CASE STUDY

ABB Johannesburg microgrid:
Reliable and affordable power that enables substantial energy savings for an industrial site

Left: ABB's Longmeadow facility in Johannesburg, South Africa

Right: ABB PowerStore Battery Energy Storage System

Seamless islanding for total continuity of supply

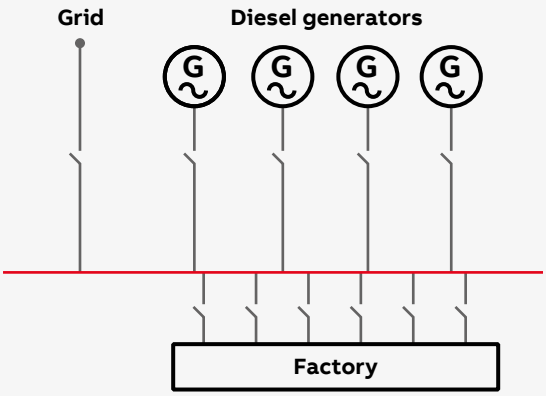
In 2016, ABB installed an integrated solar PV–diesel-battery microgrid at its Longmeadow facility in Johannesburg, South Africa. This integrates multiple energy sources and battery-based stabilization technology within a smart control system that facilitates the seamless transition between grid-connected and islanded modes without any disruption to the connected loads. The facility is now able to operate as its own 'power island', supplying reliable power 24/7 and ensuring that business continues as normal despite any planned or unplanned disturbances or outages of the main power grid. While continuity of supply is the critical factor, the ABB system also optimizes the site's use of solar power to reduce its reliance on increasingly expensive and polluting diesel fuel.

The power reliability challenge

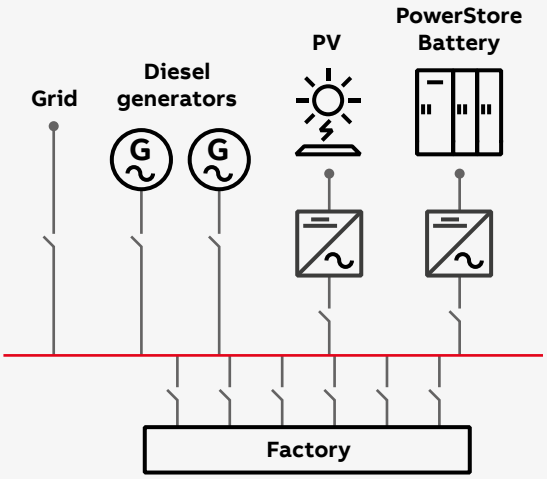
South Africa has the highest electricity demand in Africa, with up to 41 percent of its generated power consumed by the industrial sector. Although energy demand has stayed relatively flat in recent years, energy costs have steadily increased, in particular peak demand charges. These have been used as an incentive for businesses to reduce consumption at particular times of the day where utilities struggle to meet high power demand. Ageing distribution grid infrastructure, power quality issues such as voltage dips and an eventual resumption of load shedding events are additional challenges.

However, the country's businesses and production facilities need uninterrupted and reliable power supply to maintain continuous operation. Many therefore rely on diesel generators to provide a back-up power supply. This situation is not uncommon in many other parts of Africa and other regions of the world, such as South America or South East Asia, where increasing demand for electricity is also outpacing generation and distribution capacity.

Typical back up solution



Microgrid solution



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The back-up solution before (left) and after implementing the microgrid (right)

Microgrids to the rescue
Microgrids are increasingly being deployed to ensure local continuity of supply, reduce reliance on fossil fuels and defer large-scale grid investments in areas that have a weak connection to the main electricity grid.

Such grid-connected microgrids are growing in popularity to help address rising power demands, take advantage of the falling cost of renewable sources – in particular solar photovoltaic (PV) technology and batteries - and improve supply resilience and autonomy especially for critical applications.

ABB facility shows the way
ABB's 96,000-square-meter Johannesburg facility houses the company's national headquarters, as well as manufacturing facilities, with around 1,000 employees. It is supplied with power by a medium voltage grid connection to the local utility with electrical loads adding up to a total of 1000 kW.

The average daily energy consumption of the facility equates to around 2,000 typical South African households. Its energy demand has been relatively constant over the past few years, but the cost of energy is rising steadily.

Since 2009, four back-up diesel generators (two rated at 600 kVA and two rated at 800 kVA) had been feeding the different parts of the network via conventional transfer switches. Whenever one of the frequent utility power outages or short term voltage variations that affect the site occurred, these generators would island and provide backup power.

On average, the facility had to be isolated from the grid up to 10 times a month. As a result, its total energy cost in 2015, including utility fees and diesel fuel, was US$630,000.

To address this challenge, ABB has transformed the existing generator backup system into an innovative microgrid solution. Now, only two 600 kVA diesel generators are required, with the support of a 1 MVA/ 380 kWh PowerStore™ Battery based on lithium-ion (Li-ion) technology and a Microgrid Plus Control System as well as a 750 kWp rooftop solar PV (photovoltaic) system.

This world-leading solution offers fully grid-connected and off-grid functionality designed to maximize the use of renewable energy and ensure uninterrupted power supply. The seamless transition to islanded operation keeps the facility running smoothly during both planned or unplanned power outages.

The PowerStore™ Battery plays a vital role in ensuring the smooth transition from grid to back-up power during outages. It also enables peak shaving during peak consumption times. Above all, the PV–battery combination reduces the consumption of – and therefore, spending on – both grid-provided electricity and diesel fuel.

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ABB PowerStore
Battery Energy
Storage System

Intelligent, optimized control
The microgrid is managed by ABB's Microgrid Plus Control System. This enables the overall microgrid solution to manage the supply of power and balance the fossil-fuel and renewable energy sources in accordance with loads, in a cohesive and coordinated manner, preserving access to utility-grade power at all times.

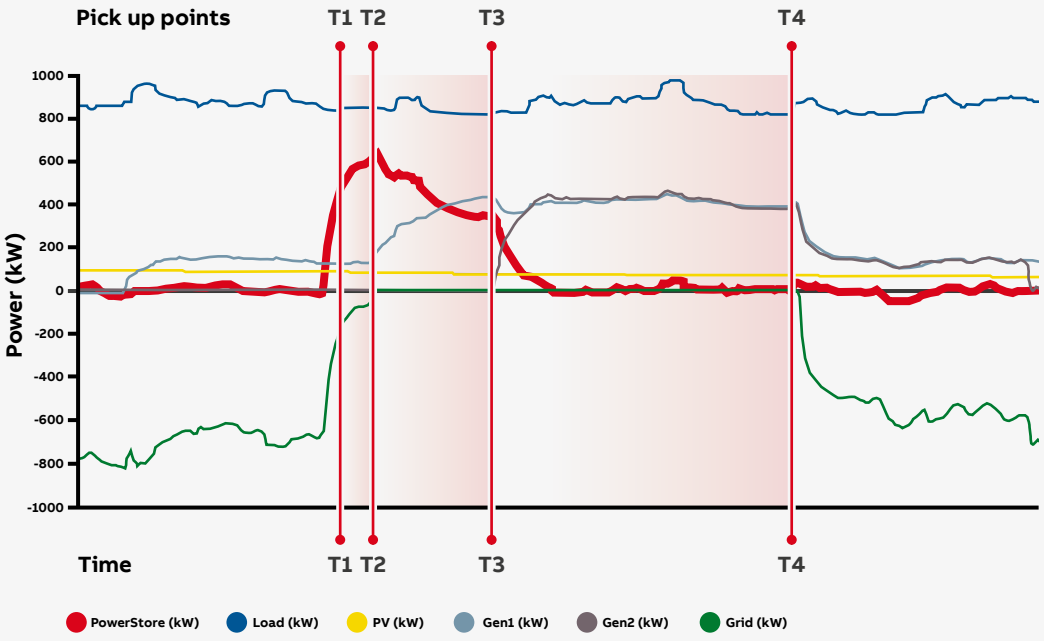
During normal operation, power is generated by the PV plant, supplemented by the grid. In event of an outage or power quality issue, the microgrid enters island mode, with a motorized circuit breaker opening to avoid feeding power back into the grid. Using its unique virtual generator capabilities, the PowerStore Battery system forms the grid and provides power to the load while maintaining utility-grade power quality for the site. For extended outages, one or both generators start automatically whenever needed, ramps up in speed and share the load with the PV plant and the PowerStore.

The main purpose of the PowerStore Battery (a compact and versatile grid stabilizing unit) is to stabilize the power system against fluctuations in frequency and voltage. It does this by rapidly absorbing or injecting power. Prior to installing the microgrid the facility suffered from an average of 10 voltage dips per month, negatively impacting production. The PowerStore mitigates these fluctuations so production can continue uninterrupted no matter the issues in the distribution grid. State of the art inverters with virtual generator mode capabilities have been deployed that make it possible for the diesel generators to be switched off for most of the time. The solution can also ensure a seamless transition from grid connected to island mode when there are outages on the grid.

A cloud-based monitoring system enables remote operation and maintenance of the microgrid, in keeping with ABB's industrial Internet of Things approach.

Seamless transition to island mode

The figure below shows a seamless transition from grid connected to island mode following a main power grid outage:



Pick up points

T1: Grid power goes to zero – PowerStore picks up all the load

T2: Diesel generator 1 starts picking up the load gradually, PowerStore reduces power output

T3: Diesel generator 2 picks up the rest of the load, PowerStore power output reduces to zero

T4: Grid power is re-established – Diesel generator power output goes to zero

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Seamless transition from grid connection to islanding mode with PowerStore (Red trace), solar PV (Yellow trace) and the two generators (Light Blue and Brown traces) – the Green trace shows the power from the grid

Substantial savings

ABB estimates that without the new microgrid solution annual diesel fuel consumption at the facility would be approximately 52,000 liters. Instead, this has been cut to about 38,000 liters – a 27 percent saving. In addition, the generators are now running for only 106 hours annually, compared to 433 hours without the microgrid – a 75 per cent reduction in running time. This has led to a reduction in annual diesel fuel costs from US$62,000 million to US$44,000, following the installation of the microgrid – a 30 percent saving.

Without the microgrid grid energy costs would have been US$610,000 in 2016.

With the microgrid they are US$460,000, which equates to a 25 percent saving.

This environmentally-friendly solution contributes to a substantial reduction of carbon emissions (by an estimated 1,000 tons per year) as well as significantly reducing the operational cost of the industrial complex.

Leon Viljoen, ABB's country management director for South Africa said:

"Securing access to reliable, high quality power is a business-critical issue for all the country's industrial operations. Since switching over to the new microgrid in June 2016 we now have full confidence that it is always 'business as normal' for this site, no matter what is happening on the local grid. As well as securing our supply, the microgrid brings a very significant added benefit in enabling us to make the best possible use of renewable energy while delivering substantial operational savings."

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