WHITEPAPER

Ensuring grid resiliency in a power-hungry world

Explore strategies for strengthening aging power infrastructures against rising demands and climate impacts, with a focus on the deployment of advanced, self-powered reclosers to enhance reliability and mitigate outages in our increasingly electrified world.

In today's fast-paced, interconnected world, power grid reliability has become essential to modern life. With our increasing dependence on technology and digital infrastructure, the need for a stable and secure power supply is also rising. A resilient energy grid helps ensure our daily lives function smoothly and plays a vital role in fostering economic development, maintaining public safety, and supporting the transition to renewable energy sources.

Aging Electric Grid and Severe Effects of Climate Change

Per the U.S. Department of Energy (DOE), more than 70% of the nation's electrical grid is over 25 years old. This aging infrastructure is particularly vulnerable to an increase in severe weather events (hurricanes, heatwaves, winter storms, high-intensity winds, etc.) stemming from rising global temperatures and leading to grid instability and a rise in electrical outages.

Severe weather events can also create other types of hazards for the electrical grid. A tree branch falling on the distribution line, lightning strikes, and wind gusts can all cause momentary faults. Similarly, a fallen tree on a distribution line, a damaged electric pole due to heavy wind gusts, or malfunctioning electric equipment can result in permanent faults that lead to sustained outages.

Surging Demand for Electric Power

Complicating matters for the U.S. electrical industry, the DOE has stated that electricity transmission systems capacity must be expanded 60% by 2030 to meet the growing demand. Furthermore, current capacity may need to be tripled by 2050 to accommodate the growing renewable energy sector and meet the increasing power demand from electric vehicles (EVs) and electric home heating.

In addition, rapid industrialization driven by technological advancements and the growing global economy has also led to a surge in energy demand. Medium-scale factories and other industrial facilities require reliable power from the distribution feeder to support around-the-clock operations. This constant demand for power increases the overall load on the grid and necessitates the implementation of grid reliability solutions.

At the same time, the shift towards a hybrid work culture, where employees split their time between working from home and the office, has further contributed to the strain on the power grid. As more people work remotely, residential energy consumption has risen dramatically, with homes now requiring more power for heating, cooling, and running electronic devices throughout the day. This shift in energy usage patterns has created new peaks in demand, challenging the grid's ability to maintain a consistent supply of power.

As a result of these shifting energy market dynamics, there is a growing need to improve distribution system reliability to the edge of the grid to eliminate momentary outages and isolate the part of the distribution grid affected by a permanent outage. This includes the three-phase distribution feeder and the laterals or taps feeding the end customers. Single-phase, self-powered reclosers can help utilities accomplish this objective.

The Evolution of Recloser Technology

To understand how single-phase, self-powered recloser technology provides greater reliability, it is beneficial to look at the existing/traditional distribution side protection devices and compare the benefits offered by self-powered reclosers.

Fused Cutouts: Utilities have traditionally deployed fuse-blowing protection techniques for single-phase and three-phase lateral circuits. When a fault occurs, the resulting surge in current causes the fuse to melt, opening the circuit and isolating the fault.

Costing a few hundred dollars, these devices are an economical solution for fault protection. However, they have some challenges. Fused cutouts can isolate a fault and prevent it from cascading, but they are not self-correcting, nor can they discriminate between a momentary or permanent fault. Additionally, they need to be replaced every time they operate, resulting in a truck roll and increasing the lifetime costs for these devices.

In addition, the fuse time current curve (TCC) may degrade during the serviceable lifetime of the fuse link, causing nuisance tripping due to miscoordination with neighboring protection devices and potentially affecting a larger number of customers. This increases downtime and costs.

Fused cutouts have been a cost-effective solution for protecting lateral circuits and oil filled overhead distribution transformers. However, every utility has a few troublesome hotspots for momentary faults in their distribution network. Fused cutouts protecting these laterals operate frequently and require a truck roll to reset them. These locations reduce the average reliability metrics of the overall distribution network and frustrate customers.

One way to eliminate momentary outages and improve network reliability is to install self-powered reclosers at strategic locations. Moreover, the capital investment in replacing the fused cutouts with self-powered reclosers is paid off within the first few years, allowing the utility to reap the benefits throughout the recloser's 15–20-year lifetime. The ability to deploy any electronic fuse TCC based on the available fault current and operating speed, which does not degrade over time, is an added benefit.

Hydraulic Reclosers: Hydraulic reclosers were the first single-phase reclosers on the market. Introduced in the 1940s, these devices combine the functions of a circuit breaker with an automatic reclosing system to eliminate momentary faults. Hydraulic reclosers were a distinct improvement over fuses as they reduced the need for manual

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Single- phase vacuum-interrupting reclosers, like ABB's Eagle self-powered recloser, help improve reliability indices for utilities by eliminating many sustained and momentary customer outages.

intervention. However, most of these existing reclosers are part of the aging infrastructure now approaching the end of its serviceable life, increasing maintenance costs and reducing effectiveness. Hydraulic reclosers also come with several drawbacks. They often use oil as an insulation medium, so they require maintenance every 3-5 years. Additionally, hydraulic reclosers are prone to oil leaks and spills, which can lead to environmental contamination and fire hazards. Their fixed continuous current/tripping current can also make them less able to handle a rapid increase in power demand. These systems typically require manual inspection and intervention, resulting in increased labor costs, longer response times, and prolonged outages. Finally, the communications capability of hydraulic reclosers is limited. The inability to remotely monitor and control hydraulic reclosers makes it difficult for utilities to optimize their distribution networks, identify potential issues proactively, and coordinate with other protection devices in the system.

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Single-Phase, Self-powered Reclosers: A Cost-Effective Solution for Grid Reliability

This new generation of single-phase, self-powered reclosers is designed to improve the reliability of distribution networks by eliminating momentary outages and isolating any permanent outages that may occur on three-phase or single-phase laterals.

A one-size-fits-all design, typically rated up to 27 kV, allows utilities to confidently deploy the device at any point in a single-phase or three-phase lateral circuit without the need to stock multiple rating variants. In addition, the robust ratings can handle increased energy demands over the lifetime of the equipment, an important consideration as the increase in urbanization and the use of electric vehicles creates a steep rise in energy requirements. A high interrupting duty paired with a long-range communication (SCADA enabled) cabinet allows utilities to deploy single-phase reclosers as an alternative to conventional three-phase reclosers with triple single trip/reclose operation, remote operation, and SCADA capability

Ideally, device control should not require any proprietary attachments or consumable components. A simple hotstick lets the lineman perform typical recloser operations like activating local communications, hot line tag mode, operating the vacuum interrupter, and creating a visual break. An operating lever in addition to the electrical operation also allows the recloser to continue to function in the event of an electrical malfunction of the actuator mechanism. This feature helps guarantee that the making and breaking of electrical contact during normal conditions occurs in a vacuum-based medium inside the interrupter and not at the recloser terminals – thus helping ensure an electric arc-free design that improves operating personnel safety. A visual break concept allows linemen to perform any maintenance or fault restoration downstream of the recloser with peace of mind. The battery-free construction also delivers a true maintenance-free product so electric utilities can avoid stocking batteries in their inventory and the need to keep them fully charged at all times.

Local communication with the recloser can be established over any handheld device like a laptop or a mobile phone through a web browser-based interface that works via Wi-Fi. This eliminates proprietary transceivers or software that require IT clearance and helps ensure fast, easy implementation of future software enhancements. or any future software updates. Moreover, an intuitive communication interface lets utility engineers and operators program the recloser easily. This includes developing protection settings and programming

user-specific TCC. Users also gain access to a rich dataset – event logs, disturbance records, load profile, security logs, etc. that are required for post-fault analysis.

Advanced self-powered reclosers are also designed to withstand the impact of climate change, making these devices a great fit for utilities to include as part of grid resilience programs. A sturdy, customized mounting frame allows the reclosers to offer a stable operation during hurricane-induced wind gusts. A 'No ice-break requirement to operate' feature offers reliable fault isolation in winter, and a non-arcing design eliminates any equipment-induced wildfires.

Upgrading existing distribution grid equipment with advanced recloser technology may sound difficult to justify financially. Fortunately, the investment often provides a return in the first few years after installation. The maintenance-free design and vacuum interrupting-based solid dielectric insulation eliminate all the truck rolls and crew time spent on maintaining the old hydraulic reclosers. The ability to offer a customizable mounting frame facilitates easy retrofitting by using the existing mounting bolts on the utility pole, thereby avoiding the time and effort spent on drilling new holes to install such devices. The ability to offer pre-programmed hydraulic recloser TCC during the purchasing stage further enhances the customer experience.

The table below illustrates the potential savings through maintenance-free design by adopting a self-powered recloser vs. a conventional hydraulic recloser.

Maintenance cost of hyraulic recloser versus solid dieletric based self-powered reclosers

Recloser type	**Oil-filled hydraulic reclosers**		**Self-powered, vacuum recloser**
Onsite maintenance once every 3 to 5 years	**Unit onsite maintenance cost**	**Total onsite maintenance cost for life expectancy period considering 5 years maintenance cycle**	**Maintenance free design**
Oil condition	$850	$4,250	$0
Oil dielectric strength			
Oil replenishment			
Other maintenance activities			
Truck roll costs			
Repair shop maintenance once every 10 years	**Unit repair shop maintenance cost**	**Total repair shop maintenance cost for life expectancy period**	**Maintenance free design**
Arc interrupting assembly	$1,000	$2,500	$0
Series trip solenoid			
Adjusting sequences & time current curves			
Bushing, head, & tank assemblies			
Truck roll costs			
Other maintenance activities			
Inventory carrying cost (estimated)	**$250**		**Universal rating**
Total maintenance costs during life	**$7,000**		**$0**

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Reference: Hydraulic recloser maintenance instructions

Futureproofing the Grid

As the world becomes increasingly reliant on electricity, the need for innovative solutions to maintain grid resiliency is paramount. Utilities must proactively tackle the challenges posed by the growing demand for electricity, added stresses on the grid, and the need to maintain a profitable operating model while improving the overall customer experience.

By embracing the next generation of reclosers, utilities can significantly improve reliability and deliver a superior customer experience. These advanced reclosers not only help minimize downtime and reduce operational costs, but also provide valuable data for predictive maintenance and proactive asset management. As we move towards a more connected, sustainable, and resilient energy landscape, investing in cutting-edge technology will be essential in ensuring grid resiliency in a power-hungry world.

ABB Inc.
305 Gregson Drive
Cary, NC 27511
United States

electrification.us.abb.com

Customer Service:
888-862-3290
abbinsidesalessupport@us.abb.com
Monday - Friday, 7am - 5:30pm, Central Time

Tech Support:
888-437-3765
Monday - Friday, 7am - 5pm, Central Time

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