



PARETO ENERGY
The Microgrid Company

AN OVERVIEW OF PARETO'S GRIDLINK: A NON-
SYNCHRONOUS DISTRIBUTED SYSTEM PLATFORM

April 15, 2016

for NIST Workshop, Power Electronics

Product: GridLink consists of commercially available components that are pre-packaged in an eHouse and delivered to a site for installation.

Key Attributes

Containerized:

- Comes pre-packaged in an eHouse
- Transformers and breakers are seated on either side of the eHouse on skids

Installation:

- Pre-assembled, factory tested, certified, shipped to site and simply dropped-in onsite
- Transformers, breakers and switchgear assembled, pre-wired, & certified at the factory

Customizable: Each eHouse arrives customized to meet site needs

Modularity: eHouses can be stacked or linked to meet infinite demand above 2MW

Example GridLink Product Specs:

(including 27 kV connection)

Size: 12' x 12' x ~100'

Weight: 50 tons

Build Time: ~9 months

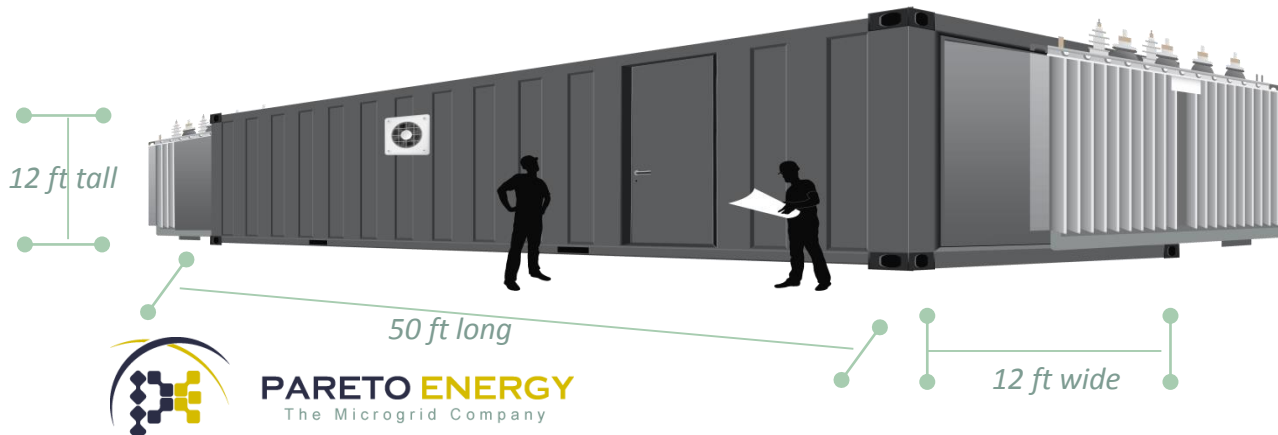
Cost: ~\$1M per MW

Models: 5 MVA Unit

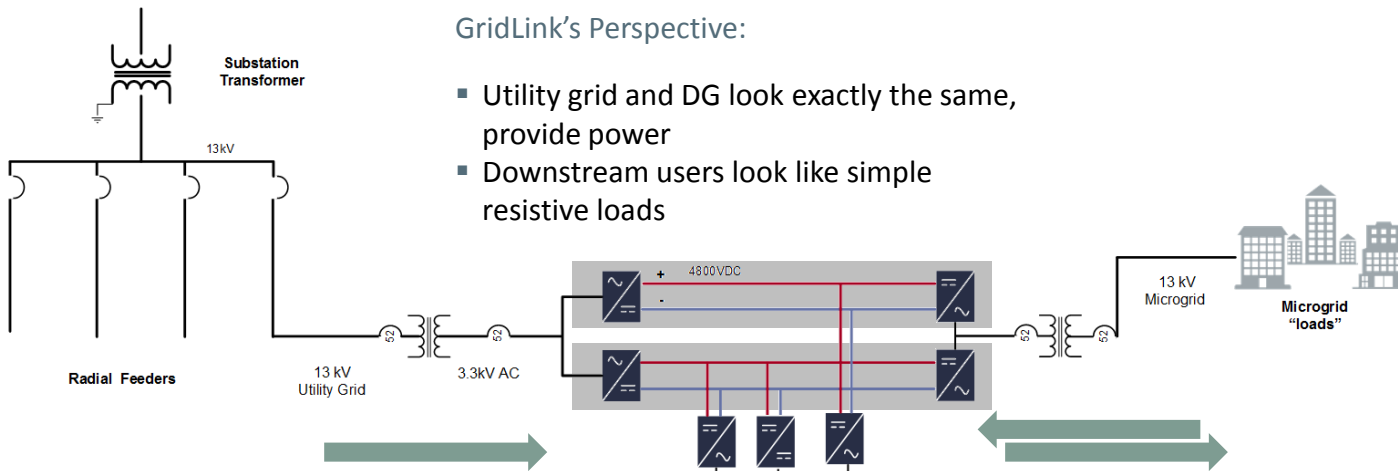
GridLink's Core Components:

- GE MV7000 inverters
- Harmonic filters
- GE transformers
- Breakers
- Cooling system
- Schweitzer Engineering Labs Communications and Controls

Example installation: 2 x 5 MVA



Import-Only Mode: GridLink has been approved for a One-Way Power configuration in New York City.



GridLink's Perspective:

- Utility grid and DG look exactly the same, provide power
- Downstream users look like simple resistive loads

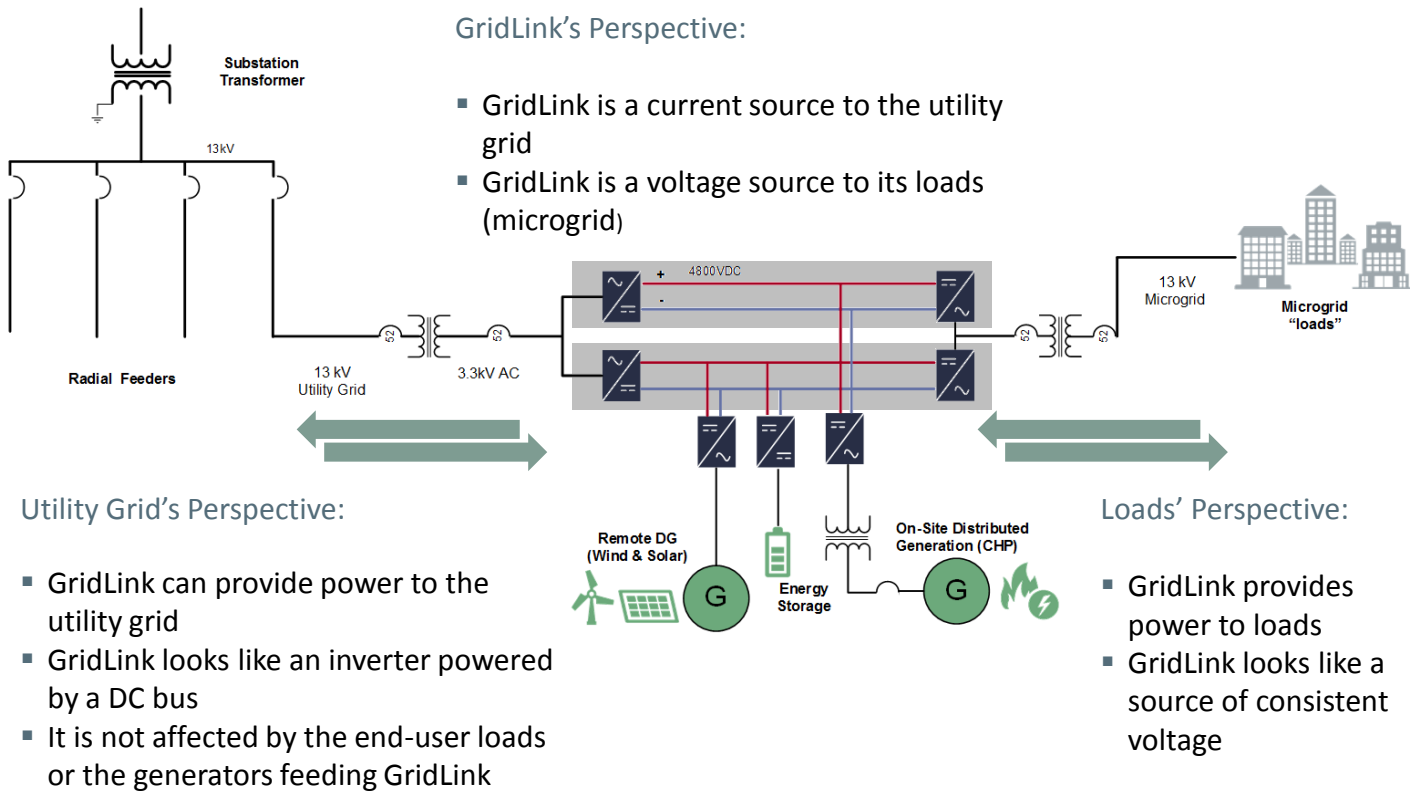
Utility Grid's Perspective:

- Utility grid provides power to GridLink.
- GridLink looks like a simple, resistive load
- It does not see the end-user loads or the generators also feeding GridLink.

Loads' Perspective:

- GridLink appears to the load as a feeder
- Does not see DG or the grid-loads only see GridLink
- Therefore, any amount of generation can be connected

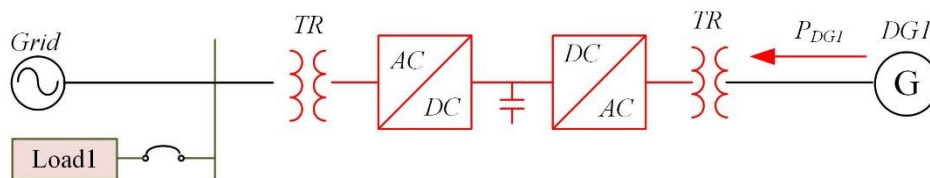
Import/Export Mode: GridLink has been approved for a Two-Way Power configuration in New York City.



Configuration Examples: GridLink design configurations for DG-to-Grid connections.

Example System 1

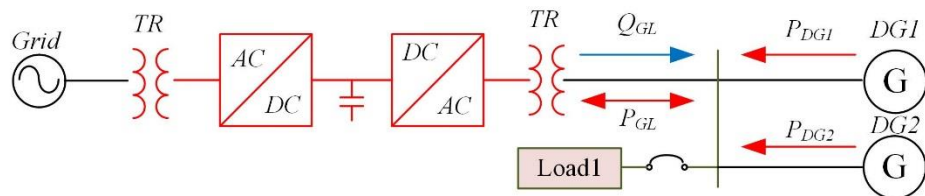
Synchronous inverter interconnection (not GridLink)



Standard way that DG is connected to the grid (ex: fuel cells, solar, storage, fly wheels, etc.)

Example System 2

GridLink retrofit of an existing bus arrangement (Kings Plaza)

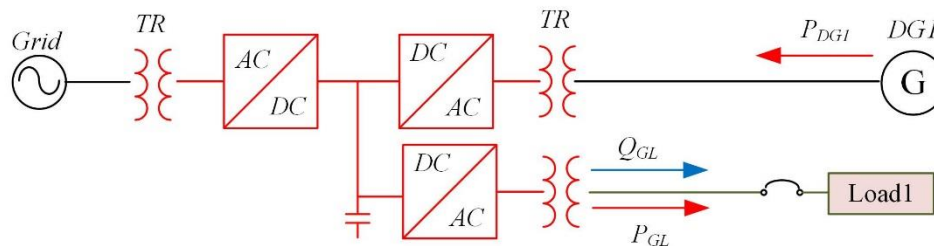


Allows for connection to the grid while:

- Isolating the synchronous generators from the grid
- Uninterrupted supply to the load in the event of generator failure

Example System 3

GridLink, as islanded voltage source

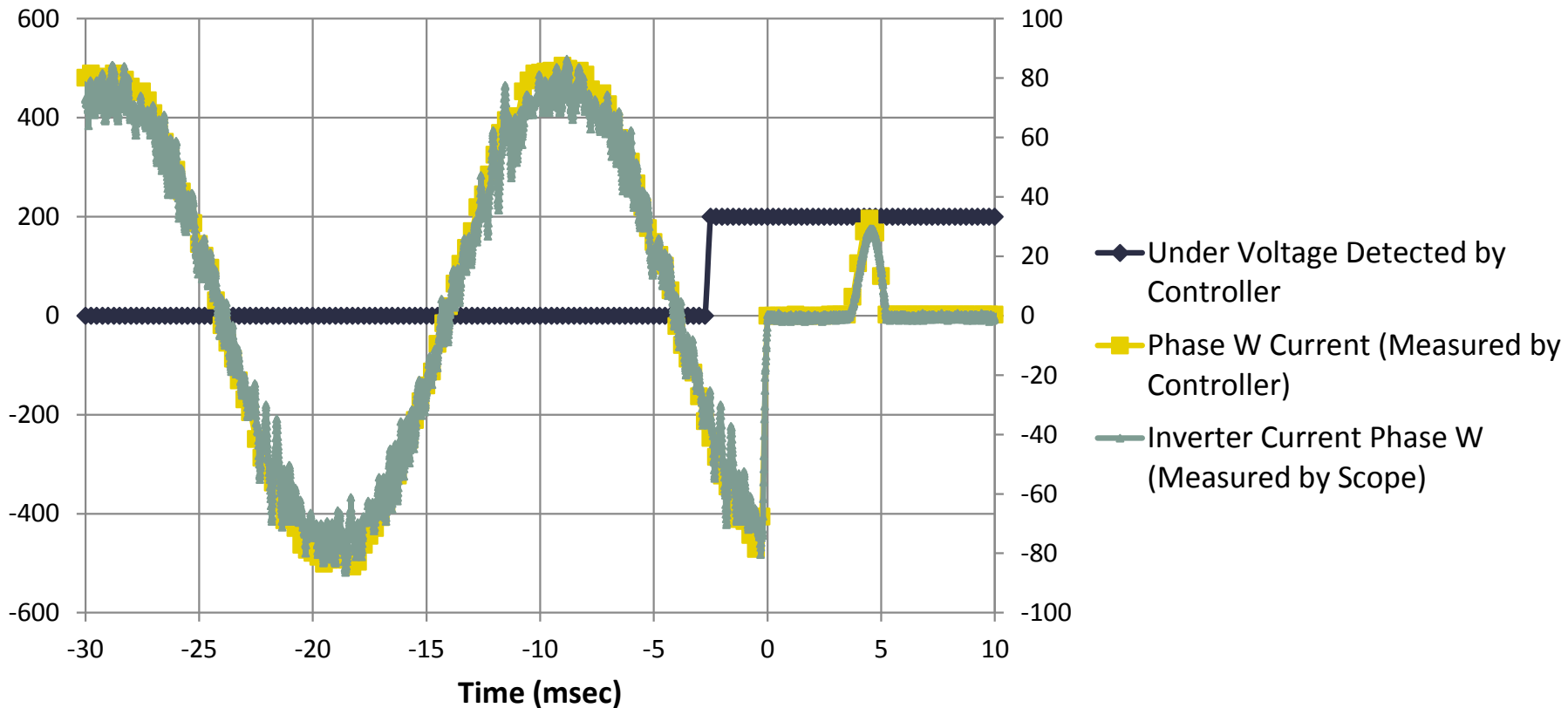


Non-synchronous connection of the generators allows:

- Same advantages as “example system 2”
- Generator to be used for fly wheel energy storage

Fault Current Mitigation: Tests show that GridLink's inverters can trip in under 1/4 cycle (0-3mms) upon detecting a drop in voltage.

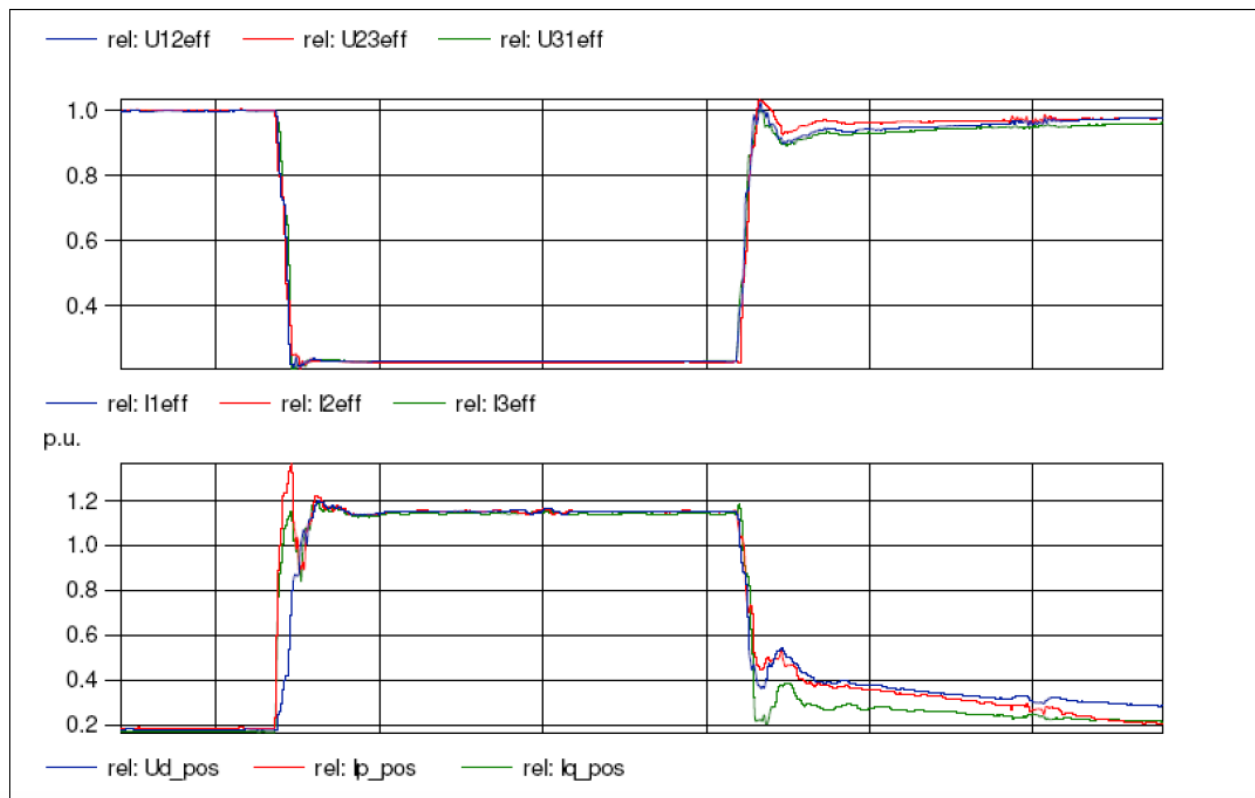
Inverter Trip Due to Grid Under-Voltage



Fault Current Ride Through: Formal tests of GridLink's power inverters confirm their ability to "ride through" fault current.

Example 1: balanced 82%-voltage-dip (18% residual voltage)

Note: 1 p.u. voltage=20kV; 1 p.u. current=144A; 1 p.u. power=5MVA

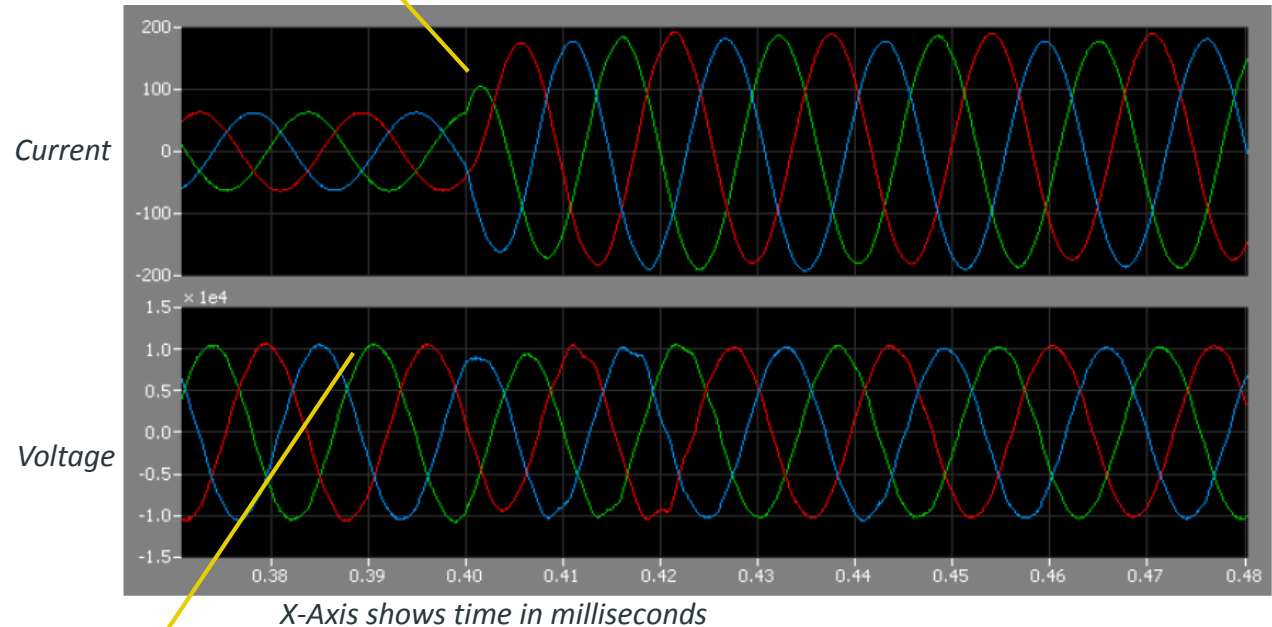


Power Quality, Voltage Control: GridLink's inverters respond quickly to large step-load changes, seamlessly managing voltage to maintain high power quality.

Voltage Control Attributes

Because the output is now an actively controlled voltage source, the inverter can make fast adjustments to keep the output voltage within tight specification, even under extreme step load changes

A dramatic, instantaneous increase in current, for example, from the starting of an induction motor, rated at 25% of the inverter rating (*worst case scenario*)

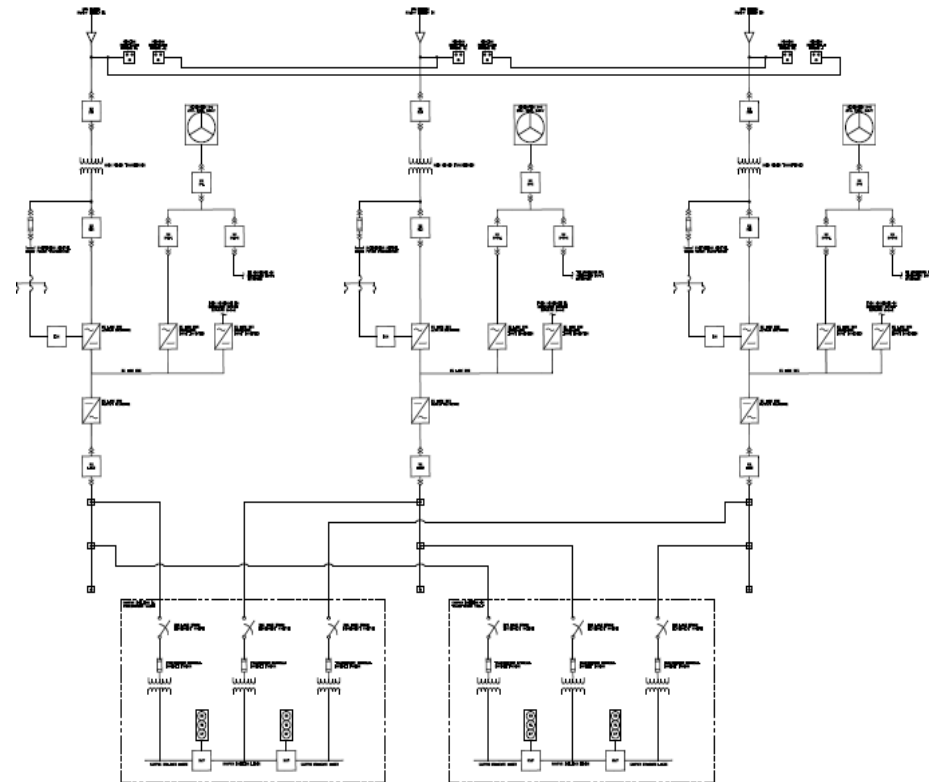


Voltage remains stable, and the shape of the waveform also remains unchanged resulting in a high quality of power

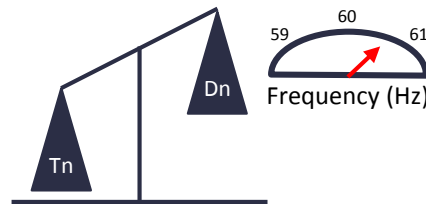
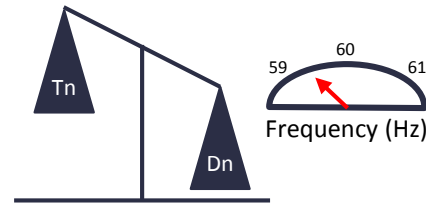
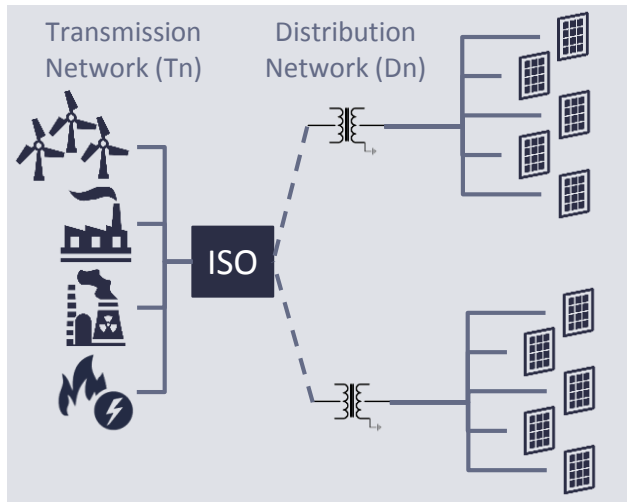
Frequency Regulation: By isolating the frequency of DG from the grid, 50Hz generators can now be connected to the utility's 60Hz grid.

Frequency Control Attributes

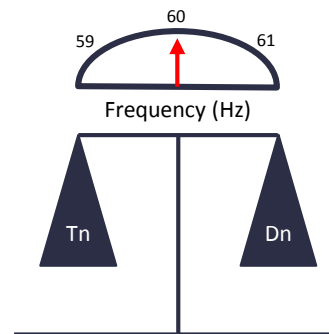
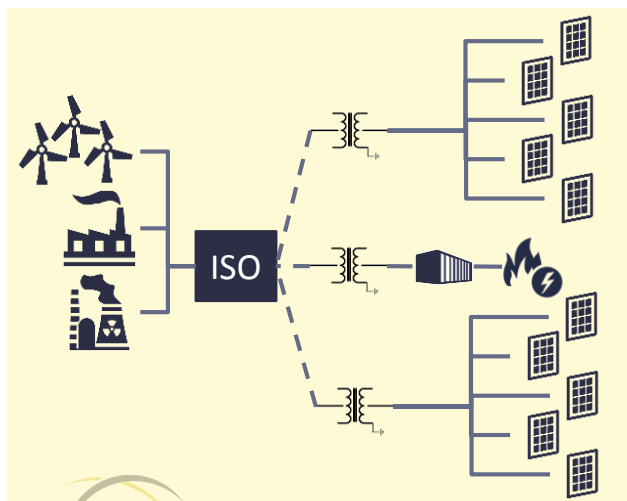
- Single Line (right) received Preliminary Approval from Con Edison to interconnect (3) 50Hz engines to their 60Hz distribution system.
- 50Hz generators run more efficiently (less fuel/emissions) than 60Hz generators used today in the US.
- This allowance affirms that when using GridLink, the frequency of the grid and that of the DG are completely isolated. Using GridLink, there is no impact on the grid.



Frequency Regulation: With its instantaneous frequency control, GridLink is a valuable tool for the ISO/TNO to regulate the grid.



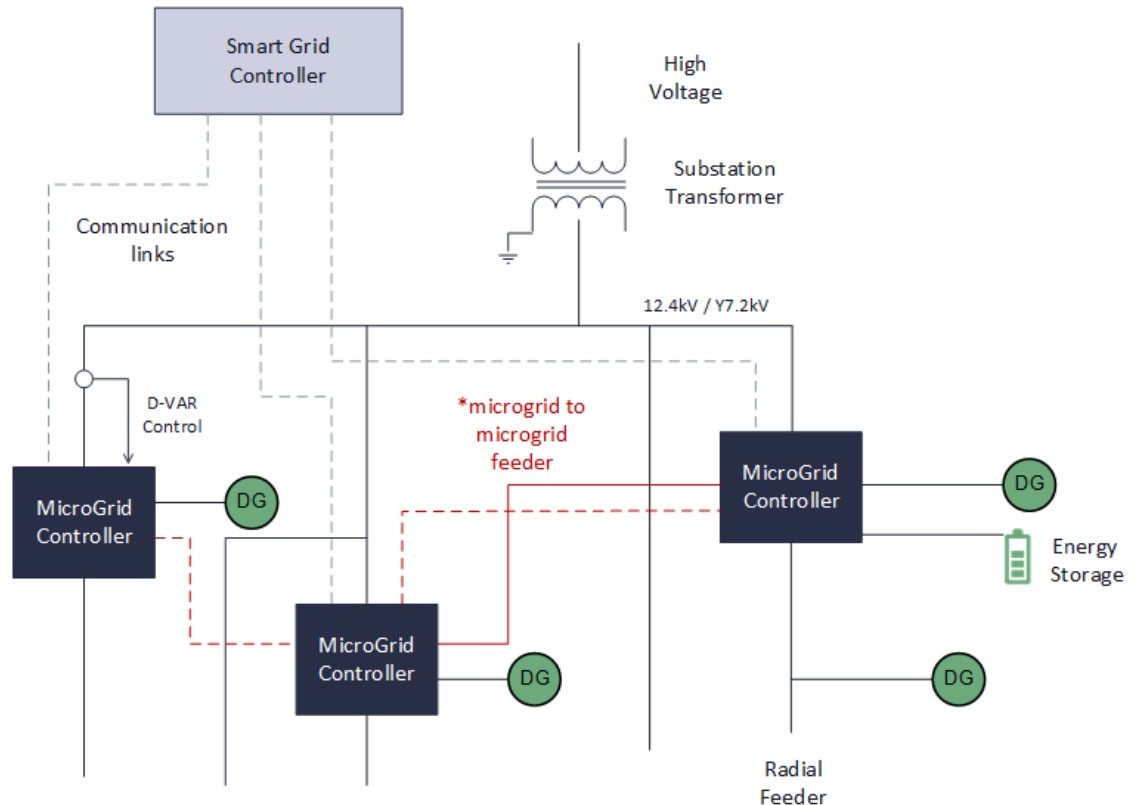
Low inertia DG causes upstream frequency regulation issues, resulting in an unfunded requirement for the ISO to maintain grid stability.



GridLink provides instantaneous power flow control for frequency regulation, enabling large CHP plants to solve stability issues at the distribution level before they ever reach the transmission network.

Expandable Networks: multiple GridLink units can be networked to add generation or balance substation loads without upgrading the existing grid.

- There are presently no existing standards for upstream utility communications and control for utility-to-microgrid interface
- A significant component of this is the commercial transactions and optimization protocols
- Pareto will set the initial standards for this type of control





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