Michael J Martin, MA, MBA, Med, SCPM, PMP
Senior Managing Consultant, Broadband Networks
michael.martin@ca.ibm.com
Global Technical Services
Global Center of Excellance in Energy and Utilities.
3600 Steeles Avenue East
Markham, Ontario, L3R 9Z7Canada
416 478 3483 direct line
416 729 9991 cellular – Canada
720 626 8755 cellular – United States

Smart Grid: UPS – The Noblest Device in Your Network

Introduction

As Utilities adopt smart grid strategies and deploy more advanced telecommunication infrastructure, there are some fundamental changes under way in the manner that the power grid is monitored and controlled. These changes include architectural design, survivability, availability, reliability, and design performance under adverse conditions.

The net result of these elementary changes is an operational transformation from manual processes to automated processes. This new dependency on computers and networks radically alters the work flow and the manner that work is performed. The power grid is now controlled by people controlling computers.

Using an analogous parallel, commercial pilots no longer fly with basic “stick and rudder” control of their aircraft; instead they command the autopilot and it in turn actually flies the airplane. Pilots have become button pushers!

In a similar manner, smart grid network operations staff now commands the computer that flies the smart grid. The impacts of these changes are most profoundly evident when the power grid is stressed during a crisis situation caused by some anomaly, such as a major catastrophic weather event.

Utilities are placing more importance on the communication networks for fault and outage awareness, isolation, and restoration. These communication networks need to be available during the worst case scenarios and are critical to the timely return of service to the Utility’s customers.

Building a telecommunication network that is more robust than the power distribution grid itself is a tall order. There are many challenges to keeping a communication network alive during a crisis. Short duration outages are much easier to deal with compared to prolonged outages that extend into hours and days. Emergency power solutions are needed that can deliver power to the telecommunication equipment even when the primary supply from the power grid has been interrupted for several days. Customers will no longer tolerate long term outages so the arrival of the smart grid heralds a means to minimize the duration of these outages and reduce the negative impact to the users.

When the power grid is down, then how is the requisite telecommunication equipment maintained in service? If outages of service extend into days and weeks, then even the best designed solutions are challenged to survive and often fail along with the power grid.

This scenario is highly problematic as it further aggravates the primarily function and purpose that the smart grid was deployed to prevent in the first place. The problem is compounded by ageing infrastructure, the imminent retirement of the best and most experienced staff, and the changes to the weather patterns. Therefore, we need these highly automated smart grids to work well and we must be able to trust that they will operate when we need them for restoration. Catastrophic long term outages are more frequent than previously experienced and appear to be an increasingly widespread experience in the future.

As a result, we need to "rethink" the approach to emergency power for the smart grid telecommunication equipment so it can deliver on its fundamental objectives.

Background

An interruption of AC (Alternating Current) power is defined as the complete loss of supply voltage or load current. Depending on its duration, an interruption is categorized as instantaneous, momentary, temporary, or sustained. Duration range for interruption types are as follows:

- Instantaneous - 0.5 to 30 cycles
- Momentary - 30 cycles to 2 seconds
- Temporary - 2 seconds to 2 minutes
- Sustained - greater than 2 minutes

The primary role of any uninterrupted power supply (UPS) solution is to provide short-term secondary power supply when the input from the primary power source fails. However, most UPS units are also capable in varying degrees of correcting common utility power problems:

- Voltage spike or sustained overvoltage
- Momentary or sustained reduction in input voltage
- Noise, defined as a high frequency transient or oscillation, usually injected into the line by nearby equipment
- Instability of the mains frequency
- Harmonic distortion: defined as a departure from the ideal sinusoidal waveform expected on the line

Therefore, the generally accepted purpose of a UPS is to bridge electrical loss or electrical power problems for short periods of time, typically less than a very few minutes.

Catastrophic Outages

Major catastrophic power outages do occur for longer intervals and cover a variety of sizes of service areas. They can be caused by a myriad of problems ranging from equipment failures to severe weather. For the most part, today's modern power grids can isolate these outages and contain them to small geographic footprints from a substation to a single feeder or even to a few lateral drops while limiting the impact to customers and reducing the duration of the event. Sophisticated smart grid solutions are aimed to further minimizing these types of smaller sized outages and restore services more rapidly than could be managed using traditional manual methods.

But what happens when the Utility is impacted by a major outage lasting many hours or days? These extended outages can be caused by major weather events like extreme heat, snowstorms, ice storms, hurricanes, tornadoes, lightning strikes, and torrential rain causing floods. While weather is a major cause of power disruption, issues such as automobile accidents, a tree branch falling on the lines, animal interference, ageing equipment or an unexplained circuit breaker tripping can also be the source of long duration chaos. When the power grid is offline for a long time, the supporting infrastructure can be dramatically and negatively impacted too, delaying or eliminating any hope of an automated and graceful restoration of service.

The argument can be made that the new smart grids, which are highly dependent on the supporting communication networks, need to have communication systems that are even more robust than the power grids that they support. If the communication networks are down in a pure smart grid scenario, then restoration falls back to manual processes. But, this is counterintuitive to the smart grid concepts and fails to justify the core business case for smart grids – improvement to customer service due to enhanced efficiency.

Most of the communication infrastructure is strong enough to withstand power failures. But, even during a sustained power outage situation, these communication networks need to have a stable source of electricity in order to function as expected. For short duration outages of less than an hour, the communication networks will easily defend against the loss of power by relying on an uninterruptable power supply or UPS. For longer duration outages, a UPS can be defined to support the communication networks for 8 to 12 hours. Based upon industry best practices and experience, this duration is optimum. Beyond this support time frame window, the UPS becomes cost prohibitive with excessive demands for maintenance (OpEx) and acquisition (CapEx).

A typical UPS is composed of an inverter, rectifier, or a converter and a set of batteries. The device has a battery charger built into it. The AC line power is used to maintain a charged condition in the batteries and when power is lost, the batteries supply power to the device to convert the battery power which is DC (Direct Current) power to either AC or DC output power. In many substations, we desire DC power instead of AC power to operate the communication network equipment. A DC output of 48 VDC is the most common power source for telecommunications equipment.

When extended power outages occur then the standard UPS solutions fail as well since they can rarely support their loads for more than eight hours. Long duration power outages are far more common than most would think, mainly resulting from adverse weather conditions.

A New Concern

After some recent experiences with several major catastrophic outages during the past two years that were measured in days and weeks, it has become apparent that even a large UPS with an 8 hour capacity would not be sufficient to keep the communication network alive over a prolonged outage period.

Yet, with the added dependency on the communication network to manage the power distribution grid restoration, it has been recognized that more thought is required to figure out an approach to keep the UPS available and standing by for when the grid is ready to be powered up after the damage is corrected.

In addition, it is vital to use the communication network to aid in the restoration by identifying points of concern before the restart action and preferably without the need for a truck roll to the site. There needs to be a way to use the communication network to solve the outage and restore the grid promptly after a catastrophic event.

These smart grid restoration objectives can only be accomplished if the communication network is alive. If it fails along with the power grid, it is counterproductive to its core mission to automate the power grid. Its value to the Utility is diminished.

Proposition for a Solution

When a catastrophic event happens, and it is evident that the outage will be extended for more than 1-3 hours, we need a means to remotely place the telecommunication network UPS solutions into a standby condition or sleep mode in order to preserve battery power for when we require it again to aid in the restart of the grid.

We can not permit the UPS to exhaust itself before the Utility is ready to power the grid back into service post of the catastrophic event. Currently, there is no established industry wide method to address this requirement.

Most UPS systems have SNMP and MIBs to integrate into a variety of network management systems (NMS) such as IBM's NetCool Omnibus. These NMS solutions provide wonderful service to remotely manage the UPS. However, if the network is down, then so is the NMS. The NMS traffic travels over the communication network and are therefore dependant on these networks. They are called "in-band" systems since the NMS traffic flows within the core communication network traffic flows or within its bandwidth.

What is needed is an "out-of-band (OOB)" NMS capability to communicate directly to the UPS when the power grid and the communication networks are both offline.

Using this OOB network, it is possible to instruct the UPS to conduct an orderly shutdown of the facilities that it supports and then place itself into a sleep mode to preserve the remaining battery power for the start up processes.

The challenge is that there is no recognized means to use an OOB in this sort of crisis scenario for UPS management. There are many OOB solutions commonly available in the ICT industry for devices like routers and switches, but these OOB networks assume that power is readily available and they operate over conventional communication networks like telephony landlines, cellular, and cable modems. However, if the grid is offline, and has been for several hours, then these carrier communication networks are very likely compromised and offline as well. Cellular and cable modems are far less robust than the power grid and likely will suffer prolonged outages even greater than the power grid experiences. Telephony landlines operated by Telcos are more robust but still struggle to meet the standards required to effectively managing the UPS requirements. Even if these carrier communication networks remain alive during a prolonged outage event, the local peripheral devices used to terminate these links would be down and therefore require a UPS to protect them during these prolonged events. Finding remote access to rural and remote sites with landline, cellular and cable modems is unlikely as well, even if they were operational during an outage.

There are several ways to shut down or wake up a UPS. These include:

- Low voltage shutdown
- Basic relay
- Programmable relay
- Programmable logic control

Conclusions

The importance of the UPS is paramount in the new reality of the smart grid. The UPS must be managed to ensure that it is available whenever it is needed to manage, monitor and control the smart grid. Emergency power solutions are critical to a rapid and automated restoration of power services to Utility customers.

With the increase of prolonged and severe power outages noted around the globe, it is vital to secure a trusted UPS solution to maintain the vital communication networks.

During recent major power disruptions, UPS has failed to perform since they have been exhausted before the grid can be restored to operation status. Therefore a means to communicate with the UPS is required in order to place the UPS into a dormant or sleep state whereby it can be held in the ready for the restoration activities when the repairs are made to the grid and a restart is warranted.

Traditional UPS designs do not accommodate this sleep mode requirement nor is there a suitable communications channel available to command them. We need to rethink the UPS to make it smart grid ready.

Since the needs for communication are sporadic, securing a dedicated bandwidth or low frequency spectrum will be hard. Therefore the best strategy will be to ride on an existing carrier and use it to reach the sites during an outage. Examples might include a data channel on the Utility's existing two way radio network, a FM radio subcarrier, TV white space, or access to a small amount of bandwidth below 1 GHz in order to achieve the desired range necessary to reach the sites.

New standards need to be developed to augment the existing standards for protocols and communications to the UPS.

The back channel communication network must be robust and will need to be even more robust then the power grid itself.

A secondary alternate backup power source may be necessary in order to maintain the UPS during prolonged outages. Solar panels, wind generators or gensets may be required, but at a penalty to the Utility's CapEx and OpEx budgets.

Without a plan to maintain emergency power to the communication networks, the core smart grid strategy is at risk.

When the UPS works well, and when it is available to restore services after a prolonged outage, it is the guardian to the entire smart grid; it is the white knight that protects the population of resources behind it. It is indeed, the noblest device in your network.

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Michael Martin has more than 35 years of experience in broadband networks, optical fibre, wireless and digital communications technologies. He is a Senior Executive Consultant with IBM's Global Center of Excellence for Energy and Utilities. He was previously a founding partner and President of MICAN Communications and earlier was President of Comlink Systems Limited and Ensat Broadcast Services, Inc., both divisions of Cygnal Technologies Corporation. He holds three Masters level degrees, in business (MBA), communication (MA), and education (MEd). As well, he has diplomas and certifications in business, computer programming, internetworking, project management, media, photography, and communication technology.