Distributed Resource Issues Related to Utility System Operations White Paper

Technical Issues

Technical requirements for the parallel operation of non-utility generation have existed at most Michigan utilities for decades. Uniform generation interconnection rules used by all utilities operating in Michigan did not exist until the Michigan Public Service Commission ("Commission") adopted administrative rules in July 2003 in Case No. U-13745. These interconnection rules required each electric utility in the state to file proposed interconnection procedures. Several Michigan utilities worked together and filed a comprehensive set of interconnection technical requirements, procedures, and boiler plate agreements (collectively "Generator Interconnection Requirements") that must be satisfied to safely and successfully operate a generating facility in parallel with the electric system. These Generator Interconnection Requirements are based on IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems and were approved by the Commission in August 2004 in Case Nos. U-14085, U-14088 and U-14091.

The remainder of this document discusses some of the technical issues that must be considered when connecting a small generator to the local distribution system.

Utility Distribution System Operation

The low voltage distribution systems operated by Michigan's utilities are typically radial in nature (as opposed to a looped or networked distribution circuit system). This means that electrical connection from one power source to another (from distribution substation to distribution substation) does not exist during normal operations. If facilities within the distribution substation or upstream subtransmission or transmission feed to the distribution substation should fail, customers are typically interrupted unless manual switching occurs while the failed facility is repaired and placed back in service. Distribution circuit feeders are usually operated as 4 wire, 3 phase grounded (Y connected with neutral grounded) circuits or 3 wire, 3 phase ungrounded (or delta connected) circuits.

The operation of and the different voltages utilized by the Michigan utilities goes back to the beginnings of electrification in Michigan and the evolution of electric service throughout the state. As a result of these differences, differences in the operation and expansion of utility distribution systems occur. The planning, relaying, fusing and operating philosophies implemented by the Michigan utilities reflect the evolution of their respective distribution systems.

Not only are planning and operating philosophies different between utilities, but each geographic location within the electric distribution system poses different electrical challenges with regard to the interconnection of parallel generation. As a result, a site specific interconnection study must be performed by the utility.

Parallel Generation Interconnection Study

The purpose of performing an interconnection study and the reason for the Generator Interconnection Requirements is to ensure the safe and reliable operation of parallel generation with the utility electric system. Protective device requirements specified by the utility are not to protect the generator from the utility. That is the responsibility of the generator. The utility specifies certain requirements to ensure the utility system and its customers are protected from the generator.

Most Michigan utilities have placed their Generator Interconnection Requirements on their respective Companies' internet web page(s) for easy access by generator developers ("Project Developer"). Utilities need to know all of the electrical characteristics of the proposed generation. The Generator Interconnection Requirements include a listing of information that the Project Developer must provide the utility.

The interconnection study will consist of an evaluation of the generator's impact on thermal loading of utility facilities, the added short circuit impact on utility facilities, and possibly the dynamic effect (or stability effect) of the generation on the existing utility distribution system. Depending on the size of facilities in the nearby distribution system, the interconnection of the generator could overload facilities (like wires, transformers, and other distribution system equipment). Similarly, a new generator could increase the available short circuit at a distribution system interrupting device beyond the device's interrupting capability. Generators operating in parallel with the electric system will influence and be influenced by disturbances (short circuits – i.e. tree falling into a line, failure of an electric facility, nearby motor starts). If the generator is large enough compared to the relative electric strength of the nearby electric system, a stability study may also need to be performed to see if the generator will remain in synchronism with the electric system during credible short circuit events. If it doesn't, out of step tripping may be required to ensure nearby utility customers are not subject to poor power quality service and ensure the generator itself is not damaged.

Besides equipment loading, short circuit and stability impacts being determined, several other issues are addressed during the interconnection study. Electrical protection of the utility distribution system from the effects of the generator during disturbances is a significant item reviewed. Synchronous, induction and inverter type generators all have different characteristics and, therefore, different protection requirements. Typically, the larger the generator, more protection requirements must be satisfied. These protection requirements can include over and underfrequency, over and undervoltage, out-of-step (or loss of synchronism), and ground protection. Depending on the size of the generator and operating voltage of the utility distribution system, an isolation transformer between the generator and the utility distribution system may be required. An isolation switching device between the generator and the utility system and an interconnection line and line termination structures are also typically required.

Other Parallel Generation/Utility System Operating Issues

Most utilities automatically reclose distribution lines at least once after an automatic sectionalizing device has operated for an electrical fault condition. This is done to increase the reliability of service to customers. Re-energizing a distribution circuit into a generator that is not off-line could significantly damage the generator, distribution system facilities, and other customer equipment.

As a result, synchronism check relays are sometimes employed on utility circuit reclosers and circuit breakers to mitigate this concern.

If the generator is large enough, the generator could possibly serve utility customers in an isolated, or islanded, mode from the rest of the utility system. Direct tripping of the generator off-line when the service from the utility is lost is sometimes employed to avoid this condition. Islanding also creates a safety hazard in that electric line workers could be subjected to energized wires and other equipment when they believe these facilities are isolated from any source of generation.

Telemetry and disturbance monitoring are an important part of larger generator interconnection installations. Utilities continuously measure their electric load in order to dispatch large central generation to balance electric load and generation. During system disturbances when portions of the electric system are out of service, it is essential to know if a generator is on-line or off-line. Post mortem analysis of a disturbance is significantly more difficult to analyze if data from local generation is not available.

Distributed resources typically have no or minimal mechanical or electrical inertia, and consequently no or minimal short circuit capability as traditionally experienced from larger generating units. Distributed resources typically have no or minimal reactive power generation capability. Consequently, utility generators may have to operate not to supply power, but to supply short circuit and voltage regulation functions to keep the electric system operating stable. Even with utility system generation stabilizing the electric grid, electronic conversion interface systems like those used to convert fuel cell and microturbine direct current power to alternating current power could go to a current limiting state resulting in potential voltage collapse. Furthermore, if a distributed resource is located in a weak part of a utility network (equivalent impedance is high, short circuit availability is low), voltage quality and power quality in general may be unacceptable.

Most distribution systems have been designed to deliver power via radial lines, or circuits, whose power source emanates from a single distribution substation. Distributed resources change the distribution design requirement completely. It approaches a transmission-type system – multiple steady state power and short circuit sources. Distribution system equipment and protection schemes are typically not designed for this. Nuisance fuse blowing and installation of transfer trip relaying are issues that must be addressed as more distributed resource units saturate the utility system.

The closer a distributed resource is connected to the load, the more often and faster it has to react to changes in the load. This can impact efficiency, control, and even reliability.

Most distributed resources generate direct current electricity and convert it to alternating current electricity through an inverter. Consequently, harmonics are generated. Manufacturers indicate that solid state power electronics technology is advancing to the point where power inverter harmonics will be negligible in the future and more than meet guidelines like IEEE 519. Pilot units installed around the country seem to indicate otherwise.

Insurance requirements could be a barrier to residential as well as small commercial penetration of distributed resources if insurance companies will not provide coverage above the traditional homeowner’s policy.

Building, fire and safety codes are not in place in some cases to allow distributed resources to be an approved source of generation.

Synchronous generators supplying power back to the utility electric system must be capable of supplying dynamic reactive power between 0.90 power factor lagging and 0.95 power factor leading at the point of receipt to the utility.

Regulatory Issues

Operating distributed resources in parallel with the utility electric system not only poses certain technical challenges, but several regulatory issues also need to be addressed. Entities seem to be pursuing the concept of a microgrid, or distributed resources serving a small electric system that may or may not be isolated from the utility electric system. Public Act 141 of 2000 Section 10q(4) states that "Only investor-owned, cooperative, or municipal electric utilities shall own, construct, or operate electric distribution facilities or electric meter equipment used in the distribution of electricity in the state." Public Act 141 would seem to prohibit the implementation of a pure microgrid unless the generator and the load met the requirements specified in PA 141 Section 10a(6).

If apparent restrictions by PA 141 were not in place, several other questions would need to be resolved to ensure the responsibility of electric service to customers is clear. Below are some other questions that will need resolution:

1. Is the entity operating the microgrid a public utility? If so, what regulations would apply? If not, what regulations would apply?

2. Does the incumbent utility have an obligation to serve, provide backup generation and/or backup delivery service when another entity is operating a microgrid within the utility's service territory?

3. If a microgrid is in operation, whether as an island or in parallel with the local utility system, who is liable for customer service? Does the local utility tariff rules apply?

4. Who would regulate power sales back to the electric grid?

5. What approvals would be required?

6. As distributed resources are microgrids develop, how would utility generation and delivery system stranded costs be resolved?

7. Would net metering apply to a microgrid operation?