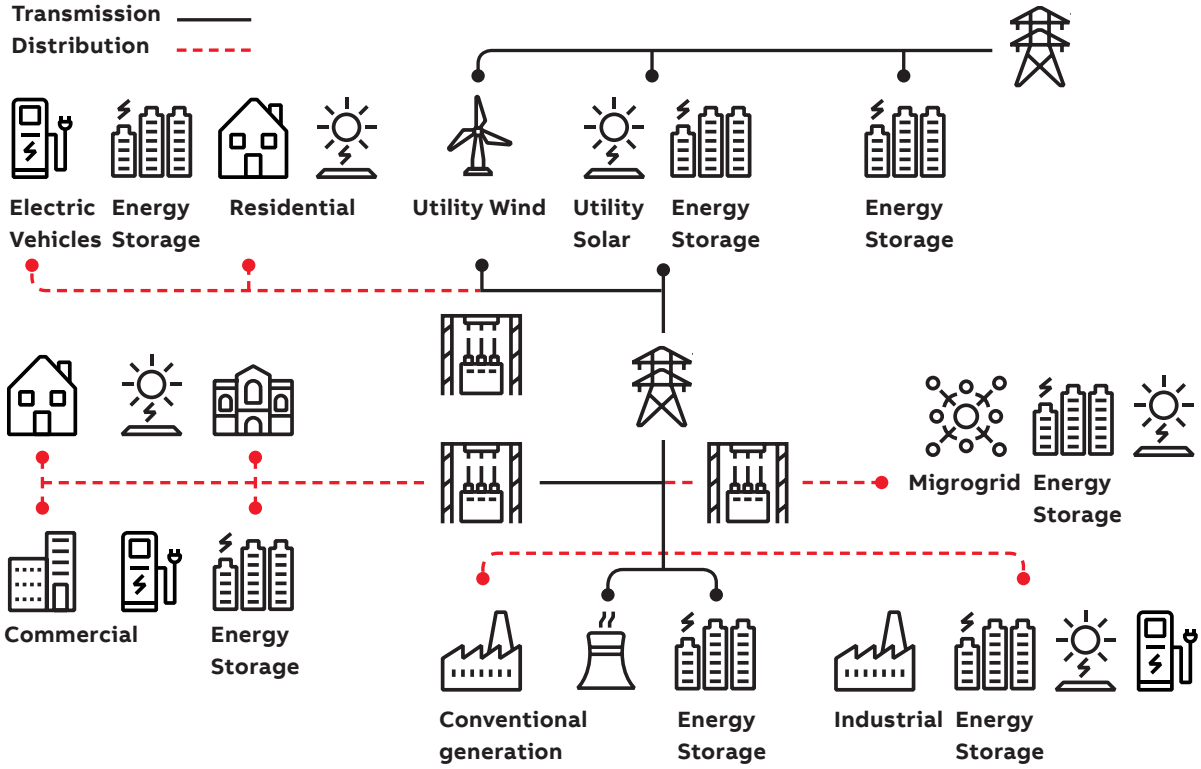
APPLICATION NOTE

ABB Solar coupled with energy storage

A wide variety of choices

Energy storage technology will be a major game changer for energy systems of the future. Together with electric vehicles, energy storage will reshape the architecture of transmission grids, unleashing the full potential of distributed generation by renewables.

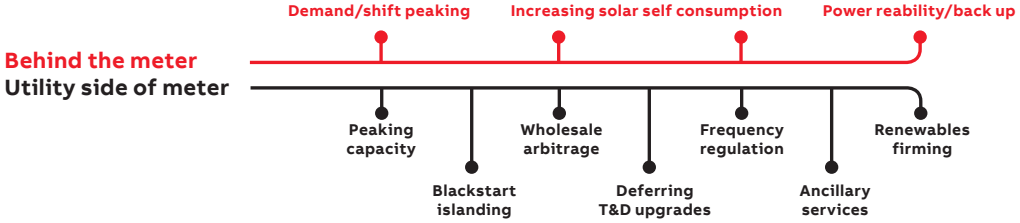
The market for energy storage is expected to grow faster than predicted in the rush to meet clean energy targets. Among different battery technologies, the reduction in lithium-ion battery production costs has been a driver for the rise of solar power self-consumption, demand response and electric mobility in all markets, from residential to industrial.



New business models taking advantage of renewable power generation at the point of consumption will provide opportunities for remote communities where the use of expensive diesel generated power prohibited economic growth.
Energy storage technology will emerge as a critical differentiator in modern energy systems allowing power consumers to producers too (prosumers).

The convergence of energy storage, renewables and digital technologies will provide new opportunities for utility operators and help them to manage the demanding performance expectations and increasing complexity of modern energy systems that will form the smart-grids of the future.

Main application for storage



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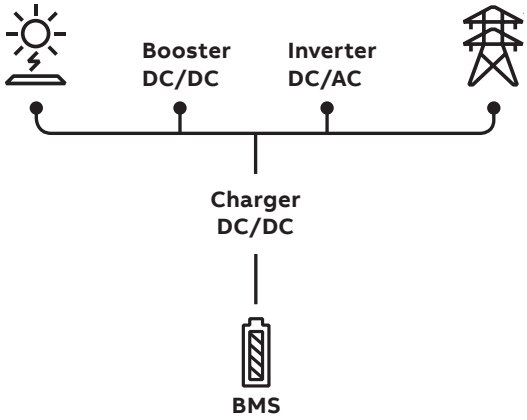
Energy storage applications

Application	Description
Load leveling / solar self-consumption	Stores power during low-load periods and delivers it during periods of high demand in order to reduce the load on less economical peak-generating facilities
Frequency regulation	Absorbs and injects active power in order to keep grid frequency within pre-set limits
Renewables firming	The energy storage system smooths the power output to eliminate rapid voltage and power swings on the electrical grid
Ramp rate control	Ability to limit the power ramps of solar or wind plants for reliable interconnection to the grid
Deferring T&D upgrades	Grid operators can place storage close to the load so it can discharge during peak system periods, reducing stress on the local equipment and instantly increasing capacity without large Transmission Distribution (T&D) investments
Peak shaving	Reduce power consumption during periods of high demand, which would reduce peak demand charges
Spinning reserve	Available power supply that can quickly respond to instant losses in generation or transmission outages
Back up	Provides power in case of blackout and/or grid outages
Power factor & voltage support	Provides reactive power compensation to regulate voltage to improve power quality
Seamless transition from grid mode connection to islanded connection	Meet the challenges for robust power supply in isolation from national grid infrastructure and gain control of your power needs on 'local' level

Energy storage topology: DC coupled and AC coupled

Two main architectures can be used to provide storage solutions together with PV installations: DC coupled and AC coupled.

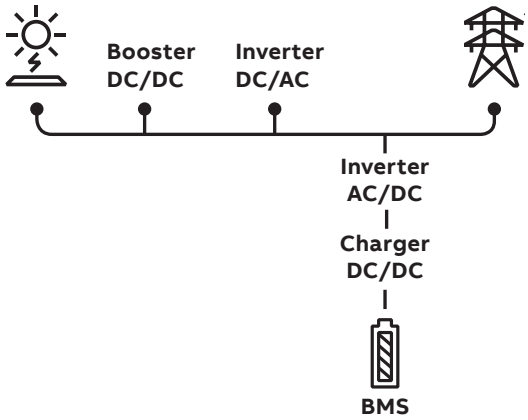
In a DC coupled solution, the battery charger is located between the booster (when required) and the inverter (DC link). The DC link voltage range is 350-600 V for single-phase applications and 550-1000 V for three-phase applications with 1000Vdc maximum while it is 680-1500 V with 1500Vdc maximum.



In the AC coupled topology the battery is charged/discharged through a battery inverter directly connected to the grid. This means that the AC current, generated from the solar inverter, will be converted (again) into DC current to be stored in the battery. The AC solution is less efficient than the DC solution (considering the same battery voltage) due to the fact that the PV energy needs to undergo multiple conversions.

Energy storage for residential applications

The demand for solar energy in residential installations is on the rise and has been for some time. Lower costs, better solar cell efficiency, a more supportive regulatory and taxation environment and concerns about climate change have all contributed to the surge in demand. At the same time, the smart home revolution means that today's consumers are more demanding and expect higher levels of control over their energy use. These 'prosumers' want to store energy and only use it when they need to, creating a growing demand for solar inverters with integrated energy storage. Consumers also want to manage their energy usage when they are away from home, whether that is from the office or from the airport returning from a holiday.



It is this demand for control and connectivity that will unlock the real potential for solar power in residential installations.

Battery voltage choice

Batteries used in PV + Storage systems can be grouped as high-voltage (HV) and low-voltage (LV) solutions.

The voltage-level difference between the DC link and the battery should not exceed a ratio of 3:1 to keep within acceptable efficiency parameters. As a practical example, a battery to be connected to a 350V DC link should not provide a minimum voltage below 150V. Lower battery voltages would require galvanic separation, and this involves a transformer and more switches, which results in higher costs and reduced reliability so, in general, high-voltage batteries offer lower system costs.

Considering the integration with residential photovoltaic plants, the DC coupled topography is the obvious solution to add storage capabilities, bringing added value to the end user through high efficiency and deep integration with an all-in-one solution.

REACT 2 (the direct evolution of the well-established REACT system) is a photovoltaic inverter (3.6 or 5kW PV power) that can also store the produced energy in a high-voltage lithium-ion battery (all-in-one solution). The system integrates the DC/DC charger in the battery module and benefits from a modular design with up to three battery modules (total up to 12kWh) that can be added or replaced anytime without the drawback of reducing the performance of the complete system.

Thanks to its integrated load manager, the system optimizes energy storage by aligning energy production with the levels of consumption.
This makes PV energy available when it is needed, whether after sunset, during the evening, or first thing in the morning.

In line with consumer demand for greater connectivity, REACT 2 has a dedicated app for smartphones or tablets. This allows the user to monitor how much renewable energy is being produced and to manage it all remotely or while at home.

When combined, the storage and load management elements make the best use of the energy created within the PV system. This avoids consumption peaks by spreading the electricity load to keep usage within the capacity of the power produced.

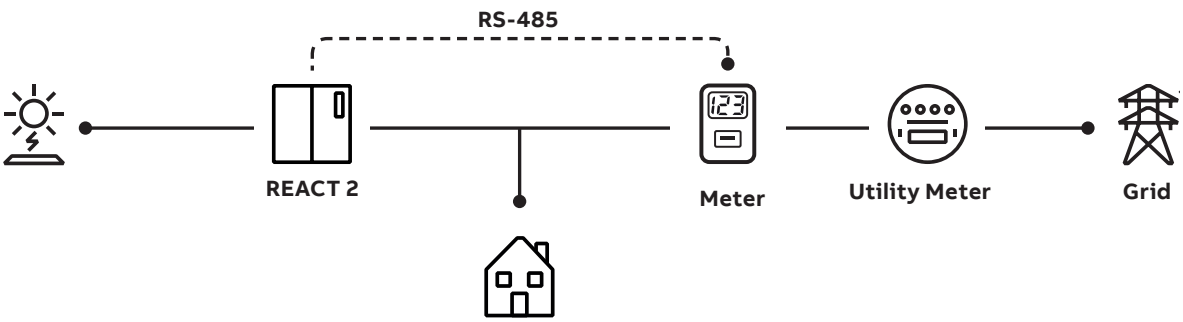
REACT 2 is a system natively coupled with the PV plant on the DC side but also offers the capability to be used as an AC coupled system, to be integrated in any existing PV plant, with the ability to extend photovoltaic capacity thanks to the integrated booster.

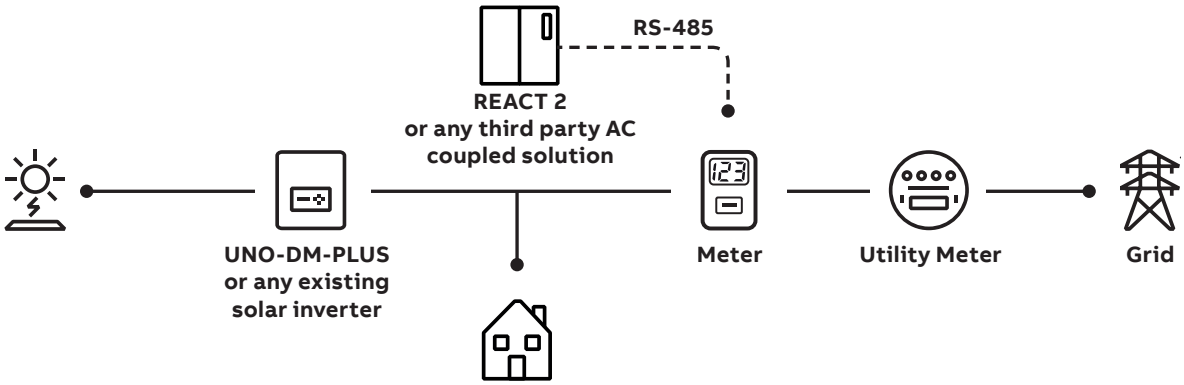
	DC coupled	AC coupled
New installation	Yes, cost effective for single inverter application	Yes, cost effective only if the plant is composed by 3 or more solar inverters
Retrofit	Yes, if the inverter needs to be replaced/added	Yes
Cost effective	Yes, up to 3 solar inverters	>3 solar inverters

	HV	LV	HV	LV
Cost effective	++	-	++	--
System efficiency	++	-	+	--
System reliability	+	-	+	-
Zero injection built in	+	+	-	-

ABB solutions

Two ABB products in particular will help meet the growing demand for intelligent residential solar installations, providing possible solutions for both storage architectures: REACT 2 and UNO-DM-PLUS.





As demand for smarter energy solutions continues to grow, REACT 2 takes advantage of ABB's cloud-based, industry-leading portfolio of digital solutions, ABB Ability™, to provide homeowners with 360° visibility over their solar power usage.

The UNO-DM-PLUS is a family of single-phase inverters, which are easy to install and fast to commission. Plug and Play connectors, both on the DC and AC side, together with wireless communication, enable simple, fast and safe installation without opening the inverter's front cover, which keeps installation time and costs to a minimum. It is the perfect solution for installation with all AC coupled storage packages available on the market.

Energy storage for commercial and industrial applications

In the pursuit of ever greater levels of sustainability, commercial and industrial (C&I) businesses can greatly benefit from the adoption of storage technologies.

On the one side, storage enables peak shaving, which means C&I businesses can save on their electricity bills by reducing peak demand.

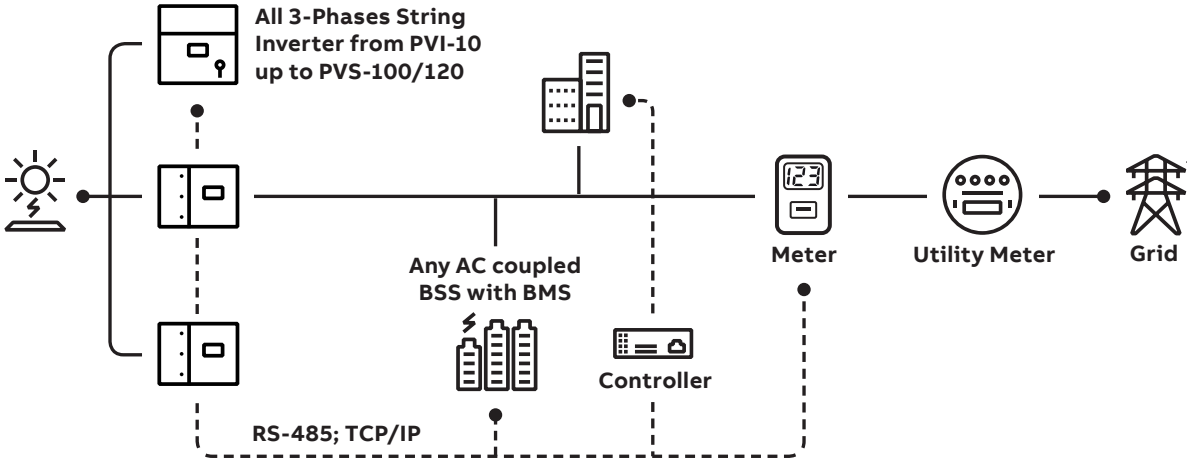
With the emerging demand for fast EV charging infrastructure, battery energy storage is an alternative to grid upgrades, enabling integration of these news peak loads with a limited impact on the site electrification and on the grid.

On the other side, batteries provide opportunities for maximizing solar self-consumption which involves storing power during the day when the solar production is higher than energy demand, and delivering it during periods of higher demand or after sunset. This load management translates into savings on additional energy cost and maximizing energy autonomy for the site.

In C&I applications, ESS installation happens on the AC side most of the times. As shown below, a very common C&I application features multiple ABB C&I solar inverters (namely PVI-10/12.5-TL, TRIO-20.0/27.6-TL, TRIO-TM-50/60, PVS-50/60-TL and PVS-100/120-TL) pushing power into a common AC bus to which an AC energy storage system - equipped with its own battery management system - could be connected.

PQpluS: modular, integrated and plug and play battery energy storage system

ABB's PQpluS is a compact and plug-and-play battery energy storage solution which enables



commercial and industrial businesses save on their electricity bills by maximizing solar self-consumption and reducing peak demand.

Integrated
ABB's PQstorI energy storage inverter, Li-Ion batteries, protection and control system - with embedded peak shaving and self-consumption algorithms - are integrated in a single cabinet, reducing the footprint and installation works and making it the right choice for solar integrators and end users. For Outdoor PQpluS, equipments are integrated in a metal enclosure with HVAC to cool the battery section.

Modular
PQpluS covers a wide range of power (kW) and storage capacity (kWh) between 30 kW and 1.6 MW to reach expected ratings. For Outdoor PQpluS, inverters and batteries can be integrated in the same enclosure (Combo) or independent enclosures.

Plug & Play
Peak shaving, load levelling, black start and power quality functions are embedded in the BESS controller to enable fast integration on a C&I site. PQpluS can also be connected to a higher-level Energy Management System (EMS) and then receive set-points to offer additional energy management services to a site.

Energy storage for utility-scale applications
With energy storage poised for rapid growth, ABB is investing in solutions and services that will enable customers to safely and reliably deploy energy storage on the utility grid. Pairing energy storage with solar optimizes the performance of the solar plant by providing instant power and ramping support during time when cloud coverage inhibits generation as well as load shifting services to accommodate the approach of nightfall and increased demand during the evening.

Strategically placed energy storage systems throughout the electrical grid increases the operational performance and reliability of the utility network, improves renewable energy source integration, helps balance electricity supply with demand, and ensures that energy is readily available when primary power sources are interrupted. Energy storage supports the entire power value chain from generation, transmission and distribution, all the way to the end users.

Standalone storage or MV AC coupled PV + storage utility-scale applications
The ABB PVS980-58BC energy storage converter is an outdoor solution rated up to 2,3MVA which fits very well as a standalone energy storage converter. In utility-scale PV plants storage can be connected as a medium-voltage (MV) AC coupled solution using the same platform for both the conversion of energy from PV panels (PVS980 as a pure solar inverter) and the storage of energy in batteries (PVS980-58BC bidirectional converter).
ABB is now leveraging economies of scale in the solar and the battery energy storage market. Benefits are obtained through common installation and commissioning practices, similar spare parts and advantages in deploying common service skill sets for the operation and maintenance of the combined solar and battery energy storage system (BESS) solutions.

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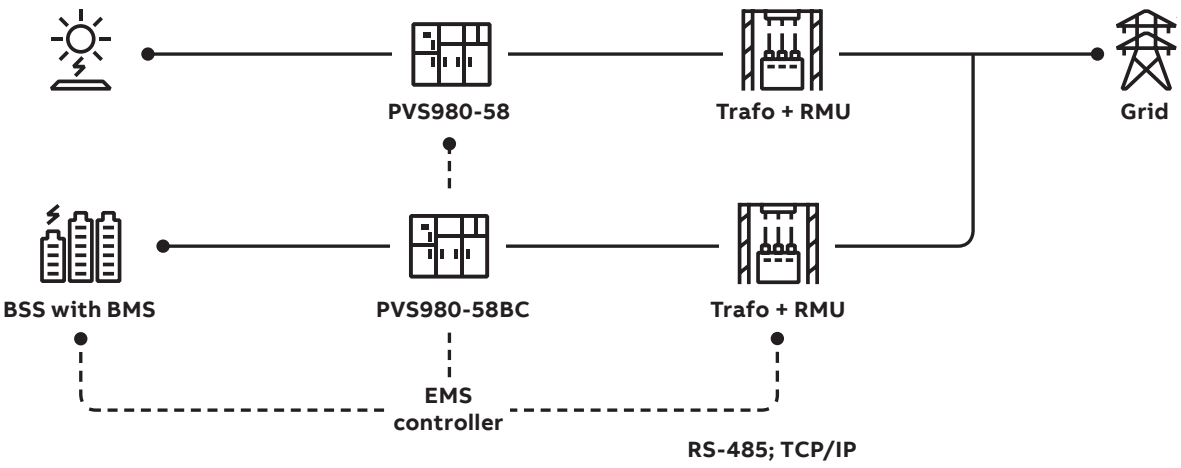
MV AC coupled PV + storage



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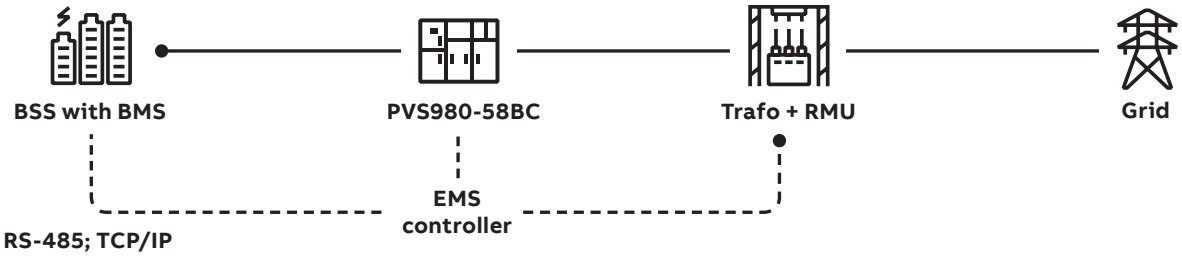
Standalone storage



ABB's new high-power energy storage power conversion system is ideal for multi-megawatt energy storage plants. It features high voltage DC for system cost savings, a self-contained cooling system, fast responding controls and is designed for harsh environmental conditions.

The full spectrum of PVS980-58BC advanced features, together with the inherent reliability and serviceability of the inverter, also makes the product suitable for large-scale microgrids in remote locations.

Microgrid solutions
In many parts of the world solar mini & micro grids have the potential to support the development of rural villages and islanded communities with reliable, economical power by reducing the use of diesel. Mini (>10kW) & micro (<10kW) grids are an ideal alternative to grid electricity in remote villages and islanded communities that do not have grid connectivity.
The growing trend for the development of microgrids across many parts of the world provided the impetus for ABB, as a leading manufacturer of electrical components and one of the market leaders in solar inverters, to launch a microgrid all-in-one solution called MGS100, which is easy to install, maintain, and monitor. Because it is modular in design it can expand easily for higher power, when required.

The MGS100 solution
ABB's MGS100 is an all-in-one solution constructed with proven ABB products that maximizes the use of solar power in combination with energy storage in the form of lead acid or lithium-ion batteries. The solution can supply reliable power for village electrification, telecom towers and small commercial/ industrial sites in on- and off-grid operation with support from AC generators.
The compact, factory-tested, single cabinet design minimizes installation and commissioning time. The MGS100 is a modular and scalable solution capable of supporting increasing future load requirements.

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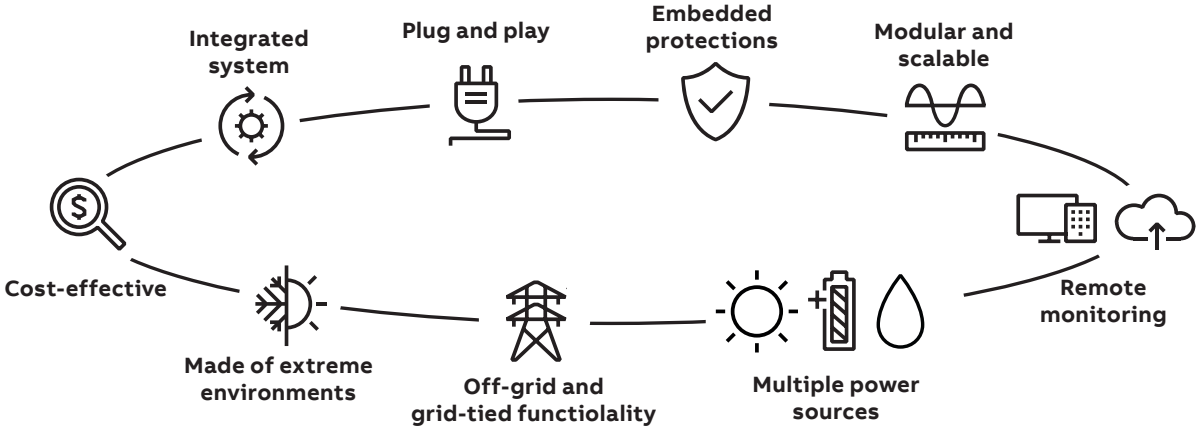
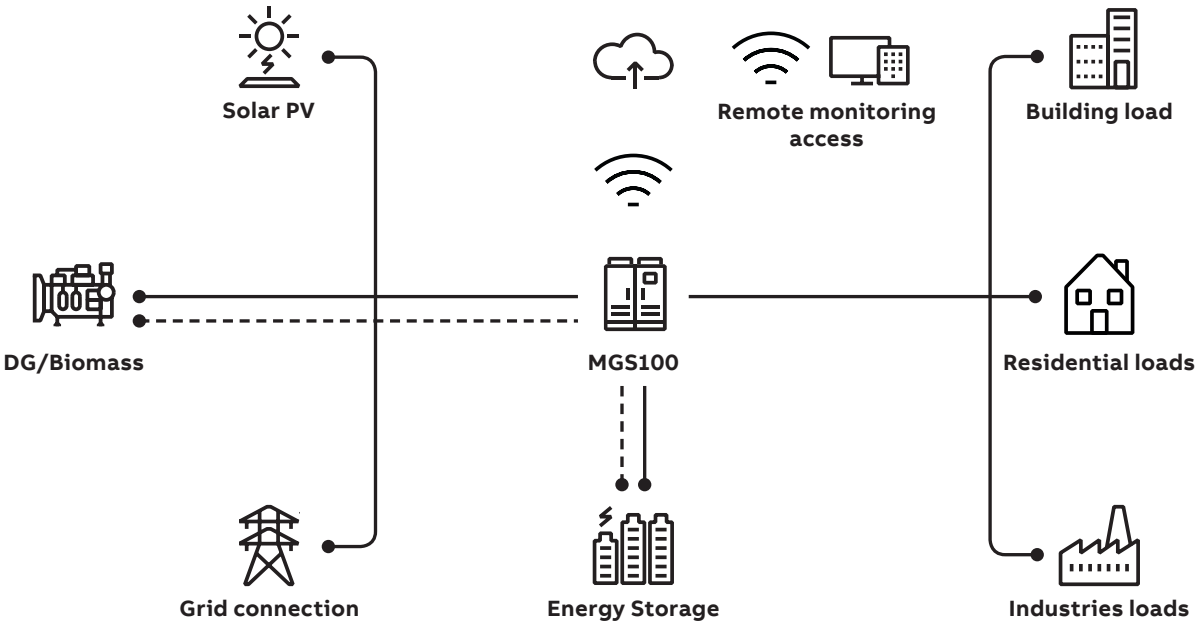
Why choose MGS100?



Robust converter design
ABB's MGS100 incorporates safety features for users and maintenance staff by mounting all the electrical components behind enclosures within one cabinet. For monitoring, it also includes a remote monitoring adapter, through which the MGS100 can be monitored and potential problems diagnosed. Software modifications/parameter settings can also be changed remotely.

Operating modes
ABB's MGS100 ensures no load disruption by seamlessly transitioning between on-grid and off-grid operation. The use of PV power is prioritized, supplying power to loads with a high efficiency. The connected batteries are charged with excess solar power and can be charged from the grid when needed, to ensure the continuous supply of power even after dusk. Any excess PV power can be returned to the grid to generate additional revenue when the batteries are fully charged.

Block diagram
The block diagram of the MGS100 system is as given below.



Conclusion
Thanks to PV technology, a revolution is underway in energy systems and electrical networks. Standard consumers are becoming prosumers, which is a paradigm shift that is taking place in all geographies around the world.
The financial viability of energy storage systems is boosting the utility of PV technology and ABB offers a range of solutions suitable for residential, commercial and industrial applications with new and innovative additional solutions in the pipeline.

For more information please contact your local ABB representative or visit:

www.abb.com/solarinverters
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ABB Storage Application Note_Global PM 20181109 09.05.2019