CWIEME GLOBAL

LEADING THE GLOBAL ELECTRICAL ENGINEERING **REVOLUTION**

Market Report: Transformer Market and Component Developments

An analysis of the global transformer and components market, growth areas and trends - covering renewables integration, mineral oil alternatives, digitalisation, solid-state transformers and global market sizing.

A market report in partnership with:

Power Technology Research
Research | Analysis | Consulting

Coilwindingexpo.com

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Table of Contents

List of Figures

List of Tables

Definitions & Acronyms

APAC	Asia-Pacific
DISCOM	Distribution Company
EV	Electric Vehicle
EMEA	Europe, the Middle East & Africa
IEA	International Energy Agency
MEA	Middle East Africa
O&G	Oil and Gas
PCB	Polychlorinated Biphenyl
SST	Solid-stateTransformer
T&D	Transmission and Distribution
TYNDP	Ten Year Network Development Plan
Yoy	Year on Year

EXECUTIVE **SUMMARY**

The influence of COVID-19 on the global economy has been multi-dimensional, intricate, and far-reaching. With 2020 having recorded the sharpest GDP decline since the mid-20th century, the consequences of the global pandemic supersede those of the financial crisis ten years prior by far.

Even though the global economy shrank by 3.5% in 2020, repercussions were unevenly distributed across economies and industries. Unlike the goods trade, the services trade has continued to under perform due to the disproportionate impact of Covid-19 on sectors, such as travel, leisure and transport. From a geographical perspective, India and Europe have been affected the most as the economic recovery in these regions was slowed down by lockdown restrictions related to second and third waves of the pandemic. The energy sector experienced a significant slowdown in 2020 due to Covid-19. Within the energy sector, the T&D equipment market dropped by ~3% in 2020. The entire supply chain of the T&D market, including transformers, was severely disrupted, as decreased electricity demand translated to less revenue and thus less capital spending for utilities. According to the International Energy Agency (IEA), global electricity demand declined by ~1% in 2020, mostly in the first half of the year as lockdowns restricted both commercial and industrial activity.

Moving forward, the International Monetary Fund (IMF) has projected a rebound in the global economic output in 2021 - with a global GDP that is more than 2% above 2019 levels, thus compensating for the decline in 2020. Moreover, according to the IEA, global T&D investments in 2021 are even expected to surpass pre-pandemic levels. PTR forecasts that within T&D, the global transformer market will grow by 10% in 2021, propelled by major electrification and infrastructure projects in the Asia-Pacific (APAC) region and the Middle East.

MARKET **SNAPSHOT**

The global transformer market shrank to USD 23.3 billion in 2020, experiencing a significant drop of 11.7% compared to 2019. Accounting for almost 50% of the global transformer market in 2020, the APAC transformer market declined by nearly 8.5% yoy to USD 11.35 billion.

The European power and distribution transformer market amounted to over USD 2.08 billion and USD 950 million respectively in 2020. This was driven by new additions to renewables and increasing penetration of Electric Vehicle (EV) charging infrastructures.

The power transformer market in Middle East and Africa (MEA) reached USD 1.76 billion in 2020, largely owed to infrastructure and energy projects planned in the region, as oil rich countries are trying to diversify their economy by developing tourism hubs. In the Americas, Covid-19 has had the most detrimental impact on South America where the economy plunged by 7.4% in 2020, due to decreased investment, supply chain disruption, and soft global commodity prices. The markets for power transformers and distribution transformers in North America amounted to USD 3.36 billion and USD 1.47 billion in 2020, respectively, as preventive measures put in place buoyed the market.

Utilities have been revamping grids to future-proof their networks against the increased power flow resulting from renewable integration and EV penetration. The renewable sector was the only sector that proved immune, recording overall growth of 7% in 2020. Specifically, there was a 21% increase in global solar capacity addition and a 15% in wind capacity addition. The renewable sector is expected to drive more than half of the increase in global electricity supply in 2021, thus setting the foundation for investment surge especially in European markets. Moreover, rapid electrification of commercial vehicles, such as Light Commercial Vehicles (LCVs) and buses, is another key factor that will significantly drive the transformer market in the US, China, and Europe. PTR anticipates that EV fleets, including passenger and commercial vehicles, will grow with a CAGR of 42% from 2020-26.

DEFINITION OF TRANSFORMER **MARKET SEGMENT**

A transformer is defined as a passive electrical device that transfers electrical energy from one circuit to another through the phenomenon of electromagnetic induction. Transformers can either be used to increase ("step up") or decrease ("step down") the voltage between different circuits.

At power generation facilities, voltages are stepped up using transformers to minimize heat losses while transmitting electricity over long distances. This high voltage is then stepped down via T&D infrastructure to different low voltage levels depending on end user applications. The industrial segment also needs transformers to step down the voltage from the input feed to bring it to the level where it can be used on plant secondary distribution. However, energy intensive industries, like O&G and the steel and mining sector, use power transformers, while less energy intensive industries have distribution transformers.

This paper covers both power and distribution transformers irrespective of distinctions based upon types, such as oil-immersed, dry-type, single-phase, three-phase, pole-mounted, or pad-mounted. Power transformers are defined as transformers operating at a voltage level greater than 72kV while distribution transformers are defined as transformers operating at a voltage level 72kV or below. Also, the analysis in this paper only considers ex-factory cost for transformers, it does not consider logistics, installation & commissioning costs.

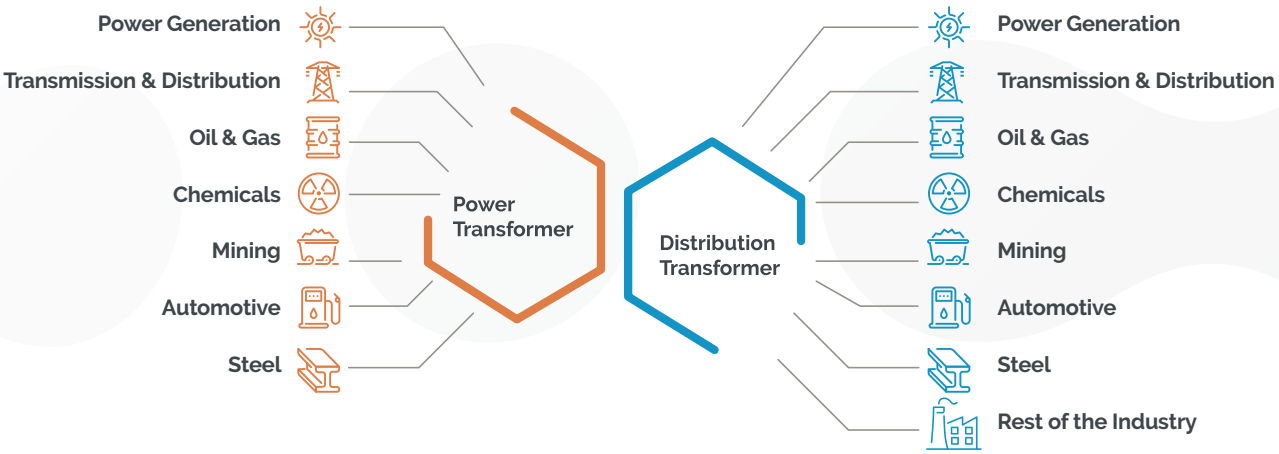


Fig 1. Covered Applications of Transformers

TRANSFORMER MARKET GLOBAL LANDSCAPE

Global demand for transformers also experienced a decline in 2020, shrinking to USD 23.3 billion, mainly due to the slowdown caused by the Covid-19 pandemic.

The contraction in 2020 affected all industries except the solar & wind energy sector. Of the total global transformer market, 31% is attributed to distribution transformers, including oil-immersed and dry-type transformers, while the remaining 69% is attributed to power transformers. Yoy, 2020 experienced a significant dip of 11.7% compared to 2019 primarily due to the economic slowdown in European countries and India caused by Covid-19. Power transformers only experienced a single digit decline of 6% (yoy) in 2020 owing to the fact that their demand is mainly coming from transmission and renewable sector only. The distribution transformer market is driven by utility distribution, power generation and industry. Covid-19 impacted all three areas (industry more than distribution and generation sectors), resulting in a massive drop of 19% (yoy) in distribution transformer market.

Electricity demand in Europe decreased by 3.5% in 2020 compared to the global decrease of 1% [1]. Close to 64% of global electricity demand is from industry, commercial and public services sectors, so economic activity is directly linked with electricity consumption. Lockdown measures significantly reduced electricity demand in many markets by 15% or more for several weeks in 2020 [1]. Utilities, which constitute more than 40% of the transformer OEMs' revenue, faced significant budget cuts and thus had to either cancel or delay planned T&D projects.

Global Opportunities

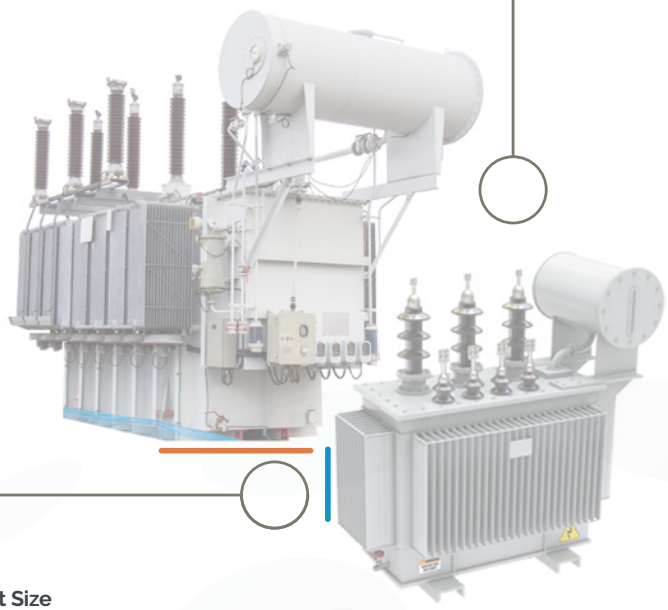
APAC: Electrification and urbanization are the two key factors driving the greenfield investments in the power grid for APAC.

Europe: Utilities are revamping their network infrastructure to cater for the massive renewable integration in the energy mix.

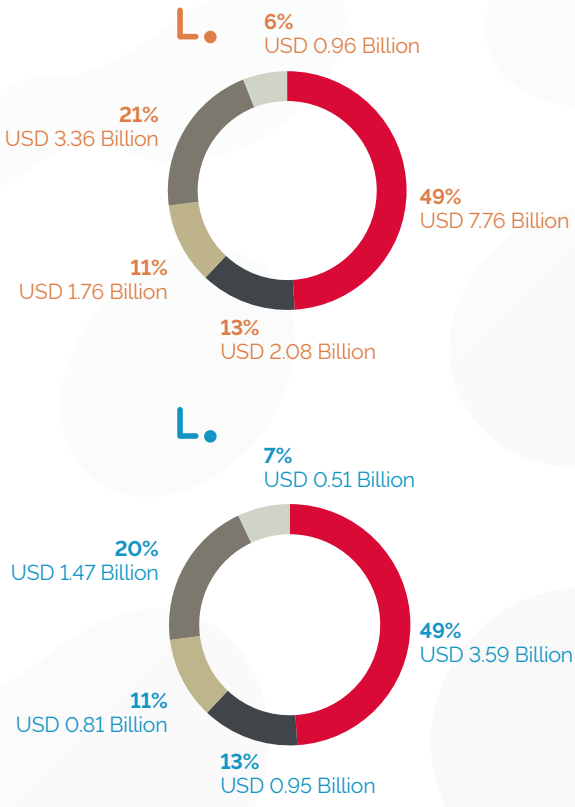
Middle-East Africa: Large infrastructure projects in the Middle East will drive the transformer market in the region.

North America: Replacements of aged grid infrastructure is the primary driver in the region.

South America: Electrification and digitalization are the key trends of the market.



Regional Market Size



Global Market Size

USD 15.98 Billion
USD 7.32 Billion

- **Power Transformer**
- **Distribution Transformer**
- South America
- North America
- Middle-East Africa
- Europe
- APAC

Fig 2. Global Transformers Market / Source: PTR

EUROPE, THE MIDDLE EAST & AFRICA

EMEA region accounted for the 24% of the global transformer market; further split into Europe (13%) and MEA (11%). The European power transformer market amounted to over USD 2.08 billion in revenue, while the distribution transformer market dropped to USD 950 million in 2020.

- The power transformer market in Germany, valued at USD 190 million, experienced a yoy dip of 8% due to significant slowdown in industrial activity including the automotive & machinery sector.
- The total transformer market in the UK was valued at USD 335 million in 2020, due to the dual effect of Covid-19 and Brexit. The UK witnessed a significant downward trend in every sector, apart from some growth in data centers.

Anticipating the ambitious renewable energy targets set in the region to combat climate change and the ever-increasing trend of EVs, many European utilities are undergoing major expansion plans to futureproof their network against increased power flow. Moreover, 50 GW cross border capacity additions by 2030 and 180 transmission and storage projects assessed in Europe's 10-year TYNDP for 2021-30 are also expected to lay the foundation for increased investment in the region.

The MEA power transformer market reached USD 1.76 billion in 2020, driven by ambitious infrastructure projects in the Middle East and electrification projects in Africa. For the first time, solar generation has also been instigating demand for transformers in the oil rich countries of the Middle East.

- Saudi Arabia is the biggest market in MEA, accounting for about 17% of the regional transformers demand in 2020. There has been a declining trend in transformer demand as infrastructure projects were put on hold owing to the lack of funding which in turn were due to significant cuts in oil production as part of the OPEC+ Agreement. The recent slump in oil prices amid Covid-19 has further decreased the transformer market to USD 300 million in 2020. Nevertheless, a high penetration of renewables into the grid infrastructure along with development of various mega projects, under Vision 2030, will fuel the demand for both power and distribution transformers, leading to growth in the upcoming years.

AMERICAS

The Americas totaled 27% of the global transformer revenue; with North America accounting for almost 20% of the global market. As a consequence of the Covid-19 pandemic and the subsequent preventive measures, the power and distribution transformer market in North America was USD 3.36 billion and USD 1.47 billion respectively in 2020.

- The total transformer market in United States was greater than USD 3.76 billion in 2020, primarily driven by replacements of aging grid infrastructure. In the United States, industry only accounts for 20% of electricity demand, while the services sector accounts for almost 40% [1]. This led to a more pronounced impact on total electricity demand, as non-essential services were hit the hardest by lockdown measures and thus resulting in subdued transformer demand. However, under Biden's administration, USD 8 billion plan (in the form of loans) has recently been rolled out for the U.S. power grid industry to modernize the nation's aging grid infrastructure. To meet the clean electricity target by 2035, significant capacity additions are expected in the renewable sector, thus driving the U.S. transformer market.
- Out of all the regions within the Americas, Covid-19 impacted South America the most. South America where the economy plunged by 7.4% in 2020. Brazil's power transformer market shrank by 8% yoy to USD 460 million, due to economic slowdown caused by multiple lockdowns, plunging investment, supply chain disruptions, and soft global commodity prices.

ASIA PACIFIC

The APAC region accounted for the largest portion of the global transformer market with 49% (USD 11.35 billion). The transformer market in APAC countries is faring relatively well when compared to the rest of the world.

- The power & distribution transformer market in China decreased to USD 2.79 billion and USD 1.2 billion, respectively - not only due to Covid-19, but also due to the completion of large rural electrification projects.
- India's transformer market was USD 2 billion in 2020 following strict lockdown measures and limited stimulus spending. Challenges concerning the financial health of state-owned companies responsible for the distribution and sale of electricity (DISCOMs) persist, hampering faster growth of their network. The Covid-19 crisis has put additional pressure on DISCOMs and therefore on the transformer market. Distribution companies in India have suffered an estimated net revenue loss of USD 3.5 to 4 billion in lieu of the Covid-19 pandemic. India missed its grid capacity addition target by a significant margin since only 53% (33,120 MVA) transformation capacity was added against annual target of 63,050 MVA in the first three quarters of FY20-21 [3]. The distribution transformer market in India experienced a significant dip of ~43% (yoy) in Apr-Dec 2020, while power transformer market declined by ~16% (yoy) for the same period [3].

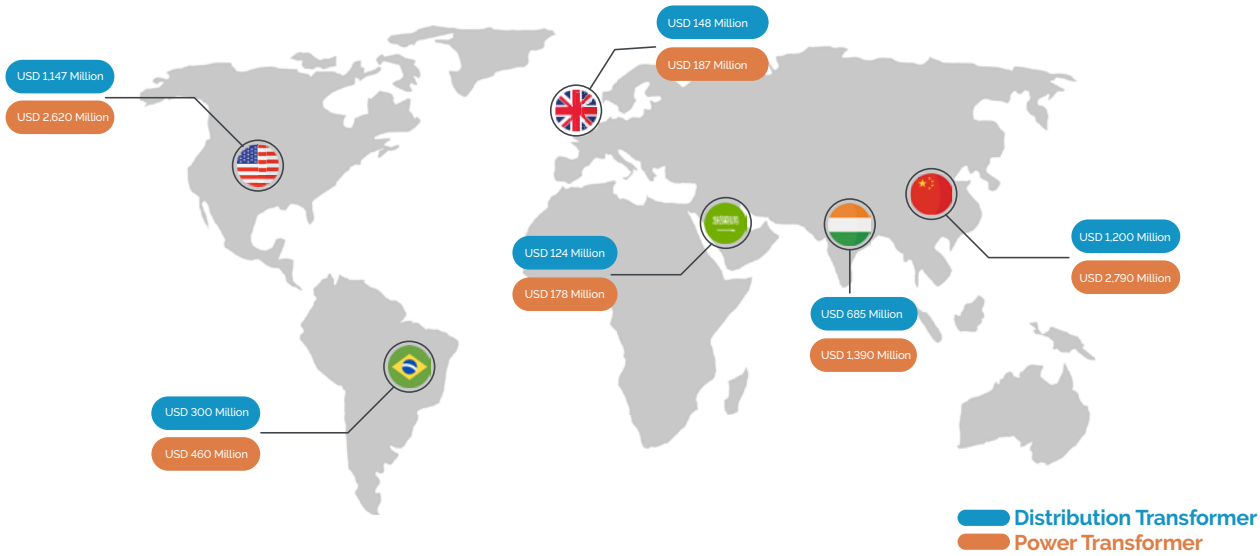


Fig 3. Key Transformer Markets / Source: PTR

COVID-19 PANDEMIC

Covid-19 not only adversely affected OEMs, but also their customers and suppliers throughout the supply chain.

The repercussions of Covid-19 on the transformer market varied across the regions and countries owing to different lockdown measures imposed by the respective governments. OEMs faced a decline in transformer demand either due to cancellation or delay of the planned projects in 2020.

Globally, investment in the T&D sector has been experiencing a negative trend since 2017, with a decline of 8% in 2019. In 2020, it further declined by 3% (yoy) in response to the economic crisis caused by the Covid-19 pandemic [4]. The U.S. and Europe were the outliers in 2020 with positive T&D sector investment (+8%), partially compensating for a significant investment drop (-16%) from rest of the world [4]. After the completion of rural electrification projects in the distribution sector of China, focus of the T&D sector investment shifted towards the transmission sector which represents a smaller share of the total grid investment and resulted in a decline of 8%. Consequently, for the first time in the decade, T&D spend of the U.S. surpassed China's spend in 2020. In contrast to developed economies, T&D investment dropped significantly more in emerging and developing economies, where development funds were steered from T&D towards the health sector. Moving forward, large grid expansion plans in China and Europe are likely to reverse the decreasing trend of global T&D sector investments in 2021, even surpassing the pre-pandemic level.

Regarding the supply chain, lead times of power transformers increased by 3-4 months due to a shortage of freight services. Capacity utilization of transformer manufacturing facilities decreased by approximately 20% globally, due to lockdowns or other forms of restrictions, and raw material prices rose mostly due to higher freight costs.

2021 OUTLOOK

While the global health crisis lingers in the first half of 2021 with second and even third waves of the virus in many regions, accelerating vaccine rollouts and major stimulus packages in many advanced economies have provided a beacon of hope. PTR anticipates the global transformer market will grow by 10% in 2021, propelled by growth in APAC and the Middle East.

- China limited the virus spread at early stages and was one of the few economies to report a positive economic growth in 2020. Dynamic growth for transformers is expected to continue through 2021, driven by exports, but especially by domestic demand, including government funded infrastructure projects. The outlook significantly improved at the end of the year, driven by recovering industrial production.
- Early estimates project India's transformer market growth in 2021 will compensate for the 2020 decline, although significant uncertainties remain linked to the evolution of infections and the rollout of vaccines.
- The transformer market in the USA is projected to reach pre-pandemic levels owing to the American Rescue Plan ('the Biden stimulus') and a successful vaccine program.
- Major European markets - Germany, France, and Spain - are anticipated to be back to 2019 levels as the utility and generation sectors ramp up investments, compensating for the decline in 2020.

KEY MARKET TRENDS

Renewables Penetration

Aggressive growth of renewable energy sources is mainly attributed to Green Energy Targets. Wind and solar energy will drive the transformer market.

Mineral Oil Alternative - Ester Oil

Key factors pushing the adoption of ester oil:
> Improved fire safety
> Eco-sustainability

Digitalization of Transformers

Online asset health monitoring is becoming vital in many key markets. Transformer intelligence enabling management to make informed maintenance decisions.

Solid-state Transformers

> Low weight/volume ratio
> High power density

Fig 4. Key Market Trends (2020)

RENEWABLES PENETRATION

After the landmark Paris Agreement, governments around the world have set ambitious renewable energy targets to combat climate change by reducing their carbon footprint. The electrical industry is also playing its part by strongly pushing the integration of renewables into the power grid - reducing the detrimental impact of conventional fossil fuel-based electricity generation (especially coal) on the environment.

Renewables have proven immune to the Covid-19 pandemic, as capacity additions increased to over 100 GW in 2020 - largely owing to rushed completion of projects before subsidy phase-out deadlines [1]. Such policy deadlines in China and the United States drove developers to complete a record number of projects in the late 2020. One was China's onshore wind projects that qualified FITs in 2018/2019 and that were under the very tight commissioning deadline of 31 December 2020. Long-term contracts, priority access to the grid, and continuous installation of new plants underpinned renewables' growth in 2020, despite decreased electricity demand, supply chain disruptions, and construction delays in many parts of the world.

Investment in the renewable sector increased by around 7% in 2020 compared with 2019, despite economic slowdown resulting from Covid-19 [4]. The share of renewables in total power sector spending (including network infrastructure) was about 45% in 2020, largely resulting from wind power installations, especially in China & the U.S [4]. An astonishing 72 GW of new wind power capacity was brought online in China, followed by the U.S. which connected more than 15 GW of onshore wind [5]. Globally, wind capacity addition almost doubled in 2020 compared to 2019, to 111 GW, while solar PV addition also expanded by almost a quarter, reaching 127 GW [5].

According to the IEA, electricity generation from renewables is set to further expand by more than 8% in 2021, reaching 8300 TWh [1]. Renewables are driving more than half of the increase in global electricity supply in 2021 and renewables' share of electricity generation is projected to reach almost 30%; with solar and wind expected to account for two thirds of the growth [1]. China alone is likely to account for almost half of the global increase in renewable electricity in 2021, followed by the United States, the European Union and India.

The transformer industry has also been significantly fueled by the penetration of renewables, as utilities around the globe have revamped their T&D infrastructure to cater to these new power additions being injected into the grid. Significant capacity additions of renewables are projected in the APAC and European region by 2025, making them hotspots for transformer suppliers. Countries in Southeast Asia aim to have a combined target of 35% renewables in the electricity mix by 2025.. It is estimated that this will create new capacity of 150 GVA in the region. Similarly, India's transformation towards cleaner electricity is expected to add 1,270 GVA network capacity by 2030. OEMs offering transformers that are compatible with the variable duty cycle of renewables (wind & solar) and are also able to sustain longer operation of peak load, will be able to capture the majority of the market share.

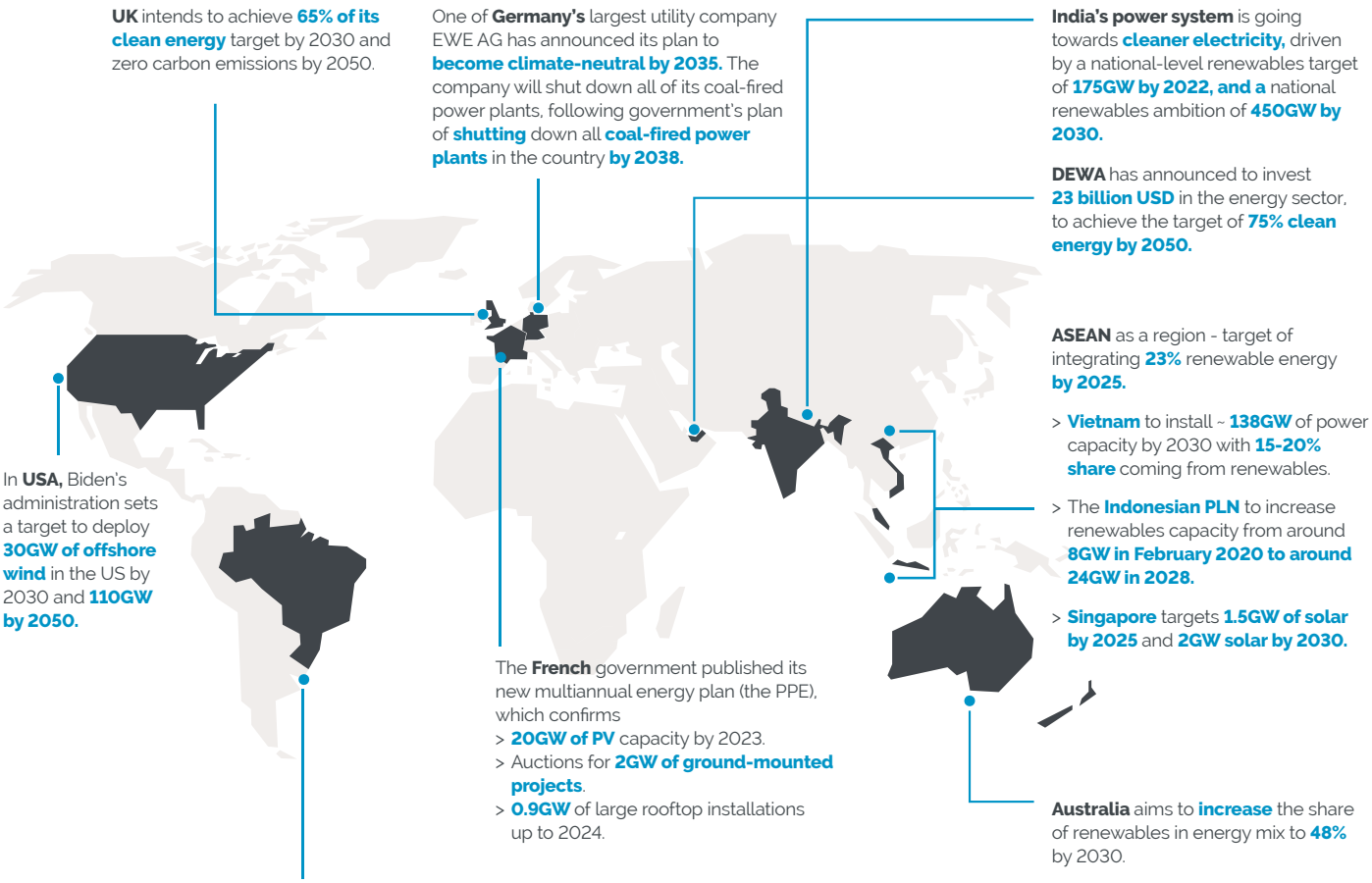


Fig 5. Renewable Energy Targets

MINERAL OIL ALTERNATIVE – ESTER

Mineral oil has been used for transformer insulation and cooling since the early days of electrical networks. While mineral oil is an effective coolant and dielectric medium, it has a relatively high potential to catch fire - being an energy rich fuel - compared to its alternatives.

Moreover, due to its non-biodegradable nature, it can be harmful to the environment if a significant quantity of it gets released into the surroundings.

Today, ester-based alternative insulation fluids are being offered in the market which claim to provide a more eco-friendly solution with better insulating properties. A comparison between the properties of ester and mineral oils is presented in the table below:

PROPERTY		Mineral Oil	Natural Ester	Synthetic Ester
	Fire Point	180°C	360°C	310°C
	Flash Point	160°C	330°C	260°C
	Biodegradility	No	Ultimately	Readily
	Toxicity	Toxic	Non-Toxic	Less Toxic
	Viscosity @ 40°C (cSt)	12	37	29
	Thermal Aging	Good	Better	Best

Tbl 1. Properties Comparison of Mineral Oil vs. Ester ⁄ Source: Manufacturers Websites

Synthetic ester was developed in the late 1970s to replace PCB based fluids in transformers where high levels of fire safety were vital. Later in the 1990s, natural esters, based on renewable seed oils, were introduced to the transformer market as an eco-friendly solution. Natural esters are better suited for use in sealed transformers, while synthetic esters are suitable for both sealed and breathing type transformers. Despite the fact that both synthetic and natural ester have been developed in parallel over the decades, natural ester-based power transformers have a majority market share in the Americas compared to synthetic ester while in Europe, synthetic ester dominates. Moreover, synthetic ester is used in new transformer installations rather than retrofilling the older transformer units.

Fire safety and environmental considerations are two key factors driving end-users to switch towards ester-based transformers. There have been numerous instances of large mineral oil transformer fires causing substantial damage to both the assets and the surrounding environment. Recently, in April 2021, a transformer fire at a substation in New York caused a reported damage of USD 25,000 despite the fact that it did not result in any major power outages. To ensure the safety of operating personnel and to prevent environmental damage, regulatory bodies have devised fire safety regulations around transformer installations. These have become stricter with time and they incentivize utilities to adopt ester-based transformers. At a historical site in London, five mineral oil transformers were recently retrofilled with synthetic ester since the installation no longer complied with existing regulation (BS EN 61936-1:2010). The regulation had changed over the years, to improve fire protection and satisfy the need for containment.

Dry-type transformers are generally preferred over oil type transformers for indoor installations in critical facilities like hospitals, airports, public buildings, and offshore O&G platforms, where fire safety is of utmost importance. However, moving forward, ester-based transformers which have better fire-resistant properties, are expected to penetrate the dry-type transformer market as well. Globally, PTR anticipates that ester-based transformers will play a significant role in shifting market share away from dry-type transformers.

Global Distribution Transformers
Annual Market (Revenue) - 2020

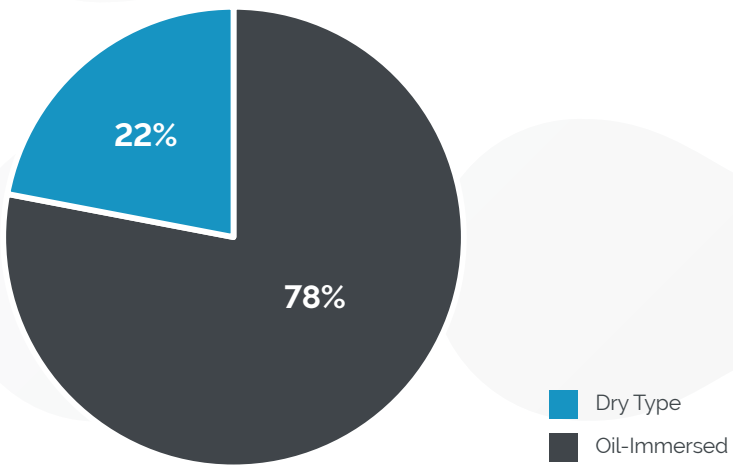


Fig 6. Global Distribution Transformers Annual Market - 2020 / Source: PTR

In addition to only a few suppliers offering ester-based solutions, cost is the major factor limiting the more widespread adoption of ester-based transformers. The price of ester-based transformers can be up to 20% higher than that of conventional mineral oil transformers.

Many utilities have performed a life-cycle cost analysis to validate the economic feasibility of integrating ester-based transformers in their networks:

- A leading utility in the U.S estimated a 33% increase in the lifetime of new transformers that are filled with ester.
- Significant savings can be made in the overall installation costs of ester-based transformers by removing active fire suppression systems like deluge valves etc. which are no longer required due to the inherent fire safety associated with ester.
- Similarly, with ester-based fluid, multiple transformers can be installed in a single housing, significantly cutting down civil engineering costs.
- Furthermore, the advanced thermal properties of ester allow OEMs to design more compact transformers - providing a higher kVA rating from a reduced footprint, thus contributing towards lower manufacturing cost.

Factoring the removal of fire safety systems, reduction in civil engineering costs and longer lifespan of ester filled transformers, PTR anticipates aggressive penetration of ester-based solutions in the coming decade.

DIGITALIZATION OF TRANSFORMERS

Transformers that are currently in operation were mostly fitted with basic sensors at the time of commissioning. These sensors, at best, alert the operators after reaching a certain setpoint when the transformer has already started to deteriorate.

Therefore, it is an operational requirement to continuously monitor the transformer's health to ensure reliability and this can be a cumbersome task. The traditional approach to avoiding unexpected transformer failures was to inspect periodically and perform preventive maintenance. However, in recent years, developments in cost-effective and reliable sensing solutions have proven to be promising in providing asset managers with actionable, intelligent data. According to the U.S. Department of Energy, utilities were able to eliminate transformer failures by 75% after implementing predictive maintenance based on digitalization.

Timely and accurate information based on real-time transformer health parameters can be provided to help in making informed decisions regarding trade-offs between loading and aging. According to a study conducted by an independent consulting & engineering services company, failure rates of the transformer were reduced by almost 40%, and life expectancy was increased by up to 50% in a digitally enabled distribution transformer with online monitoring capability. The actionable intelligence delivered by digital transformers will allow utilities to perform condition-based maintenance, instead of time-based maintenance, thus optimizing their operations, and reducing routine maintenance costs by almost 50%.

Power grid dynamics are also expected to change significantly owing to the wide-scale adoption of EVs and the dramatic growth of EV charging infrastructures. A study was conducted by a leading utility in the U.S. to anticipate future necessary investments required in its network and prepare itself for increased EVs integration. According to the study, up to 17% (12000) of service transformers in the utility's network needed to be replaced by 2030, due to overloading. This reflects a transformer replacement cost of about USD 100 per EV [6]. At present, most of the utility grids have sufficient hosting capacity, but an increase of EVs would escalate the peak load demand, thus overloading the transformer, accelerating transformer aging, and eventually the utility's network would have to upgrade.

Depending on the accessibility, EV chargers can be categorized as private and public; private charging infrastructure is typically installed inside homes, offices and for depot applications such as chargers for e-buses, e-trucks, and e-light commercial vehicles, while public charging infrastructure is available on roads, highways, gas stations, supermarkets, and airport etc. With more and more electric passenger vehicles on the road, the need for higher charging power and reduced charging time is growing exponentially. Typically, AC and low power DC chargers do not require grid upgrades, however, grid upgradation is needed for charging hubs where total charging capacity reaches 1 MW or higher. PTR anticipates rapid electrification of commercial vehicles and buses in the U.S. and European region in near future which will significantly drive the transformer market.

Simulating the aging trend of a typical distribution transformer with various EV penetration ratios showed that an EV penetration ratio of up to 30% could accelerate distribution transformer aging by almost 40% - compared to the case without EV charging. Moreover, transformer aging is sensitive, not only to a high number of EV charging points, but also to charging rates; DC chargers with high charging ramp rates are expected to have a more detrimental impact on transformer's health, compared to relatively slow AC chargers. Thus, the specifications for transformers coming online nowadays will need to allow for high EV charging loads, especially by fast DC charging points, to avoid the possibility of replacing or upgrading the transformers after a short time. According to PTR, DC charging points are expected to penetrate the EV charging market with a significant CAGR of 28.9% from 2020-26.

EV Charging Points

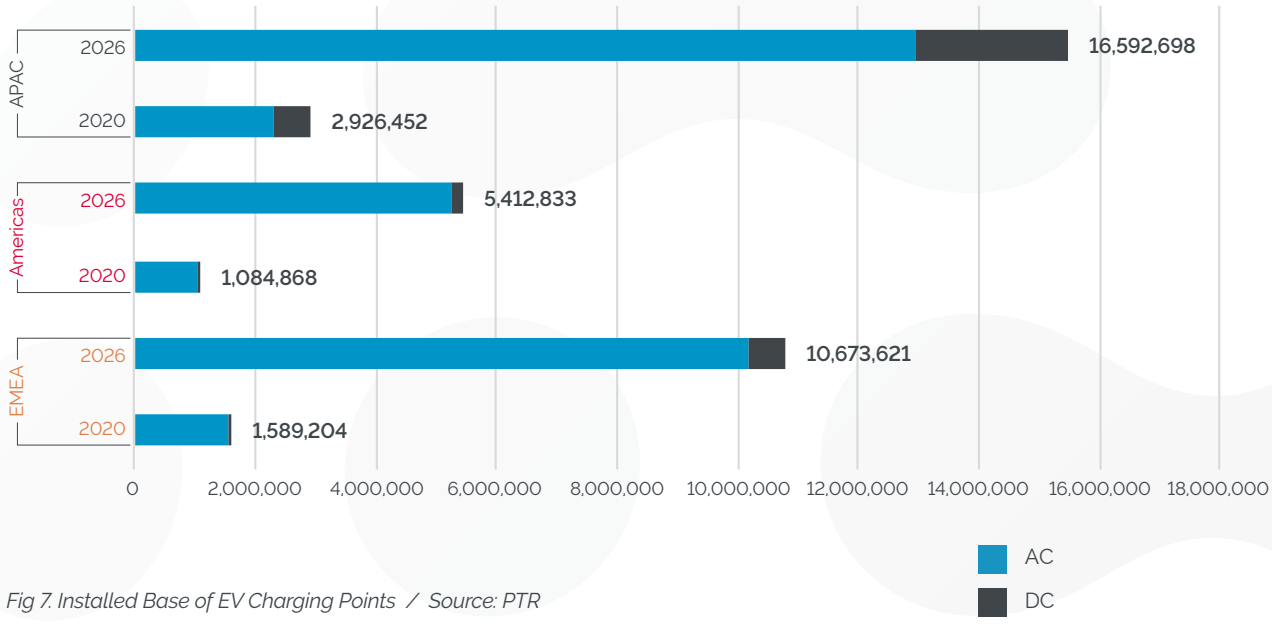


Fig 7. Installed Base of EV Charging Points / Source: PTR

SOLID-STATE TRANSFORMERS

The power grid is currently undergoing significant modernization, driven by changing demand patterns, broader electrification, EV penetration, adoption of energy-efficient technologies, and the integration of variable renewable energy sources.

All these trends have put the reliability of the outdated grid infrastructure in jeopardy. This is due to altering power flow dynamics and physical phenomena, as the network was not initially designed to accommodate the current advancements. To address these vulnerabilities, OEMs have been pursuing active transformer control technologies for online monitoring, analysis, and control of network parameters. Hitachi ABB Power Grids, for example, is collaborating with a leading research-intensive university in Singapore Nanyang Technological University, Singapore (NTU Singapore), to advance developments in SST technology.

Some advantages of SST over conventional transformers include reactive power compensation, harmonic distortion reduction, smart protection, fault ride-through control, and interconnecting networks of different frequencies and voltages. The main advantage though is a reduction in its size, weight, and volume. About half of electrical losses and one-third of weight and volume reduction have been reported for SST compared to conventional transformers in AC/DC applications. The lower weight/volume ratio and high-power density feature have instigated the high use of SSTs for high-speed trains and high-power electric locomotives. Furthermore, new types of high-speed traction drive systems, requiring an inverter unit, a solid-state transformer, a traction motor, and other key components are expected to drive the global market for solid-state transformers this decade.

Another major application, benefitting from the flexibility and controllability of SSTs, is wind turbines. Voltage fluctuations caused by the intermittent nature of wind energy can be suppressed by SSTs without requiring an additional reactive power compensator. Typically, wind energy is transferred by a step-up transformer to STATCOMs to improve the power factor before feeding to a grid. SSTs can prove instrumental in replacing both conventional transformers and STATCOMs by playing a dual role with improved reactive power compensation. With China and India markets at the forefront, APAC is anticipated to provide significant growth opportunities to the solid-state transformer market, considering the planned wind energy projects in the region.

Global Wind Capacity Additions
(2020-2026)

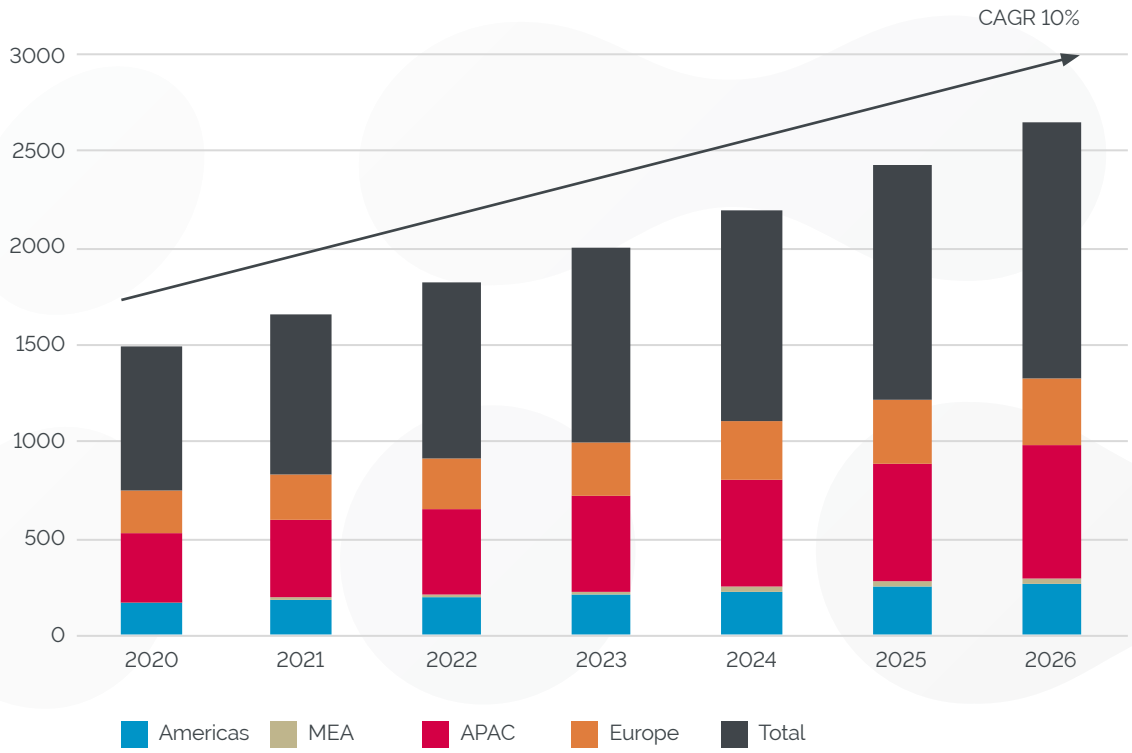


Fig 8. Global Wind Capacity Additions (2020-2026) / Source: GWEC

CONCLUSION

The effect of Covid-19 on the transformer market has been multi-dimensional, intricate, and far-reaching, impacting the global economy and trickling down to the energy sector, particularly the power grid market. In absolute terms, the global transformer market is expected to bounce back almost to its 2019 level by the end of 2021.

Moreover, delays in lead times and supply chain constraints experienced in 2020 have mostly returned to normal, providing an optimistic outlook for 2021.

Grid dynamics are changing drastically owing to aggressive penetration of renewables and EVs, forcing the utilities to opt for active power control technologies. Anticipating this, OEMs are investing heavily in developing cutting edge technologies for transformers. Eco-sustainability, digitalization and SST technology are key trends seen in the transformer market.

Factoring in the removal of fire safety systems, the reduction in civil engineering costs and longer lifespans of ester oil-based transformers, this option will present an eco-sustainable choice. PTR anticipates aggressive penetration of ester oil-based solutions in the coming decade.

Digitalization enables utilities to operate transformers for short or long-term above nameplate ratings. By utilizing optimal thermal conditions, monitoring vital parameters with smart sensors, and making informed management decisions, utilities can prevent over-capacity specification of transformers during the tendering process.

Despite the flexibility and potential benefits being offered for grid modernization, SSTs have a higher cost and a reduced lifespan. This presents a challenge to the wide scale adoption of SSTs to-date. OEMs are collaborating with academia to improve the features and services available in SSTs. Improved functionalities, such as integration with EV chargers, can potentially strengthen the business case of replacing conventional transformers with SSTs in the coming years.

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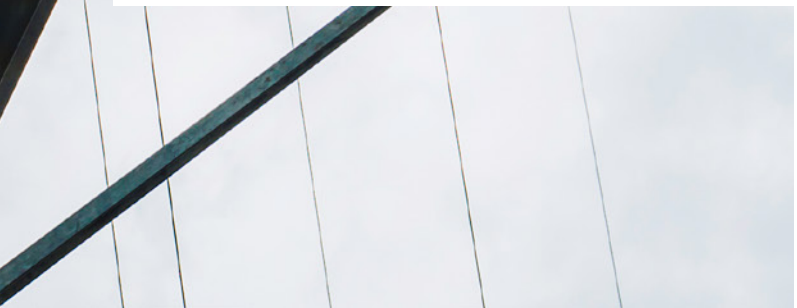

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