Energy systems around the world are undergoing fundamental changes, with main trends that we see as the four D's: demand growth, decentralization, decarbonization, and digitalization

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The four D's fundamental changes

Energy systems around the world are undergoing fundamental changes – the balance of fossil fuels and renewable energy sources is shifting towards a decarbonized portfolio. According to studies, global demand for electricity generation will increase by more than 50 % by 2040. Demand growth is mostly driven by almost a billion people still living without access to electricity, the increasing electrification of industries and the emergence of new consumers such as data centers and e-mobility.

So, the main trends that we see are the four D's: demand growth, decentralization, decarbonization, and digitalization. Decentralization and decarbonization will also bring changes to our portfolio. Because of decentralization, there will be an increasing demand for medium power transformers (MPTs) and distribution transformers for wind and photovoltaic (PV) power generation. The increasing integration of fluctuating renewable energy will also lead to a higher demand for phase-shifting transformers (PSTs), variable static reactors (VSRs) and more high voltage direct current (HVDC) systems for offshore grid connections. However, decarbonization is not only driving the type of products, but also the materials and the way we produce the equipment, so there is a shift towards more sustainable solutions such as the application of ester oil, dry-type bushings, and dry-type distribution transformers.

It is important for us to support our customers on their individual paths towards an efficient, resilient, and sustainable energy network. A good example is the replacement of sulfur hexafluoride (SF6) or other fluorinated gases, called F-gases, in instrument transformers and other transmission products. Since sustainability is of increasing significance for our customers and ourselves, we are offering applications that use dry synthetic air, so called "clean air", as an insulation medium for gas-insulated equipment.

Finally, all our products come with digitalization features that provide more and more support and value added for customers to better manage the grid and their assets, reducing CAPEX and OPEX.

These are a lot of changes, indeed, but with our broad, continuously renewed portfolio, and our global footprint, we are very well prepared to meet the changing customer demands. We have been adapting ourselves very quickly both in footprint and R&D investments. And in the end, it is all about having the right portfolio, the right people in place, and being on the edge of innovation.

Shift from products to system intelligence

Digitalization is changing the way we live and work. COVID-19 was a catalyst to digital transformation if you see how fast we have adjusted to digital home working and partly also digital home schooling.

Two years ago, Siemens shifted the paradigm by merging physics with information technology with the launch of Sensformer® - transformers with inbuilt connectivity and intuitive apps to monitor important information and provide additional value added to customers. And our digitalization journey continued: Last year we launched **Sensgear**, digital enabled circuit-breaker and gas-insulated switchgear (GIS), and **Sensformer Advanced**, a more elaborated digital solution for enhanced productivity (e.g., digital twin for overload management aimed at optimizing revenues in wind or HVDC applications) including advanced monitoring systems for predictive maintenance, e.g., partial discharge monitoring in dry-type bushings.

Just recently, we have announced under the motto "Born Connected 3.0" a further shift from products to system intelligence, including the extension of connectivity to the whole portfolio of

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He earned his MBA at the University of Maryland, USA in 2001. He started his career at a Siemens' transformers factory in Brazil during the 1990s, then he briefly moved to Motorola only to return to Siemens in 2002 where he first worked as Head of Engineering and Project Management in Brazil. After a couple of years, he moved to Germany where he held managerial positions at different business units in Erlangen and Nuremberg. Before he became Senior Vice President, he was CEO and Board Member of Siemens Transformers in Trento, Italy, and Vice President of Distribution Transformers Business Segment in Nuremberg.

We have been adapting ourselves according to the four D-drivers very quickly both in footprint and R&D investments

transmission products: high-voltage gas insulated switchgears, power and distribution transformers, bushings, coils, instrument transformers, circuit breakers, and surge arrestors are now connective. Additionally, we have launched a digital twin for enhanced productivity in circuit breakers and high voltage GISs.

But let me share a concrete example on how this systems intelligence can benefit operators:

A power producer with wind turbines, power transformers, step-up transformers, and all the other equipment, wants to maximize the revenues. If he has a digital twin for the system and knows the next day there will be strong wind, he can cool down the transformers the day before and monitor all the other equipment to allow a huge overload the next day. However, customers need the connectivity and the digital twin of every part of the equipment in the substation in order to monitor the complete system and prevent failures caused by proactive system interventions. With Born Connected 3.0, performance of the networks is increased, and operation is easier, safer, and more economical for our customers.

The feedback from the market regarding digitalized products has been excellent, which has motivated us to continue adding further digital applications on our products. Our customers are now sharing their ideas and wish lists of what they would like to see in the apps to help them increase the operational and financial performance, and that is what we are implementing.

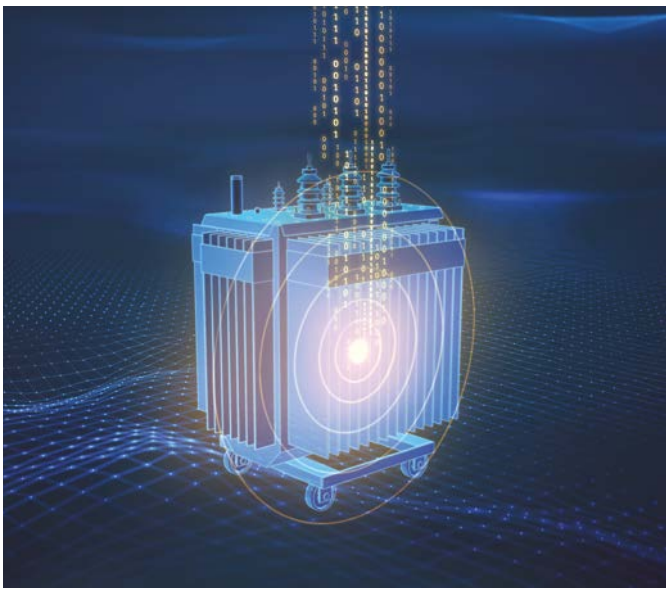
Strong value-add to the customer

To depict the benefits of digitalization for transformers, let us take a look at an example of a large distribution company in Brazil. In the event of a distribution transformer failure, the distribution system operator (DSO) does not know which transformer failed, or where the failure occurred. In this case, connectivity could have saved lots of time and money because the DSO would have known exactly which transformer needed to be fixed or replaced at the time of the failure or before it. Using Sensformer products to service and put the power back ON would have been much faster, thus improving DSO quality indicators. For end customers this means shorter blackout times. In addition, DSOs can monitor overload with Sensformer Advanced technology and - if necessary - replace transformers that frequently run under overload conditions or show irregularities to avoid failures and asset losses.

The Sensformer Advanced solution includes digital twins - digital replicas of exact units where all the data from design, manufacturing, and former operation are incorporated. Based on digital twins, overload reserves can be calculated dynamically and in real time. It is even possible to calculate the expected load forecast in advance for a certain period of time. Besides, load conditions can be simulated with a fine balance of asset aging. In general, Sensformer Advanced provides information that helps TSOs and DSOs be better prepared and well equipped for all kinds of expected and unexpected grid conditions. They can draw solutions to improve performance and operate the grid more efficiently.

Co-creation with customers

Static electrical equipment, such as transformers, does not need as much service



as rotating equipment, such as power turbines, and can run for more than 30 years. However, digitalization is opening many doors for value-added services in future – e.g., by developing solutions together with the customers to improve operation management (such as digitalization-based services) and to increase the revenues and the profit for the customers. New business models, that reflect the innovation partnership with customers and share financial results, might be possible. We are currently working with several customers to develop new ideas and maybe even new business models.

Data analysis is changing transmission grid

With the increase of intermittent renewable power in the grid, there is a higher need of data today, in order to allow operators to manage the grid and the equipment in a smarter way.

In the past, transformers had only one cycle during the day and that was in the evening when energy consumption was at its peak with no large demand during the night. Contrary to that, a transformer connected to a PV farm has hundreds of cycles during the day. The corrugated tank expands and shrinks down, other parts of equipment go through different phenomena that we did not have in the past because the sun comes and goes during the day and the load fluctuates a lot. So, the change in the grid with more renewables is impacting the equipment in many forms.

We have announced under the motto "Born Connected 3.0" a further shift from products to system intelligence, including the extension of connectivity to the whole portfolio of transmission products

Additional data converted into valuable information from the assets allows customers to optimize not only the maintenance (shortening or avoiding outages and increasing lifetime) but also the operations as per the wind example. Information is fundamental for us to manage the assets and guarantee a stable grid. All this is done through real-time data analysis and analytics.

Cybersecurity

Cybersecurity is a very important topic for us, and the concerns of our customers are legitimate because we are talking about critical infrastructure. By taking our customers' concerns very seriously we make sure that all our IOT devices and digital applications comply to the Charter of Trust, an agreement and commitment to abide by the highest cybersecurity standards, and other international standards such as NERC CIP and IEC62443.

On top of that, we also work with customers to comply to additional security measures whether needed by them or mandated by local authorities. With these measures, we raise the bar in cybersecurity, guaranteeing that Siemens Energy is a front runner in it, and so far the resonance has also been very good.

R&D

Siemens Energy yearly spends around €1 billion on R&D and, as of June 30, 2020, has over 24,000 patents, which shows the importance of R&D for the company. Also in our transformer business, R&D and innovations, such as our connective transmission equipment, help safeguard long-term success and are leading the way to a common goal we share with customers and societies around the world: a more affordable, reliable and sustainable power supply. We invest selectively in R&D to reinforce our innovation leadership position in sustainable and digital technologies.

Impact of the pandemic

During this worldwide crisis we have to focus our attention on two things: keeping the lights on by reliable power supply to consumers and keeping our people healthy. Our factories had to deal with different challenges such as

Innovations help safeguard long-term success and are leading the way to a more affordable, reliable, and sustainable power supply

closings through regulations by local governments and supply chain disruptions. We had to conduct virtual FATs without the presence of local inspectors and, naturally, sending supervisors abroad for installation commissioning became quite difficult during the pandemic.

To protect our employees, we put complex cleaning and working procedures in place and we managed operation with fewer employees due to quarantines.

A great team and digitalization helped us overcome the difficulties with minimal impact to the customers, and many of the solutions that we have developed during the pandemic will certainly stay in a post-COVID-19 world, for example, home office, digital FATs, digital supervision, etc. In terms of the market, we are very thankful that we saw a resilient transmission market, with basically no order cancellations.

Future of transmission industry

In a rapidly changing digital world, the future beyond the 5-year mark is hardly predictable. We need to look at what the four D's drivers (demand growth - decentralization – decarbonization – digitalization) mean to us in the portfolio elements, in the materials, and the processes we are using.

One thing I see clear is a significantly stronger adoption of digitalization, more digitalized products for improved OPEX and operational results – also by using digital twins. That is something all utilities are trying to achieve.

Future of the transformer market and technology

We see a steady demand in the next years as transformers are core elements in energy conversion. In general, the greater move to renewables will lead to more step-up distribution transformers for wind, more PV, phase shifting transformers, variable static reactors and HVDC systems for connecting offshore, and more medium-power transformers due to decentralization. We also see more environmentally friendly equipment (less mineral oil, more dry-type transformers, and bushings, no SF6), and an increased adoption of digitalization for improvement of operational and financial performance.

On top of that, in the transformers market, there is lot of aging equipment which will come up for renewal or replacement in the next years, which will further add to the demand.

It is important to mention that all these changes or trends in the energy market will not happen equally in all regions of the world. North America and Europe will be about energy transition and aging equipment modernization. Parts of Asia, Africa, Latin America, and the Middle East are still about growing energy demand and grid modernization.

In terms of technology, due to the decentralization, we see a growing demand for Medium Power Transformers and there we are quite strong and well positioned while growing significantly.

Regarding large power transformers, there will be more phase shifters, shunt reactors, and HVDC for offshore connections, and here we are a leading global supplier with a very extensive and innovative portfolio. For wind turbine suppliers, we talk about step-up DTs, both oil and dry-type.

Therefore, Siemens has started to invest in these innovative technologies very early. Strongly driving innovation, co-creating with customers, and extending our footprint has made Siemens Energy, for example, a leading supplier for special transformers for wind turbines (oil-filled and dry-type), supplying to all major OEMs in all regions of the world.

And, as mentioned earlier, digitalization will keep affecting us in all areas of our business - be it products, production, or advanced management systems.

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