Construction of a Microgrid for Industrial Parks

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Abstract

The Microgrid is a natural consequence of the interoperable grid. The large users are the most appropriate place to "store" electricity and shift load, but need to be compensated for their efforts and properly metered. The introduction of the Smart Meter provides much of the intelligence needed to create a Microgrid. The Utility can be provided additional resources for balancing and storing energy, the User can be provided higher reliability and potential cost savings. This paper describes the Microgrid from the viewpoint of the Industrial User - a commercial entity that can move much faster than the regulated world and an underutilized potential for handling the issues that are coming with large renewable addition and intermittent generation that will result.

1. INTRODUCTION

Pressures from deregulation, the need for more efficient and climate friendly technology combined with regulatory requirements (stick) and monetary rewards (carrot) in the form of renewable and carbon emission credits is encouraging us to move beyond the current simple grid structure. The current electric power system has performed well for a structure that was evolutionary rather than architected but, in truth, the original design was intended only to move power from a company's generation to their customers with occasional ties to the neighboring girds for purchase and sale. This structure has problems of low reliability (99.7%), single point security, and, as with many regulated industries, moves deliberately and offers limited power products. Like Telecom, the future will be an intelligent management of a central grid (the "Smart Grid") which will encourage smaller, independent, distributed Microgrids.

The Microgrid is a fundamental shift in the relationship between the utility and the load and they are resource management systems with intimate, real time knowledge of the needs and state of each of the users. Microgrids must provide energy management functions similar to a grid. Flexibility and real time communication are essential elements because they manage the character, state and needs of the users. They also need to provide new power products demanded by customers (e.g. triple redundant power, DC voltage, complex time dependent curtailment schemes).

The Microgrid is a collection of generation sources and loads that can be separated and reconnected seamlessly and bumplessly from the main grid, a process called "islanding." While in the island state, the Microgrid EMS is responsible for the frequency and load balance. When connected to the grid, the Microgrid can present itself as a much simpler load (e.g. curtailable load, demand response, peak load avoidance) and participate in the wholesale power products. Typical examples are large factories with internal power generation, large commercial or industrial building complexes with power generation such as campuses, hospitals and data centers. These often have generation and loads that are better handled at low voltage such as intermittent generation (wind, solar), new distributed loads such as V2G (Vehicle to Grid), and distributed generation such as small hydro, biomass, geothermal, CHP (combined heat and power) and others.

2. SAMPLE MICROGRID/INDUSTRIAL PLANT

In order to attract tenants, the Industrial Park would have to provide first class power, steam and basic utility systems and other benefits from the Microgrid. A simple example is shown below and this can vary markedly from site to site.

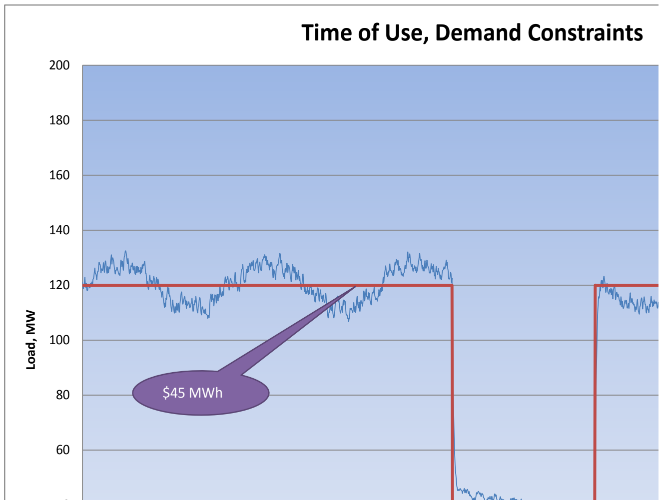

Figure 1 Time of Use and Demand Constraints

Figure 1 shows the demand curve for a site on a typical time of day tarriff. The on peak (1pm – 6pm) demand charge was based on a demand of 40 MW with the real time pricing (RTP) at $400/MWh. The off-peak demand was 120 MW with RTP pricing at $45/MWh; so the site worked hard to insure they used no more than the demand but always used it. In some sites the price is difficult to predict because the transmission operator adds a factor know as LMP (locational marginal pricing) to manage congestion at their node. The LMP charge can be a large number and can vary every 5 minutes.

Figure 2 shows a simplified sketch of the power system at an Industrial Park. The main lines from the utility are redundant – often required to come from different substations. These are usually at or near the transmission level voltage, shown here as 120 kV on the primary windings of the main transformers. The tariff can include both demand charges (charges that are assessed all the time whether used or not) and usage charges.
The main generators at in this example generate at the site voltage of 13.8 kV. A plant in the park can select to be on a single or a redundant power supply for some or their entire complex. For example, Plant 2 and Plant 4 and the Common System (water plant, sewer plant, and utilities) could be on the redundant networks; and, Plant 3 and Plant 1 on single networks. The system is operated by the Microgrid controller.

Figure 3 shows a simple schematic of one of the plants within the complex. The loads in this plant can be either 480 V or 12 kV. There are additional sources of generation inside these plants which could be CHP (combined heat and power) as noted as G3.

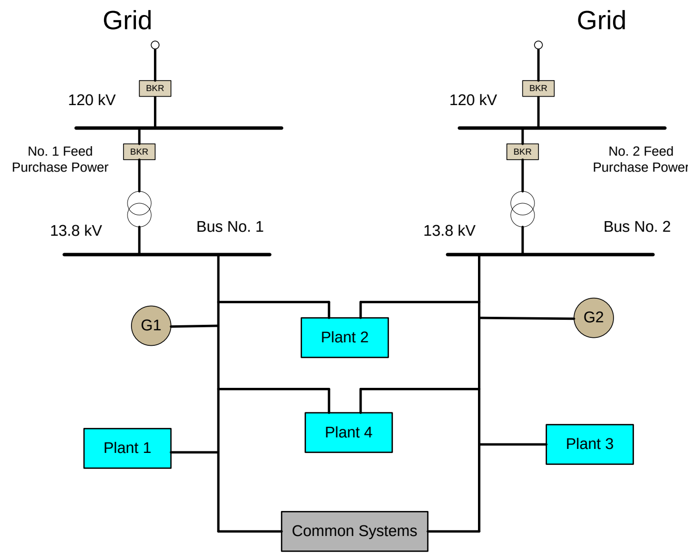

Figure 2 Typical Microgrid

This is the ideal situation for CHP which is shown here as a small gas turbine. The issue with the CHP is that stand alone, it is only 22% -26% efficient but if the heat can be used, this number can go as high as 85%. Inside the industrial park, it is feasible to have one user that needs the electricity and one that uses the heat making CHP far more cost effective. Figure 4 shows the steam system for this facility. Having a heat load is a critical part of a Microgrid.

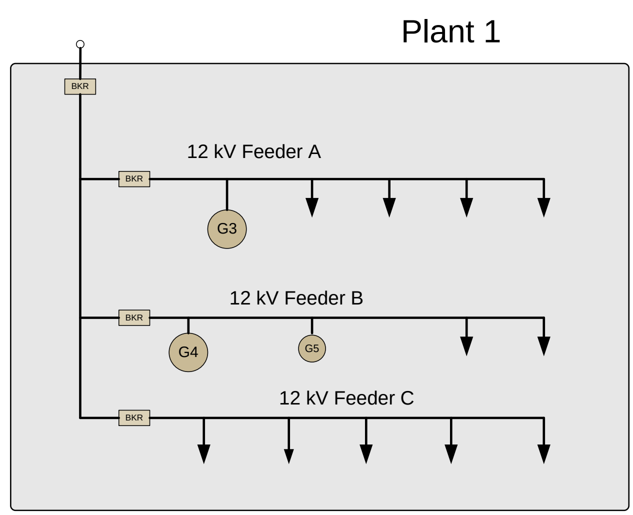

Figure 3 A typical plant

In summary, the role of the Microgrid is to manage the resources in a facility. It accepts power from the utility (Distribution or directly from the grid), sells power to the grid, participates in grid regulation
while supporting the internal facilities with redundant power and steam. It also fully utilizes distributed generation, maintains heat loads and

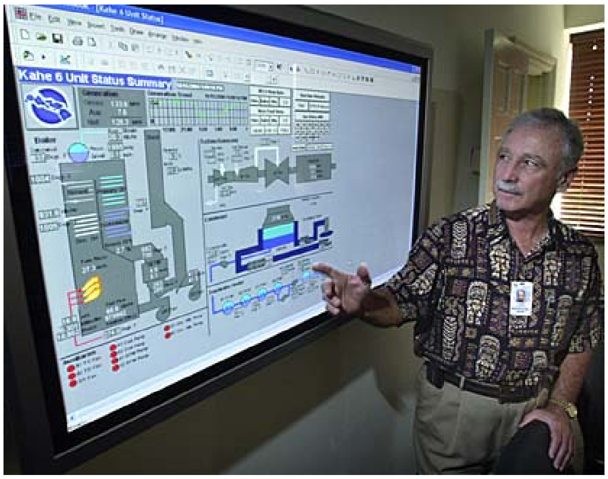

Figure 5 Microgrid Controller

accepts intermittent power. An intelligent system accepts signals from the utility or grid (e.g. curtail, demand response) and determines the scale and strategy of the response. If the grid is unstable then it will execute an islanding action seamlessly to its user. It must also manage the other utilities including steam, sewer, process/recycle water, air, distilled water, potable water, industrial gasses, and the like. Billing for these services and invoicing for any power or power products exported are the responsibility of the Microgrid. It also must cooperate with the grid or utility for bumpless reconnection. Internally to the complex, the

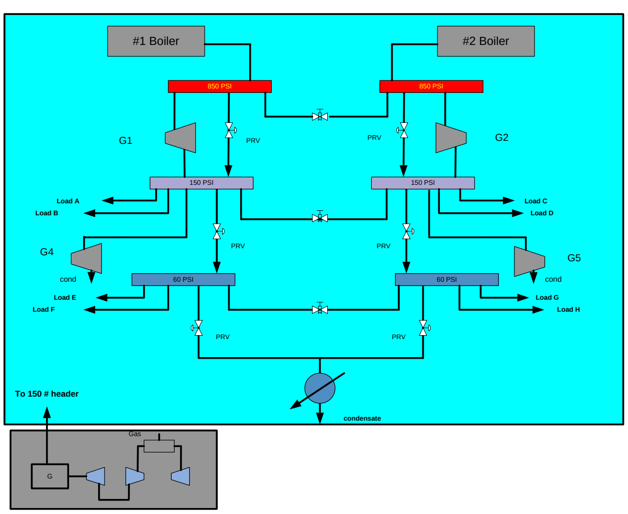

Figure 4 Steam distribution

Microgrid controller manages services as selling the heat from a CHP, providing redundant power and redundant steam, managing carbon footprint and filing of renewable and carbon credit energy information and environmental reports.

Figure 5 shows a picture or a typical display used for these functions.
To summarize the advantages:

Improved Reliability – redundant sources and ability to island.

Deferred Capital Spending for Capacity and Congestion – implementation of permanent load shifting, load management and creation of ancillary products such as regulation up, regulation down
Reduced O&M Costs – Increased information peer to peer allows common O&M desk

Enhanced security and fault monitoring – require by NERC Critical Infrastructure Program.

Increased Efficiency of Power Delivery – distributed generation, non-traditional sources and CHP or fuel cells are much more efficient if they can sell their heat output. It also can manage intermittent sources at the local, low voltage level.

Improved Electrical System Security – Common security for the power, water, sewer and physical assets.

Consumption Management – Access to the wholesale prices of power is possible in some states.

Automation – Billing, environmental and other reports are automated. ERP and real time information services could be offered as much of the information is already in the Microgrid.

Peak Load Reduction – Any demand/peak charges are monitored carefully and manages with the resources on site as allowed by contract. This could include, in addition to Distributed Energy Resources (DERs) (e.g. turbines, engines, PV, geothermal, hydro, PV, wind turbines) and storage (e.g. batteries, flywheels, plug in vehicles, high energy process materials) it can implement strategies that use alternate sources of energy such as switching from electrical drives to steam turbines or using stored refrigerant instead of compressors.

Convenience of Microgrid – There is value for documentation of energy conservation project since the detailed submetering is already in place thereby allowing the facility to determine where improvements could be achieved. This would include interfaces to loads from building systems, SCADA, EMS, DMS, DCS or PLC systems.

Energy Conservation and Reduced Costs - The measurements and procedures defined above are those needed to support the proposed ISO type improvement process mandated by the Energy Independence and Security Act of 2007, Section 1304.

Convenience – The convenience of having information readily available are numerous. The Microgrid can supply detailed analytics of a user's utility situation along with sufficient information to change their operation,

User M&O – We spoke of the Utility M&O, but there is an equivalent on the user side that might require information exchange with the Utilities.

Enhanced Customer Support - Microgrid provides both much greater data set in real time (not daily like many smart meters), real time analytics to find the problem, notification by exception and ad hoc trouble shooting.).

General Functions - Real-time access, historian, event management, visualization, and notification are part of the Microgrid.

Advanced Functions – Detection of grid instability required the implementation of synchronous phasors. In the domain of a Microgrid it also includes reasonable sized battery storage and ultra capacitors and steam turbines for seamless island and resynchronize. For grid connected systems, the Microgrid can monetize surplus power and certificates (renewable, carbon). For "green" users, the Microgrid could manage panel carports for employee parking of Plug In Hybrid Electric Vehicles (PHEV) or Plug In Electric Vehicles (PEV).