Why data center substations require specialized design

The electrical substations that serve data centers are often based on designs honed in the electrical distribution business. It's seems reasonable to assume this would be a wise practice. After all, what industry has more experience with substations than electric utilities?

But data centers have unique performance requirements. Their needs differ from those of utilities, and substations should be designed to support those needs.

According to Patrick Komischke, Engineering Manager of T&D Infrastructure and Grid Integration Solutions, here are three reasons why data centers require specialized substation design, and some specific solutions to address them.

Reliability

Electrical distribution networks that operate dozens of substations achieve reliability in part by being able to quickly reroute electricity around a substation that has been failed or taken offline for maintenance.

But data centers don't have that luxury. Most operate with power supplied through a single substation. A fault or failure can cause an outage that may cost up to $1 million an hour, according to industry estimates. Even planned maintenance can curtail data center operations or require costly workarounds.

For that reason, data center substations require a design that:

1. minimizes failures;
2. reduces the need for maintenance;
3. allows maintenance or expansion to occur without taking a substation completely offline.

These priorities may be different than those of a utility, and they're addressed through design and specification of specialized equipment – from transformers and breakers all the down to cables and switches.

It also involves built-in contingencies to address any weaknesses in the network that feeds the substation.

For example, to achieve the highest level of reliability, a data center substation must be designed to accept utility power from at least two sources. If one line suffers a power outage, the remaining line is able to continue providing all the power required to keep the data center running.

Availability

Public utilities have large field forces to conduct maintenance across their networks. They also work in a regulatory environment that may limit their ability to recover the cost of capital investments. When utilities design substations, these factors encourage a focus on reducing the initial investment rather than minimizing lifecycle costs.

But data centers require substations to be available 100 percent of the time. That need is served through components that may require higher initial investment, but which demand little or no maintenance over time.

For example, traditional substation designs specify lower-cost Air Insulated Switchgear, which has a 2,000 percent greater chance of failure than Gas Insulated Switchgear (GIS). While GIS is more costly to install, it runs far longer without maintenance – serving to reduce lifecycle operating expenses while maximizing availability of power from the substation.

GIS equipment also occupies less space, reducing the overall footprint – important for data centers in urban areas, or where the substation must be fully enclosed. And because GIS components are self-contained and connected through bus systems, they can be used to achieve a modular design that allows future expansion of the substation without it being taken out of service. As a result, capital investment on a new substation can be limited to the cost of meeting current demand, with future demand being funded only when it is actually needed.

Safety

Substations house medium- and high-voltage technology, which can cause fatal events. Such occurrences are rare, but they do happen. While utility substations are typically separated from people by distance or substantial safety barriers, data center substations may need to be in immediate proximity to the facility – sometimes even inside.

That presents risk to people and also to sensitive equipment – not just in the electrical system but in the cooling system or even servers themselves.

By specifying dry-type transformers in their substations, as one example, data centers minimize the risk of catastrophic failure because these units don't have any oil to combust.

There are a variety of other ways in which the proper design can serve the specialized needs of a data center substation. But what management most needs to know is that not all substations are the same, and they should be designed in a process that focuses on these differences.

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