White Paper

Load Banks for Microgrid Applications

ASCO Power Technologies®

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Recent years have seen expanded interest in the development and deployment of microgrids. This document explains how loads banks offer a practical solution for testing the various power sources and equipment that make microgrid deployments possible.

WHAT IS A MICROGRID?

The most common model for distributing electricity to end users is the use of public utilities. When served by a utility, communities are provided with a sole source of power from centralized supply. While utility-based power distribution typically offers economies of scale, the experience of end users is tied to the reliability of the utility power system. In addition, facilities and communities located beyond the reaches of power distribution infrastructure cannot be provided with electrical power from utility sources. Microgrids offer an alternative model for power generation and distribution.

A microgrid distribution model uses a local source or group of sources to supply electrical power to facilities and communities. Microgrids may use both renewable and fuel-based energy sources, and can be either grid-connected or off-grid systems. When disconnected from a utility grid, microgrids are said to run in *island mode*. An example of a microgrid is shown in Figure 1.

Microgrids are increasingly used as sources of primary and supplemental power. Like other power systems, they must be tested to ensure correct commissioning, operation, and maintenance. The following sections describe microgrid power sources and energy storage systems, and explain how load banks can help ensure efficient operation.

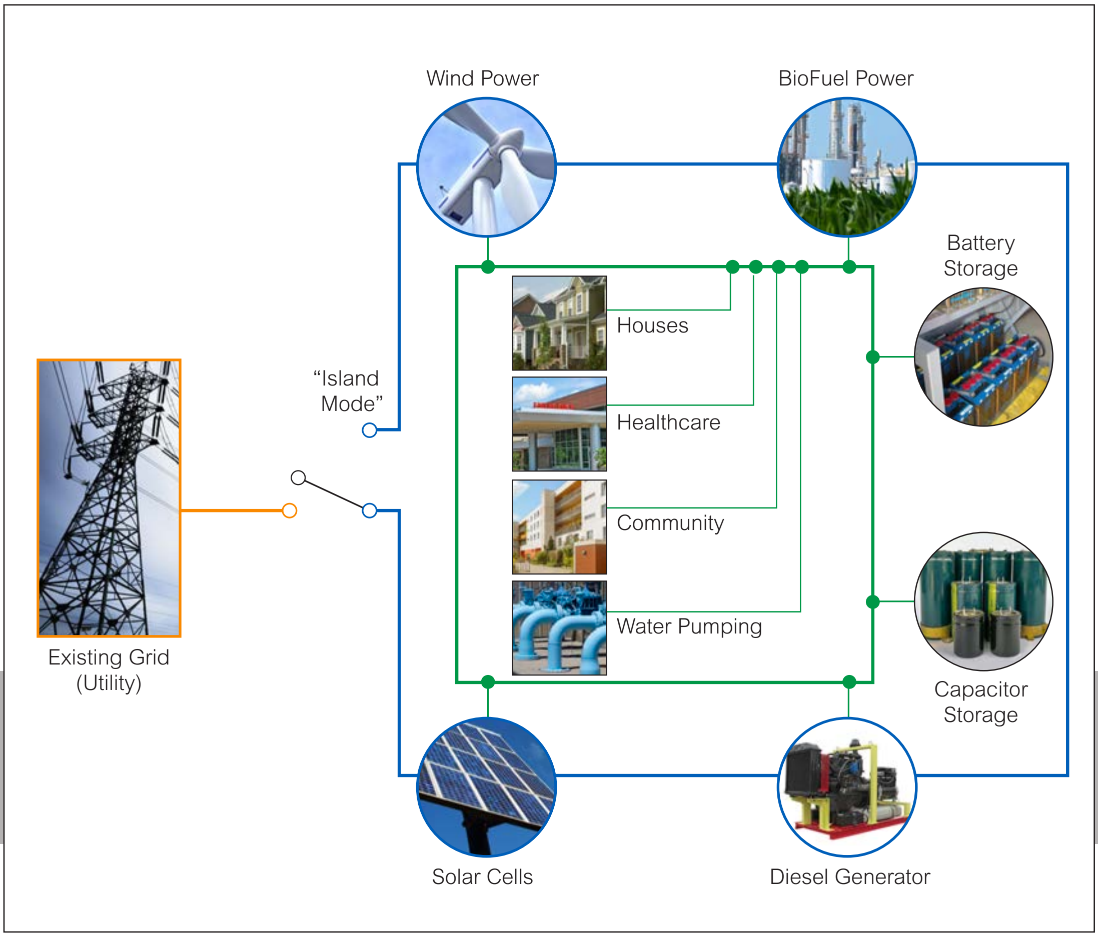


FIGURE 1: Example of microgrid configuration.

THE ROLE OF LOAD BANKS IN MICROGRIDS

Load banks apply precise and repeatable loads to electrical power sources by converting electrical energy into heat. The amount of load they provide is rated in kilowatts and the heat they generate is quantified in British Thermal Units. Common power sources found in microgrids include:

- Wind-Powered Turbines
- Photovoltaic Panels
- Diesel Generator
- Battery Storage
- Capacitive Storage

The following explains how load banks provide practical testing solutions to help ensure effective performance of these sources.

WIND-POWERED TURBINES

Wind turbines operate by forcing propeller-like blades to spin a generator to create electricity. Homes, telecommunication equipment, and water pumps are all examples of facilities and equipment that are powered by single, small wind turbines.

Small turbines (with outputs less than 100 kilowatts) are commonly found in microgrids together with diesel generators, batteries, and photovoltaic panels. These hybrid systems may be used in remote off-grid locations where connection to the utility grid is impractical or unavailable. Larger utility-scale turbines can produce up to several megawatts of power and offer economies of scale. Consequently, they are often grouped to create “wind farms” that provide bulk power to electrical grids.

Wind turbine power output changes with natural variations in wind speed. Load banks can help maintain wind turbine power output to a desired level using manual or automatic controls. When wind speeds and power outputs are high, load banks can lower net output to avoid overloading distribution systems. When wind speeds decrease, load bank controls can “shed” load to avoid overloading or stalling slow-turning turbines.

PHOTOVOLTAIC PANELS

Photovoltaic panels convert energy from sunlight into direct electrical current (DC). DC must be converted to alternating current (AC) to be usable in residences and businesses. Depending on the size of the installation, multiple strings of solar photovoltaic array cables may terminate in a single enclosure known as a Fused Array Combiner. The combiner houses fuses that protect the equipment, connectors, and cables that typically deliver DC power to an inverter.

For sources such as the photovoltaic panels used in “solar farms”, applying a DC load bank before current reaches an inverter facilitates commissioning, testing, and troubleshooting of the DC power source. Placing an AC load bank downstream of an inverter facilitates commissioning, testing, and troubleshooting of the AC source.

DIESEL GENERATORS

Diesel generators produce electricity using a diesel engine coupled to an AC generator. Whether used in a backup power system or as a microgrid power source, under-loading generators is one of the most common problems for diesel engines. Diesel gen-sets are shown in Figure 2.

When subject to under-loading, diesel engines may not reach their full operating temperature. As a result, glazing and carbon deposits can build up on the surfaces of internal parts such as piston rings. Eventually, unburned fuel residues can accumulate in exhaust systems, a condition known as wet-stacking, that decreases performance and can result in failures. Consequently, diesel gen-sets function most effectively when operated with adequate load. Many manufacturers require gen-sets be operated at a minimum of 30% of nameplate capacity; many diesel engines run optimally at 70%. Applying large load can remove fuel deposits from internal parts and exhaust components.

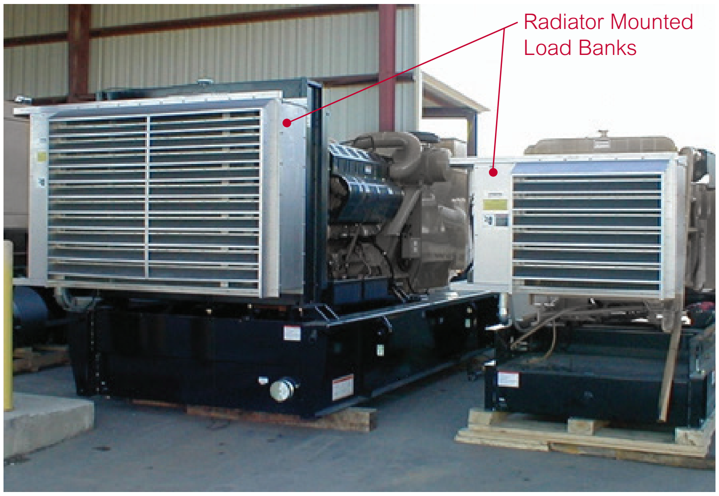
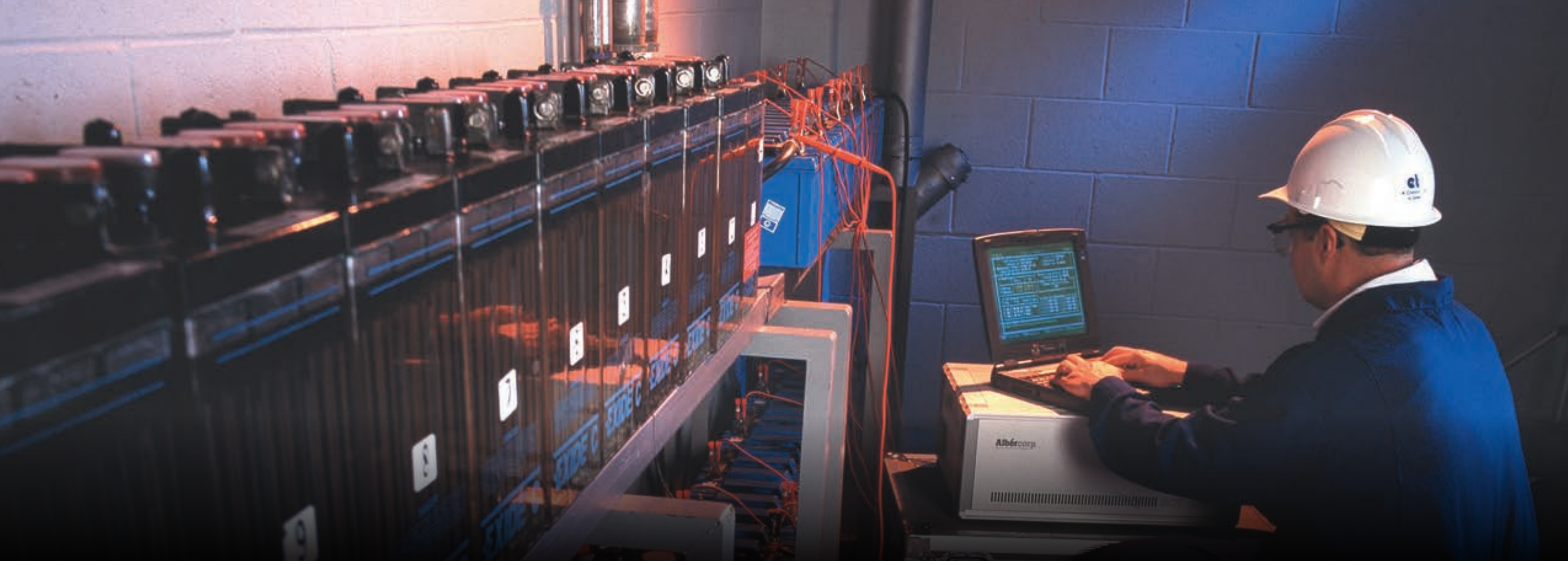


FIGURE 2: These diesel gen-sets use radiator mounted load banks to apply the required amounts of load.

An effective strategy for properly operating and testing diesel generators is to apply adequate load using a load bank. For standby gen-sets, load banks can be used to ensure minimum loading requirements are met.



In addition, a load bank test will indicate:

- An engine's ability to provide the required power output
- Voltage regulator response times
- An alternator's capability to provide the required voltage and the necessary frequency stability
- Performance of the control system under varying loads

Using data logging functions in load bank control systems, test results can be automatically recorded and analyzed to evaluate equipment condition. For additional information, please see our white paper entitled Load Bank Testing to Ensure Generator Set Performance.

BATTERY STORAGE

Microgrids typically utilize Energy Storage Systems (ESS) such as batteries to accumulate energy from renewable sources, which is then used when other sources are less active. ESS' must be regularly maintained to provide reliable service. A maintenance program includes routine capacity testing to assess battery condition and anticipate battery replacement. A load bank provides a reliable, precise, and cost-effective solution for ESS testing. Figure 3 shows components of a typical storage system and its inverters.

Battery capacity is the measure of the amount of energy that a battery can store. Capacity discharge testing assesses a battery's ability to deliver a specified amount of current at a constant rate for a specified time to a specified end voltage. Capacity discharge testing is the only true means for measuring battery capacity.

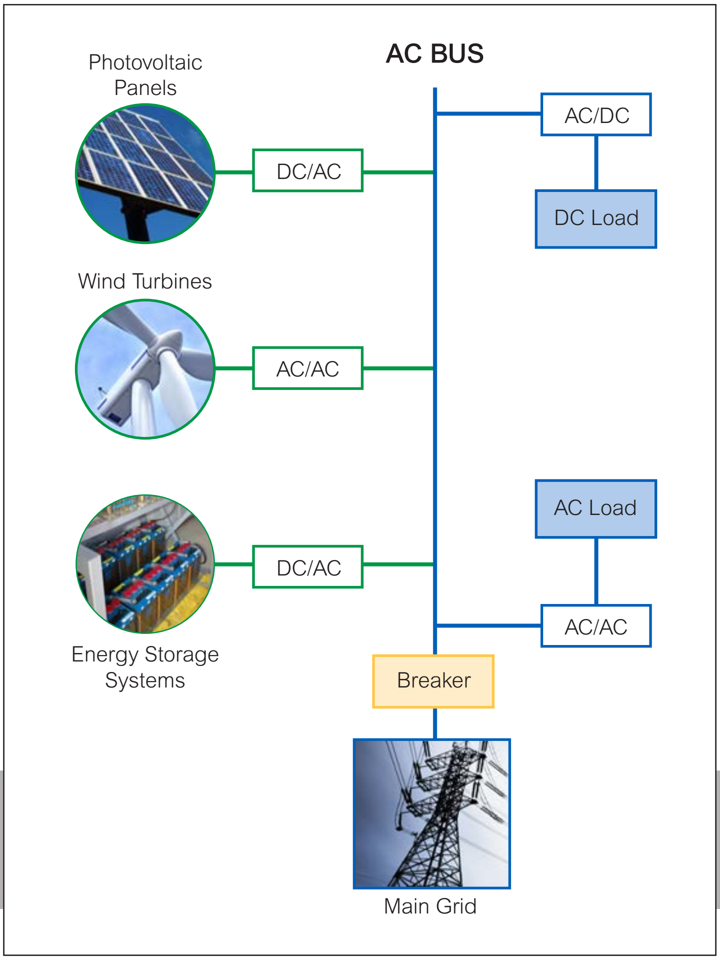


FIGURE 3: An example of typical AC Energy Storage System.

A resistive DC load bank enables facilities to properly conduct capacity tests. Periodic capacity discharge testing enables evaluation of battery service life and can help avoid catastrophic failures. Data from capacity tests can be evaluated to:

- Detect developing problems
- Evaluate whether batteries should be replaced
- Establish performance baselines for subsequent trend analyses

A DC load bank provides the accuracy and resolution required for effective capacity testing. Multiple load banks can be connected in parallel to test large battery strings. For additional information, review our white paper entitled Direct Current Load Banks for Battery Capacity Testing.

CAPACITIVE STORAGE

Ultra-capacitors are rapid-response, high-power, energy storage devices that are used to address voltage, frequency, and power quality issues. Ultra-capacitors are sometimes used in microgrids in the following ways:

Mission-Critical Microgrids power military bases, university campuses, commercial and industrial sites, and off-grid facilities. Since microgrids are self-reliant, it is critical to maintain power quality and stability. Ultra-capacitor systems can provide short-duration services such as voltage and frequency support, solar and wind power regulating, and generator bridging. Likewise, ultra-capacitors can be incorporated into hybrid ultra-capacitor battery systems that extend battery life by slowing battery charge and discharge rates.

Solar and Wind-Power Power output decreases when there is no wind to drive turbines and there is no sunlight to power photovoltaic panels. When this occurs, operators use the high power and fast response of ultra-capacitors to "smooth" fluctuations caused by intermittent power produced by renewable sources. Like the DC batteries described above, capacitive storage systems require periodic capacity discharge testing. Many load bank manufacturers offer units that can properly load these storage systems and assess performance.

SUMMARY

The use of microgrids is expected to increase, in part, because they can provide supplemental power when utility sources are unavailable. Nevertheless, the traditional and renewable power sources used in microgrids must be tested and maintained to ensure that they will provide reliable service when needed. Load banks provide repeatable and precise loading for testing both power generation and storage devices. For this reason, they are well-suited for commissioning, testing, and maintaining critical equipment in microgrid systems.

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