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# Microgrid Benefits and Example Projects

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## Executive summary

Microgrid benefits include the following:

- Energy reliability: Achieving resiliency through the microgrid's ability to island itself from the main grid and be self-sufficient
- Energy accessibility: Accessing energy at a reasonable cost when the main grid is not accessible
- Energy independence: Reducing fossil fuel consumption by integrating more renewable generation
- Energy cost optimization: Utilizing energy flexibility to optimize energy mix and grid balancing

This paper explores the benefits microgrids can provide and supplies examples of relevant microgrid projects.

## Microgrid benefits

### **Energy reliability:** Achieve resiliency through the microgrid's ability to island itself from the main grid and be self-sufficient

Power outages due to severe weather events are increasing in some regions. In August 2003, a widespread blackout caused an estimated 55 million people to lose power across the northeastern United States and eastern Canada. Many more were affected by the world's biggest power failure in India in July 2012, which left half of the country without electricity. Soon after, Hurricane Sandy lashed the eastern U.S., cutting power to eight million customers [1].

According to the Lexington Institute, regarding the resilience of the U.S. electrical grid, there are an average of at least 500,000 people affected daily by power outages, costing $119 billion annually [2].

Resiliency is increased through the microgrid's ability to island itself from the main grid and to be self-sufficient. When the main grid encounters a major problem, the microgrid is quickly decoupled and can still continue delivering energy from local sources. There may be limits to this autonomous supply due to local production, storage capability, and instantaneous status. However, with the microgrid's local management system, load priorities may be optimally managed and control strategies adjusted accordingly.

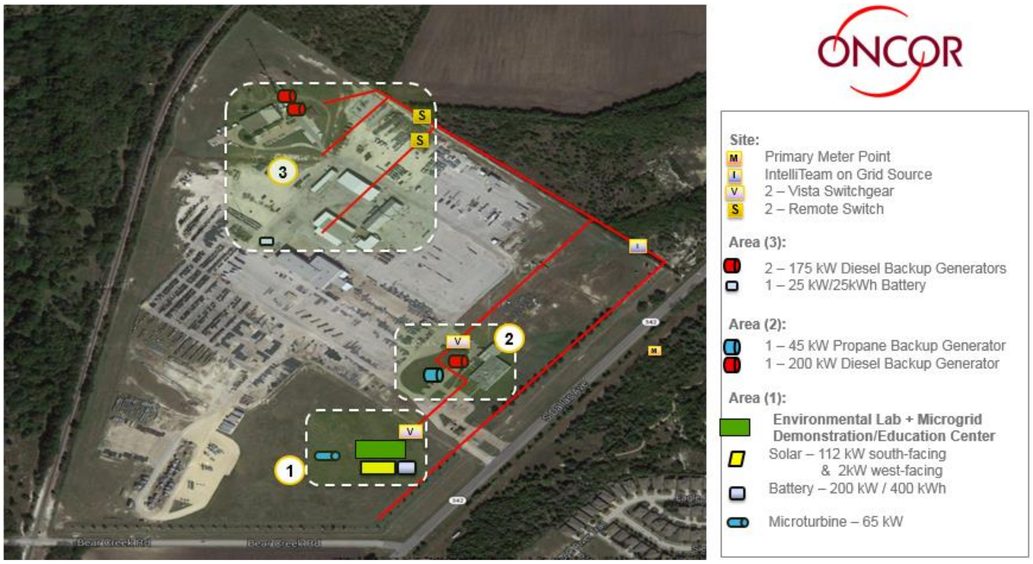
In addition, when the risk of problems is predictable (such as when a heavy storm is forecasted), the microgrid can be prepared by intentionally adopting a precautionary strategy, for example by reducing non-vital loads, preparing local generation for dispatch, and charging batteries to increase the future resilience of the system.

When issues come from the microgrid itself, for instance, when one of the sources experiences an issue or is undergoing maintenance, the microgrid enables back-up and automated reconfiguration possibilities.

*[1] How Prosumers Leverage 4 Technologies for Greener, Reliable, Economical Energy by François Borghese, Schneider Electric*
*[2] S. Bhattacharyya, S.Cobben, "Consequences of Poor Power quality – an Overview", Power Quality, book edited by Andreas Eberhard (Ed.), ISBN: 978-953-307-180-0, InTech, 2011*

**Figure 1**

*Oncor campus microgrid*



Consider an example of a campus microgrid:

Profile: 100+ acre system operating services facility

Challenge:

- Boost grid capacity and reliability
- Leverage existing resources
- Utilize dynamic, flexible microgrid technology
- Monitor and optimize distributed energy resources (DERs)
- Operate 2 solar PV arrays, 1 microturbine, 2 energy storage systems, 4 legacy generators

Solution: Oncor's innovative system comprises four interconnected microgrids and uses nine different DERs, including inverter and non-inverter-based resources that can disconnect from–and reconnect to–the main utility grid. The microgrid controller and operations software provides the information, communications, and control to monetize the value of energy flexibility by optimizing coordination of loads, generation, and storage.

Results:

- The controller safeguards operations and facilitates switching from a grid-connected mode to an off-grid mode to ensure reliable power for critical loads.
- It enables a seamless transition from individual microgrids to a configuration that leverages multiple microgrids working together as needed.
- A fault-tolerant approach allows devices to store energy from either the utility feed or any of the facility's generation sources.
- A cloud-based platform for economic dispatch and DER forecasting provides an additional layer of optimization and intelligence. Multiple use cases are supported, and it also creates the connection between the microgrid and the utility using industry standard communication protocols.

**Figure 2**

*Marine Corps Air Station Miramar mission-critical microgrid*

Consider the example of a mission-critical microgrid:

**Profile:** 3,500-acre Marine Corps Air Station Miramar operation and maintenance facility

**Challenge:**

- The Air Station's critical facilities must continue uninterrupted, even if utility power grid is compromised or damaged.
- Design must be scalable to potentially power the installation and manage electricity during peak usage.
- Design must incorporate renewable resources, advanced smart grid control systems and demand response capabilities.
- The Air Station strives to become a "net zero energy installation," which entails producing as much energy as it uses over the course of a year.

**Solution:** Miramar's innovative system is comprised of existing energy resources such as landfill gas, solar photovoltaic and energy storage systems, along with an upgraded 7 megawatt generation plant (primarily landfill gas). The microgrid controller and operations software provides situational awareness, communications, and control to monetize the value of energy flexibility by optimizing coordination of loads, generation, and storage. The system includes updates to the energy control systems and integrated microgrid controls.

**Expected Results:**

- The project is scheduled to be completed by July 2018.
- When isolated from the grid, the microgrid will be capable of powering the installation. When connected, the microgrid will intelligently interact with the grid through demand response.
- The microgrid will enhance and expand the functionality of existing on-site renewables: 1.6MW of solar PV and 3.2 MW generated by landfill methane gas.

- The Air Station is currently 50% renewable energy and is targeting 75% renewable energy by 2019, with the ultimate goal of net zero energy status.

## **Energy accessibility:** Provide access to energy at a reasonable cost when the main grid is not accessible

Microgrids could drastically speed up the deployment of smart grids and increase access to energy in developing countries.

Smart grid implementation is complex and calls for substantial adaptation of grid infrastructure. This will take time and significant capital investment. Microgrids could be a simple alternative to demonstrate the potential of smart, smaller-scale, more economical energy systems.

In developing countries where there is no energy network, the massive decentralization of local renewable sources could be inspired by the example of mobile telephony, which overcame the obstacle of investment in heavy infrastructure. Similarly, in the short term, low-power microgrids can provide pragmatic solutions for producing and delivering energy.

Consider the example of a rural electrification project for villages in Tonga:

**Profile:** 60 remote off-grid villages, 80-520 households per village, with no access to electricity

**Challenge:**
- Bring access to electricity in a sustainable way
- Eliminate the dependency on diesel
- Remove high OPEX costs of fuel and the maintenance of generators

**Solution:** Off-grid solar and battery storage systems, allowing access to energy day and night

**Results:**
- Access to electricity through 100% renewable without dependency on diesel is available.
- The 60 sites have become autonomous power plants (from 15kW to 75kW).

**Figure 3**

*Islands of Tonga rural electrification project for villages*

## **Energy independence:** Reduce fossil fuel consumption by integrating more renewable generation

For example, in the islands of Tonga, in addition to the challenge of improving energy accessibility, they must also work toward energy independence. National energy needs are met by imported petroleum to supply 15,000 customers on the four larger islands with over 90% residing on the main island of Tongatapu. Twelve mega liters of diesel fuel was used for electricity generation in the Tonga islands in 2012. About 97% of the total generation is currently by diesel engines with the rest generated from solar energy.

The Tonga Energy Road Map (TERM) is a ten-year work plan for 2010-2020 intended to reduce oil imports and Tonga’s vulnerability to oil price shocks. It also aims to increase access to modern energy services in an environmentally sustainable manner, as well as meet international requirements for reducing carbon emissions [3].

*[3] Pacific Lighthouses Renewable energy opportunities and challenges in the Pacific Islands region/Tonga from IRENA 2013 report*

## **Energy cost optimization:** Utilize energy flexibility to optimize energy mix and grid balancing

One objective is to enable self-consumption of green energy from local renewable sources to displace part or all of the energy from the main grid–helping to reduce energy-related greenhouse gas emissions. Adding local energy storage can help further maximize the use of renewable energy resources.

An additional objective is to utilize on-site distributed generation as a flexible energy asset to optimize participation in a demand response program–using local generation or load management to comply with a curtailment request. In some regions, feed-in tariffs enable customers to be compensated for feeding renewable energy back to the grid, typically without the option for self-consumption.

For example, consider the Syndicat Départemental d'Energies du Morbihan (SDEM), the utility in the Brittany region of France:

> The main office of the SDEM is a 3200 m² building that houses about 80 people.
>
> A microgrid system was set up to allow the optimization of electricity demand during consumption peaks, as well to smooth the building's load curve.
>
> Their microgrid is connected to the public, low-voltage distribution network, and therefore serves to reinforce the network and to augment the availability of energy. During times of high energy demand or reduced grid functionality due to network or generation faults, the site can relieve stress on the grid by serving its own load.

**Figure 4**

*SDEM: Syndicat Départemental d'Energies du Morbihan, France*

Their microgrid comprises the following components:

- A connection to the public LV distribution network
- A photovoltaic array with rated power of 110 kW
- Wind turbines with rated power of 2 kW and 3.6 kW
- An energy storage system composed of Li-Ion batteries and power electronic converters
- A UPS placed at the low voltage service entrance provides energy security and stabilizes the voltage and frequency of the building's electrical network in off-grid mode

- Electrical loads: Some of the electrical loads are controllable and therefore contribute to the implementation of the equilibrium of production and consumption

## Conclusion

Energy decentralization is a major development that could help tackle the energy challenges of the 21st century. Major technical and economic improvements have allowed substantial progress in decentralized energy resources–such as solar energy and storage, and the Internet of Things (IoT), driving new cooperation and optimization capabilities. Microgrids are a catalyst for the energy transition.

Microgrid benefits encompass better resiliency, easier access to energy through a less capital-intensive, modular, scalable solution that is quicker to implement, more choice around when and how to interact with the grid, and energy cost optimization.

Microgrids are already a reality with numerous success stories of turnkey solutions.

# About the authors

**Jean Wild** is the R&D program manager at Schneider Electric for microgrid and smart grid solutions. He holds an Engineering degree in Electricity from Ecole Centrale de Marseille and a Master’s degree (diplome d'etudes approfondies) in Electricity from Aix Marseille University. He specializes in power quality issues and electrical distribution, and specifically in smart energy systems in order to incorporate more renewable energies within distribution grids and microgrids. He has managed many international collaborative projects for Schneider Electric.

**Veronique Boutin** is an engineer from Ecole Superieure d'Electricite. She wrote her PhD thesis on an experimental project with a thermodynamic solar power plant. At Schneider Electric, she designed numerous automatic systems in various industrial contexts. She then focused on innovation and has been involved in several large cooperative programs such as HOMES, dedicated to energy efficiency in buildings, and Arrowhead, dedicated to cooperative automation for industry, buildings, and infrastructures. She is part of the Analytics, Applications & Programs team, where she is in charge of Proof-of-Concept demonstrations.

**Philip Barton** leads Schneider Electric’s North American strategy around organizing microgrid projects and solutions, both internally and externally with partner companies. Since 1998, Philip has led Schneider Electric teams in retrofitting entire microgrids or any part of their enabling technology, including distributed generation, power equipment, engineering services, inverters, metering, software, and power controls.

**Lance Haines** is an Engineering Solutions Specialist focused on microgrids and solar photovoltaic (PV) power plant modeling, simulation, and design. He has been in industry for 21+ years and has worked on projects involving PV inverters, intelligent load management, electric/hybrid-electric vehicle systems, and for distributed energy resources - PV, micro turbines, battery storage systems, ocean power, and fuel cells. Lance holds an MSEE from the University of Wisconsin – Madison, graduated Magna Cum Laude from Rice University with a BSEE and a BA in Spanish, and served on the working group for the IEEE 1547 interconnection standard.

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