The Power Continuity Unit: Bridging the Gap between the Legacy Grid and the Smart Grid

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ABSTRACT

DERP Technologies, LLC is designing interconnection systems to help utilities bridge the gap between today's "Legacy Grid," with its increasing frailties, and the emerging "Smart Grid," which will increase the capacity for clean distributed generation and innovative, community-based solutions for keeping critical services [1] powered up during wide-spread grid failures. Two microgrid projects are in the planning phases under the auspices of the State of Connecticut's pioneering *Microgrid Demonstration Program*, inaugurated in 2012 by the passage of Public Act #12-148. The State, in collaboration with Connecticut Light and Power (CL&P), is leading the nation in advancing new designs in microgrid applications; these microgrids are intended to make it possible for select municipal and other facilities to remain operational for up to 4 weeks when the Legacy Grid has failed, causing wide-spread black-outs.

Keywords: microgrids, adaptive islanding, critical infrastructure, diversified generation resources

1 DERP INTERCONNECTION

DERP Technologies (DERPTECH) is advancing community-based microgrid configurations with one model installed on the demand side of the meter (consumer-side) and the other integrated on the local distributed network side (or the utility side) of the meter. The generation resources are diversified and include renewables (PV Solar), energy storage, Natural Gas turbines, and other alternatives to the use of electricity when it is scarce (such as augmenting the physical plant with thermal solar and thus offsetting the critical load requirements). DERP TECH is also developing a family of interconnection devices for the interface with the grid, called the Power Continuity Unit ("PCU"), which has a number of critical functions, including adaptive islanding, load shedding, distribution management of local distributed generation sources, and asset protection (of distribution substation equipment).

2. MICROGRIDS ENHANCING THE PUBLIC HEALTH AND SAFETY: THE ROLE OF THE STATE OF CONNECTICUT

The State of Connecticut has initiated the nation's first microgrid demonstration program, implemented by the Department of Energy and Environmental Protection (DEEP). [2] The microgrid program is designed to make it possible for key services that ensure public safety to remain powered during black-outs and emergencies; this will enhance the State's emergency preparedness, especially in light of recent massive storms that have caused grid failures lasting weeks at a time.

2.1 Elements to Consider in Managing a Microgrid

Managing a Microgrid is like managing a very small vertically integrated electric utility without a transmission component, *but with generation and distribution components.*

System configuration must be known at all times and be factored into normal grid switching and operating protocols *by both the distribution company (the local utility) and the company operating the Microgrid interconnection.*

From "Microgrids in New England: Challenges and Opportunities"
By the United Illuminating Company, Connecticut Light & Power and Couch-White, LLP, legal advisors

2.2 Definition of a Microgrid from Connecticut Public Act No. 12-148

"Microgrid" means a group of interconnected loads and distributed energy resources within clearly

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defined electrical boundaries that acts as a single controllable entity with respect to the (legacy) grid and that connects and disconnects from such grid to enable it to operate in both grid-connected and island mode.

Note: When ever a local distributed generation source is operating in tandem with the bulk or "legacy" grid, this is called "parallel operation" and there are significant challenges associated with this design. It is distinctly different than any "UPS" (Uninterrupted Power Supply) and there are many challenges, including synchronization, that must be addressed.

3. MICROGRID AND DISTRIBUTED GENERATION SOLUTIONS FOR MUNICIPALITIES: A TALE OF TWO CITIES

Although the principles of microgrid design are similar on paper, each town and each setting is as unique as an individual's fingerprint. Each site is unique as to the types of generation resources that are available: PV solar, small wind turbines (horizontal and vertical axis), hydropower and co-generation are among the chief renewables and gas-fired turbines are often a part of the mix. (In Connecticut, it was an objective to "re-purpose" existing back-up generators and to find a means to extend their capacity to run for long periods of time - in some cases, up to four weeks!)

DERP Technologies LLC (DERPTECH) has had the opportunity to be involved with two towns, each with a population of roughly 20,000, that are involved with the DEEP Microgrid Demonstration project.

DERPTECH is the Microgrid Developer for the Town of Windham and is working on a project involving two public schools; the project has been dubbed "SAFE HAVEN FOR SCHOOLS™." [2] The other town, Southbury, is looking at a more complex, two-tiered approach - first utilizing existing generators and "re-purposing" their capacity for powering a microgrid -- then moving towards a larger scope, involving the addition of critical facilities and requiring what we call a "hybrid" microgrid model.

3.1 Safe Haven for Schools – Adding PV Solar and Turbines to the Mix – Windham, Connecticut

The Safe Haven for Schools model is a behind-the-meter (consumer side of the meter) microgrid plan. There are two public schools on one contiguous parcel of land and no back-up gas turbine generators on-site; however, there is a supply of natural gas (NG) going into the larger middle school. There is a limited amount of PV Solar on-site; that capacity or resource will have to be increased from 27kw to close to 270kw just to power the critical load.

DERPTECH will be working to incorporate 2 NG turbines into the generation resources for the two schools on the compound. Load-shedding capabilities will be added to the internal infrastructure to drop the total load of the two schools severely - down from over a megawatt of demand. Outdoor lighting and security will be a critical part of the plan, as the playing fields may be needed for outdoor shelter and even triage in emergencies. Energy storage and soft-load transfer switches are anticipated to be a part of the overall Safe Haven for Schools microgrid plan.

3.2 Hybrid Microgrid Plan – Mixing Behind-the Meter and Utility-Side Loads – Southbury, Connecticut

The Town of Southbury is located along Interstate 84 and would be in a critical location if evacuations were to occur along that vital highway heading east-and-west. Accordingly, it is looking to phase in an ambitious set of microgrids that initially would keep a senior center powered up, along with the adjacent City Hall. The is one large diesel generator on-site, only used as back-up power and now only for the Senior Center. With the phase-one microgrid, a backfeed through the utility's infrastructure is suggested in order to feed the City Hall as a command center. DERP TECH would be recommending the addition of PV Solar to the site and possibly energy storage to augment the diesel generator.

The phase-two is complex and will require the cooperation of the school district and the municipality; the large middle school near the Interstate would be a part of a microgrid that may also power other municipal buildings. (The School serves two jurisdictions.) In this phase, the DERP TECH model of the "Safe Havens for Schools" microgrid would be deployed. This model would involve at least one microgrid that is "behind-the-meter" (demand side) and one would be on the utility-side of the meter, requiring much more interface with the utility, including IEEE requirements (affecting the interconnection) and also SCADA reporting requirements.

4. POWER FLOW AND INTEGRATION

Power flow and integration at the substation level of the DERP-PCU and the corresponding REGS (Renewable Energy Generating Station) = supply of local Distributed Generation (DG.)

The DERP-PCU enables the integration of the Distributed Generation of clean or renewable electricity into the local distribution network. This entails installing the DERP-PCU at a node or a substation on the secondary bus. Each feeder would have its own sensors and its own Point of Common Coupling (PCC). Certain models would have the capability of being networked with other similar PCU devices. The PCU is capable of load shedding, intelligent switching, distribution management (of locally produced power), data collection, event sensing, and SCADA-related communications.

In order to provide integration and interconnection with the local grid, the DERP-PCU will have to substantially comply with the IEEE 1547 series of interconnecting standards for distributed sources of power systems. One particular standard - 1547.3 – addresses monitoring information exchange and control of the Distributed Generation source of power. The DERP-PCU will provide seamless integration and a sophisticated communication system (with wireless access) in addition to the predictive maintenance functions that protect the assets of the REGS and the substation and feeder circuits.

Resources

News Article: "DEEP Announces 1st Round of the Nation's First Statewide Microgrid & Loan Program" March 2013 -- Electric Light and Power

Webinar Presentation: "Energy Storage Solutions for Microgrids" Produced by Dept of Energy and others; held on behalf of the Connecticut's DEEP Microgrid Project, November 2012

"Microgrids in New England: Challenges and Opportunities" Power Point Presentation available on-line. Produced by the United Illuminating Company, Connecticut Light & Power and Couch-White, L.L.P. October 2012

"Clearing the Regulatory Roadblock for 21st Century Energy Infrastructure," by Mike Edmunds, February 14, 2013, Grid Talk (S&C Electric)

REFERENCES

[1] Most, but not all, microgrid designs for municipalities as are contemplated in Connecticut under Public Act No 12-148 would be consistent with NEC 702 standards -- generally considered "Optional Standby," with the parameters of the operation based largely upon the municipality's or business's discretion. This is in contrast with NEC 700 - emergency services involving life or death (such as hospitals) - and NEC 701, which is a legally required or mandated situation (nursing homes, for instance, are required to have emergency generators).

This distinction between NEC 700, 701and 702 codes does have an implication that is crucial in terms of how much time can lapse between a grid failure and when the microgrid system can be isolated and power up the critical loads. Under NEC 700, the time of power lapse cannot exceed 10 seconds. It is less crucial for 701 and more lenient still for 702.

Municipalities, in designating critical facilities, may have to look closer at these NEC codes as guidelines; as currently written, Section 7 of 12-148 defines a critical facility as "any hospital, police station, fire station, water treatment plant, sewerage treatment plant, public shelter or correctional facility, any commercial area of a municipality, a municipal center ***as defined by the chief elected official of any municipality, or any other facility or area identified by the Dept. of Energy and Environmental Protection (DEEP) as critical."*** Clearly, in this wide swath of allowable "critical facility" designations, there are examples of all three NEC code definitions -- looking more closely at these different categories of

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critical loads/facilities will demand different emergency and back-up power solutions - all within the parameters of a microgrid design.

[2] The Microgrid Program became the law in Connecticut with the passage of Public Act 12-148, Section 7. The Department of Energy and Environmental Protection (DEEP) was designated to carry out the mandated program. An initial $15 million was allocated to the Microgrid Demonstration Project.

[3] The "Safe Haven for Schools™" model is very specific as to the circuits that are required to be designated as critical. Since the public schools would likely provide food, shelter and waste management (both from toilets and kitchen operations) to neighborhoods and evacuees in emergencies, certain circuits would have to be operational 24/7. Kitchen and hot water appliances would have to be operated as needed; evaluations of the functionality with electricity vs. natural gas or propane are fundamental in preparing the "Safe Havens" for optimal emergency operations.