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RESEARCH ARTICLE

Analysing Key Trends and Growth Forecasts in the Global Transmission and Distribution Market (2022-2030)

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ABSTRACT

This study comprehensively analyses the key trends and growth forecasts in the global transmission and distribution (T&D) market from 2022 to 2030. As the global energy landscape significantly transforms towards renewable energy, the demand for efficient and reliable T&D infrastructure has become increasingly critical. The report leaves no stone unturned in examining the driving factors behind the expansion of the T&D market, including integrating renewable energy sources, technological advancements, and evolving regulatory frameworks. Through a detailed examination of market dynamics, regional developments, and competitive strategies, the study forecasts robust growth in the T&D sector, driven by increased investments in grid modernisation and smart grid technologies. The findings underscore the importance of continued innovation and strategic planning to address challenges such as grid stability, energy storage, and integrating decentralised energy systems. The report concludes with key recommendations for industry stakeholders, providing them with practical and actionable strategies to capitalise on emerging opportunities and navigate the complexities of the evolving energy market.

Keywords: *Global Transmission and Distribution Market; Growth Forecasts; Renewable Energy; Grid Modernization; Energy Market Trends*

Introduction

This analysis presents key trends and growth forecasts in the global transmission and distribution market for 2022-2030 (Gössling & Humpe, 2020; Ahmad & Zhang, 2020). The analysis, conducted with meticulous attention to detail and thoroughness, includes, among others, the generated revenue and sales of a range of transmission and distribution market segments (Gudmundsson et al., 2021). Beyond that, the report presents a comprehensive macro and micro overview of the industry driven by experts, external consultants, and research professionals (Kober et al., 2020). Consequently, the analysis features diverse opinions and considers historical growth (circa 2015-2020) fueled by the rising awareness surrounding the global transmission and distribution market (Rietmann et al., 2020). As such, the report provides granular evidence and projections that can be used for strategic planning purposes in line with the current development of the market as well as historical growth rates of the last years available for setting the bottom-up strategic forecasts. The research helps examine price-to-sales ratios and offers condensed and easy-to-use information to prepare forecasts or estimates with 2022 as the base year. The analysis provides evidence of bullish and bearish attitudes, an invaluable resource that can be used to assess trends and benchmarks. Considering the vagaries and uncertainties of regulated and deregulated markets, together with the historical patterns behind the global transmission and distribution market, the key threats and opportunities, biases, and irritants are predetermined and accordingly provide unparalleled insights and forecasts that predict the market's future growth. In that sense, this essay contributes to the literature by providing a quantitative model or algorithm that can identify competitive pressures in the future. It combines facts and opinions to forecast changes at a granular project level.

Methodology

Primary research was conducted by speaking with individuals involved in business trends and reading financial reports, press releases, corporate presentations, financial statements, annual reports, regulatory publications, and other appropriate sources. - The secondary research involved identifying the critical players in the market and conducting primary interviews with key individuals, namely the Chairperson, Chief Executive Officer, Finance Brigade, and Vice-President of Sales and Marketing/Director. - Collecting internal and external data from secondary studies. - Analyzing several annual reports, financial reports, summary reports of goods and services, regulatory publications, and other important market events, such as establishing preferential deals directly with the leading players in the market. - Conducting an inventory of extensive professional networking and media websites to improve our understanding of the trends and growth forecast and to be validated further through professional intelligence. - Unusual accurate surveys for moving analysts' research, market trends, product trends, and competitive analysis. - Reaching out to the right market research professionals to gain full knowledge of the tendencies and forecast. - Conducting reports as part of a detailed examination of knowledge about performance. These services and reports include reading monographs, submitting summary reports, and submitting reports. - Engaging with the accounting and finance brigade, they conduct deep searches and discussions with responsible individuals of the company concerned. The extensive search includes examining industry groups, collaborative market analysis, and the primary ethics and financial ideology executives. - Engaging with the company's chief accounts department, such as presidents, vice presidents, executive assistants, contacts, directors, officers, administration-level staff, and more. - Prepare analysis based on trend surveys and forecasts of the transmission and distribution developed. - Market trends and growth forecasts have been considered.

Global Energy Landscape Overview

In higher-income economies, renewable power and the electrification of transport are rapidly growing (Haldar et al., 2023; Romero-Lankao et al., 2021). Technological advances lower the cost structure of renewable electricity generation while increasing production capacity (Sperling & Henao, 2020; Jebli et al., 2020). Driven by the decreasing cost of renewable energy, green hydrogen moves from niche applications to mainstream usage (Liddle & Huntington, 2021). Integrating renewable energy sources into the power grids presents challenges for system operators, as weather-dependent electricity generation exhibits increasing volatility (Fatima et al., 2021). Therefore, grid augmentation and modernisation, alongside new energy storage solutions, are necessary to transition to climate-neutral power supply systems (Ebenezer et al., 2021). This also calls for digital solutions and communication technologies within the grid infrastructure to steer electricity flows based on demand patterns and the availability of energy resources. These innovative grid technologies accelerate the transition from passive power distribution to

active, autonomous, and user-centric networks. Expanding the global electricity grid is essential to reduce technical losses and meet increasing demand. Connecting renewable generation sources to significant demand centres allows electricity flow to be managed based on demand. Furthermore, transnational electricity connections allow for the trading of electricity between countries. There is increasing interest in building interconnectors in Africa and the Middle East, mainly due to these regions' enormous renewable energy potential. These international power highways are ultra-high voltage (UHV) lines that can carry up to 800 kV of electricity and travel thousands of kilometres. Since these mega-projects bring higher cumulative costs and risks, international political and financial cooperation among participating countries is necessary to develop long-distance and intercontinental energy highways. The table 1 includes examples of countries that are prominent in each aspect of renewable energy and grid technology development.

Table 1: Prominent examples of countries in each aspect of renewable energy and grid technology development

Aspect	Details	Country Example
Growth in Renewable Power & Transport Electrification	In higher-income economies, renewable power and the electrification of transport are rapidly growing.	**Norway** (high adoption of electric vehicles)
Technological Advances	Technological advances lower the cost structure of renewable electricity generation while increasing production capacity.	**Germany** (advancements in solar and wind energy)
Green Hydrogen	Driven by the decreasing cost of renewable energy, green hydrogen is transitioning from niche applications to mainstream usage.	**Japan** (green hydrogen initiatives)
Challenges in Grid Integration	Integrating renewable energy into power grids presents challenges due to the increased volatility of weather-dependent electricity generation.	**Australia** (grid stability issues with solar energy)
Grid Augmentation & Modernisation	Transitioning to climate-neutral power supply systems is necessary; it requires new energy storage solutions, digital solutions, and communication technologies within the grid infrastructure.	**United States** (grid modernisation projects)
Transition to Smart Grids	Innovative grid technologies accelerate the shift from passive power distribution to active, autonomous, and user-centric networks.	**South Korea** (investment in smart grid technology)
Global Electricity Grid Expansion	Expanding the global electricity grid is essential to reducing technical losses and meeting increasing demand. This would allow for the management of electricity flow based on demand and connecting renewable generation sources to significant demand centres.	**India** (expanding electricity grid to rural areas)
Transnational Electricity Connections	Transnational electricity connections enable the trading of electricity between countries. Due to their renewable energy potential, there is increasing interest in building interconnectors in Africa and the Middle East.	**Morocco** (plans to export solar energy to Europe)
Ultra-High Voltage (UHV) Lines	UHV lines can carry up to 800 kV of electricity and cover thousands of kilometres, facilitating long-distance and intercontinental energy highways.	**China** (UHV projects across vast distances)
International Cooperation	Developing long-distance and intercontinental energy highways requires international political and financial cooperation due to these mega-projects higher cumulative costs and risks.	**European Union** (Nordic-Baltic electricity market integration)

Renewable Energy Integration

Renewable energy has played an integral role in diversifying the global energy mix (Alam et al., 2020; Al Hadi et al., 2020). The role of renewables has grown from being just a niche segment to contributing to a significant portion of the global electricity demand. The trend is more prevalent in advanced countries, predominantly in Europe, to achieve climate change and sustainability goals (Iweh et al., 2021). Further, one of the significant insights of renewable energy in power generation is lowering its costs over the years. More auctions in recent years have shown steep cost reductions in solar and wind energy compared to auctions a few years back. As a result, several countries have extended the targets for renewable capacity adoption, which has created particular requirements for network and grid operators for successful integration (Beyza & Yusta, 2021).

In addition to the factors above, subsidies and other financial instruments to support renewable energy generation have decreased to reach the required level, mainly in developed countries. Despite the benefits, several technical

challenges are associated with integrating renewable energy sources into transmission and distribution networks. The increasing penetration of renewable energy sources in the generation segments has led to a transition of power systems from long-term operating adjustments to significantly shorter variable adjustments. Unlike coal or hydropower, which could take some hours to respond, variable renewable energy sources (VREs) such as wind and solar power generation can vary production within a timescale of less than 30 minutes due to supply chain inefficiencies. Such variations increase the need for greater ramping capacities on a balancing timescale, which flexible generation sources or other related mechanisms can provide. These challenges are discussed briefly in different scenarios and reports and show that the share of renewable types in the global energy matrices will significantly increase. Hence, owing to these lucrative opportunities in the future, the transmission and distribution sector and the T&D infrastructure sector will witness significant deployment in the forecast period.

To illustrate the growth of renewable energy's role in the global energy mix, figure 1 gives a conceptual chart based on the trends and factors discussed:

Chart Details:

a) X-Axis: Time (Years) from 2000 to 2030.

b) Y-Axis: Share of Renewable Energy in Global Electricity Demand (%).

c) Plotting Points:

Initial Niche Segment (2000 - 2010): Slow growth in the early years, with low percentages.

Early Growth Phase (2010 - 2015): Moderate growth, showing an upward trend.

Accelerated Expansion (2015 - 2020): Steep increase in renewable energy's share.

Current Trends and Future Outlook (2020 - 2030): Continued high growth, projecting into the future.

d) **X-Axis**: Time (Years) from 2000 to 2030.

e) **Y-Axis**: Share of Renewable Energy in Global Electricity Demand (%).

Key Points:

a) Initial Niche Segment (2000 - 2010): This segment experienced a slow, gradual increase, representing the limited adoption of renewable energy during these early years.

b) Early Growth Phase (2010 - 2015): Moderate growth as technology improved and costs decreased.

c) Accelerated Expansion (2015 - 2020): A steep increase as renewable energy became more prevalent.

d) Current Trends and Future Outlook (2020 - 2030): Continued strong growth, reflecting the increasing global focus on renewable energy.

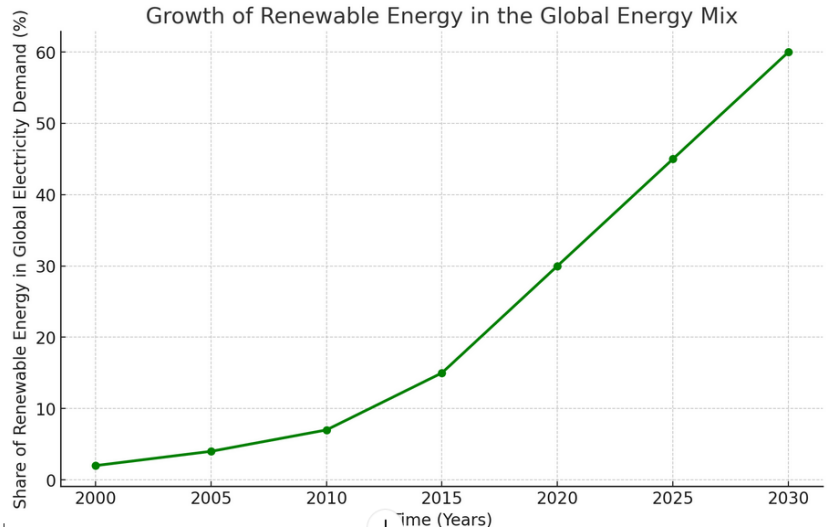

Figure 1: Growth of Renewable Energy in the Global Energy Mix

A steady increase in the demand for global electricity results from the increased use of renewable energy.

Smart Grid Technologies

Smart grid technologies available in the market consist of advanced sensors, meters, instruments, and communication networks (Dileep, 2020; Butt et al., 2021). These technologies help the system coordinate with the consumers' needs and detect and communicate changes in the supply to the utility for further actions (Colak et al., 2020). It is also called an intelligent energy management system in which, even if a line goes down, the entire grid does not fail. Only the affected part of the line stops receiving energy, while the rest of the grid continues to receive power. The drivers for smart grid technologies include keen interest from governments, technological advancements, and budgetary considerations (Gellings, 2020). The constraints in deploying these technologies depend on their complexities and expected paybacks. The potential benefits from a transmission and distribution perspective for an intelligent grid system are minimal, except that in a "one world of smart grid," the technical issues of transmission and distribution are coordinated, and their corresponding economic issues are also associated with various utilities' perspectives. The effects of these technologies are valued for the specific part of the system where they are installed. Nevertheless, it is believed that, to an increased extent, innovative grid technologies will shape the transmission and distribution market by contributing to operational efficiencies.

Key Trends in the Transmission and Distribution Market

The transmission and distribution segments are essential for the power sector's functioning, channelling electricity from one location to another (Ahmad & Zhang, 2021; Alomar, 2023). Conventional transmission systems, transformers, switchgear, and the power infrastructure we see today are becoming outdated and no longer suitable for a smart, IoT-integrated, end-to-end automated environment. Grids, substations, and transmission and distribution network components are all undergoing modernisation, with transmission and distribution networks requiring comparable upgrades to achieve desired results such as low electricity waste, minimal outages, and reduced operation and maintenance (O&M) costs (Joseph & Balachandra, 2020). Budgetary constraints, infrastructure deficits, and policy blind spots have restricted grid or T&D modernisation projects. Due to the involvement of multiple stakeholders, cajoling them to invest in next-generation infrastructure as soon as possible has emerged as a priority (Souza et al., 2022). Microgrids, smart substations, ageing infrastructure revamps, grid-scale battery installation, blockchain, distributed energy resources integration preparations, cybersecurity upgrades, EV integration, Internet of Things, and advanced analytics are some of the new technologies and programs aimed at modernising and improving T&D network operations (Molokomme et al., 2020). Over the years, a growing focus has been on the prime strategies businesses adopt in the global transmission and distribution sector. To cut O&M costs, businesses must adopt the latest technological solutions integrated with the Internet of Things. Investing early in electrical infrastructure upgrades and adopting an inorganic growth strategy will help equipment manufacturers, electrical engineering service providers, and utilities increase company value.

In order to meet global electrification and energy access targets, developing next-generation transformer technologies, finding window periods in tariff caps, and introducing cost-reflective distribution tariffs within the PERG network to attract new entrants remain crucial (Ahmad & Zhang, 2021). Adaptability, flexibility, network upgrading before the end of the network cost recovery, market trends, energy mix shifts, and technological advancements will shape the next foray of electrical equipment OEMs, electrical engineering service providers, and utilities. Although microgrid and blockchain commercial deployment scenarios have not yet crystallised, blockchain and energy trading opportunities will be gradually introduced. To ensure successful deployment, online marketplaces, auctioneers, market operators, and utilities should monitor this trend. Setting expectations correctly and building capacity for vehicle-to-grid (V2G) technologies and services are crucial. Integrators, electricity regulators, and demand-side response specialists must all work to drive 10% energy efficiency in the short term, thereby decoupling energy consumption from GDP growth.

Grid Modernization

The modernisation of ageing power infrastructure has emerged as one of the key focus areas of utilities worldwide in recent years (Hassan & Ahmed, 2022; Khumvongsa et al., 2023). Transmission and distribution grids are the last-mile networks that connect power generation resources to end-use consumers. These networks are being upgraded to build a brighter, more efficient, responsive, and resilient grid capable of integrating a larger share of renewable energy, optimising operations, and enabling customer-centric business models (Baker, 2021). Owing to these network attributes, increasing focus on grid modernisation is expected to make the T&D infrastructure critical in developing economies, with obsolete T&D infrastructure being a key barrier (Hove et al., 2021). Various transformational initiatives, plans, and strategies for grid modernisation have been planned mainly across the Organisation for Economic Co-operation and Development (OECD) countries, which signals the current advanced nature of grid infrastructure in these regions (Takeshima et al., 2021). Major drivers behind the modernisation of the grids include increasing distributed generation plans, rising renewable energy integration, and the forecasted build-up of electric vehicle (EV) fleets. Utilities globally must accommodate a multi-directional power flow through T&D infrastructure, evolving from a one-way power flow network model, primarily to improve situational awareness. According to the International Energy Agency (IEA), approximately US$ 330 billion annually is required for the worldwide modernisation of the T&D infrastructure. Despite the perspectives of a "soft" revenue impact on utilities from investments in grid infrastructure, network reinforcement investment remains a cornerstone of growth for the global T&D market, accounting for one-third of the total market from 2022-2030.

Electrification Initiatives

The International Energy Agency (IEA) has highlighted the potential influence of investment in electrification, which is expected to amplify over the forecast period (Kapustin & Grushevenko, 2020). According to an analysis of data from the Organisation for Economic Co-operation and Development (OECD), shares of final consumption of electricity (as a share of total final consumption of energy) are highest in Canada, Norway, and Switzerland, where investment in electrification can be anticipated to have the largest impacts (Rietmann et al., 2020). In Angola, the DRC, Nigeria, and Tanzania, the share of the final electricity consumption (as a share of the total final energy consumption) is below 10% (Hou et al., 2021). The motivation to increase investment in expanding electrification has been captured by varying national, regional, and global programmes, policies, and initiatives (Asim et al., 2022). The United Nations develops and monitors the Sustainable Development Goals (SDGs). The International Energy Agency (IEA) has indicated in its new four-year Global Electric Vehicle Outlook, which is published annually, that a long-term rise in electric vehicle sales and necessarily associated electricity will, in fact, essentially prevent oil demand from expansions up to 2030 (Ghandi & Paltsev, 2020). By 2030, societies using and producing electricity will probably reduce carbon emissions to a maximum of 1.3 Gigatons, constituting 1.7% of all carbon dioxide released. Initiatives continue to grow within government and associated supporting agencies promoting electrification. While they may also increase varying volumes of grid expansion, many are focused on productive uses and close-to-endpoint solar and battery storage at rural/distributed energy service levels, e.g., the USAID initiative of partner countries with Power Africa.

Growth Forecasts and Market Analysis

The global transmission and distribution market is growing at a steady rate across key regions (Yarovaya et al., 2022). Change is evident in material, cost, system, and technology applications (Ahmed & Huo, 2021). The market is experiencing substantial growth due to growing demand for green and clean energy, product innovation, consumer awareness, and efforts to reduce dangerous greenhouse gas emissions as per government regulations (Gudmundsson et al., 2021). On the contrary, substitution due to alternative technology and high investment costs will likely hamper the industry's growth from 2022 to 2030 (Yu et al., 2021). Transmission and distribution networks form the basis of the electricity supply chain from the power generating stations to the end-users. Major components of these networks include power cables, switches, transformers, circuit breakers, capacitors, insulators, poles, towers, and the associated protection and control systems in various substations (Jackson et al., 2020). Refinancing content and practices for grid projects lie at the core of the transmission and distribution business. This locates the transmission and distribution business at the forefront of efforts to understand the robustness of

forecasting, which translates to operational risk, and the actual post-installation development to define the next investment areas regarding technology and grid topology. Our deep-dive analysis and full-scale market forecast will propel vendors, utilities, technology users, government agencies, service providers, and venture capitalists to find or refine their 'go-to-approach', as per the trends and apprehensions of the industry. Our research will provide the knowledge-based insights necessary for making wise strategic decisions.

Table 2: Global Transmission and Distribution Market Overview by Country (2022-2030)

Country	Growth Drivers	Challenges	Key Components	Strategic Insights
United States	Green energy demand, product innovation, regulatory support	High investment cost, alternative technology	Power cables, transformers, circuit breakers, substations	Focus on grid modernisation and smart grid technology
China	Government regulations, consumer awareness, emission reductions	Cost barriers, need for robust grid infrastructure	Transformers, switches, poles, towers, protection systems	Massive infrastructure projects, investment in renewable integration
India	Rural electrification, clean energy initiatives	High cost, technology substitution	Insulators, capacitors, substations, protection systems	Expanding grid for rural areas, emphasis on low-cost solutions
Germany	Renewable energy transition, government support	Cost of innovation, alternative tech competition	Smart grids, renewable energy integration systems	Emphasis on energy transition and smart grid deployment
Japan	Renewable energy targets, consumer demand for clean energy	Investment cost, grid stability issues	Power cables, transformers, circuit breakers	Strategic focus on grid stability and renewable integration
United Kingdom	Regulatory push for clean energy, product innovation	Cost, grid modernisation requirements	Poles, towers, smart grid components	Heavy investment in grid modernisation and decarbonisation
Brazil	Growing energy demand, renewable energy projects	Infrastructure gaps, high cost	Substations, transformers, poles, towers	Focus on expanding grid reach and renewable projects
Canada	Clean energy initiatives, government policies	High cost of remote grid connections	Smart grids, renewable integration	Emphasis on decentralised grid systems and renewable energy
Australia	Renewable energy push, consumer awareness	High cost of materials, technology shifts	Smart grids, renewable energy systems	Development of decentralised grids and integration of renewables
France	Renewable energy transition, regulatory framework	High cost, need for grid upgrades	Power cables, transformers, protection systems	Focus on modernising grid and integrating renewable sources
South Korea	Government initiatives for green energy, consumer demand	Cost of technology, grid complexity	Smart grids, renewable integration systems	Heavy investment in smart grids and renewable integration

Explanation:

Growth Drivers: These are the primary factors contributing to the growth of the transmission and distribution market in each country, such as regulatory support for green energy, consumer awareness, and innovation.

Challenges: Each country faces high investment costs and competition from alternative technologies.

Key Components: This column lists the major components of the transmission and distribution networks that are crucial in each region.

Strategic Insights: This section provides strategic perspectives based on the current market trends and the projected growth areas.

This table structure provides a comprehensive understanding of how countries approach the transmission and distribution market, reflecting the industry's opportunities and challenges from 2022 to 2030.

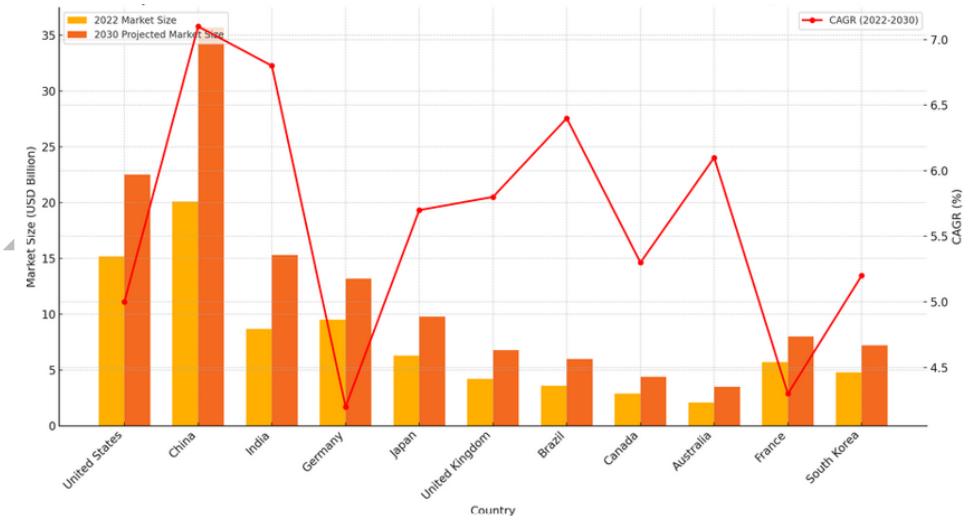

Figure 2: Key Trends and Growth Forecast in the Global Transmission and Distribution Market 2022- 2030

The figure above visually analyses key trends and growth forecasts in the Global Transmission and Distribution Market from 2022 to 2030. Here is a detailed analysis of the figure:

a. Market Size (2022 vs. 2030)
   1) China: The largest market in 2022 and projected for 2030, indicating significant investment and expansion in its transmission and distribution infrastructure.
   2) United States: The second-largest market, steadily growing from 2022 to 2030.
   3) India: Also demonstrates substantial growth, reflecting ongoing efforts in rural electrification and infrastructure development.
   4) Germany: Despite its relatively large market, Germany's growth rate is moderate, indicating a mature market.
   5) Other Countries: Markets like Brazil, Canada, Australia, and South Korea show moderate to significant growth, emphasising their focus on expanding and modernising their transmission and distribution networks.

b. Compound Annual Growth Rate (CAGR)
   1) China: Exhibits the highest CAGR, around 7%, indicating rapid growth and substantial investments in this sector.
   2) Other Countries: Australia, Brazil, and the United Kingdom also show higher CAGRs, reflecting ongoing investments in modernisation and renewable energy integration.
   3) Germany and France Show relatively lower CAGRs, reflecting the challenges in mature markets with more incremental growth.

Key Observations

1) Emerging Markets: Countries like China, India, and Brazil are experiencing higher growth rates, driven by the need to expand and modernise their infrastructure.
2) Mature Markets: Countries like Germany and France have lower growth rates, reflecting a focus on grid stability and incremental improvements rather than large-scale expansion.
3) Investment Focus: The focus on grid modernisation, renewable energy integration, and smart grid technologies is evident across the board, with varying degrees of emphasis depending on the market's maturity and growth potential.

The chart highlights the diverse growth trajectories in the global transmission and distribution market, with emerging markets like China and India leading the charge regarding market size and growth rate. While growing, mature markets focus on stability and modernisation, reflecting their different priorities and challenges. The overall trend

indicates a robust global transmission and distribution market expansion driven by renewable energy integration, infrastructure development, and technological advancements.

Conclusion and Future Outlook

The global transmission and distribution market is expected to have a positive trajectory in the forthcoming years, mainly driven by developments derived from the expected increase in electricity networks to support renewable energy sources and, as a result, increase resiliency. Among trends observed in the market is the fact that some regions are significantly investing in interconnection infrastructures between countries or provinces. The main opportunities tracked throughout the research are the new technologies, such as digital and intelligent solutions to monitor and reduce losses and augment resiliency. Challenges observed are the heavy dependency on how electrical infrastructures develop until 2050, global economies, and their strategies based on energy. The following auction, by December 2022, to allocate expansion rights towards the year 2027 will be crucial to showcase the evolution of the market based on the energy matrix effectively used. The outlook for sector players depending upon their regional energy matrices cannot be ascertained without a broad scenario perspective. Based on our pioneer research, we can suggest that the developed regions are better positioned to capitalise on the growing market for long-distance electricity in the forecast period, thereby increasing their contract pipelines or revenue. In contrast, the existing LDA under-projected markets, such as Brazil and China, are expected to continue with the same pace of contracting through 2027.

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