Non-Synchronous Energy Electronics, LLC

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An information description of NSEE's

Islanded Load Reduction Micro-Grid

An approach to Distributed Generation Integration to solve problems of Fault Currents, Load Flows and Stability that otherwise limit DG penetration levels with existing Electric Utility Distribution Grids

This description is an introductory briefing to a technical solution developed by NSEE to overcome problems associated with the integration and interconnection of significant amounts of DG into an existing utility distribution grid.

The benefits to using on-site combined heat and power systems have been well documented. The reason for their lack of widespread adoption have generally been due to limits or cost burdens placed on such projects by the electrical distribution grid requirements. For that reason we will leave the detailed commercial analysis of DG for a separate discussion, but note that much of this work has been done, including the cost burdens of the power converters required for this solution.

The solution described here provides for the integration of as much DG power as can be consumed by the local load(s), without requiring any upgrades of the local grid to support the integration. Some ancillary benefits to the existing grid, such as Dynamic VAR support, can increase the strength of the existing grid.

The following pages give a detailed description of the technical details, starting with a description of the present grid operation, followed by an example of a specific project presently in the engineering and permitting stages, with supporting attached diagrams.

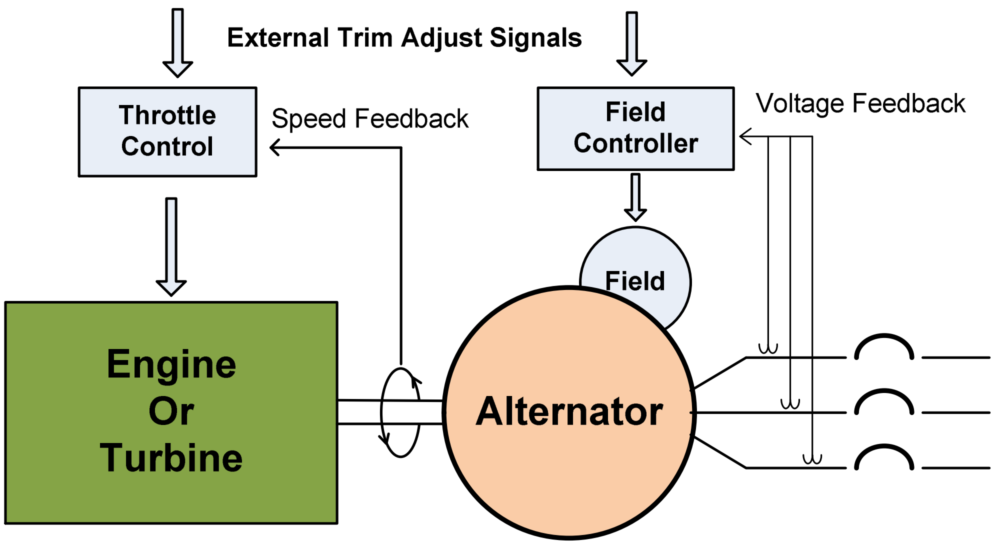
For more information, please contact the author;

Alan McDonnell
President
Non-Synchronous Energy Electronics, LLC
94 Middlesex Rd.
Merrimack, NH 03054
(603) 546-5785
alan.mcdonnell@nonsynchronous.com

A simple description of the existing, centralized power grid;

The existing grid consists of a relatively few, large synchronous rotating alternators feeding directly into a high voltage transmission grid. These alternators are usually driven by high speed steam or gas turbines or low speed hydro turbines.

Each generator has two elements of control, a mechanical throttle for power flow control, and a field excitation control to control output voltage and VAR current.



Each of these generators has internal set-point controls but also receives adjustment or trim signals from a grid operator central control. Over the years, these central controls have gotten very complex as the size of the grid and level of interconnection has grown.

These central controls are based on the premise that all generators (except for some small exceptions) feed directly into the high voltage transmission grid and the power feeds out through lower voltage distribution to the end users. Another main feature of the centralized grid is the elaborate coordinated protection schemes that are set up to be able to isolate faults to as small an area as possible, and yet shut off circuits quickly before extensive physical damage occurs due to a fault

When small DG units are installed, they are connected to the distribution level feeders as shown in the diagram below; with their power flow in the opposite direction to the normal grid power flow and uncontrolled by the larger grid controllers.

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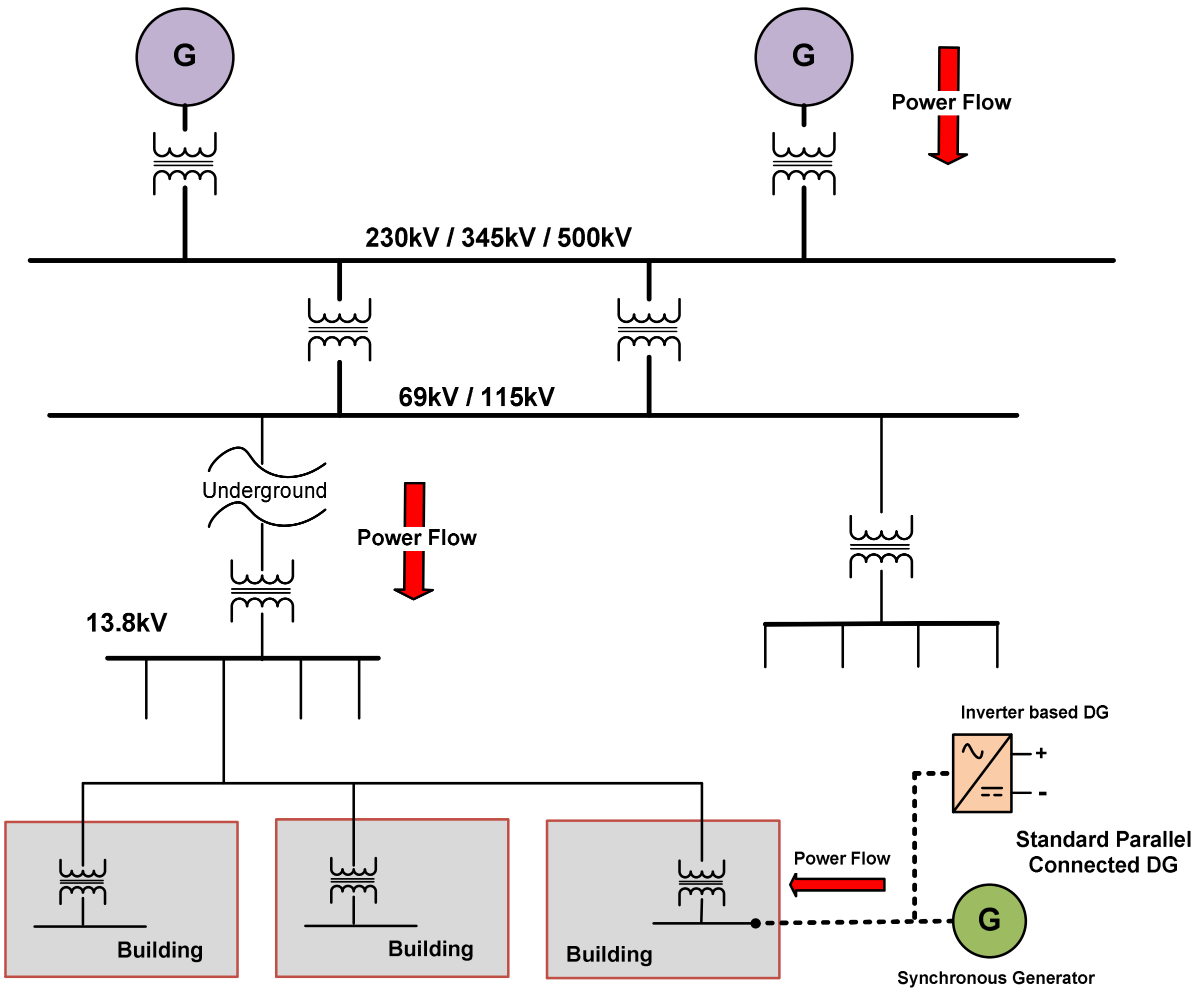

Any additions to the grid that could cause changes to the protection and control scheme need to be studied and if necessary, accommodated by making upgrades or changes to these protection and control schemes.

Since the addition of uncontrolled generators feeding directly into the distribution level feeders would cause such an upset, they are typically limited to very small part of the overall grid power supply!

Present interconnection standards such as UL1741 address the potential safety threat of anti-islanding, but do not limit the addition of fault currents and do nothing about voltage and frequency or load flow control issues.

Some have suggested that inverter based generation sources could be programmed to add both VAR control and droop controls to help stabilize the grid, but this would still require a very complicated amount of integration from the grid operators, who have very little incentive to accept such complexity.

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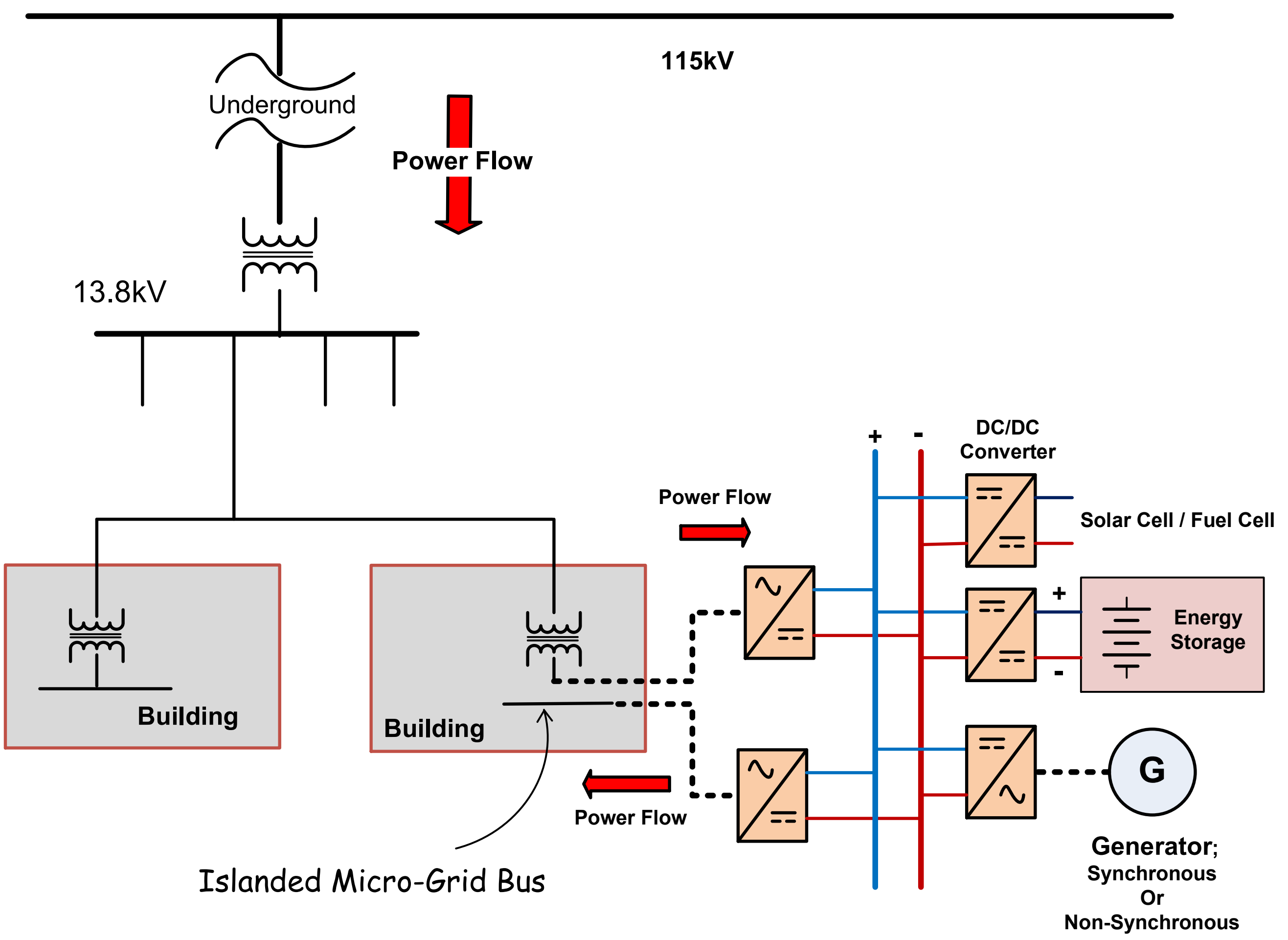
The Solution;

Islanded micro-grids that appear as load reductions to the main grid

Using inverter based power distribution, it is possible to configure the power distribution of the end user customers in such a way that the DG sources do not need to be interconnected to the grid.

If an inverter driven independent grid is established, then the DG sources can be combined into the new grid, with the existing grid simply being used as another energy source into the independent grid. Thus the new independent grid appears to the existing grid like an inverter based load (such as VFD), running at much less power than was previously the case.

The diagram below shows how such an islanded grid would be connected;



Note that power for the building loads can come from any part of the mix of;

- The Existing Grid
- On-site DG sources (whichever makes the most sense)
- Energy Storage (time limited, bi-directional)
- Heating and Cooling from the waste heat of the DG sources

The grid interface inverter is capable of reverse power flow, allowing surplus power from the DG sources to be fed upstream, but since that would bring back all of the issues of a parallel grid interconnection, we will leave this capability out for now.

The most obvious drawbacks to such a system are the capital cost of the power converters and the efficiency loss of the converters for power drawn from the grid.

Taken together with all of the advantages such a system offers, we are confident that such a solution makes economic sense in many cases, such as in dense urban areas where there is an avoided costs benefit for deferring otherwise needed system upgrades.

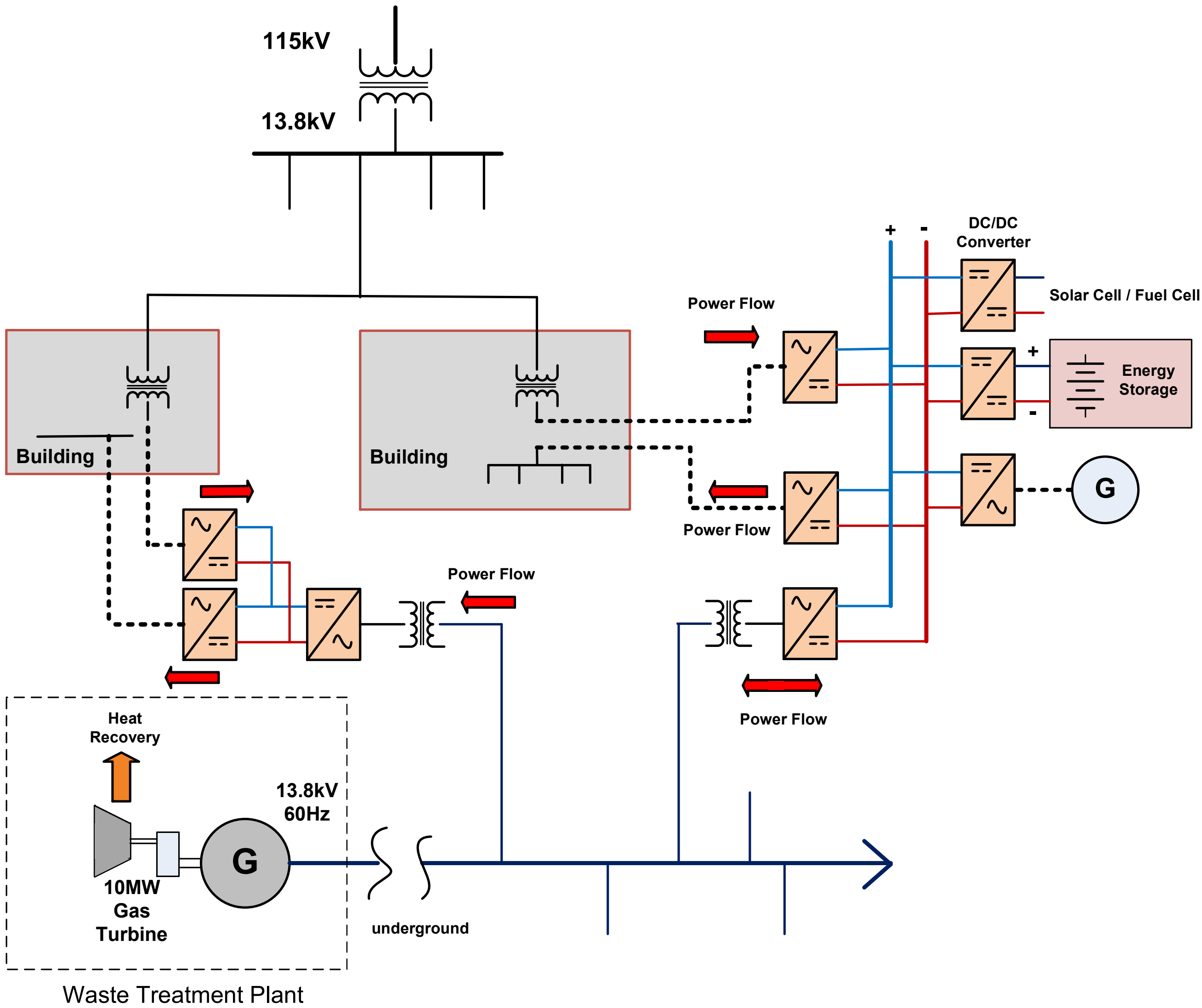
Some examples of these advantages are;

- Advantages to the building owner include much higher reliability of supply and lower overall energy costs with optimized thermal recovery. Further advantages include increased power quality and minimized costs for back up diesels and UPS systems.
- Advantages to the grid operator include deferred grid upgrade costs, the ability for dispatchable load shedding and assistance with grid stabilization through dynamic VAR control or droop controls.

This approach is new, and is very much based on the maturing technology of large, high performance power converters. We have had the basic designs reviewed and approved by URS Engineering and the CANMET Technology Research Dept. of Natural Resources Canada.

This approach can also be used for virtually unlimited expansion capabilities by connecting together multiple independent grids, much like a computer local area network. The next diagram and description gives an more clear explanation of this.

Multiple independent Grids connected together;



Note that the feeder that goes between buildings is not necessarily utility grade power, and can be used to carry net energy in either direction. The key is that each independent feeder has only one voltage source, with several current source controllers taking or giving power as required.

With this concept, there is no limit to how much power can be aggregated together to suit the individual needs. The expansion can take place as business conditions warrant, saving the need to oversize initial investment due to a lack of ability to upsize ratings as generally found in present power systems design.