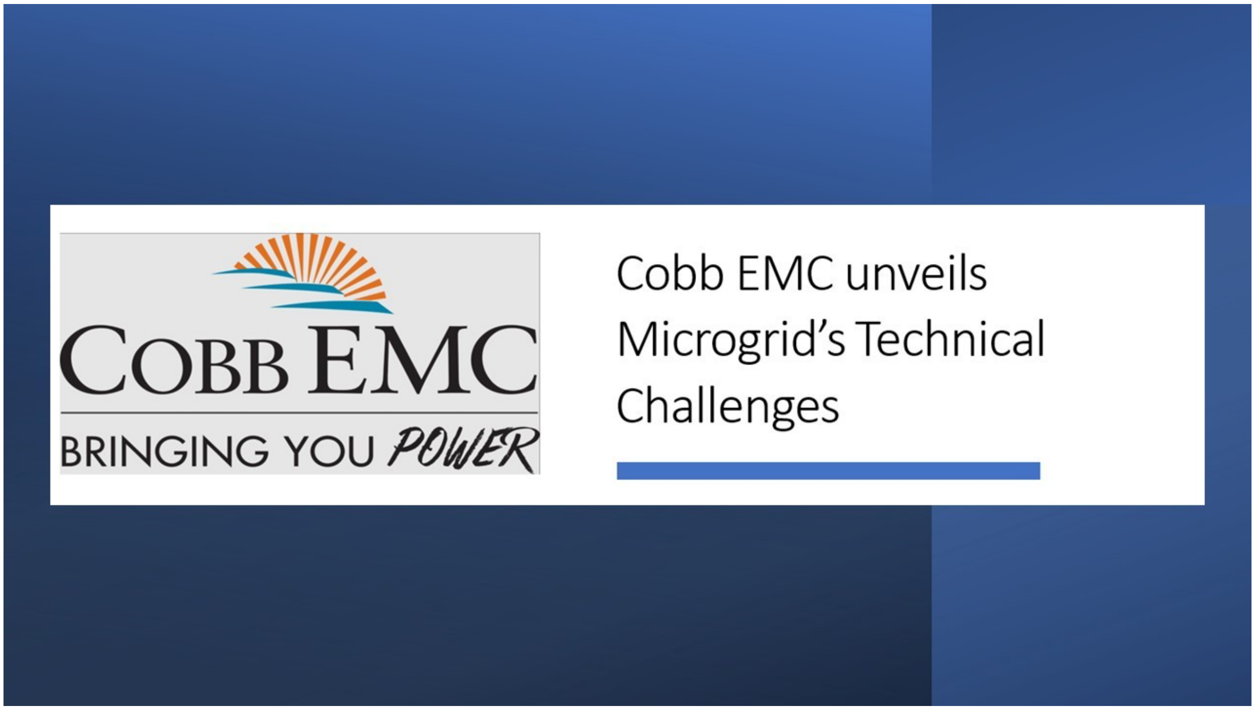

Cobb EMC Unveils Microgrid’s Technical Challenges

Published on August 18, 2021

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Microgrids are an innovative technology that provides a new paradigm in increasing resiliency during power outages. This innovation also comes with many technical challenges, and it is essential to identify these challenges early on so that they can be circumvented during the actual implementation. Part I of this article will discuss the challenges that Cobb EMC encountered during the planning phase of the microgrid implementation. Part II will share our strategies and solutions in overcoming these potential barriers. The most critical aspect of operating the microgrid is in the islanding mode when the utility is disconnected and the microgrid is transitioning from the grid-connected mode to the islanding mode. Through brainstorming sessions, we explored the potential technical challenges that we would face in order to operate a microgrid safely and reliably while in islanding mode. These challenges that we identified are discussed below.

Cobb EMC is one of the nation's largest electric cooperatives in terms of both members and revenue. Cobb EMC selected Caterpillar and Yancey Power Systems to build a microgrid on the campus of its headquarters in Marietta, Georgia. The project implementation of the microgrid project will be in the third quarter of 2021 and planned project completion in the second quarter of 2022. In order to support its sustainability goals, Cobb EMC partnered with Gas South (a wholly subsidiary of Cobb EMC) in 2019 on an innovative solar and battery energy project called Solarbe. Solarbe was commissioned and operational in September of 2020 and consisted of three parts. The first part was the installation of 1.85 MW DC solar PV on the rooftops of three campus buildings and two solar car canopies. The second was the creation of our solar Smartflower garden, and the third was the construction of the battery energy storage system (BESS) with a nameplate capacity of 1 MW/4 MWh AC.

While this is an exciting project, these Distributed Energy Resources (DER) are operating only when the grid is available. During extreme severe storm situations, it is important that our campus, particularly Power Control, Warehouse, Fleet Maintenance, and Data Centers maintain a continuity of power. While we have assets in place to help keep critical systems and locations operational, the microgrid solution can help us to achieve the objective of having the entire campus operational from a combination of the Solarbe assets and additional generating assets on campus. With the addition of the fast start natural gas-fired synchronous machine, the microgrid will ensure that the campus will remain powered for extended hours during power outages. One of the business drivers of the campus microgrid project is to build a model for future microgrid projects where Cobb EMC can offer a microgrid as a service to its Commercial and Industrial members.

1. **Handling of large inrush current in a black start mode** – Inrush current is the maximum current flow drawn from the devices such as transformers and motors when they are first energized, and it usually lasts only for a few cycles. The maximum one-hour average load during summer peaking for the campus is up to 1,100 KW. Given the large number of transformers existing on our campus with a connected capacity of more than 6,000 KVA, mitigation of the inrush current originating from the transformers and building loads could be challenging. This can cause the inverter of the grid-forming resource to trip and go offline during the black starting of the microgrid. When transformers are reenergized during a black start, the inrush current generated by the transformers could be as high as 6-8 times its rated current for a few cycles before reaching a steady state. In addition, the building's chillers and motors loads can also demand high inrush currents that could be up to 6 times their rated current. The output power from the BESS is instantaneous, but its inverter will have limited capability to handle a significant amount of inrush current during a black start.[1] As a result, it is important that you estimate the maximum magnitude of the inrush current and understand what type of inrush current mitigation strategy your microgrid vendor is proposing. It is also important to know what type of inrush current mitigation strategy they are proposing because that strategy will

determine what type of grid forming resource and control mechanism need to be used for the safe and reliable operation of the microgrid.

2. **Sizing of the synchronous generators and other assets** – If the BESS is not your option, and in case if it cannot handle the large inrush current resulting from black starting the microgrid, then the addition of an optimally sized reciprocating engine genset becomes extremely important. The capacity of the genset is important for two reasons. First, you want to make sure that the gensets will supply enough power to the entire campus during an emergency power outage. Second, the inherent capability of the synchronous machine based on its inertia and excitation control should be verified so that it can handle the campus inrush current without significant waste in oversizing the system. It is also important from a budgeting perspective that the generator is optimally sized as this asset is one of the most expensive components of the total cost of the project.

3. **Implementing system protection and control** – System protection is a major concern particularly during the islanding operation of the microgrid. The reason for this is that your existing protection scheme may not work as inverter-based DERs will limit its output current contribution to a fault (typically 1.1 to 1.5 times nominal rated current). The traditional protection scheme on the distribution system is designed to operate for relatively high fault currents supplied by the normally stiff utility source, which is your substation transformer bank. However, when a fault occurs on the main feeder while the microgrid is in an islanding mode, the DERs will not contribute enough fault current because of the lack of inertia and because it is trying to protect its electronics. Under such circumstances, our traditional feeder protection and control methods may take either a long time or even fail to correctly detect and isolate the fault and possibly even damage the equipment.

4. **Maintaining a balance between load and generation** – One of the questions that is frequently asked during the vendor evaluation process is “how the system is going to maintain a balance between the load and the power generation so that it will not cause any instability in the system.” For example, if there is excess solar generation than your current load demand, then what can be done? Does the solar inverter have the capability to curtail its output or can we charge the battery using that excess solar generation? And what if your battery is acting as the source of voltage and frequency, can it still be charged at the same time? Further, if you are utilizing a synchronous generator, can you maintain a minimum loading to avoid costly maintenance issues with the system? These questions make it clear that you need to have a strategy for each different operating scenario so that your system frequency will not suffer and create instability. It is important that the microgrid controller has the operating status of all generation assets within the microgrid so that it can coordinate these resources correctly in any of the system operating modes.

5. **Load management strategy** – Let's assume that you have sufficient generation capacity to supply power to the entire Cobb EMC campus load. What if one of the generating assets then fails or is not available due to maintenance or any other reason, or what if your peak load surpasses more than what you had initially planned for? While this would be an extremely low probability event considering Cobb EMC also has a BESS on our campus, maintaining stability in such situations is crucially important. It is important to have a load management strategy in place that would include the size, type, and priority of each load so that the microgrid controller can make an intelligent and informed decision on keeping the system stable. Otherwise, in this case, the system voltage and frequency would collapse and the whole campus would likely be subject to failure and shutdown.

6. **Seamless islanding versus black start islanding** – How do you want the microgrid to transition to islanding mode when the utility power is lost? In seamless islanding, the users will likely experience a minor brownout as the switch installed at the point of common coupling (PCC) separates the campus from the failed grid and the microgrid assets transition from being grid-connected to islanded mode. So in essence there is no downtime. However, there are two levels of devices that need to be coordinated and operated very quickly – the inverter protection of the battery (or any other grid forming DER) and the relay protection located at the PCC where the islanding action will normally occur. The response time of the relay protection located at the PCC has to be really fast, as the grid voltage and frequency is collapsing due to the fault so that it can make this transition seamlessly. The switch at the PCC needs to operate before the DER equipment is tripped offline. The seamless islanding is a preferred choice if you want to avoid handling a large amount of inrush current. On the other hand, the black start operation is relatively simple in that you will notice an outage for a very short period of time ranging anywhere from 3 to 10 seconds, depending on how quickly you ramp up your grid-forming asset. In the black start, your grid-forming resource may need to bring each load online at a time. So then the question becomes what criteria drive the decision to implement seamless islanding versus black start islanding in your microgrid? We'll discuss this more specifically in Part II of this article.

7. **Achieving effective grounding in islanding mode** – What can cause system overvoltages when a ground fault occurs? Simply put, it is the lack of effective system grounding. Ensuring that there is effective system grounding during the operation of the microgrid in islanding mode is of paramount importance for the safety of the personnel and the equipment, and that is something can be easily overlooked when designing a microgrid. There are primarily two criteria that define effective grounding: a) As per IEEE C62.92.1, if a system has a coefficient of grounding (CoG) less than 80%. This ensures that the voltages on unfaulted phases during a single phase to ground fault will not exceed 138% of line to ground voltage. b) When the system's impedance ratios meet the condition where ($0 < X0/X1 \leq 3$ and $0 < R0/X1 \leq 1$). The absence of effective grounding will cause line to ground overvoltage and that can damage

equipment, surge arresters, and single-phase load devices if they are not rated to withstand these overvoltage conditions. There are a couple of ways to implement effective grounding. One way is to create a supplemental ground source such as by designing a grounding or zig-zag transformer. There are pros and cons to having a supplemental grounding and its impact needs to be evaluated properly. A second way to implement effective grounding is to utilize Yg-delta step-up transformer for the DER where the primary winding is Grounded Wye.[2] A recent study performed by EPRI suggests that the traditional approach described above for implementing effective grounding assumes synchronous generators as DERs which would not work for the inverter-based DERs. Therefore, a study needs to be performed to determine how to implement effective grounding for inverter-based DERs.

In summary, when designing a microgrid, there must be careful attention given to the design elements discussed above for the safety of the linemen and equipment while attaining the reliability, environmental, and economic benefits of implementing your microgrid.

Acknowledgment:

The author would like to thank Kevin Fuller from CHA Companies, Bryan Snyder from Caterpillar, and Tim Jarrell & Kristen Delaney from Cobb EMC for their review and suggestions.

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[1] Investigation and Mitigation of Transformer Inrush Current during Black Start of an Independent Power Producer Plant.

[2] EPRI: Effective Grounding and Inverter-based Generation: A "NEW" look at an "OLD" subject.