MICROGRIDS FOR DATA CENTERS

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Summary of Pareto Energy's Microgrid Business Model

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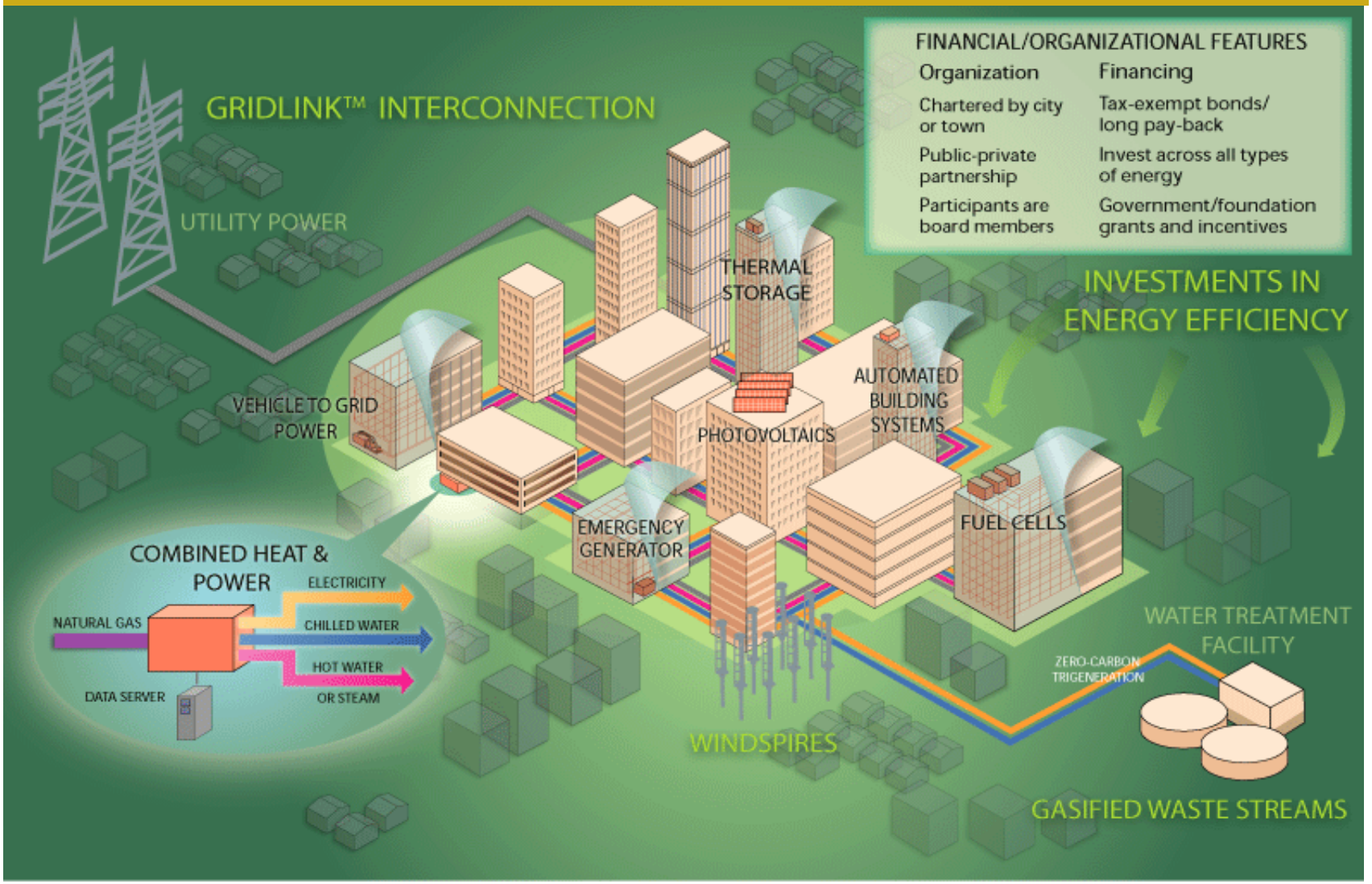
The Pareto Energy Microgrid Business Model: Patented Non-Synchronous Interconnection Technology Enables An Always Islanded Microgrid with the Ability to Plug and Play Multiple Distributed Energy Resources and to Provide Continuous Power During Utility Grid Power Outages at Below Grid Rates with Governance by the Microgrid Energy Users



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Pareto Energy has Developed Utility Company Support For its Business Model

Edison Electric Institute

May 6, 2011

Dear Mr. Warner:

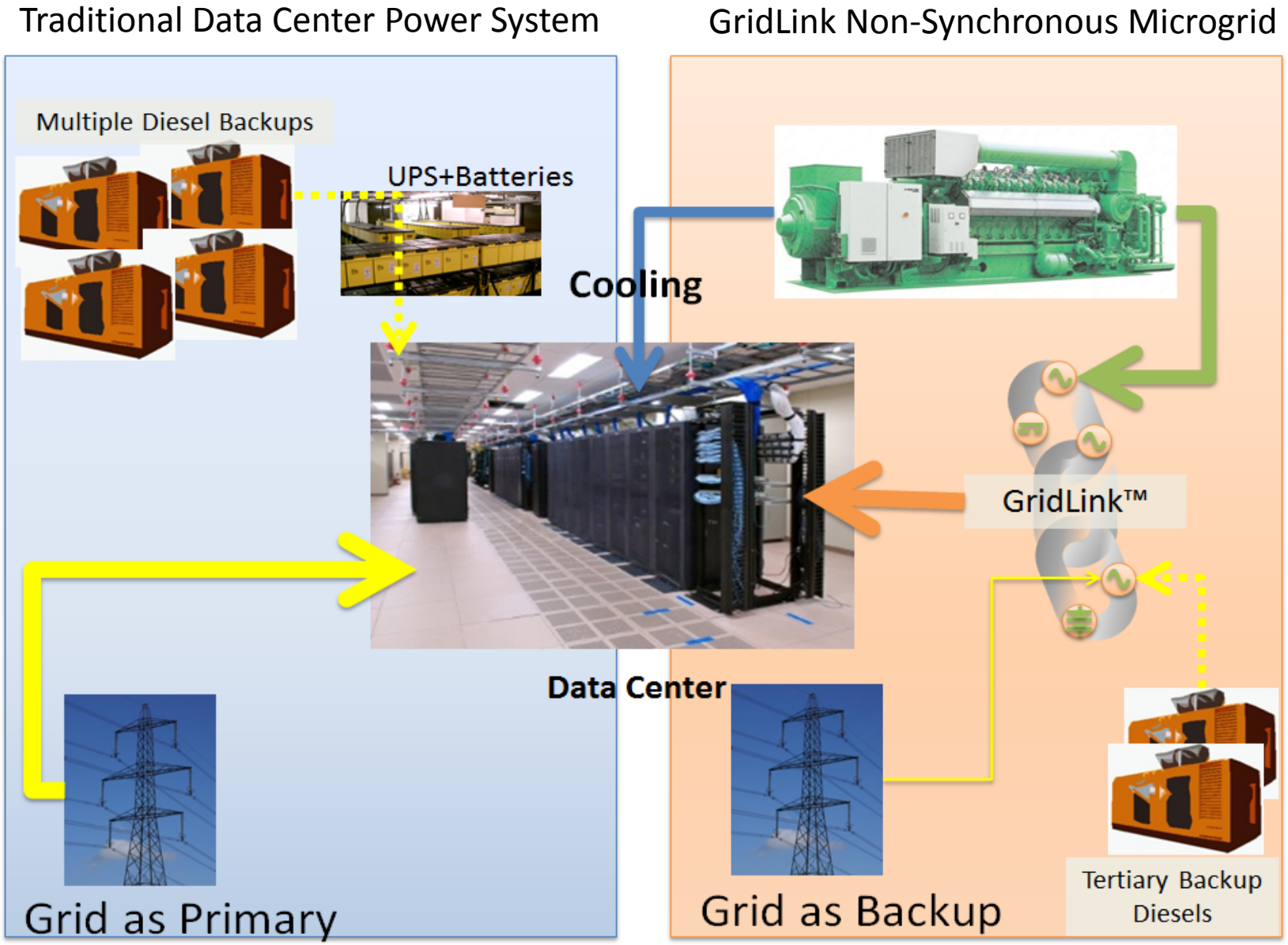
I am writing to invite you to participate in an EEI project to assess the implications of smart grid-enabled distributed resource development. As I'm sure you realize, the marriage of smart grid (SG) technologies with distributed energy resources (DER) has the potential to change fundamentally traditional utility operating paradigms, and the utility business. This has become more pressing as public policy encourages the development of DER owned by customers and third parties.

We think it is vital, therefore, to understand the implications of these new technologies and policies. We have identified your project work as among the cutting-edge demonstrations in this area.

We believe your perspectives and experience can contribute significantly to building a knowledge base about pilots that demonstrate the integration and interoperability of multiple types of DER at multiple levels and establish frameworks for stakeholder collaboration and participation by new market players.

Of particular interest to EEI are your innovative governance structure and your "GridLink" technology that enables a safe connection between a microgrid and a traditional grid. These innovations represent significant sustainable economic development assets.

The Pareto Energy Business Model for Data Centers
Traditional Backup Systems versus a GridLink Non-Synchronous Microgrid



The Pareto Energy Business Model for Data Centers
The Value Proposition for Traditional Backup Systems versus a GridLink Non-Synchronous Microgrid (Page 1 of 3)

Traditional Data Center Power System

Total Cost for Backup = $2000 / kW

Diesel = $300 - $450; Switchgear, relays = $100/kW; UPS: $1,000/kW; engineering, permitting, installation is project specific, can range from $100 to $800 / kW.

Costs of CHP Units: there is a need to oversize the generators to enable synchronization and islanding.

GridLink Non-Synchronous Microgrid

Total Cost for GridLink = $750 / kW

Inverters = $200 KW; transformers, switchgear, eHouse packaging and system controls = $200; Softcosts = $150; redundant GridLinks for n+1 = add $200.

Costs of CHP units: units can be more optimally sized due to no need for synchronization.

The Pareto Energy Business Model for Data Centers
The Value Proposition for Traditional Backup Systems versus a GridLink Non-Synchronous Microgrid (Page 2 of 3)

Traditional Backup System

Interconnection Risk: it is not unusual to encounter years of approval for synchronous interconnection and there is a risk of rejection where there are networked grids, fault current limits, or the maximum penetration depth of distributed generation has already been reached for the feeder in question.

Construction Risk: systems tend to be oversized to enable islanding and islanding must be tested on-site with significant adjustments of the switch gear systems. Any change to add additional generation modules can require a new interconnection agreement and a recalibration of islanding and synchronization.

GridLink Non-Synchronous Microgrid

Interconnection Risk: approval is typically gained within months with little chance of rejection because a non-synchronous microgrid is not interconnected to the utility grid and so the utility grid sees it as a resistive load only.

Construction Risk: with no need for synchronization, systems can be optimally-sized. GridLink units are tested off-site. Once installed the microgrid is always islanded. Additional generating modules plug and play like loads with no need for new interconnection agreements or recalibration for islanding.

The Pareto Energy Business Model for Data Centers
The Value Proposition for Traditional Backup Systems versus a GridLink Non-Synchronous Microgrid (Page 3 of 3)

Traditional Backup System

Operating Risks:

Island-mode operation depends on battery storage plus UPS to maintain high-quality power. Coordination of multiple load-following generators can be difficult and there can be limited ride-through for voltage sags and other disturbances.

Redundant on-site generators are idle or exporting excess power to utility at wholesale rates.

GridLink Non-Synchronous Microgrid

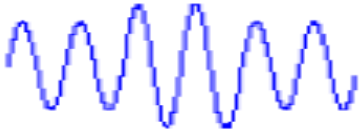
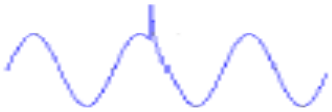
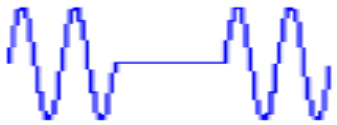
Operating Risks:

The microgrid is always islanded. Grid ride-through even for severe over/under voltage events, unbalanced phases, or poor power quality. Stable on-site generators, no trips, stalls, no load-following oscillations or control issues.

High utilization of on-site generators in place of grid power at retail rates with the option to export at retail to neighboring energy users.

Understanding the Risks of On-Site Power for Critical Infrastructure

Existing Synchronous Interconnection Technologies Must Control Multiple Disturbances in Utility AC Voltage that Would Cause the Utility Company to Disconnect the Microgrid Such that it Cannot Provide Continuous Power During Grid Power Outages. This is Technically Feasible but Economically Expensive.

Disturbance		Origin	Consequences
Voltage sag undervoltage 2.2		Short circuits in the network grid passing or on another radial. Start up of large motors	Disconnection of sensitive loads Fail functions.
Voltage swell Overvoltages 2.3		Earth fault on another phase Shut down of large loads Lightning strike on network structure Incorrect setting in substations	Ageing of insolation Disconnection of equipment May harm equipment with inadequate design margins
Harmonic distortion 5.2-5.3		Nonlinear loads Resonance-phenomena Transformer saturation Notches	Extended heating . Fail function of electronic equipment
Transients 1.1-1.2		Lightning strike Switching event	Insulation failure Reduced lifetime of transformers, motors etc.
Voltage-fluctuations/ flicker 6.0		Arc furnaces Sawmill, crushing mill Welding Wind turbines Start up of large motors	Ageing of insulation Fail functions Flicker
Short duration interruptions 2.1		Direct short circuit Disconnection False tripping Load shedding	Disconnection Disconnection
Unbalanced 4.0		One phase loads Weak connections in the network	Voltage quality for overloaded phase Overload and noise from 3-phase equipment

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The Consequences of Delayed Islanding of On-Site Power: Bradley International Airport October 2011 Outage, On-Site CHP Took Many Hours to Island

FAA Report on Bradley Outage:

…20 inches of snow fell at Bradley International. It caused a widespread commercial power failure, which caused communications problems in the airport. Luggage belts and cargo belts and elevators stopped working. There was difficulty refueling airplanes. There was difficulty de-icing aircraft. We all know that when you can't de-ice your aircraft in those conditions, you might as well weld your plane to the ramp. You're not going anywhere.

Source: http://www.faa.gov/news/speeches/news_story.cfm?newsId=13252

Not the only recent outage at Bradley:

"A power outage occurred on March 6 on 8:15 p.m. that was caused by a blip on the C L & P grid and a switch that did not operate as it should have at the Airport's cogeneration plant."
(Bradley Airport Minutes, March 2011)

The Consequences of Delayed Islanding of On-Site Power: September 2011 San Diego Outage, UC San Diego Took Many Hours to Island

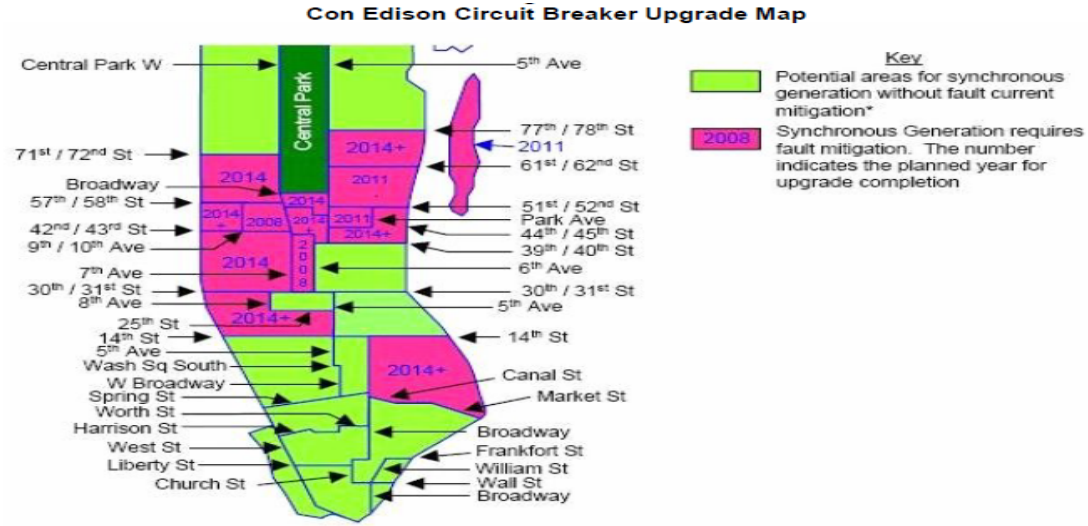
Last year, an unanticipated power outage of most of San Diego was caused by a utility worker's switching error in Arizona.

The University of California San Diego's Microgrid:

- Could not island instantaneously,
- Required 6 hours for black start, and
- After utility power was restored, required a second campus black out to resynchronize.

New York City Case Study:
Con Edison Faces Very High Costs to Accommodate Synchronized Microgrids

According to a study by Columbia University: "The fault current margin will always be linked to the total amount of electricity-generating capacity connected to the grid. As demand continues to increase each year around the city, requiring additional generation to be connected to the grid, the technological 'fixes' called for by the Public Service Commission will work for some time. At some point, however, the upgraded circuit breakers may also reach their higher-rated capacity limit, requiring yet another round of system upgrades. A second technical solution external to the grid involves the use of power electronics, which are a mix of devices used to convert, control, and improve power quality. Some manufacturers use two complementary forms of power electronics – a rectifier and an inverter – to switch from AC to DC and back to AC power in order to produce higher quality power and facilitate interconnection. The duration and complexity of the review is likely to be substantially less than for synchronous interconnection."



Source: Con Edison. *Synchronous Generation Placement Availability by Region* (website), accessed at http://m020-w5.coned.com/dg/configurations/maps.asp on July 20, 2007.

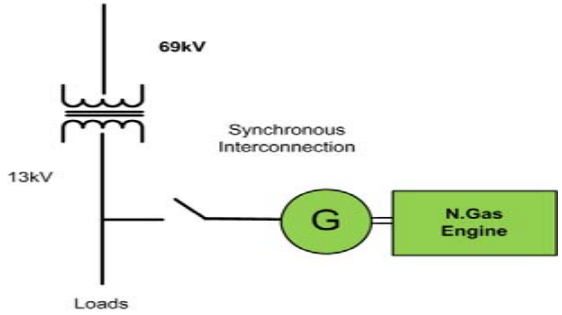
New York City Case Study
Con Edison Agrees that No Existing Technology Can Affordably Island a Microgrid to Provide Continuous Power During a Grid Power Outage
(Excerpts From the 2010 Report of the NYPSC Distributed Generation Collaborative)

"The City proposed a conceptual CHP installation with an electric power generator supplying a portion of the energy requirements at a municipal hospital campus. After its review, Con Edison noted that all the technical interconnection requirements, e.g, transfer trip, short circuit study and fault current mitigation, voltage and stability studies, telemetry, would have to be met, that the customer would be responsible for interconnection costs, including studies and system reinforcement, and that a primary connection for the generator would require that the customer employ personnel trained in high tension switching on site 24 hours a day, seven days a week. Based on those case-specific assumptions, Con Edison advised that it considers this site to be a reasonable candidate for this type of connection. Despite positive qualities of this particular City proposal, and Con Edison's agreement to investigate ways to interconnect DG in this fashion, as a general matter, this type of approach is not the preferred interconnection method for Con Edison and may be cost prohibitive for the customer. Con Edison's concerns are: … both planned and unplanned feeder outages require customer interaction with the Company for communications and breaker operations … if a feeder is planned to be removed from service, when the customer opens the breaker, Con Edison personnel would need to lock-out and tag the breaker so that outage work may be performed. When the feeder is ready to be returned to service, all of these steps must be repeated by the customer and Con Edison personnel in reverse order. Feeder testing coordination could be required, which may require actions by customer personnel." (note that in the same report Con Edison committed to 800 MW of customer-owned generation, but advised that it would take 3 to 5 years to develop interconnection solutions; in 2011. however, they approved Pareto Energy's GridLink solution.)

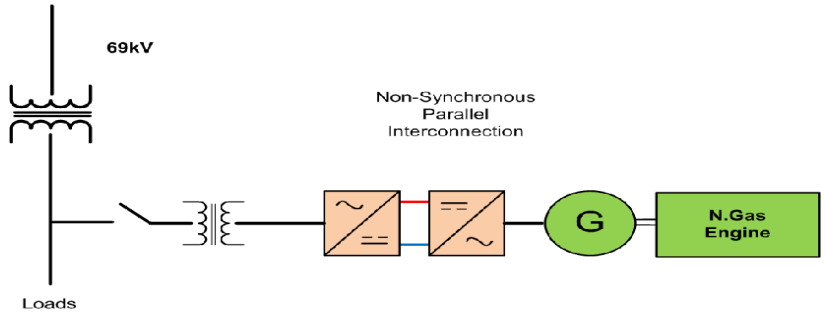
The Pareto Energy GridLink Solution

Overview of Pareto Energy's GridLink Approach

Traditionally, a generator connects to the utility grid by dumping all its power directly onto the main power line (Synchronous Interconnection).

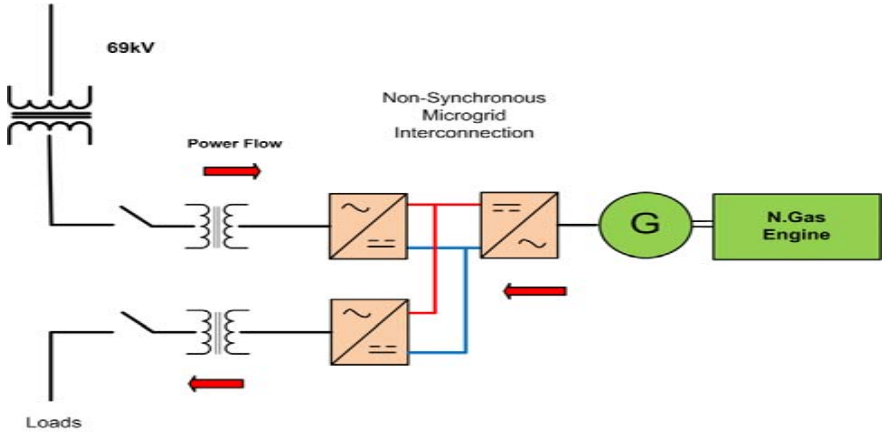


One increasingly common alternative is to use inverters to regulate the power flows from local generation onto the grid – back-to-back inverters (as shown) for rotating machinery such as engines, or single grid-tie inverters for DC sources such as solar or fuel cells.

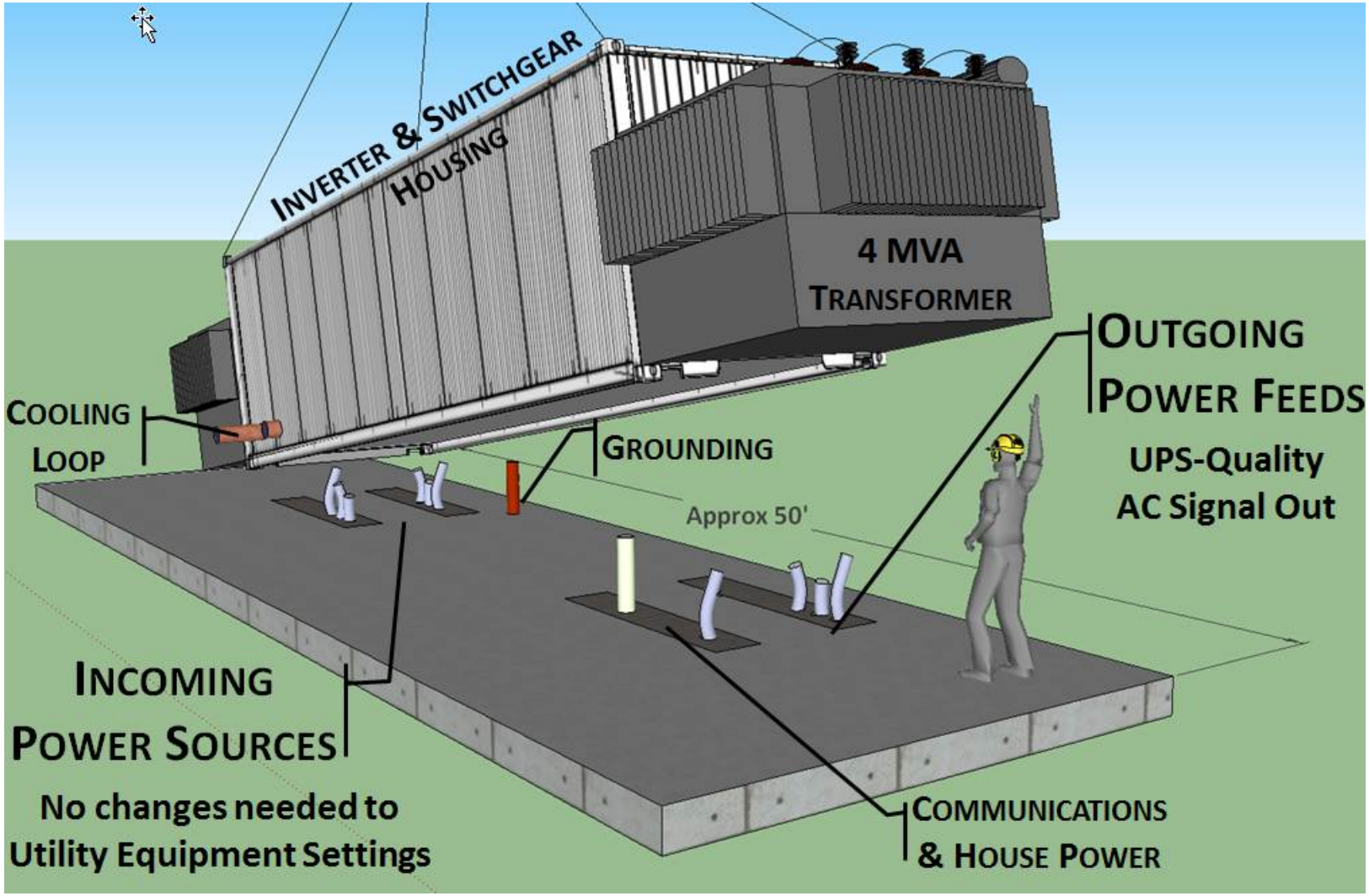


Nonetheless, all power from the local sources flows onto a distribution feeder, whether owned by the utility or the customer (Non-Synchronous Parallel Interconnection). So utilities still need to be concerned with islanding, fault current contributions, penetration depth, and other issues that can make parallel interconnection so difficult.

In contrast, in Pareto's approach, the microgrid takes over the service to a customer's loads, integrating local sources of power while still keeping them fully connected to their utility feeds. Once GridLink is cut-and-spliced into the distribution line, no power ever flows directly from the utility grid to the loads. Utility feeds are treated equally with any local sources of power, and flow through the microgrid's inverters before connecting to customer loads (Non-Synchronous Microgrid Interconnection).



Each GridLink eHouse can be customized for a particular load. The standard 6 MVA e-Houses use a redundant series of 2MVA blocks for converting the power from AC to DC and back to AC. Each package is the size of a shipping container, including two transformers. They are prepackaged and burned in at the factory for easy installation on-site.



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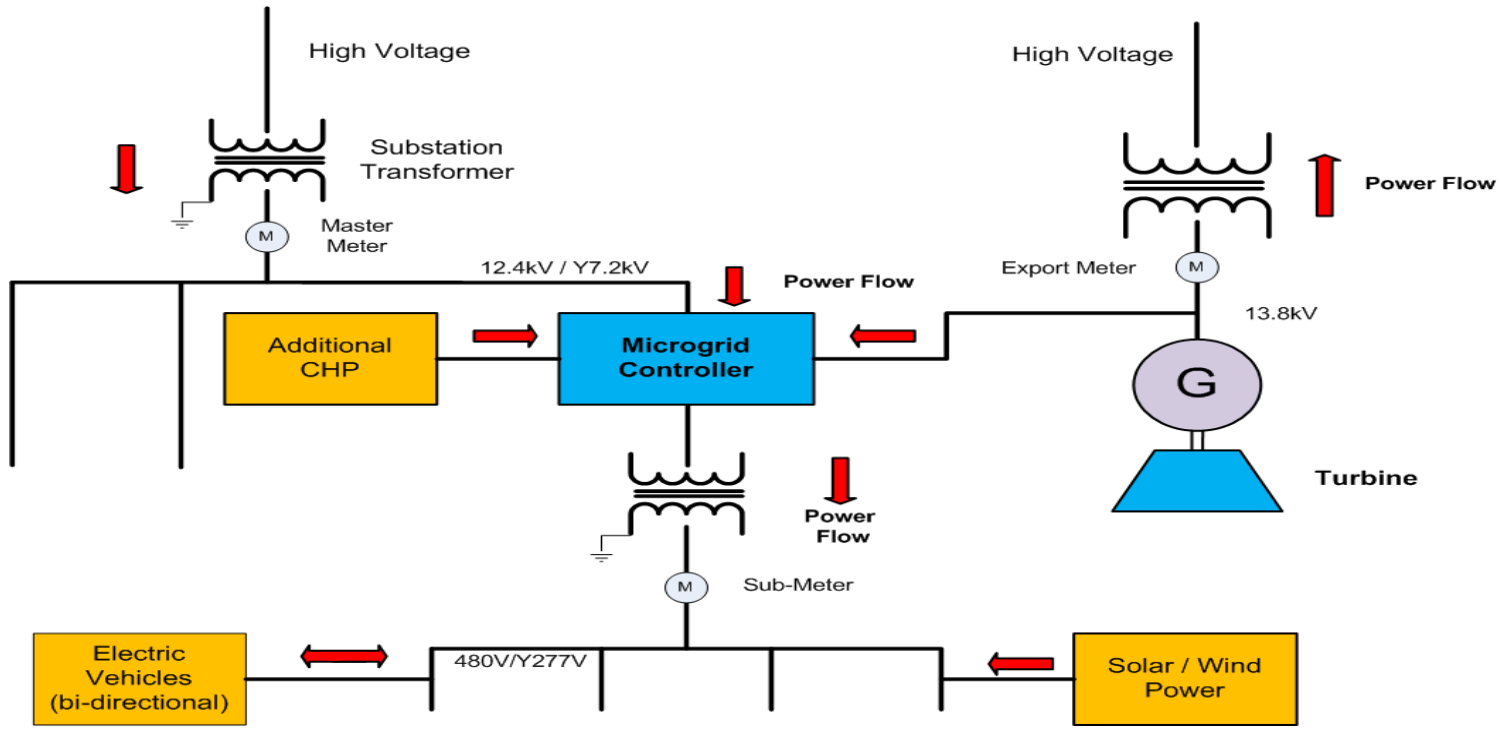
Adding New Power Generation



Once the non-synchronous microgrid is permitted, it can have power fed to it from multiple sources without requiring new utility permits. The energy can come from any source, such as solar, wind, gas engine/turbine, or energy storage. The modular nature allows the new energy to be added in the future, again without additional permitting. This is very good for testing new or experimental forms of power generation or energy storage. A system controller can be programmed to optimize the use of the different energy sources, since each can be optimized independently by the microgrid controller.

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