

# **Solid-State Transformer Market – Global Industry Size, Share, Trends, Opportunity, and Forecast Segmented by Application (Smart Grid, Traction, and Other Applications), By Region, By Competition 2018-2028.**

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## **Abstracts**

Global Solid-State Transformer Market was valued at USD 203.67 Million in 2022 and is anticipated to project robust growth in the forecast period with a CAGR of 15.38% through 2028, the solid-state transformer market in the United States and Canada was impacted by the COVID-19 pandemic. During the pandemic, several transmission and renewable projects were delayed, causing a decrease in the demand for transformers. For instance, in 2020, Greek industrial group Mytilineos' turnover from its renewables and storage development decreased by 40% due to contracting and construction delays caused by the pandemic. Increasing integration of renewable energy in the power generation mix and increasing investment in smart grid technologies are expected to drive the market during the forecast period. The technical advantages of solid-state transformers over conventional transformers are likely to drive the market.

### **Key Market Drivers**

#### **Integration of Renewable Energy**

The integration of renewable energy sources into the global power grid is a transformative force, and it is significantly driving the growth of the global solid-state transformer market. As the world intensifies its efforts to reduce carbon emissions and transition to more sustainable energy systems, solid-state transformers are emerging as a critical enabling technology for efficiently incorporating renewable energy sources like wind and solar power into the grid. Renewable energy, notably solar and wind, is inherently intermittent and variable, posing challenges to grid stability and energy

management. Solid-state transformers are poised to address these challenges by providing several key benefits,

**Efficiency and Energy Management:** Solid-state transformers are highly efficient in converting and distributing electricity. They allow for precise control and management of energy flow, making it easier to harness and optimize energy generated from renewables. **Voltage Control:** Solid-state transformers offer better voltage control and regulation, which is essential for accommodating the intermittent nature of renewables. This capability ensures a stable and reliable power supply to the grid. **Grid Resilience:** The adaptability and fault-tolerant nature of solid-state transformers enhance grid resilience. They can quickly respond to disruptions and ensure continued power supply even in the presence of intermittent renewable sources.

**Bidirectional Power Flow:** Solid-state transformers can efficiently manage bidirectional power flow, enabling surplus energy generated by renewables to be injected into the grid and facilitating the implementation of energy storage systems. **Grid Integration:** These transformers facilitate seamless integration of renewable energy sources by synchronizing them with the existing grid, ensuring a smooth transition to a greener energy mix. **Compact Design:** Solid-state transformers are typically smaller and lighter than conventional transformers, making them suitable for distributed energy systems, which are often associated with renewable energy installations.

Government policies, incentives, and environmental regulations aimed at reducing carbon emissions and promoting the adoption of renewable energy are also driving the demand for solid-state transformers. These policies encourage the modernization of the power grid and the deployment of technologies that enable the effective use of renewables. In summary, the integration of renewable energy is a compelling driver for the global solid-state transformer market. As the world shifts towards cleaner and more sustainable energy sources, these advanced transformers are essential in enhancing the efficiency, reliability, and grid stability necessary to accommodate renewable power sources effectively. This shift represents a crucial step in the journey toward a greener and more resilient global energy infrastructure.

## Electric Vehicle (EV) Charging Infrastructure

**Electric Vehicle (EV) Charging Infrastructure Driving the Global Solid-State Transformer Market** The rapid global transition to electric vehicles (EVs) has given rise to a pressing need for efficient and high-power EV charging infrastructure. This need is a significant driving force behind the growth of the global solid-state transformer market. Solid-state

transformers, with their advanced technology and capabilities, are poised to play a pivotal role in the expansion and improvement of EV charging networks. EV adoption is on the rise, with governments, industries, and consumers recognizing the environmental and economic benefits of electric vehicles. As EV sales surge, the demand for faster and more reliable charging solutions grows in tandem. Traditional transformers used in power distribution are often ill-equipped to meet the high-power demands of fast-charging stations, leading to energy losses and reliability issues.

Solid-state transformers are the solution to these challenges. They offer several key advantages that make them ideal for EV charging infrastructure. These advantages include high efficiency, reduced size and weight, enhanced power quality, and adaptability to fluctuating power demands. By efficiently converting and distributing power, solid-state transformers enable faster and more reliable EV charging, addressing the range anxiety associated with electric vehicles. They also reduce the environmental impact of charging infrastructure by minimizing energy losses, contributing to a more sustainable transportation ecosystem.

Furthermore, solid-state transformers are capable of bidirectional power flow, allowing them to integrate with the grid seamlessly. This feature opens the door to vehicle-to-grid (V2G) technology, enabling EVs to serve as grid resources and stabilize the grid during peak demand periods.

Government incentives and regulations promoting the adoption of EVs and cleaner transportation further bolster the demand for advanced charging infrastructure, further fueling the solid-state transformer market's growth. In conclusion, the expansion of electric vehicle charging infrastructure is a driving force behind the global solid-state transformer market. As the world embraces EVs and their associated benefits, the need for efficient, high-power charging solutions is clear, and solid-state transformers are poised to revolutionize the industry by ensuring faster, more reliable, and eco-friendly EV charging networks. This market evolution represents a critical step towards a more sustainable and electrified future.

## Key Market Challenges

### Reliability and Durability

Reliability and durability are two critical factors that can pose significant challenges to the growth of the global solid-state transformer market. While solid-state transformers offer numerous benefits, including enhanced efficiency and adaptability, their long-term

performance and ability to withstand the rigors of real-world grid environments remain subjects of concern. The following points outline the challenges related to the reliability and durability of solid-state transformers, Testing and Validation: Solid-state transformers require extensive testing and validation under various operational conditions to ensure their long-term reliability. This process is resource-intensive, time-consuming, and essential to demonstrate that these transformers can perform consistently and safely throughout their operational lifespan.

**Environmental Considerations:** The environment in which solid-state transformers operate can be harsh, with fluctuations in temperature, humidity, and exposure to contaminants. Ensuring that these transformers can withstand such conditions and maintain optimal performance is crucial. **Complex Electronics:** Solid-state transformers are intricate electronic devices with a multitude of components. The complexity of these systems increases the likelihood of component failures, which can affect the overall reliability of the transformer.

**Longevity:** Traditional transformers have a proven track record of longevity, with many units operating reliably for decades. Demonstrating that solid-state transformers can offer a similar level of long-term service without significant degradation remains a challenge. **Manufacturability:** Ensuring consistent quality and reliability in large-scale manufacturing of solid-state transformers is not a straightforward task. Variability in manufacturing processes can lead to differences in performance and reliability across units.

**Standardization:** The lack of standardized components and design in the solid-state transformer market can hinder reliability and interoperability. Standardization is essential for ensuring that components from different manufacturers can work seamlessly together. **Safety Concerns:** Ensuring the safety of solid-state transformers throughout their operational life is paramount. Failures or malfunctions can lead to safety hazards, which can be a deterrent for widespread adoption.

**Legacy Grid Integration:** Integrating solid-state transformers into existing grids designed for traditional transformers can be challenging. Compatibility issues can affect their overall reliability and performance in these legacy systems. **Maintenance and Repair:** Solid-state transformers, with their complex electronic components, may require specialized maintenance and repair skills. Availability of a skilled workforce and a well-defined maintenance protocol are crucial for ensuring reliability.

**Quality Control:** Maintaining strict quality control throughout the manufacturing process

is essential for producing reliable solid-state transformers. Any lapses in quality control can lead to performance issues and failures. Addressing these reliability and durability challenges requires rigorous research, development, and testing. Industry players, research institutions, and governments are investing in these efforts to refine the technology and provide solutions that can demonstrate solid-state transformers' long-term reliability and durability. As the technology matures and accumulates a track record of successful performance in real-world scenarios, confidence in its reliability is likely to grow, potentially driving wider adoption in the global energy landscape. Nonetheless, achieving this level of reliability and durability is an ongoing and evolving process.

### Technological Maturity

The technological maturity, or rather the lack thereof, is a critical challenge that can hamper the growth and adoption of the global solid-state transformer market. Solid-state transformers represent a significant technological leap over traditional transformers, but their development and deployment are still in the relatively early stages. This immaturity presents several key obstacles to their widespread use. **Reliability and Longevity:** Solid-state transformers must demonstrate long-term reliability and durability to gain the trust of utilities and industries. Traditional transformers have decades of proven performance, while solid-state transformers need to accumulate a similar track record.

**Testing and Validation:** Rigorous testing and validation are essential to ensure the safe and reliable operation of solid-state transformers under various operating conditions. Developing comprehensive testing protocols and facilities can be time-consuming and resource-intensive. **Standardization:** The lack of standardized solid-state transformer components and system architectures can hinder widespread adoption. Standardization is vital for ensuring compatibility, interoperability, and ease of integration into existing grids and infrastructure.

**Complexity:** Solid-state transformers are intricate electronic devices with many sensitive components. Their complexity can lead to challenges in manufacturing, maintenance, and repair, making them less user-friendly compared to traditional transformers. **Cost:** The advanced technology used in solid-state transformers, such as power electronics and semiconductors, can be costly. Reducing manufacturing costs is essential for competitive pricing and market accessibility.

**Market Education:** Many stakeholders, including utilities, industries, and consumers, may not fully understand the capabilities and benefits of solid-state transformers. Market

education and awareness campaigns are needed to overcome this lack of understanding. **Regulatory Frameworks:** Existing regulatory frameworks are often designed for traditional transformers, making it challenging for solid-state transformers to navigate and comply with these regulations. New standards and compliance protocols may be necessary. **Scalability:** The scalability of solid-state transformer technology is a concern. For the global market to benefit fully, manufacturing processes and supply chains must be scalable to meet the growing demand.

**Legacy Infrastructure:** Retrofitting existing grids and infrastructure designed around traditional transformers to accommodate solid-state technology can be a complex and costly process. It requires extensive planning and investment.

**Cybersecurity and Data Privacy:** Solid-state transformers incorporate digital and communication technologies, making them potential targets for cyberattacks. Ensuring robust cybersecurity measures to protect critical infrastructure is an evolving challenge. Efforts are underway to address these technological challenges. Industry players, research institutions, and governments are investing in research and development to refine and mature solid-state transformer technology. As this technology advances and accumulates a successful track record, it is likely to become a more attractive and reliable option for various applications, ultimately fostering its greater adoption in the global energy landscape. Nevertheless, it is essential to acknowledge that achieving technological maturity and overcoming these challenges is a gradual and ongoing process.

## Scale and Manufacturing

The scaling up of manufacturing capabilities represents a significant challenge for the global solid-state transformer market. While solid-state transformers offer numerous advantages in terms of energy efficiency, grid stability, and renewable energy integration, their mass production and widespread adoption face several hurdles related to scale and manufacturing. These challenges can hamper the growth and accessibility of this promising technology. **Complexity and Specialization:** Solid-state transformers are intricate electronic devices that require specialized manufacturing processes. The production of semiconductor components, advanced materials, and intricate electronics necessitates expertise and specialized equipment. Achieving high yields and consistent quality across a large-scale production can be complex.

**Economies of Scale:** Achieving economies of scale is crucial for reducing the manufacturing cost of solid-state transformers. At present, these devices tend to be

more expensive than traditional transformers due to their advanced technology. Scaling up production to reduce costs is a substantial challenge. **Supply Chain Considerations:** Developing a robust and efficient supply chain for solid-state transformers is vital. It involves sourcing critical materials, components, and semiconductor devices. Any disruptions in the supply chain can lead to delays and increased costs.

**Quality Control:** Maintaining the quality and reliability of solid-state transformers in mass production is challenging. Ensuring that each unit meets stringent performance and safety standards is crucial. Consistency in manufacturing is essential to gain the trust of utilities, industries, and consumers. **Testing and Validation:** Rigorous testing and validation processes are required to ensure the functionality and reliability of solid-state transformers. This includes testing for various operating conditions and environmental factors. Developing comprehensive testing protocols and facilities is a significant undertaking.

**Skilled Workforce:** The manufacturing of solid-state transformers demands a skilled and knowledgeable workforce. Ensuring an adequate supply of trained personnel capable of working with advanced electronics and power electronics is a challenge. **Regulatory Compliance:** Meeting regulatory standards and compliance requirements for safe and reliable operation is a crucial aspect of manufacturing solid-state transformers. Navigating these regulatory hurdles can be time-consuming and costly.

**R&D Investment:** Manufacturers need to invest significantly in research and development to refine and optimize the manufacturing processes. This includes advancements in materials, semiconductor technologies, and manufacturing techniques. Despite these challenges, industry players and governments recognize the immense potential of solid-state transformers in modernizing energy infrastructure and achieving sustainability goals. Ongoing research, development, and collaboration between manufacturers, research institutions, and governments aim to address these manufacturing challenges and facilitate the mass production of solid-state transformers. As the technology matures and economies of scale are realized, these challenges are expected to gradually diminish, making solid-state transformers more accessible and cost-effective for a wider range of applications in the global energy landscape.

## Key Market Trends

### Rise of Electric Vehicles (EVs)

The rapid rise of electric vehicles (EVs) is poised to drive the global solid-state

transformer market to new heights. EVs have gained widespread acceptance as a sustainable and efficient alternative to internal combustion engine vehicles. As the EV market continues to expand, several key factors highlight the critical role of solid-state transformers in supporting this transformation, **High-Power Charging Infrastructure:** EVs require high-power charging stations for rapid charging, and solid-state transformers are vital components in these infrastructures. They facilitate faster, more efficient, and reliable charging, addressing range anxiety concerns and promoting the widespread adoption of EVs.

**Grid Resilience and Stability:** As the number of EVs on the road increases, the demand for electricity surges during peak charging periods. Solid-state transformers play a pivotal role in maintaining grid stability by managing the fluctuations in power demand, ensuring uninterrupted service for both EVs and other electrical consumers.

**Bidirectional Power Flow:** Solid-state transformers enable bidirectional power flow, allowing EVs to not only charge from the grid but also return excess energy back to the grid. This capability is essential for vehicle-to-grid (V2G) technology, enhancing grid resilience and enabling EVs to serve as grid resources. **Energy Efficiency:** EVs and high-power charging stations must optimize energy use to reduce operational costs. Solid-state transformers, known for their energy efficiency, are key in minimizing energy losses during the charging process, contributing to the overall sustainability of EVs.

**Environmental Goals:** Governments worldwide are setting stringent emissions and environmental targets. The transition to EVs is a central part of these goals, and the efficient charging infrastructure enabled by solid-state transformers aligns with these sustainability initiatives. In conclusion, the ascent of electric vehicles is transforming the automotive industry and, in parallel, driving the demand for advanced charging infrastructure. Solid-state transformers are integral to this transformation, ensuring fast and reliable charging, grid stability, and energy efficiency. As the EV market continues to surge, the global solid-state transformer market is set to play a crucial role in supporting this electric revolution and advancing sustainable transportation solutions.

## Smart Grid Development

The development of smart grids is emerging as a powerful driver for the global solid-state transformer market. Smart grids are intelligent, digitally enabled power distribution networks that leverage advanced monitoring, communication, and control technologies. Solid-state transformers play a pivotal role in the realization of these modern grids, and several factors underscore their importance, **Grid Flexibility:** Smart grids require transformers that can adapt to the dynamic and complex energy flows within the grid.



Solid-state transformers offer the flexibility and responsiveness needed to maintain grid stability in the face of changing conditions, such as the integration of renewable energy sources and varying consumer demands.

**Efficiency and Reliability:** Smart grids prioritize efficiency and reliability, which are key attributes of solid-state transformers. These transformers are known for their high efficiency, reduced energy losses, and enhanced reliability compared to traditional transformers, contributing to the overall performance of smart grids. **Grid Monitoring and Control:** Solid-state transformers are equipped with digital control and communication capabilities, making them an integral part of the real-time monitoring and control systems essential for smart grid functionality. They enable grid operators to optimize energy distribution and respond to disruptions promptly.

**Renewable Energy Integration:** As smart grids increasingly incorporate renewable energy sources, solid-state transformers are instrumental in efficiently integrating intermittent power generation, enhancing grid stability, and managing variable energy flows. **Resilience:** Solid-state transformers enhance grid resilience by swiftly adapting to disturbances and maintaining power supply during outages or adverse conditions. Their fault-tolerant design bolsters the reliability of smart grids.

**Load Management:** The adaptability of solid-state transformers allows for more precise load management, which is essential for demand response strategies within smart grids, helping to balance supply and demand. **Energy Efficiency:** Smart grids emphasize energy efficiency, which aligns with the inherent capabilities of solid-state transformers to minimize energy losses and optimize power delivery. As the global push toward more intelligent, sustainable, and efficient energy systems continues, the demand for solid-state transformers in smart grid development is expected to grow significantly. These transformers are at the forefront of revolutionizing power distribution, enhancing grid management, and advancing the transition to more sustainable energy sources and systems.

## Segmental Insights

## Application Insights

Smart Grid Segment will dominate the market, A smart grid is an electricity network/grid enabling a two-way flow of electricity and data. The concept of the smart grid accelerated in the last two decades. It has now become an essential part of the digital transformation of the electricity sector. Due to their modular construction flexibility,

enabling bi-directional power flow, and deployment in AC and DC grids, solid-state transformers are preferred more than conventional transformers in smart grids.

The three-stage solid-state transformers are typically designed for smart grid applications in which they have bi-directional power flow to transfer power from low voltage to high voltage.

Recently, the modernization of the grid to accommodate power flows, serve reliability needs, and meet future projected usage led to the incorporation of electronic intelligence capabilities for power control purposes and operations monitoring, which is driving the demand for smart grid technologies such as solid-state transformers.

For instance, in December 2020, GridWise Alliance in the United States launched its comprehensive Policy Framework for Grid Investments in Economic Recovery, which outlines the need for USD 50 billion in federal spending for grid modernization. Several such grid modernization plans are expected to increase the demand for solid-state transformers in smart grids during the forecast period.

## Regional Insights

Asia Pacific is expected to dominate the market during the forecast period. Asia-Pacific is expected to be the largest and fastest-growing market due to the increasing investment in smart grid technology and the increasing demand for electricity, leading to increased investment in power infrastructure across the region.

China is the world's largest market for power transmission and distribution (T&D). It is projected to become a significant consumer of smart grid technology, supported by its policy to reduce carbon emissions and commitment to green development. \$\$\$In 2021, the total electricity generation from the various sources in the Chinese power sector was 8.11 trillion kilowatt-hours (KWh). Energy sources contributing to the country's energy generation include coal, natural gas, the nuclear, wind, hydro, biofuels, and solar energy. Since China has the largest industrial sector, the country's energy demand has been rising continuously owing to rapidly growing industrial demands.

With the growing investment in distribution networks, companies are now focusing on smart grids, which is likely to drive the demand for SST in China during the forecast period.

## Key Market Players

Siemens Ag

Eaton Corporation

General Electric Company

Red Box Aviation

Vollspark

Alstom Sa

Varentec Inc.

Power Systems And Controls, Inc.

Hitachi Abb

Schneider Electric

Report Scope:

In this report, the Global Solid-State Transformer Market has been segmented into the following categories, in addition to the industry trends which have also been detailed below:

Global Solid-State Transformer Market, By Application:

Smart Grid

Traction

Other

Global Solid-State Transformer Market, By Region:

North America

United States

Canada

Mexico

Asia-Pacific

China

India

Japan

South Korea

Indonesia

Europe

Germany

United Kingdom

France

Russia

Spain

South America

Brazil

Argentina

Middle East & Africa

Saudi Arabia

South Africa

Egypt

UAE

Israel

### Competitive Landscape

Company Profiles: Detailed analysis of the major companies presents in the Global Solid-State Transformer Market.

### Available Customizations:

Global Solid-State Transformer Market report with the given market data, Tech Sci Research offers customizations according to a company's specific needs. The following customization options are available for the report:

### Company Information

Detailed analysis and profiling of additional market players (up to five).

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- 13.9.4. Key Personnel
- 13.9.5. Key Product/Services

### **14. STRATEGIC RECOMMENDATIONS**

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