

The image features a central graphic of the letters '5G' in a bold, dark blue font. This text is enclosed within a circular network of white nodes connected by thin lines, resembling a mesh or globe. The background consists of four tall, red metal telecommunication towers with multiple satellite dishes, set against a sky with soft, golden light from a low sun. The lower portion of the image is dominated by a blue gradient with a pattern of overlapping, semi-transparent hexagons, representing a cellular network.

5G

50 Years of Growth, Innovation and Leadership

Global Telecom DC Power System Market Insight

5G to Drive Connectivity Infrastructure Improvements, Open Revenue Streams

A Frost & Sullivan White Paper

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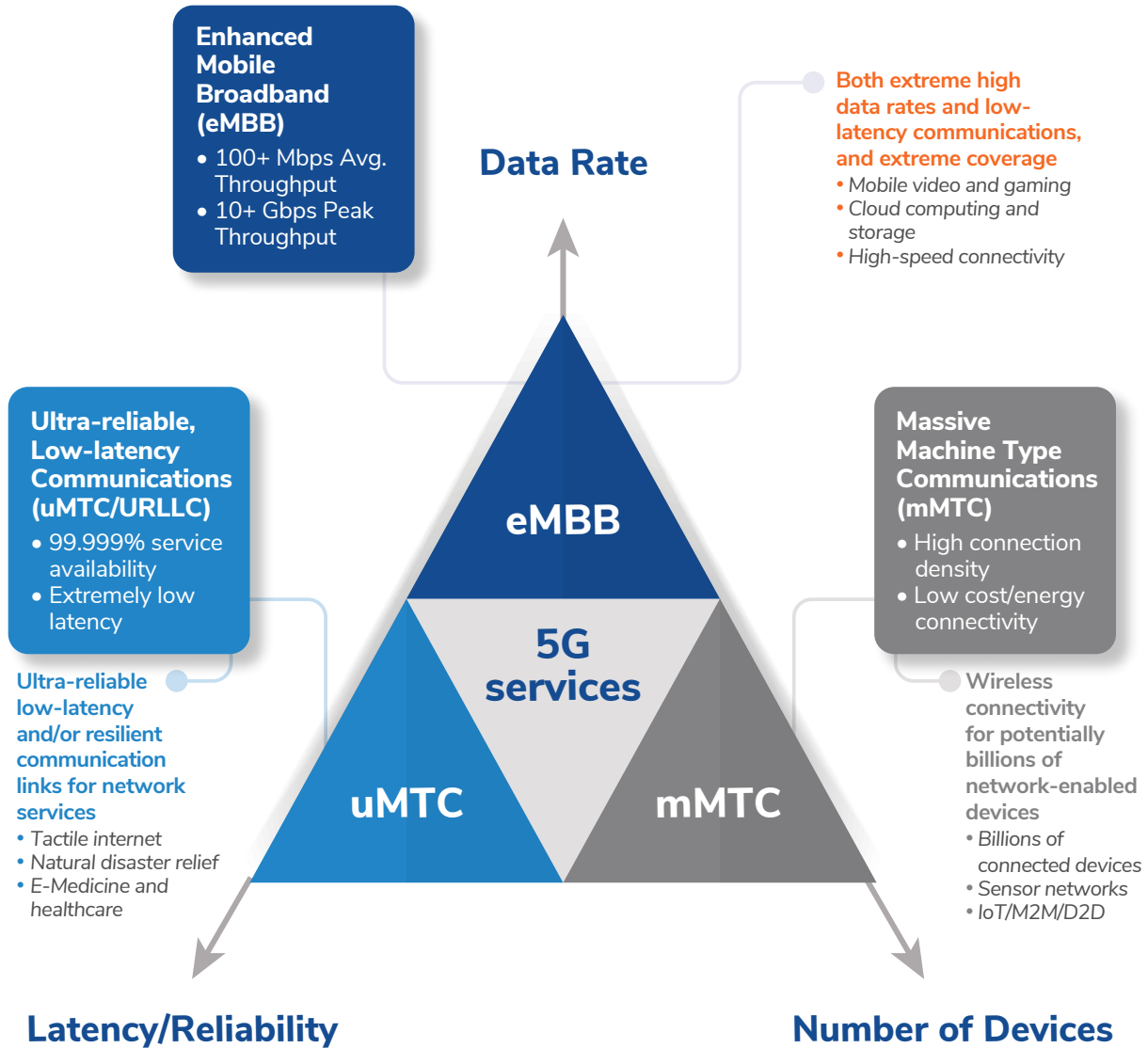
INTRODUCTION

The telecommunication industry continuously delivers a potent combination of network capabilities and flexible options for network deployment, service delivery, and network management, all of which dramatically improve mobile operators' ability to deliver differentiated, customized, and scalable customer experiences. The deployment of 5G networks will be optimized to support various traffic profiles, including high throughput for video/streaming, low latency for voice/emergency, and low energy for low-power Internet of Things (IoT) devices/sensors. The following are key trends for 5G:

- ▶ 5G will usher in an age of boundless connectivity and intelligent automation. As mobile connectivity becomes established as the core foundation of connected societies, 5G will play a key role in delivering customized mobile data services that are available on-demand.
- ▶ The expedited completion of 5G standards is a positive trend that will support commercial 5G deployments. High-speed, low-latency, reliable, and secure enhanced mobile broadband will be the prime use case for early stage 5G deployments, followed by mobile 5G services delivered on compatible handsets and other devices.
- ▶ Augmented reality (AR) and virtual reality (VR) will revolutionize the customer experience in gaming, retail shopping, and other customer-centric applications running on 5G networks. The consumer experience will be enhanced as high data rates are achieved.
- ▶ Frost & Sullivan research indicates that higher network speeds drive higher per-device mobile data consumption. For example, a 4G smartphone consumes more mobile data than a 3G smartphone in a given time period. 5G promises significantly higher data speeds over the current generation of 4G networks and will drive increased data traffic that must be managed efficiently.

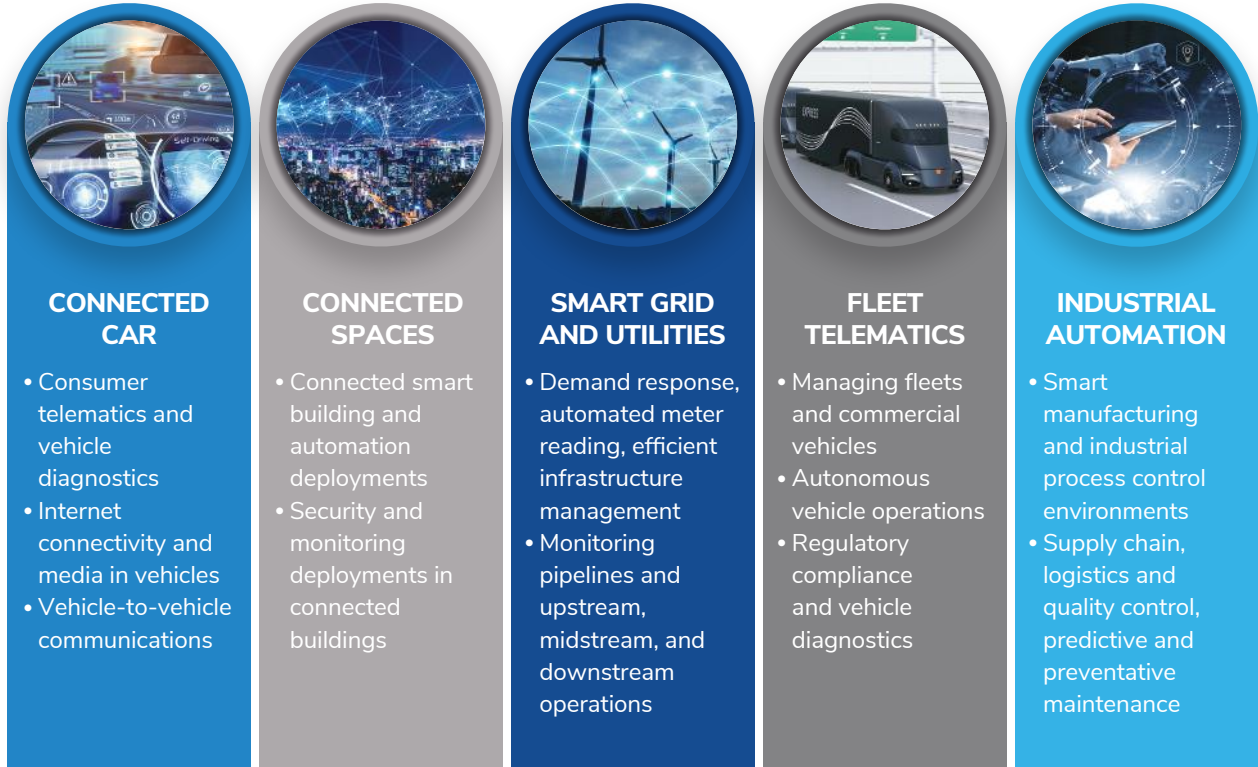


EXHIBIT 1: ENHANCED USE CASES THAT WILL BE DRIVEN BY 5G IN THE GLOBAL 5G MARKET IN 2018



Source: 3GPP; Frost & Sullivan

EXHIBIT 2: 5G MARKET—MAJOR GROWTH OPPORTUNITIES FOR IOT IN 5G, GLOBAL, 2018



Source: Frost & Sullivan

Vendors in the telecommunication industry that want to provide customers with continued services must have a perfect power uptime, and relying on DC power systems ensures that this complex grid of commerce and information remains operational 24/7.

This white paper outlines some of the key trends witnessed in the DC power systems market and looks at how market revenues have grown and are expected to continue growing, based on data that Frost & Sullivan has independently researched and gathered. This white paper highlights strategies employed by Huawei, a company in the spotlight for maintaining a global leadership position in several regional DC power system markets.

GLOBAL DC POWER SYSTEM MARKET OVERVIEW

The increase in telecommunication infrastructure spending because of 4G and 5G deployments will likely increase the demand for DC power systems. While North America and Europe are experiencing slower growth because of a large installed base of DC power systems, India, China, Latin America, the Middle East, Africa, Southeast Asia, and Australasia will continue offering high-growth opportunities. The overall market is expected to grow at a compound annual growth rate (CAGR) of 3.2% from 2019 to 2025, suggesting market maturity and strong competition. Limited product innovation leads to low margins, thus resulting in moderate growth prospects. Companies in this market are working to improve reliability, scalability, energy efficiency, product management, security, control, optimal system design, and cost-effective deployment. In addition, companies that can leverage technical and product differentiation strategies, while remaining sensitive to price, may find the competitive advantage.

The emergence of 5G is expected to create significant growth opportunities in the United States, Europe, and Asia-Pacific (e.g., Japan, South Korea, and China). Because developed countries have completed the majority of their build-outs, opportunities in this market are shifting toward emerging economies in Asia-Pacific and Latin America. For instance, in Latin America, Brazil has long-term growth opportunities in the telecom space, whereas Mexico has maintained steady growth in telecom investments. In Asia-Pacific, India is moving toward digital transformation across all sectors/industries, presenting a clear opportunity for telecom operators to create a viable mobile ecosystem.



Market Drivers

As the telecommunication industry continues to evolve, from a data and voice standpoint, DC power systems that can sustain the backbone of power in networks continue to be an essential requirement. The demand for robust telecom infrastructure is increasing in developing countries because the demand for faster connectivity has resulted in many changes in the telecom industry. For example, the move from copper to optical fiber fixed lines and from circuit switching to packet switching has ensured a higher speed of data transfer and has enabled increased data and voice traffic. The expansion of wireless infrastructure worldwide is driving the sales of DC power systems, and growing investments in new infrastructure and telecom equipment in developing regions are driving the growth of DC power systems.

The demand for reliability goes hand in hand with growing telecom networks, driving the need for robust DC backup power systems to eliminate communication downtime. While mature regions are overhauling their existing infrastructure to benefit from higher efficiency systems, developing regions are looking for cost-effective, cutting-edge solutions for new installations. In both cases, telecom network reliability cannot be compromised and is mostly dependent on robust backup power solutions that compensate for any lack of grid power. Any network downtime could cause significant losses for businesses.

The introduction of energy-efficient systems has been the key to increasing the demand for DC power systems. With the rising cost of energy and the rising environmental consciousness among customers, the availability of energy-efficient systems is driving the replacement of old systems.

These new systems can be easily integrated with existing power architectures, have a smaller footprint, and offer a quick payback on the total cost of ownership (TCO). Manufacturers have introduced intelligent energy and battery monitoring systems that are valued by customers and further drive this replacement cycle.

Connectivity requirements are increasing in almost every region worldwide. People require on-the-go connection, which is not feasible without a robust infrastructure to sustain this demand. Therefore, a DC power system is an essential backup power component for providing reliable power 24/7.

Market Restraints

The industry still has challenges impacting the growth of DC power systems. For example, intense competition and the lack of technology innovation have resulted in restricted demand. In addition, the market is witnessing a phase of intense competition, with consolidation activity taking place among key manufacturers. The most recent acquisitions of Alpha Technologies by EnerSys and GE Critical Power by ABB are prime examples. In addition, Delta acquired Eltek in 2014.



Intense price competition has restrained the growth of DC power systems, with over 100 manufacturers worldwide competing on price. This competition is further intensified by local manufacturers offering inferior solutions that are not always reliable but cost much less. These local manufacturers can drive Tier I manufacturers to reduce their prices significantly, which cuts into margins. Price competition intensity decreases as the power range increases, resulting in more profitable opportunities in the medium-to-high DC power system ranges. In addition, the lack of product differentiation adds to the market's highly competitive nature, making it mandatory for manufacturers to price competitively.

Developed regions are impacting DC power system spending because they limit their spending on core telecom infrastructure upgrades and new construction. Several countries are completing 3G and 4G network build-outs, after which, network upgrades will not be necessary for at least a couple of years, thus further reducing the demand for DC power systems. In addition, import and production regulations in emerging economies can hinder DC power system growth. For example, the Argentinean government has imposed stringent import and production regulations aimed at fostering local companies and local jobs. Import regulations mandate product quality reports and require the federal administration of public income tax authorization permits. Even when power units are imported, the Argentinean government requires local manufacturers to provide cabinets made of galvanized steel or aluminum. These procedures make it cumbersome for global manufacturers to conduct business in the country.

The many political and macroeconomic uncertainties in Ecuador, the Dominican Republic, and Venezuela affect telecom infrastructure spending. Even with interest in building telecom infrastructure, progress is and will remain slow unless governments provide an infrastructure growth impetus.


Changing Landscape with 5G Deployment

5G networks are expected to handle more data and complex computation with billions of connected devices, providing global businesses and economies with unprecedented insights and the ability to drive radical changes in the next five years. 5G will significantly reduce latency and bring new levels of reliability for seamless connectivity in the connected ecosystem. 5G networks will boost network range and speeds up to 10 gigabits per second (Gbps) or more to support new applications, including AR, connected vehicles, and IoT, thereby realizing the limitless bandwidth use potential for both consumers and enterprises.

Multiple frequency bands are expected to be deployed in a single site. The number of sites with more than five frequency bands will account for over 45% of the deployment in the next four to five years, with some sites possibly reaching up to 10 bands. Site power demand will likely surge as frequency bands increase. With the use of radio access network (RAN) and massive multiple-input, multiple-output (MIMO) technology, the total power consumption of a 5G site will likely exceed 10 kilowatts (kW).

These trends in consumption give rise to operator challenges in the 5G evolution, including the following:

- **High cable loss**—In 5G deployments, the 5G active antenna unit (AAU) will be deployed as the main RAN equipment on the tower. In the AAU remote power supply scenario, the cable voltage drop will increase because the load on the tower is larger than with the 4G network, resulting in excessive cable loss. In some cases, the input voltage of the equipment on the tower cannot meet the working requirements; therefore, to avoid cable loss, cable modernization is needed, which incurs new cable investments and long delivery periods.
- **Insufficient mains input**—The increasing power consumption of one 5G frequency is expected to be between 3.5 kW and 4.5 kW, which is about three times that of the 4G network. The increase of site power consumption requires more mains capacity, possibly leading to insufficient mains input and thus delaying 5G deployment by about six months, with the cost of transformer modernization at about \$20,000.
- **Adding new cabinets**—The new 5G equipment, such as baseband unit (BBU) and transmission equipment, requires new space and heat dissipation capacity, while the increasing power demand requires the expansion of existing breakers and backup batteries. However, existing cabinets have limited space to add more equipment, thus resulting in the investment of new cabinets and adding to the high reconstruction cost.



5G will significantly reduce latency and bring new levels of reliability for seamless connectivity in the connected ecosystem.

- **High TCO because of traditional single-point capacity expansion and box stacking**—The traditional energy product design emphasizes the single point expansion of hardware and the adoption of hardware migration or replacement, cabinet addition, and infrastructure redeployment, thereby creating the difficult problem of high costs and long periods of reconstruction. The purchase cost of new hardware (e.g., rectifier, power distribution, backup power, and temperature control) is only the tip of the iceberg for site energy facility modernization. The heavy cost is the hidden reality, such as mains modernization, cable replacement, installation by crane, and foundation/floor reinforcement.

5G requires faster and more economical power solutions:

- **Simplified deployment and evolution based on the energy target network**—To resolve the new challenges of energy facilities in the 5G era, an efficient solution with simplified, economical, and flexible capacity expansion must be deployed. Energy facilities must reuse existing network assets as much as possible, reduce the purchase of new hardware, minimize infrastructure reconstruction, simplify engineering installation, refrain from adding more space, and support the smooth evolution of 5G services. In the pole site scenario, all devices should be installed on poles without any extra site space. In the traditional green site scenario, one site with only one cabinet is required to minimize the number of cabinets at the site area.
- **Innovative intelligent technologies to reduce the difficulty of engineering reconstruction**—The evolution capability of the existing power supply is limited, while traditional solutions require one or more new power cabinets, which involves installing the cabinet, reinforcing the foundation/floor, and renegotiating the site. The new 5G energy solution requires innovative intelligence to reduce engineering reconstruction difficulties and achieve the fast and simplified deployment of 5G. In the case of insufficient mains supply, the traditional solution is to expand the mains access and change the transformer, which involves many processes, such as engineering survey, renegotiation, and cable installation. The new 5G energy solution should be free of mains modernization as much as possible and take advantage of the power supply itself to overcome the problem of insufficient mains supply. To achieve the optimal load-power supply model, the power supply should be synergistic to the mains, energy storage, and load. In addition, the new energy storage solution should have the energy buffer pool function. When the mains supply fails to



meet the load requirements, the system controls the energy storage battery to supplement the power supply gap, such as shaving the peak load. In this way, the mains reconstruction is not a requirement, and 5G can be quickly deployed. Compared with 2/3/4G, the power consumption of the 5G device is greatly improved. In the remote power supply scenario, the - 48Vdc + common cable power supply solution suffers high cable loss, high voltage drop, and limited effective power supply distance, which means this solution cannot adapt to the 5G network's higher requirements. In addition, when the mains supply is disconnected, the backup battery starts working and the output voltage of the lead-acid battery decreases because it is discharged. In heavy load scenarios, the system's load capacity and power supply reliability are severely affected. Traditional modernization solutions use a - 48Vdc + thick cable/double cable solution to supply power, wherein the cable investment is high, the increasing weight of the new cable is heavy, and the reconstruction is difficult. In this case, the system's load capacity and power supply reliability cannot be improved after the mains supply is disconnected. To resolve this challenge, the new 5G power solution should save on cable investments as much as possible and improve the system's load capability without changing the thick cables. The solution that is highly recognized by the industry today is the voltage-boosting power supply.

- **Fuel removal and green resource access**—In areas with no mains supply or weak mains supply, the traditional wireless site usually uses a diesel generator (DG) for power backup. The DG's low load rate (generally less than 20%) makes fuel efficiency low as well, which requires frequent operation and maintenance (O&M) and related costs. The 5G power solution should optimize the



DG's working efficiency because the efficiency of the DG output is optimal when the load rate is about 80%, thus improving the DG's fuel consumption efficiency and service life. Once the DG is working, the battery is intelligently charged by a high current during peak hours so that the battery can be used longer during valley hours, which reduces the DG's running time, fuel consumption, and related O&M costs. In areas with better solar conditions, the solar resource should be considered a main power supply. A solar access solution should independently learn and build a site's internal synergy among

traffic, batteries, and DG status to improve the power supply balance during service peak and valley hours, thus maximally reducing the DG's operating time and maybe even removing the DG completely. In urban areas, operators are burdened with high electricity fees, and global climate change is challenged because CO₂ emissions increased by 1.6% in 2017 and by approximately 2.7% in 2018; therefore, the solar resource as a green energy could be applied to save electricity and reduce CO₂ emissions.

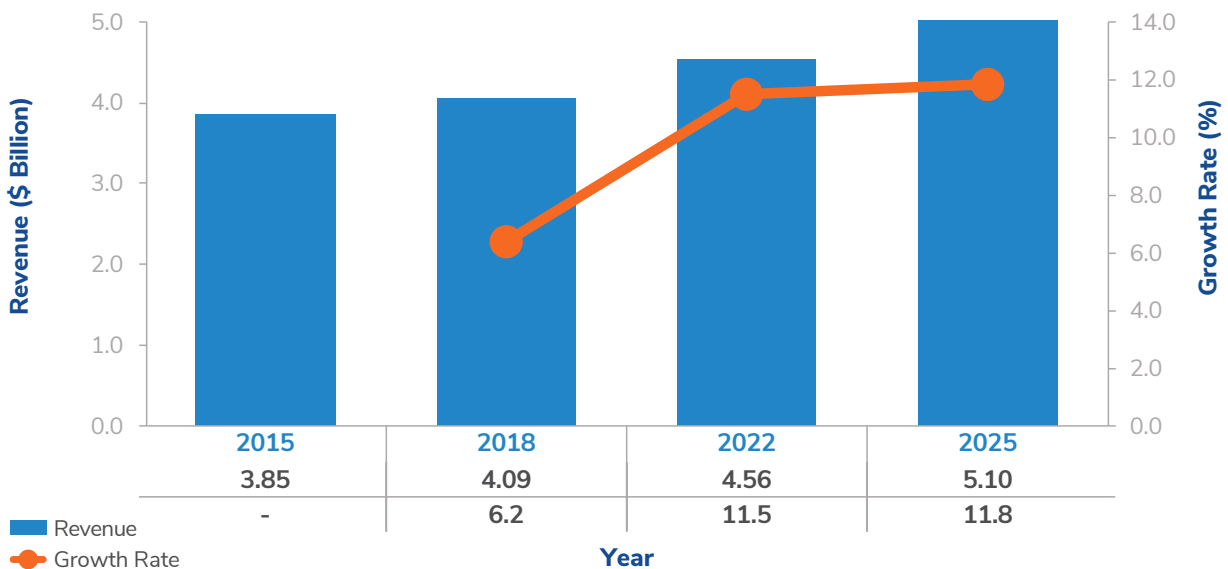
GLOBAL MARKET SIZE AND OPPORTUNITY

Telecom infrastructure growth is directly related to the growth of backup power systems. Total market revenue is expected to increase at a CAGR of 3.2% from 2019 to 2025, and the market is expected to witness a growth in demand for DC power systems because major telecom providers and their global partners are aggressively looking at deploying 5G installations. Global regions, such as Latin America, the Middle East, and Africa, continue to present significant opportunities because telecom networks in these regions are either aging or insufficient to support growth. Asia-Pacific will continue to see strong investments in the telecom sector because of the deployment of 4G networks and the pilot testing of 5G networks. North America and Europe saw the reduction in build-outs of wireless networks as major telecom operators completed their last round of 4G network and infrastructure updates. However, because of 5G rollouts, China, Europe, the United States, and South Korea will likely witness strong demand for DC power systems.

Compared with the traditional 2/3/4G era, the power supply reliability needs to be greatly improved because of the higher network reliability requirement from 5G. Therefore, power supply manufacturers' end-to-end service capability must be higher than that in the 2/3/4G era. According to market share changes in the past five years, DC power system manufacturers that survive on low prices and low-quality strategies have been phased out. However, Tier I manufacturers that have high-quality solutions and a mature delivery capability will continue to have a stronger and bigger footprint in the high-power segment.

Key manufacturers, such as Huawei, Vertiv, Delta (Eltek), and ABB (GE Critical Power), will continue to dominate the market, with a combined market revenue share of 84.4%. Among these Tier I vendors, Huawei has seen significant revenue growth, increasing 20% in 2018 from 2016. In addition, Huawei continues to dominate the global DC power systems market, with a significant presence in Europe, Asia-Pacific, Latin America, the Middle East, and the African sub-continent.

EXHIBIT 3: TOTAL DC POWER SYSTEMS MARKET: REVENUE FORECAST, GLOBAL, 2015-2025



Note: All figures are rounded. The base year is 2018.

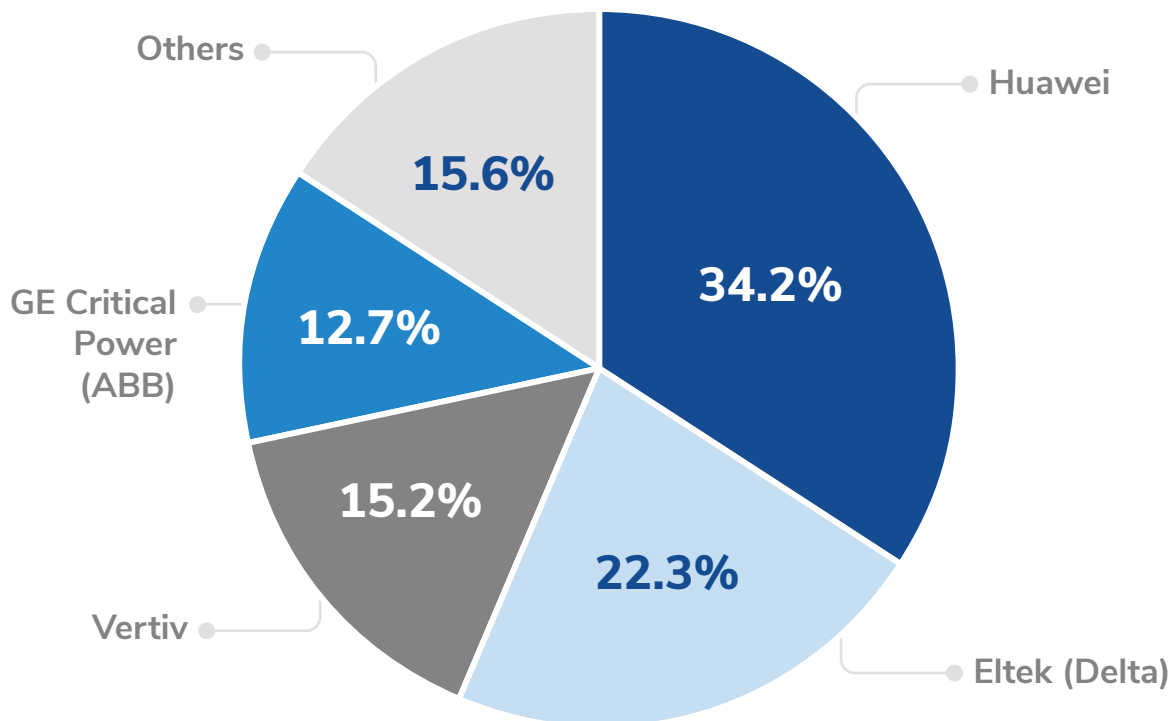
Source: Frost & Sullivan

GLOBAL MARKET SHARE

The global market has more than 70 competitors, with Tier I manufacturers controlling about 84.4% of the total market. The remaining manufacturers are smaller regional participants. Mergers and acquisitions have been fairly active worldwide, such as the recent and most significant acquisitions of GE Critical Power by ABB and Alpha Technologies by EnerSys. Emerson Network Power rebranded itself as Vertiv, and one of the biggest acquisitions was Eltek by Delta in 2014.

Huawei holds the largest global market share of 34.2%. The company has a significant presence in almost all regions worldwide, except North America. Huawei's significant market penetration is based on the strength of its product line and its clear and aligned vision for growth.

EXHIBIT 4: TOTAL DC POWER SYSTEMS MARKET: MARKET SHARE, GLOBAL, 2018



Note: All figures are rounded. The base year is 2018.

Source: Frost & Sullivan

CONCLUSION

Differentiators also include Workfront Fusion, which delivers connectors and APIs to integrate a broad Continuous power availability and higher energy-efficiency products are no longer standards for telecom operators and communication network owners but have become prerequisites. Manufacturers are providing an extensive range of DC power systems that delivers the most innovative, intelligent, and dependable solutions, such as DC power, distribution, control, and monitoring systems. In the DC power systems market, the focus is on product efficiency, continued innovation in flexible system design, management software, quality control, and green energy solutions. Higher product efficiency and continued innovation allow manufacturers to provide customers with maximum equipment life at lower operational costs. The commitment to developing best-in-class products through visionary innovation has resulted in superior products that leverage smarter energy, thus providing customers and partners with an enhanced experience.

5G will be a major market driver for DC power system deployment and will enhance the connectivity infrastructure to handle high data traffic and bandwidth allocation, without compromising the infrastructure. 5G will act as a key enabler for manufacturers to develop and deploy new connected solutions, thereby improving worker productivity, safety, and asset performance across stakeholders' value chain. In addition, 5G will provide the data transfer rates and capacity needed for the widespread adoption of critical functions, such as autonomous vehicles, and Industrial IoT (IIoT) in the future, which will open up new revenue streams for operators and establish new business models for connected ecosystems, apart from regular subscriber business.

Traditional power solutions provide only basic power supply and backup functionalities and thus cannot support the long-term evolution requirement of 5G. To drive 5G power solutions, new design concepts need to be simple, intelligent, and green. In addition, new solutions require an end-to-end energy-saving design, in terms of power supply, conversion, power backup, power distribution, cooling, and load. 5G power solutions need to be simple and, as much as possible, free of legacy assets modernization. The equipment should be designed with high density, less space, easy installation, and easy O&M. More intelligent features should be used for full link efficiency improvements, such as artificial intelligence (AI) and cloud technologies, to achieve multi-level intelligent collaboration between the power supply and the network equipment. Furthermore, new design concepts have allowed access to green energy, such as solar resources, which greatly reduce sites' operating expenditure by saving on fuel and electricity and reducing emissions.



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