Powering the future of small cells and beyond

Mobile data traffic has grown 4,000-fold since 2007 and will continue growing at a rate of 53 percent annually through 2020[1]. 1,000x the bandwidth, new business models, new applications (connected cars, IoT, etc.). It's a brand new world! What's required? More spectrum, the Internet of Things, and many more cell sites.

5G deployment may be several years away, yet it is already proving to be a major disrupter of the status quo. In preparing their networks to handle the massive demands for more bandwidth, new applications, lower latency and ubiquitous coverage, mobile network operators (MNOs) have begun the process of cell densification in their existing 4G networks. The result is a significant increase in the number of small cells being installed.

What defines a small cell?

The definition for "small cell" has broadened as applications have increased. According to Small Cell Forum, the term describes any operator-controlled, low-powered radio access node, including those that operate in licensed spectrum and unlicensed carrier-grade Wi-Fi. This includes microcells, picocells, femtocells and metrocells that typically have a range from 10 to several hundred meters.

For the purposes of this paper, we have excluded in-building and venue solutions such as distributed antenna systems (DAS) which are typically part of the macro layer.

The current efforts represent a small percentage of the millions of new small cells that will be needed to deliver the much-anticipated promises of 5G. As small cell deployment continues to increase, mobile network operators are facing a host of fundamental challenges, including how to deliver power to each individual node without breaking the bank.

The challenges of cell densification

Between 2015 and 2025, new nonresidential small cell deployments are expected to grow at a compound annual rate of 36 percent, to reach almost 8.5 million—22 times higher than in 2015[2]. A recent survey indicated that 40 percent of operators expect to deploy between 100 and 350 small cells per square kilometer (indoors and outdoors) in the areas they densify by 2020[2]. While estimates regarding the degree of small cell density vary, the consensus is that mobile network operators will require more than 10 small cells per current macro cell in urban areas to densify their networks in the next few years[3].

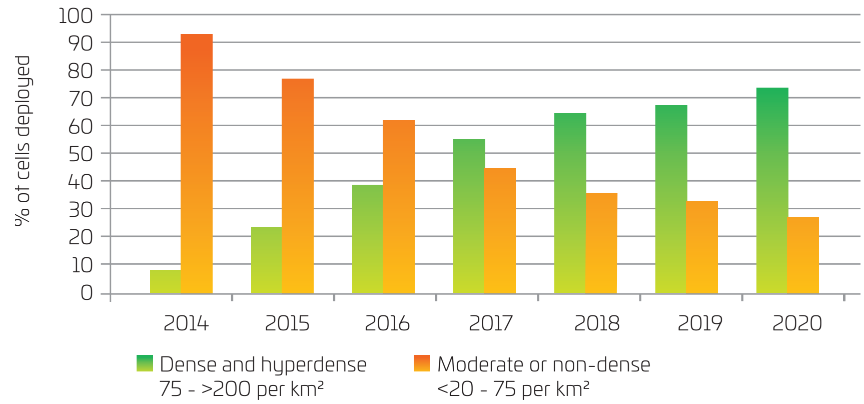

Figure 1. Distribution (%) of new small cells deployed by density
Source: Rethink Technology Research, "SON Deployment Trends and Forecasts"; 2016

Thus far, the key driver of small cell growth is the need for more coverage and capacity in heavily populated urban and suburban areas—environments for which small cells are perfectly adapted. Compact, discreet and able to support beamforming and massive MIMO, they enable ubiquitous, high-capacity coverage within urban canyons and suburban shopping districts.

As the need for ubiquitous, high-density coverage increases, small cells must move closer to subscribers in order to support new higher-frequency wireless services and stricter signal quality requirements. This will involve locations that are more discreet and compact—lamp posts, utility poles, street furniture including signs.

The advanced capabilities of today's 5G-ready small cells mean added power requirements. Increased data traffic requires more computational power. Although massive MIMO can help improve spectral efficiency, power efficiency is generally lower and a typical three-sector small cell can require 200–1,000 watts of power. The challenge is how to get power to large numbers of small cells in a cost-effective and repeatable way that supports fast and efficient rollouts.

The first step involves recognizing that the traditional model for powering macro cell sites does not apply to small cells. mobile network operators are used to the deliberate and structured process involved in permitting, building and provisioning their macro cell locations. Each tower location is carefully planned and site specific in order to eliminate any on-site surprises once construction begins.

Cell densification requires a wholesale shift in that mindset. The sheer number of small cells needed means operators must accelerate deployment with "cookie-cutter" processes. At the same time, they must be equipped and agile enough to adapt their siting, backhaul and power solutions on the fly. There are also power-specific challenges operators must address.

> Light-touch "cookie cutter" processes will have to replace heavier, custom-engineered processes to control the cost and to speed up the delivery of those hundreds of thousands of cells.
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> DeLoitte, Small Cells, Big Changes, March 2017

Connection cost vs average revenue per user (ARPU)

Whether it's a small cell or macro cell tower, the cost to connect to the power grid is similar. Estimates range from $5,000–$15,000 per location. In the case of a macro cell tower that serves thousands of revenue-generating users, the cost to initially connect power can be easily justified. For a small cell that serves only a couple of hundred people, the cost to connect to the power grid represents a much larger share of the day one CapEx compared to the macro site. Therefore, justifying the expense of a dedicated electrical connection to the small cell becomes far more difficult.

New space constraints

A macro tower site is pre-designed with the power cabinet and power meter typically housed in a dedicated space within the shelter. In deploying urban small cells, mobile network operators must work within the constraints of the available space. On lamp posts or utility poles, for example, there may not be room for a dedicated power source, meter or backup power supply. Small cell solutions that can integrate with street furniture or are available pre-assembled for faster turn-up can help operators deal with these challenges.

The need to plan for power

Typically, the first step in network design focuses on coverage. For small cells, that means ensuring infill coverage between buildings, along urban canyons, and in other hard-to-reach areas. Often, it's not until after the site survey that engineers discover there is no electrical power close to some of the proposed small cell locations. Tapping power from existing buildings and/or getting municipal approval involves negotiations with building owners, tenants and local agencies, and takes time. Total time needed to deploy small cells is now estimated at 18 to 24 months[4].

Power and backhaul present similar challenges

In addition to the power challenge, mobile network operators must also plan for backhaul from each small cell location. Many in the industry, including CommScope, contend that one logical way to accomplish both is to run both power and optical transmission along the same path or even within the same cable.

Emerging need for power backup

It should be noted that relying on power from the grid does not necessarily guarantee 100 percent uptime. Electrical feeds can be—and often are—interrupted by lightning strikes, blown transformers, auto accidents and even rodents. In recent years, the grid's susceptibility to outages has led to networks investing more heavily in battery backup systems. This will become increasingly more important for small cells.

Until now, small cells have largely been deployed to supplement coverage and capacity within the macro layer. As power backup in the macro layer becomes the norm, there has been less urgency to invest in small cell power backup. However, in the future, small cells will also be used to offer new 5G services based on the new 5G radio standard. Those include ultra-reliable low latency and massive IoT scenarios, as well as many more that have yet to be developed.

In a grid-powered heterogeneous 5G network, macro cells most likely will have their current battery or diesel generator backup. So, a power outage would have less impact on the macro layer. However, small cells—which do not presently come with power backup—would be down during a power outage. While the macro layer may be sufficient to maintain a basic level of service for customers within the coverage area, it would not be able to support those applications that make full use of the new 5G features. Small cells deployed to fill coverage gaps in critical areas will likely be among the first to need backup. Therefore, power backup should be part of any small cell deployment plans prior to day one rollout.

Here again, applying a macro solution to a small cell power problem will not work. While battery backups can be added to a macro site without affecting siting issues, this is not often the case with small cells. In some instances, the power backup solution can take up more space than the small cell itself; if that backup solution involves a diesel generator there are additional permitting and environmental issues to overcome as well.

Addressing the power challenge

When it comes to tackling the various issues of powering small cells, there are a few existing options and each has its opportunities and obstacles.

Power from the grid: For the vast majority of mobile network operators, obtaining an ac power feed from the utility grid is the go-to solution for powering wireless networks, and has been for a long time. As a result, the solution is very familiar to those working with it in the field. However, the process requires intense planning and project management. Figure 3 illustrates the degree of planning and project management required to run grid power to a single site.

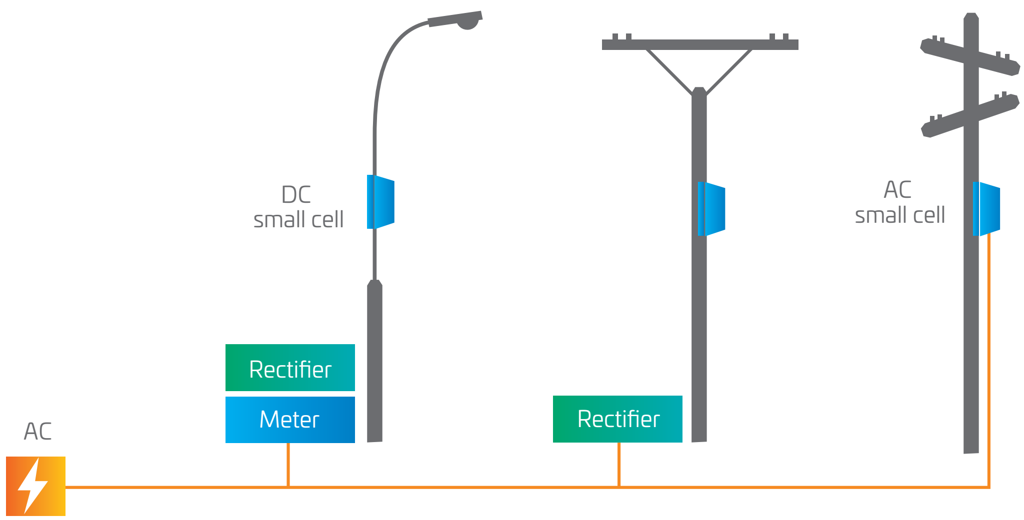

Figure 2. Example of utility grid power solution

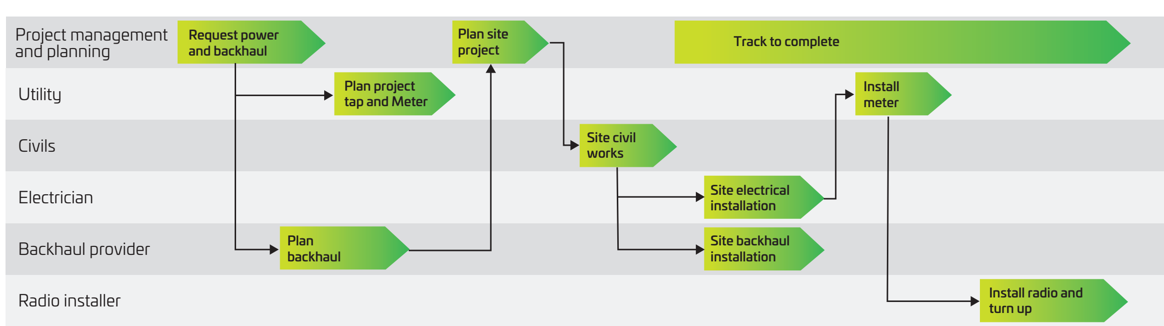

Figure 3. The typical process of connecting to the grid

But, as mentioned, this method becomes less attractive as mobile network operators shift from deploying fewer and larger-capacity macro-based cell sites to thousands of smaller capacity small cells. Challenges include the cost and time involved in getting a power drop (metered or un-metered) to each individual node. Additionally, network engineers must solve the issue of equipping each site with battery backup in space-constrained urban locations and satisfying tougher aesthetic regulations.

Hybrid fiber coaxial (HFC): HFC networks are now the mainstay of the cable television industry. By utilizing the power-carrying capability of the integrated coaxial cable, they also provide an alternative solution to the small cell power challenge. As operators work to meet increasing subscriber demand they continue to invest and improve their outside plant. This involves upgrading their 60/90 VAC power plant, adding more power injection points, pushing fiber deeper into the network and deploying remote distributed-access architectures. Estimates are that 80 percent of HFC plant miles have network power availability[5]. This includes fiber portions of the plant where coaxial cable can run in parallel, as a back-feed from an optical node, to make power available. In most cases the power availability is more than adequate for Wi-Fi hotspots or small cells. The challenges with HFC networks are that it is still not ubiquitous and, where operators do not own their own backhaul networks, they must lease from other providers.

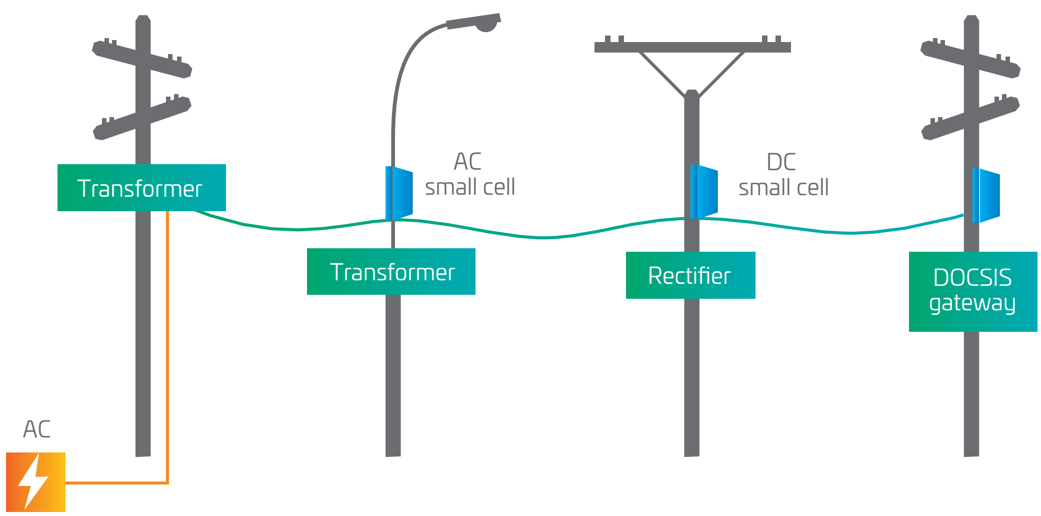

Figure 4. Example of an HFC power solution

Twisted pair: A second possibility involves tapping the power-carrying capability of the legacy copper telephone networks, also known as a remote feed telecommunications (RFT) circuit. There are essentially two approaches to this solution. RFT-C is current limited to 60 mA and typically supports less than 20 watts of power at 320 volts. RFT-V, which typically operates at ±190 volts, is voltage-limited to 100 watts of injected power per pair.

The main advantage of the RFT solution is the ability to re-use the existing copper plant. However, the small-diameter copper pairs provide limited power under the current standard and exhibit high power losses over extended distances. At a length of 3,000 meters, the 100 watts of injected power drops to about 60 watts of effective power. Additionally, there is a general lack of documentation regarding available copper wires within the public-switched telephone network (PSTN). So identifying the right power injection points is also a challenge.

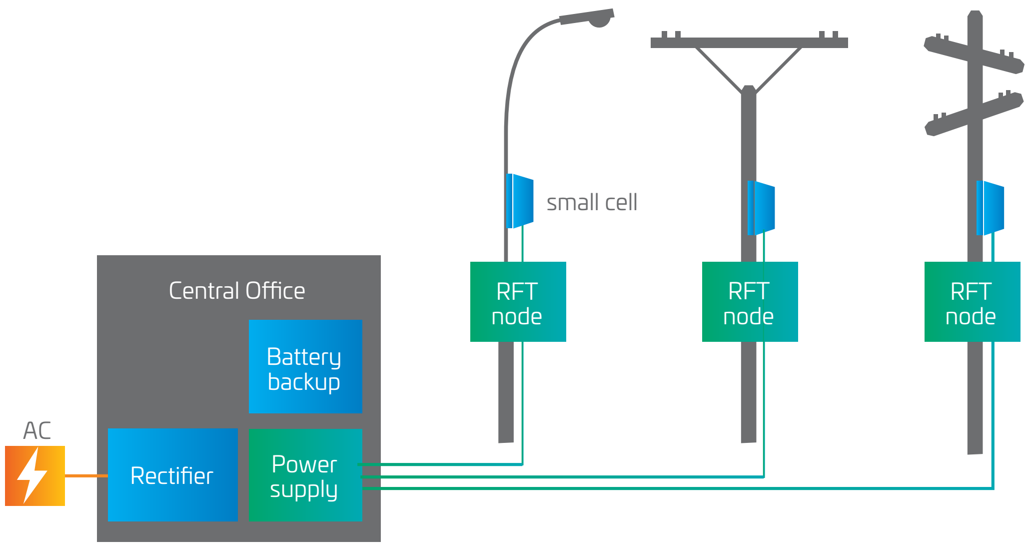

Figure 5. Basic configuration of an RFT circuit

Power over Ethernet (PoE): Since Power over Ethernet was introduced—in the early 2000s—manufacturers, industry organizations and standards bodies have made good progress in expanding its capabilities and applications. The latest Power over Ethernet standard, IEEE P802.3bt (PoE++), is expected to be finalized in 2018 and will support up to 71.3 watts (dc) per device port[6]. As such, its use in a small cell environment would be limited to very low-powered Wi-Fi access points.

In addition to power restrictions, Power over Ethernet is also distance limited, with PoE++ rated for a maximum distance of 100 meters. There are solutions that enable operators to use Power over Ethernet over longer distances. CommScope's Powered Fiber Cable System, which includes a Power over Ethernet extender, increases the span up to three kilometers. While it removes the distance limitations, the power limitation remains. Moreover, the speed and latency requirements for small cell backhaul dictates the use of fiber, which further weakens the business case for Power over Ethernet.

Distributed power connectivity: A new approach being developed by CommScope uses hybrid fiber cabling to deliver power and connectivity from a central location to a cluster of neighboring small cells. A suitable centralized location can be anywhere that has access to power and the optical network, such as an outdoor distribution cabinet, telecom closet or macro base station location.

This approach takes advantage of evolving hybrid fiber cabling as well as advancements in dc power delivery. Such improvements have increased the efficiency of dc-dc conversion to more than 95 percent and enabled the use of higher voltage levels to transport more power over long distances more efficiently.

Meanwhile, the use of hybrid fiber cabling enables operators to combine power conductors and the fiber cables in the access network. For example, it becomes possible to power and connect dozens of small cell locations—spaced 200 meters apart—from a single location with local grid power and room for power backup.

By eliminating the excessive time and costs required for a utility drop, mobile network operators are able to deploy power to their small cells faster and less expensively in places where power is not quickly and easily available. It also allows for battery backups or generators at the centralized location to support busy or mission-critical small cells.

Therefore, the solution is ideal when both power and data connectivity can be deployed as part of a greenfield rollout, and where multiple new locations can be clustered around a single point of connection to the grid.

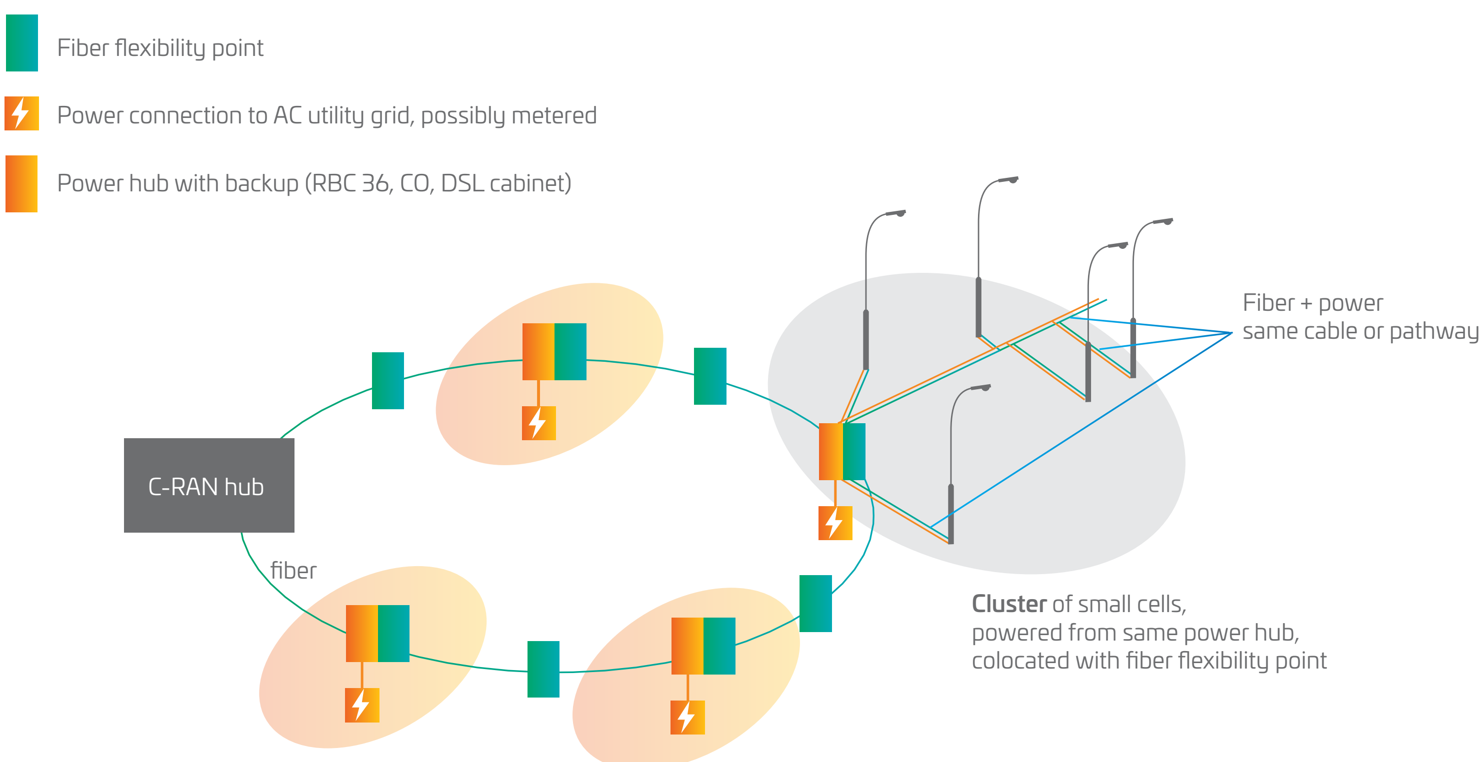

Figure 6. Cluster power solution in support of a C-RAN deployment

By reducing the number of uncontrolled variables—scheduling delays, electrician availability, additional meters—the distributed power connectivity solution gives operators full control over how, when and where to add small cell coverage. This enables mobile network operators to swiftly respond to new market opportunities and increase speed to revenue—capabilities that are critical in an increasingly competitive market place.

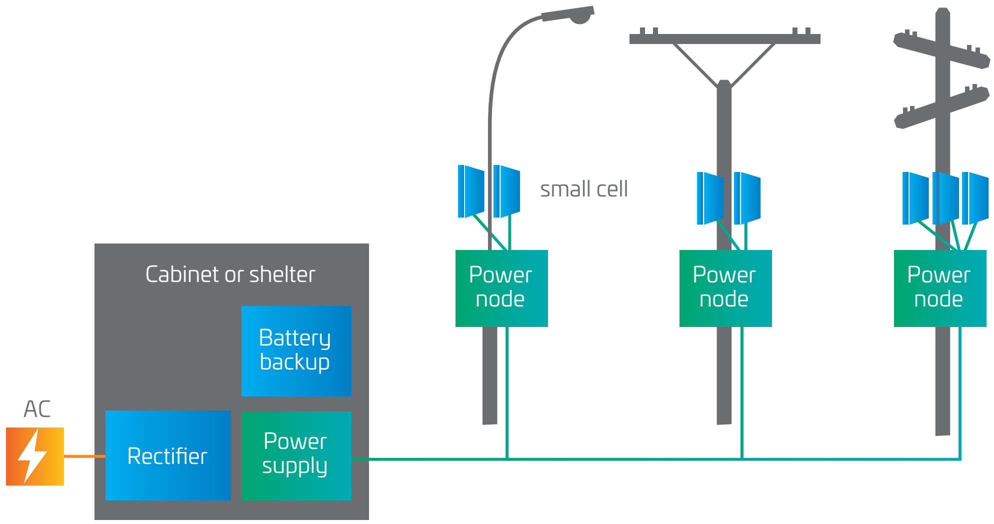

Figure 7. Example of a low voltage dc power solution

CommScope: Empowering the future of small cells and beyond

Led by small cells, the number of mobile RAN nodes is exploding as mobile network operators and wireless providers evolve toward converged, 5G-enabled networks. Deploying and supporting these devices means balancing the requirements of three key interconnected challenges: site acquisition, backhaul/fronthaul and power. Without affordable and reliable power for the tens of millions of projected small cells, network densification will stall.

At CommScope, we're working to develop smart power solutions for 5G small cells; solutions that provide operators more options for deploying their networks in the fastest and most economical way possible. Initiatives such as our distributed power connectivity solution can not only help operators reduce their power costs, speed installation and increase network reliability, they offer insight into how we'll eventually power the billions of remote connected devices in the years to come. It's our job to know what's next.

As you explore your 5G options, consider how CommScope can help prepare for and discover its full potential. We can develop and participate in 5G workshops, requests for quote, information sessions and other partnership opportunities.

To stay up to date on our ongoing efforts in power solutions, visit our DC Power Supply Solutions for Cell Sites solutions landing page.

[1] Convergence of Computing, Caching, and Communications; March 21, 2017; IEEE Access
[2] SCF Operator Survey; Small Cell Forum, survey report; December 5, 2017
[3] What you need to know about the rise of small cell infracos; Delta Partners Group, report; March 2017
[4] Small cell deployments take 18-24 months, and that won't change anytime soon; Fierce Wireless; September 20, 2017
[5] Maintaining The Power Advantage In HFC Networks; CommScope, technical paper; 2017
[6] Laying the groundwork for a new level of Power over Ethernet; CommScope, white paper; April 2017

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