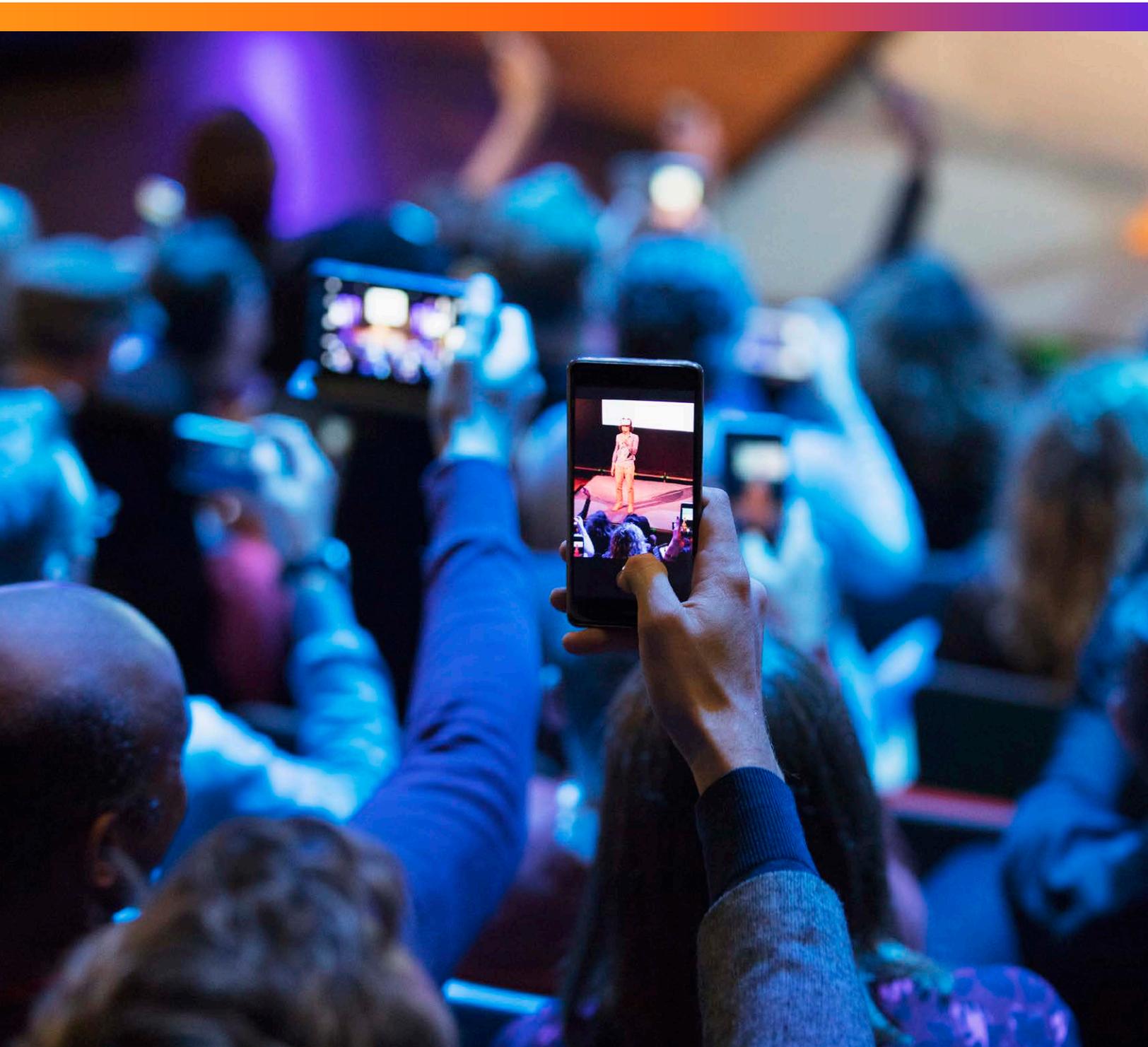




A Practical Guide to Enabling 5G Deployments



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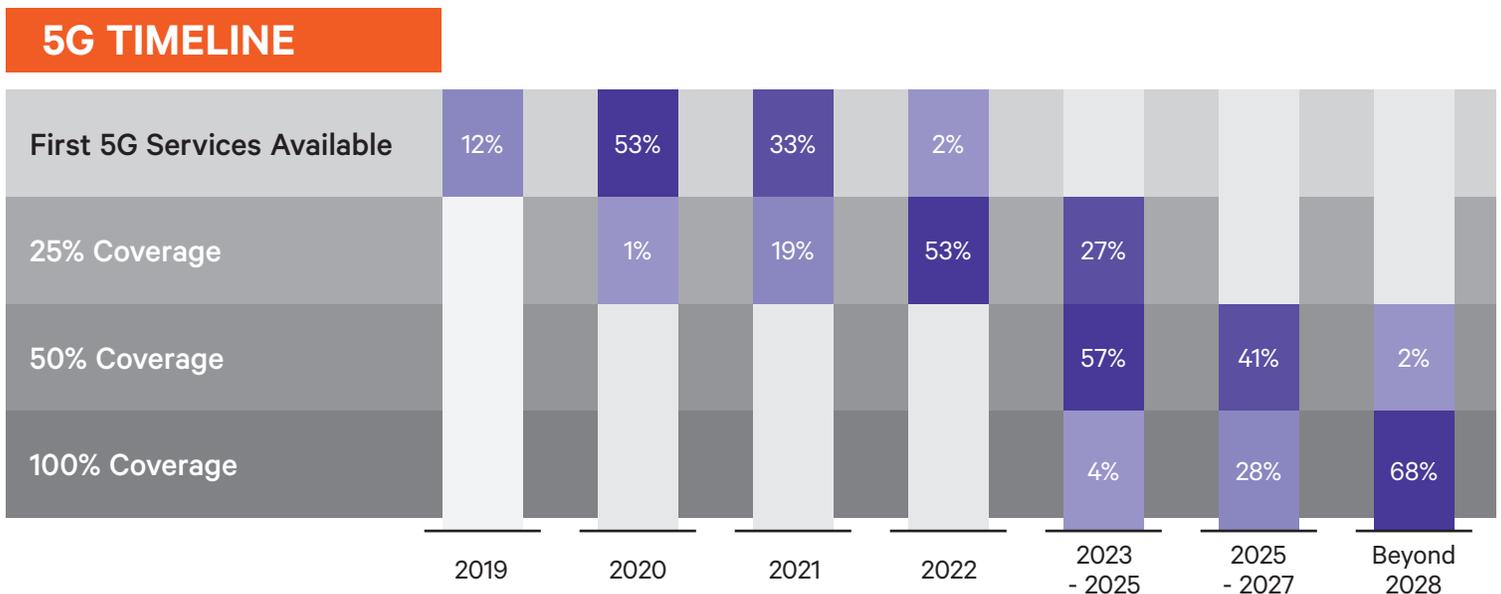
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The Arrival of the 5G Era

According to a report from 451 Research titled, “Telco Study on 5G Reveals Industry Hopes and Fears: From Energy Costs to Edge Computing Transformation,” 5G will be “the most impactful and difficult network upgrade ever faced by the telecom industry.”

The report, sponsored by Vertiv, is based on an in-depth survey of more than 100 global telecom decision makers with visibility into 5G deployment plans. It not only outlines the “hopes and fears” of telecom operators on the cusp of a new era; it makes clear that the transformation has already begun. Twelve percent of survey participants have begun deploying 5G in 2019 with an additional 86 percent planning to deploy 5G services by 2021.

When do you expect your company to reach the following 5G milestones? (n=105)



Source: 451 Research

But while telecom operators are moving forward aggressively to capitalize on this opportunity, there are still questions to be answered and challenges to be met. Almost two-thirds (62 percent) of survey participants say they are still in the process of building out operational plans to support 5G. That’s not surprising considering the majority of respondents (68 percent) do not expect to achieve total 5G coverage until 2028 or later.

As standards continue to evolve, new use cases are enabled and networks are transformed, telecom operators—and the enterprises they support—will need to make significant investments in their network. Those investments will be focused on supporting densification, adding computing and storage capacity at the edge and adapting to 5G’s higher energy requirements.

Vertiv, which delivers critical infrastructure for data center, telecom and industrial applications, has published this practical guide to help the industry manage this historic transformation.

Specifically, this report is applicable to network infrastructure directors (core and access), procurement teams as well as third-party telecom consultants.

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Preparing Your Network for 5G

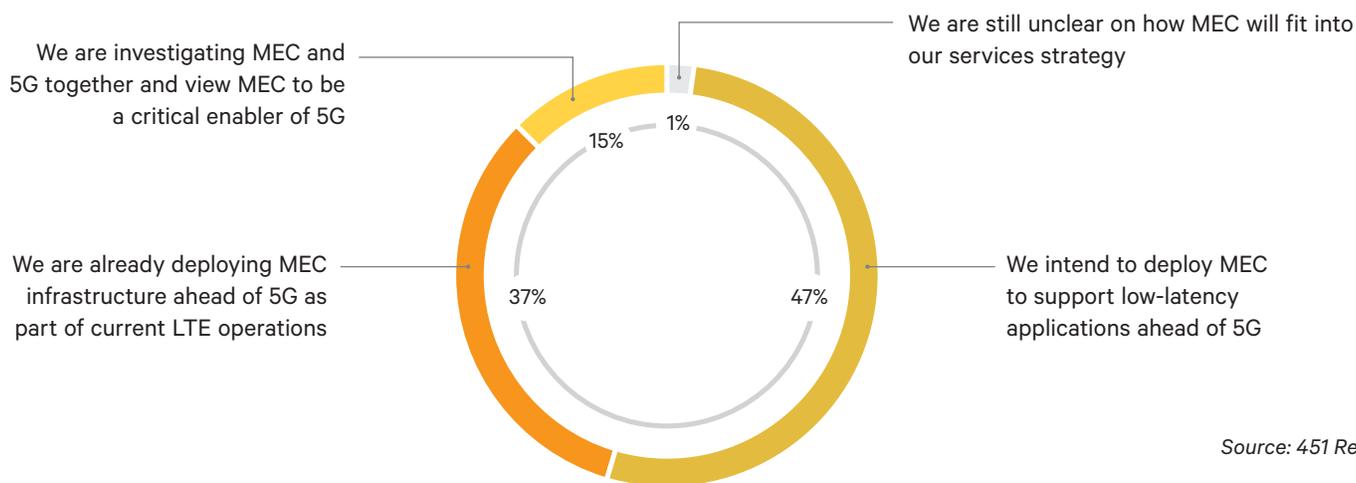
With everything that must be considered when rolling out 5G services, it's easy to underestimate the role specific critical infrastructure will play in enabling 5G success. For example, the power and cooling systems that exist today will need to be expanded and, in some cases, upgraded, to ensure the long-term reliability, maintainability and profitability of 5G network technology. Five areas telecom operators and enterprises should be evaluating today to ensure they are prepared for 5G tomorrow include:

1. Deploying MECs Quickly and Efficiently

A critical part of the transformation to 5G will be the need for multi-access edge computing (MEC) locations within the network. These MEC sites—essentially compact, self-contained micro data centers—leverage 5G's low latency and high bandwidth to bring the capabilities of the cloud directly to the radio access network.

MEC sites form an important part of the 5G value chain as they open the 5G edge to third-party applications and services targeted to mobile subscribers, enterprises and vertical segments. According to the 451 Research report, four out of five survey participants globally have either already deployed MEC infrastructure or intend to ahead of their impending 5G rollouts.

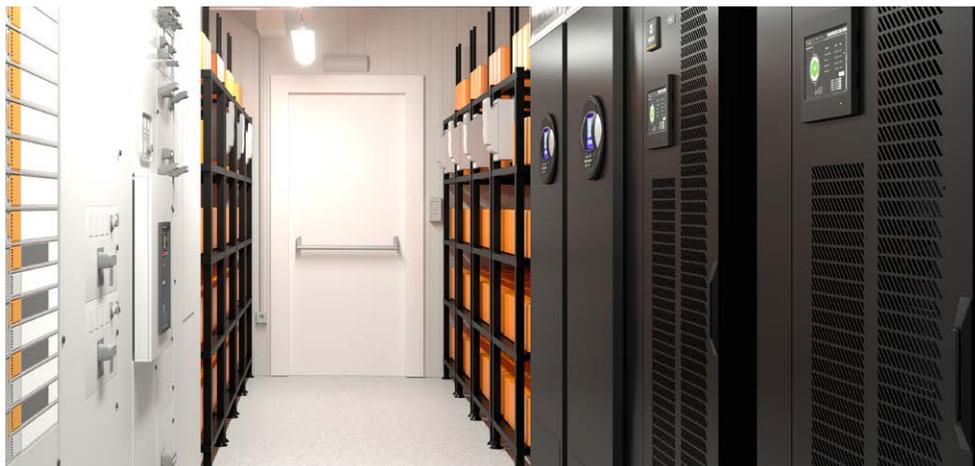
Which of the following statements best characterize your company's current MEC plans? (n=105)



Source: 451 Research

This, of course, represents only the first wave of MEC deployments. Deployments will continue throughout the extended 5G rollout, particularly as new use cases emerge that depend on the combination of 5G and MEC for their adoption and growth.

Vertiv classifies these use cases as Data Intensive (e.g., virtual reality, smart factories), Human-Latency Sensitive (e.g., augmented reality, smart retail), Machine-to-Machine Latency Sensitive (e.g., smart grid, smart security) and



Vertiv™ SmartMod™

Life Critical (e.g., digital healthcare, autonomous vehicles). For more information on edge use cases, see the Vertiv White Paper, Defining Four Edge Archetypes and their Technology Requirements.

Integrated and prefabricated systems and enclosures will play an important role in enabling telecom operators to meet the demand for MEC quickly and efficiently. Prefabrication refers to the process of manufacturing and assembling units of capacity (racks, rows, rooms, data hubs, power and thermal infrastructure) off-site to ensure standardization, efficiency and speed. Because prefabricated systems employ a modular approach to design and fabrication, they are inherently scalable.

For base station MEC sites supporting services to mobile users, rugged outdoor enclosure solutions similar to those currently being used for networking gear and batteries are being adapted to support the computing and storage required. Integrating IT equipment into the traditional base station equipment configuration allows enhanced support for 5G services.

For enterprise applications, such as 5G supporting IoT in industrial applications, fully integrated IT enclosures provide the same degree of standardization and speed of deployment. Whether configured in individual racks, rows or aisles, these standardized and repeatable solutions allow for cost optimization in deployment, limit over provisioning and leverage shared learning across sites to ensure that documentation, training, monitoring and maintenance is near-identical.

Key Questions to Ask:

- How many MEC sites will be required to support the early phases of 5G adoption?
- How much compute/storage capacity will be required by the typical MEC site?
- Is it possible to create a standardized MEC configuration that can be used across the network?
- How will MEC sites scale as more capacity is required?
- How will MEC sites be monitored and managed?



Installation of Vertiv™ SmartMod™

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2. Tailoring Availability to Service Requirements

Criticality requirements will likely vary across the increasingly dense 5G network so it's important to create a flexible availability strategy that optimizes capital investments while ensuring high availability for critical applications.

In core and regional data hubs, availability requirements will likely remain the same or increase as 5G brings new services and more data. AC and DC UPSs will continue to be the foundation for ensuring uninterrupted services in these facilities. The intelligent controls integrated into today's UPS systems now enable these systems to respond to changes in incoming power quality and demand to maximize energy efficiency. At the same time, increased connectivity and advanced analytics are supporting new service paradigms that enable condition-based and predictive maintenance to reduce service costs and minimize the risk of unplanned downtime.

Shifting to smaller spaces (<10x rack spaces), including micro colocation sites at the edge, there will often be varying levels of redundancy and availability required depending on the applications deployed and coinciding with redundancy within the network itself.

For example, in a multi-rack MEC supporting 5G services, one rack footprint may need UPS, another no UPS, and a third UPS with N+1 redundancy. Evaluating the feasibility of a UPS rack-mount-based method to target specific requirements will enable distributed redundancy at the rack level, eliminating overprovisioning of UPS capacity and potentially reducing capex requirements.



Key Questions to Ask:

- How will 5G impact availability requirements across each layer of the distributed network?
- What 5G-enabled applications will require high levels of availability at the edge? What applications can tolerate lower levels of availability?
- How can we leverage network redundancy to offset the need for dedicated backup power within some racks?
- What UPS topology is best suited for a particular application or edge location?
- How will remote backup power systems be monitored and serviced?

3. Ensuring Adequate Power and Cooling Capacity

Ninety-four percent of participants in the 451 Research study expect 5G to increase network energy consumption. In addition, 5G could significantly increase the amount of data moving across the network and being processed from the edge to the core. It isn't too early to begin planning for those changes.

Infrastructure systems sized for a pre-5G world may not be able to handle the increased load. As with core data center systems, it simply isn't economical to provision infrastructure systems for capacities that may exist five or six years in the future when 5G is fully deployed. The key to managing 5G growth from an infrastructure perspective is to specify and deploy infrastructure solutions that enable new capacity to be added with minimal disruption as is the case with modular UPS systems and integrated solutions.

One area that requires special attention is edge cooling. Sites that could operate without dedicated cooling in the past may soon be operating at higher densities that require new approaches to thermal management.

This trend is reflected in the 451 Research report, which found that between 2019 and 2024 no energy saving method is projected to grow more than new cooling techniques. Currently being used by 43 percent of survey participants, this number is expected to spike to 73 percent in 2024 as operators seek cost-effective solutions to deal with the increased heat being generated.

Well-designed outdoor enclosures now integrate thermal management systems that safely leverage outdoor air to deliver free cooling in a wide range of climates, supported by standby HVAC systems that only kick in during high temperature or emergency conditions. Likewise, fully contained indoor systems bring cooling close to the source of heat and contain hot air for highly efficient thermal management. Rack-mount air management systems should also be considered for switching cabinets that will be experiencing increased loads as a result of 5G.



Vertiv™ XTE 801

Key Questions to Ask:

- How will 5G impact thermal management requirements across each layer of the distributed network?
- How can we leverage free cooling to reduce thermal management costs across the network?
- What is the most effective thermal management technology to deploy in MECs?
- How will 5G impact the thermal management requirements of switching cabinets?

4. Enabling Remote Monitoring and Management

As new computing locations come on-line via MECs, the ability to remotely monitor and manage those location will grow increasingly important. While some telecom operators have resisted remote monitoring in the past due to security concerns, the sheer quantity of disparate end points required to support widespread 5G coverage will force them to address this challenge. Participants in the 451 Research survey identified data center infrastructure management (DCIM) or critical infrastructure management software as the top technology enabler in this category, followed by energy/power management.

Secure solutions that deliver continuous connectivity and monitoring of critical infrastructure, supported by a robust service network, will be an essential tool in managing the increasingly distributed 5G network.

These services, which are available today, can be customized to application requirements, including hardware maintenance and software updates. They can also provide users with an online portal for reporting alarms and health summaries, keeping operators informed of critical system operation without having service technicians visiting sites constantly.

Key Questions to Ask:

- How can remote sites be securely connected to enable monitoring and management?
- How will sites be monitored?
- How can we use the data collected from remote sites to improve operations?
- How will remotes sites be serviced?

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5. Mitigating Higher Energy Consumption

Telecom operators will need to get more aggressive in deploying energy-saving technologies to mitigate the impact on operating costs resulting from the higher energy consumption of 5G technology. The move to 5G is likely to increase total network energy consumption by 150-170 percent by 2026, with the largest increases in macro, node and network data center areas. Three key strategies for accomplishing this emerged in the 451 Research study:

- Operators will continue to focus on minimizing AC-to-DC conversions in the network to eliminate the power losses that occur with each conversion. Seventy-nine percent of survey participants said this was a focus today, while 85 percent said it will be a focus five years from now. DC power systems with AC-to-DC converters offer a minimum number of conversion steps. Used in combination with ultra-high-efficient rectifiers (>98% efficiency), these systems are being deployed to minimize power losses in the network.
- Many operators also expect to deploy “new” cooling techniques, such as economization or free cooling, to combat the expected increase in costs associated with cooling more sites consuming more power. While economization has been employed in the data center for years these technologies are now being integrated into base system enclosures that can operate cost-effectively in a wide range of climates. In five years, 73 percent of survey respondents expect to be using these technologies compared to 43 percent today.
- Upgrades from VRLA to lithium ion batteries also show significant growth. Currently, 66 percent of survey participants are upgrading their batteries. Five years from now, that number is projected to jump to 81 percent. Lithium ion batteries will be an important tool as networks densify to accommodate the shorter distances 5G millimeter waves can travel. In fact, the 451 Research report predicts, “this massive densification will potentially require operators to double the number of radio access locations around the globe in the next 10-15 years.” Lithium ion batteries not only provide much greater power density than VRLA batteries, they have a longer life, reducing service requirements and replacement costs over the life of the battery.



Key Questions to Ask:

- What will be the long-term impact of 5G energy requirements on operating budgets?
- Where do energy inefficiencies exist in the network?
- What energy-saving strategies and technologies are available today that weren't available when equipment was deployed?

Infrastructure Solutions for the 5G Evolution

Vertiv has a range of infrastructure solutions to help enterprises and telecom operators transform 5G plans into reality. Deploying data and analytics to design highly reliable and efficient systems that are simple, sustainable, and future-ready, Vertiv collaborates closely with our customers to ensure infrastructure solutions meet the exact requirements of the application.

Racks and Integrated Systems for Indoor Environments



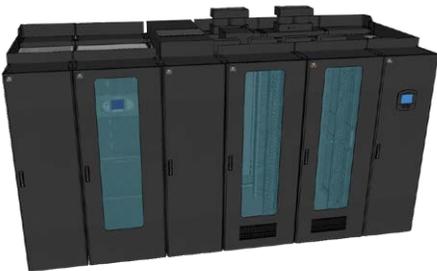
Vertiv™ VR Rack

The Vertiv VR rack supports a wide variety of equipment including servers, storage, switches, routers, PDUs, UPSs, console port servers and KVM switches. It is delivered ready for high density environments and mission critical needs, enabling fast deployment and global standardization.



Vertiv™ SmartRow™ DCR

A self-contained, modular data center row designed to simplify IT deployments in indoor spaces. With capacities up to 10 racks and integrated cooling, UPS, power distribution, fire suppression, and backup ventilation, the SmartRow enables standardization of complete micro data center configurations across multiple locations while maximizing installation speed.



Vertiv™ SmartRow™ DCX

SmartRow DCX combines four to fourteen racks with data center-grade thermal management, UPSs, power management, monitoring and control technologies and cable management all in an enclosed room-neutral system. It combines standardization with multiple configuration options to support future expansion, power and cooling redundancy levels and emergency ventilation.



Vertiv™ SmartAisle™

An intelligent row-based system that optimizes infrastructure deployment and management by integrating data center racks, power, row cooling, aisle containment, monitoring and control technologies in a compact, efficient design that supports up to 40 racks.

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Integrated Enclosure for External Environments



Vertiv™ SmartMod™

A prefabricated small data center leveraging Vertiv critical power, thermal management and monitoring and control technologies to support up to 100 kW of IT equipment in an easy and fast-to-deploy outdoor enclosure. Configuration options are available to provide desired redundancy and battery runtime.

Power Protection and Backup – AC



Liebert® PSI™5

An advanced pure-sine wave, line interactive UPS that provides excellent power backup and surge protection in cost-effective models from 500 to 3000 VA. The Liebert PSI family features Automatic Voltage Regulation (AVR) technology that protects against utility power fluctuation without battery operation, extending battery life. Liebert PSI5 UPS operates at a high 0.9 output power factor and can be configured with a network communications card to enable remote monitoring and power management.



Liebert® GXT5

An online double conversion UPS solution that offers premium power outage protection and continuous power conditioning in a compact and flexible deployment system. The Liebert GXT5 is Energy Star 2.0 certified thanks to efficiency of up to 95% in on-line mode and 98% in Active Eco- Mode controls. Its higher power factor provides more usable power at the outlet so more loads can be connected. It includes individual receptacle control for runtime management and power cycling of individual connected equipment. The Liebert GXT5 is covered by a 3-year full coverage warranty with optional 2-year extension. Available in 500 to 3000 VA capacities, the Liebert GXT5 single-phase UPS is ideally suited to protect critical infrastructure in both centralized and edge network applications.



Liebert® NXC 80-200kVA

The Liebert® NXC 10 - 200 kVA range offers reliable and flexible secure power in a fully integrated package solution. Its highly efficient transformer-free double conversion technology delivers installation and running cost savings and its combination of performance features, multiple internal battery configurations and three phase/single phase output flexibility makes it compatible to a wide range of applications. The Liebert NXC range has been designed to optimize specific rating requirements, thus enhancing flexibility and installation space needs.



Liebert® EXS

Simplicity, reliability and efficiency in a compact three-phase power solution that can support capacities up to 20 kVA. The integrated design and reduced footprint of the Liebert EXS provide maximum power capacity while high efficiencies and low installation costs contribute to reduced total cost of ownership.



Vertiv™ HPL Lithium Ion Battery Cabinet

A cabinet-based lithium ion battery system that delivers seamless integration between batteries, the monitoring system and the UPS. The Vertiv HPL is configured in a cabinet the size of a standard data center rack and is shipped fully assembled with six lithium ion battery modules. Up to eight cabinets can be connected to a single UPS.

Power Protection and Backup – DC



NetSure™ 1100

Designed for small cell or DAS sites, the 1000 Watt and 2000 Watt rectifiers in the high-efficiency NetSure 1100 Series accept AC or DC inputs and offer flexible installation options that include pole or wall mounting. IP65 housing allows installation in the harshest outdoor environments. Fanless cooling eliminates maintenance and results in silent operation.



NetSure™ 5100

Designed to discretely power critical infrastructure at the network edge with optimized management, security and control. The NetSure 5100 is a compact -48/+24 Volt 600 A DC power solution that features an advanced control unit and up to 29 positions for high-efficiency eSure rectifiers (2000 W) or -48 V to +24 V converters (1500 W) or solar converters (2000 W).



NetSure™ 7100

Modular high-power density DC power systems with up to 210 kW capacity in a single cabinet. System configurations are also available with integrated inverters to deliver both AC and DC back up in a single cabinet. NetSure 7100 can be equipped with the ultra-high efficiency R48-3500E4 rectifier.

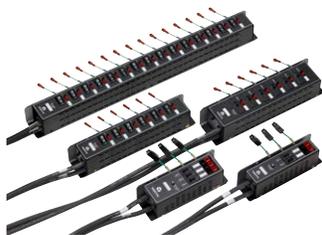
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Power Distribution



Vertiv™ Geist™ Basic Rack PDUs

Geist's Basic PDUs offer reliable power distribution to the cabinet to help manage power capacity and increase functionality. They cover a wide variety of electrical options, ranging from 10 A to 120 A in IEC, NEMA, British, Schuko and mixed configurations.



NetSure™ RDB PDU

Featuring plug-and-play connectors for simple field installation, NetSure RDB Series, 48V Rack Distribution Units are designed for ultimate ease of use. The NetSure RDB PDU features a space-saving design that can handle up to an 8.4 kW load.



Vertiv™ Geist™ Monitored Rack PDU

Reliable rack power distribution that provides a comprehensive view of power usage, both at the rack and via remote access, available in a variety of electrical and receptacle configurations. Unit-level and outlet-level monitoring options are available, including sensor integration for temperature and humidity and BMS integration. They include free Geist Director and Vertiv Power Insight software.



Vertiv™ Geist™ Switched Rack PDU

Reliable rack power distribution with a comprehensive view of critical IT equipment power usage, both at the rack and via remote access with the added ability to lock receptacles, remotely turn on, turn off, or reboot power at each outlet. Available in a variety of electrical and receptacle configurations.

Thermal Management



Vertiv™ Geist™ SwitchAir

A family of 1U and 2U rackmount airflow management devices for switches mounted in the rear of a rack in traditional hot aisle / cold aisle configurations. Channels provide a dedicated path for cold-aisle air to travel to the intake of the switch through active or passive airflow management. The SwitchAir also creates a barrier preventing recirculation of hot exhaust air from the hot aisle from entering switch intakes.



Vertiv™ VRC

A compact in-rack cooling system designed for edge environments, the Vertiv VRC delivers 3.5 kW of variable capacity cooling. It is available as a self-contained configuration, with heat rejection through plenums to the room or ceiling, and as a split system using a refrigerant loop and outdoor condenser.



Liebert® CRV

An efficient, high availability row-based cooling system featuring advanced controls and performance optimization. The Liebert CRV has a capacity of 19.6 kW per unit.



Liebert® PCW

Liebert PCW is the ideal chilled water cooling unit, providing an efficient solution for data center and server room air conditioning. This water cooling system is available in a wide variety of configurations and capacities, ranging from 200 kW to 6 MW.



Liebert® HPW

High Performance Wall-mount Cooling Solution for Telecom Mobile Applications
 Liebert HPW is the ultimate cooling system ideal for Mobile Telecom Network remote access node in shelters and containers. The Liebert HPW units are packaged, outdoor, wall-mount cooling solutions, with the traditional up-flow or the innovative down-flow air delivery solutions.

IT Management Systems



Avocent® LCD For Local Access/Control

A local access controller that enables ease of access to multiple servers to simplify the process of making software upgrades, troubleshooting and system monitoring.



Avocent® MergePoint Unity KVM

A family of KVM switches that include both KVM-over-IP and serial console technologies to provide a complete remote management solution to access and control servers, networking equipment and other devices. The Avocent MergePoint Unity switch enhances the in-band management typically done through the NIC of IT equipment by providing secure and remote out-of-band connections directly to the physical KVM, USB and serial ports.

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Avocent® Matrix KVM

A scalable and configurable solution for connecting hundreds of users to thousands of servers and workstation equipment in a secure, real-time manner.



Avocent® ACS 800 Advanced Serial Console

A compact and cost-effective serial console system that brings serial access, environmental monitoring, IoT integration and remote networking capability to edge sites. The ACS 800 supports in-band and out-of-band management and Zero Touch Provisioning.



Avocent® ACS 8000 Advanced Serial Console

Enterprise-class serial console that provides in-band and out-of-band serial access, environmental monitoring, IoT integration and remote networking capability. The ACS 8000 is available in 8-, 16-, 32- and 48-port models that fit in 1U of rack space with single and dual AC and DC power options.

Infrastructure Management and Remote Monitoring



Trellis™ Power Insight

Trellis™ Power Insight is a complimentary web-based application designed to remotely monitor up to 100 Vertiv UPSs and rPDUs.



Vertiv™ Remote Monitoring

Provides 24/7 alarm monitoring with call escalation notifying when an alarm condition is present, or 24/7 equipment analysis with call escalation notifying when critical alarms are present, and action is required. When coupled with a service contract, a customer engineer is automatically dispatched to the site to address the alarm.



Avocent® DSView™

Avocent DSView centralizes the management of multiple KVM switches to deliver secured web-browser-enabled sessions of on-network infrastructure controls. It features standards-based encryption, out-of-box integration to enterprise authentication and authorization, and threshold-based event notification by site.



Vertiv™ Environet

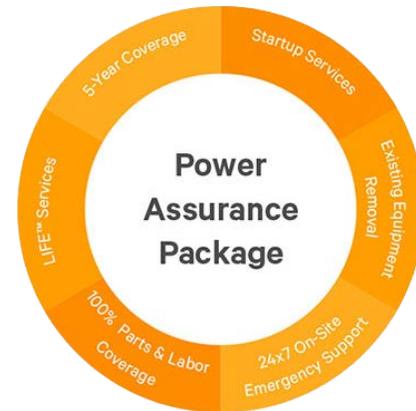
A comprehensive monitoring solution that delivers access to real-time, holistic information on equipment operation to enable energy monitoring and proactive management of moves, adds and changes. Environet works with infrastructure from any manufacturer, allowing colocation providers to use one system to monitor multiple tenants separately.



Trellis™ Critical Insight

Trellis™ Critical Insight is a powerful web-based building and site monitoring platform with software tools to manage energy conservation projects, identify key operational problems and analyze the results. The platform supports major communications protocols, including Modbus® and SNMP to allow sharing data with enterprise or third-party systems to accomplish a range of tasks.

EDGE Services



Vertiv™ Power Assurance Package

Delivers convenient and cost-effective support for power systems at distributed sites, including startup and installation, onsite support and emergency response with 100% parts, labor and travel coverage.



LIFE™ Services

Provides continuous monitoring and data analysis by remote system engineers to quickly, accurately, and safely restore equipment to its proper operating condition.

About Vertiv

Vertiv brings together hardware, software, analytics and ongoing services to ensure its customers' vital applications run continuously, perform optimally and grow with their business needs. Vertiv solves the most important challenges facing today's data centers, communication networks and commercial and industrial facilities with a portfolio of power, cooling and IT infrastructure solutions and services that extends from the cloud to the edge of the network. Headquartered in Columbus, Ohio, USA, Vertiv employs around 20,000 people and does business in more than 130 countries. For more information, and for the latest news and content from Vertiv, visit [Vertiv.com](https://www.vertiv.com).

