for connection to the grid, typically from 115 kV to 500 kV, where considerations associated with the harmonics and core design are taken.

Their use is becoming wider to integrate renewables, for example, in offshore wind applications located in the onshore substations where, typically, a step-up transformer at the onshore substation raises the voltage to the system level, and another transformer connects the STATCOM to the system. The combination of those two transformers into one single unit, a three-winding transformer

Figure 2. Variable shunt reactor

Figure 3. FACTS - Flexible Alternating Current Transmission Systems

Figure 4. Phase-shifting transformer

The line voltage regulator efficiently adjusts the voltage to the desired value by using a booster-feeder transformer technology in combination with mechanical switches, added controls and intelligence

with a third winding devoted to the STATCOM is an innovative solution to optimize the footprint, losses and overall cost. The main associated challenges are related to defining, in coordination and cooperation with the system integrator, the right operating conditions for the STATCOM. The transformer also needs to be prepared for simultaneous loading considering the power output of the wind farm and the STATCOM; and the right set of tests, for example, the heat run, have to be defined for verification at the manufacturing stage.

We can find an example of this type of innovative solution in an offshore wind farm in Scotland that includes three winding autotransformers with 400 MVA capacity stepping up from 220 kV to 400 kV with a ±15 % on load regulation. A tertiary winding is available to feed a STATCOM at 34.5 kV requiring a simultaneous loading of 220 MVA. The regulation margin and the impedances between windings were selected to fit the operating conditions of the STATCOM. It is worth highlighting that the power of the tertiary winding (220 MVA) is higher than the equivalent power of the autotransformer (180 MVA) which makes the design concept different when compared to traditional system autotransformers.

Phase-shifting transformers

Phase-shifting transformers are another alternative to control the power flow in the transmission systems. Strategically located in certain nodes of the grid, they optimize and support better use of the existing assets, for example, to balance the load between certain lines under certain network conditions and reducing losses. They are traditional and cost-effective solutions that, in some cases, avoid the need to invest in system upgrades, improve system stability and optimize the transmission capacity.

Phase-shifting transformers are complex pieces of equipment, with wide regulating windings providing the phase angle regulation, in some cases with a double core that may be located in one or two tanks in the larger units.

In those larger units, there are multiple challenges associated to the dielectric part due to the particular configuration of the windings and how they are exposed to the system voltage transients; the internal design with multiple leads; the externals with the different tanks being coupled; with the many connections and bushings, and the limitation in size and dimensions for transport.

Line Voltage Regulators

The increasing amount of power generated from renewable resources, especial-

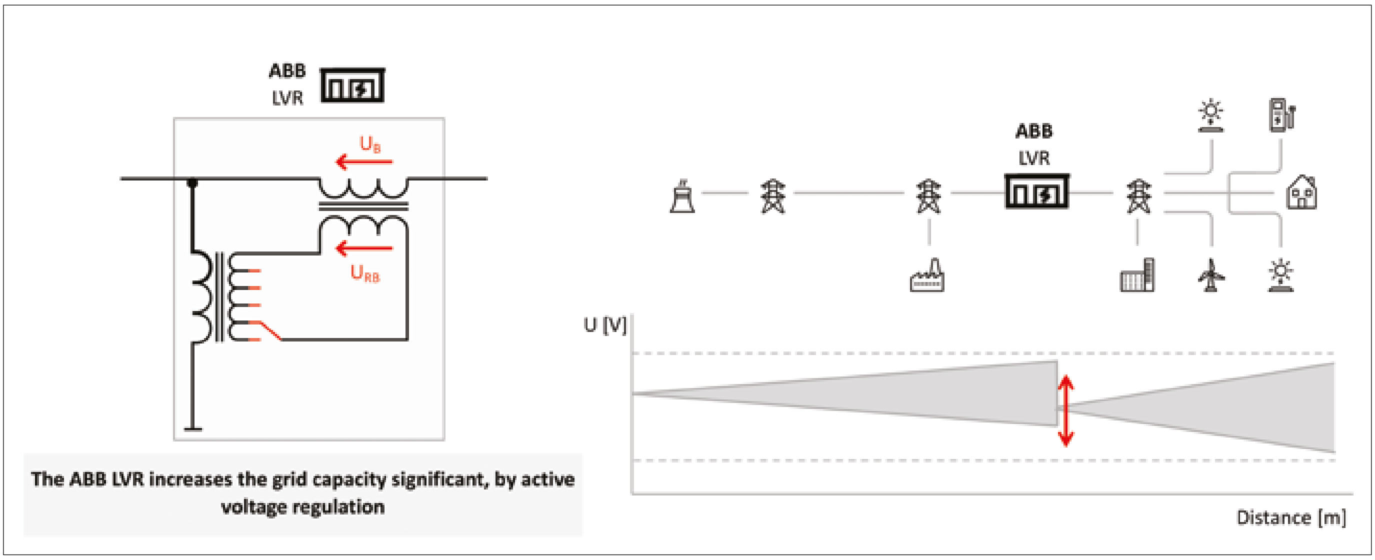

Figure 5. The line voltage regulator scheme

ly wind and photovoltaics, is changing the topology of the grid, in some cases, with many small producers directly feeding energy into the local distribution system resulting in a more dynamic and intermittent power mix. This can result in instability and frequent variation of voltage levels in the distribution network, an increased risk of the voltage exceeding the prescribed voltage range, and the need to limit or even interrupt the renewable generation.

Conventional solutions involve network upgrades or adding regulation to the distribution transformers, but an innovative concept like the line voltage regulators (LVR) may be applied in the low-voltage (LV) and in the medium-voltage (MV) distribution grids.

The line voltage regulator automatically adjusts the voltage to the desired value by using a booster-feeder transformer technology in combination with mechanical switches, added controls and intelligence, with minimal energy losses, allowing regulation of the voltage in ranges of plus/minus 10 %. They can be installed in the medium and low voltage sides of the grid, with the most suitable

Figure 6. Transformer resilience

> **Electric grids are becoming more flexible and robust, allowing a quicker response to outages with the use of well-known technologies such as fault detection, isolation and restoration**

location depending on the network topology. LVRs may avoid the need to install several regulated distribution transformers, being an economically sound solution.

Grid Resilience

The impact of an extended power outage could be very important and have multiple consequences. Utilities are prepared for such events (such as severe weather or physical attacks) by maintaining a robust and resilient grid.

Electric grids are becoming more flexible and robust, allowing a quicker response to outages, for example, with the use of well-known technologies such as fault detection, isolation and restoration. Additionally, asset management systems are prepared to support an optimal grid efficiency.

Transformers are prepared to withstand many network incidents, but their reliability can be further enhanced. For example, the purpose of the short circuit tests is not only to check the design, but also the manufacturing aspects of the transformers to be prepared for such critical events. Today, we can find multiple references of short circuit tested transformers of different types up to 765 kV.

Mobile transformers

The transformer industry is also supporting those efforts with other innovations that include spare transformers and mobile or fast deployable solutions (not just transformers but full substations are available), that, in conjunction with a contingency plan, allow the replacement, substitution or bypassing of the existing equipment.

The use of high-temperature insulation[1] is allowing the use of more compact and easier to transport transformers, especially for larger power and voltages, with some other things taken into consideration, such as high overloadability (to further reduce dimensions), and the use of ester fluids (to help with fluid containment or liquid-filled transportation).

Transformers may also be prepared for connection to different voltage levels, with multi-winding and/or multitap configurations, adding versatility and reducing the number of units to cover the contingency in a region or a whole system.

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[1] As defined in international standards:
IEC 60076-14:2013 Power transformers - Part 14: Liquid-immersed power transformers using high-temperature insulation materials
1276-1997 - IEEE Guide for the Application of High-Temperature Insulation Materials in Liquid-Immersed Power Transformers

Figure 7. Mobile substation

On the installation side, the use of pluggable equipment and bushings help to reduce the time to be ready for service. A contingency plan for fast deployment is one of the most important aspects to make sure that everything will be ready and will work smoothly when needed. Those include having the transformers stored in a central location, having transport permits in place, and all equipment prepared for assembly, being maintained regularly, with predefined installation locations and connecting means for operation at the different substations.

Transformer hardening

The development of transformer hardening (in preparation to resist external attacks), ranges from physical protection by means of armored shields till the use of ballistic protection coatings complemented with dry bushings, impact sensors and automated cooling valves, providing no visual difference with standard transformers.

Different transformer hardened installations are already in place in North America, with overall protection measures that cover the whole substation.

Rupture resistant transformers

Even if power transformers are rigid and strong assemblies, when extreme pressure builds up due to internal faults, it may involve tank rupture, creating the risk of fire with the associated safety and environmental hazards. Rupture resistant transformers are an innovative solution to manage that risk and increase reliability, as they are prepared to absorb energy from internal arcing [3-4].

This technology involves analysis and modelling to make the most rigid areas flexible and the weakest points stronger with rupture control points. All of this is defined with a combination of advanced engineering simulations using finite element analysis with quasi steady-state models; with material selection and with manufacturing processes, all in order to have controlled tank deformations to absorb arc energy and predesigned rupture points at the cover.

> **Digitalization offers a whole ecosystem of products for the users to manage their assets, providing insights and support for the decision-makers**

Some features include bent corners, moving the weld joints away from these high-stress locations, fully penetrating weld joints of the tank wall and flexible connections between the tank wall and the bottom plate. The use of other risk mitigation measures like dry bushings or ester fluids further complements and enhances the benefits of a rupture resistant transformer.

The typical application includes power transformers in critical locations, such as generation power plants, autotransformers at large transmission nodes, and underground applications.

Distribution transformers with transient voltage protection

During the circuit breaker operation, reignitions can create fast transient over-voltages inside the transformer. That happens in installations that include fast-switching (such as vacuum or gas-insulated) circuit breakers in line with a medium-voltage distribution transformer. The risk of transformer damage or failure is especially high when the breakers are close-coupled to the transformer. Other factors that increase the risk are lots of cables upstream from the circuit breaker or facilities that allow disconnection under load. Other phenomena include amplification of voltage due to resonance inside the transformer.

The transformers with transient voltage protection incorporate varistors[2] (also known as zinc-oxide -ZnO- or metal oxide -MO- varistors), placed strategically along the windings to limit such transient over-voltages that combined with advanced winding design provide resistance against fast transients. This is a full transformer integrated protection compared to the more traditional solution (a resistor-capacitor snubber circuit installed as a standalone device or inside the transformer) since the varistors do not affect standard transformer size and dimensions. It also reduces the maintenance operations associated with oil-filled capacitors in the snubber.

This is an example of innovation applied to distribution transformers, and it is utilizing solutions widely used in other types of transformers (varistors have been largely used internally in the regulating windings of power transformers [5] to increase reliability).

6. Digitalization

Digitalization is one of the main trends in the field of transformer innovation. Apart from providing a set of digital products and solutions, digitalization also offers a whole ecosystem of products for the users to manage their assets, and for the operation of systems, thus moving ahead from monitoring to expert systems with digital twins prepared to replicate and simulate, providing insights for the decision-makers, and enabling multiple opportunities to do more with less effort.

The use of digital twins is starting on the transformer operational side, but also to cover the design, manufacturing and implementation stages, with different aspects, that go from 3D modelling and simulations to expert systems based on machine learning and artificial intelligence algorithms to predict the performance, and other parameters such as condition, life expectancy and overloadability.

The application of digitalization is not only restricted to large power grids with digital transformers integrated into dig-

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[2] In the large number of publications on MO resistors and MO surge arresters, different terms are used for basically the same object: ZnO varistor, ZnO resistor, MO varistor, MO resistor, varistor, ZnO or MO arrester, MO surge arrester, etc. This has historical reasons, and also depends on the technical community or the kind of research and development performed.

> **Artificial intelligence and machine learning techniques are used to convert a large amount of measured data into meaningful results**

ital substations. It is also applied in distribution systems and industries where digital distribution transformers enable smart operations, for example, to address the challenges associated with smaller-scale renewables and electrical charging for e-mobility or to secure continuous operation or preventive condition-based maintenance.

Many of those applications may seem straightforward, but behind the scenes, there is a lot of work going on to develop holistic solutions ranging from sensors, IT infrastructure and a backbone of integrated intelligence; all that packaged into a digital ecosystem that is user friendly and safe from the cybersecurity standpoint.

Other innovations worth highlighting are robots for internal inspections of power transformers. Like drones for power transmission lines, a submersible robot allows internal inspections without draining the oil with benefits for the transformer (avoiding exposure to the ambient), but also increase the safety of the personnel and easing and shortening the whole process. It opens a wide range of possibilities in the maintenance and transformer service activities, that can be complemented with the use of virtual reality enabling remote support or training.

From monitoring to digital transformers

Transformer monitoring is not a new concept with a whole range of sensors and online monitoring devices that are available, ranging from e-devices that are the digital evolution of thermometers, pressure relief devices and Buchholz relays, to humidity and gas analyzers, bushings and partial discharge monitors.

The step forward is to integrate all those sensors into digital transformers, converting the data into actionable intelligence, and then all that integrated into digital substations providing a holistic approach to optimize operations and maintenance. Different connectivity methods are available with cybersecurity in mind, from standalone modes, till substation or fleet level. A straightforward example of application is related to dynamically managing the transformer load, adapted to different systems and ambient conditions, enhancing the overloading capability with no/little effect on lifetime.

The future of transformers is digital – we already have native digital transformers covering the whole range of applications, from distribution till the larger power transformers with all the associated benefits, just as cars come equipped with a series of sensors, alarms and devices from the factory.

As transformers are complex pieces of equipment, there are no straightforward algorithms that directly use the data and convert it into meaningful results. Artificial intelligence and machine learning techniques make a difference in that field. [1]

Machine learning

The key element of the process is the training of the algorithm with actual data and expert human supervision. Good data and expertise are fundamental to this process.

A good example of machine learning application is in the field of getting an automatic classification of the operating condition of power transformers to help asset management, correlating data to the physical condition to prioritize maintenance, provide early warning information, etc.

A reference case [1] was developed with data from one thousand transformers that were individually analyzed by human experts. Each transformer in the database was scored with a 'green', 'yellow' or 'red' card depending on the data, the interpretation of human experts, or even after some calculations were carried out with traditional formulas or algorithms normally used by experts to identify operational issues.

After that, the machine learning algorithms were used to analyze 200 new (unseen) cases during training with the results showing an impressive accuracy near 97 %.

The machine learning algorithms, however, did not utilize or were given any of the engineering tools employed by human experts. The algorithms only employed the raw data in a supervised learning process.

Machine learning algorithms then open a wide variety of opportunities to enhance transformer utilization and maintenance, assisting in all the asset management processes.

Asset management

Digitalization opens the door to the future of asset management, with an ongoing path towards preventive and condition-based maintenance replacing traditional time-based maintenance. This implies not only maintenance savings but also may prevent failures and extend the life of the transformers, by prioritizing maintenance on high-risk transformers. An estimated 5 to 15 years life extension can be achieved with properly focused preventive maintenance programs.

On a long-term and strategic level, a condition assessment study gives management a clear picture of the maintenance and renewal investments that are required over the next 20 to 30 years to provide asset reliability and availability. This type of insight provides solid information to compare different asset management strategies and to choose the approach that best supports the overall technical and financial strategy of the company.

In the medium term, a condition assessment gives asset managers the inputs necessary to make the best use of maintenance or replacement budgets. Funds can be allocated to units that show the best return of investment while reducing technical and environmental operation risks. And in the short term, the assessment can indicate how to apply the maintenance actions that secure the operations and asset reliability required.

Figure 8. APM (asset performance management) tool

Digitalization enables expert asset management systems to ease those long-medium-short term decisions. It also helps to analyze and keep track of all the available data and information with built-in intelligence and machine learning tuned algorithms; evaluate the condition of the asset and the expected life; help the decision-making process; optimize the operational and maintenance spend; maximize the capabilities of the assets and budgets; and build business cases for repair/replace decisions.

Furthermore, it opens the option to multiple opportunities out of the traditional approach towards autonomous systems based on artificial intelligence, the same as how the automotive industry is getting closer to autonomous mobility.

7. Sustainability

Transformers are contributing in many ways to sustainability, with multiple innovations already in place, like dry bushings, or dry transformers growing in size and voltage (i.e., tenths of MVAs, 145 kV) being used in urban locations and also used in electrical transportation and trains.

These innovations are expanding the field of application – dry transformers and their use is growing. The oil to dry transition is especially remarkable on transformer bushings with sustainability being complemented with reliability and safety-related advantages.

The use of ester fluids, providing biodegradability and other benefits, is becoming more extensive, and the range of application is also growing in voltage and rating, reaching up to 400 kV. The main challenges associated with esters come from:

- The dielectric side, because of the different behavior of esters, especially in large fluid volumes, that cast attention on the insulation structures;
- The thermal design and cooling equipment dimensioning because of their different viscosity compared to mineral oil;
- Bushings and tap changers, where the specific type and ratings need to be validated to operate with these fluids.

Transformer losses are being also driven down, with even thinner and lower loss core materials, amorphous core steel, or calculation tools used to reduce the load losses. Special care is paid to the reducing of the stray losses that in power transformers are not just statistically adjusted but calculated with loss mitigation techniques, for example, determining the optimum location and dimensioning of magnetic shielding.

Many advances can also be highlighted from the regulatory point of view, for example, with the implementation of minimum energy performance standard (MEPS) for transformers in many regions and countries, and other ongoing efforts, such as the United for Efficiency initiative (U4E) led by the United Nations Environment, to accelerate the adoption of energy-efficient transformers supported by model regulations intended for use by regulatory authorities in developing and emerging economies to help them in promoting energy-efficient transformers, especially distribution transformers with the relevant contribution to energy losses.

> **Noise is a sustainability factor; with the advances in the noise calculations techniques, it is possible to achieve power transformers noise to be below 50 dB without the use of external mitigation techniques**

It is worth mentioning the total cost of ownership (TOC) here. Even if its application is extended in some cases, it is not yet a common practice, especially for investors who primarily have capital expenditure as their main focus.

Energy efficiency also comes from how the grid is configured and operated, for example, by transmitting energy more efficiently by using higher voltages, both AC and DC, or by using systems that make more efficient use of the network, with transformers playing an important role in interconnections and Flexible Alternating Current Transmission Systems (FACTS) as already addressed earlier.

Noise is also a factor to consider, especially when it comes to operations in urban (or close to) areas, with advances in how the load noise is calculated and controlled, allowing power transformers to be below 50 dB(A) without the use of external mitigation techniques.

The last topic about sustainability is the circular economy. Recycling or reusing – such as the oil reclaiming practice – is well spread. However, modern capabilities for on-site repair activities, including high voltage testing, has opened the door to refurbishment and repowering of existing transformers. On-site capabilities also allow larger rating transformers to be built on-site if the size or weight restrictions limit the transportability, as it will be more efficient to have larger three-phase rating transformers, than smaller rating units or equivalent single-phase ones.

Figure 9. Printing robot studio

While losses (that remain during the whole lifecycle) are the main contributor to the carbon footprint of transformers, it is good to have an overall awareness of how other factors impact them – starting from raw material processing, manufacturing and transportation activities – so as not to lose sight of the importance of them all [7-8].

8. The future of transformers

The future of transformers is still to be written, with digitalization and other innovations already mentioned playing an important role.

The innovation path will follow, pushing new boundaries and supporting new applications of the energy industry with additional developments in materials, design, technology, but also moving into a different paradigm to cover the whole value chain of how the transformers are specified and conceived, designed, manufactured, operated and maintained.

Many futuristic ideas already applied in other industries are giving us some hints and may show the path to additional innovations, for example, the already commented upon autonomous systems (or semi-autonomous as a first step), or the pay-per-use business model (energy as a service), where users do not own the assets but just pay for the energy while others take care of everything else.

Digital twins, as also mentioned, will play an increasingly important role. We may anticipate users purchasing the physical assets and their twins to help operation and maintenance, but other than that, the digital twin can be used at the conceptual and design stage to shorten design and manufacturing cycles, helping in the integration into the overall substation. Manufacturing will

Figure 10. Power semiconductors

also benefit from digitalization with data-driven processes and much more.

Some other innovations worth mentioning as a closure are:

Additive manufacturing, 3D printing

Additive manufacturing is a general trend in the industry of parts and components with well-known advantages. Associated to transformers, one of the main challenges may be the maximum size of the parts that can be built by 3D printing. The use of the right materials also needs to be addressed.

The use of this type of application may change how the transformers are designed and manufactured, opening a wide range of possibilities.

Nanomaterials

The use of nanomaterials to enhance transformer fluids properties is another trend to follow. There are several technical papers already published on this topic, but there is still not enough experience in the use of these type of solutions in transformers.

In terms of performance, the following properties can be enhanced by the use of nanomaterials:

- Breakdown voltage, improving the dielectric strength of the insulation structure. Partial discharge generation should be considered;
- Viscosity, with a direct impact on thermal performance as it will affect the speed of the fluid through the active part;
- Fire and flash points, mainly due to safety reasons.

From a maintenance point of view, these types of solutions may provide a way to reduce maintenance operations or to extend the life of the fluid.

Power electronics

There is an increasing interest in the use of power electronics and solid-state devices because of their advantages, as these components reach higher ratings.

Figure 11. Semiconductors manufacturing process

> **The future of energy is complex, demanding and yet exciting; transformer innovations are helping us to prepare for that future today**

Standardization bodies are starting to review the traditional definition of transformers based on electromagnetic induction only to accommodate future developments that may apply to transformers and their associated components.

Associated challenges, such as the generation of harmonics, will need to be evaluated, especially considering the change of the landscape of energy distributed generation.

There are different initiatives in the industry, at different levels of progress, that look at their application in transformers, but we may expect real results or conclusions only in the coming years.

Other ideas

To close, we bring a non-exhaustive list of ideas, the feasibility, applicability and interest of which will be determined by the future: energy harvesting sensors; plug and play transformers; automated controlled manufacturing; further globalization and equalization of different transformer types, and many others to come.

The future of energy is complex, demanding and yet exciting. Transformer innovations are helping us to prepare for that future today.

Note: This article was first presented at ARWtr19, the 6th International Advanced Research Workshop on transformers held in September 2019 in Cordoba, Spain.

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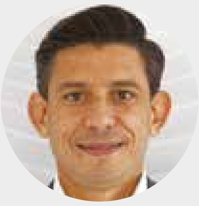

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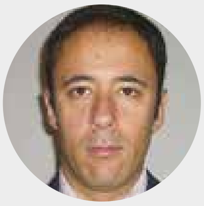

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