

According to "World Energy Outlook 2020", power generation using renewable energy resources is expected to grow rapidly over the next decades

ABSTRACT

Power transmission plays a crucial role in the future energy transition. Siemens Energy recognises trends in energy transition with sustainable power transmission, thus started developing technologies that are actively shaping the path to a climate-friendly future. Siemens Energy offers transformers and components for best-in-class renewables integration while keeping the transmission grid reliable and resilient.

KEYWORDS

climate-friendly, eco-friendly, energy transition, power transmission, sustainability

Shaping the energy transition with sustainable power transmission

The energy transition is a tremendous global task

The Paris Agreement, a legally binding international treaty on climate change, was adopted by 196 parties end of 2015 and entered into force on 4 November 2016. It was agreed to limit global warming to well below 2 °C, preferably to 1.5 °C, compared to pre-industrial levels. However, the newest UN emission report, published end of 2020, stated that the world is on course for more than a 3 °C spike, even if climate commitments are met. In order to limit global warming, all countries worldwide need to rapidly reduce global greenhouse gas emissions as fast as possible. About 42 % of global CO₂ emissions in 2018 accrued in electricity and heat production (source: IEA in 2018). For the necessary energy transition, not only do governments have a special responsibility in creating the right framework conditions but also the energy sector has a central role in actively shaping the path to a climate-friendly future by providing necessary technologies.

Power transmission plays a crucial role in the energy transition

In their annual report “World Energy Outlook 2020,” the International Energy Agency (IEA) draws alternative scenarios of the future energy landscape. The COVID-19 pandemic has caused an ongoing huge disruption to the energy sector, and there is a wide range of energy future scenarios. According to the outlook, global energy demand might rebound to its pre-crisis level in early 2023, or even later, depending on when the pandemic is brought under control, and it is still unclear how much efforts countries and companies will put in increasing the sustainability of the energy system. However, the outlook at all the scenarios shows that power generation using renewable energy resources is expected to grow rapidly over the next decades, with solar and wind expecting the highest growth in global electricity generation.

Siemens Energy offers two technologies of step-up transformers, especially for wind applications: fire resistant GEAFO[®] transformers up to 40.5 kV and FITformer[®] WIND transformers up to 66 kV

The IEA points out that the backbone of today's power systems, the electricity grids, might develop as the weak link in the energy transformation. Even in the Stated Policies Scenario, without any additional efforts than already announced to increase the sustainability of the energy system, IEA sees an 80 % increased demand for transmission and distribution grid expansion in the next decade compared to the previous decade. Companies like Siemens Energy recognised early that energy transmission and distribution would be one major key to a successful energy transformation, thus also started early to develop technologies that are actively shaping the path to a climate-friendly

future – in a sustainable, affordable and reliable manner.

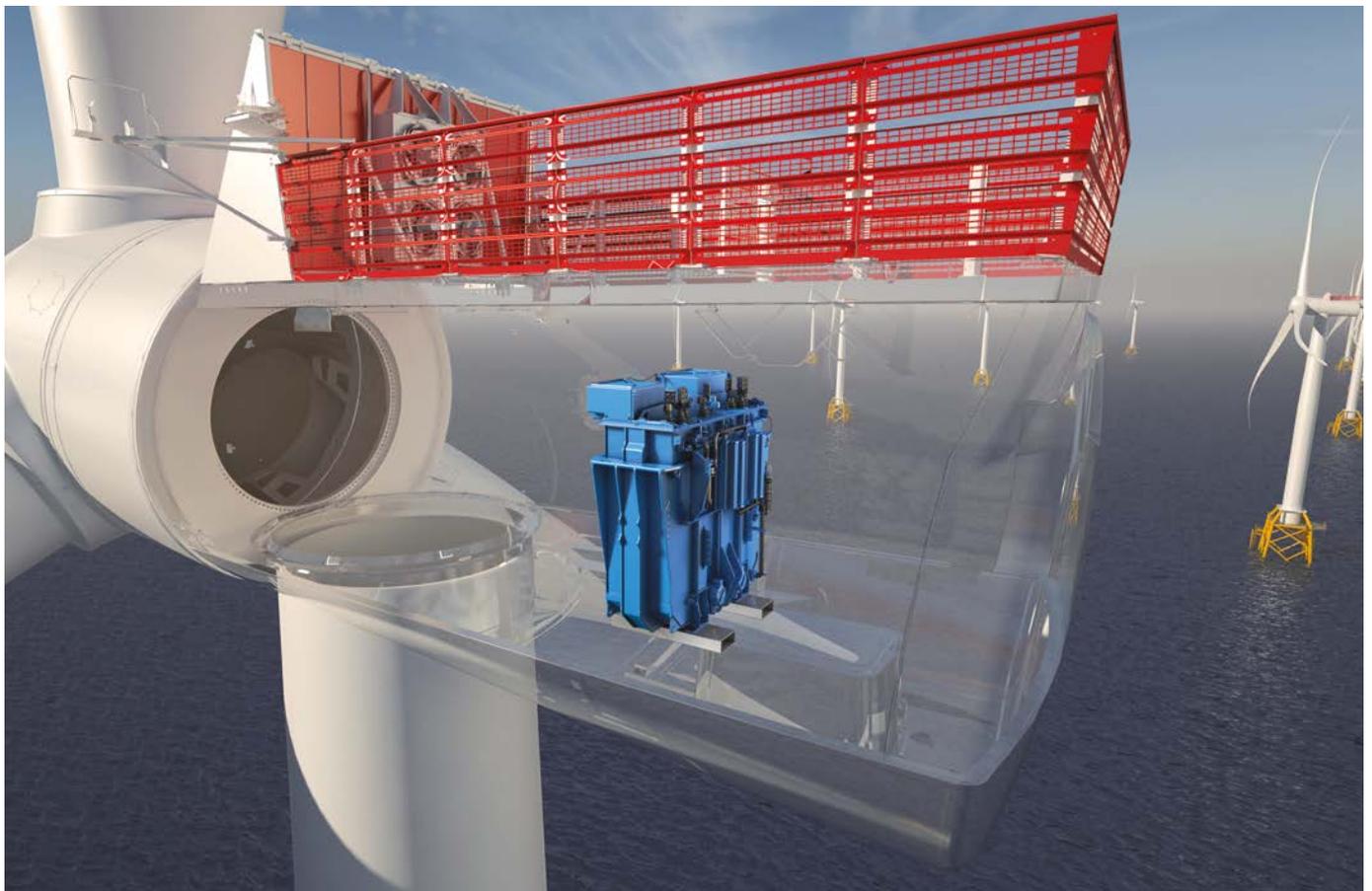
Siemens Energy offers transformers and components for best-in-class renewables integration while keeping the transmission grid reliable and resilient

Undoubtedly, the society needs a massive expansion of renewable energies to combat climate change while also meeting the global energy demand. However, the increased integration of fluctuating resources also poses new challenges to the grid resulting in a higher demand for certain transmission technologies. Power trans-

mission grids will be further extended by implementing a lot more high-voltage direct current (HVDC) systems, AC- and DC-offshore grids, and extended AC- and DC-onshore grid connections. Siemens Energy's portfolio already comprises most of the relevant elements and is continuously expanded through innovation.

To integrate renewable energy sources into the transmission grid, the generated electricity needs to be converted to the requisite voltage level by a step-up transformer. Siemens Energy offers two technologies of step-up transformers, specially designed for wind applications: fire resistant GEAFO[®] cast-resin transformers of up to 40.5 kilovolts (kV) and FITformer[®] WIND transformers of up to 66 kV, with ester, a flame-retardant, and biodegradable insulating fluid. Both types are compact, environmentally friendly, and extremely reliable.

The increasing use of renewable energy sources does not only lead to growing grid complexity but also to increasing power fluctuations. Shunt reactors are used for voltage control and reactive power com-



FITformer[®] WIND in the nacelle of an offshore wind turbine

Siemens Energy offers various products to cope with the increasing power fluctuations caused by the increasing infeed of renewable energy



Variable shunt reactor

pensation. They continuously adjust reactor power rating to actual needs. Variable shunt reactors by Siemens Energy are not only designed as compact units for ongoing adjustment to changes in grid conditions but are also low-maintenance units with minimal service demands.

To reduce energy loss from long cables and extended grids, the voltage level should be maintained on the desired level. This can be done by means of voltage regulators. These tapped autotransformers are a highly reliable solution for stabilising voltage fluctuation in the grid. Siemens Energy voltage regulators come in 1-phase or 3-phase models. Different cooling systems are available, and the regulators can be applied to any electrical system to improve voltage quality.

In an increasingly complex power generation landscape and a growing energy market, the capability to control the flow of power is gaining crucial importance. This is the area where phase-shifting



Voltage regulator

Both Sensgear® and Sensformer® can be enhanced with a digital twin feature, which simulates the asset performance nearly in real-time, offering temporary overloads without compromising on lifetime

transformers are implemented into AC grids. They protect lines, make grids more reliable, reduce transmission losses and thus contribute to the reduction of CO₂ emissions. Phase-shifting transformers are among the most economical and cost-efficient solutions for power-flow management while avoiding expensive grid extensions.

Siemens Energy supports grid operators to increase transmission efficiency

Siemens Energy has been working hard to improve the efficiency of its products over the last decades. Great progress was made, and to date, large power transformers have peak efficiencies above 99.5%. Minimum energy efficiency requirements have even been defined by authorities (e.g., Eco design regulation (EU) No. 548/2014).

For transmitting a large amount of power over long distances, HVDC technology offers the most efficient means. The solution can also be used to connect asyn-

chronous grids. Siemens Energy offers a comprehensive portfolio of fit-to-purpose HVDC systems and necessary equipment, e.g., highly reliable and tailored-to-fit HVDC transformers and bushings.

Another essential lever in transmission efficiency is grid management – there, intelligent digital information systems act as a real accelerator. In 2020, Siemens Energy launched Sensproducts® as a consequent evolution of Sensformer®, digitally enabled transformers, and Sensgear® digitally enabled switchgear products. Sensproducts® combine status information of Sensformer® and Sensgear® and form an agile system intelligence platform for supporting system operators to manage grids and substations most efficiently. All assets of a high-voltage substation transmit data to a highly secure cloud-based platform that offers a near real-time information channel parallel to the SCADA (supervisory control and data acquisition)

system, a solution for control and protection of power grids. The collected data of Sensproducts® are analysed by expert algorithms offering enhanced substation reliability and increased asset productivity.

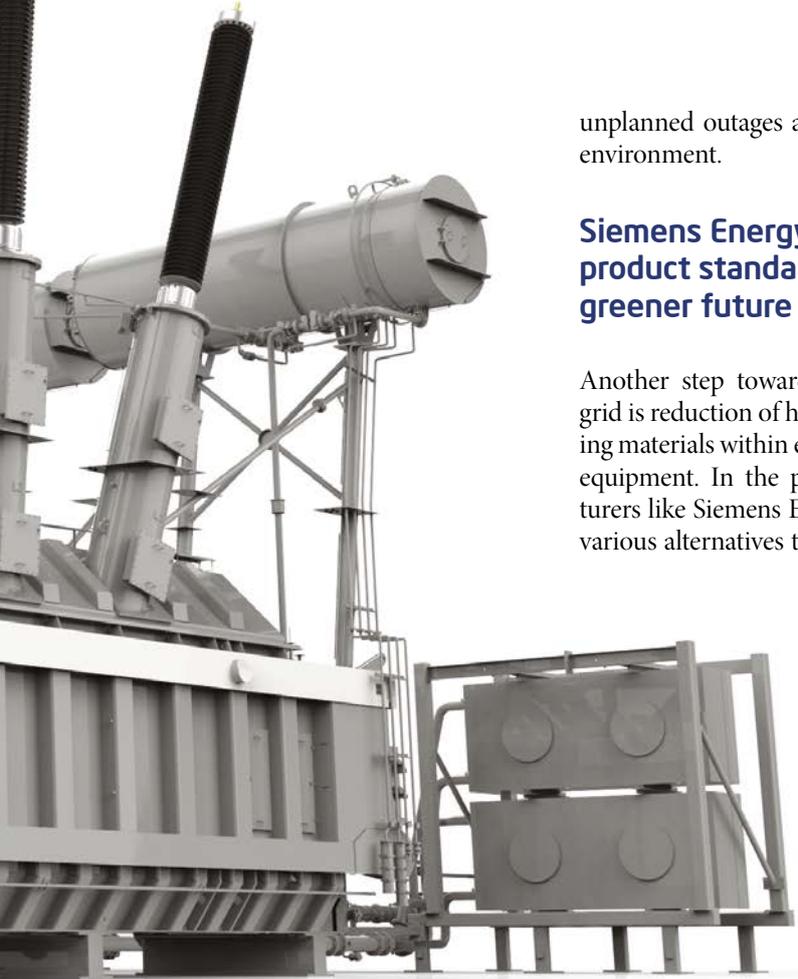
Both Sensgear® and Sensformer® can be enhanced with a digital twin feature, which virtually simulates the physical assets performance nearly in real-time to increase productivity and availability, offering temporary overloads without compromising on lifetime. This innovation acts as a facilitator for operators and managers, as it provides a life consumption view of the assets and a full temperature view of the transformer. In addition, the digitalisation of assets enables preventive detection of critical situations such as gas and oil leakages, thereby avoiding



Phase-shifting transformer



HDVC transformer



unplanned outages and emissions to the environment.

Siemens Energy goes beyond product standards for a greener future

Another step towards a greener power grid is reduction of hazardous and polluting materials within existing transmission equipment. In the past years, manufacturers like Siemens Energy came up with various alternatives that foster the transi-

tion to an environmentally conscious and greenhouse gas-reduced power transmission.

For centuries, power and distribution transformers have been filled with mineral oil for electrical insulation and cooling. However, if there is any leakage, it can be harmful to the environment and in combination with sparks and oxygen, easily combustible. Siemens Energy has been a leading transformer manufacturer using natural or synthetic esters instead of mineral oil. These biodegradable ester fluids are environmentally friendly, which makes them the first choice for places where high environmental standards are required, such as offshore wind platforms. Besides, ester fluids are extremely fire-safe due to high flame and flashpoint values and today also meet cold temperature environment specifications.

In 2020, Trench, a Siemens Energy subsidiary, launched the first ester-impregnated transformer bushings. These bushings are filled with synthetic ester as an insulating liquid, which ultimately



Transformer filled with eco-friendly ester oil

improves the aging resistance of the ester bushing portfolio and can prevent several well-known failure modes of conventional oil-impregnated bushings. Besides, they can mitigate the fire risk and have an improved thermal class allowing many options for overload operation. Both natural and synthetic esters

are biodegradable and thereby safe for the environment.

Another sustainable product is the dry-type transformer. The Siemens Energy GEAFFOL® cast-resin distribution transformers exceed the highest safety standards. They have excellent electrical, me-

chanical, and thermal characteristics and have also proven to be particularly compatible with the environment. With epoxy resin insulation instead of a liquid insulator, the GEAFFOL® transformers are flame resistant and self-extinguishing. They are also completely recyclable.



Trench products: blue instrument transformer w/o SF6 gas and ester-impregnated transformer bushings

SF6, the most popular gas to insulate instrument transformers, is a very potent greenhouse gas, with a global warming potential of 22,800 times that of CO2 over a 100-year period. Trench, a Siemens Energy subsidiary, is one step ahead and has introduced the world's first instrument transformers up to 420 kV with zero global warming potential during operation. These instrument transformers use clean air as an insulation medium – this is not only environmentally friendly and reducing the CO2 footprint, but also makes the products maintenance-free and suitable for low-temperature applications at -50 °C and below.

In 2020 Siemens Energy launched Pretact EcoSafeT™ - the world's first concept of a fire-safe and explosion-proof substation. It sets new standards in environment, health, and safety to achieve a reliable fire-

safe solution for the entire substation and all its products. Owing to its modular concept, customers can choose from different performance levels and features to adjust the products to specific environmental and safety needs.

The success of the energy transition depends on forward-thinking transmission OEMs - like Siemens Energy

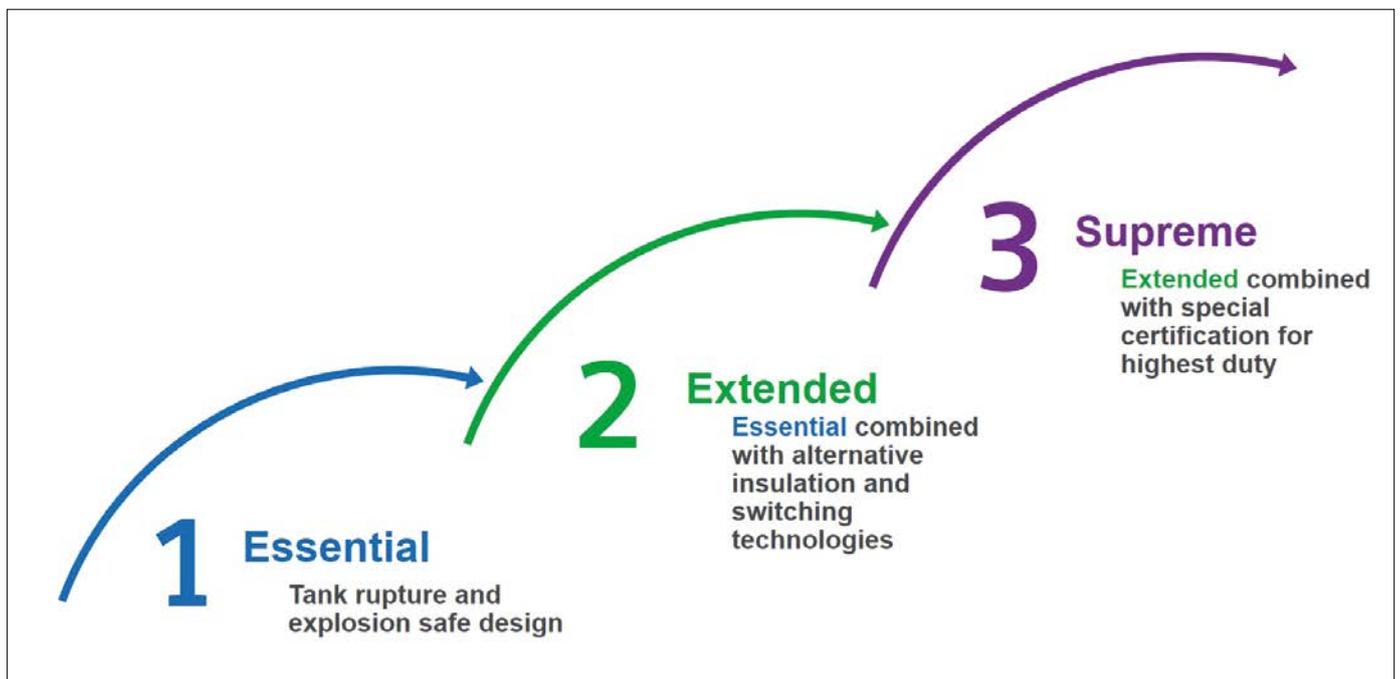
Energy transmission and distribution play a key role in a successful energy transition. Companies like Siemens Energy are expanding their transmission technologies and portfolio with high-efficient products that go beyond currently valid standards and enable the integration of renewables by innovative products for securing grid stability. At the same time, digitalisation is implemented to support smarter and more efficient utilisation of existing resources. With Sensformer® and Sensgear®, Siemens Energy is a pioneer in this area and is extending the portfolio rapidly.

The energy transition is a global task and demands the commitment of every individual. At the same time, everybody profits from it – individuals, societies, but also economies. The necessary technologies are already available or are proactively in development. Now it is up to all of us to speed up the implementation!



GEAFOLE® cast-resin distribution transformer

In 2020 Siemens Energy launched Pretact EcoSafeT™ - the world's first concept of a fire-safe and explosion-proof substation



Pretact EcoSafeT™ concept