

How Modernization with Connected MV and LV Switchgear Unlocks Stronger Business Continuity

by Isabelle Feunette

Executive summary

Fundamental changes in switchgear design now lower LV and MV distribution lifecycle costs and decrease carbon footprint. As aging switchgear continually increases support costs, safety exposures and down-time, the new generation of “connected” technologies enable new digital concepts such as predictive maintenance and remote monitoring. The combination of smart sensors and digital services now allow for higher systems availability and decreased support costs. This paper illustrates best practices for digital-driven switchgear modernization and offers advice for environmentally responsible switchgear technology transitions.

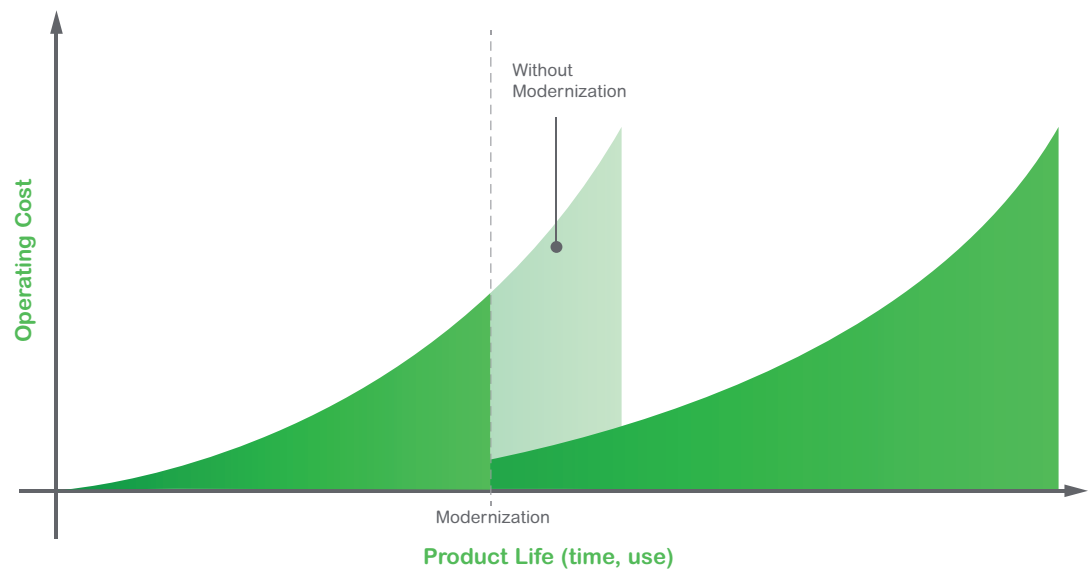
Introduction

Whenever disruptive technology changes are introduced into a particular market (like smart switchgear in this case) a certain level of uncertainty is felt among affected stakeholders. Changes require a different way of thinking and some new processes and procedures need to be considered. However, if that minor, short-term inconvenience results in long term gains and improvements in competitiveness, then the decision to change is justified. The prospect of not moving forward exponentially increases the risk of falling behind.

For those with older switchgear technologies in place, a conflict exists. Industry standards are evolving at a much faster rate than in the past. From a strategic standpoint, organizations are at risk for falling behind competitors. Marketplace responsiveness erodes because of increased instances of downtime and/or higher internal support cost structures (funds are diverted to maintenance instead of to driving new business growth – see **Figure 1**).

Figure 1

Maintenance costs increase as products are allowed to get older. A timely upgrade can reset the bar on Maintenance costs



On the tactical side, there are also numerous warning signs indicating that the time is right to modernize – or suffer the consequences of business disruption. These warning signs include:

- A drop in spare parts availability
- Higher maintenance costs
- An advanced degree of equipment wear
- Critical processes face higher downtime risk
- Increases in carbon footprint and power consumption
- Skill shortages as it pertains to on-site switchgear operations/ maintenance experts, many of whom are retiring
- Changes in regulations or growth and/or consolidation of the existing facility

Within most organizations, it is not uncommon to have a mix of power distribution technologies that span over 2-3 generations and several different technology architectures (e.g., air, oil, SF6, vacuum). The central question is how to modernize and ensure reliability when operating from an antiquated technology base.

There are several factors to consider. An overriding concern may be the need to improve safety. Another issue may be the cost and duration of fixes. A third factor may be the ability to monitor and efficiently manage the network.

The options that organizations now have for addressing these types of challenges have greatly increased in recent years. Thanks to the emergence of the Industrial Internet of Things (IIoT) trend, the linkage of connectivity, cloud, and analytics technologies is simplified and switchgear systems are enriched as a result. Connected technologies (software, cloud, and 'smart' sensing devices) have become key enablers that can provide detailed levels of energy management and systems performance data analysis which enables better monitoring of energy consumption and safety. For example, sensors for condition monitoring can unlock predictive and preventive asset management strategies by feeding data to experts who perform sophisticated analytics from remote sites.

Uptime now a critical success factor

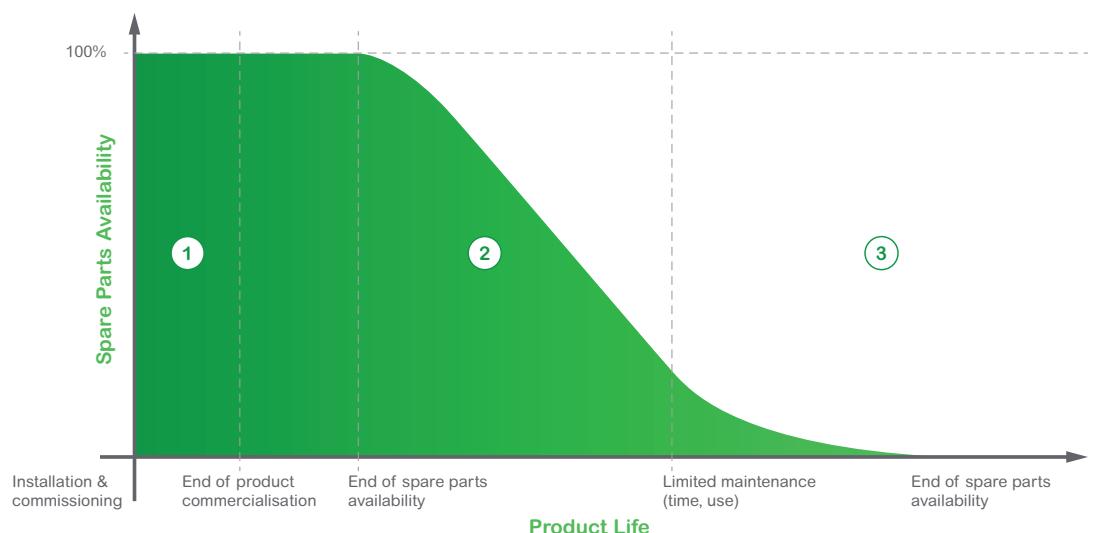
The permanent availability of electricity is vital for economies that rely on connectivity and "always on" systems that keep business moving at an ever-increasing pace. The interruption of critical processes due to power outages, voltage sags or interruptions can result in lost productivity, damaged production equipment and products, downed computers, delays in delivery, costs for cleaning and restart and, in a worst case, injury to people and pollution of the environment.

As a result, the cost of downtime is higher than ever. Among Fortune 1000 companies, for example, the average total cost of unplanned application downtime per year is \$1.25 billion to \$2.5 billion. A single hour of downtime now costs 98% of firms at least \$100,000, and 86% of businesses say that the cost for one hour of downtime is \$300,000 or higher.¹ Power distribution anomalies contribute significantly to these numbers.

For many organizations, the availability of spare parts plays an important role in securing uptime and availability. Switchgear asset owners can enter into agreements with manufacturers to supply parts for both current and legacy products. These spare parts typically remain obtainable for a period of 10 years after a product is no longer commercially available).

Figure 2

Spare parts availability is affected by the phase out scheduling of equipment manufacturers



¹ ITIC, "Hourly Downtime Costs Rise: 86% of Firms Say 1 Hour of Downtime Costs \$300K", May, 2019

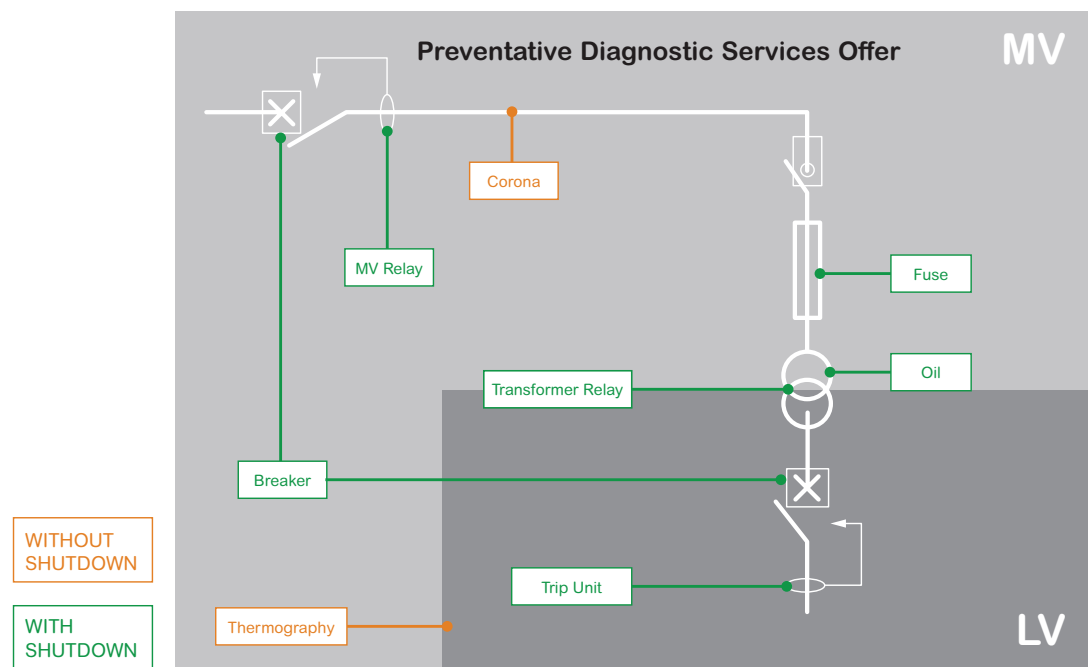
When the spare parts are no longer readily available, the continuity of service and support is at risk. If a device breaks down, no parts may be available to fix it and the expertise for proper installation of the parts is difficult to secure. At this stage, launching a solution modernization initiative is advisable. **Figure 2** above illustrates the stages of the spare parts life cycle.

Diagnostics evolving from on site to remote

When it comes to detection of equipment wear, diagnostics plays an important role. Switchgear wears out and deteriorates over time with use. Inside of switchgear, aging materials reduce equipment reliability. Both dielectric breakdown of insulating components and degradation of aging mechanical parts can disrupt equipment uptime. This is especially true of switchgear that runs in harsh environments where dust, vibration, contaminants and corrosive elements such as salt are more pronounced. With new technologies available today a solution can be installed that resists dusty, dirty, contaminated environments. The hermetically sealed components make the switchgear much more robust so that required maintenance visits are few and far between – even in the harshest of environments.

Figure 3

Types of switchgear components on which diagnostics can be performed

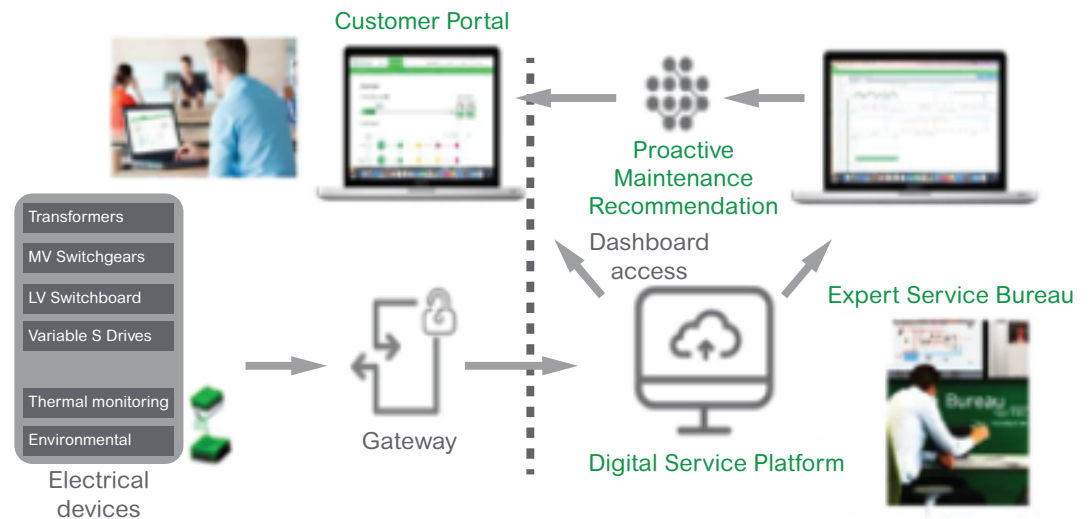


Diagnostic tools can verify the wear and tear of electrical components (see **Figure 3**) and compare current performance to how the equipment performed when new. Many companies have decided to decrease the instances of performing on-site diagnostics because of technician availability issues, an increased potential for human error, and health-related safety concerns. New approaches for performing these diagnostics now involve smart sensors, 24/7 online monitoring by a team of remote analytics experts, and the analysis of data trends to determine if equipment is experiencing anomalies. The same principles are also applied for the monitoring of circuit breakers which provides much more insight regarding their health.

New digital solutions are capable of automatically collecting data on site and consolidating that data to the cloud where analytical models perform the work of reviewing the data. Once the data is collected, the analytical engine then flags the data and generates dashboard charts and graphs for easy interpretation. Experts then review the results. If an anomaly is detected, experts are in a position to validate the anomaly and provide proactive maintenance recommendations, thereby ensuring normal operation of the systems (see **Figure 4**).

Figure 4

Digitization now enables switchgear remote monitoring and predictive maintenance



Modernization safety improvements

The new generation of electrical engineers and technicians want compact, safe, and low maintenance switchgear. Electrical workers responsible for the testing, installing and maintaining MV switchgear, face the risk of electrical shock from accidental contact with energized parts and injury from arc flash events. The new switchgear technologies are safer by design. Workers are protected by advanced, hermetically-sealed insulation, arc resistant features, and integrated grounding and interlocking. These features greatly reduce the probability of an incident.

Implementation of grounding switches at the switchgear design phase greatly improves overall worker safety. Interlock schemes protect workers from grounding onto live parts, and live line indicators provide a visual safety layer. Integrated grounding switches decrease the likelihood of human error by eliminating additional dangerous steps during the manual grounding process. Now the need to expose personnel to energized equipment before panels or covers are removed can be avoided.

Modern switchgear is equipped with safety levels that are not present in the legacy technology. For example, a sequence of operations with interlocks deenergizes and grounds the components before a human can gain access to the inside of the equipment. The new technology interlocking system includes fixtures within the switchgear called grounding switches. The design requires that the breaker be open for the grounding switches to be grounded. A device within the equipment physically connects the conductors to a ground to ensure that it is open and at ground potential.

In addition, through remote monitoring and diagnosis of equipment problems, technicians can now safely proceed to the site to perform repairs knowing, ahead of time, the nature of the problem and the proper tools required to fix the problem.

CAPEX and OPEX reduction

Modern switchgear digital advantages:

- Sensors that reliably measure environmental differences within the switchgear cubicles
- An ability to perform predictive maintenance to assure high availability of electrical equipment
- Improved safety through advanced notice of potential equipment failure
- Assured connectivity and linkages between sensors, cloud-based data aggregators, and consolidated data analysis

As switchgear components continue to age, the frequency and duration of maintenance incidents grows. At some point, the labor will get so intensive, that it becomes more cost effective (especially from a cost of downtime and safety perspective) to upgrade to new equipment.

As a result of new technology breakthroughs, it is now easier for end users to incrementally invest in lower capital-intensive switchgear technology purchases in order to dramatically lower their operating expense. In addition, depending upon the age of the existing installed base of switchgear, units can be retrofitted to improve connectivity, safety and to introduce digital monitoring. Retrofit vs. New cost comparisons should be made on a case-by-case basis.

Consumers of switchgear have been paying for oversized switchgear installations for years. For a long time, oversizing was the only way that users could guarantee consistent performance and predictability. Now, thanks to recent innovations, it no longer has to be that way. Rightsizing of switchgear is both prudent and cost effective especially from a TCO perspective. Some of the modern switchgear available today, for example, is 10 to 15% less expensive to purchase than traditional switchgear, and, over a 30-year lifespan, is less costly to operate by a factor of 5 to 10X.

In addition, with modern switchgear, the collection and adaptive analysis of data from increasing numbers of cost-effective and intelligent sensors improves switch-gear asset uptime. With easier access to information, monitoring operations become simpler and equipment performance more predictable.

Introducing some of these changes through technology upgrades can be implemented in the short to medium term. Others can be integrated gradually with users and manufacturers incrementally adding functions to their existing legacy systems as new international IIoT standards are established.

When justifying investments in new technologies, facility and engineering teams need to communicate to their executives the cost of inaction when outdated technologies are not replaced or upgraded. As mentioned earlier, the average cost of an infrastructure failure is \$100,000 per hour. Those downtime costs escalate when lost revenue from cancelled services, legal liability, and damaged to corporate reputation are also considered.

Lower carbon emissions

The continuous availability of electricity is vital for a data-driven economy that relies on connectivity to facilitate information flow. Yet maintaining such an environment can sometimes come at an environmental cost.

Connected switchgear technologies (which include software, cloud, and 'smart' sensing devices) are key enablers for accelerating an organization's carbon foot-print reduction. In fact, some of the newest switchgear available in the marketplace today is now SF6-free.

Sulphur Hexafluoride (SF6) is a greenhouse gas that has been traditionally used as an insulator and breaker medium within switchgear and other MV electrical transmission and distribution equipment. At end-of-life, governments require strict adherence to SF6-related equipment disposal regulations. Although SF6 is not toxic or harmful to people in its natural state, it must be contained so that it does not escape to the atmosphere and increase the levels of greenhouse gasses.

SF6 poses a threat since it is an enabler of global warming. The Kyoto Protocol requires that nations around the world monitor its use. SF6 has the highest Global Warming Power (GWP) of all the gasses, has an atmospheric life span of 3,200 years, and is 23,500 times stronger than CO₂.

Because SF6 is no longer present in some of these new switchgear units, there is no need to undergo mandated expensive and time consuming SF6 end-of-life procedures – a big benefit to the switchgear owner and to the environment.

The new "pure air and vacuum" SF6-free switchgear designs maintain the same levels of reliability and safety when switching power loads. The pure air insulation means that switchgear operators and technicians don't have to learn new practices, keeping them safer when installing and maintaining these new units.

When modernizing, these new SF6-free technologies should be considered as they represent a leap forward for sustainability, health, and safety. Enabled with digital features, environmentally-safe switchgear unlocks the powerful benefits of data across multiple-industry applications.

Responsible SF6 Disposal Practices

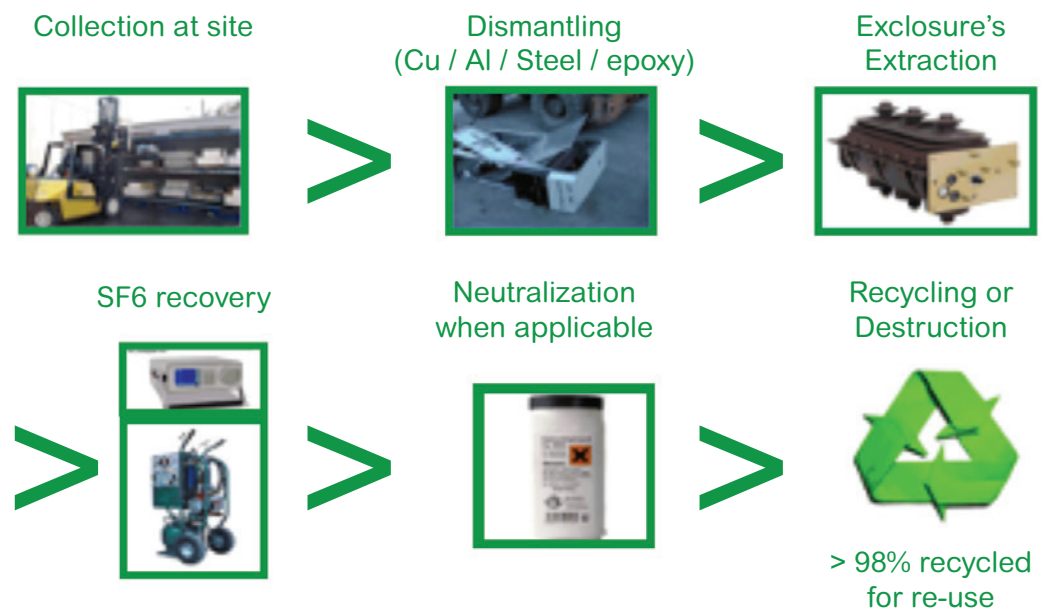
Part of any modernization program is the proper disposal of the older technology units that are being displaced. Under certain circumstance older switchgear units can be disassembled and the spare parts used either to support other older switchgear installations within the organization or sold to a dealer who specialize in locating and selling older spare parts.

In cases where SF6 is present in the switchgear special disposal procedures need to be followed:

- Launching an SF6 disposal initiative begins by auditing equipment that is near its end of life; the audit is the basis for developing a disposal and recycling plan.
- Electrical equipment owners select a trained and certified disposal/recycling partner to manage the process.
- When dismantling equipment, waste managers segregate and store SF6, copper, aluminum and iron in separate containers. Using a vacuum pump and task-specific valves, operators can safely extract the SF6.
- At a recycling center, purification processes remove water, air, and the remaining small quantities of toxic and corrosive by-products.

Figure 5

Proper SF6 disposal is highly regulated and must adhere to specific procedures



In accordance with national or regional regulation, only licensed, authorized hazardous waste managers may handle, transport, recycle or destroy SF6. Pickup, transport and dismantling of obsolete electrical equipment is subject to regulatory codes, with tight guidelines for documentation, labeling, packaging and safe handling.

By working with reputable licensed and authorized partners like Schneider Electric, most SF6 technology MV and HV electrical equipment owners can safely and cost-effectively dispose of their spent equipment.

Conclusion

Success factors surrounding modernization include improved safety of people onsite (fewer accidents), reduced need for preventive maintenance due to better equipment health status insight, the ability to perform condition-based maintenance through continuous remote monitoring, and the ability to perform predictive maintenance (acting before the failure).

In addition, from a strategic perspective, digital “smart” switchgear can redefine the company’s approach to asset management strategies towards a more data-driven and analysis-based model.

Changes can be proposed in an evolutionary as opposed to a revolutionary fashion. As various generations of switchgear often reside together across end user locations, switching over need not be an all or nothing proposition. A pilot can be run to compare performance and cost of new technology to old, with future expansion stages set to reflect company specific timelines and business needs.



About the author

Isabelle Feunette is the Marketing Offer Director for Modernization and Spare Parts Services at Schneider Electric. She holds an executive master's degree in Purchasing & Supply Chain Management from the HEC School of Management and holds a Diplôme d'Etudes Approfondies (DEA) degree in Geostatistics from the Ecole des Mines in Paris, France. Over her 15-year career at Schneider Electric, she has designed and deployed sales inventory and operation planning for standard products worldwide and has developed and deployed service and operations-relation planning governance programs.



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