PARETO ENERGY

MICROGRID TECHNOLOGY & BUSINESS MODELS FOR DECENTRALIZED ENERGY

Presentation to:

Not Your Grandma's Infrastructure: The Urban Energy Revolution

September 28, 2012

Pareto Energy Background and Contact

The Business

Pareto Energy develops urban peer-to-peer power networks known as microgrids. Microgrids digitally monitor, manage and control sustainable energy resources located at or near their point of use. Pareto Energy invents microgrid power control technology, designs microgrid architecture, and arranges microgrid project financing, operation and maintenance.

GridLink™

Pareto Energy has invented a patent-pending technology known as GridLink that serves as the interface between the inherited infrastructure of the utility company "macrogrid" and the multiple sustainable energy resources of emerging microgrids. Integrating sustainable energy resources into the existing utility grid has been an expensive, tediously long, and sometimes impossible procedure. GridLink overcomes this with a straight forward plug-and-play process.

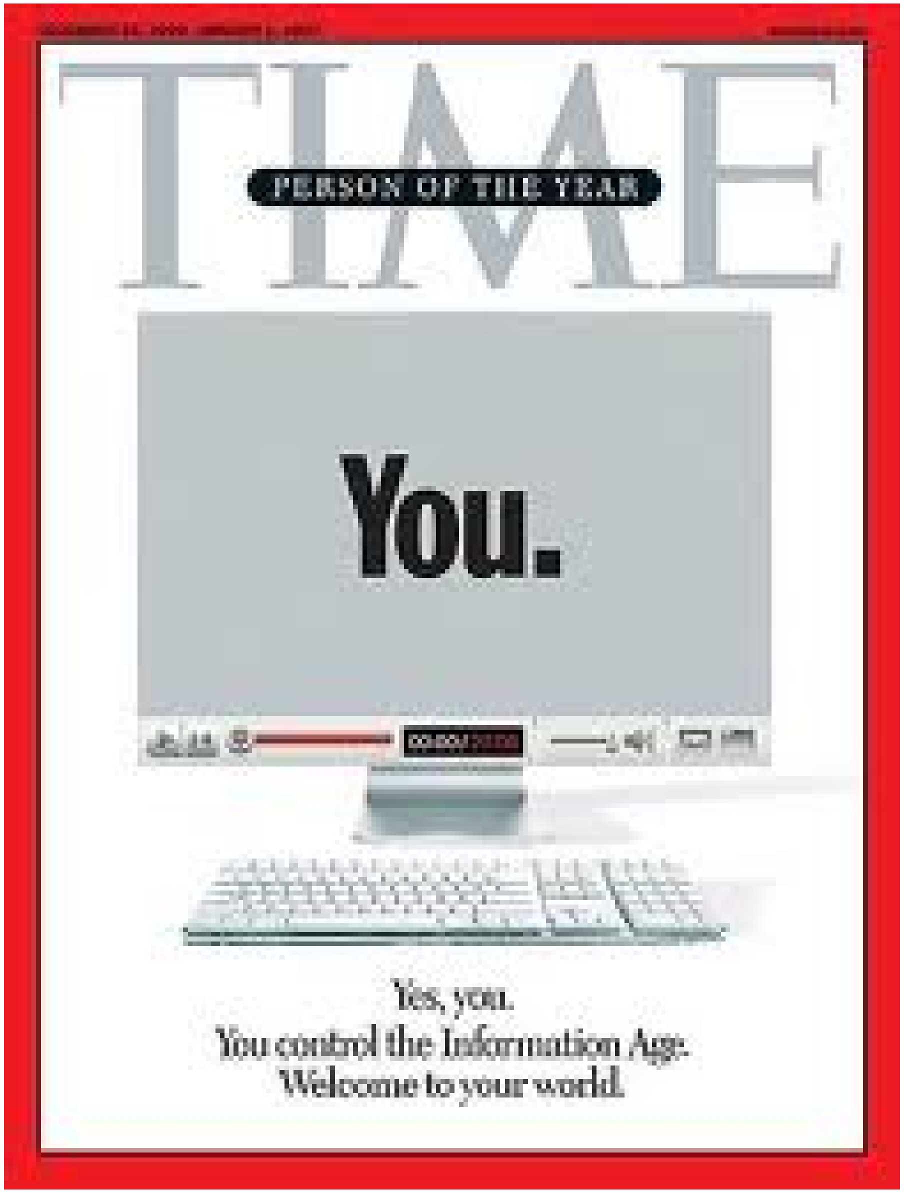
Energy Improvement Districts

To develop the market for microgrids, Pareto Energy establishes public-private partnerships known as Energy Improvement Districts ("EIDs"). In 2006, the Company signed a strategic alliance with the US Conference of Mayors to assist cities and municipalities in establishing EID microgrids. Since then, we have passed enabling legislation in several States and built a broad level of support from numerous communities. Feasibility studies suggest that a typical EID microgrid, fully financed by Pareto, will reduce energy bills by more than 15 percent while lowering emissions of CO_2, SO_2 and NO_x. Moreover, using microgrids with grid backup will reduce expected power outages from twice a year to once every five years. Therefore, microgrids can be important for serving critical infrastructure such as financial and R&D facilities and military bases. EIDs also promote the optimal mix of public financing with private tax incentives.

Contact: Guy G. Warner, gwarner@paretoenergy.com

The Theoretical:
Some Background on Decentralized Telecoms and Computing

After 50 Years of Decentralizing Telecommunications & Computing Time Magazine Names “You” as Person of the Year



“It's a story about community and collaboration on a scale never seen before. It's about the cosmic compendium of knowledge and the million-channel people's network and the online metropolis. It's about the many wresting power from the few and helping one another for nothing and how that will not only change the world. For seizing the reins of the global media, for founding and framing the new digital democracy, for working for nothing and beating the pros at their own game, TIME's Person of the Year for 2006 is you.”

Technology to Protect Existing Phone Networks Results in Decentralized Telecommunications. Commercialization Takes Over 25 Years.

Carterphone Case
Users Can Plug & Play with
Protective Devise

Plug & Play
Home & Office Devices

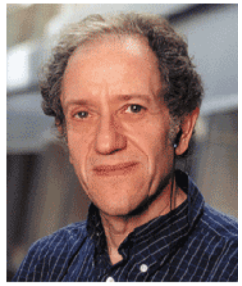
56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81

Hushaphone Case:
Users Can Supplement Service
with their own Device

Modem Connected
Terminals to Mainframes

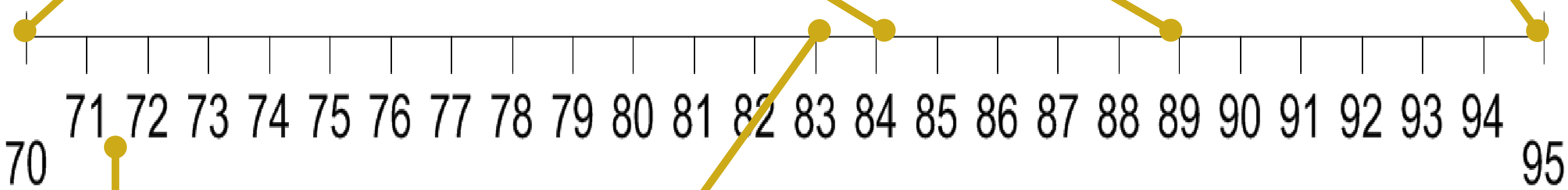
Federal Development of Network Connection Protocols Results in Decentralized Computing. Commercialization Takes Over 25 Years.

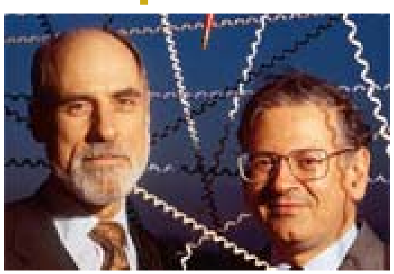
ARPA-NET



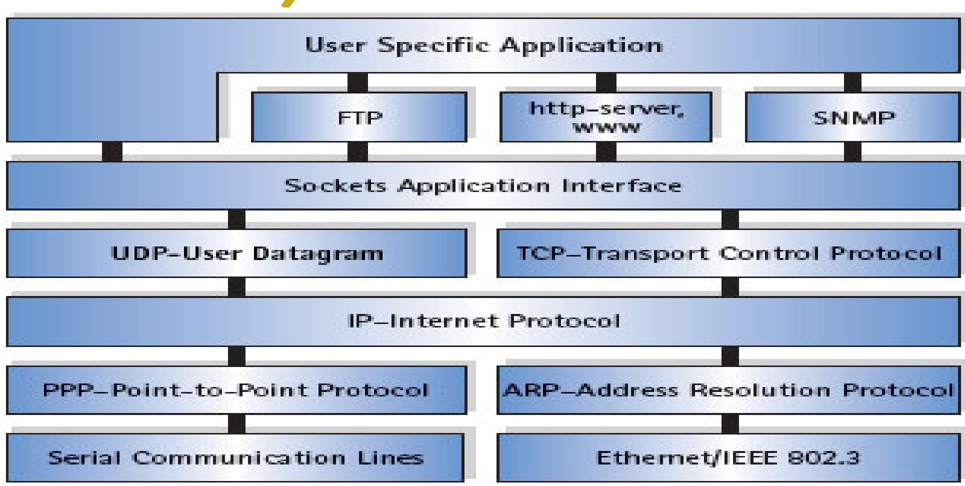
Appleman:
IBM MVS/VM/OS2

BSD Unix



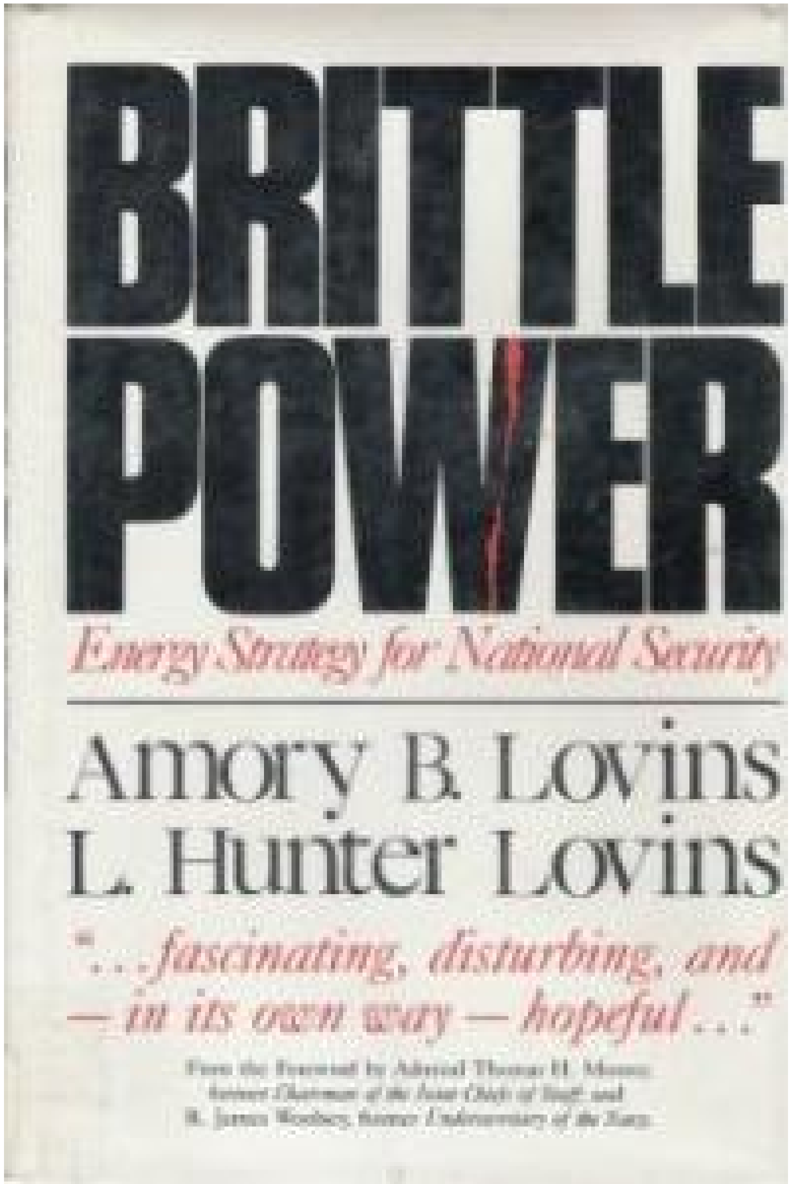


Cerf & Kahn



Protocols

Decentralized Power Networks have not been Fully Commercialized Despite Almost 30 Years of Effort. Lack of Interconnection Technology and Government Leadership has been the Problem.



1983 – Case for decentralized power networks was widely published.

Unlike decentralized telecoms, no devices to protect existing power networks have been developed.

Unlike decentralized computing and the internet, the Federal Government has not been a major adopter of distributed generation and has not been a force for developing network protocols for interconnecting customer-owned power with utility-owned grids.

Interconnection as a Technical Problem
Introducing the Non-Synchronous Microgrid Solution

The Largest Trading Floor in the World:
Highly Reliable Decentralized Telecommunications and Computing Networks
But a Remarkably Exposed and Unreliable Centralized Power Network

There is no Shortage of Generation Solutions: A Data Center Combined Heat & Power System Results in Less Expensive Power than the Utility Grid if Utility Interconnection is Solved

The Consequences of Delayed Islanding of On-Site Power: Bradley Airport October 2011 Power Outage On-Site CHP System 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)

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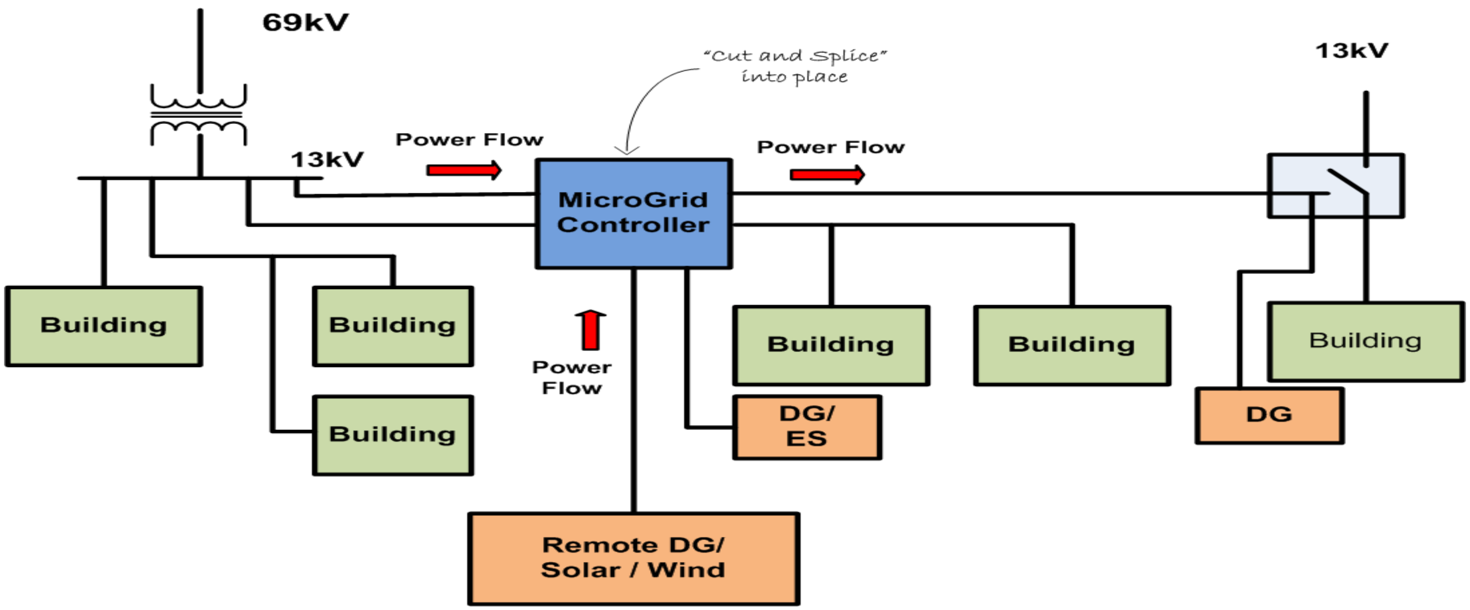
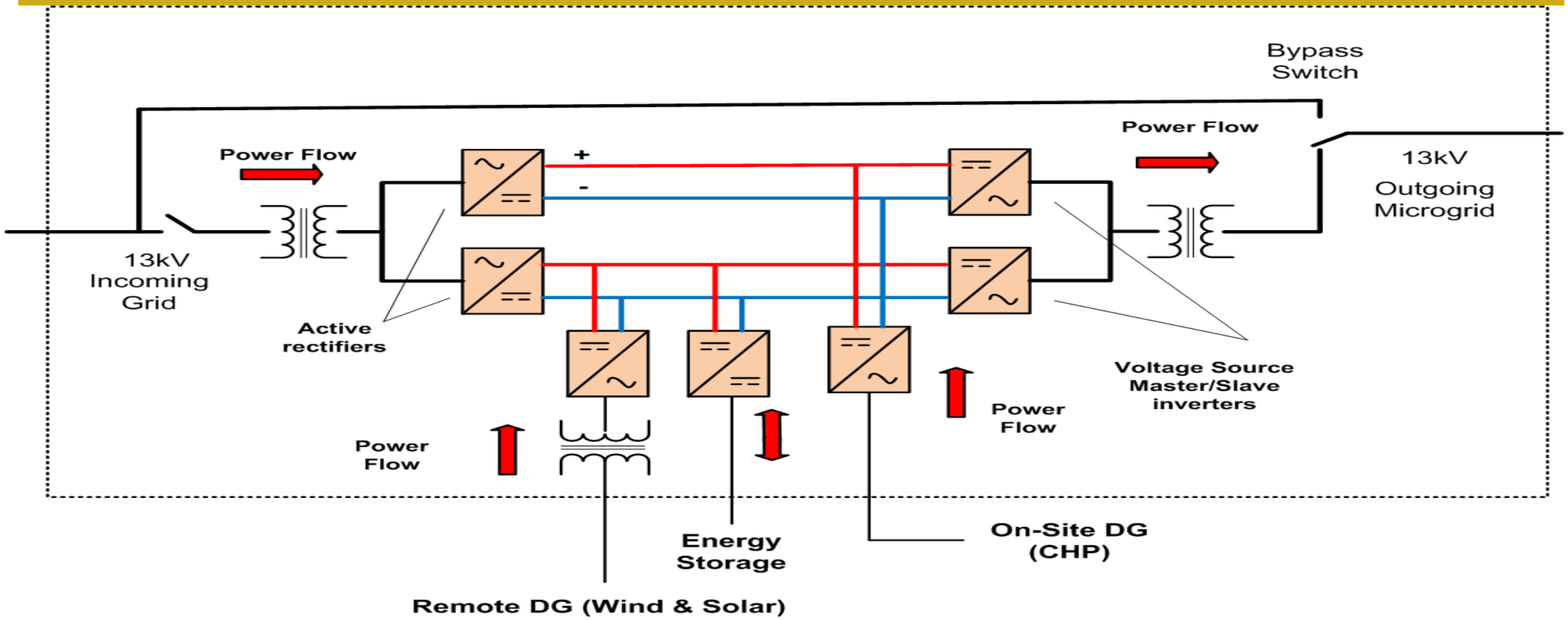
GridLink Enables an Always-Islanded Non-Synchronous Microgrid Using Back-to-Back AC-DC and DC-AC Power Conversion for Power Flows From Both the Utility Grid and From Customer-Owned Distributed Generation



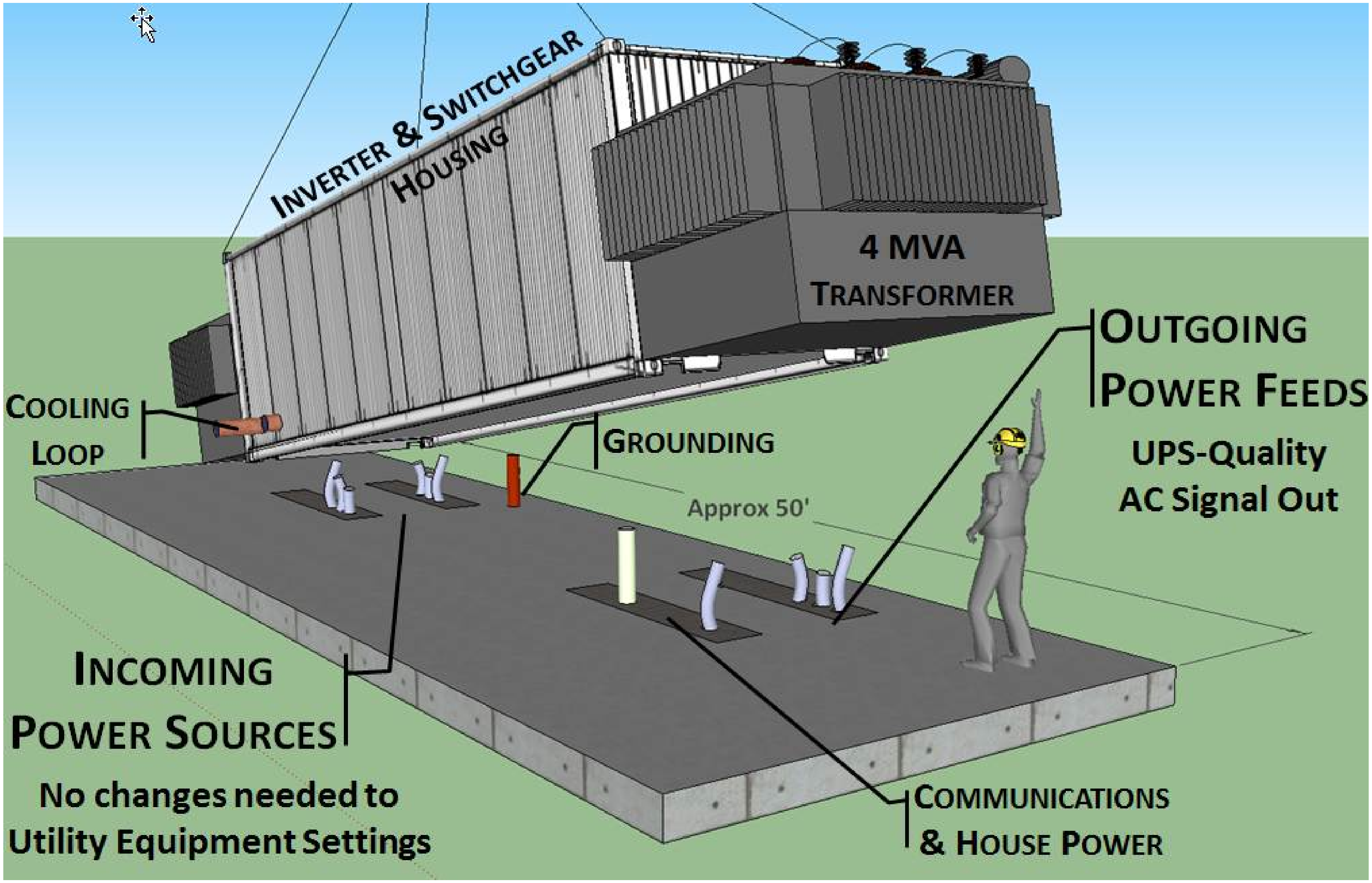
The big difference is that the GridLink "blue box" appears to the upstream grid as demand only, so that the generators that also feed the blue box are not seen by the grid. Consequently, the voltage, frequency and phase angle of the utility grid and the customer-owned distributed generation are completely isolated from one another. This allows for distributed generation to plug and play anywhere in the grid without all of the other complications of a synchronous generator interconnection. A further advantage is that distributed generators run more efficiently at variable speeds which they cannot do if they have to be synchronized to the utility grid.

What is Inside the "Blue Box"?

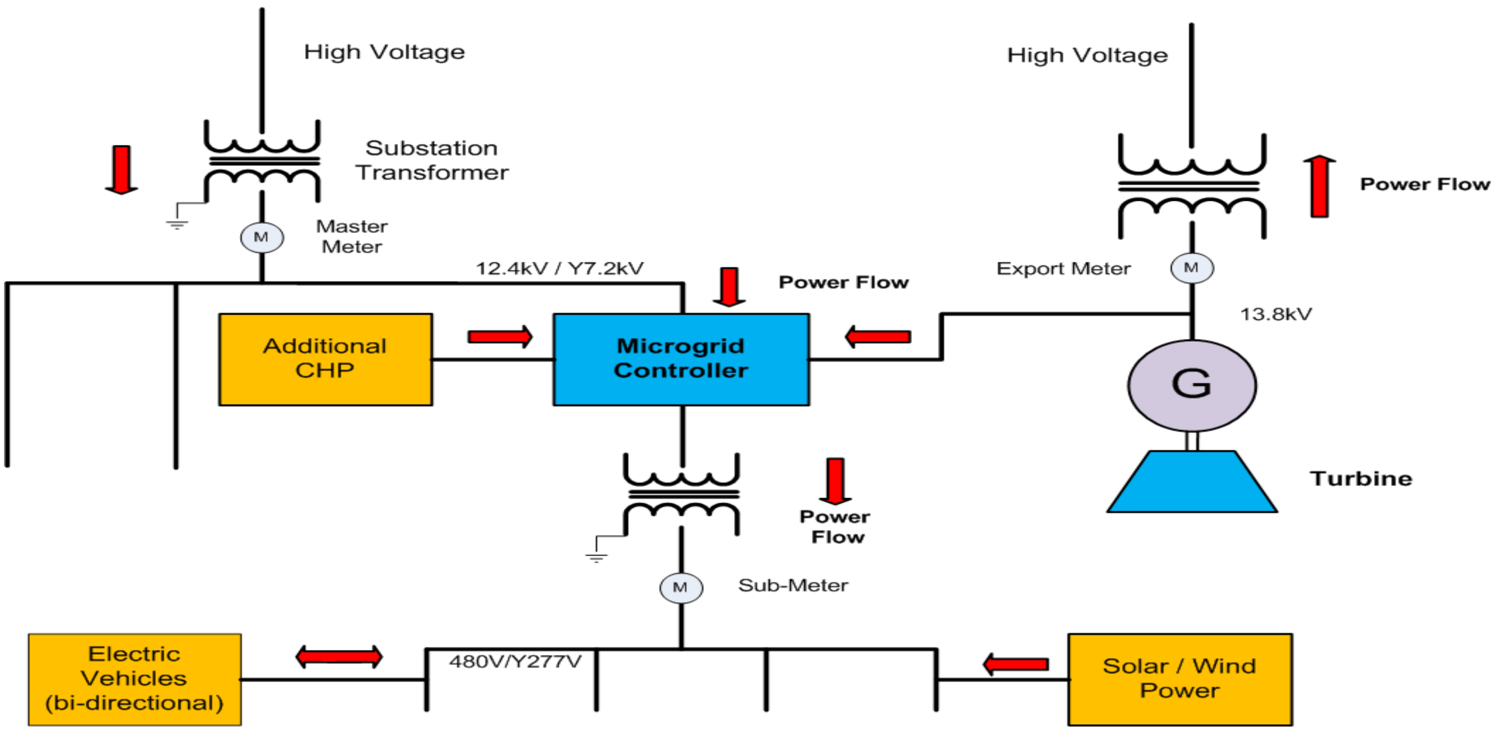


Power is distributed exactly as it was when the customer was using utility grid power alone except that the microgrid customer can now draw from both the existing grid and as many distributed generators as they care to install. The new microgrid uses power electronics and back-to-back power converters to create a new grid that is functionally equivalent to the utility network it is replacing. There is redundancy built into the microgrid with a primary and backup inverter for each generation source, as well as the system redundancy of being able to feed from two independent sources, the utility grid and customer-owned distributed generation.

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.



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.

Engineers and Utility Companies Agree that Non-Synchronous Microgrids with GridLink Can Affordably Island Customer-Owned Distributed Generators to Provide Uninterrupted Power During a Grid Power Outage

11/08 — Matthew Brown URS

URS Washington Group:

GridLink will "preclude any potential detrimental effects on the power delivery system [and] eliminate the potential of voltage, frequency, and phase-angle mismatching between the facilities and the utility grid."

2/09 — Connecticut Light & Power

"the proposed generator will not have an impact on the CL&P distribution system."

5/11 — EEI Edison Electric Institute

"...cutting-edge GridLink technology enables a safe connection between a microgrid and a traditional grid"

6/11 — pepco

" The proposed generators will not operate in parallel with the Pepco electric distribution system."

8/11 — Silicon Valley Power, City of Santa Clara

" Master Interconnection Agreement"
- One application for microgrid, covers all future generation.

12/11 — Honeywell

Use GridLink to integrate microgrids and on-site power with Building Automation & Controls:

- load reduction,
- energy efficiency, and
- demand response.

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Interconnection as a Problem of Property Rights & Institutional Change: Introducing the Energy Improvement District Solution

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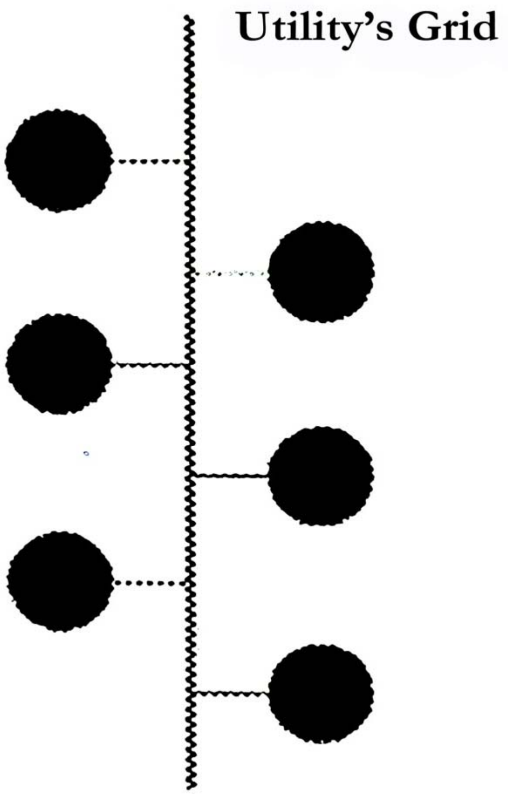
Non-Utility Management and Governance of Transmission
Independently-Managed DG Added at the Transmission Level

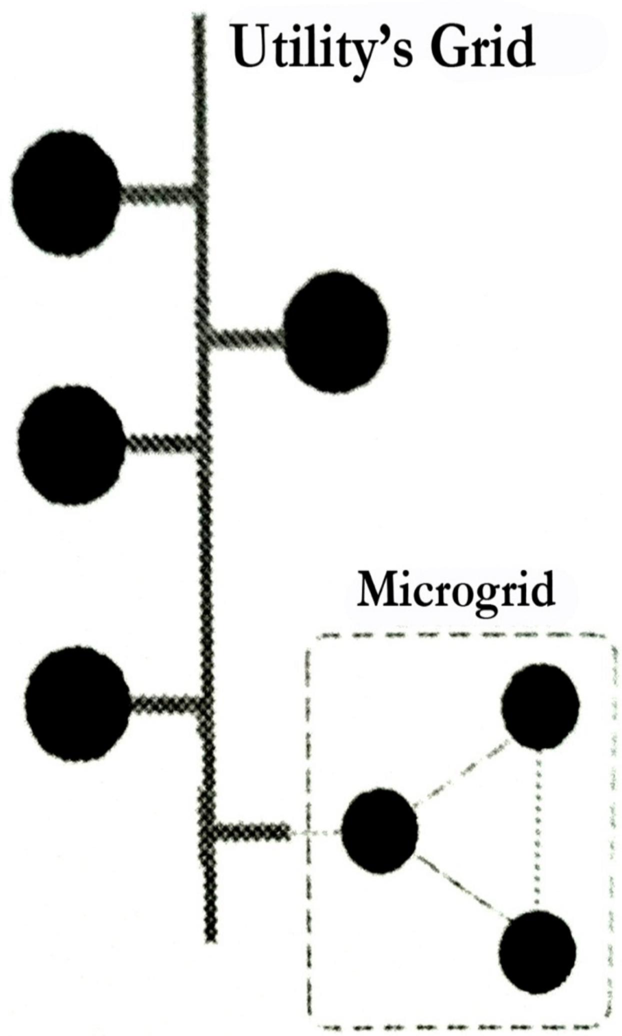


1978 – PURPA, eventually 15,000 MW of DG capacity to the transmission grid. System control problems that many feared never emerged.

FERC Order 2000 and deregulation in many states resulted in utility ownership but third-party management and governance of the transmission network. Utilities were compensated for loss of the rights of access by generation to the transmission system and later loss of management of the transmission system.

Note that microgrids interconnected at the transmission level often go down during grid outages, probably due to synchronization problems.

Utility Management of Access to The Distribution Grid
DG Added Passively at the Distribution Level with Anti-Islanding

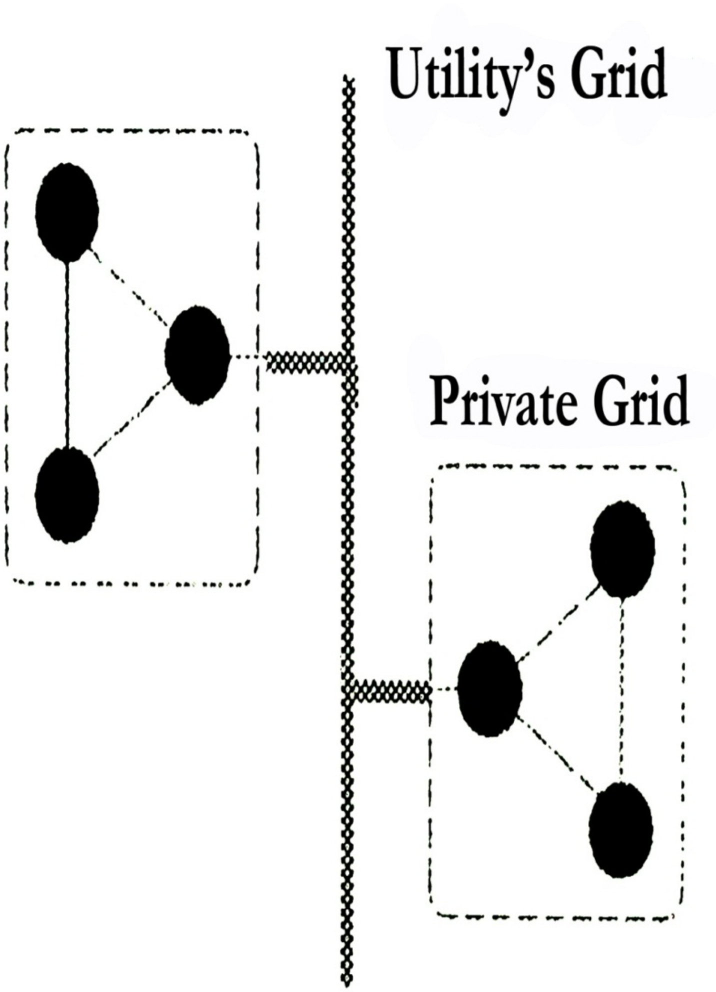


At the distribution level, most states enable customer-owned generation where private wires do not cross public roadways and where for a microgrid of more than about 1.5 to 3 MW there are anti-islanding requirements.

With anti-islanding, these microgrids tend to go down for extended periods during utility grid outages. All interconnection standards in the US are designed with this level of utility management and control in mind.

European regulation has focused much more on interconnection technologies that would enable microgrids to stay up during utility grid outages

Microgrids Coexist with the Utility Grid
DG Substitutes for Traditional Substation Upgrades in Certain Areas



Note this arrangement will not emerge without interconnection solutions to actively interconnect DG to the utility grid so that microgrids stay up when there is a grid power outage.

With some limitations there is now legal precedent allowing customer-owned microgrids with wires running across public roadways in Connecticut, New Jersey, Pennsylvania, and California.

Connecticut has an Energy Improvement District law and just introduced legislation for $300 million of funding to supplement the grid with microgrids.

Consolidated Edison has committed to 800 MW of customer-owned distributed generation and is working on interconnection technologies.

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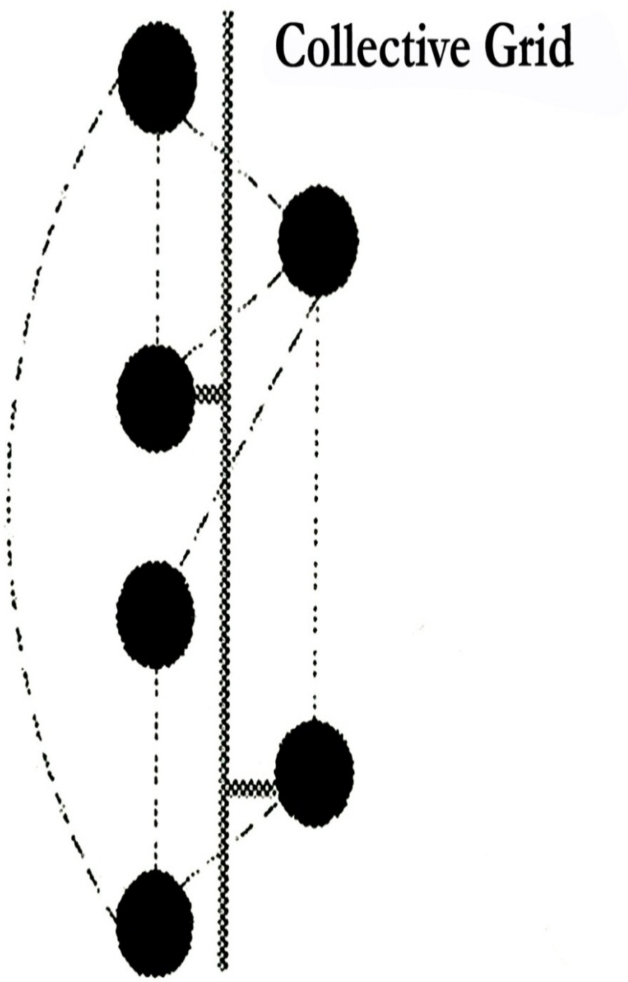
Collective Grid

Network of Microgrid-to-Microgrid Connections at the Distribution Level

Management as an Infrastructure Commons Like the Internet

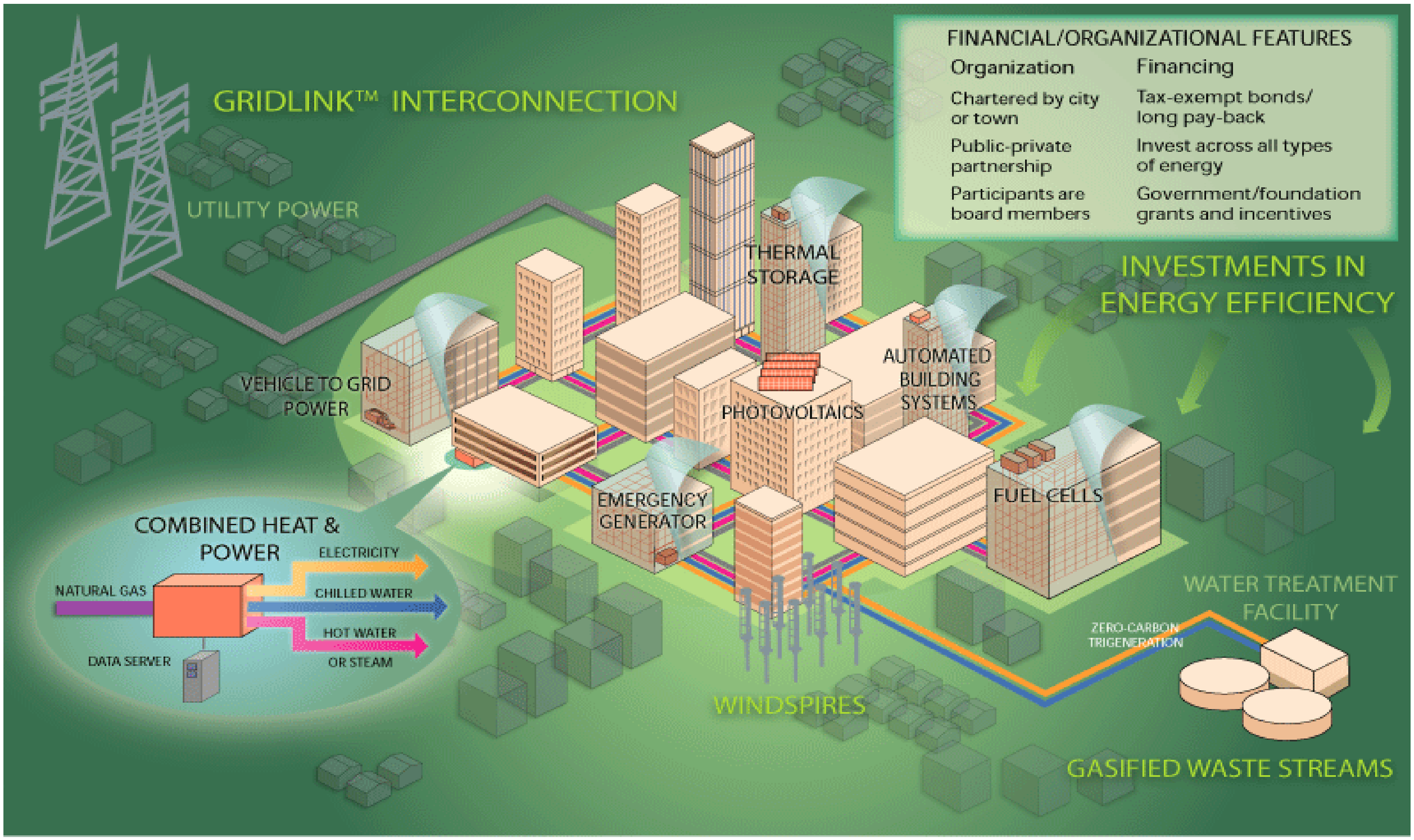


Some day there may be enough microgrid penetration to support a microgrid-to-microgrid mesh network, but this is largely a theoretical concept.

Some municipal utilities may have perfected this arrangement – little information is available. For example, the Wallingford, Connecticut municipal grid has an interconnected microgrid serving a bio-tech facility. Whereas, the CL&P grid went down in last October's snow storm for more than a week, the entire Wallingford grid restored power in less than 24 hours and it appears the biotech microgrid stayed up throughout the storm.

The Energy Improvement District Model Being Developed By Pareto Energy for a Microgrid to Serve the NYU Polytechnic Institute in Brooklyn

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



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The Prospects for Non-Synchronous Microgrids in New York

There are Powerful Stakeholders Pushing for NYC to Become More Self-Sufficient with Clean Distributed Generation

NYCEDC
New York City Economic Development Corp.

THE PORT AUTHORITY
OF NEW YORK & NEW JERSEY

NewYork Power Authority
Generating more than electricity

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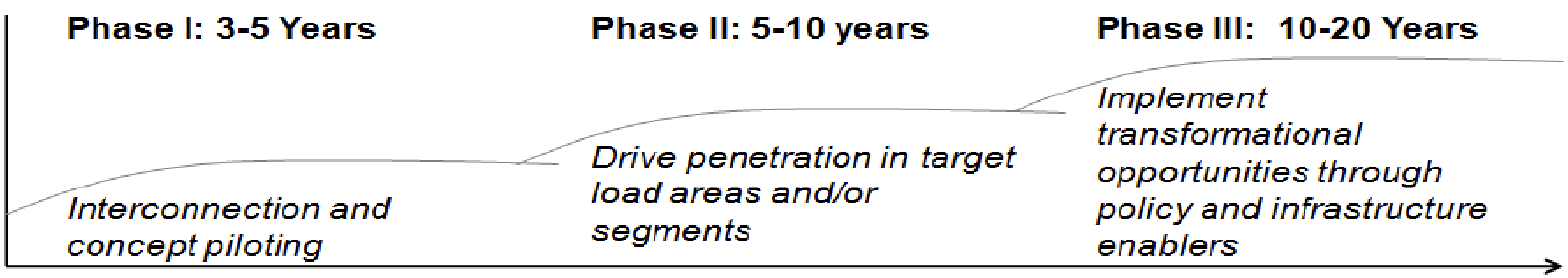
Mayor's PLANYC Results in Initiative for 800 MW's of Customer-Owned Distributed Generation. Consolidated Edison's Long Range Plan Sets Time Line.

CONSOLIDATED EDISON COMPANY OF NEW YORK

Electric System Long Range Plan: Assessment Documents

Assessment Document 2: Distributed Generation

Figure 3-1: Implementation Plan: Distributed Generation

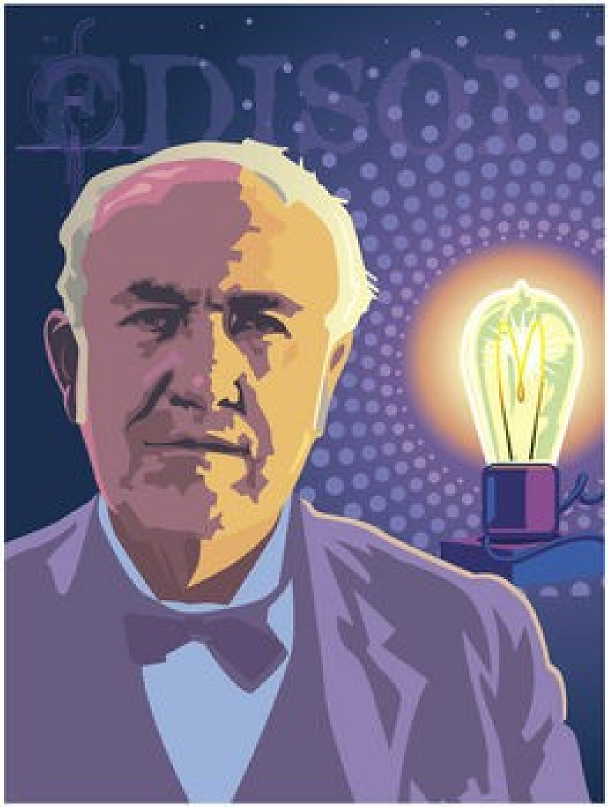


"Continue partnering with customers and other stakeholders … and distributed generation advocates to facilitate the interconnection of distributed generation facilities and examine the opportunity to pilot new projects and concepts."

"Promote adoption of distributed generation in areas of the service territory where it can be the most beneficial to meet customer and Company objectives, including: reducing cost, increasing reliability, improving air quality and lowering greenhouse gas emissions. Results … will shape the subsequent strategy of the Company."

"Focus on more transform-ational opportunities through new policy and infrastructure enablers. By this time, tech-nology standards should begin to emerge among the multitude of technologies being tested today. These standards will allow for simplified intercon-nection and management of disparate devices in the network"

Con Edison Recognizes that Decentralized Energy with Distributed Generation is not a New Idea



"As early as 1901, Thomas Edison himself was devising ways to leverage distributed generation (DG) technologies in his home. Although in the end his plan was unsuccessful, a century later some distributed generation technologies have become not only cost effective options, but also offer an opportunity to increase system reliability by relocating load from the central station to the end-use location; and to reduce greenhouse gas (GHG) emissions."

"To date, Con Edison has been a partner with the community; assisting customers in interconnection of their distributed generation facilities."

"Customers can choose to use their distributed generation for emergency use only, to offset thermal energy requirements, for peak shaving, for total energy offset, or to produce surplus energy to sell back to the grid."

Source: Con Edison 2010 Long Range Electric System Plan

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Con Edison Agrees that No Existing Technology Can Affordably Island a Microgrid to Provide Uninterrupted Power During a Grid Power Outage

"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."

Source: Consolidated Edison, 2010 Distributed Generation Collaborative Final Report

Consolidated Edison Envisions Centralized Control of Customer-Owned Distributed Generation that is at Odds with the Vision of Non-Synchronous, Customer-Controlled Microgrids

"To capture additional value from distributed generation, resources must be monitored at a minimum and preferably dispatchable and verifiable, which may require underlying equipment enhancements such as advanced metering infrastructure (AMI)."

"DG may require distribution system protection to support two-way power flow as well as communication between the distributed generation resource and the utility control center."

"Successful installation of distributed generation also requires addressing known problems of power quality and interconnectivity issues."

-- Source Consolidated Edison 2010 Long Range Electric System Plan

Other Con Edison Observations about the Plan for 800 MWs of Customer-Owned Distributed Generation. Excerpts from Con Edison 2010 Long Range Plan.

"Many natural gas-fired distributed generation units remain extremely noisy and odorous and will not be welcomed by residents in certain neighborhoods. Installation of technologies that include exhaust or emissions can only be installed by customers able to safely direct those emissions away from people living and working in the vicinity of the unit."

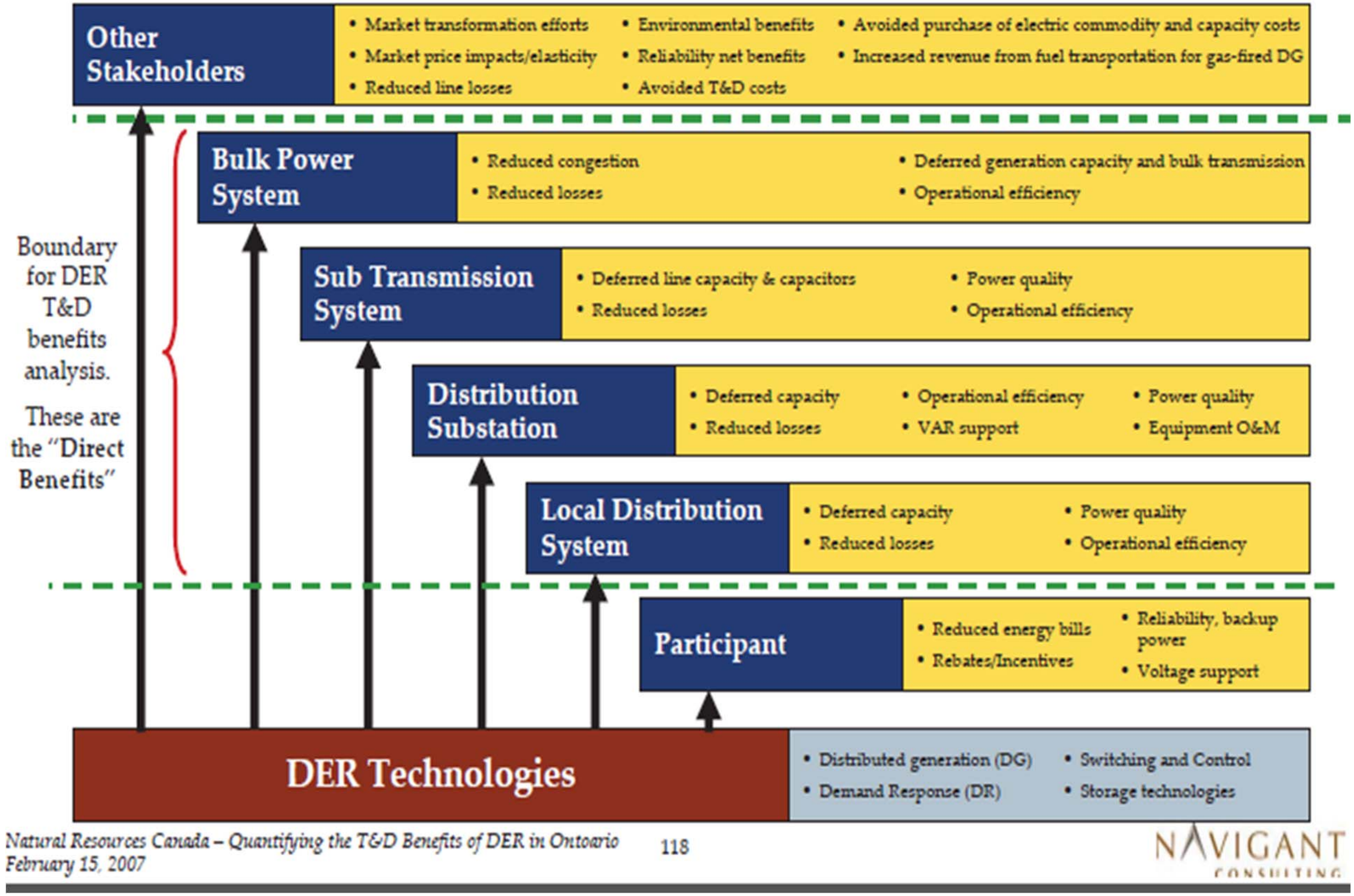
"The adequacy of the gas infrastructure should be evaluated—Con Edison's gas system long range planning effort is studying what enhancements or upgrades are required to the gas system to support ."

"Many customers do not have the extra space required for a generating unit and purchasing additional space is often not feasible."

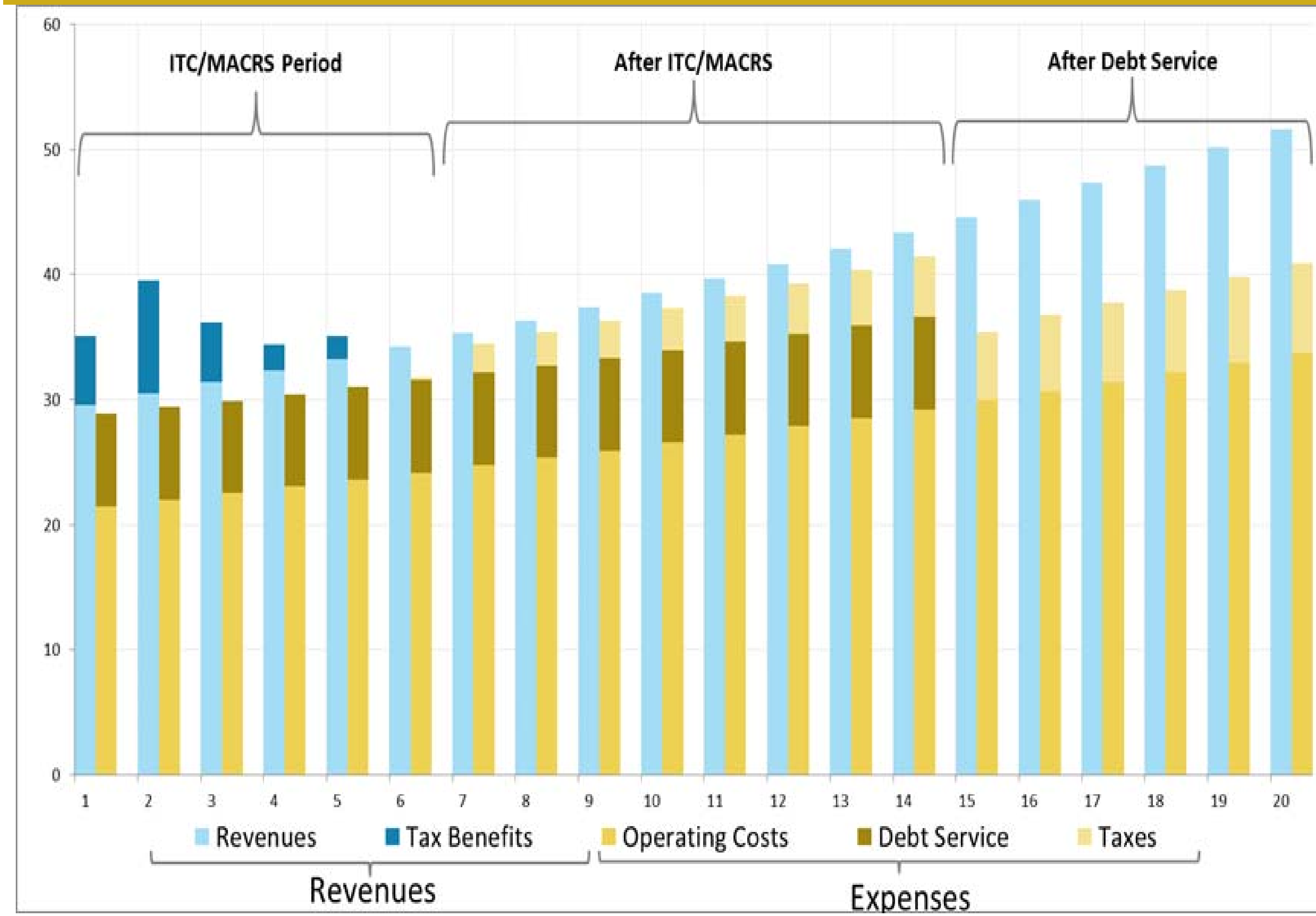
"As a significant portion of this technical potential is assumed to be from renewable sources, a large portion will not be coincident peak and only the coincident portion will translate into a reduction of demand on our system."

"Utility ownership of renewables should be permitted in order to support broad scale deployment."

Measurable Benefits of Distributed Generation to Multiple Stakeholders



NYU-Poly Microgrid:
Summary of Anticipated Economic Benefits



NYU-Poly Microgrid
Summary of Anticipated Environmental Benefits