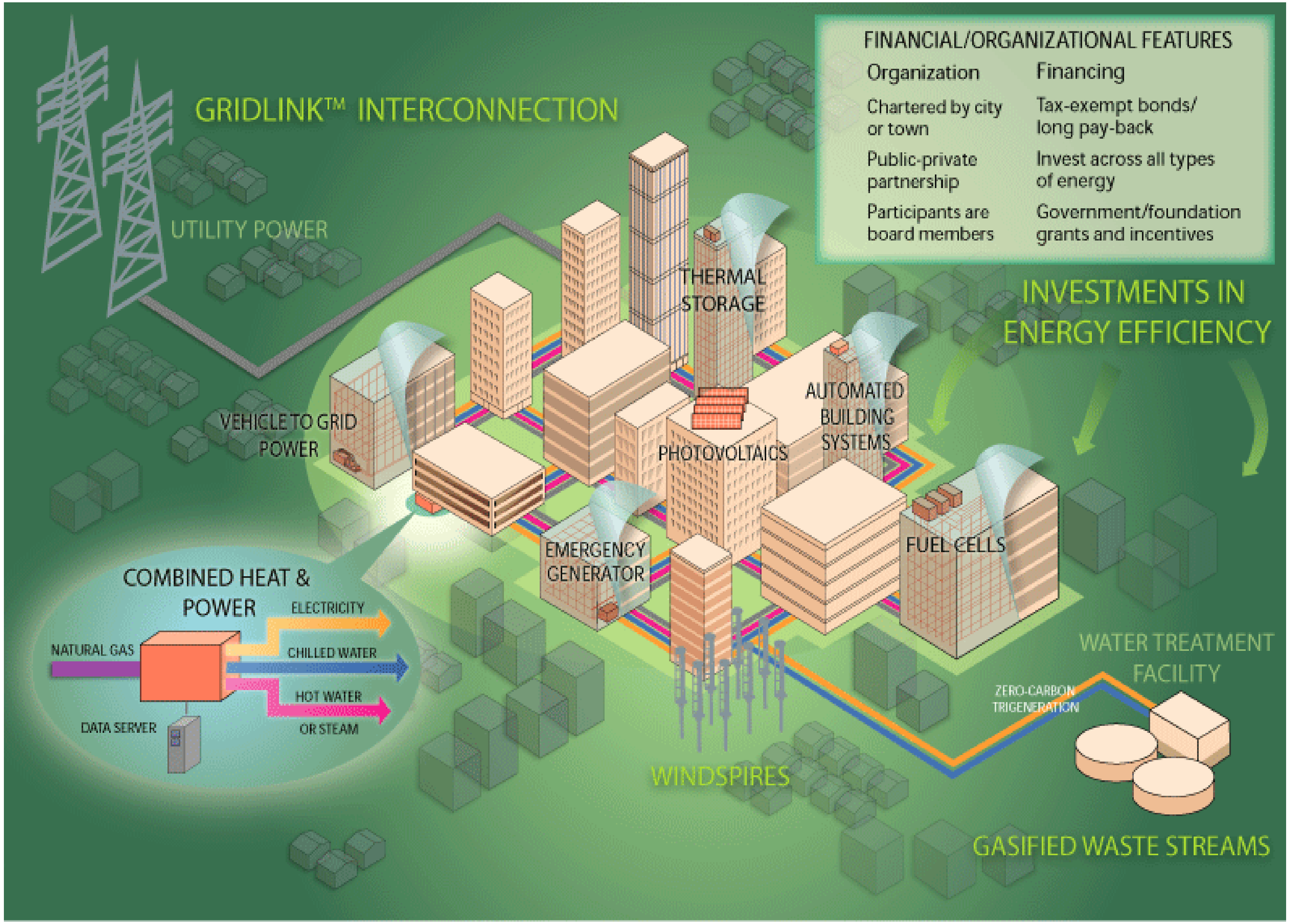
PARETO ENERGY

The Microgrid Company

Financial and Engineering Case Study:
A Two-Sided Platform Business Model for Microgrids Using Existing CHP Facilities in Brooklyn and Queens

Microgrid 2017 Conference

Two-Sided Microgrid Platform Business Model: utility customers provide a portion of the power, heating and cooling services previously provided mostly by a regulated utility monopoly. Private capital investors fund some of the power distribution infrastructure previously funded entirely by utility investment.



Post-REV Data on CHP Engineering and Economics in NYC

- 340 MW of CHP in 45 plants
- size range 1 – 150 MW; average size = 7.5 MW
- Average age of plant = 19 years.
- Best run plants vs. Alternative of Importing Power from Utility Grid:
  - 5 times more reliable,
  - half the cost
  - 30 percent lower carbon footprint
- At risk return on assets ~ 4 to 5% versus >9% guaranteed rate of return to Con Ed.
- Not allowed to participate in BQDM program for decreasing grid congestion.
- Synchronous interconnection preferred by Con Ed eliminates reliable microgrid-to-Macrogrid sales of real and reactive power in the NYISO markets.
- Non-synchronous interconnection to an inverter in parallel not allowed.

Introducing the NYC Economic Stakeholders: Considering the objective function of each market participant in the conversion from a one-sided to a two-sided utility business model.

Microgrid Owner: return on microgrid assets > return on investing in real estate or non-energy cost saving equipment. Must generally be around 9% in NYC.

Platform Investor: internal rate return on investing in interconnection platform > internal rate of return in investing in alternative smart grid technology. Generally about 12% in NYC.

Utility Shareholder: profits from being a distributed system platform provider > profits lost from microgrid power deferring investments in more expensive transmission and distribution infrastructure. Shareholders would forego returns on investments estimated to be more than $5 per watt for at least 5 years.

Utility Rate Payer (as represented by the NYSPSC): benefits of deferring investment in traditional grid infrastructure plus having access to more reliable, affordable and environmentally sustainable power > amounts paid to microgrid owners for microgrid-to-Macrogrid transactions. Currently, NYSPSC has authorized ratepayer subsidy to microgrid power ~ $1.80 per watt for one substation in Brooklyn. Also, microgrids can earn ~ $0.45 per watt per year for selling ancillary services to the utility grid through ISO-managed markets.

Proposed Microgrid Use Case for Brooklyn and Queens

Invest $1.50 per watt in a open source power electronics platform to interconnect customer-owned CHP networks ("microgrids") to the utility owned transmission and distribution grid ("Macrogrid").

Defer substation upgrade investments of between $5 and $17 per watt for 5 years.

Earn ~ $0.45 per watt per year from microgrid-to-Macrogrid sales of real power capacity and energy for load following, primary frequency response and grid black starting and reactive power capacity and and energy for voltage regulation.

Share total microgrid profits between microgrid owners/customers and ConEd shareholders/rate payers to increase the economic welfare of all four.

Solution to Optimize each Stakeholders Objective Function: a two-sided platform business model provides off-the-shelf power electronics technology and financial optimization tools to enable network efficiencies and to equitably distribute benefits between the microgrid owners/customers and utility shareholders/rate payers.

Technical Challenge

Using electro-mechanical switch gear to interconnect the Macrogrid with the Microgrid poses significant technical challenges and results in excessive interconnection costs and negative impacts on network efficiencies.

Economic Challenge

How can the utility maintain shareholder value in converting to a two-sided platform? Is there a Pareto Optimal way to monetize transactions and share savings from the network efficiencies of a two-sided platform business model such that no party is worse off?

Electrical Engineering

Power Electronics replace electro-mechanical switchgear for interconnection

+

Financial Engineering

Economic optimization models distribute earnings equitably between microgrid owners, ratepayers & shareholders

Electrical Engineering Solution

Use a power electronics platform to non-synchronously interconnect tyo

1) Protect the macrogrid from the microgrid
   (i.e. eliminate fault current contributions)
2) Allow the microgrid to maintain power seamlessly during a macrogrid outage
   (i.e. ride through faults from the macrogrid)
3) Qualify the microgrid as a least-cost option for maintaining grid stability
   (e.g. voltage/frequency control)

Financial Engineering Solution

Use real options modeling techniques to create an optimal market-based distribution of gains from network efficiencies where utilities do not lose revenues, DG owners can increase the rate of return on assets, and the ISO pays the same or less for grid services.

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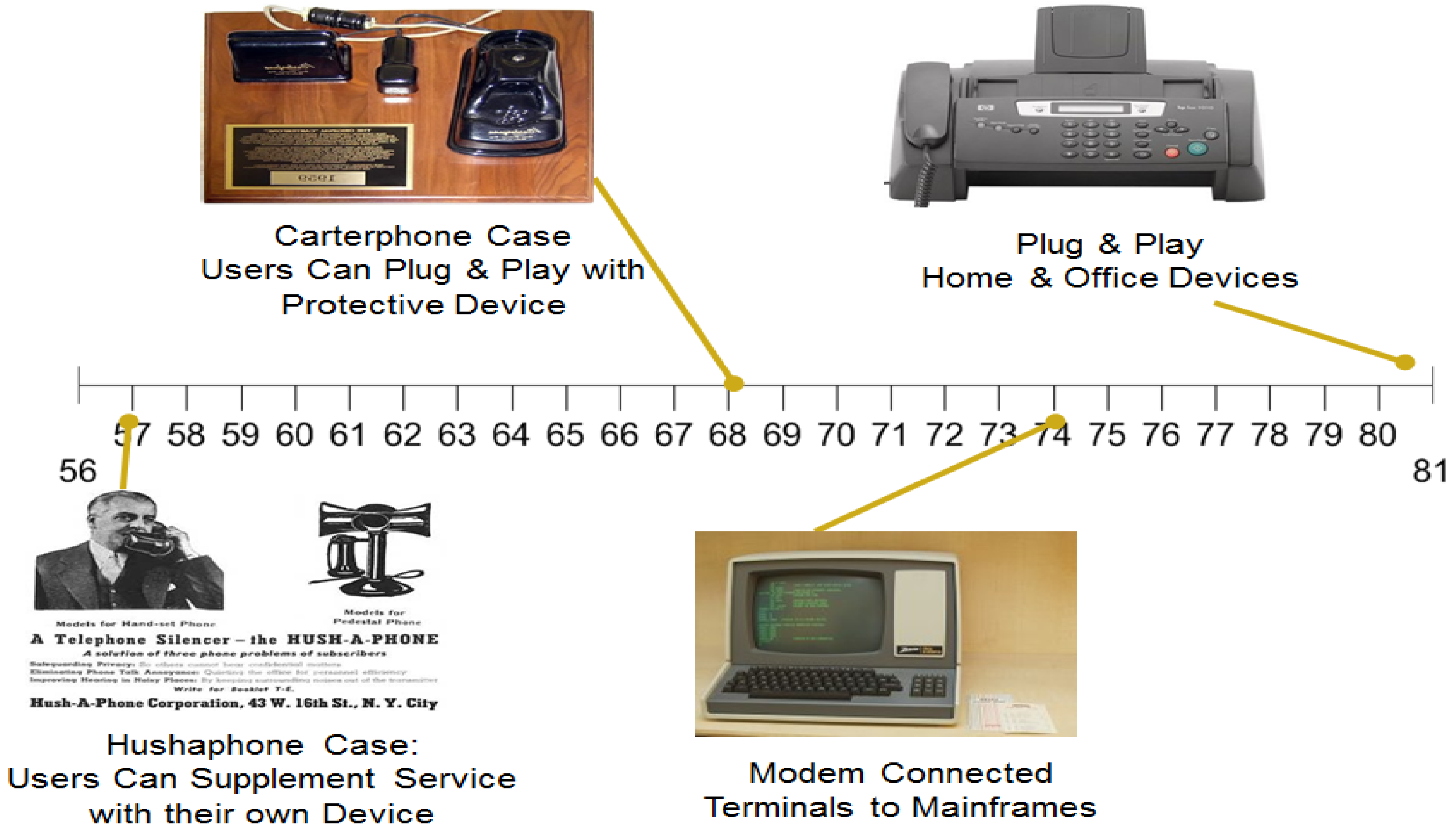
In summary, there are 4 missing components from the eight things needed for microgrids to gain critical mass in New York City.

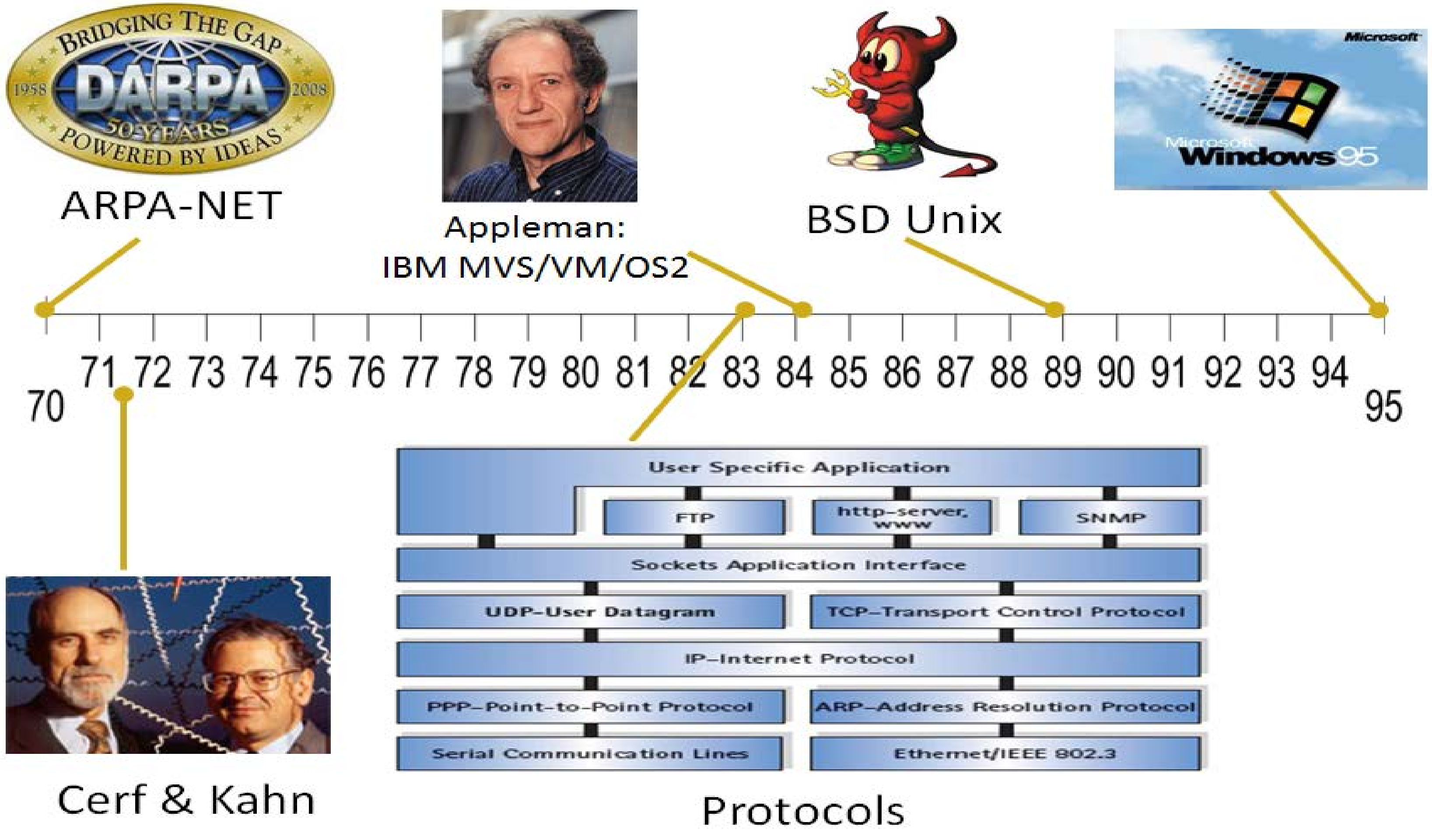
- ✓ Can serve a diversity of loads by supplementing grid power with a diversity of distributed energy resources (demand management, demand response and distributed generation).
- ✓ Do not waste heat (i.e., make maximum use of combined heat and power).
- ✓ Not more expensive than what the cost of power would be without a microgrid.
- x Provide safe and affordable access to Con Ed's utility network.
- x Result in win-win-win benefits for microgrid users, other rate payers and utility company shareholders.
- x Need a community within which users can pool their economic and management resources to govern a microgrid as an infrastructural commons; self-determination of the community is recognized by higher-level authorities.
- x As a disruptive technology, also need a market segment with significant first adopters and a significant number of demonstration projects.

The same four missing components were needed to obtain critical mass for the internet. (Slide 1 of 2)
Decentralized telecoms took 25 years to:

1. Gain safe and affordable access to the network with the modem; and
2. Discover win-win business models for the customers and the utilities.



The same four components were needed to obtain critical mass for the internet. (Slide 2 of 2)
Decentralized computing took 25 years to:
3. Organize the internet as a self-governing infrastructural commons; and
4. Develop a first adopter with significant demonstration projects.



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Two-Sided Platform Business Model

Understanding the Open Source Engineering Solution: test reports from the installation of off-the-shelf power electronics at customer sites in the field prove fault current mitigation and fault ride through can be achieved by interconnecting an inverter in parallel with the utility grid at 40 percent less than the cost of interconnecting a generator in parallel.

Excerpt from a report by GE:

Following a meeting in New York on June 11, 2014, the utility ConEd asked for a report which demonstrates that the planned inverters for interconnecting the 8 MWs of the 12.6 MW CHP serving the Kings Plaza Shopping Center do not inject fault current into the ConEd 27 KV power system. Subsequently, for the inverters manufactured by GE Power Conversion being FRT (fault current ride through) compliant to the grid codes of Germany and those similarly adopted in many other countries and utilities, the report was compiled. The examples shown originate from real-life FRT tests performed on similar inverter power electronics topology and control architecture. The report describes the EUT (Equipment Under Test) to demonstrate the similarity in both power electronics and control electronics to be used for Kings Plaza. The main conclusion is that the inverters do not allow … generator fault current to be injected into ConEd's power system. In addition, the inverters help to recover ConEd voltage by controlled reactive current injection during voltage dips. Independently from their real power output to ConEd's grid, the inverters can control the reactive power output to assist in stabilizing ConEd's 27 KV power system.

Open-source power electronics platforms consist of commercially available components that are pre-packaged and pre-tested in an eHouse and then 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

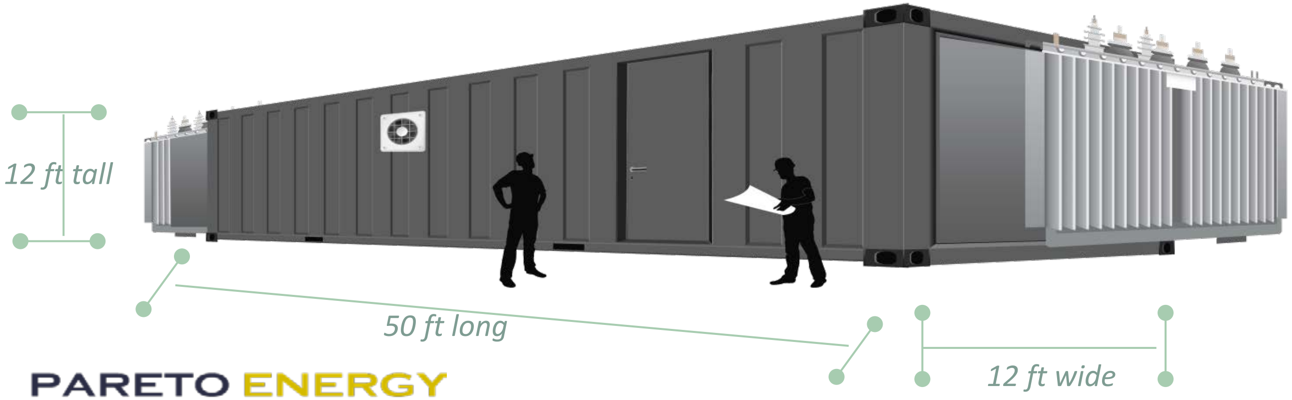
Installation:

- 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 installation: 2 x 5 MVA



Specs:

(including 27 kV connection)

Size: 12' x 12' x ~100'

Weight: 50 tons

Build Time: ~9 months

Cost: $1.20 per watt

Models: 5 MVA Unit

Core Components:

- Inverters
- Harmonic filters
- Transformers
- Breakers
- Cooling system
- Relays with GPS read of voltage and frequency eliminates need for expensive telemetry or communications

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Project Cash Flows
Interconnection using a power electronics platform for 8 MWs of CHP at the Kings Plaza Shopping Center and Marina

Year	0	1	2	3 to 10
Project Cash Outflows:				
Interconnection Cost	$ (12.00)			
Construction Loan Repayment		$ (8.28)	$ -	$ -
Utility Shareholder Profit Share	-	$ (2.85)	$ (2.70)	$ -
Utility Ratepayer Profit Share		$ (1.04)	$ (1.04)	$ (1.04)
Shared Savings to Microgrid Users	-	$ (2.43)	$ (2.43)	$ (2.43)
Total Cash Outflows	$ (12.00)	$ (14.60)	$ (6.17)	$ (3.47)
Project Cash Inflows:				
Cash From Project Finance Loan	$ 8.04	$ -		
IPEC Plan or BQDM Program		$ 5.12		
NYSERDA Demonstration Project Contract		$ 2.00		
Increased fuel efficiency		$ 1.44	$ 1.44	$ 1.44
NYISO BTM-NG Market	-	$ 3.74	$ 3.74	$ 3.74
Total Cash Inflows	$ 8.04	$ 12.30	$ 5.18	$ 5.18
Project Net Cash Flow Loss or Gain	$ (3.96)	$ (2.30)	$ (0.99)	$ 1.71
Equity Investor Internal Rate of Return	12%			
Utility Ratepayer Cashflows				
IPEC Plan and BQDM Program Incentives	$ (5.12)			
NYSERDA Incentives	$ (2.00)			
Ratepayer Rebate		$ 1.04	$ 1.04	$ 1.04
Total Ratepayer Costs	$ (7.12)	$ 1.04	$ 1.04	$ 1.04
Net Utility Ratepayer Cash Flow	$ 3.25	8%		
Net Utility Shareholder Cash Flow	$ 5.55	14%		
Net CHP Developer Cash Flow	$ 6.47	16%		
Net CHP Owner Cash Flow	$ 24.30	61%		

Real Options Financial Optimization

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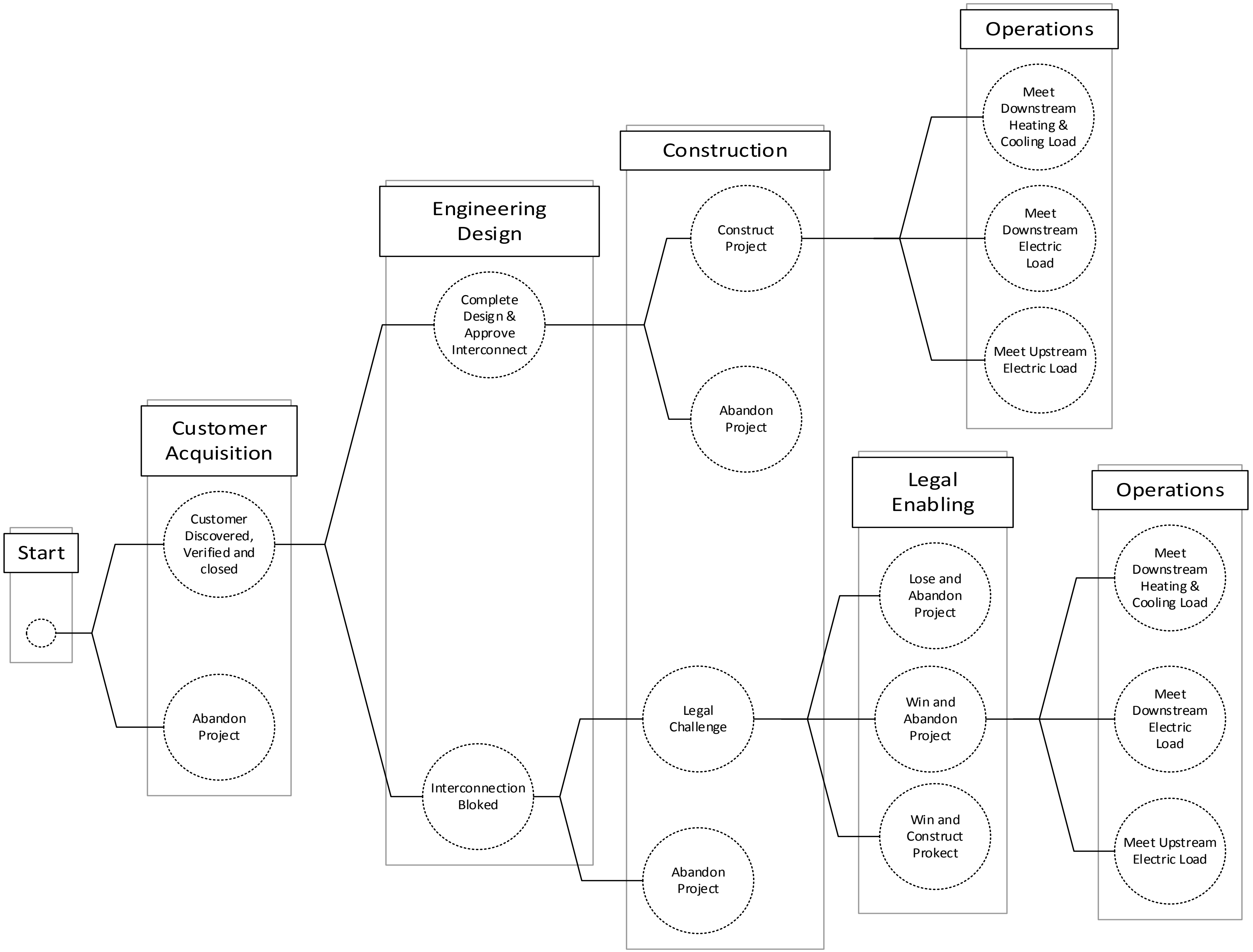
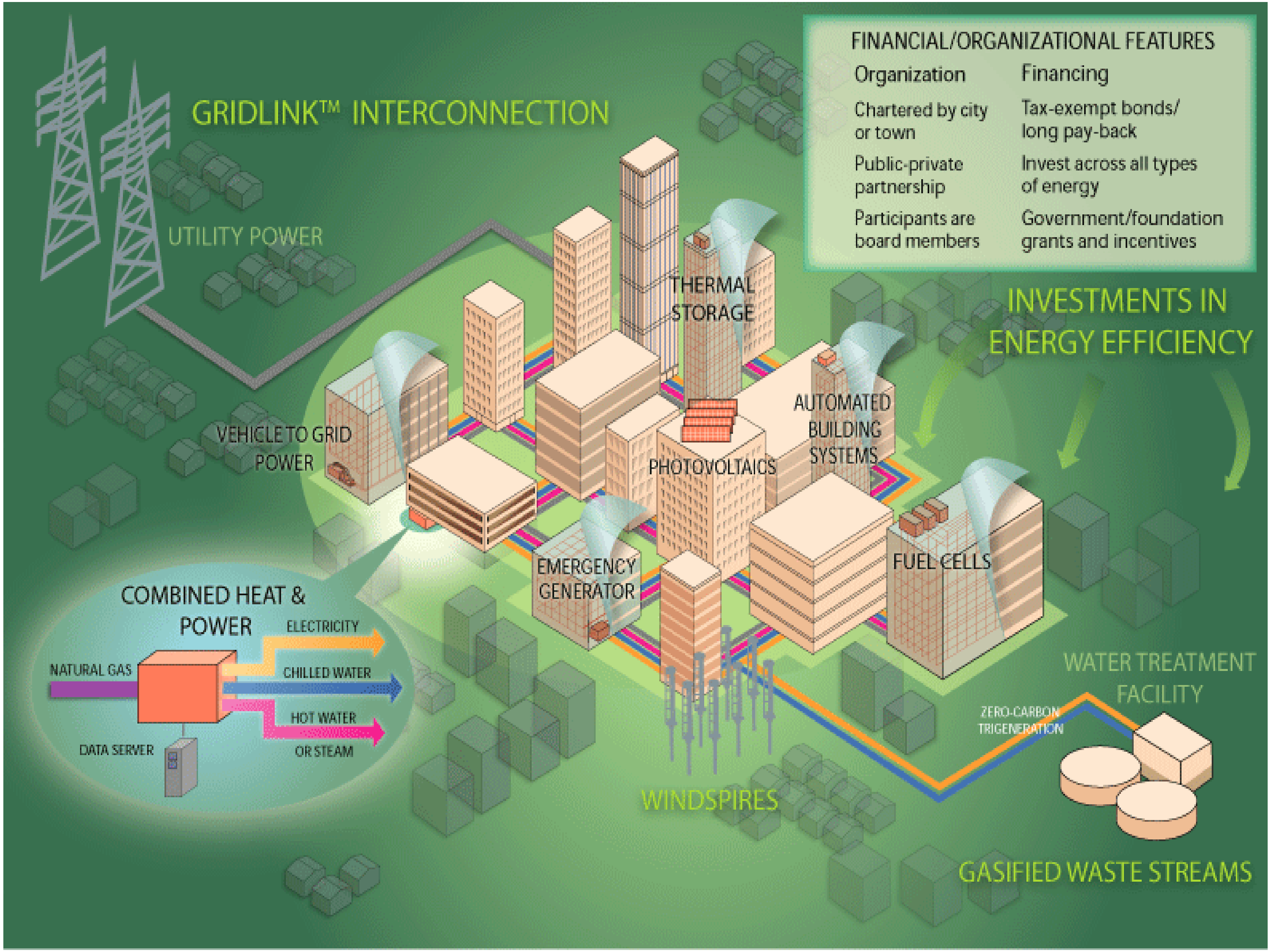


Start
Customer Acquisition
Customer Discovered, Verified and closed
Abandon Project
Engineering Design
Complete Design & Approve Interconnect
Interconnection Bloked
Construction
Construct Project
Abandon Project
Legal Challenge
Abandon Project
Operations
Meet Downstream Heating & Cooling Load
Meet Downstream Electric Load
Meet Upstream Electric Load
Legal Enabling
Lose and Abandon Project
Win and Abandon Project
Win and Construct Prokect
Operations
Meet Downstream Heating & Cooling Load
Meet Downstream Electric Load
Meet Upstream Electric Load

Common Pooled Resources


FINANCIAL/ORGANIZATIONAL FEATURES
Organization
Chartered by city or town
Public-private partnership
Participants are board members
Financing
Tax-exempt bonds/ long pay-back
Invest across all types of energy
Government/foundation grants and incentives
GRIDLINK™ INTERCONNECTION
UTILITY POWER
THERMAL STORAGE
INVESTMENTS IN ENERGY EFFICIENCY
AUTOMATED BUILDING SYSTEMS
VEHICLE TO GRID POWER
PHOTOVOLTAICS
EMERGENCY GENERATOR
FUEL CELLS
COMBINED HEAT & POWER
ELECTRICITY
NATURAL GAS
CHILLED WATER
HOT WATER OR STEAM
DATA SERVER
WATER TREATMENT FACILITY
ZERO-CARBON TRIGENERATION
WINDSPIRES
GASIFIED WASTE STREAMS

Elinor Ostrom's Principles for User Self-Governance of a Community’s Nature or Infrastructure as Common Pooled Resources

Define clear group boundaries.

Match rules governing use of common goods to local needs and conditions.

Ensure that those affected by the rules can participate in modifying the rules.

Make sure the rule-making rights of community members are respected by outside authorities.

Develop a system, carried out by community members, for monitoring members’ behavior.

Provide accessible, low-cost means for dispute resolution.